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# CHARACTERIZATION OF THE PRESENCE AND SOURCES OF DIAZINON IN THE CASTRO VALLEY CREEK WATERSHED

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## DISCLOSURE STATEMENT

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## EXECUTIVE SUMMARY

Diazinon, an organophosphate insecticide, has been detected in creeks throughout the Bay Area. Previous toxicity studies showed that storm runoff in Castro Valley Creek was frequently toxic to the aquatic test organism *Ceriodaphnia dubia*, and that diazinon was the most likely cause of this toxicity (Hansen, 1995). Since its watershed is fairly representative of urban land use patterns in the East Bay and the stream is also part of long-term stream monitoring studies, Castro Valley Creek was selected as the site for a more detailed study of diazinon in surface runoff.

The main purpose of this study was to characterize the temporal and spatial patterns of occurrence of diazinon in the Castro Valley Creek watershed. Runoff at the discharge point for the entire watershed was sampled during multiple storm events to record both seasonal and within-event variations in diazinon concentration. Analysis of these data suggested how seasonal and hydrologic factors may affect diazinon levels, and provided the basis for estimates of concentrations in unsampled runoff and of the total mass of diazinon discharged during the 1995-96 water year. Repeated sampling during and after storm events showed how long diazinon concentrations remained elevated after storms. Since a pollutant's toxicity to aquatic organisms depends on both the concentration and the duration of exposure, the persistence of diazinon in creeks is an important consideration in assessing the ecological impact of diazinon.

Sampling at multiple locations was used to evaluate the spatial distribution of diazinon within the watershed. Results from five major subcatchments indicated that sources are not restricted to particular areas, and samples from street gutters showed that at a smaller scale individual diazinon sources may be very localized. A few street gutter samples contained very high concentrations of diazinon. Data from street gutter samples were used to form a rough estimate of the number of sources in the watershed. Three selected residences were given experimental applications of diazinon to see if subsequent runoff could contain high concentrations of diazinon. Although limited in scope, the test results suggest that residential users applying diazinon in accordance with label directions may contribute significantly to the diazinon in runoff in Castro Valley Creek.

This report is part of a coordinated effort to increase available information about urban pesticide toxicity in surface waters of the Bay Area and to develop a control strategy. Related reports summarize the current problems and questions related to diazinon (Katznelson and Mumley, 1997), discuss its use and formulation (Scanlin and Cooper, 1997), and propose a framework for control strategies to reduce diazinon levels in creeks (Scanlin and Gosselin, 1997) .

## ES-1 DIAZINON IN CASTRO VALLEY CREEK

Temporal variation in diazinon levels were studied at the lower end of the watershed at station S3, where flow meters provide continuous records of flow rates and discharge volumes. Discrete samples were taken at fixed flow intervals by an automatic sampler during selected storm events in the 1995-96 and 1996-97 rainy seasons. Samples were analyzed for diazinon using ELISA (enzyme linked immuno-sorbent assay), which permits rapid testing of large numbers of samples.

Diazinon was detected in all of the sampled events. Event mean concentrations (EMCs) during 1995-96 ranged from 180 to 820 nanograms per liter (ng/l; equivalent to parts per trillion). High EMCs of diazinon were observed during fall and spring months, corresponding to periods when estimated application rates were high. High EMCs were inversely correlated with flow volumes during the two weeks preceding sampled events; this suggests that diazinon accumulates on watershed surfaces during intervals of dry weather and is then washed into the creek by subsequent storms. These relationships with season and antecedent flow appeared to be stronger for the 1995-96 season than for 1996-97. Average EMCs for 1996-97 events were somewhat lower than for 1995-96, which may be related to year-to-year differences in application rate and weather patterns.

The temporal variation of diazinon concentrations within storms followed two main patterns: concentrations either rose to a high initial peak and then gradually declined, or remained at a more constant, intermediate level throughout the storm. Low antecedent flow appeared to be associated with events showing high early peaks, possibly because more diazinon had accumulated, or because recently applied diazinon was easily washed off during the early part of the storm. Diazinon concentrations decreased gradually after storms, taking about 2 days to decrease 50% from the end-of-storm levels. Although individual storms were usually relatively short, closely spaced events or high within-storm EMC's can maintain diazinon concentrations over 150 ng/l for extended periods of up to a week. Previous toxicity tests have shown that this level of exposure can cause toxicity to *Ceriodaphnia dubia* test organisms during that time. Animals in the creek may thus receive toxic exposures to diazinon several times during the rainy season, which could have an impact on aquatic life.

EMCs and the discharged volumes of water were used to calculate the total mass of diazinon discharged in each sampled event. Mass discharge increased with increasing event flow volume, even though dilution may have reduced the average concentration. The seasonal and hydrologic patterns observed in sampled events were used to estimate EMCs and mass discharge for unsampled events. Non-storm or dry weather flows, defined as flows less than 5 cubic feet per second (cfs), were assumed to have lower diazinon concentrations than storm flows. The total amount of diazinon discharged from Castro Valley Creek during the 1995-96 water year was estimated at about 600 grams, or about 0.3% of the estimated annual usage in the watershed. About 90% of this amount was discharged during periods of storm flow (greater than 5 cubic feet per second), while the remainder was discharged during dry weather and non-storm flows.

## ES-2 DISTRIBUTION OF SOURCES WITHIN THE CASTRO VALLEY CREEK WATERSHED

Grab samples were taken by hand at different locations within the watershed to evaluate spatial patterns of diazinon occurrence. During different storm events, sampling was performed at either the subcatchment level or more locally in residential neighborhoods. Analysis of these samples showed that diazinon sources are widely distributed throughout the watershed.

Runoff was sampled at half-hour intervals during the storm of April 1, 1996 at five subcatchments that comprised 78% of the watershed area. Diazinon concentrations ranged from 50 to 1250 ng/l in individual samples and from 200 to 690 ng/l when averaged for each subcatchment. Mean subcatchment concentration was higher in subcatchments with less open space.

Grab samples taken from 45 street gutters in residential sections of Subcatchments 2 and 3 on May 16, 1996 were more variable, with concentrations ranging from non-detect (<30 ng/l) to 79,000 ng/l. Most sample concentrations were much lower, and the median sample concentration (80 ng/l) was similar to levels previously observed in rainfall samples. Higher diazinon levels were not restricted to particular neighborhoods, and adjacent gutters which drained independent sets of residential properties often had very different concentrations.

Some street gutters contain high diazinon levels on more than one occasion, suggesting that there may be some consistent sources. However, average street gutter concentrations were more similar to the concentrations observed for S3 and the subcatchments. An experimental calculation was made to estimate the number of sources in the watershed. If each street gutter sample with a diazinon concentration greater than 100 to 400 ng/l contained one source property in its drainage area, an estimated two to four percent of the properties in the total area sampled could be considered to be sources. (Extrapolation of these percentages suggests that a total of 300-600 households in the watershed may be sources during spring storm events.)

## ES-3 RESIDENTIAL RUNOFF STUDY

Since outdoor residential application appears to be a major use of diazinon in urban areas (Scanlin and Cooper, 1997), an attempt was made to verify whether application at recommended rates could produce the high concentrations observed in street gutter samples. Test applications were made during February 1997 at two residences in Castro Valley and one in a similar neighborhood in Oakland. Liquid concentrate (25% diazinon) was mixed and applied to outdoor paved areas in a quantity two-thirds of the amount recommended for control of ants. Grab samples were taken of runoff from roof, patio or driveway areas at each site during subsequent rainfall events.

On-site runoff on the sprayed properties contained diazinon concentrations of up to 1,200,000 ng/l several days after application. Patio and driveway runoff concentrations were higher than those in roof drains. Diazinon was still detected on-site seven weeks after application, and rainfall samples taken at one sprayed property after application showed elevated concentrations of diazinon up to 1300 ng/l. Rainfall during this period was insufficient to produce enough runoff for sampling in street gutters near these properties; however, these results indicate that outdoor residential use of liquid diazinon in accordance with the label directions is a possible source of the diazinon observed in the creek and storm drains. Alternative formulations such as granules were not tested and may contribute an unknown amount of diazinon to runoff.

# 1.0 INTRODUCTION

## 1.1 BACKGROUND

Diazinon is an organophosphate insecticide. It is widely used for both agricultural and urban pest control. In urban areas, it is primarily used for the outdoor control of ants, fleas, spiders and grubs. The estimated annual per capita urban use of diazinon in Alameda County (CA) is 0.02 lbs. (9g) of active ingredient (Scanlin and Cooper, 1997).

This widespread use of diazinon may be having a negative impact on water quality in urban creeks. Toxicity tests conducted on storm water samples from throughout Alameda County have shown toxicity to a standard laboratory test organism, *Ceriodaphnia dubia* (WCC, 1991, 1994, 1995, 1996a). A toxicity identification evaluation (TIE) determined that diazinon was the primary cause of this toxicity (Hansen, 1995). The presence of diazinon in storm water is not limited to Alameda County. Diazinon was consistently detected in storm water samples collected from residential watersheds throughout the San Francisco Bay area and the Central Valley of California, often at concentrations that cause toxicity to test organisms (Katznelson and Mumley, 1997).

Concern about the potential impact of diazinon in Bay Area waters led to the formation of the Urban Pesticide Committee by representatives of diverse agencies and organizations (Katznelson and Mumley, 1997). Several related reports arising from efforts by the committee discuss different aspects of diazinon use (Scanlin and Cooper, 1997), policy issues and current knowledge (Katznelson and Mumley, 1997) and proposals for a control strategy (Scanlin and Gosselin, 1997). This report provides information about diazinon in a typical urban watershed as a complement and support to the other publications.

The objectives of this study were (1) to characterize the temporal variations of diazinon concentrations in Castro Valley Creek, (2) to track the sources of diazinon in the watershed, and (3) to determine if the application of diazinon in accordance with label directions could be contributing to the observed toxic concentrations.

## 1.2 WATERSHED DESCRIPTION

The Castro Valley Creek Watershed, a sub-watershed of the San Lorenzo Creek drainage, covers an area of 5.5 square miles in west central Alameda County (Figure 1.2.1). It has been selected for ongoing water quality monitoring by Alameda County because it contains a representative mix of residential and commercial land uses (WCC 1995, 1996a). Previous sampling has shown consistently high levels of both diazinon and toxicity in runoff samples from Castro Valley Creek and suggested that a number of hydrologic factors may affect diazinon concentrations.

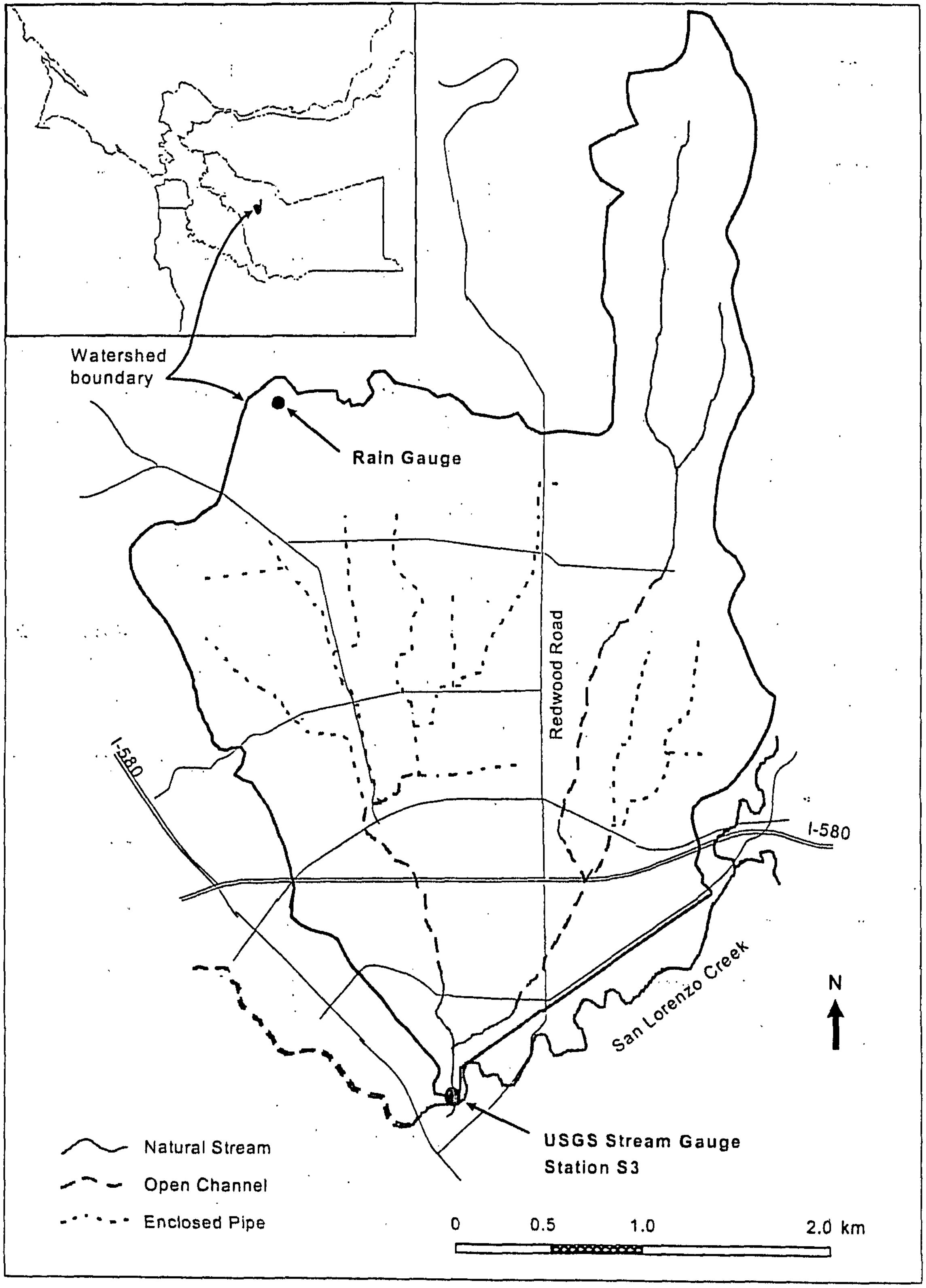

Figure 1.2.1 Location Map of Castro Valley Creek Watershed

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The population in the area is approximately 35,000. The area is predominantly low density residential development (50%), with some open space (35%), and commercial development (15%). There are 11,600 assessed parcels with single family residential units and 3,200 with multiple family units. Mean household income is approximately $50,000 (US Census Data, 1990, Sandy Rivera, Alameda County Planning Department, pers. comm.).

Mean annual rainfall in the watershed is about 21 inches, with over 95% occurring between October 1 and May 31. The soils are predominantly clays and silty clays. The downstream portion of the creek is still in a relatively natural state but most of the upper portions have been channelized or enclosed (Figure 1.2.1). The elevation ranges from 200 to 500 feet (65 to 160 meters) above mean sea level.

Castro Valley Creek flows year round. Summertime flows average about 0.2 cubic feet per second (cfs). The peak flow of record was 1,350 cfs during a storm event on January 23, 1983. The annual flow for 1995-96 water year (October 1 to September 30) was approximately 120 million cubic feet.

# 2.0 DIAZINON IN CASTRO VALLEY CREEK

## 2.1 OBJECTIVES AND METHODS

This portion of the study examined the occurrence of diazinon in combined runoff from all parts of the watershed, which is discharged at sampling station S3 (figure 1.2.1). The primary objective was to characterize temporal variations in diazinon over the course of a storm season. The relationship of these temporal variations with hydrologic (flow-related) variables was also examined and the results used to estimate the total mass of diazinon that was discharged during the year. The sampling data were also used to study how diazinon levels varied within and after each storm event.

All of the samples discussed in this section of the report were collected at station S3 near the mouth of Castro Valley Creek (Figure 1.2.1), which is the site of United States Geological Survey (USGS) gaging station number 1181008. Storm runoff samples were collected using an ISCO 3700 sampling device and an ISCO 3230 flow meter; which are housed in the USGS gaging station. The flow meter provided continuous stream level measurements that were converted to flow discharge (cubic feet/second) using the USGS rating curve for the site. These level or discharge observations were automatically recorded at two-minute intervals during most storm events and at ten-minute intervals throughout the rainy season. USGS discharge data (USGS, 1996) were used to to determine flow volumes at other times of the year. Flow meter readings were used by the sampler to control the discharge volume (cubic feet) represented by each water sample collected. The sampler could be set to keep separate discrete samples for different segments of a storm event or to combine flow-weighted subsamples into a single composite sample. Supplementary "grab" samples were collected manually during periods of non-storm flow (< 5 cfs), using 20 ml borosilicate glass vials that were rinsed in creek water immediately before sampling.

All samples were analyzed for diazinon using an enzyme linked immuno-sorbent assay (ELISA) method. Some samples were also sent to a laboratory for confirmation. (See Appendix A for additional description of sampling protocol and QA/QC procedures.) The event mean concentration (EMC) of diazinon for each sampled event was obtained either through analysis of a composite sample or through a calculation based on analysis of discrete samples (see Appendix B).

## 2.2 SEASONAL VARIATION IN DIAZINON CONCENTRATION

To examine if there were any seasonal trends in diazinon levels, flow-weighted samples were taken for twelve storm events throughout the 1995-96 rainy season (October - May). Diazinon was found above the detection level of 30 ng/l in all samples; EMCs for the sampled events ranged from a low of 180 nanograms/liter (ng/l, or ppt) to a high of 820 ng/l (Table 2.2.1). EMCs were highest in December and May, as shown in Figure 2.2.1, which also plots the seasonal hydrograph (flow discharge as a function of time) at S3 from December 1995 through May 1996. There was no significant rainfall for the season prior to December 1995.

**Table 2.2.1 Hydrologic (Stream Flow) Parameters and Mean Diazinon Concentrations for Sampled Events at Station S3 in Castro Valley Creek During the 1995-1996 Storm Season.**

| Event Number | Start Date | Start Time for Sampling | Sampling Duration (hr:min) | Flow Volume (cubic feet x 1,000) | Diazinon Event Mean Concen. (ng/l) | Flow Volume Previous 2 weeks (cf x 1,000) | Avg. Temp. Previous 30 Days (°F) (1) |
|---|---|---|---|---|---|---|---|
| 1 | 12/4/95 | 2:30 | 28:00 | 147 | 820 | 225 | 59.5 |
| 2 | 12/10/95 | 17:50 | 10:50 | 1,746 | 700 | 565 | 59.5 |
| 3 | 12/11/95 | 18:40 | 13:00 | 6,063 | 300 | 6,240 | 59.4 |
| 4 | 12/29/95 | 12:10 | 3:40 | 745 | 660 | 2,100 | 54.5 |
| 5 | 1/16/96 | 5:50 | 3:00 | 4,739 | 320 | 460 | 52.9 |
| 6 | 1/18/96 | 14:40 | 13:00 | 3,075 | 250 | 9,190 | 53.1 |
| 7 | 1/20/96 | 22:20 | 8:10 | 2,688 | 200 | 13,030 | 53.1 |
| 8 | 2/3/96 | 20:50 | 12:20 | 2,732 | 190 | 24,360 | 51.8 |
| 9 | 3/4/96 | 8:10 | 14:00 | 3,300 | 180 | 20,780 | 56.1 |
| 10 | 4/1/96 | 9:50 | 6:20 | 2,893 | 290 | 1,250 | 57.5 |
| 11 | 4/17/96 | 16:00 | 6:00 | 1,713 | 450 | 4,451 | 58.4 |
| 12 | 5/15/96 | 12:00 | 12:00 | 4,700 | 700 | 720 | 63.7 |

(1) Source: NOAA daily temperature data for Newark, CA

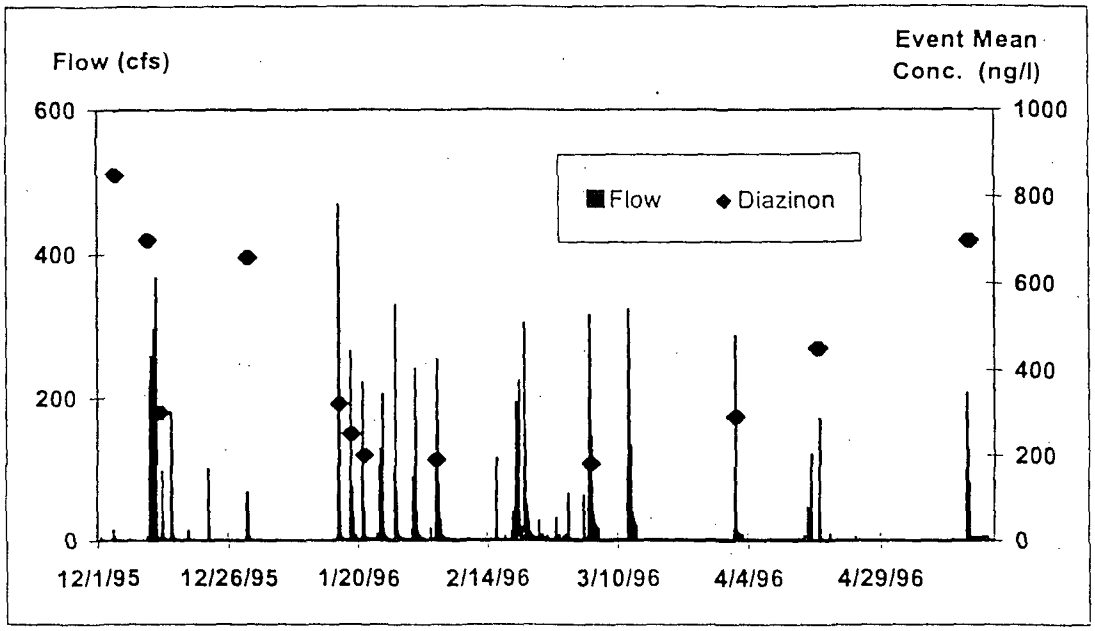

**Figure 2.2.1** **Event Mean Concentrations of Diazinon for Sampled Events and Stream Flow (Discharge) at Station S3 Between December 1, 1995 and May 21, 1996**

Diazinon concentrations appear to vary seasonally, declining in the winter and increasing again in spring. Sampling during previous years also found that higher concentrations occurred during fall and spring (WCC, 1994, 1995, 1996a). This variation in diazinon levels parallels the seasonal pattern of use: the amount of diazinon applied in urban areas is lowest in winter and rises again in March, with the heaviest monthly applications in summer and early fall (Department of Pesticide Regulation data, from Scanlin and Cooper, 1997). Correlation analysis showed that for 1995-96 events EMC was highly correlated ($p < 0.05$) with mean air temperature for the previous month (Table 2.2.2). Average temperatures generally vary seasonally and are also associated with greater insect activity, which may stimulate application of pesticides.

Some of the variation in diazinon is probably also due to hydrologic factors. EMCs had a strong negative correlation with two-week antecedent flow (the total volume of water discharged during two weeks prior to a given storm event). In other words, less rainfall prior to an event was associated with higher EMCs, possibly through accumulation of diazinon on the watershed area between storms. Similar strong negative correlations between diazinon levels and antecedent flow or antecedent rainfall have also been identified in previous monitoring data from Castro Valley Creek (WCC, 1996a).

**Table 2.2.2 Pearson Correlation Coefficients for Diazinon with Seasonal and Hydrologic Parameters at Station S3 During 1995-1996**

| | *EMC* | *Antecedent Flow Volume* | *Prev. 30 Day Temp* | *Event Flow Volume* | *Event Mass Discharge* |
|---|---|---|---|---|---|
| EMC Diazinon | 1.00 | | | | |
| 2 Week Antecedent Flow Volume | **-0.70** | 1.00 | | | |
| Previous 30 Day Average Temperature | **0.64** | -0.54 | 1.00 | | |
| Event Flow Volume | -0.47 | 0.10 | 0.10 | 1.00 | |
| Event Mass Discharge | 0.20 | -0.35 | **0.59** | **0.70** | 1.00 |

**Bold** indicates $p < 0.05$

A similar correlation analysis performed on the ten events sampled in 1996- 97 showed no significant relationships between EMC and the other variables (i.e. correlation coefficients were all lower, with $p > 0.05$). This difference may have been partly due to the smaller samples size. (EMCs and hydrologic variables for 1996-97 events are given in Appendix B.) When the pooled 1995-97 data were analyzed, the correlation relationships of EMC to temperature and antecedent flow were similar to the 1995-96 results shown in Table 2.2.2. Spearman correlation analysis, which uses relative ranking of sample values for each variable instead of the values themelves, showed similar or higher coefficients for these relationships on both the 1995-96 and 1995-97 datasets ($p < 0.01$); good agreement between the Pearson and Spearman coefficients suggests that the data do not present any major conflicts with the statistical assumptions necessary for the Pearson analysis.

Larger storms were somewhat associated with lower EMCs: there was a weak negative correlation between EMC and the event flow volume, which was only significant ($p < 0.05$) for Spearman correlations on the two-year dataset. Part of this is difference is probably due to year-to-year variation, since the 1995-96 events had a lower average event flow volume and higher average EMC than the 1996-97 events ($p <= 0.05$, t-test). The 1996-97 storm season also began and ended earlier, with the sampled period starting on October 29 and ending January 22, so that the lack of sampled events during spring could have affected the average EMC (see May 1997 data in Table 3.2.2).

However, when the total amount of diazinon per storm event was calculated (see Section 2.3 below), it continued to increase as event flow volume increased (Pearson and Spearman correlation coefficients >= 0.70, $p < 0.01$). This suggests that additional diazinon was washed into runoff during heavy rainfall, but that it was more diluted.

These results suggest that diazinon concentrations in Castro Valley Creek were affected by both seasonal use and hydrologic factors. Multiple regression analyses were performed on the 1995-96 data to examine how combinations of variables were related to EMCs. The adjusted value of $R^2$, the proportion of variation in EMC that was explained by the regression equation, was 0.44 when only antecedent flow volume was used as the independent variable, but increased for the combinations of event flow volume with log-transformed antecedent flow (adj. $R^2 = 0.65$) or event flow with previous temperature (adj. $R^2 = 0.66$). Based on these results, the timing of storm events, antecedent flow and event flow volume were all considered in developing the estimate for total mass discharge of diazinon in 1995-96 (Section 2.3).

Relationships derived from a single storm season may be a poor predictor for EMCs during other years. Figure 2.2.2 shows EMC values for 1995-96 and 1996-97 plotted as a function of antecedent flow volume. Linear and log-linear curves that are plotted in Figure 2.2.2 to show the trend of the 1995-96 data do not fit the lower EMCs found in the 1996-97 data. Year-to-year variations in use and rainfall patterns could make it difficult to detect trends in diazinon levels measured over several seasons.

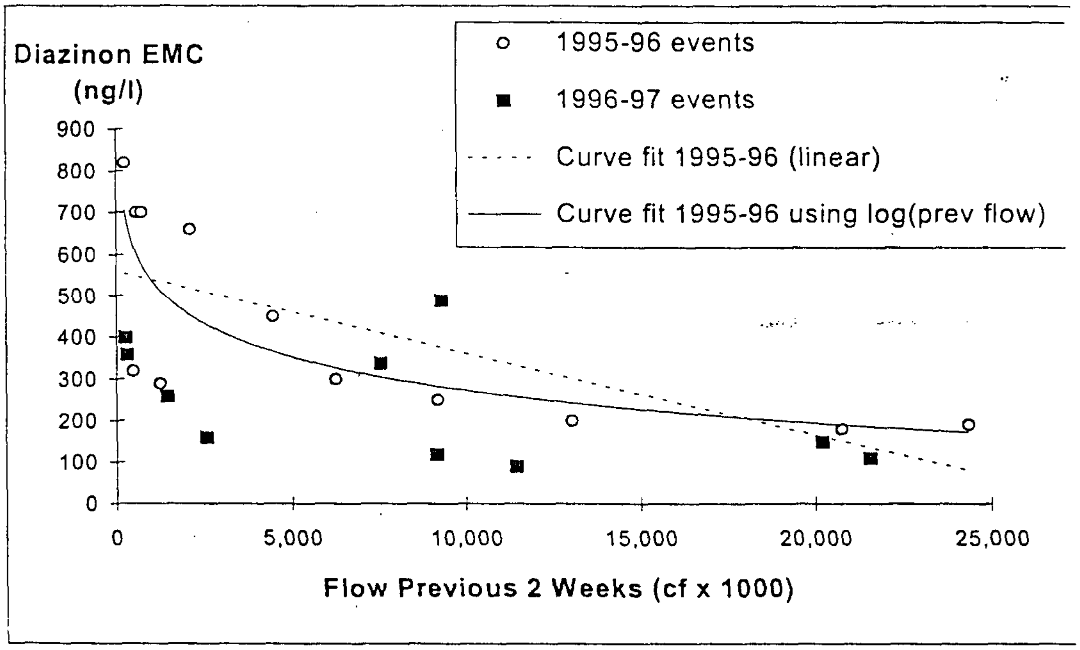

**Figure 2.2.2 Diazinon Event Mean Concentration and 2-Week Antecedent Flow Volume for Two Seasons at Station S3, with Predicted Relationships Based on 1995-1996 Data**

## 2.3 MASS DISCHARGE

An estimate of the total mass of diazinon discharged from Castro Valley Creek during the period from October 1, 1995 through September 30, 1996 was made by combining estimates for different components of the total discharge volume (Table 2.3.1). First, the EMC and event flow volume from the each of the twelve sampled events were multiplied to calculate the amount discharged in the sampled storm events. Then, estimated EMCs were used to calculate the amount discharged in unsampled storm flow. For the purpose of this report, storm flow was defined as having a discharge rate greater than 5 cfs. Periods when flow was less than 5 cfs were categorized as either non-storm flow between storms, or dry weather flows outside of the rainy season. EMCs for these two categories were estimated from occasional samples taken during periods of low flow (see Section 2.5, WCC 1997b).

The total flow volume from December 1995 through May 1996 was approximately 116 million cubic feet (mcf) of which 84.2 mcf was storm flow (Figure 2.3.1). The twelve sampled events accounted for 44% of the storm flow volume. Figure 2.3.2 shows the seasonal hydrograph and the mass of diazinon discharged for each sampled storm event. The per event mass of diazinon discharged during the sampled events ranged from a low of 3.4 grams to a high of 93.2 grams (Table 2.3.2). Mass discharge was highly correlated (0.70) with total flow volume for a given event and also less strongly with season (represented by previous temperature in Table 2.2.2). The estimated total mass discharge of diazinon for these sampled events was 354 grams (12 oz.).

**Table 2.3.1 Estimated Mass Discharge of Diazinon from the Castro Valley Creek Watershed from October 1, 1995 to September 30, 1996**

| | Flow Volume (mcf) | Average Concentration (ng/l) | Mass (grams) |
|---|---|---|---|
| Sampled Events | 35 | 361 | 354 |
| Unsampled Events | 44 | 287 | 358 |
| Non-storm Flow (Dec-May) | 38 | 60 | 64 |
| Dry Weather Flow (Oct, Nov, Jun-Sep) | 3 | 60 | 5 |
| Totals | 120 | | 781 |

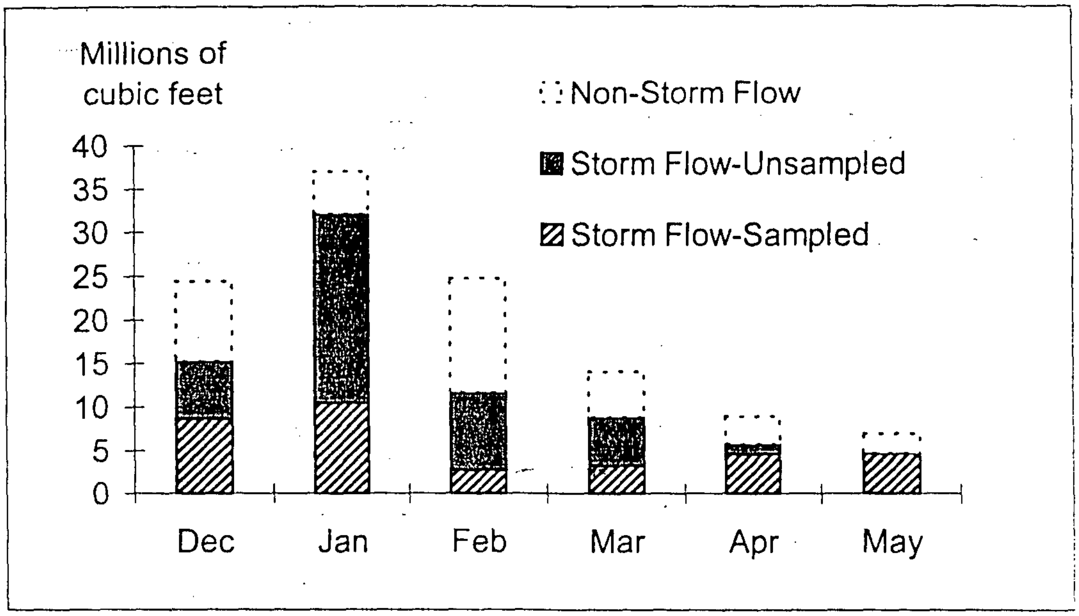

Figure 2.3.1 Monthly Flow at Station S3 between December 1, 1995 and May 21, 1996

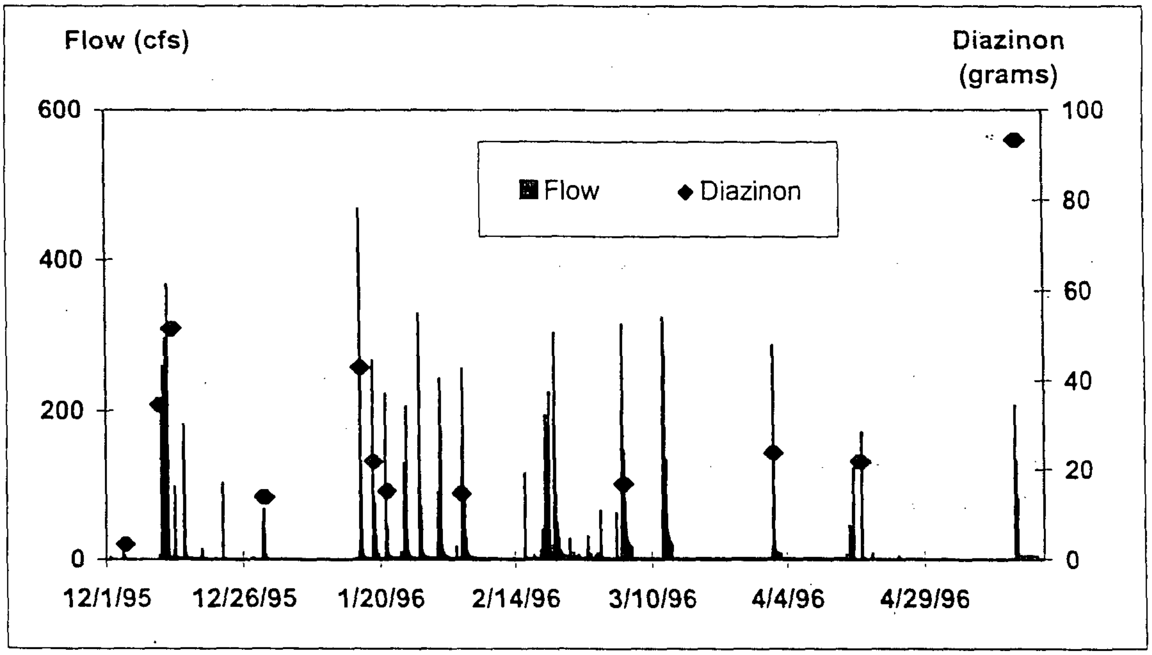

Figure 2.3.2 Estimated Diazinon Mass Discharge for Sampled Events and Stream Flow at Station S3 during 1995-1996 Storm Season

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## Table 2.3.2 Hydrologic Parameters and Mass Discharge of Diazinon for Sampled Events at Station S3 During 1995-1996

| Event Number | Start Date | Sampling Duration (hr:min) | Flow Volume (cubic feet x 1,000) | Diazinon Event Mean Concen. (ng/l) | Diazinon Estimated Mass (grams) | Flow Volume Previous 2 weeks (cf x 1,000) |
|---|---|---|---|---|---|---|
| 1 | 12/4/95 | 28:00 | 147 | 820 | 3.4 | 225 |
| 2 | 12/10/95 | 10:50 | 1,746 | 700 | 34.6 | 565 |
| 3 | 12/11/95 | 13:00 | 6,063 | 300 | 51.5 | 6,240 |
| 4 | 12/29/95 | 3:40 | 745 | 660 | 13.9 | 2,100 |
| 5 | 1/16/96 | 3:00 | 4,739 | 320 | 42.9 | 460 |
| 6 | 1/18/96 | 13:00 | 3,075 | 250 | 21.8 | 9,190 |
| 7 | 1/20/96 | 8:10 | 2,688 | 200 | 15.2 | 13,030 |
| 8 | 2/3/96 | 12:20 | 2,732 | 190 | 14.7 | 24,360 |
| 9 | 3/4/96 | 14:00 | 3,300 | 180 | 16.8 | 20,780 |
| 10 | 4/1/96 | 6:20 | 2,893 | 290 | 23.8 | 1,250 |
| 11 | 4/17/96 | 6:00 | 1,713 | 450 | 21.8 | 4,451 |
| 12 | 5/15/96 | 12:00 | 4,700 | 700 | 93.2 | 720 |
| Totals | | | 34,541 | | 354 | |

Table 2.3.3 lists the event flow volume, estimated EMC, and calculated mass discharge for the 15 storm events that were not sampled. Most of the unsampled storm flow volume occurred between January 20th and March 11th. EMCs for most of the storm flow during this period were estimated at 200 ng/l based on sampled events during this period. Higher values were assumed for the storm events on February 15th and April 16th because these were small storms with low antecedent flow volumes (see Section 2.2). EMCs for the unsampled December events were estimated at 400 ng/l because of the higher EMCs during sampled December events. The average non-storm and dry weather concentration was estimated at 60 ng/l based on a limited number of samples taken (see Tables 2.5.1 and 2.5.2, WCC 1997). All mass discharge estimates were obtained by multiplying the estimated concentration by the flow volume.

Combining the mass discharge of diazinon from the 12 sampled storm events with the mass discharge from the 15 events that were not sampled, together with the diazinon in non-storm flow, resulted in an estimated mass discharge of approximately 800 grams (26 oz.). Assuming an estimated annual usage of 0.02 ~~oz.~~ lbs. (9g) per person (Scanlin and Cooper, 1997), the total mass discharged in Castro Valley Creek was approximately 0.3 percent of the total mass applied in the watershed.

## Table 2.3.3 Stream Flow Volume and Estimated Diazinon for Unsampled Events at Station S3 During the 1995-1996 Storm Season

| Start Date | Start Time | Event Duration (hr:min) | Flow Volume (cf x 1,000) | Assumed Diazinon Concentration (ng/l) | Estimated Diazinon Mass (grams) |
|---|---|---|---|---|---|
| 12/11/95 | 4:40 | 14:00 | 4,182 | 400 | 47.4 |
| 12/13/95 | 9:50 | 9:00 | 1,697 | 400 | 19.2 |
| 12/15/95 | 4:12 | 8:44 | 3,012 | 400 | 34.1 |
| 12/18/95 | 11:10 | 3:42 | 181 | 400 | 2.1 |
| 12/22/95 | 6:18 | 3:44 | 850 | 400 | 9.6 |
| 12/29/95 | 16:00 | 4:00 | 839 | 400 | 9.5 |
| 1/16/96 | 8:58 | 11:02 | 3,248 | 280 | 25.8 |
| 1/18/96 | 13:00 | 1:40 | 595 | 300 | 5.1 |
| 1/24/96 | 7:38 | 23:04 | 5,048 | 200 | 28.6 |
| 1/27/96 | 5:10 | 16:52 | 5,308 | 200 | 30.1 |
| 1/30/96 | 15:20 | 28:40 | 7,441 | 200 | 42.1 |
| 2/4/96 | 9:10 | 20:50 | 4,558 | 160 | 20.7 |
| 2/15/96 | 16:52 | 4:20 | 985 | 600 | 16.7 |
| 2/18/96 | 16:30 | 89:30 | 2,234 | 200 | 12.7 |
| 2/23/96 | 23:20 | 2:40 | 274 | 200 | 1.6 |
| 2/27/96 | 5:30 | 2:40 | 298 | 200 | 1.7 |
| 2/28/96 | 17:40 | 10:00 | 251 | 200 | 1.4 |
| 2/29/96 | 15:00 | 3:00 | 376 | 180 | 1.9 |
| 3/3/96 | 12:00 | 6:00 | 347 | 180 | 1.8 |
| 3/11/96 | 23:00 | 20:00 | 5,281 | 200 | 29.9 |
| 4/16/96 | 5:00 | 5:00 | 1,138 | 500 | 16.1 |
| 4/19/96 | 15:50 | 0:50 | 44 | 200 | 0.2 |
| **Totals** | | | **44,005** | | **358** |

## 2.4 WITHIN STORM VARIATION

To examine how diazinon concentrations varied during storm events, discrete samples were taken throughout nine of the sampled events at station S3. Discrete concentrations ranged from 118 to 1,832 ng/l. Figure 2.4.1 shows that the variation in diazinon concentrations appeared to follow one of two main patterns during an event. During Events 2 and 5 (Figure 2.4.1 (a) and (c)) the peak concentration occurred early and was followed by a marked decline, with peak concentrations more than 3 times the concentration at the end of the storm. During other storms such as Events 3 and 10 (Figure 2.4.1 (b) and (d)), diazinon concentrations remained relatively consistent. The high peak concentrations observed in events 2 and 5 appeared to be associated with low antecedent flow volume (Table 2.2.1). This relationship could reflect an accumulation of diazinon between storms that was readily washed off at the start of the next rainfall. However, if accumulation alone was reponsible for initial peaks, they would be expected to occur only in events with high EMCs. Since different parts of the watershed contribute to different portions of the hydrograph (Baker and Richards, 1990), differences in spatial variation of diazinon could also produce different temporal patterns at Station S3 for different events.

**Table 2.5.1 Diazinon Concentrations in Non-Storm Flow (<5 cfs) at Station S3 during 1995-1996 and 1996-1997 Storm Seasons**

| Sample Date | Time | Diazinon Concentration (ng/l) | Hours after End of Storm Flow | % of Initial Post-Storm Concentration |
|---|---|---|---|---|
| 12/4/95 | 12:00 | 760 | 0 | 100 |
| 12/5/95 | 6:30 | 570 | 18.5 | 75 |
| 4/16/96 | 9:00 | 640 | 0 | 100 |
| 4/16/96 | 16:20 | 610 | 7.3 | 95 |
| 4/17/96 | 5:40 | 250 | 20.7 | 40 |
| 5/16/96 | 1:00 | 400 | 0 | 100 |
| 5/17/96 | 2:00 | 210 | 26 | 52 |
| 10/29/96 | 13:00 | 460 | 0 | 100 |
| 10/30/96 | 8:00 | 420 | 19 | 91 |
| 10/31/96 | 23:00 | 190 | 58 | 41 |
| 11/1/96 | 15:30 | 110 | 74.5 | 24 |

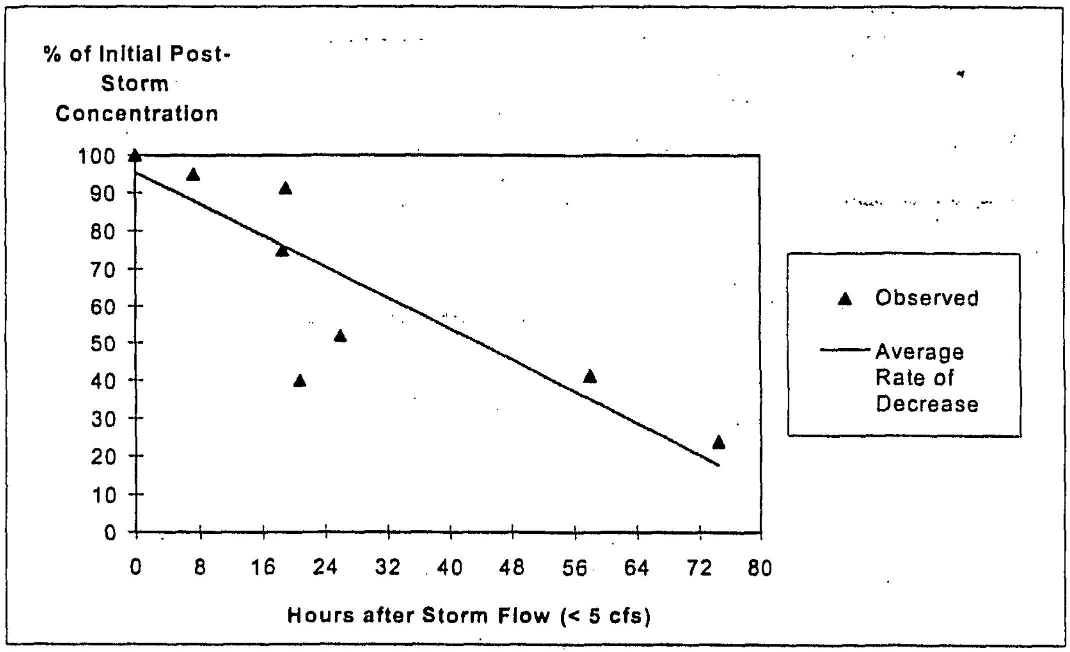
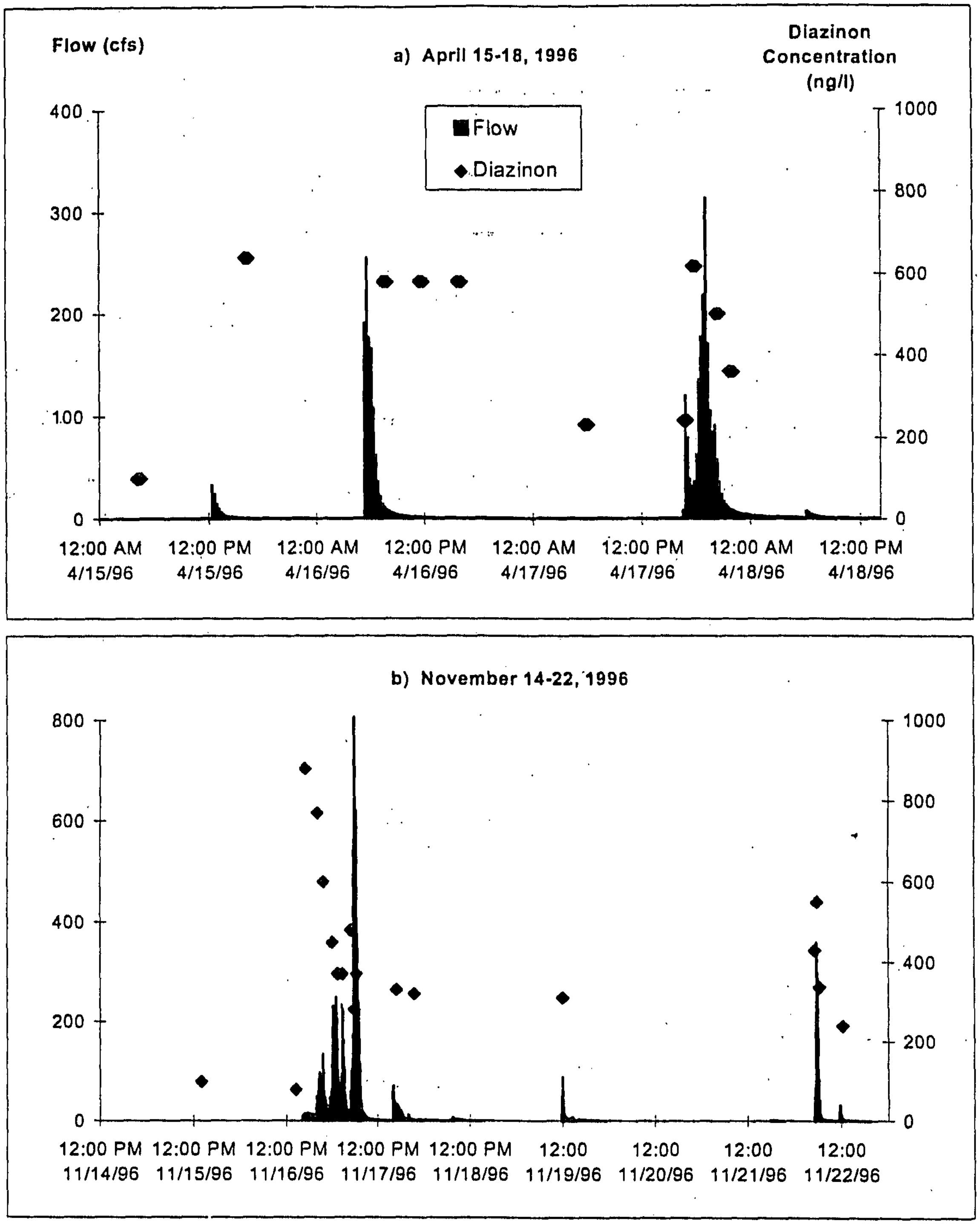


Figure 2.5.2 Proportion of Diazinon Concentration Remaining in Runoff at Varying Intervals After End of Storm Flows for Selected Storm Events at Station S3

The size of the watershed and the pattern of rainfall also affect in-stream concentrations. Since Castro Valley is a small urbanized watershed, storm flow recedes quickly following a rain event (WCC, 1995). Duration of storm flow during 1995-96 ranged from 50 minutes on April 19, 1996 to 28 hours on December 11, 1995. As seen above, concentrations declined when the storm flow receded. In a larger watershed, peak concentrations would tend to be lower while median concentrations would tend to be higher (Baker and Richards, 1990).

Previous toxicity testing of Castro Valley Creek runoff samples has shown that diazinon concentrations of 300 to 500 ng/l are lethal to *Ceriodaphnia dubia* at exposure times of 48 hours ($LT_{50}$, median time to lethality; Katznelson and Mumley, 1997). Thus, post-storm concentrations during December 5-6, 1995 could have remained high enough to kill 50% of *C. dubia* populations in the 48 hour period during and after the storm. Also, as can be seen in Figure 2.5.3, frequent storm events can cause concentrations to remain elevated for an extended period of time. Since diazinon concentrations of 150-300 ng/l are lethal to *C. dubia* when exposure times ($LT_{50}$) are 4 to 7 days (Hansen 1995, Katznelson and Mumley, 1997; see also Bailey et al., 1997), periods of intermittent storm events could also cause mortality to animals living in the creek.

Grab samples taken at S3 during longer intervals of dry weather occasionally contained diazinon concentrations as high as 220 ng/l (Table 2.5.2). During May 1997, concentrations at S3 remained above 150 ng/l long enough to be toxic to *C. dubia*. The dry weather sampling summarized in Table 2.5.2 was performed during months when storms may be expected in most years, but always took place after at least 21 days without significant rainfall in the watershed. The factors affecting dry weather concentrations of diazinon are outside the scope of this report; see WCC (1997b) for discussion.



Note: Horizontal (time) and vertical flow scales vary

**Figure 2.5.3** Diazinon Concentration and Flow at Station S3 for Selected Periods of Storm Flow (<5 cfs) and Non-Storm Flow in 1996

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## Table 2.5.2 Diazinon Concentrations in Dry Weather (Non-Storm) Flows at Station S3 During 1996-97

| Sample Date | Time | Diazinon Concentration (ng/l) |
|---|---|---|
| **10/4/96** | 10:20 | 80 |
| **10/6/96** | N.A. | 75 |
| **10/8/96** | 12:00 | 50 |
| **2/3/97** | 10:10 | 35 |
| **2/21/97** | 10:00 | 80 |
| **5/15/97** | 10:10 | 220 |
| **5/17/97** | 10:00 | 200 |
| **5/19/97** | 11:00 | 170 |
| **5/21/97** | 10:00 | 180 |

Source: WCC (1997b)

N.A.: Sampling time not available

# 3.0 DISTRIBUTION OF DIAZINON SOURCES IN THE CASTRO VALLEY CREEK WATERSHED

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## 3.1 OBJECTIVES AND METHODS

The purpose of this portion of the study was to gather data on the geographic distribution of diazinon sources in the watershed. A major objective was to determine if the sources were distributed throughout the watershed or if there were localized "hot spots." All of the samples discussed in this section of the report were "grab" samples which were collected in 20 ml glass vials. Samples were analyzed using ELISA.

## 3.2 SUBCATCHMENT CONCENTRATIONS

The first step in determining the distribution of diazinon sources was to collect samples from five subcatchments within the watershed (Figure 3.2.1). These subcatchments drain 78% of the watershed. Samples were not collected from the other portions of the watershed because there were no discrete discharge points from other large areas.

During a storm event on April 1, 1996, grab samples were collected every half hour at the discharge points of the subcatchments. Diazinon was detected in all of the samples collected, in concentrations ranging from 51 ng/l to 1248 ng/l. The mean subcatchment concentrations ranged from 201 ng/l to 675 ng/l (Table 3.2.1). Diazinon levels in discrete samples at S3 during this event are also shown for reference, but since there is no hydrograph data for the subcatchments, subcatchment results are not directly comparable with those from station S3.

The mean subcatchment concentrations were all similar in magnitude to the EMCs measured at S3. The area-weighted average of all subcatchments, 390 ng/l, was similar to the watershed EMC of 290 ng/l at S3. These results suggest that the sources of diazinon were distributed throughout the watershed. Much of the difference in concentrations appears to be related to differences in land use. Subcatchments with higher percentages of open space (such as parks or undeveloped land) had lower concentrations of diazinon than those with little open space. This suggests that application of diazinon is more associated with developed areas. Runoff samples from other watersheds with a higher proportion of open space than the Castro Valley watershed also tend to contain lower diazinon concentrations (WCC, 1994, 1995; Hansen 1995). Subcatchment 5, with the highest proportion of commercial development, had the second highest mean diazinon concentration. (For purposes of this report, "commercial" land use includes multi-family residential areas).

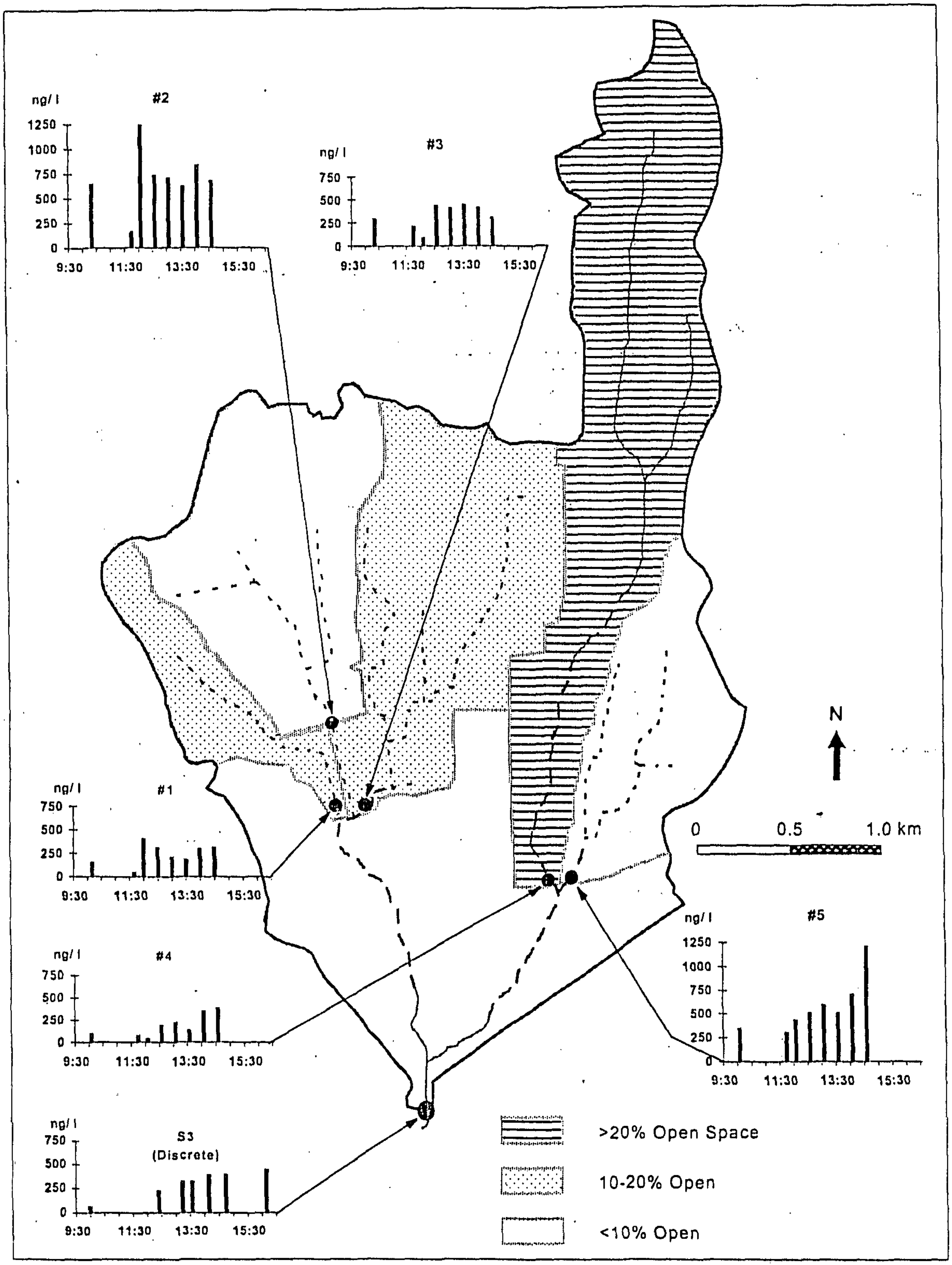

Figure 3.2.1 Diazinon Concentrations in Storm Runoff from Selected Subcatchments of the Castro Valley Creek Watershed on April 1, 1996

Table 3.2.1 Mean Diazinon Concentrations in Runoff from Subcatchments of the Castro Valley Creek Watershed on April 1, 1996

| | | Land Use Percentage | | | | |
|---|---|---|---|---|---|---|
| Subcatchment Number | Area (acres) | Commercial | Open | Residential | % Pervious Area | Mean Diazinon Concentration (ng/l) |
| 1 | 214 | 15 | 15 | 70 | 61 | 246 |
| 2 | 536 | 4 | 9 | 87 | 62 | 675 |
| 3 | 678 | 19 | 10 | 71 | 53 | 343 |
| 4 | 908 | 4 | 52 | 44 | 80 | 201 |
| 5 | 391 | 37 | 3 | 60 | 41 | 595 |

Source for subcatchment data: Alameda County Flood Control District

Table 3.2.2 show that diazinon concentrations varied among all subcatchments that were sampled during extended intervals (greater than 3 weeks) of dry weather within the 1996-97 storm season. Subcatchment 4, which had the lowest average concentrations during the May 1996 storm event, had a high concentration of 3400 ng/l in one dry weather sample in May 1997. All of the subcatchments sampled in dry weather tended to have higher diazinon concentrations in the spring. While the conditions affecting dry weather concentrations of diazinon are outside the scope of this report (see WCC 1997b for details and discussion), these results also suggest that diazinon sources are found in all subcatchments.

## Table 3.2.2 Diazinon Concentrations in Dry Weather (Non-Storm) Flow from Selected Subcatchments of the Castro Valley Creek Watershed During 1996-97

| Month | Date | Diazinon (ng/l) in Subcatchment: | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| October 1996 | 4 | 50 | 228 | 107 | 326 |
| | 6 | 51 | 38 | 87 | 135 |
| | 8 | 36 | 39 | 62 | 116 |
| | 11 | ND | 50 | ND | 57 |
| February 1997 | 3 | 14 | 19 | 12 | 16 |
| | 21 | ND | 228 | 107 | ND |
| | 23 | 42 | 59 | 133 | 128 |
| | 25 | ND | ND | 53 | 47 |
| May 1997 | 15 | 323 | 50 | ND | ND |
| | 17 | 662 | 2959 | 188 | 31 |
| | 19 | 113 | ND | 48 | 3400 |
| | 21 | 106 | 48 | 69 | 285 |

Source: WCC (1997b)
ND: non-detect (< 30 ng/l)

## 3.3 STREET GUTTER CONCENTRATIONS,

To gather data on the distribution of sources within the subcatchments, samples were collected from 45 randomly selected street gutters during a storm event on May 15, 1996. All of the samples were collected in residential areas within Subcatchments 2 and 3 (Figure 3.3.1; see also Appendix C). Each sample represented a separate local drainage area, usually consisting of between 5 and 15 residential properties.

Diazinon concentrations in street gutters were highly variable, ranging from less than 30 ng/l to over 70,000 ng/l (Figure 3.3.2). The median sample concentration was 80 ng/l, a level which has previously been found in rainfall samples from Castro Valley. The mean sample concentration was 3,900 ng/l for all samples, or 450 ng/l with the two highest concentrations excluded. Since the two samples with concentrations above 10,000 ng/l both came from small drainage areas (about 5 properties each; Jim Scanlin, pers. obs.), the high concentrations may have been due to a smaller dilution factor for diazinon coming from a single property. Therefore the area-weighted average concentration for all street gutter samples was probably less than 3,900 ng/l. For comparison, the average concentration at the discharge point for the watershed (Station S3) during this event was about 700 ng/l (Figure 2.2.1).

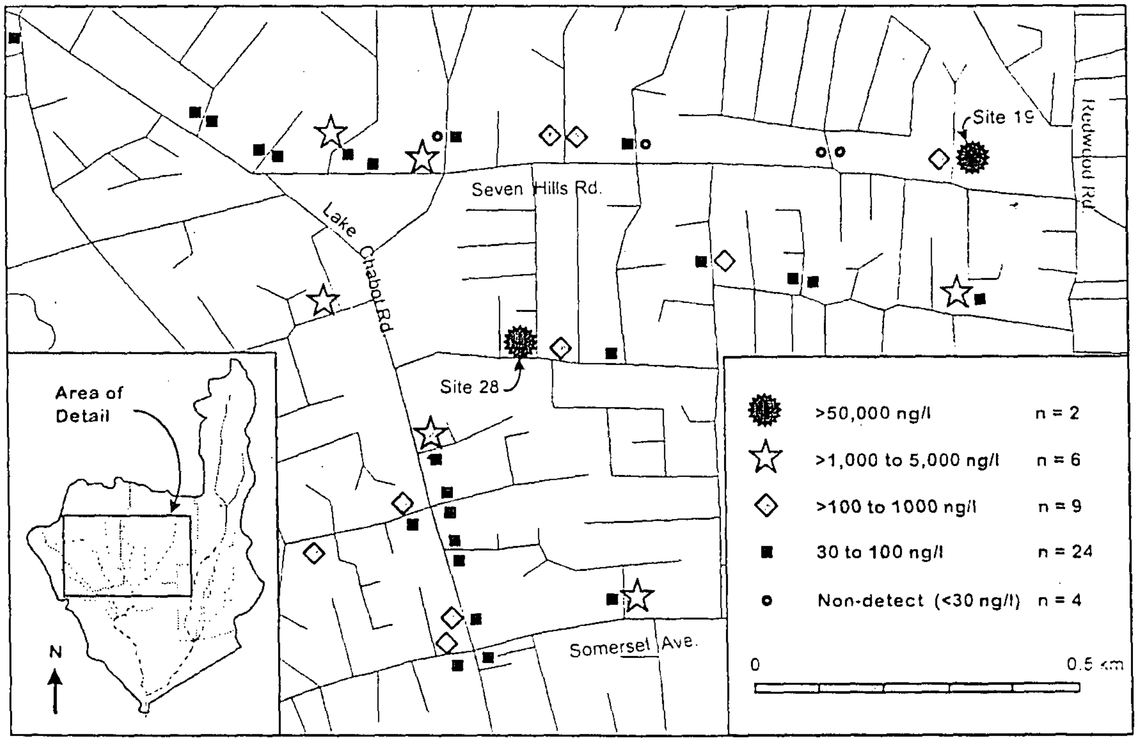

**Figure 3.3.1 Diazinon Concentrations in Storm Water Runoff Collected in Street Gutters in Castro Valley on May 16, 1996**

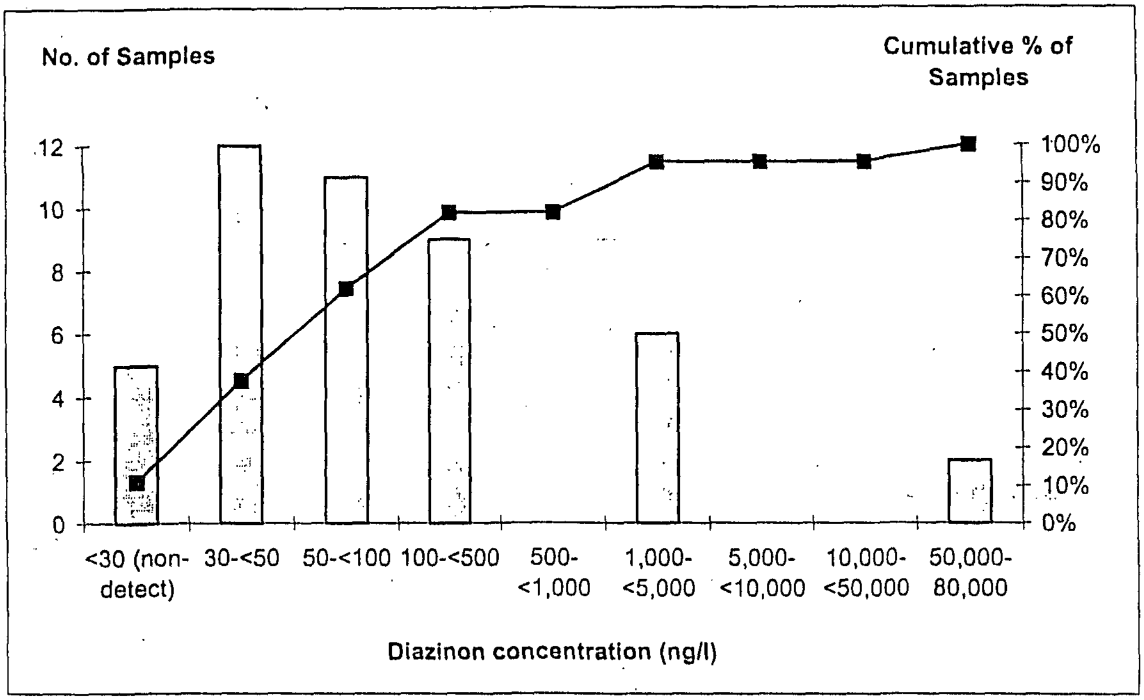

**Figure 3.3.2 Distribution of Diazinon Concentrations in Selected Street Gutters in Castro Valley on May 15, 1996**

Based on these results, an experimental calculation was used to form a rough estimate of 300-600 sources of diazinon in the entire watershed during the sampled event (See Appendix C for assumptions and details of the estimation). A basic assumption used for estimation was that a street gutter sample with a diazinon concentration above an arbitrary threshold level of 100-400 ng/l was considered a source. It was further assumed that when a sample met this criterion, the individual source was a single property within the area drained by that street gutter. Using an average estimate of 10 properties per street gutter sample, 2 to 4 percent of the 450 properties in the sampled areas were sources. Since most of the properties in Subcatchments 2 and 3 were single-family homes, this was roughly equivalent to 2 to 4 percent of the households. Extrapolation of these percentages to the 14,800 properties in the entire watershed suggests that 300 to 600 of these were diazinon sources for the sample event.

To determine whether the two sites with the highest concentrations were consistent "hot spots", these sites were sampled again during the fall of 1996. Samples were taken at the beginning and end of a rainfall event that occurred on November 16-17. Street gutter concentrations at Site 19 were moderately high in November but much lower than in May (Table 3.3.1). Site 28 had a very high concentration of 39,000 ng/l at the beginning of the November storm. These results suggest that there may be some consistent sources of diazinon in the watershed. Both of these "hot spots" were located in Subcatchment 3, which had intermediate levels of diazinon during the sampling on April 1, 1996. Street gutter samples from a similar residential area draining to nearby San Leandro Creek showed similar consistency, with high concentrations persisting at some sites during several storm events (WCC, 1997a).

**Table 3.3.1 Diazinon Concentrations in Selected Castro Valley Street Gutters Sampled in May and November 1996**

| Site | Sample Date | Sample Time | Cumulative Event Rainfall | Diazinon Concentration (ng/l) |
|---|---|---|---|---|
| **19** | 5/15/96 | 13:54 | 0.1" | 71,000 |
| **19** | 11/16/96 | 18:40 | 0.1" | 314 |
| **19** | 11/17/96 | 8:00 | 0.4" | 562 |
| **28** | 5/15/96 | 14:21 | 0.1" | 79,000 |
| **28** | 11/16/96 | 18:50 | 0.1" | 37,000 |
| **28** | 11/17/96 | 8:00 | 0.4" | 2,000 |

# 4.0 RESIDENTIAL RUNOFF STUDY

## 4.1 OBJECTIVES AND METHODS

The purpose of this portion of the study was to determine if the use of diazinon in accordance with label directions could result in the observed diazinon concentrations in Castro Valley Creek.

Diazinon was applied to two residential properties in Castro Valley and one residential property in Oakland (located approximately 14 km northwest of the Castro Valley watershed). The diazinon was applied at the Castro Valley sites between 14:00 and 15:00 PST on February 26, 1997. The diazinon was applied at the Oakland site between 15:00 and 15:45 PST on February 28, 1997. All of the properties receiving test applications of diazinon were single-family residences on approximately one-eighth acre lots. Foundation perimeter length was approximately 120-150 feet (35-45 m) for all three residences.

The amount of diazinon applied at each property was two-thirds of the quantity recommended on the product label for the control of ants. At each site, four ounces of liquid concentrate diazinon (25% active ingredient) was mixed with two gallons of water in a hand held sprayer. (The directions called for six ounces in three gallons of water.) The solution was sprayed in a strip approximately 3 feet (1m) wide around the foundation of each house, and on the edges and in the cracks of paved surfaces of driveways, walkways and patios.

Grab samples of runoff from roofs, patios and driveways were taken at each site during subsequent rainfall events. (See Appendix D for a detailed description of sampling locations, and Appendix E for rainfall data.) None of these events produced enough runoff to permit sampling from street gutters beyond the edges of the properties. Samples were collected using 20 ml glass vials and were analyzed using ELISA.

At the Oakland site, rainfall samples were also collected several days after application. The rainfall samples were collected in a glass 9" x 13" baking pan. The pan was soaked in a 10% bleach solution then washed with soap and water and rinsed with tap water. The pan was placed on the railing of a deck 20 feet above the ground. The rain that accumulated in the pan was poured into a glass vial for cold storage prior to analysis. A similar sample was collected at the same time at an unsprayed Oakland residence located 6 km away.

## 4.2 RESULTS AND DISCUSSION

Diazinon was detected in all samples, which were taken up to seven weeks after application. Roof runoff samples ranged from 57 ng/l to 17,000 ng/l (Table 4.2.1). Patio and driveway runoff samples ranged from 735 ng/l to 1,200,000 ng/l. Concentrations were highest immediately after application and decreased over time. The highest on-site concentration was 15 times the highest concentration observed in street gutter samples. Since street gutter samples from Sites 19 and 28 each represented small areas of no more than five residences (James Scanlin, pers. obs.), a 33 percent dilution of the on-site sample could produce concentrations similar to the highest street gutter samples.

**Table 4.2.1 Diazinon Concentrations in Storm Water Runoff at Residential Properties Following Test Spray Application on February 26-28, 1997**

| Site | Sample Date | Sample Time | Days Since Application | Cumulative Rainfall | Concentration ng/l |
|---|---|---|---|---|---|
| Oak. Roof Drain 1 | 3/2/97 | 2:40 | 1.5 | 0.03" | 17,000 |
| Oak. Roof Drain 1 | 3/2/97 | 7:30 | 1.7 | 0.19" | 1,100 |
| Oak. Roof Drain 1 | 3/15/97 | 19:30 | 15 | 0.24" | 1,250 |
| Oak. Roof Drain 1 | 3/16/97 | 8:55 | 16 | 0.24 | 350 |
| Oak. Roof Drain 1 | 3/30/97 | 20:05 | 30 | 0.51" | 250 |
| Oak. Roof Drain 1 | 4/18/97 | 5:30 | 48 | 0.52" | 590 |
| Oak. Roof Drain 1 | 4/18/97 | 20:00 | 48 | 0.91" | 57 |
| Oak. Drain 1 + Patio | 3/2/97 | 2:40 | 1.5 | 0.03" | 150,000 |
| Oak. Drain 1 + Patio | 3/3/97 | 7:30 | 1.7 | 0.19" | 40,000 |
| Oak. Drain 1 + Patio | 4/18/97 | 20:00 | 48 | 0.91" | 735 |
| Oak. Roof Drain 2 | 3/16/97 | 10:30 | 16 | 0.26" | 3,800 |
| Oak. Roof Drain 3 | 3/16/97 | 10:30 | 16 | 0.26" | 3,300 |
| Oak. Driveway | 3/16/97 | 10:30 | 16 | 0.26" | 110,000 |
| Oak. Patio | 3/16/97 | 10:30 | 16 | 0.26" | 880,000 |
| CV1 Patio | 3/3/97 | 8:30 | 5 | 0.08" | 1,200,000 |
| CV1 Patio | 4/18/97 | 18:00 | 50 | 0.44" | 3,500 |
| CV1 Patio | 4/19/97 | NA | 51 |  | 16,000 |
| CV1 Driveway | 4/18/97 | 18:00 | 50 | 0.44" | 6,000 |
| CV1 Roof Drain | 4/18/97 | 18:00 | 50 | 0.44" | 50 |
| CV1 Roof Drain | 4/19/97 | NA | 51 |  | 340 |
| CV2 Patio 1 | 4/18/97 | 18:00 | 50 | 0.44" | 110,000 |
| CV2 Patio 2 | 4/18/97 | 18:00 | 50 | 0.44" | 1,400 |
| CV2 Driveway | 4/18/97 | 18:00 | 50 | 0.44" | 91,000 |
| CV2 Roof Drain | 4/18/97 | 18:00 | 50 | 0.44" | 220 |

Diazinon concentrations in rainfall at the sprayed site ranged from 240 to 1,300 ng/l (Table 4.2.2). This was higher than the concentration found in many street gutter samples. In contrast, rainfall samples taken at the Oakland site prior to the application of diazinon were consistently below 100 ng/l, as was the sample from the unsprayed site. Diazinon in rainfall near treated properties may thus be a pathway for diazinon to enter storm drain runoff.

Recommended rates of application for lawns and garden areas differ from those for paved areas (six fluid ounces of liquid concentrate per 1000 square feet of lawn). A test application was also made on a lawn at a third residence in Castro Valley, but no runoff was produced from the lawn during the sampling period. This study was not able to evaluate the likelihood of applications to lawn and garden areas contributing to diazinon in runoff. Other formulations such as granules are commonly used on lawns (Scanlin and Cooper, 1997), but their potential contribution to diazinon is unknown.

**Table 4.2.2 Diazinon Concentrations in Oakland Rainfall Samples, March 1997**

| Site and Sample Number | Sample start | | Sample end | | Cumulative Event Rainfall | Diazinon Concentration (ng/l) |
|---|---|---|---|---|---|---|
| | Date | Time | Date | Time | | |
| Test 1 | 3/1/97 | 18:00 | 3/2/97 | 9:00 | 0.23" | 1,300 |
| Test 2 | 3/15/97 | 19:00 | 3/15/97 | 19:30 | 0.01" | 240 |
| Test 3 | 3/15/97 | 19:35 | 3/16/97 | 10:00 | 0.02" | 930 |
| Unsprayed | 3/1/97 | 20:00 | 3/2/97 | 8:30 | 0.23" | 60 |

## 4.3 CONCLUSIONS

Preliminary results indicate that use of liquid concentrate formulations of diazinon in accordance with label directions can not be ruled out as a source of the observed toxic concentrations in Castro Valley watershed. This has important implications for design of strategies to reduce diazinon concentrations in runoff (Scanlin and Gosselin, 1997).

## 5.0 SUMMARY AND CONCLUSIONS

Diazinon was found in storm runoff throughout the 1995-96 and 1996-97 storm seasons, in all parts of the Castro Valley Creek watershed. This study tracked temporal variations in diazinon concentrations for the aggregate runoff from the watershed, and also evaluated spatial variation at both intermediate (subcatchment) and small (residential neighborhood) scales.

Event mean concentrations for sampled 1995-96 storm events in Castro Valley Creek ranged from 180 to 820 ng/l, with peak concentrations of diazinon reaching 1800 ng/l for short periods. Low antecedent flow during the 2 weeks preceding an event was a major factor in predicting EMC, but seasonal patterns of diazinon application probably increased diazinon levels during events in fall and spring. Variations in EMC may also have been caused by differences in the hydrographs for individual events, or by year-to-year differences in diazinon application.

The total amount of diazinon discharged from Castro Valley Creek during the 1995-96 water year was estimated at about 600 grams, or about 0.3 percent of the estimated annual usage in the watershed. Approximately 90% of the mass discharge occurred during storm flows greater than 5 cfs.

Higher flows appeared to reduce EMCs, but increased the mass discharge for individual events. This suggests that some diazinon is readily washed off during small storm events, while a larger quantity is present in the watershed and enters runoff during heavier rainfall.

Diazinon concentrations over 300 ng/l sometimes persisted in Castro Valley Creek for periods of 48 hours after storm flow ended. These exposures were sufficient to be toxic to aquatic animals, and confirm the suggestions of previous studies that diazinon probably causes toxicity in Castro Valley Creek. Chronic toxic exposure to diazinon, caused by persistence of concentrations above 150 ng/l for periods up to a week long, may also have an impact on aquatic life in Castro Valley Creek.

The sources of diazinon are widespread, occurring in all subcatchments of the watershed. During the storm of April 1, 1996, runoff from more densely developed subcatchments generally contained higher average concentrations than runoff from subcatchments with more open space. Samples from street gutters were also geographically variable; a few street gutter sampling sites had diazinon levels over 2000 ng/l on different dates, but average street gutter concentrations were more similar to the concentrations observed for Station S3 and the subcatchments.

Based on street gutter results and various sets of assumptions about the number of sources within each street gutter drainage area, the estimated number of sources in the watershed is 300 to 600, or up to 4 percent of the households. Some sources may be consistent, producing high street gutter concentrations during more than one storm event.

Test applications of diazinon on exterior paving and foundation perimeter areas produced maximum runoff concentrations of 1,200,000 ng/l on the residential properties that were sprayed. This was greater than the maximum observed concentrations in street gutter samples, and over 300 times the average. These results suggest that applications of liquid diazinon according to the label directions could be responsible for much of the diazinon entering storm runoff. The potential runoff contribution of other formulations of diazinon or of applications to lawn and garden areas is unknown.

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## Appendix A. ELISA Analyses for Diazinon: Quality Assurance

### A.1.0 ELISA--General Description

This appendix focuses on the use of enzyme linked immunosorbent assay (ELISA) kits specific for diazinon. Most of the discussion is reproduced from WCC (1996b). ELISA techniques for other environmental contaminants, e.g., PCBs, PAHs, etc., will be referred to briefly in the following text where applicable. For in-depth understanding of the general features of immunoassays and, specifically, enzyme linked immunosorbent assays (ELISA), the reader may consult publications by ELISA kit manufacturers (Millipore, Ohmicron, or Ensys product lines) available at the ACFCWCD Water Resources Laboratory (Hayward) or by request from the manufacturers themselves.

### A.1.1 WHY USE ELISA

Analytical laboratory techniques for detection of diazinon and other pesticides at low concentrations are expensive and require lengthy turnaround times. If the cost of analysis can be reduced, pesticide concentrations can be determined for more samples and the extent of spatial and temporal contamination can be better characterized. If results can be obtained more rapidly, control strategies can be implemented in a timely fashion. The development of enzyme linked immunosorbent assays (ELISAs) provides a rapid and inexpensive alternative to the traditional analytical methods used to determine pesticide concentrations.

### A.1.2 SPECIFICITY OF THE IMMUNE RESPONSE

The immune response of mammals to foreign materials introduced into their bodies utilizes both cellular mechanism (for example, appearance of "killer T-cells" that recognize and kill viruses and bacteria ), and humoral response (e.g., production of soluble antibody proteins that circulate in the blood). Scientists have been "raising" antibodies for decades by injecting inactivated pathogenic bacteria into laboratory or farm animals. These inactivated organisms are foreign antigens, i.e., materials that the animal has not been exposed to before and which elicit an immune response in the injected animal. Some very important human vaccines were produced that way.

Specific antibodies have been raised for research and analytical work as well. Small organic molecules such as diazinon are not good antigens and need to be attached to a bigger "carrier" in order for the immune system to respond and start producing antibodies against them. A batch of antibodies raised against a specific compound **xxx** is often called "anti-xxx antibody" (e.g., anti-diazinon antibody).

Polyclonal antibodies are isolated from the serum of immunized animals and consist of a mixture of antibody proteins that recognize different areas in the antigen molecule. Monoclonal antibodies are raised in tissue-cultures of antibody-producing cells that have been derived (cloned) from one cell which was isolated very early in the immune response process, when each cell "learns" to produce one type of antibody protein. Naturally, monoclonal antibodies are more specific in their recognition ability because they "see" only one component of the antigen molecule and will not recognize other components which different molecules may share with the target antigen.

Antibodies work by binding their antigens and disposing of them or making them harmless in other ways. Specificity is essential, because the body contains a host of functional molecules that should not be bound. This feature is the cornerstone of immunoassays: we are using antibodies to bind specific substances in a mixture of non-target molecules. The antigen-antibody complex is relatively stable and can be isolated from the mixture by various methods. The most common method is to immobilize the antibodies on a solid surface, expose them to the mixture and allow them to bind our target analyte, and then wash off the rest of the mixture. The diazinon ELISA uses anti-diazinon antibodies attached to the inside surfaces of plastic microwells to "pull" diazinon molecules out of a complex mixture of substances. An indirect way, utilizing the principle of competition with labeled diazinon, allows for quantification of the diazinon pulled from the mixture.

### A.1.3 THE PRINCIPAL STEPS IN ELISA

In the first step, the unknown water sample suspected of containing diazinon is added to a microwell together with a known quantity of enzyme-labeled diazinon (a conjugate of diazinon and horseradish peroxidase). The ambient (free) diazinon and the added enzyme-labeled diazinon compete for the limited number of binding sites on the antibodies, and eventually bind in proportion to their relative abundance (concentration) during the incubation period.

In the second step, all unbound molecules are removed by rinsing the well thoroughly, while the bound analytes remain attached.

In the third step, a substrate for the enzyme is added at non-limiting concentration. The enzyme transforms the substrate into a colored molecule at a rate that depends on the number of enzyme molecules in this well. After a fixed period of time, the enzyme reaction is stopped by addition of acid.

In the fourth step, the color intensity is quantified by measuring the amount of light absorbed by the color molecules present in the solution in the well. If the intensity of color is high it means that there was a lot of enzyme in the well, which means that the conjugate "won" the competition, which means that there was very little or no diazinon in our ambient sample. On the other hand, if the intensity of color is low, we know that we had many molecules of diazinon in our sample.

In the fifth step, the amount of diazinon in the sample is calculated. Each ELISA "run" uses enough microwells (24 or 36) to allow comparison of color produced in wells that had environmental samples (of unknown diazinon concentrations) with color produced in wells with known concentrations of free diazinon and in wells without diazinon at all. Three concentrations of free diazinon are used for calibration of each run, and the concentrations of diazinon in all the ambient samples tested in the run are calculated from that calibration curve.

### A.1.4 LABORATORY PROCEDURES

The diazinon ELISA reagent kits sold commercially include five essential components: 1) diazinon stock solution; 2) anti-diazinon antibodies (attached to wells or tubes); 3) enzyme-labeled diazinon (a conjugate of diazinon and horseradish peroxidase); 4) substrate for the enzyme, and 5) acid to stop the enzymatic reaction. For this study, EnviroGard diazinon plate ELISA kits intended for water testing were purchased from

EnSys Environmental Products (now Strategic Diagnostics Inc., Newark DE). All tests of water samples were performed in the ACFCWCD Water Resources Laboratory. The kits were used according to the manufacturer's instructions, except that the concentrations used for diazinon calibrators were altered slightly, from 30, 100 and 500 nanogram per liter (ng/l) to 25, 100 and 400 (ng/l). All measurements were made using adjustable-volume micropipettors; all dilutions were made with HPLC grade water (Fisher).

Diazinon calibrators were prepared in water by serial dilutions of the stock solution (component 1). Water samples obtained from streams or street drains were initially tested without dilution or at 25% dilution; if the initial test showed concentrations greater than the highest calibrator concentration, another test was made with a larger dilution factor. Samples and calibrators were introduced into the antibody coated wells (component 2), and immediately mixed with the diazinon-enzyme conjugate (component 3). There are 12 wells in one plastic strip.

Diazinon molecules in samples or calibrators were allowed to compete with conjugated diazinon for one hour (A1.3, first step), all the unbound molecules were washed away in cold tap water (second step), a substrate (component 4) was added and allowed to react with the enzyme for 30 minutes (third step) until the reaction was stopped with acid (component 5), and the intensity of the color in each well was recorded by measuring the absorbance of light at 450 nm (fourth step).

All data were recorded carefully throughout the entire procedure. Data for weights, volumes, dilution factors, and absorbance were subsequently entered into a spreadsheet that has been developed for this purpose (fifth step). The spreadsheet incorporates the calibrator data into a built in curve and calculates the diazinon concentration in nanogram per liter for water samples.

## A.2.0 SOURCES OF UNCERTAINTY AND ERROR

Several sources of uncertainty were identified concerning the nature of diazinon in water samples, separate experiment to evaluate the effects of holding time in different containers prior to ELISA testing. Several sources of analytical error are also outlined below.

### A.2.1 Sources of Uncertainty

Representativeness of the sample: Discrete or composite samples taken by the stream sampler represented known volumes of runoff water associated with specific portions of the storm hydrograph. However, samples from storm drain lines or street gutters could represent different parts of the hydrograph depending on local rainfall and drainage conditions.

Holding temperature: Samples were kept refrigerated after collection and prior to the ELISA assay. Occasionally the cooling ice in the stream sampler melted before samples could be removed, resulting in higher temperatures and potential loss of part of the diazinon.

Holding time: Samples were typically tested within 1 to 3 days. Repeated sampling from spiked samples held at 0-4°C for up to 14 days showed that none of the original diazinon was lost during the first four days, but up to 30% was lost after 14 days (Figure A.2.1).

Holding container: Compositing and subsampling of the spiked sample followed the same procedures used in preparing composite samples. The sample was composited in a 20 liter glass carboy and pumped into containers with a peristaltic pump. Three replicates were filled for five types of containers: one liter polyethylene bottles used to collect discrete samples (PL), one liter glass bottles (GL), 20 ml glass scintillation vials (GS), 125 ml wide mouth glass jars with Teflon-lined screw caps (WGM) and 10 l plastic collapsible cubitainers (PC). Results were similar for all container types (Figure A.2.1).

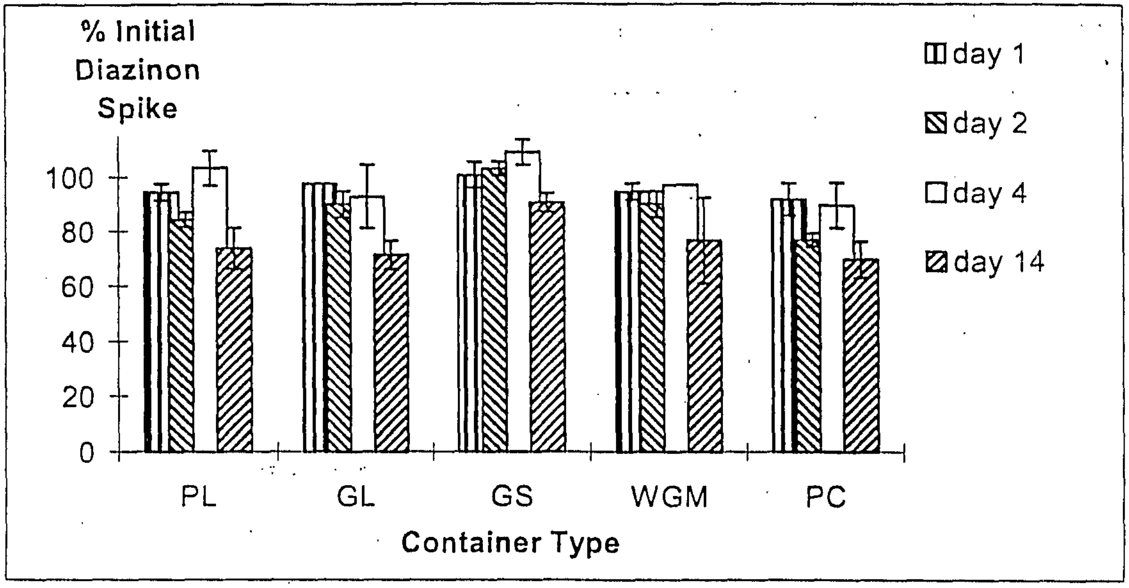

**Figure A.2.1 Percentage of Original Diazinon Spike Remaining in Test Containers After Different Holding Times**

Subsample representativeness: Sample containers were agitated and allowed to settle for a few minutes before aliquots were removed for assay. However, the variation among replicates of the spiked samples suggest that mixing may have been less complete in larger sample containers than in the scintillation vials. In samples with large amounts of suspended sediment, these particles may have "scavenged" some diazinon from the water, resulting in a lower concentration in the aliquots than in the sample at the time of collection.

## A2.2 Sources of Error

Pipetting: Dispensing small volumes of water or samples using air displacement pipettors is a source of error. We pipetted at least 100 microliters (μl)when air displacement pipettors were employed, and used positive displacement pipetting for smaller volumes.

Incubation time: Differences among wells are inevitable because filling the wells with samples takes part of the incubation period. To minimize the difference in incubation time, we restricted the number of wells used in a single run, put replicate calibration standards both at the beginning and the end of the run, and used the average for the calibration curve.

Absorbance reading: For the first 22 ELISA runs made during the 1995-96 runoff season, the absorbance (color density) was measured by diluting the contents of each well in 500 µl of water in a test tube and reading it against a water blank in a photospectrometer (EnSys, now SDI, Newark DE). Samples were read in order of increasing density, or decreasing diazinon concentration. For the last 17 runs absorbances were read directly from the microwells using a strip reader (Millipore, now SDI, Newark DE). The photospectrometer method does not permit rereading of the sample and introduces an additional dilution step. It also takes more time; repeat readings made using the strip reader show that there is some loss of color during the 10-20 minutes required to read one run on the photospectrometer.

## A.3.0 PERFORMANCE EVALUATION AND QA/QC RESULTS

ELISA methodology differs from laboratory analytical methods in several aspects. Table A.3.1 summarizes some of these inherent differences.

These inherent differences dictate different ways to assess the performance of the methods and to evaluate the quality and reliability of the data. However, the two methodologies share many quality assurance elements.

TABLE A.3.1 COMPARISON OF ELISA METHODOLOGY WITH CONVENTIONAL ANALYTICAL TECHNIQUES

| Aspect | ELISA | Analytical method |
|---|---|---|
| Extraction (Water) | None | Liquid-Liquid extraction |
| Separation from other analytes | Specific antibody (does not separate all the analyte molecules) | Gas chromatography or Liquid chromatography |
| Detection | Competition for specific antibody followed by color production and absorbance measurements | Mass spectroscopy or nitrogen-phosphorous detectors |
| Method blank | Highest output reading | Lowest output reading |

### A.3.1 ELISA-Specific QA/QC Issues

Detection limit

In contrast to analytical methods, the ELISA method has no blank value (because zero diazinon results in highest color production) and the detection limit is defined by what is considered as a significant difference in absorbance between zero diazinon and the lowest concentrations of free diazinon in the calibration curve. For the work performed at the concentrations of free diazinon in the calibration curve. For the work performed at the ACFCWCD laboratory in Hayward, a detection limit of 30 ng/l in water was considered reliable.

Cross reactivity

The specificity of an antibody is measured as cross-reactivity, or the degree to which the antibody will bind with non-target compounds. With the exception of some affinity for pirimiphos-ethyl and pirimiphos-methyl, the antibody in the diazinon kit used for this study is very specific to diazinon. Chlorpyrifos, a closely related organophosphorous insecticide, is not detected by this ELISA diazinon kit at concentrations of up to 1000 parts per billion (ppb).

Interference

Substances that affect the antibodies in a non-specific way (e.g. sediment or oil molecules that may stick to the surface of the wells and cover the antibody) will hinder attachment of diazinon conjugate even in the absence of free diazinon. This will cause a false positive result.

Confirmation requirements

ELISA reagent kits have been approved by EPA as screening tools generally used in a semi-quantitative mode (e.g., analyte concentration is greater than 1 ppm and lower than 10 ppm). In the regulatory context, ELISA results need confirmation by conventional analytical techniques for a certain percentage of samples (5-20%). Although our study was not within regulatory context, several composite samples were analyzed both by ELISA and by a sensitive LC/MS method (Quanterra Analytical, Sacramento), and a good agreement was found (see "accuracy" below).

### A.3.2 General QA/QC Elements

Precision

The precision of a measurement is an expression of the degree of reproducibility of results. It can be determined by evaluating the variability among laboratory replicates and by analyzing duplicate samples. The percent coefficient of variation (%CV) calculated for each set of replicates or duplicates is a measure of precision. The % CV is the standard deviation of the diazinon concentration in replicates, divided by the mean concentration and multiplied by 100.

The precision of the diazinon ELISA kits used in this study was evaluated in two ways: "true" replicates (solution from the same sample dilution is introduced into two wells), and "dilution" replicates (solution from two different dilutions (e.g., 25% and 6.25%) of the same sample are introduced into two wells). Calibrators mixed from stock solution are "true" replicates. The kit manufacturer recommends that replicate calibrators placed in adjacent wells have a maximum %CV of 15%. Due to assay drift (see below), calibrators placed at the beginning and end of the run would be expected to vary somewhat more. Out of 35 ELISA runs containing two sets of calibrators, 29 had less than 15%CV for all four calibrator pairs; the mean %CV of the 140 calibrator pairs was 14.5%, slightly less than 15%CV (the standard deviation, or SD, was 11.5%).

Table A.3.2 summarizes the %CV results for 73 samples that had two or more replicates falling within the range of the calibration curve. While the average %CV was less than 15%, a few replicates were much more variable. There was no difference in variability between "true" and "dilution" replicates, or for within-run replicates as opposed to replicates tested in different runs. These results show that the ELISA methodology gave consistent results throughout the study period.

**Table A.3.2 Variation in Diazinon ELISA Results for Replicate Runoff Samples Taken in Castro Valley and San Leandro Watersheds during 1995-1996 Storm Season**

| | | all replicates | "true" replicates | "dilution" replicates | within same ELISA run | multiple runs |
|---|---|---|---|---|---|---|
| No. of replicated samples | | 73 | 16 | 57 | 53 | 20 |
| Using average calibrators | mean %CV | 11.68 | 13.81 | 11.08 | 12.57 | 9.32 |
| | SD of %CV | 9.89 | 10.96 | 9.58 | 10.23 | 8.70 |
| | maximum %CV | 50.46 | 31.03 | 50.46 | 50.46 | 31.03 |
| Using different calibrator sets | mean %CV | 9.56 | 9.46 | 9.59 | 9.83 | 8.84 |
| | SD of %CV | 6.97 | 6.81 | 7.07 | 6.98 | 7.07 |
| | maximum %CV | 28.99 | 22.32 | 28.99 | 28.99 | 22.32 |

Three of the runs showed a systematic shift in calibrator absorbances between the beginning and end calibrator sets, suggesting assay drift was occurring due to differences in incubation times within the runs. Sample values were recalculated for these runs, with beginning wells calculated from the beginning calibrator set only, the end wells from the end calibrators, and the middle wells from the average of both calibrator sets. After this recalculation, which affected seven replicate sets, the maximum %CV was reduced, but there were still some high values up to 29%CV that could be due to a variety of error sources.

## Accuracy

Accuracy is the nearness of a measurement to its true value. Accuracy of the analysis is evaluated through the use of standard analyte solutions. In the ELISA runs, the diazinon stock solution provided in the ELISA reagent kit was used both for calibration and for reference to the "true" concentration. Stock dilutions from different kits and different manufacturing lots were tested together and produced similar results.

The samples analyzed by Quanterra for confirmation provide an independent measure of accuracy, because the laboratory uses a different standard analyte solution. Table A.3.3 summarizes the diazinon data obtained by the analytical laboratory and by ELISA for the same composite samples. Here, the relative percent difference (RPD) is the difference between the laboratory and ELISA results divided by the average of the two results and multiplied by 100. Unlike the %CV, the RPD may have either a negative or positive value, depending which of the two results was used first; this is useful in detecting a trend of bias caused by the method. The average %CV and the RPD are greater than that used in the laboratory's quality assurance program, and also greater than for replicates within ELISA runs. However, the 40% average of the absolute values for RPD is reasonable agreement for tests from different laboratories using different analysis methods.

**Table A.3.3 Comparison of ELISA Results and Laboratory Analysis for Diazinon in Composite Runoff Samples**

| sample date | Diazinon concentration, ng/l | | Holding time, days | | RPD | %CV |
|---|---|---|---|---|---|---|
| | Lab | ELISA | Lab | ELISA | | |
| 12/11/95 | 320 | 276 | 14 | 2 | 14.6 | 10.3 |
| 1/16/96 | 205 | 386 | 23 | 1 | -61.1 | 43.2 |
| 1/16/96 | 220 | 367 | 23 | 1 | -50.0 | 35.4 |
| 1/19/96 | 170 | 254 | 20 | 2 | -39.6 | 28.0 |
| 1/18/96 | 140 | 240 | 21 | 2 | -52.8 | 37.3 |
| 3/4/96 | 280 | 156 | 14 | 1 | 56.9 | 40.2 |
| 3/4/96 | 120 | 89 | 14 | 1 | 29.4 | 20.8 |
| 4/1/96 | 280 | 342 | 16 | 2 | -19.9 | 14.1 |
| 4/1/96 | 370 | 267 | 16 | 2 | 32.3 | 22.8 |
| Average: | | | | | -10.0 | 28.0 |
| Average of absolute RPD: | | | | | 39.6 | |

Laboratory samples were typically held for longer periods of time before analysis. Figure A.3.1 plots the RPD against the difference in holding time for the two types of analysis; the RPD shows a bias that is positive for samples held less than three weeks but negative when laboratory holding times were longer. Laboratory samples that were tested more than three weeks after sample collection showed consistently lower results than the ELISA tests that were performed within 48 hours, as would be expected from the results of holding time tests (Section A.2.1). However, laboratory analyses made between 2 and 3 weeks after collection produced consistently higher results than the ELISA. Based on these results, laboratory tests that were made within the same time frame as the ELISA would probably show higher RPDs for all samples.

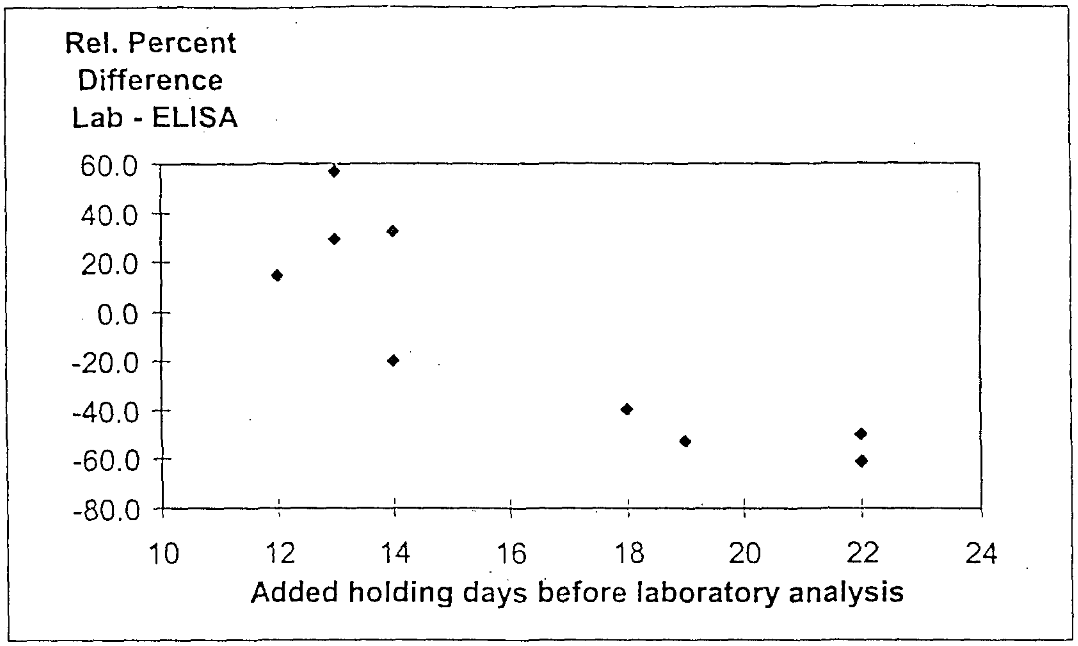

Figure A.3.1 Relative Percent Difference for ELISA Results and Laboratory Analyses Made After Different Sample Holding Times

# Appendix B . Sample Results and Hydrological Data From Station S3

## Contents

## Table B.1 Sample Data and Diazinon Event Mean Concentration Calculations for Station S3 During 1995-96 Storm Season

| 1995-96 Station S3 SAMPLE ID (1) | Sample date | time | Initial Sample (ppt) | Notes (2) | Beginning Calibrator (3) | End Calibrator (3) | Multiplier Factor (4) | Event Mean Concentration Used |
|---|---|---|---|---|---|---|---|---|
| cv56d1#1(25%) | 12/4/95 | 237 | 758 | | 585 | | | |
| cv56d1#2(25%) | 12/4/95 | 249 | 874 | | 689 | | 2 | |
| cv56d1#4(25%) | 12/4/95 | 316 | 1008 | | 811 | | 2 | |
| cv56d1#6(6.25%) | 12/4/95 | 353 | 844 | | | 1192 | | |
| cv56d1#6(25%) | 12/4/95 | 353 | 1339 | | *1124* | | 2 | |
| cv56d1#8(6.25%) | 12/4/95 | 455 | 635 | | | 927 | | |
| cv56d1#8(25%) | 12/4/95 | 455 | *874* | | 689 | | 2 | |
| cv56d1#9(6.25%) | 12/4/95 | 543 | 551 | | | 817 | | |
| cv56d1#9(25%) | 12/4/95 | 543 | *874* | | 689 | | | |
| cv56d1#10(6.25%) | 12/4/95 | 658 | 414 | | | 635 | | |
| cv56d1#10(25%) | 12/4/95 | 658 | *874* | | 689 | 1051 | 2 | |
| cv56d1#12(25%) | 12/4/95 | 816 | 874 | | 689 | 1051 | 2 | |
| cv56d1#14(25%) | 12/4/95 | 941 | 874 | | 689 | 1051 | 2 | |
| cv56d1#16(25%) | 12/4/95 | 1120 | 874 | | 689 | 1051 | 2 | |
| cv56d1#17(25%) | 12/4/95 | 1212 | 758 | | | 927 | 2 | |
| cv56d1#20(25%) | 12/5/95 | 625 | 571 | | | 720 | 2 | |
| **Discrete #1** | 12/4/95 | 2:37-6:2[illegible]=823 | | | | | | 820 |
| cv56d2#1(12.5%) | 12/10/95 | 1754 | 241 | | | 303 | | |
| cv56d2#1(50%) | 12/10/95 | 1754 | *241* | | 191 | | 1 | |
| cv56d2#2(50%) | 12/10/95 | 1943 | 1106 | r, e- | 877 | | 1 | |
| cv56d2#3(12.5%) | 12/11/95 | 236 | 1459 | | | 1838 | 1 | |
| cv56d2#3(25%)-retest12/29 | 12/11/95 | 236 | 782 | h18 | | | | |
| cv56d2#4(50%) | 12/11/95 | 241 | 1106 | r, e- | 877 | | 1 | |
| cv56d2#5(50%) | 12/11/95 | 245 | 838 | r, e- | 665 | | 3 | |
| cv56d2#8(12.5%) | 12/11/95 | 258 | 838 | | | 1056 | | |
| cv56d2#8(25%)-retest12/29 | 12/11/95 | 258 | 516 | h18 | | | | |
| cv56d2#8(50%) | 12/11/95 | 258 | 729 | | 579 | | 5 | |
| cv56d2#15(12.5%) | 12/11/95 | 330 | 635 | | | 800 | 4 | |
| cv56d2#15(50%) | 12/11/95 | 330 | 481 | | 382 | 606 | | |
| cv56d2#18(50%) | 12/11/95 | 346 | 553 | | 439 | 696 | 4 | |
| cv56d2#23(12.5%) | 12/11/95 | 431 | 635 | | | 800 | | |
| cv56d2#23(50%) | 12/11/95 | 431 | 419 | | 332 | 528 | 3 | |
| **Discrete #2** | 12/10/95 | 17:54-4:31(12/11) | **16,870/24 = 703** | | | | | 700 |
| cv56C#1(50%) | 12/11/95 | 18:48-7:73(12/12) | 276 | | 219 | 348 | | |
| Quanterra LC/MS | 12/11/95 | 18:48-7:73(12/12) | 320 | 14 days | | | | |
| **Composite #1** | 12/11/95 | 18:48-7:73(12/12) | | | | | | 300 |

| 1995-96 Station S3 SAMPLE ID (1) | Sample date | time | Initial Sample (ppt) | Notes (2) | Beginning Calibrator (3) | End Calibrator (3) | Multiplier Factor (4) | Event Mean Concentration Used |
|---|---|---|---|---|---|---|---|---|
| cv56d3#3(25%) | 12/29/95 | 1218 | 681 | | | 800 | | |
| cv56d3#3(25%) | 12/29/95 | 1218 | 1031 | | 877 | | | |
| cv56d3#4(25%) | 12/29/95 | 1234 | 1031 | | 877 | | | |
| cv56d3#5(25%) | 12/29/95 | 1242 | 898 | | 764 | | 2 | |
| cv56d3#7(25%) | 12/29/95 | 1258 | 898 | | 764 | | | |
| cv56d3#8(25%) | 12/29/95 | 1308 | 898 | | 764 | | 2 | |
| cv56d3#10(25%) | 12/29/95 | 1328 | 681 | | 579 | | 2 | |
| cv56d3#12(25%) | 12/29/95 | 1345 | 898 | | 764 | 1056 | 2 | |
| cv56d3#14(25%) | 12/29/95 | 1348 | 592 | | 504 | 696 | 2 | |
| cv56d3#17(25%) | 12/29/95 | 1520 | 516 | | 439 | 606 | 2 | |
| cv56d3#19(25%) | 12/29/95 | 1528 | 516 | | 439 | 606 | 2 | |
| cv56d3#21(25%) | 12/29/95 | 1535 | 449 | | | 528 | 2 | |
| cv56d3#24(25%) | 12/29/95 | 1549 | 449 | | | 528 | 2 | |
| Discrete #3 | 12/29/95 | 12:18-15:49 | 13,916/21=663 | | | | | 660 |
| cv56d4#1(20%) | 1/16/96 | 609 | 771 | | | | 1 | |
| cv56d4#3(20%) | 1/16/96 | 626 | 324 | | | | 3 | |
| cv56d4#7(20%) | 1/16/96 | 656 | 193 | | | | 3 | |
| cv56d4#9(20%) | 1/16/96 | 713 | 193 | | | | 4 | |
| cv56d4#13(20%) | 1/16/96 | 742 | 193 | | | | 4 | |
| cv56d4#17(20%) | 1/16/96 | 803 | 193 | | | | 5 | |
| cv56d4#23(20%) | 1/16/96 | 847 | 229 | | | | 3 | |
| Discrete #4 | 1/16/96 | 5:50 - 8:35 | | | | | | 250 |
| Composite #2 | 1/16/96 | 5:50 - 8:35 | 386 | | | | | 390 |
| Quanterra LC/MS | 1/16/96 | 5:50 - 8:35 | 190 | 22 days | | | | |
| Quanterra Dup. | 1/16/96 | 5:50 - 8:35 | 220 | 22days | | | | 320 |
| cv56d5#2(20%) | 1/18/96 | 1509 | 379 | sc | | | | |
| cv56d5#6(20%) | 1/18/96 | 1702 | 218 | sc | | | | |
| cv56d5#8(20%) | 1/18/96 | 1832 | 144 | sc | | | | |
| S3C38(25%) | 1/18/96 | 14:40-3:40(1/19) | 267 | | | | | |
| S3C38(100%) | 1/18/96 | 14:40-3:40(1/19) | 240 | | | | | |
| Composite #3 | 1/18/96 | 14:40-3:40(1/19) | | | | | | 250 |
| Quanterra LC/MS | 1/18/96 | 14:40-3:40(1/19) | 170 | 9 days | | | | |

| 1995-96 Station S3 SAMPLE ID (1) | Sample date | time | Initial Sample (ppt) | Notes (2) | Beginning Calibrator (3) | End Calibrator (3) | Multiplier Factor (4) | Event Mean Concentration Used |
|---|---|---|---|---|---|---|---|---|
| cv56g6S3(25%) | 1/20/96 | ~14:00 | 67 | | | | | |
| cv56d6#1(25%) | | 2222 | 131 | | | | | |
| cv56d6#3(25%) | 1/20/96 | 2235 | 201 | | | | | |
| cv56d6#4(25%) | 1/20/96 | 2240 | 267 | | | | | |
| cv56d6#6(25%) | 1/20/96 | 2258 | 267 | | | | | |
| cv56d6#8(25%) | 1/20/96 | 2322 | 201 | | | | | |
| cv56d6#10(25%) | 1/21/96 | 7 | 201 | | | | | |
| cv56d6#12(25%) | 1/21/96 | 135 | 232 | | | | | |
| cv56d6#13(25%) | 1/21/96 | 208 | 175 | | | | | |
| cv56d6#15(25%) | 1/21/96 | 605 | 151 | | | | | |
| cv56d6#16(100%) | 1/21/96 | 624 | 118 | | | | | |
| cv56d6#16(25%) | 1/21/96 | 624 | 131 | | | | | |
| **Discrete #6** | 1/20/96 | 22:20-6:30(8/31) | 205 | | | | | 200 |

| 1995-96 Station S3 SAMPLE ID (1) | Sample date | time | Initial Sample (ppt) | Notes (2) | Beginning Calibrator (3) | End Calibrator (3) | Multiplier Factor (4) | Event Mean Concentration Used |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| cv56d7#4(25%) | 2/3/96 | 2100 | 98 | | 81 | 115 | | |
| cv56d7#4 | 2/3/96 | 2100 | 105 | | *95* | | | |
| cv56d7#5(25%) | 2/4/96 | 410 | 420 | r, e+ | 380 | 459 | | |
| cv56d7#5 | 2/4/96 | 410 | 292 | | *279* | | 1 | |
| cv56d7#7(25%) | 2/4/96 | 425 | **314** | | | 348 | 1 | |
| cv56d7#7 | 2/4/96 | 425 | **252** | | 239 | | 1 | |
| cv56d7#9(25%) | 2/4/96 | 504 | 175 | | | 200 | | |
| cv56d7#9 | 2/4/96 | 504 | *163* | | 151 | | 2 | |
| cv56d7#13(25%) | 2/4/96 | 619 | 175 | | | 200 | | |
| cv56d7#13 | 2/4/96 | 619 | *163* | | 151 | | 1 | |
| cv56d7#15(25%) | 2/4/96 | 632 | 175 | | | 200 | | |
| cv56d7#15 | 2/4/96 | 632 | *188* | | 176 | | 2 | |
| cv56d7#20(25%) | 2/4/96 | 709 | 113 | | | 132 | | |
| cv56d7#20 | 2/4/96 | 709 | *105* | | 95 | 115 | 2 | |
| cv56d7#24(25%) | 2/4/96 | 902 | 131 | | | 152 | | |
| cv56d7#24 | 2/4/96 | 902 | *121* | | 111 | 132 | 1 | |
| **Discrete #7** | 2/4/96 | 4:10-9:02 | **2041/11=185.5** | | | | | 190 |
| | | | | | | | | |
| cv56g8S3(25%) | 2/15/96 | 1655 | 539 | | ***471*** | | | |
| cv56g8S3(6.25%) | 2/15/96 | 1655 | 497 | | 434 | 570 | | |
| | | | | | | | | |
| cv56g9S3#1 (25%) | 3/4/96 | 1400 | 228 | | | | | |
| cv56g9S3#2 (25%) | 3/4/96 | 1406 | 228 | | | | | |
| cv56g9S3c39 | 3/4/96 | 8:10-22:10 | *185* | | | | | |
| cv56g9S3c39 (25%) | 3/4/96 | 8:10-22:10 | 127 | | | | | |
| Quanterra LC/MS | 3/4/96 | 8:10-22:10 | 280 | 14 days | | | | |
| **Composite #4** | 3/4/96 | 8:10-22:10 | | | | | | 180 |
| | | | | | | | | |
| CV56D10#1 | 4/1/96 | 956 | **73** | | 54 | 82 | 1 | |
| CV56D10#3 (25%) | 4/1/96 | 1220 | **235** | | 202 | 269 | 1 | |
| CV56D10#4 (25%) | 4/1/96 | 1232 | **235** | | 202 | 269 | 1 | |
| CV56D10#7 (25%) | 4/1/96 | 1310 | 310 | | | **351** | 1 | |
| CV56D10#9 (25%) | 4/1/96 | 1332 | 310 | | | 351 | 2 | |
| CV56D10#10 (25%) | 4/1/96 | 1338 | 270 | | | 307 | 1 | |
| CV56D10#14 (25%) | 4/1/96 | 1407 | 356 | | | **400** | 1 | |
| CV56D10#16 (25%) | 4/1/96 | 1440 | 356 | | | **400** | 1 | |
| CV56D10#19 (25%) | 4/1/96 | 1608 | 409 | | | **456** | 1 | |
| **Discrete #10** | | 9:50-16:10 | | | | | | 310 |
| CV56g10S3gMar31 | 4/1/96 | ~14:00 | 44 | | **42** | | | |
| CV56g10S3C | 4/1/96 | 8:50-17:00 | 288 | | ***289*** | | | 290 |
| CV56g10S3C (25%) | 4/1/96 | 8:50-17:00 | 396 | | **382** | | | |
| Quanterra LC/MS | 4/1/96 | 8:50-17:00 | 280 | 16 days | | | | |

| 1995-96 Station S3 SAMPLE ID (1) | Sample date | time | Initial Sample (ppt) | Notes (2) | Beginning Calibrator (3) | End Calibrator (3) | Multiplier Factor (4) | Event Mean Concentration Used |
|---|---|---|---|---|---|---|---|---|
| CV56D11#1 (6.25%) | 4/15/96 | 1723 | 538 | | 481 | 600 | | |
| CV56D11#1 (25%) | 4/15/96 | 1723 | *681* | | 628 | 738 | 1 | |
| CV56D11#2 (6.25%) | 4/16/96 | 904 | 473 | | | 528 | | |
| CV56D11#2 (25%) | 4/16/96 | 904 | *642* | | | 696 | 1 | |
| CV56D11#3 (6.25%) | 4/16/96 | 1619 | 647 | | 550 | | | |
| CV56D11#3 (25%) | 4/16/96 | 1619 | 692 | | *609* | | 1 | |
| CV56D11#4 (25%) | 4/17/96 | 543 | 190 | | 246 | 221 | | |
| CV56D11#4 (25%) | 4/17/96 | 543 | 286 | | 221 | | | |
| CV56D11#4 | 4/17/96 | 543 | 284 | | *254* | | 1 | |
| CV56D11#5 (25%) | 4/17/96 | 1645 | 232 | | 119 | | | |
| CV56D11#5 | 4/17/96 | 1645 | 252 | | 224 | 282 | 1 | |
| CV56D11#6 (25%) | 4/17/96 | 1654 | *511* | | 447 | 581 | 1 | |
| CV56D11#6 | 4/17/96 | 1654 | 390 | rc, e- | 350 | 432 | | |
| CV56D11#8 (25%) | 4/17/96 | 1717 | 617 | | 542 | 699 | 1 | |
| CV56D11#10 (25%) | 4/17/96 | 1810 | *468* | | | 533 | 1 | |
| CV56D11#10 | 4/17/96 | 1810 | 396 | rc, e- | | 438 | | |
| CV56D11#13 (25%) | 4/17/96 | 1831 | *433* | | | 494 | 1 | |
| CV56D11#13 | 4/17/96 | 1831 | 382 | rc, e- | | 423 | | |
| CV56D11#1B (25%) | 4/17/96 | 1950 | 403 | | | | 0.5 | |
| CV56D11#1B (25%) | 4/17/96 | 1950 | 507 | | | | 0.5 | |
| CV56D11#2B (25%) | 4/17/96 | 2006 | 511 | | | | 1 | |
| CV56D11#3B (25%) | 4/17/96 | 2024 | 365 | | | | 1 | |
| CV56D11#4B (25%) | 4/17/96 | 2119 | 360 | | | | 1 | |
| CV56D11#6B | 4/18/96 | | 271 | | | | 1 | |
| CV56D11#6B (25%) | 4/18/96 | | 257 | | | | | |
| **Estimated EMC** | | | 450 | *Estimated | | | | 450 |
| cv56d12# 1 (25%) | 5/15/96 | | 957 | | 909 | | | |
| cv56d12# 2 (25%) | 5/15/96 | 12:35 | 898 | | | 947 | 1 | |
| cv56d12# 2 (25%) | 5/15/96 | 12:35 | 992 | | 941 | | | |
| cv56d12# 3 (25%) | 5/15/96 | 12:38 | 1307 | | 1235 | | 1 | |
| cv56d12# 4 (25%) | 5/15/96 | 12:41 | 1189 | | 1125 | | 2 | |
| cv56d12# 7 (25%) | 5/15/96 | 12:49 | 1099 | | 1041 | | 3 | |
| cv56d12# 9 (25%) | 5/15/96 | 12:53 | 1175 | | 1112 | | 2 | |
| cv56d12# 11 (25%) | 5/15/96 | 12:57 | 1069 | | 1013 | 1129 | 2 | |
| cv56d12# 15 (25%) | 5/15/96 | 13:04 | 938 | | 891 | 989 | 4 | |
| cv56d12# 18 (25%) | 5/15/96 | 13:09 | 758 | | | 797 | 4 | |
| cv56d12# 21 (25%) | 5/15/96 | 13:15 | 801 | | | 843 | 2 | |
| cv56d12# 24 (25%) | 5/15/96 | 13:22 | 805 | | | 846 | 2 | |
| cv56d12# 1B (25%) | 5/16/96 | 15:06 | 881 | | | | 5 | |
| cv56d12# 2B (25%) | 5/16/96 | 15:26 | 753 | | | | 2.5 | |
| cv56d12# 3B (25%) | 5/16/96 | 15:53 | 785 | | | | 2.5 | |
| cv56d12# 4B (25%) | 5/16/96 | 16:16 | 759 | | | | 2.5 | |
| cv56d12# 5B (25%) | 5/16/96 | 16:42 | 704 | | | | 2.5 | |
| cv56d12# 6B (25%) | 5/16/96 | 18:00 | 532 | | | | 2.5 | |
| cv56d12# 6B (25%) | 5/16/96 | 18:00 | 656 | | | | 2.5 | |
| cv56d12# 7B (25%) | 5/16/96 | 18:17 | 565 | | | | 2.5 | |
| cv56d12# 8B (25%) | 5/16/96 | 18:34 | 556 | | | | 2.5 | |
| cv56d12# 9B (25%) | 5/16/96 | 18:50 | 559 | | | | 2.5 | |
| cv56d12# 10B (25%) | 5/16/96 | 20:04 | 552 | | | | 10 | |
| cv56d12# 11B (25%) | 5/16/96 | 22:55 | 413 | | | | 10 | |
| cv56d12# 12B (25%) | 5/16/96 | 0:44 | 402 | | | | 10 | |
| CV56d12# 13B | 5/17/96 | 1:57 | 305 | c1 | 270 | | | |
| CV56d12# 13B (25%) | 5/17/96 | 1:57 | 256 | c1 | 209 | | | |
| Discrete # 12 | | | | | | | | 700 |

## Footnotes to Table B.1

| | | |
|---|---|---|
| (1) Sample type codes: | cv56dxx | discrete, flow-weighted sample |
| | cv56cxx | composited from discrete samples |
| | cv56gxx | grab sample |
| (2) Codes in "Notes": | Estimate d | Peak flow was not sampled. Concentrations estimated from samples surrounding peak. |
| | d | below detection limit = 25 ppt |
| | r | above range of standard curve = 400 ppt (derived) |
| | rc | %BO beyond range for lowest of 400 calibrators |
| | e- | probably underestimates diazinon concentration |
| | e+ | probably overestimates diazinon concentration |
| | c1,c2,c3 | one or more calibrators exceed 15%CV between replicates |
| | sc | single set of calibrators in this run--no replicates |
| | cx | first set of calibrators from previous run, not on same strips |
| | cy | last set of calibrators from following run, not on same strips |
| | h18 | holding time = 18 days before this run, some diazinon has broken down |
| | ~time | time of sampling is approximate |
| (3) Beginning/End Calibrator: | | Alternative values for ELISA results using single set of calibrators closest to each sample within the run, instead of average of both sets of calibrators |
| (4) Multiplier Factor: | | Concentrations of analyzed samples assigned to adjacent unanalyzed samples |

Notes on interpretation of ELISA results:

1 15%CV = maximum suggested allowance for 2 replicate samples, equivalent to:

| | |
|---|---|
| ppt | at 25 ppt |
| ppt | at 100 ppt |
| ppt | at 250 ppt |
| ppt | at 400 ppt |

When the difference between replicates is less than the above, either or both may be reasonable estimates.

Multiply these numbers by dilution factor for approx. range of variation in the concentration of original sample

2 Linear standard curve approximates actual absorbance curve, but tends to underestimate concentration at 25 and 400 ppt, and overestimate at 100 ppt. This bias may be 10-15% of the sample value, depending on run.

"e-" and "e+" notes are shown when the best estimate in bold face is proably biased as noted.

"rc" note indicates actual sample concentration is probably over 400 ppt

3 "d" or "r" values have been deleted unless no other value is available

# Table B.2 Sample Data and Diazinon Event Mean Concentration Calculations for Station S3 During 1996-97 Storm Season

| 1996-97station S3 SAMPLE ID (1) | Sample date | time | Initial Sample (ppt) | Notes (2) | Beginning Calibrator (3) | End Calibrator (3) | Multiplier Factor (4) | Event Mean Concentration Used |
|---|---|---|---|---|---|---|---|---|
| cv67d1#1 (25%) | 10/29/96 | 305 | 113 | | | | 1 | |
| cv67d1#2 (25%) | 10/29/96 | 316 | 336 | | | | | |
| cv67d1#2 (25%) | 10/29/96 | 316 | 246 | | | | | |
| cv67d1#2 (25%) | 10/29/96 | 316 | 256 | | | | 1 | |
| cv67d1#3 (25%) | 10/29/96 | 327 | 381 | | | | 1 | |
| cv67d1#4 (25%) | 10/29/96 | 334 | 435 | | | | | |
| cv67d1#4 (25%) | 10/29/96 | 334 | 466 | | | | 1 | |
| cv67d1#4 (25%) | 10/29/96 | 334 | 472 | | | | | |
| cv67d1#4 (25%) | 10/29/96 | 334 | 485 | | | | | |
| cv67d1#5 (25%) | 10/29/96 | 339 | 429 | | | | | |
| cv67d1#5 (25%) | 10/29/96 | 339 | 460 | | | | 1 | |
| cv67d1#5 (25%) | 10/29/96 | 339 | 541 | c1 | | | | |
| cv67d1#6 (25%) | 10/29/96 | 343 | 300 | | | | 1 | |
| cv67d1#7 (25%) | 10/29/96 | 347 | 370 | | | | 1 | |
| cv67d1#8 (25%) | 10/29/96 | 351 | 372 | | | | 1 | |
| cv67d1#9 (25%) | 10/29/96 | 355 | 379 | | | | 0.5 | |
| cv67d1#9 (25%) | 10/29/96 | 355 | 429 | | | | 0.5 | |
| cv67d1#10 (25%) | 10/29/96 | 359 | 501 | c1 | | | | |
| cv67d1#10 (25%) | 10/29/96 | 359 | 512 | | | | 1 | |
| cv67d1#10 (25%) | 10/29/96 | 359 | 528 | | | | | |
| cv67d1#11 (25%) | 10/29/96 | 403 | 457 | sc | | | | |
| cv67d1#12 (25%) | 10/29/96 | 408 | 415 | | | | | |
| cv67d1#12 (25%) | 10/29/96 | 408 | 442 | | | | 1 | |
| cv67d1#12 (25%) | 10/29/96 | 408 | 493 | | | | | |
| cv67d1#12 (25%) | 10/29/96 | 408 | 529 | | | | | |
| cv67d1#13 (25%) | 10/29/96 | 414 | 455 | | | | | |
| cv67d1#13 (25%) | 10/29/96 | 414 | 485 | | | | 1 | |
| cv67d1#13 (25%) | 10/29/96 | 414 | 543 | | | | | |
| cv67d1#13 (6.25%) | 10/29/96 | 414 | 465 | | | | | |
| cv67d1#13 (6.25%) | 10/29/96 | 414 | 485 | | | | | |
| cv67d1#13 (6.25%) | 10/29/96 | 414 | 503 | | | | | |
| cv67d1#14 (25%) | 10/29/96 | 422 | 353 | | | | | |
| cv67d1#14 (25%) | 10/29/96 | 422 | 396 | | | | | |
| cv67d1#14 (25%) | 10/29/96 | 422 | 424 | | | | 1 | |
| cv67d1#14 (25%) | 10/29/96 | 422 | 470 | | | | | |
| cv67d1#15 (25%) | 10/29/96 | 435 | 379 | | | | 1 | |
| cv67d1#16 (25%) | 10/29/96 | 454 | 336 | | | | 0.5 | |
| cv67d1#16 (25%) | 10/29/96 | 454 | 492 | | | | 0.5 | |
| cv67d1#17 (25%) | 10/29/96 | 510 | 472 | | | | | |
| cv67d1#17 (25%) | 10/29/96 | 510 | 495 | | | | 1 | |
| cv67d1#17 (25%) | 10/29/96 | 510 | 540 | sc | | | | |
| cv67d1#18 (25%) | 10/29/96 | 521 | 194 | | | | | |
| cv67d1#18 (25%) | 10/29/96 | 521 | 342 | | | | | |
| cv67d1#18 (25%) | 10/29/96 | 521 | 365 | | | | 1 | |
| cv67d1#18 (25%) | 10/29/96 | 521 | 416 | | | | | |
| cv67d1#18 (25%) | 10/29/96 | 521 | 509 | | | | | |

| 1996-97station S3 SAMPLE ID (1) | Sample date | time | Initial Sample (ppt) | Notes (2) | Beginning Calibrator (3) | End Calibrator (3) | Multiplier Factor (4) | Event Mean Concentration Used |
|---|---|---|---|---|---|---|---|---|
| cv67d1#20 (25%) | 10/29/96 | 538 | 290 | | | | 1 | |
| cv67d1#21 (25%) | 10/29/96 | 549 | 306 | | | | 1 | |
| cv67d1#22 (25%) | 10/29/96 | 610 | 216 | | | | 1 | |
| cv67d1#23 (25%) | 10/29/96 | 635 | 431 | c1 | | | 1 | |
| cv67d1#24 (25%) | 10/29/96 | 653 | 279 | | | | 1 | |
| | | | | | | | | |
| **Discrete #1** | | | | | | | 375 | |
| | | | | | | | | |
| cv67d1#1B (25%) | 10/29/96 | 1251 | 460 | | | | | |
| cv67d1#2B | 10/30/96 | 751 | 358 | | | | | |
| cv67d1#2B (25%) | 10/30/96 | 751 | 479 | | | | | |
| cv67d1#3B | 10/31/96 | 2257 | 206 | | | | | |
| cv67d1#3B | 10/31/96 | 2257 | 175 | | | | | |
| | | | | | | | | |
| cv67c1S3A (25%) | 10/29/96 | | 293 | | | | | |
| cv67c1S3A (25%) | 10/29/96 | | 313 | | | | 0.333 | |
| cv67c1S3A (25%) | 10/29/96 | | 326 | | | | | |
| cv67c1S3B (25%) | 10/29/96 | | 306 | | | | | |
| cv67c1S3B (25%) | 10/29/96 | | 359 | | | | 0.333 | |
| cv67c1S3B (25%) | 10/29/96 | | 553 | | | | | |
| cv67c1S3C (25%) | 10/29/96 | | 396 | | | | | |
| cv67c1S3C (25%) | 10/29/96 | | 405 | | | | 0.333 | |
| cv67c1S3C (25%) | 10/29/96 | | 411 | | | | | |
| | | | | | | | | |
| **Event 1 composite** | | | | | | | 359 | 360 |
| | | | | | | | | |
| cv67d1Grab | 11/1/96 | 1530 | 87 | | | | | |
| cv67d1Grab | 11/1/96 | 1530 | 131 | | | | | |
| cv67d1Grab (25%) | 11/1/96 | 1530 | 104 | | | | | |
| | | | | | | | | |
| cv67d2#1 (25%) | 11/16/96 | 2010 | 770 | | | | 1 | |
| cv67d2#1 (25%) | 11/16/96 | 2010 | 934 | | | | | |
| cv67d2#2 (25%) | 11/16/96 | 2101 | 818 | | | | 1 | |
| cv67d2#3 (25%) | 11/16/96 | 2149 | 532 | | | | 0.5 | |
| cv67d2#3 (25%) | 11/16/96 | 2149 | 608 | | | | 0.5 | |
| cv67d2#3 (25%) | 11/16/96 | 2149 | 706 | | | | | |
| cv67d2#3 (25%) | 11/16/96 | 2149 | 812 | | | | | |
| cv67d2#5 (25%) | 11/17/96 | 12 | 413 | | | | 1 | |
| cv67d2#5 (25%) | 11/17/96 | 12 | 496 | | | | 1 | |
| cv67d2#7 (25%) | 11/17/96 | 50 | 392 | | | | 1 | |
| cv67d2#7 (25%) | 11/17/96 | 50 | 409 | | | | 1 | |
| cv67d2#9 (25%) | 11/17/96 | 126 | 364 | | | | 1 | |
| cv67d2#9 (25%) | 11/17/96 | 126 | 374 | | | | 1 | |
| cv67d2#11 (25%) | 11/17/96 | 244 | 368 | | | | 1 | |
| cv67d2#11 (25%) | 11/17/96 | 244 | 375 | | | | 2 | |
| cv67d2#11 (25%) | 11/17/96 | 244 | 513 | | | | | |
| cv67d2#11 (25%) | 11/17/96 | 244 | 614 | | | | | |

| 1996-97station S3 SAMPLE ID (1) | Sample date | time | Initial Sample (ppt) | Notes (2) | Beginning Calibrator (3) | End Calibrator (3) | Multiplier Factor (4) | Event Mean Concentration Used |
|---|---|---|---|---|---|---|---|---|
| cv67d2#14 (25%) | 11/17/96 | 501 | 402 | | | | 1 | |
| cv67d2#16 (25%) | 11/17/96 | 550 | 274 | | | | 1 | |
| cv67d2#16 (25%) | 11/17/96 | 550 | 292 | | | | 1 | |
| cv67d2#18 (25%) | 11/17/96 | 601 | 216 | | | | 1 | |
| cv67d2#18 (25%) | 11/17/96 | 601 | 245 | | | | 1 | |
| cv67d2#20 | 11/17/96 | 611 | 332 | | | | 2 | |
| cv67d2#22 | 11/17/96 | 626 | 370 | | | | 2 | |
| **Discrete #2** | | | | | | | 406 | |
| cv67C2S3 (25%) | 11/17/96 | | 380 | | | | | |
| cv67C2S3 (25%) | 11/17/96 | | 473 | c1 | | | | |
| **Event 2 Composite** | | | | | | | 380 | 400 |
| cv67d2#1B | 11/17/96 | 1650 | 331 | | | | 1 | |
| cv67d2#2B | 11/17/96 | 2035 | 320 | | | | 1 | |
| cv67d2#3B | 11/19/96 | 1203 | 323 | | | | 0.5 | |
| cv67d2#3B | 11/19/96 | 1203 | 302 | | | | 0.5 | |
| cv67d2#4B (25%) | 11/22/96 | 517 | 414 | | | | 0.5 | |
| cv67d2#4B (25%) | 11/22/96 | 517 | 456 | | | | 0.5 | |
| cv67d2#5B (25%) | 11/22/96 | 546 | 529 | | | | 0.5 | |
| cv67d2#5B (25%) | 11/22/96 | 546 | 595 | | | | 0.5 | |
| cv67d2#6B (25%) | 11/22/96 | 557 | 204 | | | | 0.5 | |
| cv67d2#6B (25%) | 11/22/96 | 557 | 229 | | | | 0.5 | |
| cv67d2#7B (25%) | 11/22/96 | 613 | 336 | | | | 1 | |
| cv67d2#8B | 11/22/96 | 1215 | 271 | | | | | |
| cv67d2#8B (25%) | 11/22/96 | 1215 | 206 | | | | | |
| cv67d2#8B (25%) | 11/22/96 | 1215 | 234 | | | | 1 | |
| **Discrete Event 2A** | | | | | | | 344 | 340 |
| cv67d2gS3-1 | 11/15/96 | 1400 | 90 | | | | | |
| cv67d2gS3-1 | 11/15/96 | 1400 | 111 | | | | | |
| cv67d2gS3-2 | 11/16/96 | 1515 | 78 | | | | | |
| cv67d2gS3-2 | 11/16/96 | 1515 | 93 | | | | | |
| cv67d2gS3-3 (25%) | 11/16/96 | 1700 | 876 | | | | | |
| cv67d2gS3-4 | 11/22/96 | 1235 | 45 | | | | | |
| cv67d2gS3-5 | 11/25/96 | 1245 | 54 | | | | | |
| cv67d2gS3-6 | 12/2/96 | 1300 | 211 | | | | | |
| cv67d2#9B | 12/1/96 | 410 | 327 | | | | | |
| cv67d2#9B | 12/1/96 | 410 | 295 | | | | | |
| cv67d2#10B | 12/3/96 | 1848 | 380 | | | | | |
| cv67d2#10B | 12/3/96 | 1848 | 437 | r | | | | |

| 1996-97station S3 SAMPLE ID (1) | Sample date | time | Initial Sample (ppt) | Notes (2) | Beginning Calibrator (3) | End Calibrator (3) | Multiplier Factor (4) | Event Mean Concentration Used |
|---|---|---|---|---|---|---|---|---|
| cv67d3#1 | 12/4/96 | 2209 | 441 | r | | | | |
| cv67d3#1 (25%) | 12/4/96 | 2209 | 351 | | | | 3 | |
| cv67d3#5 (25%) | 12/5/96 | 4 | 305 | | | | 1 | |
| cv67d3#5 (25%) | 12/5/96 | 4 | 261 | | | | 1 | |
| cv67d3#7 (25%) | 12/5/96 | 109 | 292 | | | | 1 | |
| cv67d3#7 (25%) | 12/5/96 | 109 | 196 | sc | | | 1 | |
| cv67d3#9 (25%) | 12/5/96 | 231 | 217 | sc | | | 2 | |
| cv67d3#11 (25%) | 12/5/96 | 316 | 208 | | | | 3.5 | |
| cv67d3#15 (25%) | 12/5/96 | 420 | 362 | | | | 4 | |
| cv67d3#19 (25%) | 12/5/96 | 556 | 163 | | | | 3.5 | |
| cv67d3#22 (25%) | 12/5/96 | 750 | 228 | | | | 2 | |
| **Discrete #3** | | | | | | | **261** | **260** |
| cv67d3#1B | 12/6/96 | 2 | 252 | | | | | |
| cv67d3gS3-1 | 12/4/96 | 1340 | 228 | sc | | | | |
| cv67d3gS3-1 | 12/4/96 | 1340 | 75 | | | | | |
| cv67d3gS3-1 (25%) | 12/4/96 | 1340 | 83 | sc,d | | | | |
| cv67d3gS3-2 | 12/6/96 | 1440 | 153 | sc | | | | |
| cv67d3gS3-2 (25%) | 12/6/96 | 1440 | 117 | sc | | | | |
| cv67d4#2 (25%) | 12/6/96 | 15:44 | 249 | | 197 | | | |
| cv67d4#2 (25%) | 12/6/96 | 15:44 | 131 | | | 168 | | |
| cv67d4#3 (25%) | 12/9/96 | 8:25 | 213 | | 166 | | 2 | |
| cv67d4#3 (25%) | 12/9/96 | 8:25 | 134 | | | 171 | | |
| cv67d4#7 (25%) | 12/10/96 | 4:34 | 245 | | 193 | | | |
| cv67d4#7 (25%) | 12/10/96 | 4:34 | 136 | | | 174 | 4 | |
| cv67d4#11 (25%) | 12/10/96 | 6:02 | 165 | | 127 | | 3 | |
| cv67d4#15 (25%) | 12/10/96 | 7:04 | 172 | | 132 | | 2.5 | |
| cv67d4#15 (25%) | 12/10/96 | 7:04 | 141 | | | 179 | 2.5 | |
| cv67d4#19 (25%) | 12/10/96 | 8:39 | 121 | | 91 | | | |
| cv67d4#19 (25%) | 12/10/96 | 8:39 | 118 | | | 152 | 4 | |
| cv67d4#22 (25%) | 12/10/96 | 9:57 | 113 | | | 145 | 2 | |
| cv67d4#23 | 12/10/96 | 10:56 | 137 | | 114 | | 1 | |
| cv67d4#23 (25%) | 12/10/96 | 10:56 | 127 | | 96 | | | |
| cv67d4#23 (25%) | 12/10/96 | 10:56 | 161 | | | 204 | | |
| **Discrete #4** | | | | | | | **123** | **120** |
| cv67c4S3 (25%) | 12/10/96 | 8:05 | 167 | | | | | |
| **Event 4 Compostite (includes Dec 6 sample)** | | | | | | | **170** | |

| 1996-97station S3 SAMPLE ID (1) | Sample date | time | Initial Sample (ppt) | Notes (2) | Beginning Calibrator (3) | End Calibrator (3) | Multiplier Factor (4) | Event Mean Concentration Used |
|---|---|---|---|---|---|---|---|---|
| cv67c5S3 | 12/23/96 | | 380 | c1,sc-400,rc | | | | |
| cv67c5S3 (25%) | 12/23/96 | | 560 | c1,sc-400 | | | | |
| cv67c5S3 (25%) | 12/23/96 | | *488* | | | | | |
| **Event 5 composite** | | | | | | | | 490 |
| cv67c6S3-1 | 12/30/96 | | 100 | | | | | |
| cv67c6S3-1 (25%) | 12/30/96 | | 123 | | | | | |
| cv67c6S3-1 (25%) | 12/30/96 | | 106 | | | | | |
| cv67c6S3-1 | 12/30/96 | | 141 | | | | | |
| cv67c6S3-1 | 12/30/96 | | 149 | | | | | |
| **Event 6 Composite** | | | | | | | | 150 |
| cv67c6S3-2 | 12/31/96 | | 79 | | | | | |
| cv67c6S3-2 | 12/31/96 | | 155 | | | | | |
| cv67c6S3-2 (25%) | 12/31/96 | | 110 | | | | | |
| cv67c6S3-2 (25%) | 12/31/96 | | 114 | | | | | |
| cv67c6S3-3 | 1/1/97 | | 67 | | | | | |
| cv67c6S3-3 | 1/1/97 | | 110 | | | | | |
| cv67c6S3-3 | 1/1/97 | | 117 | | | | | |
| cv67c6S3-3 (25%) | 1/1/97 | | 97 | d | | | | |
| cv67c6S3-3 (25%) | 1/1/97 | | 98 | d | | | | |
| **Event 6A composite** | | | | | | | | 110 |
| cv67g6S3 | 1/2/97 | 13:45 | 60 | | | | | |
| cv67g6S3 | 1/2/97 | 13:45 | 68 | | | | | |
| cv67g6S3 (25%) | 1/2/97 | 13:45 | 47 | d | | | | |
| CV67C7 S3-1 (100%) | 1/23/97 | - | 157 | | | | | |
| CV67C7 S3-1 (25%) | 1/23/97 | | 115 | | | | | |
| **Event 7 Composite** | | | | | | | | 160 |
| CV67C7 S3-2 (100%) | 1/26/97 | | 88 | | | | | |
| **Event 7A Composite** | | | | | | | | 90 |

## Footnotes to Table B.2

| (1) Sample type codes: | | |
|---|---|---|
| | cv56dxx | discrete, flow-weighted sample |
| | cv56cxx | composited from discrete samples |
| | cv56gxx | grab sample |

| (2) Codes in "Notes": | | |
|---|---|---|
| | Estimate d | Peak flow was not sampled. Concentrations estimated from samples surrounding peak. |
| | d | below detection limit = 25 ppt |
| | r | above range of standard curve = 400 ppt (derived) |
| | rc | %BO beyond range for lowest of 400 calibrators |
| | e- | probably underestimates diazinon concentration |
| | e+ | probably overestimates diazinon concentration |
| | c1,c2,c3 | one or more calibrators exceed 15%CV between replicates |
| | sc | single set of calibrators in this run--no replicates |
| | cx | first set of calibrators from previous run, not on same strips |
| | cy | last set of calibrators from following run, not on same strips |
| | h18 | holding time = 18 days before this run, some diazinon has broken down |
| | ~time | time of sampling is approximate |

(3) Beginning/End Calibrator: Alternative values for ELISA results using single set of calibrators closest to each sample within the run, instead of average of both sets of calibrators

(4) Multiplier Factor: Concentrations of analyzed samples assigned to adjacent unanalyzed samples

Notes on interpretation of ELISA results:

1 15%CV = maximum suggested allowance for 2 replicate samples, equivalent to:-

| | |
|---|---|
| ppt | at 25 ppt |
| ppt | at 100 ppt |
| ppt | at 250 ppt |
| ppt | at 400 ppt |

When the difference between replicates is less than the above, either or both may be reasonable estimates.
Multiply these numbers by dilution factor for approx. range of variation in the concentration of original sample

2 Linear standard curve approximates actual absorbance curve, but tends to underestimate concentration at 25 and 400 ppt, and overestimate at 100 ppt. This bias may be 10-15% of the sample value, depending on run.
"e-" and "e+" notes are shown when the best estimate in bold face is proably biased as noted.
"rc" note indicates actual sample concentration is probably over 400 ppt

3 "d" or "r" values have been deleted unless no other value is available

## Table B.3 Hydrologic (Stream Flow) Parameters and Mean Diazinon Concentrations for Sampled Events at Station S3 in Castro Valley Creek During the 1996-1997 Storm Season.

| Event Number | Start Date | Start Time for Sampling | Sampling Duration (hr:min) | Flow Volume (cubic feet x 1,000) | Diazinon Event Mean Concen. (ng/l) | Flow Volume Previous 2 weeks (cf x 1,000) | Avg. Temp. Previous 30 Days (°F) (1) |
|---|---|---|---|---|---|---|---|
| 1 | 10/29/96 | 2:50 | 4:00 | 524 | 360 | 282 | 60.9 |
| 2 | 11/16/96 | 16:10 | 14:20 | 5,209 | 400 | 248 | 55.2 |
| 2A | 11/22/96 | 5:00 | 7:10 | 920 | 340 | 7,521 | 55.3 |
| 3 | 12/4/96 | 20:20 | 11:30 | 6,879 | 260 | 1,431 | 54.1 |
| 4 | 12/6/96 | 12:00 (2) | 27:40 (2) | 6,345 (3) | 120 | 9,152 | 54.3 |
| 5 | 12/21/96 | 1:30 (2) | 5:50 (2) | 10,920 (3) | 490 | 9,304 | 53.1 |
| 6 | 12/29/96 | 10:30 (2) | 20:45 (2) | 1,006 | 150 | 20,199 | 52.2 |
| 6A | 1/1/97 | 2:40 (2) | 13:50 (2) | 9,581 | 110 | 21,568 | 53.1 |
| 7 | 1/21/97 | 12:00 (2) | 21:50 (2) | 6,207 | 160 | 2540 | 49.7 |
| 7A | 1/21/97 | 12:00 (2) | 32:10 (2) | 9,977 | 90 | 11,437 | 49.9 |

Notes:

(1) Source: NOAA daily temperature data for Oakland Airport

(2) estimated starting time and duration of sampling for composited samples

(3) estimated from flow data at 10 minute intervals instead of 2 minutes

**Table B.4** Diazinon in Storm Runoff Samples Taken from Castro Valley During 1994-95 Storm Season

| SAMPLE ID | Sampling date | Sampling time | Diazinon (ppt) |
|---|---|---|---|
| cv45c1S3 | 11/5/94 | 1320 | 533 |
| cv45c2S3 | 11/25/94 | | 460 |
| cv45c3S3 | 1/3/95 | 1030 | 186 |
| cv45c4S3 | 1/8/95 | 2300 | 92 |
| cv45g1Bee | 2/28/95 | 1225 | 3260 |
| cv45g1Con | 2/28/95 | 1245 | 2499 |
| cv45g1Hey | 2/28/95 | 1300 | 1081 |
| cv45g1CVcrk-Knox | 2/28/95 | 1210 | 100 |
| cv45g1S3 | 2/28/95 | 1200 | 65 |
| cv45g2CVcrk-Knox | 3/9/95 | 1105 | 205 |
| cv45g2S3 | 3/9/95 | 1050 | 190 |
| cv45g3Con | 4/7/95 | 1230 | 556 |
| cv45g3Chabcrk-Knox | 4/7/95 | 1215 | 285 |
| cv45g3Hey | 4/7/95 | 1245 | 395 |
| cv45g3CVcrk-Knox | 4/7/95 | 1210 | 377 |
| cv45g3Seav | 4/7/95 | 1300 | 105 |
| cv45g3Grab1 | 4/7/95 | 1125 | <30 |
| cv45g3Grab2 | 4/7/95 | 1135 | 99 |
| cv45g3Grab3 | 4/7/95 | 1145 | 535 |
| cv45g3Grab4 | 4/7/95 | 1155 | 207 |
| cv45g3Grab5 | 4/7/95 | 1205 | 173 |
| cv45g3Grab6 | 4/7/95 | 1250 | 397 |
| cv45g4Con | 4/15/95 | 1420 | 272 |
| cv45g4CVBvd | 4/15/95 | 1520 | 292 |
| cv45g4Hey | 4/15/95 | 1510 | 1352 |
| cv45g4Seav | 4/15/95 | 1500 | 291 |
| cv45d1#1 | 4/15/95 | 1410 | 33 |
| cv45d1#2 | 4/15/95 | 1430 | <30 |
| cv45d1#3 | 4/15/95 | 1440 | <30 |
| cv45d1#4 | 4/15/95 | 1450 | 58 |
| cv45d1#5 | 4/15/95 | 1510 | 236 |
| cv45d1#6 | 4/15/95 | 1530 | 289 |
| cv45d1#7 | 4/15/95 | 1550 | 233 |
| cv45d1#8 | 4/15/95 | 1600 | 252 |
| cv45d1#9 | 4/15/95 | 1620 | 266 |
| cv45d1#10 | 4/15/95 | 1640 | 284 |
| cv45d1#11 | 4/15/95 | 1750 | 319 |

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Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, CA 94607-4014
Attn: Revital Katznelson

Sample Date: 12/10/96
Report Date: 12/27/96

Page 1 of 2

Sample I.D. No: 941202NC/C9943
S3
APPL Sample No: R24179-45962W

Date Received: 12/12/96
Date Extracted: 12/13/96

Method 8140 Results (OP Pesticides):

| Compound | Concentration µg/L | Quantitation Limit µg/L |
|---|---|---|
| Azinphosmethyl | ND* | 1.0 |
| Bolstar | ND | 0.10 |
| Chlorpyrifos | 0.03 J | 0.05 |
| Coumaphos | ND | 0.10 |
| Def | ND | 0.10 |
| Demeton-s | ND | 0.20 |
| Diazinon | 0.16 | 0.05 |
| Dichlorvos | ND | 0.20 |
| Dimethoate | ND | 0.10 |
| Disulfoton | ND | 0.10 |
| EPN | ND | 0.10 |
| EPTC | ND | 0.10 |
| Ethion | ND | 0.10 |
| Ethoprop | ND | 0.10 |
| Fensulfothion | ND | 0.50 |
| Fenthion | ND | 0.10 |
| Malathion | ND | 0.10 |
| Merphos | ND | 0.10 |
| Mevinphos | ND | 0.70 |
| Naled | ND | 0.50 |
| Parathion, ethyl | ND | 0.10 |
| Parathion, methyl | ND | 0.10 |
| Phorate | ND | 0.10 |
| Prowl | ND | 0.10 |
| Ronnel | ND | 0.10 |
| Stirophos | ND | 0.10 |
| Tokuthion | ND | 0.10 |
| Trichloronate | ND | 0.10 |
| Trifluralin | ND | 0.10 |
| **Non Target** | | |
| Prometon | 0.12 | 0.10 |
| Simazine | 0.69 | 0.50 |

J = Estimated value, below quantitation limit.
ND = None Detected

Tested By Paula Young

Checked By

Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, CA 94607-4014
Attn: Revital Katznelson

Sample Date: 12/10/96
Report Date: 12/27/96

Page 2 of 2

Sample I.D. No: 941202NC/C9943
S3
APPL Sample No: R24179-45962W

Date Received: 12/12/96
Date Extracted: 12/13/96

Method 8321 Results (Carbamates):

| Compound | Concentration µg/L | Quantitation Limit µg/L |
|---|---|---|
| Aminocarb | ND* | 0.4 |
| Aldicarb | ND | 0.4 |
| Barban | ND | 3.5 |
| Benomyl (Carbendazim) | ND | 0.4 |
| Bromacil | ND | 0.4 |
| Carbaryl | ND | 0.07 |
| Carbofuran | ND | 0.07 |
| Chloropropham | ND | 3.5 |
| Chloroxuron | ND | 0.4 |
| Diuron | 1.4 | 0.4 |
| Fenuron | ND | 0.4 |
| Fluometuron | ND | 0.4 |
| Linuron | ND | 0.4 |
| Methomyl | ND | 0.07 |
| Methiocarb | ND | 0.4 |
| Mexacarbate | ND | 3.5 |
| Monuron | ND | 0.4 |
| Neburon | ND | 0.4 |
| Oxamyl | ND | 0.4 |
| Propachlor | ND | 3.5 |
| Propham | ND | 3.5 |
| Propoxur | ND | 0.4 |
| Siduron | ND | 0.4 |
| Tebuthiuron | ND | 0.4 |

ND = None Detected

Tested By Brad Anderson

Checked By Jamie Cooper

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Attn: Revital Katznelson

Sample Date: NA
Report Date: 12/27/96

Page 1 of 4

Sample I.D. No: 941202NC/C9943
Blank for samples
taken 12/10/96
APPL Sample No: R24179-961213W

Date Received: NA

Date Extracted: 12/13/96

Method 8140 Results (OP Pesticides):

| Compound | Concentration µg/L | Quantitation Limit µg/L |
|---|---|---|
| Azinphosmethyl | ND* | 1.0 |
| Bolstar | ND | 0.10 |
| Chlorpyrifos | ND | 0.05 |
| Coumaphos | ND | 0.10 |
| Def | ND | 0.10 |
| Demeton-s | ND | 0.20 |
| Diazinon | ND | 0.05 |
| Dichlorvos | ND | 0.20 |
| Dimethoate | ND | 0.10 |
| Disulfoton | ND | 0.10 |
| EPN | ND | 0.10 |
| EPTC | ND | 0.10 |
| Ethion | ND | 0.10 |
| Ethoprop | ND | 0.10 |
| Fensulfothion | ND | 0.50 |
| Fenthion | ND | 0.10 |
| Malathion | ND | 0.10 |
| Merphos | ND | 0.10 |
| Mevinphos | ND | 0.70 |
| Naled | ND | 0.50 |
| Parathion, ethyl | ND | 0.10 |
| Parathion, methyl | ND | 0.10 |
| Phorate | ND | 0.10 |
| Prowl | ND | 0.10 |
| Ronnel | ND | 0.10 |
| Stirophos | ND | 0.10 |
| Tokuthion | ND | 0.10 |
| Trichloronate | ND | 0.10 |
| Trifluralin | ND | 0.10 |
| **Non Target** | | |
| Prometon | ND | 0.10 |
| Simazine | ND | 0.50 |

* ND = None Detected

Checked By Pamela Cooper

Woodward-Clyde Consultants
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Attn: Revital Katznelson

Sample Date: NA
Report Date: 12/27/96

Page 3 of 4

Sample I.D. No: 941202NC/C9943
Blank for samples
taken 12/10/96
APPL Sample No: R24179-961213W

Date Received: NA

Date Extracted: 12/13/96

Method 8321 Results (Carbamates):

| Compound | Concentration μg/L | Quantitation Limit μg/L |
|---|---|---|
| Aminocarb | ND* | 0.4 |
| Aldicarb | ND | 0.4 |
| Barban | ND | 3.5 |
| Benomyl (Carbendazim) | ND | 0.4 |
| Bromacil | ND | 0.4 |
| Carbaryl | ND | 0.07 |
| Carbofuran | ND | 0.07 |
| Chloropropham | ND | 3.5 |
| Chloroxuron | ND | 0.4 |
| Diuron | ND | 0.4 |
| Fenuron | ND | 0.4 |
| Fluometuron | ND | 0.4 |
| Linuron | ND | 0.4 |
| Methomyl | ND | 0.07 |
| Methiocarb | ND | 0.4 |
| Mexacarbate | ND | 3.5 |
| Monuron | ND | 0.4 |
| Neburon | ND | 0.4 |
| Oxamyl | ND | 0.4 |
| Propachlor | ND | 3.5 |
| Propham | ND | 3.5 |
| Propoxur | ND | 0.4 |
| Siduron | ND | 0.4 |
| Tebuthiuron | ND | 0.4 |

* ND = None Detected

Checked By Tamie Cooper

Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, CA 94607-4014
Attn: Revital Katznelson

Report Date: 12/27/96

Project ID No: 941202NC/C9943

APPL Spike ID: R24179 45962W 961213WA

Concentration Units: µg/L

SPIKES

| Method | Analysis | Date | Amt in Sample | Amt Spiked | Results | Percent Recovery | RPD |
|---|---|---|---|---|---|---|---|
| 8140 | Diazinon | 12/13/96 | 0.00 | 0.333 | 0.284 | 85.3 | 18 |
| 8140 | Ethion | 12/13/96 | 0.00 | 0.333 | 0.346 | 104 | 16 |

APPL Spike ID: R24179 45962W 961213WB

| Method | Analysis | Date | Amt in Sample | Amt Spiked | Results | Percent Recovery | RPD |
|---|---|---|---|---|---|---|---|
| 8140 | Diazinon | 12/13/96 | 0.00 | 0.333 | 0.237 | 71.2 | 18 |
| 8140 | Ethion | 12/13/96 | 0.00 | 0.333 | 0.294 | 88.3 | 16 |

Comments:

Checked By Jamie Cooper

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Attn: Revital Katznelson

Report Date: 12/27/96

Page 4 of 4

Project ID No: 941202NC/C9943

APPL Spike ID: R24179 45962W 961213WA

Concentration Units: µg/L

SPIKES

| Method | Analysis | Date | Amt in Sample | Amt Spiked | Results | Percent Recovery | RPD |
|---|---|---|---|---|---|---|---|
| 8321 | Methomyl | 12/13/96 | 0.00 | 0.267 | 0.197 | 73.9 | 1.01 |
| 8321 | Carbofuran | 12/13/96 | 0.00 | 0.267 | 0.204 | 76.5 | 6.18 |
| 8321 | Linuron | 12/13/96 | 0.00 | 0.533 | 0.439 | 82.3 | 0.46 |

APPL Spike ID: R24179 45962W 961213WB

| Method | Analysis | Date | Amt in Sample | Amt Spiked | Results | Percent Recovery | RPD |
|---|---|---|---|---|---|---|---|
| 8321 | Methomyl | 12/13/96 | 0.00 | 0.267 | 0.199 | 74.6 | 1.01 |
| 8321 | Carbofuran | 12/13/96 | 0.00 | 0.267 | 0.217 | 81.4 | 6.18 |
| 8321 | Linuron | 12/13/96 | 0.00 | 0.533 | 0.437 | 81.9 | 0.46 |

Comments:

Checked By

**Woodward-Clyde Consultants**
500 12th Street, Suite 100, Oakland, CA 94607-4014
(510) 893-3600

# Chain of Custody Record

Appl Lab

PROJECT NO. 941020NC/C9943

SAMPLERS: (Signature)

| DATE | TIME | SAMPLE NUMBER | Sample Matrix (S)oil, (W)ater, (A)ir | EPA Method | EPA Method 8140 | EPA Method 8321 | EPA Method | | | | | | | | Number of Containers | REMARKS (Sample preservation, handling procedures, etc.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12-10 | 11:00 | S3 | W | | X | X | | | | | | | | | 3 | OPs and Carbamates at the lowest DL available<br>Please send invoice and report to R. Katznelson, WCC (address above) (510) 874 3048 |

TOTAL NUMBER OF CONTAINERS 3

| | | | | | |
|---|---|---|---|---|---|
| RELINQUISHED BY: (Signature) | DATE/TIME 12-10-96 11:00 | RECEIVED BY: (Signature) Fed Express | RELINQUISHED BY: (Signature) Fed Express | DATE/TIME | RECEIVED BY: (Signature) |
| METHOD OF SHIPMENT: | | SHIPPED BY: (Signature) | COURIER: (Signature) | RECEIVED FOR LAB BY: (Signature) | DATE/TIME 12/11/96 10:15 |

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500 12th Street, Suite 100
Oakland, CA 94607-4014
Attn: R. Katznelson

Sample Date: 10/29/96
Report Date: 11/19/96

Page 1 of 3

Sample ID No : 941020NA/C9943
CV67C153
APPL Sample No: R23944-44765

Date Received: 10/31/96
Date Extracted: 11/01/96

Results of OCl Pesticides Water Analysis by EPA Method 8080

| Compound | Units | Concentration | Quantitation Limit |
|---|---|---|---|
| Aldrin | µg/L | 0.014 J | 0.025 |
| a-BHC | µg/L | ND | 0.025 |
| b-BHC | µg/L | ND | 0.025 |
| d-BHC | µg/L | 0.011 J | 0.025 |
| g-BHC (Lindane) | µg/L | ND | 0.025 |
| Chlordane | µg/L | 0.017 J | 0.025 |
| Dieldrin | µg/L | ND | 0.025 |
| Endosulfan I | µg/L | ND | 0.025 |
| Endosulfan II | µg/L | ND | 0.025 |
| Endosulfan sulfate | µg/L | ND | 0.025 |
| Endrin | µg/L | ND | 0.025 |
| Endrin aldehyde | µg/L | ND | 0.025 |
| Endrin ketone | µg/L | ND | 0.025 |
| Heptachlor | µg/L | ND | 0.025 |
| Heptachlor epoxide | µg/L | ND | 0.025 |
| 4,4'-DDE | µg/L | 0.022 J | 0.025 |
| 4,4'-DDT | µg/L | 0.032 | 0.025 |
| 4,4'-TDE/DDD | µg/L | 0.014 J | 0.025 |
| Methoxychlor | µg/L | ND | 0.025 |
| Toxaphene | µg/L | ND | 1.00 |

AMENDED

J = Estimated value below quantitation limit
ND = None Detected

Tested by: Paula Young

Checked by:

Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, CA 94607-4014
Attn: R. Katznelson

Sample Date: 10/29/96
Report Date: 11/19/96

Page 2 of 3

Sample ID No : 941020NA/C9943
CV67C153
APPL Sample No: R23944-44765

Date Received: 10/31/96
Date Extracted: 11/01/96

Results of OP Pesticides Water Analysis by EPA Method 8140

| Compound | Units | Concentration | Quantitation Limit |
|---|---|---|---|
| Azinphosmethyl | µg/L | ND | 1.0 |
| Bolstar | µg/L | ND | 0.10 |
| Chlorpyrifos | µg/L | 0.13 | 0.05 |
| Coumaphos | µg/L | ND | 0.20 |
| Def | µg/L | ND | 0.10 |
| Demeton-s | µg/L | ND | 0.20 |
| Diazinon | µg/L | 0.45 | 0.05 |
| Dichlorvos | µg/L | ND | 0.20 |
| Dimethoate | µg/L | ND | 0.10 |
| Disulfoton | µg/L | ND | 0.10 |
| EPN | µg/L | ND | 0.10 |
| Ethion | µg/L | ND | 0.10 |
| Ethoprop | µg/L | ND | 0.10 |
| Fensulfothion | µg/L | ND | 0.50 |
| Fenthion | µg/L | ND | 0.10 |
| Malathion | µg/L | 0.11 | 0.10 |
| Merphos | µg/L | ND | 0.10 |
| Mevinphos | µg/L | ND | 0.70 |
| Naled | µg/L | ND | 0.50 |
| Parathion, ethyl | µg/L | ND | 0.10 |
| Parathion, methyl | µg/L | ND | 0.10 |
| Phorate | µg/L | ND | 0.10 |
| Prowl | µg/L | ND | 0.10 |
| Ronnel | µg/L | ND | 0.10 |
| Stirophos | µg/L | ND | 0.10 |
| Tokuthion | µg/L | ND | 0.10 |
| Trichloronate | µg/L | ND | 0.10 |
| Trifluralin | µg/L | ND | 0.10 |

ND = None Detected

Tested by: Paula Young

Checked by: Mike Day

Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, CA 94607-4014
Attn: R. Katznelson

Sample Date: 10/29/96
Report Date: 11/19/96

Page 3 of 3

Sample ID No : 941020NA/C9943
CV67C153
APPL Sample No: R23944-44765

Date Received: 10/31/96
Date Extracted: 11/05/96

Results of Water Analysis by EPA Method 8321

| Compound | Units | Concentration | Quantitation Limit |
|---|---|---|---|
| Aminocarb | µg/L | ND | 0.4 |
| Aldicarb | µg/L | ND | 0.4 |
| Barban | µg/L | ND | 3.5 |
| Benomyl (Carbendazim) | µg/L | ND | 0.4 |
| Bromacil | µg/L | ND | 0.4 |
| Carbaryl | µg/L | 0.09 | 0.07 |
| Carbofuran | µg/L | ND | 0.07 |
| Chloropropham | µg/L | ND | 3.5 |
| Chloroxuron | µg/L | ND | 0.4 |
| Diuron | µg/L | 1.0 | 0.4 |
| Fenuron | µg/L | ND | 0.4 |
| Fluometuron | µg/L | ND | 0.4 |
| Linuron | µg/L | ND | 1 |
| Methomyl | µg/L | ND | 0.07 |
| Methiocarb | µg/L | ND | 0.4 |
| Mexacarbate | µg/L | ND | 3.5 |
| Monuron | µg/L | ND | 0.4 |
| Neburon | µg/L | ND | 0.4 |
| Oxamyl | µg/L | ND | 0.4 |
| Propachlor | µg/L | ND | 3.5 |
| Propham | µg/L | ND | 3.5 |
| Propoxur | µg/L | ND | 0.4 |
| Siduron | µg/L | ND | 0.4 |
| Tebuthiuron | µg/L | ND | 0.4 |

ND = None Detected

Tested by: Brad Anderson

Checked by: Mike Ray

Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, CA 94607-4014
Attn: R. Katznelson

Sample Date: NA
Report Date: 11/19/96

Sample I.D. No: **BLANK** *Associated with sample group: R23944*
APPL Sample No: R23944-961111W BLK

Date Received: NA
Date Extracted: 11/01/96

Results of OCl Pesticides Water Analysis by EPA Method 8080

| Compound | Units | Concentration | Quantitation Limit |
|---|---|---|---|
| Aldrin | µg/L | ND | 0.01 |
| a-BHC | µg/L | ND | 0.01 |
| b-BHC | µg/L | ND | 0.01 |
| d-BHC | µg/L | ND | 0.01 |
| g-BHC (Lindane) | µg/L | ND | 0.01 |
| Chlordane | µg/L | ND | 0.01 |
| Dieldrin | µg/L | ND | 0.01 |
| Endosulfan I | µg/L | ND | 0.01 |
| Endosulfan II | µg/L | ND | 0.01 |
| Endosulfan sulfate | µg/L | ND | 0.01 |
| Endrin | µg/L | ND | 0.01 |
| Endrin aldehyde | µg/L | ND | 0.01 |
| Endrin ketone | µg/L | ND | 0.01 |
| Heptachlor | µg/L | ND | 0.01 |
| Heptachlor epoxide | µg/L | ND | 0.01 |
| 4,4'-DDE | µg/L | ND | 0.01 |
| 4,4'-DDT | µg/L | ND | 0.01 |
| 4,4'-TDE/DDD | µg/L | ND | 0.01 |
| Methoxychlor | µg/L | ND | 0.01 |
| Toxaphene | µg/L | ND | 0.20 |

AMENDED

ND = None Detected

Checked by: Pamela Cooper

appl
AGRICULTURE & PRIORITY POLLUTANTS LABORATORIES, INC.
4203 West Swift ▼ Fresno, California 93722 ▼ Phone 209.275-2175 ▼ Fax 209.275-4422

Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, CA 94607-4014
Attn: R. Katznelson

Sample Date: NA
Report Date: 11/18/96

Sample I.D. No: **BLANK** *Associated with sample group: R23944*
APPL Sample No: R23944-961101W BLK

Date Received: NA
Date Extracted: 11/01/96

Results of OP Pesticides Water Analysis by EPA Method 8140

| Compound | Units | Concentration | Quantitation Limit |
|---|---|---|---|
| Azinphosmethyl | µg/L | ND | 1.0 |
| Bolstar | µg/L | ND | 0.10 |
| Chlorpyrifos | µg/L | ND | 0.05 |
| Coumaphos | µg/L | ND | 0.10 |
| Def | µg/L | ND | 0.10 |
| Demeton-s | µg/L | ND | 0.20 |
| Diazinon | µg/L | ND | 0.05 |
| Dichlorvos | µg/L | ND | 0.20 |
| Dimethoate | µg/L | ND | 0.10 |
| Diphenamid | µg/L | ND | 0.10 |
| Disulfoton | µg/L | ND | 0.10 |
| Ethion | µg/L | ND | 0.10 |
| Ethoprop | µg/L | ND | 0.10 |
| Fensulfothion | µg/L | ND | 0.20 |
| Fenthion | µg/L | ND | 0.10 |
| Malathion | µg/L | ND | 0.40 |
| Merphos | µg/L | ND | 0.10 |
| Methyl trithion | µg/L | ND | 0.20 |
| Mevinphos | µg/L | ND | 0.70 |
| Naled | µg/L | ND | 0.50 |
| Parathion, ethyl | µg/L | ND | 0.10 |
| Parathion, methyl | µg/L | ND | 0.10 |
| Phorate | µg/L | ND | 0.10 |
| Phosalone | µg/L | ND | 0.10 |
| Prometon | µg/L | ND | 0.10 |
| Prowl | µg/L | ND | 0.10 |
| Ronnel | µg/L | ND | 0.10 |
| Simazine | µg/L | ND | 0.50 |
| Trichloronate | µg/L | ND | 0.10 |
| Trifluralin | µg/L | ND | 0.10 |

ND = None Detected

Checked by: Pamela Cooper

appl
AGRICULTURE & PRIORITY POLLUTANTS LABORATORIES, INC.

4203 West Swift ▼ Fresno, California 93722 ▼ Phone 209.275-2175 ▼ Fax 209.275-4422

Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, CA 94607-4014
Attn: R. Katznelson

Sample Date: NA
Report Date: 11/19/96

Sample I.D. No: **BLANK** *Associated with sample group: R23944*
APPL Sample No: R23944-961105W BLK1

Date Received: NA
Date Extracted: 11/05/96

Results of Water Analysis by EPA Method 8321

| Compound | Units | Concentration | Quantitation Limit |
|---|---|---|---|
| Aminocarb | µg/L | ND | 0.4 |
| Aldicarb | µg/L | ND | 0.4 |
| Barban | µg/L | ND | 3.5 |
| Benomyl (Carbendazim) | µg/L | ND | 0.4 |
| Bromacil | µg/L | ND | 0.4 |
| Carbaryl | µg/L | ND | 0.07 |
| Carbofuran | µg/L | ND | 0.07 |
| Chloropropham | µg/L | ND | 3.5 |
| Chloroxuron | µg/L | ND | 0.4 |
| Diuron | µg/L | ND | 0.4 |
| Fenuron | µg/L | ND | 0.4 |
| Fluometuron | µg/L | ND | 0.4 |
| Linuron | µg/L | ND | 0.07 |
| Methomyl | µg/L | ND | 0.07 |
| Methiocarb | µg/L | ND | 0.4 |
| Mexacarbate | µg/L | ND | 3.5 |
| Monuron | µg/L | ND | 0.4 |
| Neburon | µg/L | ND | 0.4 |
| Oxamyl | µg/L | ND | 0.4 |
| Propachlor | µg/L | ND | 0.4 |
| Propham | µg/L | ND | 3.5 |
| Propoxur | µg/L | ND | 3.5 |
| Siduron | µg/L | ND | 0.4 |
| Tebuthiuron | µg/L | ND | 0.4 |

ND = None Detected

Checked by: James Cooper

**APPL Sample:** 44765W

**Spike Report:** MS / MSD

| Method | Extraction Date | Analysis Date |
|---|---|---|
| 8080 | 11/1/96 | 11/18/96 |

| Analyte | CAS Number | Units | Amount in Sample | Amount Added | Recovery MS | Recovery MSD | Percent MS | FLAG | Percent MSD | FLAG | RPD | FLAG | Recovery Limit | RPD Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aldrin | 309-00-2 | µg/L | 0.0181 | 0.0267 | 0.0283 | 0.0266 | 38.2% | | 31.8% | | 6.2% | | 30-99 | 31 |
| 4,4'-DDT | 50-29-3 | µg/L | ND | 0.0667 | 0.0581 | 0.0538 | 87.1% | | 80.7% | | 7.7% | | 47-118 | 18 |
| Dieldrin | 60-57-1 | µg/L | ND | 0.0667 | 0.0433 | 0.0423 | 64.9% | | 63.4% | | 2.3% | | 45-122 | 14 |
| Endrin | 72-20-8 | µg/L | ND | 0.0667 | 0.0585 | 0.0490 | 87.7% | | 73.5% | | 18% | | 61-133 | 19 |
| Heptachlor | 76-44-8 | µg/L | 0.0556 | 0.0267 | 0.0656 | 0.0673 | 37.5% | | 43.8% | | 2.6% | | 28-125 | 26 |
| Lindane | 58-89-9 | µg/L | ND | 0.0267 | 0.0180 | 0.0192 | 67.4% | | 71.9% | | 6.5% | | 49-132 | 16 |

ABBREVIATIONS & FLAGS

ND None Detected

NA Not Applicable

NE Not Established

◆ Recovery is outside of the acceptable percentage range

**APPL Sample:** 44765W

**Spike Report:** MS / MSD

| Method | Extraction Date | Analysis Date |
|---|---|---|
| 8140 | 11/1/96 | 11/7/96 |

| Analyte | CAS Number | Units | Amount in Sample | Amount Added | Recovery MS | Recovery MSD | Percent MS | FLAG | Percent MSD | FLAG | RPD | FLAG | Recovery Limit | RPD Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Disulfoton | 298-04-4 | µg/L | ND | 0.333 | 0.245 | 0.259 | 73.6% | | 77.8% | | 5.6% | | 47-117 | 22 |
| Ethion | 563-12-2 | µg/L | ND | 0.333 | 0.319 | 0.312 | 95.8% | | 93.7% | | 2.2% | | 65-134 | 20 |
| Parathion, methyl | 298-00-0 | µg/L | ND | 0.333 | 0.249 | 0.261 | 74.8% | | 78.4% | | 4.7% | | 55-164 | 24 |
| Phorate | 298-02-2 | µg/L | ND | 0.333 | 0.151 | 0.153 | 45.3% | | 45.9% | | 1.3% | | 22-96 | 24 |
| Stirophos | 22248-79-9 | µg/L | ND | 0.333 | 0.289 | 0.261 | 86.8% | | 78.4% | | 10% | | 68-128 | 25 |

ABBREVIATIONS & FLAGS

| | |
|---|---|
| ND None Detected | NE Not Established |
| NA Not Applicable | ◆ Recovery is outside of the acceptable percentage range |

**APPL Sample:** 961105W

**Spike Report:** LCS

| Method | Extraction Date | Analysis Date |
|---|---|---|
| 8321 | 11/5/96 | 11/5/96 |

| Analyte | CAS Number | Units | Amount in Sample | Amount Added | Recovery LCS | Percent LCS | FLAG | Recovery Limit |
|---|---|---|---|---|---|---|---|---|
| Carbaryl | 63-25-2 | µg/L | ND | 0.267 | 0.257 | 96.3% | | 40-131 |
| Carbofuran | 1563-66-2 | µg/L | ND | 0.267 | 0.218 | 81.6% | | 44-128 |
| Methomyl | 16752-77-5 | µg/L | ND | 0.267 | 0.223 | 83.5% | | 37-113 |

ABBREVIATIONS & FLAGS

| | | | |
|---|---|---|---|
| ND | None Detected | NE | Not Established |
| NA | Not Applicable | ◆ | Recovery is outside of the acceptable percentage range |

**APPL Sample:** 44756W

**Spike Report:** MS / MSD

| Method | Extraction Date | Analysis Date |
|---|---|---|
| 8321 | 11/5/96 | 11/5/96 |

| Analyte | CAS Number | Units | Amount in Sample | Amount Added | Recovery MS | Recovery MSD | Percent MS | FLAG | Percent MSD | FLAG | RPD | FLAG | Recovery Limit | RPD Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carbaryl | 63-25-2 | µg/L | ND | 0.267 | 0.245 | 0.215 | 91.8% | | 80.5% | | 13% | | 40-131 | 30 |
| Carbofuran | 1563-66-2 | µg/L | ND | 0.267 | 0.141 | 0.090 | 52.8% | | 33.7% | ◆ | 44% | ◆ | 44-128 | 30 |
| Methomyl | 16752-77-5 | µg/L | ND | 0.267 | 0.267 | 0.221 | 100% | | 82.8% | | 19% | | 37-113 | 30 |

ABBREVIATIONS & FLAGS

| | | | |
|---|---|---|---|
| ND | None Detected | NE | Not Established |
| NA | Not Applicable | ◆ | Recovery is outside of the acceptable percentage range |

**Woodward-Clyde Consultants**
500 12th Street, Suite 100, Oakland, CA 94607-4014
(510) 893-3600

# Chain of Custody Record

App Lab

PROJECT NO. 94 1020NA /C9943

SAMPLERS: (Signature) A Feng (FOR JIM SCANLIN)

| DATE | TIME | SAMPLE NUMBER | Sample Matrix (S)oil, (W)ater, (A)ir | ANALYSES<br>EPA Method 8080 | EPA Method 8140 | EPA Method 8321 | EPA Method | Number of Containers | REMARKS (Sample preservation, handling procedures, etc.) |
|---|---|---|---|---|---|---|---|---|---|
| 10/29 | composite | CY67C153 | water | X | X | X | | 4 | OCs, OPs and Carbamates at the lowest DL available |
| | | | | | | | | | Please send invoice and report to R. Katznelson, WCC (address above) (510) 874 3048 |
| | | | | | | | | TOTAL NUMBER OF CONTAINERS | |

| | | | | | |
|---|---|---|---|---|---|
| RELINQUISHED BY (Signature)<br>Arleen Feng | DATE/TIME<br>10/30/96 | RECEIVED BY : (Signature)<br>Fed Express | RELINQUISHED BY : (Signature)<br>Fed Express | DATE/TIME | RECEIVED BY (Signature) |
| METHOD OF SHIPMENT :<br>FED EX | | SHIPPED BY : (Signature) | COURIER : (Signature) | RECEIVED FOR LAB BY : (Signature) | DATE TIME<br>10/31/96 10:15 |

Chilled & intact

## Appendix C. Estimation of Number of Sources in Castro Valley Watershed

A basic assumption used for estimation of the number of sources was that each street gutter sample with a diazinon concentration elevated above an arbitrary threshold level represented an individual diazinon source. It was further assumed that only one property within the area drained by a street gutter sample was responsible for the elevated concentration. If a threshold level of 400-500 ng/l was selected, only 8 of the 45 samples contained sources; if the threshold was 100 ng/l. then 17 samples contained sources (Table C.1). These figures were used to bracket the minimum and maximum ranges of the estimate.

Taking an average estimate of 10 properties per street gutter sample, 450 properties were represented in the total area sampled. This estimate was verified by a rough visual estimation of the proportion of Subcatchments 2 and 3 that was covered by the street gutter sampling (Figure C.1), combined with census figures for the number of households in these subcatchments (Table C.2). The 8 to 17 assumed sources then represented between two and four percent of the properties in the sampled area. Since most of the properties in Subcatchments 2 and 3 were single-family homes ("residential" in Table 3.2.1), this was roughly equivalent to 2-4 percent of households.

Application of these percentages to the 14,800 residential units in the entire watershed results in an estimate of 300-600 sources of diazinon in the watershed. About one-fourth of the residential units represent multiple-family dwellings (which are lumped under "commercial" land use in Table 3.2.1) than the sampled area. Patterns of diazinon use and application may be somewhat different for households living in multiple unit dwellings, and it is possible that on an area basis these areas contribute more diazinon to runoff (See Section 3.2). However, it was assumed here that the percentage of these households associated with diazinon in runoff would be the same as for single-family residential areas.

## Table C.1 Diazinon in Street Gutters in Castro Valley on May 15, 1996

| Site | Sample time | Diazinon (ng/l) | Assumed No. of Sources Per Sample Maximum (100 ng/l) | Minimum (500 ng/l) |
|---|---|---|---|---|
| 28 | 14:21 | 79,000 | 1 | 1 |
| 19 | 13:54 | 71,000 | 1 | 1 |
| 10 | 13:27 | 4,100 | 1 | 1 |
| 36 | 14:45 | 3,700 | 1 | 1 |
| 29 | 14:24 | 2,700 | 1 | 1 |
| 21 | 14:00 | 2,400 | 1 | 1 |
| 42 | 15:03 | 1,500 | 1 | 1 |
| 7 | 13:18 | 1,400 | 1 | 1 |
| 2 | 13:03 | 400 | 1 | |
| 3 | 13:06 | 400 | 1 | |
| 43 | 15:06 | 400 | 1 | |
| 12 | 13:33 | 310 | 1 | |
| 18 | 13:51 | 260 | 1 | |
| 24 | 14:09 | 180 | 1 | |
| 27 | 14:18 | 130 | 1 | |
| 13 | 13:36 | 120 | 1 | |
| 45 | 15:12 | 110 | 1 | |
| 6 | 13:15 | 80 | | |
| 30 | 14:27 | 80 | | |
| 1 | 13:00 | 80 | | |
| 4 | 13:09 | 80 | | |
| 25 | 14:12 | 80 | | |
| 31 | 14:30 | 80 | | |
| 35 | 14:42 | 70 | | |
| 39 | 14:54 | 60 | | |
| 32 | 14:33 | 60 | | |
| 34 | 14:39 | 60 | | |
| 20 | 13:57 | 50 | | |
| 22 | 14:03 | 40 | | |
| 23 | 14:06 | 40 | | |
| 26 | 14:15 | 40 | | |
| 33 | 14:36 | 40 | | |
| 38 | 14:51 | 40 | | |
| 41 | 15:00 | 30 | | |
| 5 | 13:12 | 30 | | |
| 8 | 13:21 | 30 | | |
| 15 | 13:42 | 30 | | |
| 37 | 14:48 | 30 | | |
| 40 | 14:57 | 30 | | |
| 44 | 15:09 | 30 | | |
| 9 | 13:24 | ND | | |
| 11 | 13:30 | ND | | |
| 14 | 13:39 | ND | | |
| 17 | 13:48 | ND | | |
| 16 | 13:45 | ND | | |
| Totals | | | 17 | 8 |

Table C.2 Separate estimate of number of households in sampled area

| | Maximum | | | Minimum | | |
|---|---|---|---|---|---|---|
| | Zone | | | Zone | | |
| (Approximated by census tracts) | 2 | 3 | Total | 2 | 3 | Total |
| % of subcatchment area sampled (Figure C.1) | .15 | 10 | | 10 | 5 | |
| Households per subcatchment | 2600 | 4380 | 6980 | 2600 | 4380 | 6980 |
| Households in sampled area | 390 | 438 | **828** | 260 | 219 | **479** |

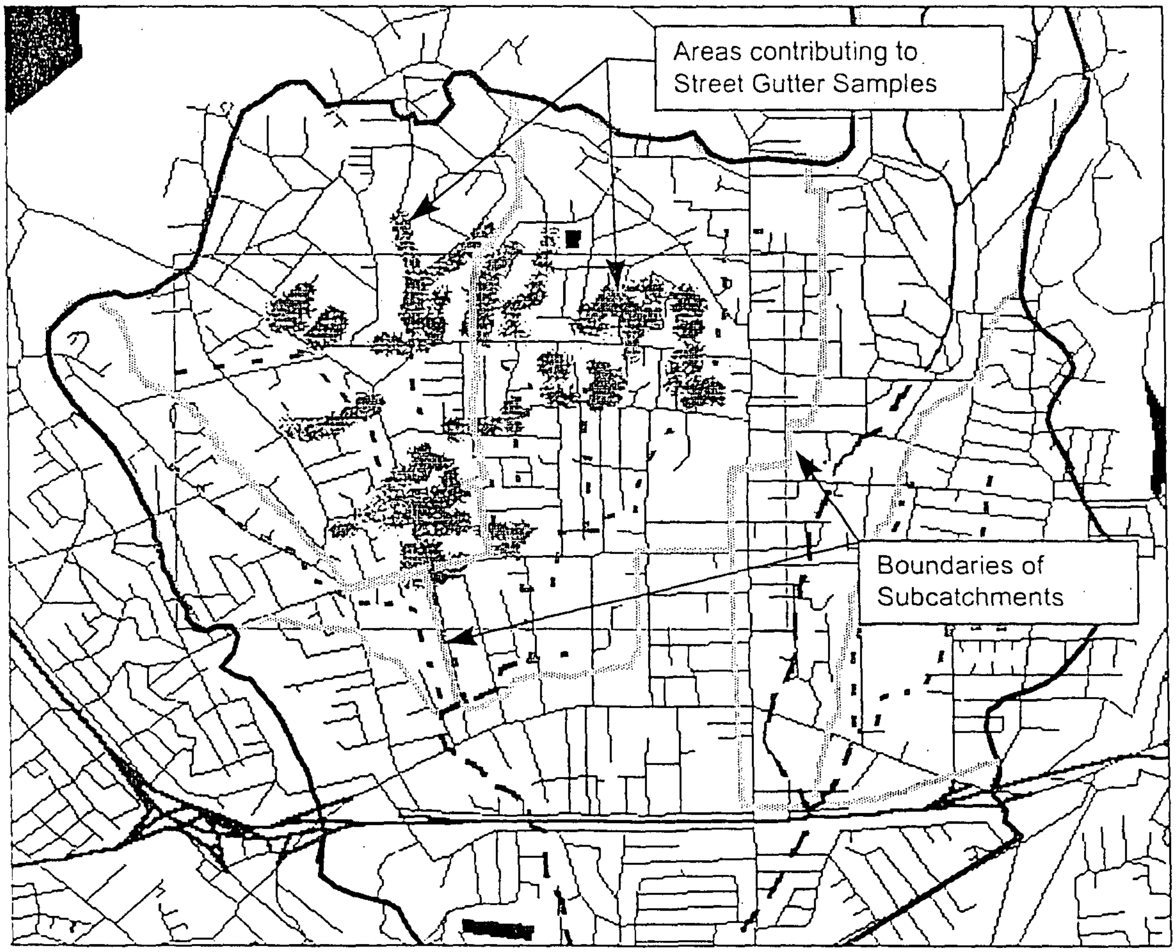

Figure C.1 Estimated Area Drained by Street Gutters Sampled in Castro Valley on May 15, 1996

## Appendix D. Runoff Study Sampling Locations

| Site | Sampling Location | Description of Sampling Location |
|---|---|---|
| Oakland | Roof Drain | Downspout from roof gutter |
| Oakland | Drain + Patio | Runoff from roof downspout after running across 6 ft (1.8m) of patio |
| Oakland | Driveway | Puddle at bottom of 40 ft. (12m) long driveway |
| Oakland | Patio | Puddle on paved patio |
| Castro Valley 1 | Patio | Puddle on paved patio |
| Castro Valley 1 | Driveway | Runoff from base of 20 ft. (6m) long driveway |
| Castro Valley 1 | Roof Drain | Downspout from roof gutter |
| Castro Valley 2 | Patio | Puddle on paved patio |
| Castro Valley 2 | Driveway | Puddle at bottom of 20 ft. (6m) long driveway |
| Castro Valley 2 | Roof Drain | Downspout from roof gutter |

## Appendix E . 1995-1997 Castro Valley Rainfall Data

Rainfall Data from Gauge at Arcadian Reservoir (Castro Valley) for 1995-97 Storm Season

Rainfall Data from Gauge at Arcadian Reservoir (Castro Valley) for 1996-97 Storm Season

Rainfall Data from Gauge in Backyard near Redwood Road and SR 13 ("Andreasgage", Oakland) from 2/3/97 to 4/24/97

Rain Gauge Location: Arcadian Reservoir, Castro Valley

| MONTH | DAY | YEAR | HOUR | INCHES | MONTHLY TOTAL |
|---|---|---|---|---|---|
| 11 | 1 | 95 | 3 | 0.04 | |
| | | | | | 0.04 |
| 12 | 1 | 95 | 18 | 0.04 | |
| 12 | 1 | 95 | 19 | 0.04 | |
| 12 | 3 | 95 | 20 | 0.04 | |
| 12 | 3 | 95 | 24 | 0.04 | |
| 12 | 4 | 95 | 2 | 0.04 | |
| 12 | 4 | 95 | 3 | 0.07 | |
| 12 | 4 | 95 | 5 | 0.04 | |
| 12 | 4 | 95 | 7 | 0.04 | |
| 12 | 4 | 95 | 8 | 0.04 | |
| 12 | 4 | 95 | 10 | 0.04 | |
| 12 | 4 | 95 | 12 | 0.04 | |
| 12 | 7 | 95 | 3 | 0.04 | |
| 12 | 9 | 95 | 7 | 0.04 | |
| 12 | 10 | 95 | 18 | 0.04 | |
| 12 | 10 | 95 | 24 | 0.04 | |
| 12 | 11 | 95 | 3 | 0.31 | |
| 12 | 11 | 95 | 4 | 0.20 | |
| 12 | 11 | 95 | 5 | 0.12 | |
| 12 | 11 | 95 | 6 | 0.12 | |
| 12 | 11 | 95 | 7 | 0.04 | |
| 12 | 11 | 95 | 8 | 0.19 | |
| 12 | 11 | 95 | 9 | 0.28 | |
| 12 | 11 | 95 | 10 | 0.24 | |
| 12 | 11 | 95 | 11 | 0.07 | |
| 12 | 11 | 95 | 12 | 0.04 | |
| 12 | 11 | 95 | 15 | 0.04 | |
| 12 | 11 | 95 | 16 | 0.04 | |
| 12 | 11 | 95 | 17 | 0.08 | |
| 12 | 11 | 95 | 19 | 0.20 | |
| 12 | 11 | 95 | 20 | 0.27 | |
| 12 | 11 | 95 | 21 | 0.24 | |
| 12 | 11 | 95 | 22 | 0.24 | |
| 12 | 11 | 95 | 23 | 0.07 | |
| 12 | 12 | 95 | 5 | 0.04 | |
| 12 | 12 | 95 | 6 | 0.04 | |
| 12 | 12 | 95 | 7 | 0.32 | |
| 12 | 12 | 95 | 8 | 0.27 | |
| 12 | 12 | 95 | 11 | 0.04 | |
| 12 | 12 | 95 | 12 | 0.04 | |
| 12 | 13 | 95 | 9 | 0.04 | |
| 12 | 13 | 95 | 14 | 0.24 | |
| 12 | 13 | 95 | 16 | 0.16 | |
| 12 | 15 | 95 | 4 | 0.07 | |
| 12 | 15 | 95 | 5 | 0.20 | |
| 12 | 15 | 95 | 7 | 0.16 | |
| 12 | 15 | 95 | 8 | 0.16 | |
| 12 | 15 | 95 | 9 | 0.04 | |
| 12 | 18 | 95 | 7 | 0.03 | |
| 12 | 18 | 95 | 10 | 0.04 | |
| 12 | 18 | 95 | 11 | 0.04 | |
| 12 | 18 | 95 | 12 | 0.04 | |
| 12 | 18 | 95 | 13 | 0.08 | |
| 12 | 18 | 95 | 14 | 0.04 | |
| 12 | 22 | 95 | 6 | 0.08 | |
| 12 | 22 | 95 | 7 | 0.16 | |
| 12 | 22 | 95 | 8 | 0.08 | |
| 12 | 22 | 95 | 9 | 0.04 | |
| 12 | 27 | 95 | 18 | 0.03 | |
| 12 | 29 | 95 | 12 | 0.12 | |
| 12 | 29 | 95 | 13 | 0.12 | |
| 12 | 29 | 95 | 14 | 0.04 | |
| 12 | 29 | 95 | 15 | 0.12 | |
| 12 | 29 | 95 | 16 | 0.12 | |
| 12 | 29 | 95 | 17 | 0.08 | |
| 12 | 29 | 95 | 18 | 0.07 | |
| 12 | 29 | 95 | 19 | 0.04 | |
| 12 | 30 | 95 | 2 | 0.04 | |
| | | | | | 6.65 |
| 1 | 15 | 96 | 23 | 0.04 | |
| 1 | 15 | 96 | 24 | 0.04 | |
| 1 | 16 | 96 | 5 | 0.04 | |
| 1 | 16 | 96 | 6 | 0.20 | |
| 1 | 16 | 96 | 7 | 0.43 | |
| 1 | 16 | 96 | 8 | 0.47 | |
| 1 | 16 | 96 | 9 | 0.40 | |
| 1 | 16 | 96 | 10 | 0.12 | |
| 1 | 16 | 96 | 11 | 0.03 | |
| 1 | 16 | 96 | 14 | 0.08 | |
| 1 | 18 | 96 | 14 | 0.16 | |
| 1 | 18 | 96 | 15 | 0.24 | |
| 1 | 18 | 96 | 16 | 0.15 | |
| 1 | 18 | 96 | 17 | 0.04 | |
| 1 | 18 | 96 | 21 | 0.04 | |
| 1 | 19 | 96 | 1 | 0.04 | |
| 1 | 19 | 96 | 2 | 0.04 | |
| 1 | 19 | 96 | 3 | 0.04 | |
| 1 | 19 | 96 | 5 | 0.04 | |
| 1 | 19 | 96 | 6 | 0.04 | |
| 1 | 19 | 96 | 11 | 0.04 | |
| 1 | 20 | 96 | 21 | 0.04 | |
| 1 | 20 | 96 | 22 | 0.04 | |
| 1 | 20 | 96 | 23 | 0.39 | |
| 1 | 20 | 96 | 24 | 0.04 | |
| 1 | 21 | 96 | 2 | 0.12 | |
| 1 | 21 | 96 | 6 | 0.08 | |
| 1 | 23 | 96 | 17 | 0.04 | |
| 1 | 23 | 96 | 21 | 0.04 | |
| 1 | 24 | 96 | 6 | 0.04 | |
| 1 | 24 | 96 | 7 | 0.04 | |
| 1 | 24 | 96 | 9 | 0.11 | |
| 1 | 24 | 96 | 10 | 0.20 | |
| 1 | 24 | 96 | 12 | 0.08 | |
| 1 | 24 | 96 | 13 | 0.04 | |
| 1 | 24 | 96 | 15 | 0.08 | |
| 1 | 24 | 96 | 20 | 0.12 | |
| 1 | 24 | 96 | 21 | 0.15 | |
| 1 | 24 | 96 | 22 | 0.04 | |
| 1 | 24 | 96 | 23 | 0.04 | |
| 1 | 27 | 96 | 5 | 0.08 | |
| 1 | 27 | 96 | 6 | 0.20 | |
| 1 | 27 | 96 | 7 | 0.23 | |
| 1 | 27 | 96 | 8 | 0.24 | |
| 1 | 27 | 96 | 10 | 0.04 | |
| 1 | 27 | 96 | 16 | 0.04 | |
| 1 | 27 | 96 | 17 | 0.04 | |
| 1 | 30 | 96 | 15 | 0.08 | |
| 1 | 30 | 96 | 16 | 0.04 | |
| 1 | 30 | 96 | 18 | 0.11 | |
| 1 | 30 | 96 | 19 | 0.12 | |
| 1 | 30 | 96 | 20 | 0.08 | |
| 1 | 30 | 96 | 21 | 0.04 | |
| 1 | 30 | 96 | 22 | 0.04 | |
| 1 | 30 | 96 | 24 | 0.16 | |
| 1 | 31 | 96 | 1 | 0.08 | |
| 1 | 31 | 96 | 2 | 0.04 | |
| 1 | 31 | 96 | 4 | 0.15 | |
| 1 | 31 | 96 | 5 | 0.24 | |
| 1 | 31 | 96 | 6 | 0.08 | |
| 1 | 31 | 96 | 7 | 0.04 | |
| 1 | 31 | 96 | 8 | 0.12 | |
| 1 | 31 | 96 | 9 | 0.15 | |
| | | | | | 6.89 |
| 2 | 3 | 96 | 4 | 0.08 | |
| 2 | 3 | 96 | 5 | 0.04 | |
| 2 | 3 | 96 | 6 | 0.04 | |
| 2 | 3 | 96 | 22 | 0.04 | |
| 2 | 4 | 96 | 4 | 0.08 | |
| 2 | 4 | 96 | 5 | 0.12 | |
| 2 | 4 | 96 | 6 | 0.08 | |
| 2 | 4 | 96 | 7 | 0.23 | |
| 2 | 4 | 96 | 9 | 0.32 | |
| 2 | 4 | 96 | 10 | 0.11 | |
| 2 | 4 | 96 | 11 | 0.08 | |
| 2 | 4 | 96 | 13 | 0.08 | |
| 2 | 4 | 96 | 14 | 0.04 | |
| 2 | 4 | 96 | 19 | 0.04 | |
| 2 | 4 | 96 | 20 | 0.08 | |
| 2 | 4 | 96 | 23 | 0.04 | |
| 2 | 5 | 96 | 2 | 0.04 | |
| 2 | 7 | 96 | 6 | 0.04 | |
| 2 | 15 | 96 | 15 | 0.04 | |
| 2 | 15 | 96 | 17 | 0.08 | |
| 2 | 15 | 96 | 18 | 0.03 | |
| 2 | 15 | 96 | 19 | 0.24 | |
| 2 | 15 | 96 | 20 | 0.08 | |
| 2 | 17 | 96 | 22 | 0.04 | |
| 2 | 18 | 96 | 16 | 0.04 | |
| 2 | 18 | 96 | 17 | 0.04 | |
| 2 | 18 | 96 | 19 | 0.04 | |
| 2 | 18 | 96 | 21 | 0.04 | |
| 2 | 18 | 96 | 24 | 0.15 | |
| 2 | 19 | 96 | 1 | 0.08 | |
| 2 | 19 | 96 | 12 | 0.12 | |
| 2 | 19 | 96 | 13 | 0.24 | |
| 2 | 19 | 96 | 14 | 0.08 | |
| 2 | 19 | 96 | 15 | 0.07 | |
| 2 | 19 | 96 | 17 | 0.20 | |
| 2 | 20 | 96 | 4 | 0.24 | |
| 2 | 20 | 96 | 5 | 0.12 | |
| 2 | 21 | 96 | 1 | 0.07 | |
| 2 | 21 | 96 | 2 | 0.08 | |
| 2 | 21 | 96 | 3 | 0.40 | |
| 2 | 21 | 96 | 4 | 0.15 | |
| 2 | 21 | 96 | 5 | 0.20 | |
| 2 | 21 | 96 | 6 | 0.12 | |
| 2 | 21 | 96 | 7 | 0.04 | |
| 2 | 21 | 96 | 10 | 0.08 | |
| 2 | 22 | 96 | 22 | 0.31 | |
| 2 | 23 | 96 | 23 | 0.08 | |
| 2 | 23 | 96 | 24 | 0.04 | |
| 2 | 24 | 96 | 18 | 0.04 | |
| 2 | 24 | 96 | 19 | 0.04 | |
| 2 | 25 | 96 | 16 | 0.04 | |
| 2 | 27 | 96 | 5 | 0.04 | |
| 2 | 27 | 96 | 6 | 0.08 | |
| 2 | 27 | 96 | 7 | 0.04 | |
| 2 | 27 | 96 | 20 | 0.08 | |
| 2 | 28 | 96 | 17 | 0.03 | |
| 2 | 28 | 96 | 23 | 0.04 | |
| 2 | 28 | 96 | 24 | 0.04 | |
| 2 | 29 | 96 | 15 | 0.08 | |
| 2 | 29 | 96 | 16 | 0.16 | |
| | | | | | 5.83 |
| 3 | 3 | 96 | 13 | 0.12 | |
| 3 | 3 | 96 | 14 | 0.04 | |
| 3 | 4 | 96 | 8 | 0.11 | |
| 3 | 4 | 96 | 12 | 0.08 | |
| 3 | 4 | 96 | 13 | 0.12 | |
| 3 | 4 | 96 | 14 | 0.12 | |
| 3 | 4 | 96 | 15 | 0.20 | |
| 3 | 4 | 96 | 20 | 0.04 | |
| 3 | 4 | 96 | 23 | 0.04 | |
| 3 | 5 | 96 | 2 | 0.03 | |
| 3 | 10 | 96 | 7 | 0.04 | |
| 3 | 10 | 96 | 9 | 0.08 | |
| 3 | 11 | 96 | 2 | 0.04 | |
| 3 | 11 | 96 | 9 | 0.04 | |
| 3 | 11 | 96 | 10 | 0.12 | |
| 3 | 11 | 96 | 21 | 0.04 | |
| 3 | 11 | 96 | 23 | 0.08 | |
| 3 | 11 | 96 | 24 | 0.12 | |
| 3 | 12 | 96 | 1 | 0.23 | |
| 3 | 12 | 96 | 2 | 0.12 | |
| 3 | 12 | 96 | 3 | 0.24 | |
| 3 | 12 | 96 | 4 | 0.15 | |
| 3 | 12 | 96 | 5 | 0.04 | |
| 3 | 12 | 96 | 6 | 0.12 | |
| 3 | 12 | 96 | 7 | 0.12 | |
| 3 | 12 | 96 | 13 | 0.12 | |
| 3 | 12 | 96 | 14 | 0.08 | |
| 3 | 12 | 96 | 15 | 0.04 | |
| 3 | 28 | 96 | 24 | 0.11 | |
| 3 | 31 | 96 | 24 | 0.04 | |
| | | | | | 2.67 |
| 4 | 2 | 96 | 14 | 0.59* | |
| 4 | 15 | 96 | 12 | 0.04 | |
| 4 | 16 | 96 | 5 | 0.16 | |
| 4 | 16 | 96 | 6 | 0.20 | |
| 4 | 17 | 96 | 16 | 0.04 | |
| 4 | 17 | 96 | 17 | 0.08 | |
| 4 | 17 | 96 | 18 | 0.11 | |
| 4 | 17 | 96 | 19 | 0.24 | |
| 4 | 17 | 96 | 20 | 0.04 | |
| 4 | 18 | 96 | 5 | 0.08 | |
| 4 | 19 | 96 | 15 | 0.04 | |
| 4 | 19 | 96 | 16 | 0.04 | |
| 4 | 19 | 96 | 17 | 0.04 | |
| 4 | 24 | 96 | 10 | 0.04 | |
| | | | | | 1.15 |
| 5 | 15 | 96 | 12 | 0.04 | |
| 5 | 15 | 96 | 13 | 0.31 | |
| 5 | 15 | 96 | 14 | 0.20 | |
| 5 | 15 | 96 | 15 | 0.11 | |
| 5 | 15 | 96 | 16 | 0.12 | |
| 5 | 15 | 96 | 17 | 0.04 | |
| 5 | 15 | 96 | 18 | 0.12 | |
| 5 | 15 | 96 | 19 | 0.20 | |
| 5 | 15 | 96 | 20 | 0.04 | |
| 5 | 15 | 96 | 21 | 0.04 | |
| 5 | 15 | 96 | 22 | 0.07 | |
| 5 | 15 | 96 | 23 | 0.08 | |
| 5 | 15 | 96 | 24 | 0.03 | |
| 5 | 16 | 96 | 1 | 0.12 | |
| 5 | 16 | 96 | 11 | 0.04 | |
| 5 | 17 | 96 | 4 | 0.04 | |
| 5 | 17 | 96 | 21 | 0.04 | |
| 5 | 21 | 96 | 10 | 0.04 | |
| 5 | 21 | 96 | 11 | 0.04 | |
| 5 | 21 | 96 | 14 | 0.08 | |
| 5 | 21 | 96 | 15 | 0.04 | |
| | | | | | 1.89 |
| | | | GRAND TOTAL | | 25.91 |

*CUMMULATIVE TOTAL DUE TO COMPUTER LOCKUP

Rain Gauge Location: Arcadian Reservoir, Castro Valley
Sensor 1932 Cumulative rainfall 1996-97

| DATE | TIME | INCHES |
|---|---|---|
| 12/31/96 | 22.54 | 12.05 |
| 12/31/96 | 17:21 | 12.01 |
| 12/31/96 | 5:09 | 12.01 |
| 12/30/96 | 19:50 | 12.01 |
| 12/30/96 | 19:38 | 11.97 |
| 12/30/96 | 16:57 | 11.93 |
| 12/30/96 | 4:45 | 11.93 |
| 12/29/96 | 18:33 | 11.89 |
| 12/29/96 | 15:07 | 11.89 |
| 12/29/96 | 13:39 | 11.85 |
| 12/29/96 | 12:54 | 11.81 |
| 12/29/96 | 12:48 | 11.77 |
| 12/29/96 | 12:38 | 11.73 |
| 12/29/96 | 12:23 | 11.69 |
| 12/29/96 | 12:08 | 11.65 |
| 12/29/96 | 9:48 | 11.61 |
| 12/29/96 | 4:22 | 11.57 |
| 12/28/96 | 16:10 | 11.57 |
| 12/28/96 | 3:58 | 11.57 |
| 12/27/96 | 19:50 | 11.57 |
| 12/27/96 | 19:45 | 11.54 |
| 12/27/96 | 15:48 | 11 5 |
| 12/27/96 | 14:23 | 11.5 |
| 12/27/96 | 3:34 | 11.46 |
| 12/26/96 | 23:57 | 11.46 |
| 12/26/96 | 22:05 | 11.42 |
| 12/26/96 | 21:59 | 11.38 |
| 12/26/96 | 21:53 | 11.34 |
| 12/26/96 | 21:47 | 11.3 |
| 12/26/96 | 21:44 | 11.26 |
| 12/26/96 | 21:42 | 11.22 |
| 12/26/96 | 21:41 | 11.18 |
| 12/26/96 | 21:39 | 11.14 |
| 12/26/96 | 21:37 | 11.1 |
| 12/26/96 | 18:53 | 11.06 |
| 12/26/96 | 17:54 | 11.02 |
| 12/26/96 | 17:06 | 10.98 |
| 12/26/96 | 16:36 | 10.94 |
| 12/26/96 | 15:22 | 10 91 |
| 12/26/96 | 9:12 | 10.91 |
| 12/26/96 | 8:00 | 10.87 |
| 12/26/96 | 3:10 | 10.83 |
| 12/25/96 | 14:58 | 10.83 |
| 12/25/96 | 2:46 | 10.83 |
| 12/24/96 | 14:35 | 10.83 |
| 12/24/96 | 2:23 | 10.83 |
| 12/23/96 | 14:11 | 10.83 |
| 12/23/96 | 1:59 | 10 83 |
| 12/22/96 | 13:47 | 10.83 |
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| 12/22/96 | 1:35 | 10.79 |
| 12/21/96 | 23:07 | 10.79 |
| 12/21/96 | 21:34 | 10.75 |
| 12/21/96 | 21:11 | 10.71 |
| 12/21/96 | 20:47 | 10.67 |
| 12/21/96 | 20:14 | 10.63 |
| 12/21/96 | 19:28 | 10.59 |
| 12/21/96 | 18:14 | 10.55 |
| 12/21/96 | 17:43 | 10.51 |
| 12/21/96 | 16:41 | 10.43 |
| 12/21/96 | 16:26 | 10.39 |
| 12/21/96 | 16:07 | 10.35 |
| 12/21/96 | 15:51 | 10.31 |
| 12/21/96 | 15:23 | 10.28 |
| 12/21/96 | 14:58 | 10.24 |
| 12/21/96 | 14:40 | 10.2 |
| 12/21/96 | 14:28 | 10.16 |
| 12/21/96 | 14:07 | 10 12 |
| 12/21/96 | 13:49 | 10.08 |
| 12/21/96 | 13.26 | 10.04 |
| 12/21/96 | 13:23 | 10 |
| 12/21/96 | 12:54 | 10 |
| 12/21/96 | 12:26 | 9 96 |
| 12/21/96 | 11:34 | 9.88 |
| 12/21/96 | 11:05 | 9.84 |
| 12/21/96 | 10:36 | 9.8 |
| 12/21/96 | 10.14 | 9.76 |
| 12/21/96 | 9:39 | 9.72 |
| 12/21/96 | 9:09 | 9.69 |
| 12/21/96 | 8:47 | 9.65 |
| 12/21/96 | 8:29 | 9.61 |
| 12/21/96 | 8:07 | 9.57 |
| 12/21/96 | 7:24 | 9.49 |
| 12/21/96 | 6:55 | 9.45 |
| 12/21/96 | 6:39 | 9.41 |
| 12/21/96 | 6:25 | 9.37 |
| 12/21/96 | 6:06 | 9.33 |
| 12/21/96 | 5.54 | 9.29 |
| 12/21/96 | 5.33 | 9.25 |
| 12/21/96 | 5:13 | 9.21 |
| 12/21/96 | 4:53 | 9 17 |
| 12/21/96 | 4:33 | 9.13 |
| 12/21/96 | 4:14 | 9.09 |
| 12/21/96 | 3.50 | 9 06 |
| 12/21/96 | 3.22 | 9.02 |
| 12/21/96 | 3:14 | 8.98 |
| 12/21/96 | 3:10 | 8.94 |
| 12/21/96 | 3.08 | 8.9 |
| 12/21/96 | 3.07 | 8.86 |
| 12/21/96 | 3:06 | 8.82 |
| 12/21/96 | 3:03 | 8.78 |
| 12/21/96 | 3:01 | 8.74 |
| 12/21/96 | 2:49 | 8.66 |
| 12/21/96 | 2:41 | 8 62 |
| 12/21/96 | 2:31 | 8.58 |
| 12/21/96 | 2:20 | 8.54 |
| 12/21/96 | 2:08 | 8.5 |
| 12/21/96 | 1:57 | 8.46 |
| 12/21/96 | 1:46 | 8.43 |
| 12/21/96 | 1:20 | 8.35 |
| 12/21/96 | 1:11 | 8.31 |
| 12/21/96 | 1:04 | 8.31 |
| 12/21/96 | 0.39 | 8.27 |
| 12/20/96 | 12:59 | 8.23 |
| 12/20/96 | 0:48 | 8.23 |
| 12/19/96 | 12:36 | 8.23 |
| 12/19/96 | 0.24 | 8.23 |
| 12/18/96 | 12:12 | 8.23 |
| 12/18/96 | 0:00 | 8.23 |
| 12/17/96 | 11.48 | 8.23 |
| 12/16/96 | 23:37 | 8.23 |
| 12/16/96 | 11.25 | 8.23 |
| 12/15/96 | 23:13 | 8.23 |
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| 12/14/96 | 22:49 | 8.23 |
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| 12/13/96 | 10:13 | 8.23 |
| 12/12/96 | 22:40 | 8.23 |
| 12/12/96 | 22:30 | 8.19 |
| 12/12/96 | 22:24 | 8.15 |
| 12/12/96 | 21:52 | 8.11 |
| 12/12/96 | 9:50 | 8.07 |
| 12/12/96 | 6:08 | 8.07 |
| 12/12/96 | 5:16 | 8 03 |
| 12/12/96 | 4:48 | 7.99 |
| 12/12/96 | 1.10 | 7.95 |
| 12/12/96 | 0.05 | 7.91 |
| 12/11/96 | 23:59 | 7.87 |
| 12/11/96 | 23:55 | 7.83 |
| 12/11/96 | 21.38 | 7.8 |
| 12/10/96 | 4:16 | 6.93 |
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| 12/10/96 | 3:51 | 6.81 |
| 12/10/96 | 3.34 | 6.77 |
| 12/10/96 | 3:17 | 6.73 |
| 12/10/96 | 2.41 | 6.65 |
| 12/10/96 | 2.22 | 6.61 |
| 12/9/96 | 20:54 | 6.57 |
| 12/9/96 | 18:12 | 6.57 |
| 12/9/96 | 17:43 | 6.54 |
| 12/9/96 | 16 12 | 6.5 |
| 12/9/96 | 8 42 | 6.46 |
| 12/9/96 | 6.57 | 6.46 |
| 12/8/96 | 20.30 | 6.42 |
| 12/8/96 | 8.18 | 6.42 |
| 12/7/96 | 20 06 | 6 42 |
| 12/7/96 | 7:54 | 6 42 |
| 12/6/96 | 19 42 | 6.42 |
| 12/6/96 | 7 30 | 6 42 |
| 12/6/96 | 5 40 | 6 42 |
| 12/5/96 | 23.26 | 6.38 |
| 12/5/96 | 19:19 | 6.34 |
| 12/5/96 | 8.31 | 6 34 |
| 12/5/96 | 7.07 | 6.3 |
| 12/5/96 | 6.19 | 6 3 |
| 12/5/96 | 5.33 | 6.26 |
| 12/5/96 | 5.23 | 6.22 |
| 12/5/96 | 5:14 | 6 18 |
| 12/5/96 | 5.07 | 6.14 |
| 12/5/96 | 4.59 | 6 1 |
| 12/5/96 | 4.32 | 6.06 |
| 12/5/96 | 3.55 | 6.02 |
| 12/5/96 | 3:39 | 5.98 |
| 12/5/96 | 3:34 | 5.94 |
| 12/5/96 | 3:25 | 5.91 |
| 12/5/96 | 3.17 | 5.87 |
| 12/5/96 | 3:10 | 5.83 |
| 12/5/96 | 3:00 | 5.79 |
| 12/5/96 | 2:54 | 5.75 |
| 12/5/96 | 2:41 | 5.71 |
| 12/5/96 | 2.26 | 5.67 |
| 12/5/96 | 2:12 | 5.63 |
| 12/5/96 | 2:05 | 5.59 |
| 12/5/96 | 1.54 | 5.55 |
| 12/5/96 | 1:47 | 5.51 |
| 12/5/96 | 1:36 | 5.47 |
| 12/5/96 | 1:16 | 5.43 |
| 12/5/96 | 0:32 | 5.39 |
| 12/4/96 | 23:53 | 5.31 |
| 12/4/96 | 23:40 | 5.28 |
| 12/4/96 | 23:29 | 5.24 |
| 12/4/96 | 23:22 | 5.2 |
| 12/4/96 | 23:13 | 5.16 |
| 12/4/96 | 22:54 | 5.12 |
| 12/4/96 | 22:38 | 5.08 |
| 12/4/96 | 22:28 | 5.04 |
| 12/4/96 | 22:16 | 5 |
| 12/4/96 | 22:08 | 4.96 |
| 12/4/96 | 21:57 | 4.92 |
| 12/4/96 | 21:51 | 4.88 |
| 12/4/96 | 21:40 | 4.84 |
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| 12/4/96 | 21:17 | 4.72 |
| 12/4/96 | 20:59 | 4.69 |
| 12/4/96 | 20:26 | 4.65 |
| 12/4/96 | 19:52 | 4.61 |
| 12/4/96 | 18:55 | 4.57 |
| 12/4/96 | 18:54 | 4.57 |
| 12/4/96 | 6:43 | 4.53 |
| 12/3/96 | 18:31 | 4.53 |
| 12/3/96 | 6:19 | 4.53 |
| 12/2/96 | 18:07 | 4.53 |
| 12/2/96 | 5:55 | 4.53 |
| 12/1/96 | 17:43 | 4.53 |
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| 12/1/96 | 4:16 | 4.53 |
| 12/1/96 | 3:53 | 4.49 |
| 12/1/96 | 3:36 | 4.45 |
| 12/1/96 | 3:24 | 4 41 |
| 12/1/96 | 2:59 | 4.37 |
| 12/1/96 | 2:40 | 4.33 |
| 12/1/96 | 2:28 | 4.29 |
| 12/1/96 | 2:14 | 4.25 |
| 12/1/96 | 0.33 | 4.21 |
| 11/30/96 | 17:20 | 4.17 |
| 11/30/96 | 5:08 | 4.17 |
| 11/29/96 | 16.56 | 4.17 |
| 11/29/96 | 4:44 | 4.17 |
| 11/28/96 | 7:42 | 4.17 |
| 11/28/96 | 4:20 | 4.13 |
| 11/27/96 | 16:08 | 4.13 |
| 11/27/96 | 3:56 | 4 13 |
| 11/26/96 | 15:45 | 4.13 |
| 11/26/96 | 3:33 | 4.13 |
| 11/25/96 | 15:21 | 4.13 |
| 11/25/96 | 3:09 | 4.13 |
| 11/24/96 | 14:57 | 4.13 |
| 11/24/96 | 2:45 | 4.13 |
| 11/23/96 | 14:33 | 4.13 |
| 11/23/96 | 2:21 | 4.13 |
| 11/22/96 | 14:09 | 4.13 |
| 11/22/96 | 11:51 | 4.13 |
| 11/22/96 | 10:55 | 4.09 |
| 11/22/96 | 8.31 | 4.06 |
| 11/22/96 | 5:33 | 3.98 |
| 11/22/96 | 5:31 | 3.94 |
| 11/22/96 | 5.30 | 3.9 |
| 11/22/96 | 5.24 | 3 86 |
| 11/22/96 | 5 18 | 3.78 |
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| 11/22/96 | 4 53 | 3.7 |
| 11/22/96 | 4:28 | 3 66 |
| 11/22/96 | 4.19 | 3.62 |
| 11/22/96 | 1:58 | 3.58 |
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| 11/21/96 | 13:46 | 3 54 |
| 11/21/96 | 1:34 | 3.54 |
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| 11/19/96 | 13:45 | 3.5 |
| 11/19/96 | 12:58 | 3 46 |
| 11/19/96 | 12:21 | 3.46 |
| 11/19/96 | 11:33 | 3.43 |
| 11/19/96 | 11:23 | 3.39 |
| 11/19/96 | 10:43 | 3.31 |
| 11/19/96 | 0:46 | 3.27 |
| 11/18/96 | 12:34 | 3.27 |
| 11/18/96 | 6:57 | 3.27 |
| 11/18/96 | 6:00 | 3.23 |
| 11/18/96 | 0:22 | 3.19 |
| 11/17/96 | 19:30 | 3.19 |
| 11/17/96 | 18:23 | 3.15 |
| 11/17/96 | 16:46 | 3.11 |
| 11/17/96 | 16:25 | 3.07 |
| 11/17/96 | 15:46 | 3.03 |
| 11/17/96 | 15:31 | 2.99 |
| 11/17/96 | 15:11 | 2.95 |
| 11/17/96 | 12:11 | 2.91 |
| 11/17/96 | 6:48 | 2.91 |
| 11/17/96 | 6.34 | 2.87 |
| 11/17/96 | 6:19 | 2.83 |
| 11/17/96 | 6:15 | 2.8 |
| 11/17/96 | 6:12 | 2.76 |
| 11/17/96 | 6:09 | 2.72 |
| 11/17/96 | 6:05 | 2.68 |
| 11/17/96 | 6:00 | 2.64 |
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| 11/17/96 | 5:49 | 2.56 |
| 11/17/96 | 5:40 | 2.52 |
| 11/17/96 | 5:36 | 2.48 |
| 11/17/96 | 5:33 | 2.44 |
| 11/17/96 | 5:28 | 2.4 |
| 11/17/96 | 5.25 | 2.36 |
| 11/17/96 | 5:19 | 2.32 |
| 11/17/96 | 4:57 | 2.28 |
| 11/17/96 | 4:29 | 2.24 |
| 11/17/96 | 4:14 | 2.2 |
| 11/17/96 | 3:41 | 2.17 |
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| 11/17/96 | 2:24 | 2.05 |
| 11/17/96 | 2:20 | 2.01 |
| 11/17/96 | 2:06 | 1.97 |
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| 11/17/96 | 1:03 | 1.85 |
| 11/17/96 | 0:44 | 1.81 |
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| 11/17/96 | 0:11 | 1.69 |
| 11/17/96 | 0:04 | 1.65 |
| 11/16/96 | 23:59 | 1.61 |
| 11/16/96 | 23:57 | 1.61 |
| 11/16/96 | 23:54 | 1.57 |
| 11/16/96 | 23:40 | 1.54 |
| 11/16/96 | 23:28 | 1.5 |
| 11/16/96 | 23:12 | 1.46 |
| 11/16/96 | 22:39 | 1.38 |
| 11/16/96 | 21:53 | 1.34 |
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| 11/16/96 | 21:08 | 1.22 |
| 11/16/96 | 20:50 | 1.18 |
| 11/16/96 | 20:33 | 1.14 |
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Rain Gauge Location: Arcadian Reservoir, Castro Valley
Sensor 1932 Cumulative rainfall 1996-97

| DATE | TIME | INCHES |
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| 1/2/97 | 4:55 | 14.84 |
| 1/2/97 | 4:52 | 14.8 |
| 1/2/97 | 4:47 | 14.76 |
| 1/2/97 | 4:44 | 14.72 |
| 1/2/97 | 4:40 | 14.69 |
| 1/2/97 | 4:36 | 14.65 |
| 1/2/97 | 4:28 | 14.61 |
| 1/2/97 | 4:21 | 14.57 |
| 1/2/97 | 4:09 | 14.53 |
| 1/2/97 | 4:01 | 14.49 |
| 1/2/97 | 3:57 | 14.45 |
| 1/2/97 | 3:52 | 14.41 |
| 1/2/97 | 3:42 | 14.37 |
| 1/2/97 | 3:32 | 14.33 |
| 1/2/97 | 3:19 | 14.29 |
| 1/2/97 | 3:04 | 14.25 |
| 1/2/97 | 2:51 | 14.21 |
| 1/2/97 | 1:55 | 14.17 |
| 1/2/97 | 1:42 | 14.13 |
| 1/2/97 | 1:29 | 14.09 |
| 1/2/97 | 1:12 | 14.06 |
| 1/1/97 | 22:51 | 14.02 |
| 1/1/97 | 21:26 | 13.98 |
| 1/1/97 | 17:45 | 13.94 |
| 1/1/97 | 17:23 | 13.94 |
| 1/1/97 | 16:15 | 13.9 |
| 1/1/97 | 16:09 | 13.86 |
| 1/1/97 | 16:04 | 13.82 |
| 1/1/97 | 15:45 | 13.74 |
| 1/1/97 | 15:31 | 13.7 |
| 1/1/97 | 15:27 | 13.66 |
| 1/1/97 | 15:15 | 13.62 |
| 1/1/97 | 15:03 | 13.58 |
| 1/1/97 | 14:56 | 13.54 |
| 1/1/97 | 13:08 | 13.5 |
| 1/1/97 | 12:34 | 13.46 |
| 1/1/97 | 11:13 | 13.43 |
| 1/1/97 | 11:00 | 13.39 |
| 1/1/97 | 10:27 | 13.35 |
| 1/1/97 | 10:21 | 13.31 |
| 1/1/97 | 10:11 | 13.27 |
| 1/1/97 | 9:44 | 13.23 |
| 1/1/97 | 9:32 | 13.19 |
| 1/1/97 | 9:27 | 13.15 |
| 1/1/97 | 9:19 | 13.11 |
| 1/1/97 | 9:09 | 13.07 |
| 1/1/97 | 9:03 | 13.03 |
| 1/1/97 | 8:56 | 12.99 |
| 1/1/97 | 8:49 | 12.95 |
| 1/1/97 | 8:45 | 12.91 |
| 1/1/97 | 8:41 | 12.87 |
| 1/1/97 | 8:36 | 12.83 |
| 1/1/97 | 8:24 | 12.8 |
| 1/1/97 | 8:15 | 12.76 |
| 1/1/97 | 8:07 | 12.72 |
| 1/1/97 | 7:59 | 12.68 |
| 1/1/97 | 7:41 | 12.64 |
| 1/1/97 | 6:34 | 12.56 |
| 1/1/97 | 6:28 | 12.52 |
| 1/1/97 | 6:24 | 12.48 |
| 1/1/97 | 6:22 | 12.44 |
| 1/1/97 | 6:17 | 12.4 |
| 1/1/97 | 6:13 | 12.36 |
| 1/1/97 | 5:33 | 12.32 |
| 1/1/97 | 4:57 | 12.32 |
| 1/1/97 | 4:48 | 12.28 |
| 1/1/97 | 3:19 | 12.24 |
| 1/1/97 | 2:50 | 12.2 |
| 1/1/97 | 2:41 | 12.13 |
| 1/1/97 | 2:36 | 12.09 |

**Rain Gauge Location: near Redwood Road x SR 13, Oakland**

Recorder Status
Type: 674L-8K Event Capacity: 2035 Recorder ID: TEST
Time at Recorder: 04/24/97 12:30:14 Last Update: 12/18/95 12:18:17
Signal process: Not Applicable
Types of Events Recorded: Lo===>Hi
Total time LOW: 00:04:15 Total time HI: 492 days 19:44:4

Number of Events Recorded: 2036

Rainfall per Event: 0.01"

cumulative rainfall , inches

| rain sample | spray test | Time of event | | Type of Event | | | |
|---|---|---|---|---|---|---|---|
| | | 2/3/97 | 19:23:01 | Pulse | Low | to | HIGH |
| | | 2/3/97 | 21:50:12 | Pulse | Low | to | HIGH |
| | | 2/3/97 | 21:52:23 | Pulse | Low | to | HIGH |
| | | 2/3/97 | 21:55:38 | Pulse | Low | to | HIGH |
| | | 2/3/97 | 22:20:06 | Low | to | HIGH | |
| | | 2/3/97 | 23:34:35 | Pulse | Low | to | HIGH |
| | | 2/4/97 | 7:00:28 | Pulse | Low | to | HIGH |
| | | 2/4/97 | 18:23:29 | Pulse | Low | to | HIGH |
| | | 2/8/97 | 8:45:10 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:32:51 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:35:20 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:35:57 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:36:15 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:36:27 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:36:48 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:37:18 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:37:52 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:38:25 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:39:27 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:41:04 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:43:08 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:44:03 | Pulse | Low | to | HIGH |
| | | 2/17/97 | 1:52:10 | Low | to | HIGH | |
| | 0.00 | 2/19/97 | 12:48:44 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 1:54:56 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 2:04:51 | Pulse | Low | to | HIGH |
| | 0.03 | 3/2/97 | 2:16:59 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 3:24:09 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 4:29:36 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 5:15:33 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 5:39:28 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 5:43:18 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 5:47:52 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 5:51:56 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 5:55:35 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 5:57:58 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 6:01:39 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 6:06.30 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 6:11:48 | Low | to | HIGH | |
| | | 3/2/97 | 6:16:43 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 6:17:39 | Pulse | Low | to | HIGH |
| | | 3/2/97 | 6:21:01 | Pulse | Low | to | HIGH |
| | 0.19 | 3/2/97 | 6:34:31 | Pulse | Low | to | HIGH |
| | | 3/3/97 | 5:31:55 | Pulse | Low | to | HIGH |
| | | 3/3/97 | 5:54:01 | Pulse | Low | to | HIGH |
| | | 3/3/97 | 5:56:36 | Pulse | Low | to | HIGH |
| | | 3/3/97 | 7:45:25 | Pulse | Low | to | HIGH |
| | 0.24 | 3/15/97 | 19:04:37 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 9:27:46 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 9:44:20 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 13:08:42 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 13:12:05 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 13:16:34 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 13:20:02 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 13:22:54 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 13:25:54 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 13:29:11 | Low | to | HIGH | |
| | | 3/16/97 | 13:31:37 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 13:36:48 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 17:16:41 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 17:21:19 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 17:22:50 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 17:23:32 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 17:25:34 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 17:27:45 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 17:28:28 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 17:33:49 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 19:54:12 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 20:01:08 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 21:45:02 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 21:46.24 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 22:14:37 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 22:26:56 | Pulse | Low | to | HIGH |
| | | 3/16/97 | 22:33:43 | Pulse | Low | to | HIGH |
| | 0.51 | 3/21/97 | 17:35:15 | Pulse | Low | to | HIGH |
| | 0.52 | 3/31/97 | 11:47:18 | Pulse | Low | to | HIGH |

cumulative rainfall , inches

| spray test | Time of event | | Type of Event | | | |
|---|---|---|---|---|---|---|
| | 4/18/97 | 14:53:27 | Pulse | Low | to | HIGH |
| | 4/18/97 | 15:07:22 | Pulse | Low | to | HIGH |
| | 4/18/97 | 15:22:29 | Pulse | Low | to | HIGH |
| | 4/18/97 | 15:33.58 | Pulse | Low | to | HIGH |
| | 4/18/97 | 15:41:32 | Pulse | Low | to | HIGH |
| | 4/18/97 | 15:45:30 | Pulse | Low | to | HIGH |
| | 4/18/97 | 15:51:32 | Pulse | Low | to | HIGH |
| | 4/18/97 | 15:57:47 | Pulse | Low | to | HIGH |
| | 4/18/97 | 16:03:38 | Pulse | Low | to | HIGH |
| | 4/18/97 | 16:09:49 | Pulse | Low | to | HIGH |
| | 4/18/97 | 16.16:55 | Pulse | Low | to | HIGH |
| | 4/18/97 | 16.27:23 | Pulse | Low | to | HIGH |
| | 4/18/97 | 16:31:17 | Pulse | Low | to | HIGH |
| | 4/18/97 | 16:33:58 | Pulse | Low | to | HIGH |
| | 4/18/97 | 16:37:57 | Pulse | Low | to | HIGH |
| | 4/18/97 | 16:51:06 | Pulse | Low | to | HIGH |
| | 4/18/97 | 17:01:26 | Pulse | Low | to | HIGH |
| | 4/18/97 | 17:05:16 | Pulse | Low | to | HIGH |
| | 4/18/97 | 17:17:06 | Pulse | Low | to | HIGH |
| | 4/18/97 | 17:22:30 | Pulse | Low | to | HIGH |
| | 4/18/97 | 17:30:21 | Pulse | Low | to | HIGH |
| | 4/18/97 | 17:38:23 | Pulse | Low | to | HIGH |
| | 4/18/97 | 17:52:39 | Pulse | Low | to | HIGH |
| | 4/18/97 | 18:12:25 | Pulse | Low | to | HIGH |
| | 4/18/97 | 18:27:38 | Pulse | Low | to | HIGH |
| | 4/18/97 | 18:42:53 | Pulse | Low | to | HIGH |
| | 4/18/97 | 18:53:39 | Pulse | Low | to | HIGH |
| | 4/18/97 | 18:55:34 | Pulse | Low | to | HIGH |
| | 4/18/97 | 18:57:29 | Pulse | Low | to | HIGH |
| | 4/18/97 | 18:59:22 | Pulse | Low | to | HIGH |
| | 4/18/97 | 19:00:41 | Pulse | Low | to | HIGH |
| | 4/18/97 | 19:02:06 | Pulse | Low | to | HIGH |
| | 4/18/97 | 19:03:34 | Pulse | Low | to | HIGH |
| | 4/18/97 | 19:04:16 | Pulse | Low | to | HIGH |
| | 4/18/97 | 19:21:12 | Pulse | Low | to | HIGH |
| | 4/18/97 | 19:51:18 | Pulse | Low | to | HIGH |
| | 4/18/97 | 19:52:32 | Pulse | Low | to | HIGH |
| | 4/18/97 | 19:55:27 | Pulse | Low | to | HIGH |
| 0.52 | 4/18/97 | 19:59:12 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:03:00 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:06:02 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:12:27 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:14:00 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:15:33 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:17:27 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:20:02 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:21:08 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:27:42 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:35:11 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:36:25 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:37:18 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:38:04 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:39:55 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:42:31 | Low | to | HIGH | |
| | 4/18/97 | 20:55:08 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:56:34 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:57:08 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:57:49 | Pulse | Low | to | HIGH |
| | 4/18/97 | 20:58:52 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:00:05 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:05:46 | Low | to | HIGH | |
| | 4/18/97 | 21:07:22 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:08:11 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:10:00 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:13:09 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:14:29 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:16:36 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:18:56 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:25:07 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:35:23 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:39:42 | Pulse | Low | to | HIGH |
| | 4/18/97 | 21:44:36 | Low | to | HIGH | |
| | 4/18/97 | 21:48:01 | Low | to | HIGH | |
| | 4/18/97 | 21:53:00 | Low | to | HIGH | |
| | 4/18/97 | 21:59:11 | Pulse | Low | to | HIGH |
| | 4/18/97 | 22:09:34 | Pulse | Low | to | HIGH |
| | 4/18/97 | 22:15:18 | Pulse | Low | to | HIGH |
| | 4/18/97 | 22:25:24 | Pulse | Low | to | HIGH |
| | 4/18/97 | 22:33:32 | Pulse | Low | to | HIGH |
| | 4/18/97 | 22:36:23 | Pulse | Low | to | HIGH |
| | 4/18/97 | 22:39:18 | Pulse | Low | to | HIGH |
| | 4/18/97 | 22:41:36 | Pulse | Low | to | HIGH |
| | 4/18/97 | 22:44:30 | Pulse | Low | to | HIGH |
| | 4/18/97 | 22:49:35 | Pulse | Low | to | HIGH |
| | 4/18/97 | 22:53:12 | Low | to | HIGH | |
| | 4/18/97 | 22:55:23 | Pulse | Low | to | HIGH |
| | 4/18/97 | 22:56:56 | Pulse | Low | to | HIGH |
| | 4/18/97 | 23:00:23 | Pulse | Low | to | HIGH |
| | 4/18/97 | 23:09:12 | Pulse | Low | to | HIGH |
| | 4/18/97 | 23:18:53 | Pulse | Low | to | HIGH |
| | 4/19/97 | 0:24:35 | Pulse | Low | to | HIGH |
| | 4/20/97 | 14:12:15 | Pulse | Low | to | HIGH |
| | 4/22/97 | 21:10:54 | Pulse | Low | to | HIGH |
| | 4/24/97 | 6:51:40 | Pulse | Low | to | HIGH |