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Water Quality and Biological Effects of Urban Runoff on Coyote Creek

Phase I
Preliminary Survey

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WATER QUALITY AND BIOLOGICAL EFFECTS OF URBAN RUNOFF ON COYOTE CREEK

Phase I - Preliminary Survey

by

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Grant No. R805418

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FOREWORD

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Research and development is that necessary first step in problem solving, and involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources; for the preservation and treatment of public drinking water supplies; and for minimizing the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research and is a vital communications link between the researcher and the user community.

An evaluation of the receiving water effects of urban runoff is necessary before urban runoff control goals and practices can be established and selected. This report presents the preliminary results of an evaluation of the water quality and biological effects of urban runoff on Coyote Creek, near San Jose, California. Coyote Creek, upstream and in the study area, receives minimal pollutant discharges, except for urban runoff. The biological, water and sediment quality gradients observed illustrate significant degradation in the quality of the creek in the urban area. Additional studies, currently being conducted in Coyote Creek, will attempt to establish local control goals for urban runoff. These results and study procedures can be evaluated by others in various parts of the country for their own use.

Francis T. Mayo, Director
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ABSTRACT

This preliminary report presents the initial results and conclusions from the EPA-sponsored demonstration study of the water quality and biological effects of urban runoff on Coyote Creek, near San Jose, California. This first phase included investigating various field procedures that would be most sensitive in evaluating water, sediment and biological changes in the creek as it passed through the urban area. The procedures identified as most promising are currently being used in additional Coyote Creek studies.

The report describes the characteristics of urban runoff affecting the creek, sources of urban runoff pollutants, effects of urban runoff and potential controls for urban runoff. Local urban runoff characterization information is summarized, based on a previous EPA sponsored demonstration project in the area (Demonstration of Non-Point Pollution Abatement Through Improved Street Cleaning Practices-EPA grant No. S804432, Pitt 1979) and from the local "208" study (Metcalf and Eddy 1978). Sources of urban runoff pollutants in the study area are being investigated as an important part of the field activities of the project and include sampling runoff from many source areas (such as street surfaces, parking lots, landscaped areas, rooftops and rain).

Various short- and long-term biological sampling techniques were used to evaluate the fish, benthic macroinvertebrate and attached algae conditions at many stations in the creek, above and within the urban area. Creek water and sediment samples were also obtained and analyzed for a broad list of parameters. In most cases, very pronounced gradients of these creek quality indicators were observed, with the urbanized portion of the creek being significantly degraded. Current additional monitoring is being conducted to identify the urban runoff control goals necessary to improve creek quality to adequate levels.

This preliminary report is submitted in partial fulfillment of Grant No. R805418 by Woodward-Clyde Consultants, San Francisco, California, under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period November 1977 to May 1980.

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SECTION 1

INTRODUCTION

This report describes a study conducted to investigate the sediment, water quality and biological effects of urban runoff in a small receiving water. The project was conducted simultaneously with the last parts of a demonstration project conducted by Woodward-Clyde Consultants for the City of San Jose, California, and the Environmental Protection Agency entitled, "Demonstration of Non-Point Pollution Abatement Through Improved Street Cleaning Practices" (Pitt 1979). Many of the data collected during this previous project were used for the runoff effects study.

The purpose of this study was to investigate the kinds of sediment, water quality and biological changes that can occur in streams as they pass through urban areas. This report should be useful to decision makers in developing urban runoff control programs. Coyote Creek and San Jose were excellent study areas for the following reasons:

- Coyote Creek is not affected by sanitary or industrial wastes in the region of study.
- Coyote Creek is a small stream transversing a large urban area, with its upstream waters passing through two man-made reservoirs. These reservoirs control the creek discharge. Flow monitoring stations exist.
- The upper reaches of Coyote Creek in the proposed study area pass through an undeveloped area and are not affected by urban runoff until the creek reaches San Jose.
- Many Western cities discharge into similar small receiving waters and the expected receiving water effects due to urban runoff are significant.
- The recently completed EPA-funded research project in San Jose (Pitt 1979) contributed detailed pollution-source information for a portion of the study area and enabled the effort needed to describe the conditions in the watershed to be significantly reduced.

This project has resulted in data that demonstrates a degradation of sediment, water quality and biological conditions in Coyote Creek as it passes through San Jose. This information is needed to estimate the amount of urban runoff control that may be necessary in order to improve these Coyote Creek conditions. The three major elements of this study included investigating the sources of urban runoff pollutants, the effects of these pollutants on the beneficial uses of the receiving waters, and how the problem pollutants in the urban runoff can be best controlled.

The first phase in designing an urban runoff control program is to identify which pollutants need to be controlled. This is best determined by directly monitoring the receiving water, sediments, and beneficial uses. This monitoring can be supplemented with computer modeling by using locally calibrated runoff and receiving water models. Few, if any, models are available that can predict actual biological beneficial use impairments. Therefore, if biological uses of the receiving water are important, actual biological conditions must be studied. Hydrology data, along with sediment and water column chemical analyses, are necessary to estimate cause and effect relationships. Control areas having acceptable biological conditions must also be analyzed to help define goal conditions. Those parameters that exceed these goal conditions for various sections of the receiving water can then be identified. Seasonal variations of removal goals needed to obtain acceptable discharge limits should also be determined, as beneficial uses and receiving water assimilative capacities change with season. Most of the information presently available from this project addresses this first phase.

The next phase in an urban runoff control program is to determine the sources of the problem pollutants in the watershed. These sources must be verified and quantified through actual field monitoring for the identified problem pollutants. Runoff samples, along with dry samples from the source areas, should be analyzed. Source strengths should be estimated by season for the problem pollutants. The source areas associated with each problem pollutant can then be identified and assigned priorities. Source area information is also being obtained as part of this project, and preliminary information is presented in this report.

The third phase in developing an urban runoff control program is to determine what control measures can be used in the identified "problem" source areas. Many of these control measures have been examined in area-wide wastewater management ("208") studies, and in research projects in various locations throughout the country. The effectiveness of the various control measures in the different source areas must also be determined by local studies. Literature information can be used to make a preliminary control design that can be modified with local experience. Much information concerning street cleaning effectiveness in the study area was obtained in a previous project (Pitt 1979). Information concerning other urban runoff control measures was obtained from the literature.

The field and laboratory activities conducted as part of this study were preliminary phases of a larger project and involved intensively sampling Coyote Creek during the spring and early summer months of 1978. Preliminary results of later phases of this project (source-area information and continued biological, water and sediment analyses) have also been used in the preparation of this report. The objectives of this study were to quantify the biological and sediment quality macro-scale gradient as the creek passed through an urban area. The type and magnitude of changes in the sediment quality and biological community in Coyote Creek was examined as the creek passed through San Jose between Lake Anderson and the confluence of Silver Creek. This urban area includes the Keyes St. and Tropicana study areas that were investigated as part of the San Jose street cleaning demonstration project (Pitt 1979). In this reach of Coyote Creek, there are minimal discharges except for urban runoff. Each sampling area included a stretch of stream several hundred meters long, which was selected based on the geography and physical/biological/chemical homogeneity of that stretch of stream. Each urban sampling area was located between adjacent urban runoff outfalls. This was necessary to reduce individual outfall influences on the samples. A continuation of this study will include specific outfall micro-scale studies.

Various parameters were analyzed as part of this study. The following list summarizes those parameters that were generally analyzed at each biological/sediment sampling station:

- fish
- benthic organisms including aquatic insects, crustaceans, and molluscs
- attached algae
- rooted aquatic vegetation (when present)
- sediment size distribution
- sediment biochemical oxygen demand, chemical oxygen demand, total organic carbon and volatile solids
- sediment ammonia, nitrates, organic nitrogen, orthophosphates and sulfates
- complete elemental scan of the sediment by spark source mass spectrophotometry - SSMS (including heavy metals)
- complete organic scan of the sediment by mass spectrophotometry/gas chromatography - MSGC (including PCB's and pesticides)
- biological tissue analyses for lead and zinc.

During the first phase of this study, most of the biological sampling was conducted during two adjacent periods during the spring and early summer, while the sediment and water column samples were only collected once. Most of the initial sampling program began in March and ended in June, 1978. Other data obtained in the winter of 1978-1979 and the spring of 1979 were also considered in preparing this report. The data were analyzed to determine the type and magnitude of changes that occurred in Coyote Creek as it passed through the urban area. Additional data will be collected during Phase II.

The following sections of this report present the sampling methodology and preliminary conclusions; describe the study area; San Jose urban runoff characteristics; sources of urban runoff pollution in San Jose; the biological, sediment and water quality effects of urban runoff; and potential controls of urban runoff.

SECTION 2

SAMPLING METHODOLOGY AND PRELIMINARY CONCLUSIONS

Hydrology: Lake Anderson discharge values were obtained from the Santa Clara Valley Water District and creek flows at the sampling stations were observed by the field personnel. Flows were maintained at all sampling stations during the biological sampling phases and sediment collection period. The lake discharges varied greatly and creek flows were augmented in the study area by infiltration pond discharges and by groundwater. The sampling period was also characterized by normal rains.

Receiving water chemistry: Coyote Creek water grab samples were analyzed for major parameters after a single sampling at locations above and within San Jose. The water was very turbid, hard to very hard, and had high ammonia and coliform bacteria concentrations. A marked increase in nitrites, ammonia, turbidity, chlorides and specific conductance was found as the creek passed through the urbanized area of the watershed. The concentrations are expected to be greater and the trends more evident during and immediately after rains.

Runoff water chemistry and yields: Runoff water quality data was obtained from other studies (Pitt 1979; Metcalf and Eddy 1978). The data were analyzed by an equilibrium water chemistry computer program to estimate the specific chemical compounds that would remain soluble and which ones would settle out in the receiving water sediments. These data were also used to estimate a total urban area runoff yield for the study area. Many parameters were found to exceed beneficial use criteria in the runoff. The non-urban stations were found to be exposed to very little quantities of pollutants, while the urban stations were exposed to increasing amounts in a downstream direction. It is suspected that much of the heavy metals, oils and greases tended to accumulate in the sediments, while nutrients remained soluble.

Sediment quality: Sediment samples were obtained by carefully scooping bottom material into glass jars and sealing the containers underwater. The samples were then frozen and delivered to a laboratory for analysis. The urban samples contained higher concentrations of many of the parameters as compared to the non-urban samples. Sulfates (33 to 60 times greater), lead (about 10 times greater), and orthophosphates (up to about 4 times greater), were notable examples. Much more silt was also found in the urban samples, signifying a greater discharge of finer sediments from the urban area. Past studies (Sartor and Boyd, 1972; Pitt and Amy, 1973; and Pitt, 1979) have shown that the finer particulates associated with urban runoff typically have greater concentrations of many pollutants than larger particulates. The urban samples also had significantly greater concentrations of high molecular weight hydrocarbon and oxygenated compounds.

Organic tissue analyses: Selected organisms (mosquito fish, filamentous algae, crayfish and cattail plant segments) were obtained at most sampling stations. These were chemically digested and analyzed for total lead and zinc concentrations. Lead concentrations in urban samples of algae, crayfish and cattails were 2 to 3 times greater than in non-urban samples, while zinc concentrations in urban algae and cattail samples were about 3 times the non-urban sample concentrations. Fish lead and zinc concentrations did not noticeably increase. Bioaccumulation of lead and zinc in the organisms compared to the sediments occured for many of the samples and stations (up to a maximum factor of about 6). Bioaccumulation of lead and zinc in the organisms compared to water column concentrations was at least 100 to 500 times greater, depending on the organism.

Fish, benthic macroinvertebrates and attached algae: Fish were collected throughout the study area by seining representative habitats in both riffles and pools. Captured fish were identified and counted and the total length for each individual was recorded. Replicate benthic macroinvertebrate samples were collected from natural substrates in both pool and riffle habitats by means of an Ekman dredge and a Surber sampler, as appropriate. Additionally, artificial substrates (replicate pairs of Hester-Dendy multiplate samplers) were employed at each sampling area. The benthic samples were washed through a 500μ sieve and the organisms retained on the screen were picked, sorted, and preserved in 70% ethanol for identification and enumeration. Attached algae was sampled from both natural and artificial substrates throughout the various reaches of the stream. Qualitative samples of attached algae were collected by scraping uniform areas of natural substrates such as logs, rocks, etc. Quantitative collections were made with the use of artificial substrates (diatometers equipped with glass slides) suspended in the water column. Qualitative samples were preserved in 5% buffered formalin for later identification. Diatometer samples were scraped, cleaned with 30% hydrogen peroxide and potassium permangate, identified, and counted.

These preliminary biological investigations in Coyote Creek have indicated distinct differences in the taxonomic composition and relative abundance of the aquatic biota present in the various reaches of the stream. The non-urbanized section of the creek has been found to support a comparatively diverse assemblage of aquatic organisms including at least 12 species of fish and various benthic macroinvertebrate taxa such as mayflies, caddisflies, aquatic beetles, midges, blackflies, snails, and fingernail clams. In contrast, however, the urbanized portion of the stream has been shown to comprise an aquatic community that is generally lacking in diversity and is dominated by pollution tolerant fishes such as mosquito fish and pollution tolerant benthic invertebrates such as tubeficid worms.

Phase II Studies: During 1979, additional tests in Coyote Creek will be conducted to obtain data during more biologically critical sampling periods and to better define the transition zone between the urban and non-urban portions of the watershed. A limited sediment quality survey on a micro-scale near a major storm drain outfall in the urban area will also be conducted. The following paragraphs briefly describe the phase II field studies:

- Gradient survey. A survey of the creek gradient through the study area will enable changes in gradient that may affect the biological conditions in the creek to be determined.

- Temperature survey. Natural and man-induced temperature gradients can have an effect on the biological community and may be caused by urban runoff, dam release, vegetation shading, groundwater infiltration, etc. Day and night temperature surveys of water temperature will therefore be conducted.

- Micro analyses. Closely spaced sediment samples will be collected at various depths above, at and below a storm drain outfall located in the urbanized portion of the watershed. Various physical and chemical analyses (sediment size distribution, COD, Kjeldahl nitrogen, total phosphorus, sulfur, arsenic, lead, and zinc) will be performed on each sample.

- Water and sediment chemical analyses. Water and sediment samples will be collected at each study area during the biological surveys. Creek flows will also be monitored at each study area and the long-term dam releases will be obtained. The phase I studies have identified the parameters noted above as the most indicative of urban runoff problems in Coyote Creek. Manual replicate sediment samples and composited water samples will be obtained for analyses at each study area during each collection period.

- Continuing biological studies in Coyote Creek during 1979 will focus on delineating the changes in the resident aquatic biota which potentially result from the influences of urban runoff pollution within the watershed. The differences in the taxonomic composition and abundance of aquatic organisms which populate the urbanized and non-urbanized reaches of the stream will be further investigated. Fish and benthic macroinvertebrate populations in early spring and autumn of 1979 will be studied. By scheduling collections during these periods, it will be possible to augment the earlier data collected in 1978 and thereby gain additional information regarding the seasonal aspects of changes in the stream biota populations. Sampling locations will be chosen to allow further determination of the types and magnitudes of changes that occur in the stream biota as the creek is subjected to increased urban runoff loadings. The 1979 biological field studies include the following elements:

  Fish. The seasonal distribution of the fishes in Coyote Creek from Anderson Dam to the confluence of Silver Creek will be examined. Whereas the previous work has relied heavily upon the use of seines for the collection of fishes, the future work will be conducted with a Smith Root type VII electroshocker, or equivalent.

Benthic Macro-invertebrates. The macro-invertebrate sampling previously conducted at each area will be expanded using dredges, Surber samplers, Hester-Dendy multiple samplers and drift and sweep nets. The collection of benthos from representative habitats within the stream will be stressed.

SECTION 3

COYOTE CREEK WATERSHED DESCRIPTION

GENERAL DESCRIPTION

Figure 3-1 is a map of the San Francisco Bay Area showing the location of the Coyote Creek watershed. The Coyote Creek main channel (including the middle fork) is about 130 kilometers (80 miles) long, drains generally in a northwesterly direction, and empties into the extreme south end of San Francisco Bay, north of San Jose, California. Several major flow-control devices occur on Coyote Creek for flood control and groundwater recharge purposes. The largest are both manmade lakes, Lake Anderson and Coyote Lake. Discharges from these lakes are controlled by the Santa Clara Water District and the water is used for groundwater infiltration in the local south Santa Clara County area. The watershed itself is about 70 kilometers (45 miles) long, about 15 kilometers (10 miles) wide, and contains about 80,000 hectares (200,000 acres). Nearly 15 percent of the watershed (about 12,000 hectares or 30,000 acres) is a developed urban area. This urban area is part of the San Jose metropolitan area, and is located along the northwest portion of the watershed. Figure 3-2 is a detailed map of the Coyote Creek watershed. For much of its length, Coyote Creek flows in a northwesterly direction along the western edge of the watershed. The elevation of the watershed ranges from sea-level to 916 meters (3002 ft). Near the San Jose metropolitan area, the lower portions of the watershed are characterized by a broad plain on the west and rolling foothills on the east. Upstream from the metropolitan area, the waterhed is within an area of rugged hills. A narrow portion of the watershed between Lake Anderson and the metropolitan area is used for light agricultural purposes. The upper headwaters of Coyote Creek are in extremely rugged terrain with slopes commonly exceeding 30 percent. These upper areas are characterized by chapparal-covered hills, and gullies, and are mostly within the Henry Coe State Park. Non-park land in the upper reaches of the watershed is mostly used for low density cattle grazing.

Coyote Creek empties into the south terminus of San Francisco Bay. Typical average daily flows in the northern part of the creek are less than 1.5 cubic meters per second (50 cfs). Major storm flows, however, can approach 30 cubic meters per second (1000 cfs). The flows in the northern part of the creek are controlled by the two dams. The area of study was located between the furthest downstream dam (Lake Anderson) and the first major confluence (Silver Creek) well within the City of San Jose. Of this 32-kilometer (20-mile) study section approximately 8 kilometers (5 miles) is urbanized and 24 kilometers (15 miles) is non-urbanized. The non-urban section is characterized by relatively low intensity agricultural or open space uses. Sampling stations were located in both the urban and non-urbanized sections of the stream for comparison.

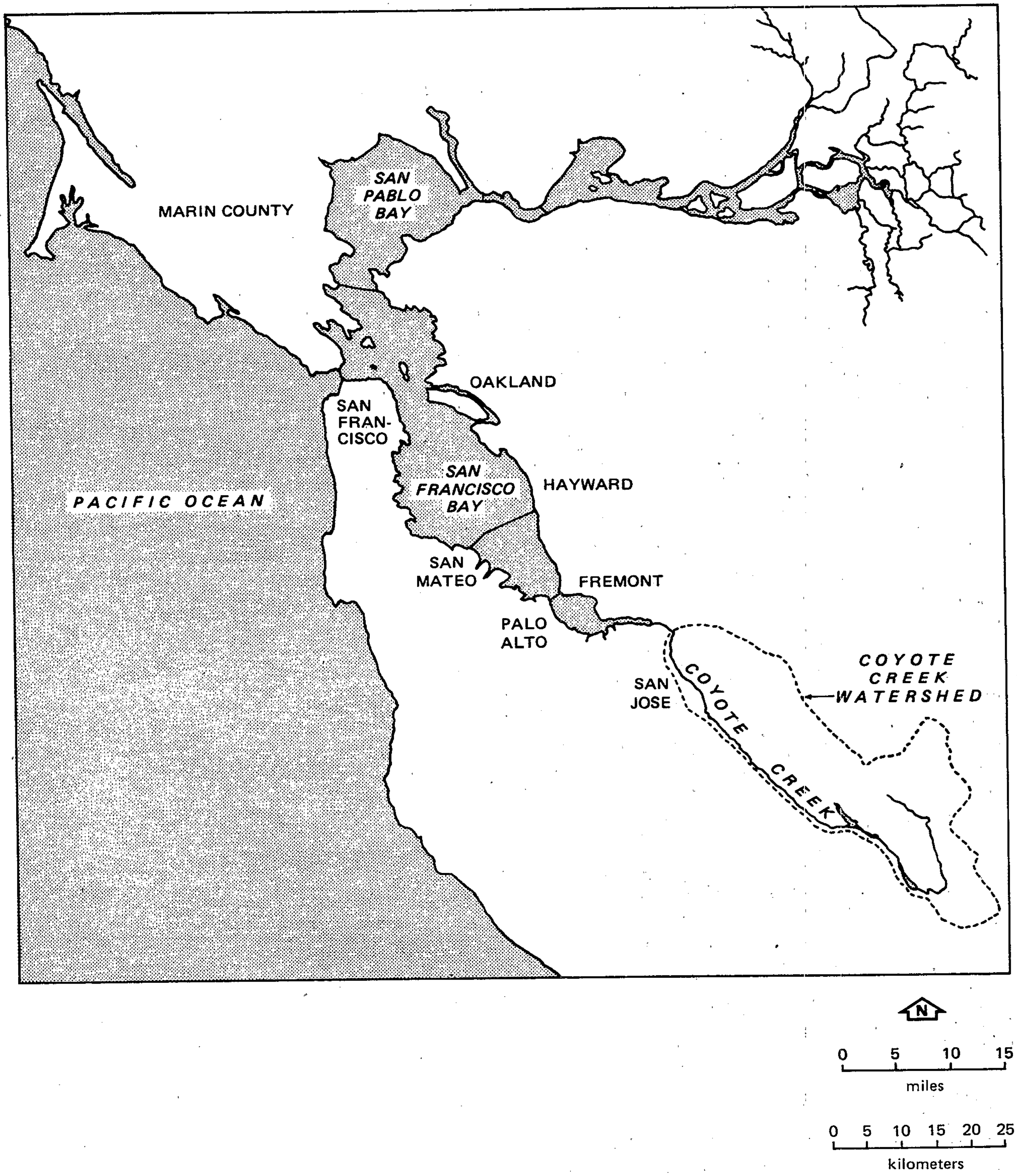

Figure 3-1. San Francisco Bay Area showing the general location of the Coyote Creek watershed.

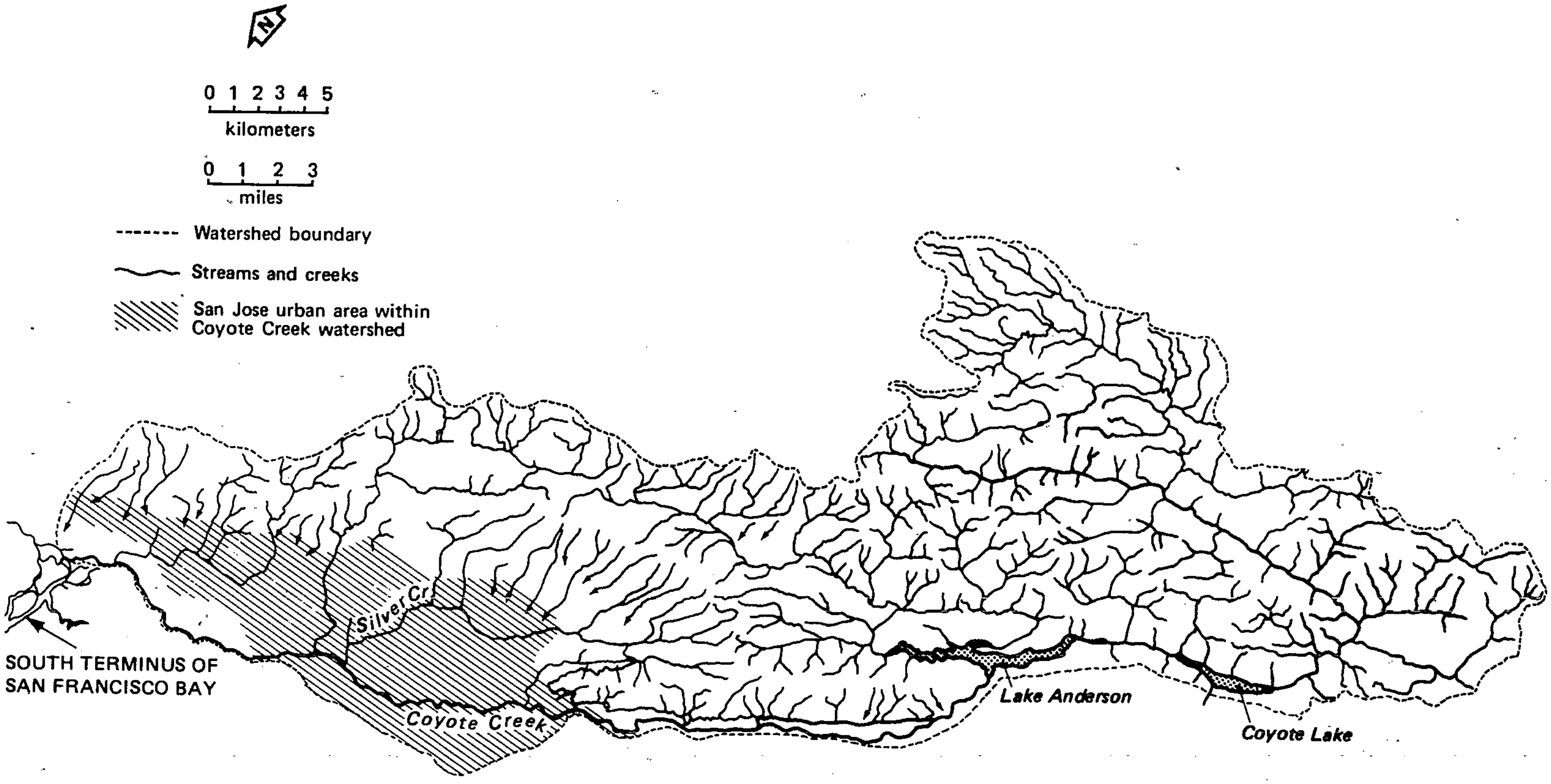

Figure 3-2. Coyote Creek watershed.

HYDROLOGY

Figure 3-3 shows the water releases from Lake Anderson during the period of study. Water releases during February 1978 and into the first week of March were quite irregular, varying from almost zero up to about one cubic meter per second (35 cfs). During the rest of March through the end of April, the releases slowly decreased from one cubic meter per second (35 cfs) down to about 0.3 cubic meter per second (10 cfs). During May, the releases were increased quickly to about 2.3 cubic meters per second (80 cfs) where they were mantained through June, 1978. This spring and early summer period of 1978 followed two years of severe drought in the study area. The first major rains occurred the previous November and a normal rain season occurred during the period of study. Typical rainfall in the watershed below Lake Anderson averages about 33 centimeters (13 inches) per year and can range from 50 to 71 centimeters (20 to 28 inches) per year in the watershed above Lake Anderson. The severe drought preceeding this study resulted in rains of about one-half these amounts. The creek conditions were monitored and sampling was initiated when flows appeared to stabilize. The benthic sampling therefore occurred about 4 months after the first rains and about 1 month after the period of irregular creek flows. The creek flows during the first portion of this sampling were consistent but relatively low and increased substantially during the remaining portion of the sampling period.

Coyote Creek is an important element to the Santa Clara Valley Water District's groundwater recharge program, and has several groundwater recharge basins located adjacent to the channel in the study area. There are several diversion channels which carry water out of Coyote Creek into these recharge basins and out of the recharge basins into the creek. Therefore, the water releases as shown in Figure 3-3 do not represent the flow conditions in Coyote Creek at the sampling stations. Some of the stations were affected by recharge basin discharges (Coyote Creek water that was previously diverted for recharge), direct groundwater influx along the creek banks into the creek, and dry weather flows from storm drain outfalls. The dry weather flows are mostly composed of domestic water line leaks, residential area irrigation and car washing water. Some of the stations were also affected by direct groundwater infiltration and dammed pools in the creeks. Therefore, certain stretches of the creek can be dry for short periods of time, but downstream reaches can have flowing water from these other sources. The sampling stations were carefully selected so that running water was available during the entire period of study.

OUTFALL LOCATIONS

Table 3-1 describes the stormwater outfalls and drainage areas along a 20 kilometer (12 mile) reach of Coyote Creek, between the Silver Creek confluence and the town of Coyote. San Jose's storm drainage maps were examined and the outfalls and drainage areas were plotted on USGS quad sheets. Figure 3-4 shows the locations of these 37 outfalls, along with the two areas studied during the street cleaning demonstration project (Pitt 1979). There are 0.6 to 3 storm drain outfalls per kilometer (1 to 5 per mile) along this stretch of Coyote Creek. There are other storm drain outfalls downstream from the Silver Creek confluence but they are not included in this table or figure as

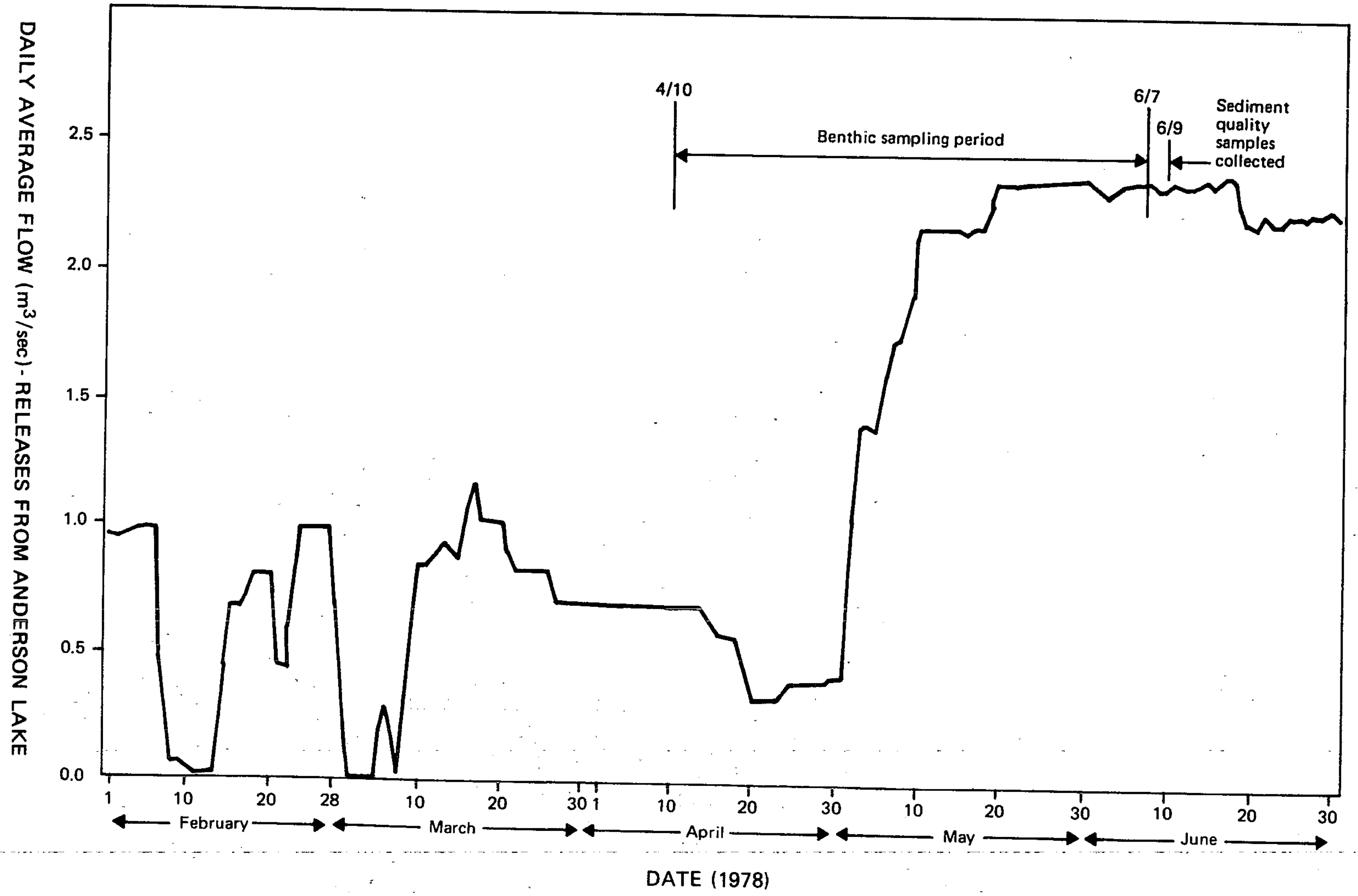

Figure 3-3. Lake Anderson releases during study period.

Table 3-1. DESCRIPTION OF STORMDRAIN OUTFALLS AND DRAINAGE AREAS BETWEEN SILVER CREEK CONFLUENCE AND THE TOWN OF COYOTE ON COYOTE CREEK

Outfall Number	Approximate Outfall Location	Outfall Entry	Outfall Diameter (cm)	Approximate Drainage Area (hectares)
1	240 m N of Julian	west	46	10
2	at Julian	west	46	15
3	60 m S of Julian	east	69	80
4	240 m S of Julian	east	140	40
5	60 m S of Santa Clara	west	46	10
6	360 m S of Santa Clara	east	53	10
7	60 m N of San Carlos	west	53	30
8	at E Williams	east	20	5
9	60 m S of E Williams	west	76	35
10	150 m S of I-280	west	110	10
11	at Martha*	west	69	35
12	at Story Rd	east	76	10+
13	at W Alma	west	150	80
14	180 m S of W Alma	east	69	40
15	at Phelan	east	170	100
16	300 m S of Phelan	west	69	5
17	790 m N of Tully	east	180	80
18	450 m N of Tully	east	91	10
19	at Tully	east	140	300
20	at Tully .	west	91	60
21	60 m S of Tully	west	91	30
22	670 m S of Tully	west	84	20
23	970 m N of Capital Expwy.	west	170	200
24	at Capital Expwy.	east	110	30
25	at Capital Expwy.	west	61	10
26	420 m S of Capital Expwy.	east	91	40
27	670 m S of Capital Expwy.	east	46	10
28	1300 m S of Capital Expwy.	west	84	60
29	1500 m S of Capital Expwy.	east	61	15
30	1500 m W of 101	west	30	2
31	1200 m W of 101	west	30	2
32	670 m W of 101	west	91	60
33	300 m W of 101	west	30	15
34	240 m W of 101	west	30	5
35	1200 m S of 101	west	140	200
36	1800 m S of 101	west	120	20
37	near Piercy Road	west	110	25

*Keyes St. study area in previous study (Pitt 1979).

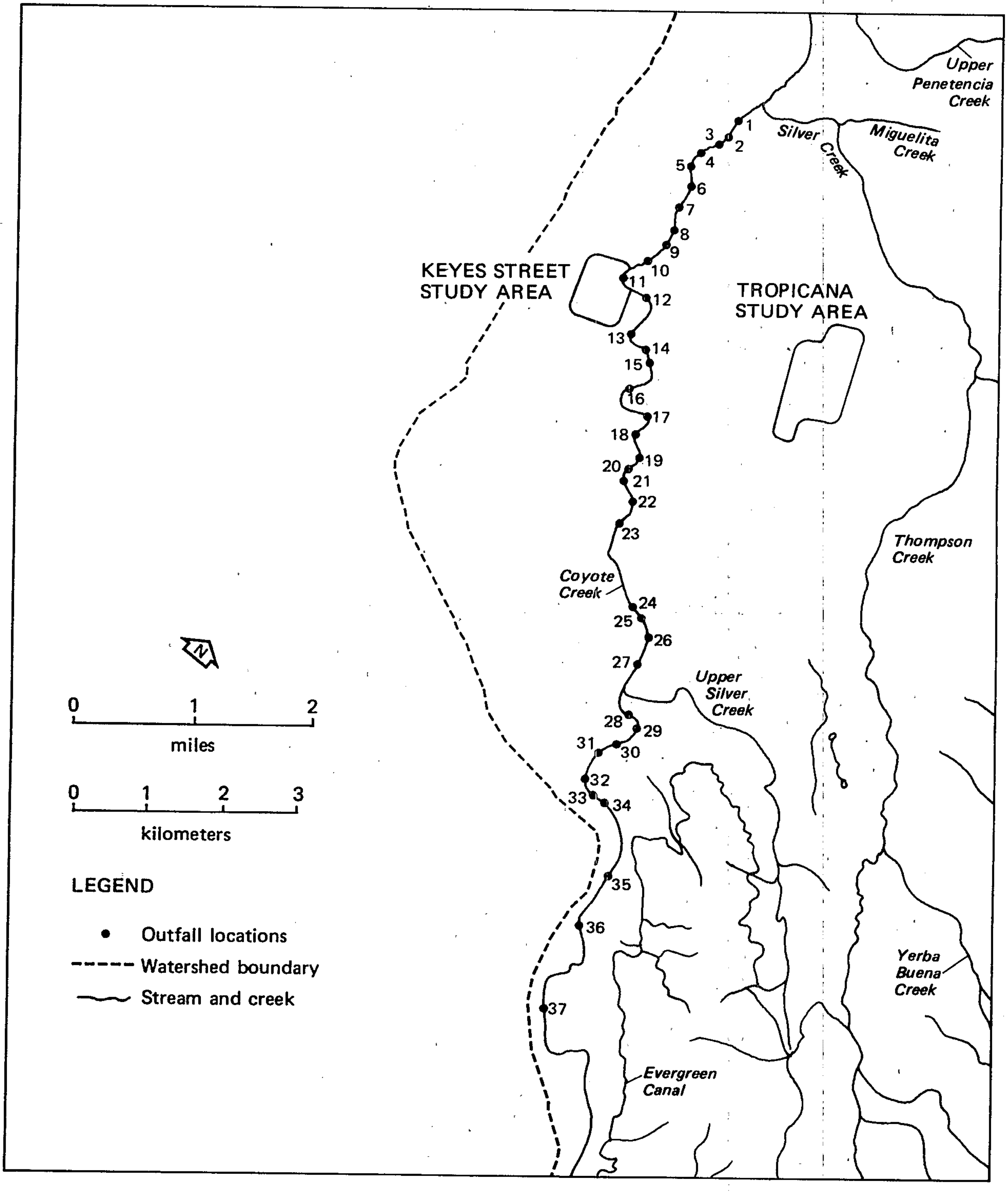

Figure 3-4. Locations of stormwater outfalls within area of study.

they are outside of the study area. A few non-listed storm drain outfalls may be located upstream from the outfalls shown on the map. Although they may range from 20 to 180 centimeters (8 to 72 inches), most of the outfall diameters are about 76 centimeters (30 inches) in diameter. The drainage area per outfall ranges from 2 to 320 hectares (5 to 800 acres) with most of the outfalls draining areas of less than 40 hectares (100 acres). The sediment and biological sampling stations located in the urbanized area were within this 20 kilometer (12 mile) section of the creek. Baseline (non-urban) monitoring stations were located upstream of those outfalls but below Anderson Dam.

SAMPLING STATION DESCRIPTIONS

Table 3-2 lists the monitoring stations studied during the first phase of this project. Also shown are the distances from the creek terminus at San Francisco Bay and elevation values for each station. The activities conducted at each station are also listed.

Table 3-2. SAMPLING STATION DESCRIPTIONS

Name	Distance From Creek Mouth (Kilometers)	Approx. Elevation (m)	Water Quality Samples (March 1977)	Biological and Sediment Samples (March-June 1978)
Non-urban area, below Lake Anderson:				
Cochran	60.1	120	X	X
Miramonte	54.7	95		X
Riverside	51.2	85	X	
Coyote	46.9	75	X	
Metcalfe	45.4	70		X
Tennant	41.9	65	X	
Urban area, above Silver Creek:				
Hellyer	34.6	45	X	
Tully	29.6	30	X	
Derbe	28.0	25		X
William	24.6	20	X	X
Tripp	21.9	20		X
Urban area, below Silver Creek:				
Berryessa	20.1	15	X	
Trimble	15.3	5	X	
Dixon	6.4	0	X	

Figure 3-5 shows the elevation of Coyote Creek and the locations of the water quality, sediment and biological sampling stations. Stations above 35 kilometers (22 miles) from the creek mouth were located upstream of the San Jose urban area. Table 3-3 shows the drainage area breakdown for each station. The urban stations have between 3 and 4% (1700 to 2500 hectares or 4000 to 6000 acres) of their total drainages urbanized, while the non-urban stations have less than 0.1% of their drainage areas urbanized.

Table 3-3. WATERSHED AREA ABOVE SAMPLING STATIONS

	Non-Urban Stations			Urban Stations		
	Cochran	Miramonte	Metcalfe	Derbe	William	Tripp
Total Area (hectares)	49,510	50,260	52,360	56,300	56,920	57,260
Urban Area (hectares)	<5	<5	<50	1740	2150	2460
Non-Urban Area (hectares)	49,510	50,260	52,360	54,560	54,770	54,800
Percent Urban	0.01	0.01	0.1	3.2	3.9	4.5

The following list briefly describes the conditions encountered at each sampling station:

- Cochran. The substrate was characterized by cobbles and gravel, with some sand. Riffle and flowing pool habitat predominates. The water temperature is depressed due to dam water releases. The banks are tree-lined and the creek is heavily shaded. The stream width varied from 5 to 10 m (15 to 30 ft). Depth was about 1 m (3 ft) and flow was less than 0.5 m/sec (1.5 ft/sec).
- Miramonte. The substrate at this location was also characterized by cobbles and gravel, with some sand; habitat consisted of riffles and flowing pools. Some trees were present, but the area was generally open. The water temperature was still depressed due to dam water releases. The creek was about 0.5 m (1.5 ft) deep, 3 to 5 m (9 to 15 ft) wide and flowed at about 1 m/sec (3 ft/sec).
- Riverside. The creek at this location flows along a diversion channel adjacent to agricultural lands and a golf course. The channel was 2 to 3 m (6 to 9 ft) wide, 1 m (3 ft) deep and flowed at about 0.5 m/sec (1.5 ft/sec). The creek was mud-bottomed with some cobbles being present along the shoreline. Bankside vegetation was limited to grasses and the creek had little shading.

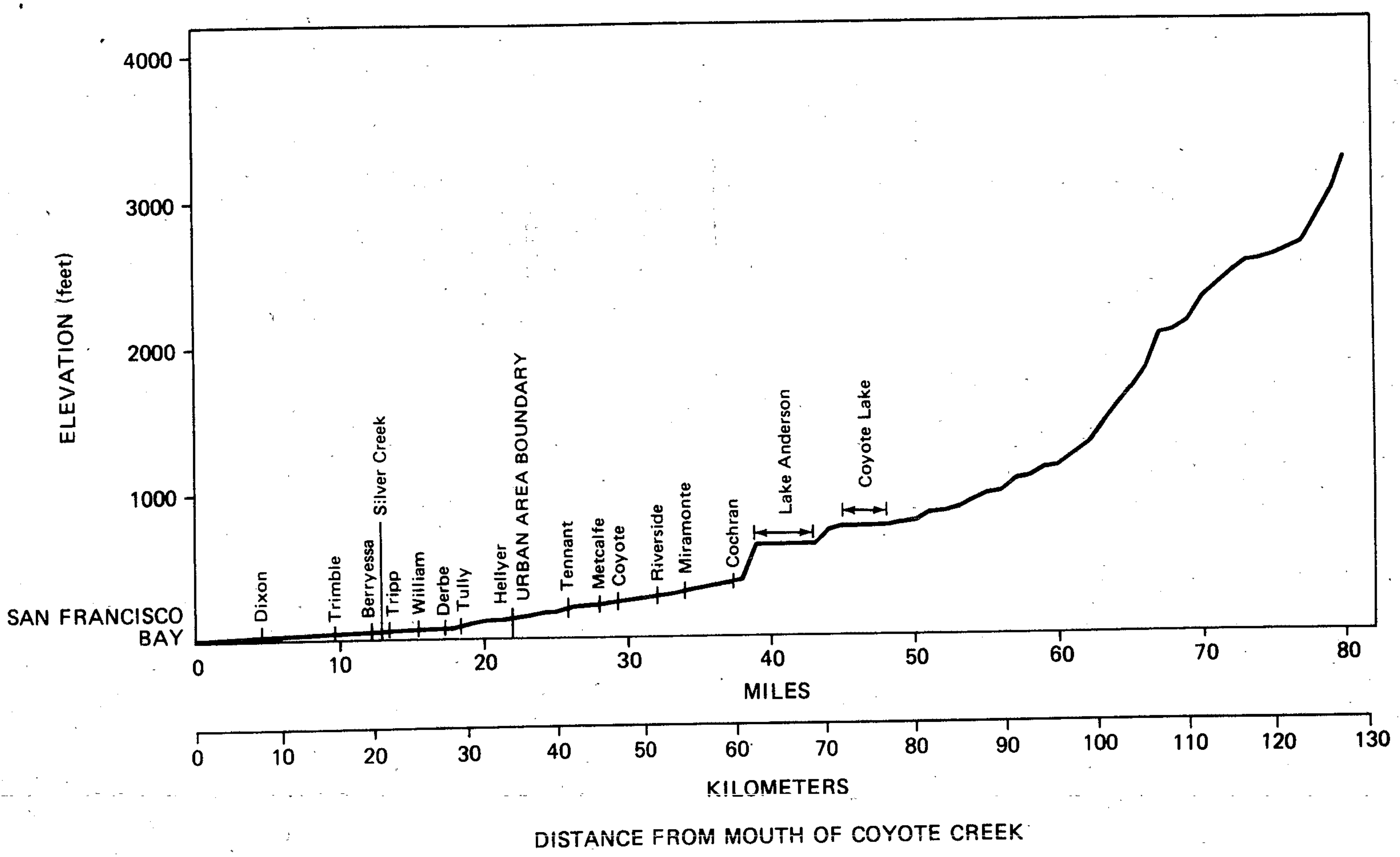

Figure 3-5. Elevation and location of sampling stations.

- Coyote. This section of stream was bordered by agricultural land, was 5 to 8 m (15 to 25 ft) wide, and generally less than 0.5 m (1.5 ft) deep. The creek was flowing at a velocity of about 0.3 m/sec (1 ft/sec). Substrate was comprised of sand and cobbles overlain with silt. The stream banks were lined with shrubs and trees, and the creek was partially shaded.

- Metcalfe. The creek substrate was cobble and gravel with some sand. The study site was generally unshaded, and had riffle and flowing pool habitats. The creek was about 0.5 m (1.5 ft) deep, 3 to 8 m (9 to 25 ft) wide and flowed at about 0.5 m/sec (1.5 ft/sec).

- Tennant. This section of the creek was comprised of pools, long runs, and riffles. The creek was from 2 to 15 m (6 to 45 ft) wide and ranged from 0.2 to over 1 m (0.5 to over 3 ft) in depth. Deeper portions may exist in some pool areas. The creek was flowing at velocities up to about 1 m/sec (3 ft/sec). The substrate was primarily comprised of gravel and cobbles, with an accumulation of silt being present in the pools. The banks were bordered by grasses and trees and the creek was partially shaded.

- Hellyer. The width of Coyote Creek at this station ranged from about 2 m (6 ft) along short riffles to about 12 m (36 ft) along slowly flowing pools. Substrate ranged from gravel to silt and mud, and the depth varied from 0.2 to about 1 m (0.5 to about 3 ft). Portions of the banks were tree-lined and shaded.

- Tully. This reach of Coyote Creek consisted entirely of pool habitat. Much debris and downfall were accumulated at the upstream side of the Tully Road Bridge which effectively dammed the stream. Very little flow was observed downstream of that location. The pools were mud-bottomed, 8 to 10 m (24 to 30 ft) wide, and appeared to be 1 to 2 m (3 to 6 ft) deep. The banks were tree-lined and well shaded.

- Derbe. This portion of the creek was mostly slowly flowing pools, with some short riffles. The bottom was gravel and sand with some silt. The creek was about 0.8 m (2.5 ft) deep and 1 to 3 m (3 to 9 ft) wide. Much debris and downfall was in the water and it was well shaded.

- William. Habitat along this reach of the stream consisted primarily of slowly flowing pools. Some short riffles were present in upstream areas. The water in this area was markedly clearer than at the upstream stations. The width was about 2 to 3 m (6 to 9 ft) and the stream ranged to about 0.5 m (1.5 ft) in depth. The flow was approximately 0.3 m/sec (1 ft/sec). Bottom substrate consisted of mud, silt, and detritus.

- Tripp. Here the creek had sand and silt substrate, with some gravel. It was mostly characterized by flowing pools with some short riffles. The stream was 0.5 to 1 m (1.5 to 3 ft) deep and 2 to 4 m (6 to 12 ft) wide. It was tree lined and well shaded.

- Berryessa. Pool habitat was dominant upstream of Berryessa Road and riffle habitat predominated downstream. The creek ranged from 3 to 5 m (9 to 15 ft) in width and varied from 0.2 to about 1 m (0.5 to about 3 ft) in depth. The flow was about 0.3 m/sec (1 ft m/sec). The substrate was chiefly comprised of gravel and sand, overlain with silt. The banks were tree-lined.

- Trimble. The creek was dominated by pool habitat upstream of Trimble Road, whereas riffle habitat was predominant downstream. The creek was about 3 m (9 ft) wide, its depth ranged from about 0.1 to 0.3 m (0.3 to 1 ft) and the flow was about 0.5 m/sec (1.5 ft/sec). The substrate consisted of sand, gravel and some cobbles all overlain with varying amounts of silt. Although some trees were present, the stream banks were generally bordered by herbaceous vegetation.

- Dixon. This station is located in a tidal channel, just upstream from the mouth of the creek and consisted entirely of flowing pool habitat. The creek flow is influenced by the tidal action of San Francisco Bay and is contaminated by the downstream discharge from the San Jose-Santa Clara wastewater treatment facility (an advanced secondary sewage treatment facility having a capacity of about 1.5 billion liters per day, 400 MGD). The creek was about 10 m (30 ft) wide, 1.5 m (4.5 ft) deep at low tide, and mud-bottomed.

SECTION 4

CHARACTERIZATION OF URBAN RUNOFF

Runoff water quality data obtained from the street cleaning demonstration study (Pitt 1979) were examined to estimate urban runoff yields and chemical characteristics. These data were analyzed by an equilibrium water chemistry computer program to estimate the specific chemical compounds and to estimate those that would remain soluble and those that would settle out into the receiving water sediments. This information is presented in Tables 4-1 and 4-2 and shows that most of the urban runoff pollutants are soluble (except for possibly lead and phosphate) and would be expected to be carried in the water column of the receiving water. However, almost all (95%) of the inorganic lead compounds expected in urban runoff (mostly forms of lead carbonate and lead phosphate) are expected to occur as insoluble particulates and, depending upon their size, may settle out in the sewerage or into the receiving water sediments. Two others that may settle out are chromium and phosphate. This was substantiated in the field studies by the large concentrations of lead that were found in the urban creek sediments. The soluble forms of the other parameters monitored are mostly expected to be in the ionic form.

The information presented in Tables 4-1 and 4-2 and data obtained from the Santa Clara County area-wide wastewater managment plan (Metcalf and Eddy 1978), were used to estimate the urban area unit pollutant yields for the study area. Table 4-3 presents these urban runoff yields on a pounds per acre per year basis. The estimated annual urban runoff yields affecting the monitoring stations in Coyote Creek are also shown. The non-urban stations are affected by substantially smaller quantities of the monitored pollutants. These non-urban stations are affected by runoff from undeveloped and agricultural areas, whereas the urban stations are affected by urban areas in addition to these undeveloped and agricultural areas. The pollutant yields in the creek affecting the urbanized stations are all substantially greater than the quantities affecting the non-urban stations. As an example, the total solids discharges affecting the creek in the urban areas are more than one hundred times greater than the total solids discharges affecting the non-urban areas. The lead discharges affecting the urban areas were also several thousand times greater than the lead discharges affecting the non-urban areas.

Table 4-1. FLOW-AVERAGED SOLUBLE URBAN RUNOFF CONCENTRATIONS (mg/l as parameter, except as noted)

Parameters	Keyes Study Area		Tropicana Study Area			Min.	Max.	Average
Date of Storms:	3/15 and 16/77	3/23 and 24/77	3/15 and 16/77	3/23 and 24/77	4/30 and 5/1/77			
Total Ca(1)	2.8	19	11	15	16	2.8	19	13
Ca++	2.8	18.5	10.0	14.0	15.5	2.8	18.5	12.2
$CaSO_4$	<0.1	1.4	0.7	1.5	1.7	<0.1	1.7	1.1
$CaHCO_3$+	<0.1	<0.1	<0.1	0.4	<0.1	<0.1	0.4	0.1
Total Mg	1.4	3.9	3.9	6.2	4.8	1.4	6.2	4.0
Mg++	1.4	3.8	3.8	5.9	4.6	1.4	5.9	3.9
$MgSO_4$	0.1	0.5	0.5	1.1	0.9	0.1	1.1	0.6
$MgHCO_3$+	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	0.2	<0.1
Total K	1.5	3.0	1.9	3.4	3.5	1.5	3.5	2.7
K+	1.5	2.9	1.9	3.4	3.5	1.5	3.5	2.6
Total Na	2.1	9.2	14	27	23	2.1	27	15
Na+	2.1	9.2	14	27	23	2.1	27	15
Total Cu	0.02	0.04	0.02	0.013	0.05	0.013	0.05	0.03
Cu+	0.01	0.02	0.01	0.01	0.05	0.01	0.05	0.02
Cu++	0.005	0.01	0.004	0.002	<0.001	<0.001	0.01	0.004
$CuCO_3$	0.006	0.01	0.007	0.004	<0.001	<0.001	0.01	0.005
$CuHPO_4$	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
CuOH+	0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Total Cd	0.004	0.004	<0.002	<0.002	0.002	<0.002	0.004	0.002
Cd++	0.004	0.004	<0.002	0.002	0.002	<0.002	0.004	0.002
$CdSO_4$	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001
CdCl+	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total Zn	0.11	0.32	0.10	0.12	0.27	0.10	0.32	0.18
Zn++	0.11	0.31	0.10	0.12	0.26	0.10	0.31	0.18
$ZnPO_4$	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.001
$ZnSO_4$	<0.001	0.02	0.005	0.009	0.02	<0.001	0.02	0.011
Total Pb (2,3)	0.27	0.76	0.22	0.20	0.66	0.20	0.76	0 42
Pb++	<0.001	0.01	0.003	0.002	<0.001	<0.001	0.01	0.003
$PbCO_3$	0.005	0.02	0.02	0.02	<0.001	<0.001	0.02	0.01
Total Cr	0.01	0.03	0.01	0.009	0.02	0.009	0.03	0.04
$Cr(OH)_2$	0.02	0.05	0.02	0.02	<0.001	<0.001	0.05	0.02
CrOH+	<0.001	<0.001	<0.001	<0.001	0.03	<0.001	0.03	0.006
Total CO_3	0.006	0.055	0.013	0.022	<0.001	<0.001	0.055	0.019
Total HCO_3	16	150	37	62	<0.001	<0.001	150	53
HCO_3	0.006	0.008	0.01	0.01	<0.001	<0.001	0.01	0.007

Table 4-1. (concluded)

Parameters	Keyes Study Area		Tropicana Study Area			Min.	Max.	Average
Total SO_4	6.3	18	15	26	27	6.3	27	18
$SO_4^{=}$	6.2	17	14	24	25	6.2	25	17
Total Cl	3.9	12	12	16	18	3.9	18	12
Cl^-	3.9	12	12	16	18	3.9	18	12
Total ortho PO_4	3.3	0.2	2.2	0.5	6.0	0.2	6.0	2.4
$H_2PO_4^-$	2.7	0.2	0.9	0.3	4.4	0.2	4.4	1.7
$MgHPO_4$	<0.001	<0.001	<0.001	<0.008	<0.001	<0.001	0.008	0.002
Total NO_3	0.5	0.9	1.5	0.5	0.3	0.3	1.5	0.7
NO_3^-	0.5	0.9	1.5	0.5	0.3	0.3	1.5	0.7
Total Hg	<0.001	0.0001	<0.0001	<0.0001	0.0002	<0.0001	0.0002	<0.0001
Kjeldahl N	8.0	3.6	3.1	3.8	15	3.1	15	6.7
pH, pH units	7.0	6.7	6.9	7.0	6.3	6.3	7.0	6.8
ORP, mV	135	140	130	110	78	78	140	120
Temp, °C	15	15	15	15	15	15	15	15
spec. cond., umhos/cm	33	100	80	120	130	33	130	93
Turbidity, NTU	43	86	37	38	41	37	86	49
Total Solids	150	680	180	110	380	110	680	300
Total dissolved solids	34	110	83	66	160	34	160	91
Suspended solids	110	570	97	41	220	41	570	210
Volatile sus.solids	—	40	—	5	—	5	40	23
Disolved oxygen	6.5–9.4	7.4–9.9	7.4	7.5–8.6	—	6.5	9.9	8
BOD_5	30	22	25	17	28	17	30	24
COD	130	350	77	160	260	77	350	200
TOC	34	140	19	48	290	19	290	110

The above compounds are all soluble, except for the "total" values which include soluble and insoluble compounds
The following compounds are expected to occur in urban runoff in solid form and are therefore not shown on the above table:

(1) $CaHPO_4$
(2) $PbCO_3$
(3) $Pb_3(PO_4)_2$

The "total" values represent all valence states.

Table 4-2. PRIMARY DISTRIBUTION OF METALS AND LIGANDS IN URBAN RUNOFF (%)

Parameters	Keyes Study Area		Tropicana Study Area			Min.	Max.	Average
Date of Storms	3/15 and 16/77	3/23 and 24/77	3/15 and 16/77	3/23 and 24/77	4/30 and 5/1/77			
Calcium:								
Ca^{++}	98.4	97.3	91.0	95.0	96.8	91.0	98.4	95.7
$CaSO_4$	<1	2.2	1.8	2.9	3.2	<1	3.2	2.0
$CaHCO_3$	<1	<1	<1	1.0	<1	<1	1.0	0.2
$CaHPO_4$ (a solid)	<1	<1	6.5	1.0	<1	<1	6.5	1.5
Total	98.4(1)	99.5	99.3	99.0	100.0	98.4	100.0	99.4
Magnesium:								
Mg^{++}	97.9	96.8	96.7	95.2	95.9	95.2	97.9	96.5
$MgSO_4$	1.2	2.7	2.4	3.7	3.9	1.2	3.9	2.8
$MgHCO_3+$	<1	<1	<1	1.1	<1	<1	1.1	0.2
Total	99.1(2)	99.5	99.1(3)	100.0	99.8	99.1	100.0	99.5
Potassium:								
K^+	99.9	99.8	99.9	99.8	99.7	99.7	99.9	99.8
Sodium:								
$Na+$	100.0	99.9	99.9	99.9	99.9	99.9	100.0	99.9
Copper:								
Cu^+	54.6	54.5	57.8	68.0	95.0	54.5	95.0	66.0
Cu^{++}	24.4	32.1	21.5	13.0	4.5	4.5	32.1	19.1
$CuCO_3$	15.3	10.6	17.9	17.1	<1	<1	17.9	12.2
$CuHPO_4$	2.5	<1	<1	<1	<1	<1	2.5	0.5
$CuOH+$	2.9	1.9	<1	1.5	<1	<1	2.9	1.3
Total	99.7	99.1	97.2[4,11]	99.6	99.5(4)	97.2	99.7	99.1
Zinc:								
Zn^{++}	97.5	97.6	97.6	96.6	96.3	96.3	97.6	97.1
$ZnPO_4$	1.3	<1	<1	<1	<1	<1	1.3	0.3
$ZnSO_4$	<1	2.2	1.9	3.0	3.1	<1	3.1	2.0
Total	98.8	99.8	99.5	99.6	99.4(5)	98.8	99.9	99.4
Lead:								
Pb^{++}	<1	1.3	1.5	1.2	<1	<1	1.5	0.8
$PbCO_3$	1.3	2.1	6.4	8.0	<1	<1	8.0	3.6
$PbCO_3$ (a solid)	<1	96.1	<1	89.8	<1	<1	96.1	37.2
$Pb_3(PO_4)_2$(a solid)	98.0	<1	91.1	<1	98.8	<1	98.8	57.6
Total	99.3	99.5	99.0(6)	99.0(7)	98.8	98.8	99.5	99.2
Chromium:								
$Cr(OH)_2$	100.0	100.0	100.0	100.0	<1	<1	100.0	80.0
$Cr(OH)^{++}$	<1	<1	<1	<1	99.8	<1	99.8	20.0
Total	100.0	100.0	100.0	100.0	99.8	99.8	100.0	100.0
Carbonate:								
HCO_3^-	99.6	14.1	81.6	60.2	—	14.1	99.6	63.9
H_2CO_3	<1	84.3	17.7	38.2	—	<1	84.3	35.1
$PbCO_3$ (a solid)	<1	1.4	<1	<1	—	<1	1.4	0.4
Total	99.6	99.8	99.3(8)	98.4(9)	—	98.4	99.8	99.4
Sulfate:								
$SO_4=$	97.8	91.9	94.2	92.0	92.2	91.9	97.8	93.6
$CaSO_4$	1.0	5.5	3.1	4.0	4.5	1.0	5.5	3.6
$MgSO_4$	1.1	2.3	2.4	3.5	2.8	1.1	3.5	2.4
Total	99.9	99.7	99.7	99.5	99.5(10)	99.5	99.9	99.6
Chloride:								
Cl^-	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Phosphate:								
$Pb_3(PO_4)_2$ (a solid)	20.3	<1	23.2	<1	27.6	<1	27.6	14.2
H_2PO_4	79.0	98.4	27.9	62.1	71.9	37.9	98.4	67.9
$CaHPO_4$ (a solid)	<1	<1	38.2	36.0	<1	<1	38.2	14.8
$MgHPO_4$	<1	<1	<1	1.2	<1	<1	1.2	0.2
Total	99.3	98.4	99.3[11]	99.3[12]	99.5	98.4	99.5	97.1
Nitrate:								
NO_3^-	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Other parameters (all <1%) are as follows:

(1) CaHCO and $CaSO_4$
(2) $MgHCO_3$ and $MgHPO_4$
(3) $MgHCO_3$
(4) $CuSO_4$
(5) $ZnHPO_4$
(6) PbCl
(7) $PbOH^+$
(8) $CaHCO_3$ and $MgHCO_3$
(9) $NaCO_3$
(10) $NaSO_4$
(11) $CuHPO_4$ and $ZnHPO_5$
(12) $ZnHPO_4$

Table 4-3. ANNUAL URBAN RUNOFF YIELD AFFECTING EACH STATION (Ton/year)

Parameter	Urban Area Unit Yield (kg/hectare/yr)	Monitoring Station					
		-----Non Urban Area----			-----Urban Area-----		
		Cochran	Miramonte	Metcalf	Derbe	William	Tripp
Total Solids	280	<1	<1	<10	490	600	690
COD	90	<1	<1	<10	150	190	220
BOD_5	45	<1	<1	<10	78	100	110
Kjeldahl N	2.8	<0.1	<0.1	<0.1	4.9	6.0	6.9
Ortho-PO_4	1.5	<0.01	<0.01	<0.1	2.5	3.2	3.6
Lead	1.1	<0.01	<0.01	<0.01	2.0	2.5	2.7
Zinc	0.11	<0.001	<0.001	<0.01	0.2	0.3	0.3
Chromium	0.11	<0.001	<0.001	<0.01	0.2	0.3	0.3
Copper	0.16	<0.001	<0.001	<0.01	0.3	0.4	0.4
Cadmium	0.0011	<0.0001	<0.0001	<0.0001	0.002	0.003	0.003

SECTION 5

SOURCES OF URBAN RUNOFF POLLUTANTS

One of the major problem areas yet to be sufficiently addressed concerning urban runoff is knowing the relative contributions from different pollutant sources in the watershed to the outfall yield. Sources that are further from the storm drainage system and require overland flow have a very low yield of most pollutants when compared with parking lots or street surfaces that are impervious and located adjacent to the drainage system. Table 5-1 presents the preliminary results from an additional phase of this project, which is examining potential sources of urban runoff pollutants. This phase of the study involves collecting runoff samples during rainstorms from different areas within San Jose. These are all small areas and include different types of building roofs, parking lots, and gutter flows. Rainfall and outfall samples are also being collected for chemical analyses. As expected, rain, in most cases had the lowest associated pollutant concentrations. The parking lot and gutter flows had the greatest concentrations of many of the monitored pollutants. Monitored puddles in a city park had much greater concentrations of total solids, specific conductance, and nitrates than any of the other samples.

Table 5-2 is a generalization of urban runoff pollutant sources for common pollutants. No one source area is expected to contribute significant quantities of most of the pollutants, but some of the areas are expected to be quite important. Street surfaces are expected to be responsible for significant contributions of many heavy metals. Oxygen demanding materials and nutrients are thought to originate mostly from landscaped and vacant areas. Table 5-3 is also a generalization and attempts to show the major contributors affecting these major areas and the approximate annual average delivery yields from each of the source areas to the outfall yield. Vacant lots and landscaped areas typically are the most pervious surfaces in an urban area and are also located farthest from the urban drainage system; therefore, they contribute little flow. Landscaped and vacant areas make up almost half of the total area in the San Jose urban area. However, only 5% of the rainfall falling on these areas is expected to contribute to the outfall flow. Similarly, very little of the potential pollutant yield from these areas is expected to affect the outfall. Rooftops, which make up 15-20% of the urban area, are also located a relatively long distance away from the storm sewerage system. Rooftops are directly connected to the storm sewerage system and require considerable overland flow. Therefore, the outfall runoff yield from rooftops is expected to be about 30%. Sidewalks, which make up about 5% of the urban area, are located closer to the storm drainage system, but some of their drainage flow is directed toward adjacent landscaped or other pervious area. Therefore, only about

Table 5-1. URBAN RUNOFF POLLUTANT CONCENTRATIONS FROM MAJOR AREAS (mg/l, unless otherwise noted)

Parameter	Outfall	Gutter Flow	Parking Lot	Park Puddles	Commercial Tar and Gravel Roof	Residential Composition Shingle Roof	Rain
pH, pH Units	7.8	7.5	7.0	7.3	7.5	6.5	6.4
Specific Conductance, (umhos/cm)	185	130	45	2400	155	11.2	10.4
Turbidity, NTU	29	100	26	21	1	<1	<1
Total Solids	162	235	340	2140	186	18	30
BOD_5	8	13	22	3	7	3	3
COD	97	172	176	69	131	19	12
$O\text{-}PO_4$	0.23	0.12	0.47	0.32	0.02	0.08	0.03
Total PO_4	0.34	0.31	0.49	0.42	0.07	0.10	0.03
Kjeldahl N	1.52	2.41	1.47	1.32	4.37	0.71	0.64
NH_3	0.25	0.42	0.35	1.23	1.06	0.50	0.36
NO_3	0.74	0.42	0.13	285	0.22	0.09	0.09
S	4	2	<1	15	5	<1	<1
SO_4	13	7	<1	38	21	<1	<1
As	<0.01	<0.01	0.02	0.10	<0.01	0.01	<0.01
Zn	0.06	0.14	0.23	0.01	0.08	0.18	0.04
Pb	0.08	0.67	1.09	0.035	0.019	0.017	<0.01
Cr	0.009	0.049	0.071	0.010	<0.005	<0.005	<0.005
Cu	0.013	0.029	0.046	0.031	0.11	<0.005	0.010
Total Coliform Bacteria (MPN/100ml)	>2400	>2400	540	49	170	<2	8
Fecal Coliform Bacteria (MPN/100ml)	>2400	920	350	49	9	<2	2
Fecal Strep. Bacteria (MPN/100ml)	>2400	>2400	>2400	920	17	920	<2
Fecal Coliform/Fecal Strep. Ratio	-	<0.4	<0.2	0.5	0.5	<0.002	>1

Table 5-2. POTENTIAL SIGNIFICANT URBAN RUNOFF POLLUTANT SOURCES

Common Urban Runoff Pollutants	Potential Significant Pollutant Sources						
	Rooftops	Street Surfaces	Parking Lots	Landscaped Areas	Vacant Land	Construction Sites	Other (Industrial and Solid Waste Runoff)
Sediment		X			X	X	
Oxygen Demanding Matter				X			
Nutrients				X	X		
Bacteria		X			X		
Heavy Metals		X	X				
Pesticides/Herbicides				X			
Oils and Grease		X	X			X	
Floating Matter				X			
Other Toxic Materials	X	X	X				X

Table 5-3. MAJOR URBAN AREAS AND DELIVERY YIELDS TO OUTFALL (Percent)

Pollutant Contributors	Lawn and Landscaped Areas 5%	Vacant Lots 5%	Rooftops 30%	Sidewalks 45%	Parking Lots 50%	Street Surface 75%
Dustfall	X	X	X	X	X	X
Pecipitation	X	X	X	X	X	X
Tire Wear	X (Adjacent)			X	X	X
Auto Exhaust Particulates	X (Adjacent)			X	X	X
Other Auto Use (Fluid Drips, Wear Prod.)				X	X	X
Vegetation Litter	X	X		X	X	X
Construction Erosion		X				
Other Litter		X		X	X	X
Bird Feces	X	X	X	X		
Dog Feces	X	X				X
Cat Feces	X	X				
Fertilizer Use	X					
Pesticide Use	X					

half of the runoff yield from sidewalks enters the receiving water flow. Parking lots in the urban area make up about 7% of the area and are mostly paved and impervious. Again, some of the runoff from the parking lots (especially at homes and apartments) is directed towards adjacent pervious areas, and only about half of the parking lot runoff is expected to reach the receiving waters. Street surfaces, however, are located close to the storm drainage system and are almost impervious. Street surfaces are about 15-20% of the urban area and most of the runoff originating from the street surfaces is expected to reach the outfall. Some of the street surface flow, however, does not reach the outfall because of infiltration in streets in poor condition and evaporation. Dustfall and precipitation affect all of these major area components. Dustfall, however, is not a major pollutant source but is mostly a mechanism for pollutant transport. Most of the dustfall monitored in an urban area is resuspended particulate matter from street surfaces or wind erosion products from vacant areas. Some point source air pollutant emissions also contribute to dustfall pollution. The bulk of the dustfall, however, is contributed by the other major pollutant sources.

Automobile tire wear is a substantial source of zinc in urban runoff and is mostly deposited on street surfaces and adjacent areas. About half of the settleable particulates lost due to tire wear settle on the street and the remaining material settles within about 6 meters (20 feet) of the roadway. Auto exhaust particulates are also important pollutant contributors for heavy metals, especially lead, and mostly affect street surfaces and adjacent areas. Other automobile use pollutant contributions are associated with fluid losses by drips, spills and mechanical wear products. Other heavy metals and asbestos are important pollutants associated with these other automobile losses. Most of these pollutants directly affect parking lots and street surfaces, with some material landing on adjacent areas due to wind transportation.

Vegetation litter can be a significant pollutant component in almost all of these source areas. Leaf fall on streets in San Jose is an important street surface pollutant in the fall months. Animal feces can contribute relatively important nutrient and bacteria quantities in the urban area, but it mostly affects vacant and landscaped areas. Fertilizer and pesticide use is mostly associated with landscaped areas, but large amounts of pesticides can be used to control plant growths on impervious surfaces. Fertilizers may be used in large quantities in road maintenance operations.

Table 5-4, based on preliminary results, estimates the percentage contribution of the various pollutants from the different source areas studied. Rooftops are seen to contribute the least amount of pollutants in almost all cases, while the pervious areas can contribute the majority of the solids, oxygen demanding materials, and some nutrients. Parking lots, street surfaces, and sidewalks are expected to contribute the majority of the heavy metals, bacteria, and some nutrients to the total outfall runoff yield.

Most of the street surface dust and dirt material (by weight) are local soil erosion products, while some material is contributed from motor vehicle emissions and wear. Minor contributions are made by wear of the street surfaces for smooth streets in good condition. The specific makeup of street surface contaminants is a function of many site conditions and varies widely.

Table 5-4. CONTRIBUTIONS FROM VARIOUS AREAS TO OUTFALL RUNOFF YIELDS (Percent)

Parameter	Street Surfaces and Sidewalks	Parking Lots	Landscaped Areas and Vacant Lots	Rooftops
Total Solids	40	10	50	2
COD	25	15	50	5
BOD_5	25	20	50	2
Ortho PO_4	45	30	20	10
Total PO_4	65	20	15	5
Total Kjeldahl N	50	10	25	15
NH_3	50	10	20	20
NO_3	20	1	75	2
Total S	45	<1	50	5
SO_4	50	<1	40	5
As	<1	15	70	10
Zn	60	20	1	20
Pb	80	20	<1	<1
Cr	80	20	2	<1
Cu	60	20	10	10
Total Coliform Bacteria	>95	<5	<1	<1
Fecal Coliform Bacteria	>95	<3	<1	<1
Fecal Strep Bacteria	>60	>10	<3	<30

Many pollutant sources are specific to a particular area and on-going activities. For example, iron oxides are associated with welding operations and strontium, used in the production of flares and fireworks, would probably be found on the streets in greater quantities around holiday times or at the scenes of traffic accidents.

Relative deposition values for the different pollutants from the various source areas are summarized in Table 5-5. These deposition values are the percentage of the total pollutant deposited in the urban areas. The deposition rates are much larger than the pollutant yields to the outfall. As a comparison, Table 5-6 shows the relative yields from these source areas to the total outfall runoff yield. The deposition rates for some of the pollutants are shown to be relatively high for some of the impervious areas, but these source yields are reduced substantially when infiltration is considered. Automobile activity is responsible for most of the heavy metal yield in the runoff and about half of the total solids yield. Vegetation sources contribute most of the oxygen demand materials, while dog feces and fertilizer use are expected to contribute most of the nitrogen in urban runoff.

Table 5-7 summarizes expected San Jose urban runoff characteristics. These conditions could vary substantially for other areas of the country but do point out important considerations in urban runoff. If all of the total solids pollutant depositions in an urban area were added up, only about 1/3 would reach the outfall. Only about 10% of the nutrients and oxygen demanding materials deposited may affect the receiving water quality, but most of the heavy metals deposited in the area would affect the receiving waters. The remaining deposited pollutants that are washed off of the source areas and do not reach the outfall would be accumulated in other areas in the urban environment. The most significant pollutant "sinks" in the urban area are expected to be soils, groundwater, and plants. As an example, many studies have shown significant concentrations of heavy metals in roadside soils and vegetation (Farwer and Lyon 1977; McMullen and Faoro 1977; Olson and Skogerboe 1975, and Pitt and Amy 1973). As noted earlier, much of this material (about 15% of the total deposition of total solids) can be associated with dustfall. Most of this dustfall however is resuspended particulates from the streets and vacant areas and is not an actual source of urban runoff pollutants, except for point source air pollution emissions that may settle out.

Table 5-5. RELATIVE ANNUAL SOURCE DEPOSITIONS (Percent)

Source	Total Solids	BOD_5	TKN	Pb	Zn	Cr	Cu
Precipitation	10	3	5	<1	15	<1	10
Tire Wear	5	<1		10	80	10	5
Auto and Street Use	20	1	1	90	1	70	50
Vegetation	40	95	15				
Construction Erosion	20		<1	<1	2	10	2
Bird Feces	2	<1	<1	<1	<1		
Dog Feces			40				
Cat Feces			<1				
Fertilizer Use			40				
Other	3	1				10	30

Table 5-6. RELATIVE ANNUAL RUNOFF YIELD CONTRIBUTIONS (Percent)

Source	Total Solids	BOD_5	TKN	Pb	Zn	Cr	Cu
Precipitation	10	10	20	<1	20	<1	5
Tire Wear	5	1		1	80	3	2
Auto and Street Use	50	10	10	100		90	80
Vegetation	30	70	10				
Construction Erosion	5		<1	<1	<1	1	<1
Bird Feces	5	<1	1	<1	<1		
Dog Feces			30				
Cat Feces			<1				
Fertilizer Use			30				
Other	3	5				5	15

Table 5-7. EXPECTED SAN JOSE URBAN RUNOFF CHARACTERISTICS

	Total Solids	BOD_5	TKN	Pb	Zn	Cr	Cu
Expected Outfall Runoff Yield (kg/ha/yr)*	280	45	2.8	1.1	0.11	0.11	0.16
Percentage of Deposition Yield to Outfall (%)	30	10	10	90	20	70	60
Major Sources Contributing to Runoff Yield	Auto and Street Use	Vegetation	Dog Feces and Fertilizer Use	Auto and Street Use	Tire Wear	Auto and Street Use	Auto and Street Use

*Multiply kg/ha/yr by 0.892 to obtain lb/acre/yr.

SECTION 6

EFFECTS OF URBAN RUNOFF

RUNOFF AND RECEIVING WATER QUALITY DURING STORMS

Table 4-1 showed the ranges and average runoff pollutant concentrations for several monitored storms in San Jose. Coyote Creek, the receiving water, has water quality concentrations in the urban area similar to the runoff conditions during storms. These water quality conditions only occur during the time of storm runoff. The water quality in the urbanized area of Coyote Creek improves somewhat during dry weather. Therefore, care must be taken to consider beneficial uses that are actually being impaired. As an example, nobody would be swimming in the creek during storms, but aquatic life could be severely impacted during storms. Table 6-1 compares these runoff concentrations to recommended water quality criteria for various beneficial uses. The water quality criteria values shown for these uses are recommended maximum limits designed to protect the beneficial uses with a reasonable amount of safety. If a monitored concentration exceeds these criteria, it does not mean that a problem exists, but that a problem may occur and additional monitoring may be necessary to define the relationships between water quality and impairment of the beneficial uses for the specific receiving water. The following list summarizes the parameters that exceeded the recommended beneficial use criteria.

Livestock: Pb*
Wildlife: none
Aquatic life: Cr, Cd*, Pb*, Hg*, BOD_5, turbidity*, suspended solids*
Marine life: PO_4*, Cd, Cu, Zn
Recreational uses: PO_4*
Freshwater public supply: Cd, Pb*
Irrigation: Cd

The heavy metals--cadmium, chromium, lead, mercury, and zinc--along with phosphates, BOD, suspended solids, and turbidity can exceed the recommended criteria. Drinking water standards are not compared because the water would be treated before use and the freshwater public supply criteria would apply. The high turbidity of the runoff water is expected to exceed the narrative criterion for aquatic life. Observed average and maximum suspended solids runoff concentrations exceeded the aquatic life criterion. All of the runoff phosphate concentrations exceeded the marine life criterion by a large amount, and the average and maximum phosphate concentrations exceeded the recreation criterion by a large amount. The phosphate recreation criterion

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*The maximum monitored value was greater than ten times the minimum recommended criterion.

Table 6-1. RUNOFF WATER QUALITY COMPARED TO BENEFICIAL USE CRITERIA

Parameter[a]	Overall Observed			Beneficial Use Criteria[b]				
	Min.	Max.	Avg.	Irrigation	Livestock	Wildlife	Aquatic Life	Marine Life
pH (pH units)	6.0	7.6	6.7	4.5 → 9.0 desired	-	6.0 → 9.0 desired	6.0 → 9.0 desired	6.5 → 8.5 desired
Temp. (°C)	14	16.5	16	Narrative	-	Maintain natural pattern	Narrative	Narrative[c]
DO	5.4	12.8	8.0	-	-	-	Usually 5.0 mg/l min.	6.0 mg/l min.
Turbidity (NTU)	4.8	130	49	-	-	-	Small change	-
TDS	22	376	150	500 → 5000 mg/l max.	-	-	Narrative	-
SS	15	845	240	Narrative	-	-	80 mg/l	-
NO_3	0.3	1.5	0.7	Narrative	450 mg/l (including NO_2)	-	-	-
PO_4	0.2	17.6	2.4	-	-	-	-	0.0003 mg/l
Cl	3.9	17.6	12	-	-	-	-	-
SO_4	6.3	27	18	-	-	-	-	-
Na	2.1	26.8	15	Narrative	-	-	-	-
Cd	<0.002	0.04	0.01	0.01 → 0.05 mg/l max.	0.05 mg/l	-	0.004 → 0.03 mg/l max. for soft → hard water	0.01 mg/l
Cr	0.005	0.04	0.02	0.1 → 1.0 mg/l max.	1.0 mg/l	-	0.03 mg/l	0.1 mg/l
Cu	0.01	0.09	0.03	0.02 → 5.0 mg/l max.	0.5 mg/l	-	Narrative	0.05 mg/l
Pb	0.10	1.5	0.4	5.0 → 10.0 mg/l max.	0.1 mg/l	-	0.03 mg/l	Narrative
Hg	<0.0001	0.0006	<0.0001	-	0.001 mg/l	Narrative	0.00005 mg/l	0.1 mg/l
Zn	0.06	0.55	0.18	-	25 mg/l	-	Narrative	0.1 mg/l
BOD_5	17	31	24	-	-	-	10 mg/l	Narrative

Sources: McKee and Wolf 1963; USEPA 1973; USEPA 1975.

[a] Parameters are measured in mg/l unless otherwise noted.

[b] Maximum limits unless stated as desired range or minimum values.

[c] Narrative implies a potential conflict between the parameter and beneficial use, but lack of data or too many important site specific conditions do not allow a specific value to be used as a general criterion.

is designed to prevent eutrophication* in receiving waters. Average and maximum cadmium concentrations exceeded the irrigation, aquatic life, marine, and freshwater supply criteria. Maximum copper and chromium concentrations in the runoff also exceeded the aquatic life and marine criteria. All of the lead concentrations in the runoff exceeded the livestock, aquatic life, and freshwater supply criteria by large amounts. The maximum runoff mercury concentrations exceeded the aquatic life criterion by a large amount. The average and maximum zinc runoff concentrations exceeded the marine life criterion. All of the observed BOD_5 concentration values in the runoff exceeded the aquatic life criterion. As these data show, those parameters most potentially responsible for water quality impairment are solids, cadmium, lead, and mercury for aquatic life uses; orthophosphates for marine life; orthophosphates for recreational use (eutrophication); and lead for freshwater public supply.

Preliminary data show that high suspended solids and phosphate concentrations in the non-urban area during wet weather can also greatly exceed the aquatic life and marine life criteria, respectively. The phosphate concentration may also exceed the recreation criteria.

Table 6-2 presents a comparison between secondary sanitary wastewater effluent and urban runoff for the study areas. The average and peak one hour runoff concentrations observed and average secondary sanitary wastewater effluent concentrations are shown along with the ratios between them. The sanitary wastewater treatment facility is a modern, advanced secondary treatment plant serving the study area. The short term effects of urban runoff on a receiving water occur (by definition) during and immediately following a runoff event: short-term effects are associated with instantaneous concentrations. A comparison between the urban runoff average concentrations and the sanitary wastewater treatment plant effluent average concentrations shows that the concentrations of lead, suspended solids, COD, cadmium, TOC, turbidity, zinc, chromium, and BOD_5 are all higher in the runoff than in the sanitary wastewater effluent. Copper and Kjeldahl nitrogen, in addition to the previously listed parameters, have greater runoff peak concentrations than the wastewater average concentrations. Therefore, urban runoff may have more important short-term effects on receiving waters than average treated sanitary wastewater effluent.

The annual yield for the different sources gives a measure that indicates potential long-term problems. Table 6-2 also shows the annual sanitary wastewater treatment plant effluent yield expressed in weight per year (derived from monthly average concentrations and effluent quantities), and the calculated street surface portion of the annual urban runoff yield, also expressed in weight per year for a similar service area. On an annual basis, the total orthophosphate and Kjeldahl nitrogen yields associated with the street surface runoff are less than 4% of the total sanitary wastewater treatment plant effluent

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*Excessive algae growth that may become a nuisance.

Table 6-2. COMPARISON OF URBAN RUNOFF, STREET SURFACE YIELDS AND WASTEWATER TREATMENT PLANT EFFLUENT

mg/l	Runoff Concentration (mg/l unless otherwise noted)		STP[a] Effluent Concentration (mg/l unless otherwise noted)	Ratio of Avg. Runoff to STP Conc.	Ratio of Peak Runoff to Avg. STP Conc.	Annual Street Surface Runoff[b] (Tonne/yr)	Annual STP Effluent (Tonne/yr)	Ratio of Street Surface Runoff to STP Annual Yield
Parameter	Avg.	Peak (1-hr)	Average					
Ca^{++}	13	19	65	0.20	0.29	260	7300	0.04
K^{+}	2.7	3.5	24	0.11	0.15	54	2900	0.02
Mg^{++}	4.0	6.2	35	0.11	0.18	82	4300	0.02
Na^{+}	15	27	220	0.07	0.12	300	27,000	0.01
Cl^{-}	12	18	330	0.04	0.05	250	41,000	0.006
$SO_4^{=}$	18	27	150	0.12	0.18	390	18,000	0.02
HCO_3	54	150	230	0.23	0.66	1100	29,000	0.04
NO_3	0.7	1.5	4.9	0.14	0.31	15	600	0.03
BOD_5	24	30	21	1.1	1.4	560	2500	0.2
COD	200	350	35[c]	5.6	10	2300	4300[c]	0.5
KN	6.7	25	24	0.28	1.1	100	2900	0.03
Ortho PO_4	2.4	18	19	0.13	0.92	36	2400	0.02
Total Solids	350	950	1000	0.34	0.92	7100	130,000	0.04
TDS[d]	150	380	1000	0.15	0.37	3000	130,000	0.02
Suspended Solids	240	850	26	9.2	32	5400	3200	1.7
Cd	0.01	0.04	0.002	5	20	0.03	0.25	0.1
Cr	0.02	0.04	0.016	1.3	2.5	2.8	2.0	1.4
Cu	0.03	0.09	0.081	0.37	1.1	4.3	10	0.4
Pb	0.4	1.5	0.0098	41	150	28	1.2	24
Zn	0.18	0.55	0.087	2.1	6.3	4.3	11	0.4
Hg	<0.0001	0.0006	0.0019	<0.05	0.32	<0.002	0.24	<0.008
Specific Conductance (umhos/cm)	120	660	1900	0.06	0.36	—	—	—
Turbidity (NTU)	49	130	20	2.5	6.5	—	—	—
pH (pH Units)	6.7	7.6	7.6	—	—	—	—	—
TOC[e]	110	290	30	3.5	9.7	2300	3700	0.6

[a] San Jose/Santa Clara secondary sanitary wastewater treatment plant serving 850,000 people. These values could vary substantially for other facilities.

[b] About 200 people correspond to 1 curb-mile (2880 curb-miles in San Jose/575,000 population). Therefore, a population of 850,000 corresponds to about 4250 curb-miles, with about 1100 curb-miles of streets surfaced with oil and screens, and about 3150 curb-miles of streets surfaced with asphalt. The city has about 62,000 urbanized acres.

[c] Estimated.

[d] Total dissolved solids.

[e] Total organic carbon.

Source: Pitt 1979

plus street surface runoff yield. Total solids, cadmium, and mercury in the street surface runoff contribute from 5 to 15% of the total respectively, while chemical oxygen demand, biochemical oxygen demand, and copper contribute from 10 to 50% of this total. Suspended solids, chromium, zinc, and lead in the street surface runoff contribute more than 50% of the total.

These data show that for a receiving water getting both secondary treated sanitary wastewater and untreated urban runoff, additional improvements in the sanitary wastewater effluent may not be as cost-effective as some urban runoff treatment (except for nutrients). That is especially true for lead where more than 95% of the total wasteload is due to street surface runoff. If all of the lead were removed from the sanitary wastewater effluent, the total annual lead discharge would only decrease by about 4%.

DRY WEATHER RECEIVING WATER QUALITY

Limited data are available concerning Coyote Creek water quality during dry weather. Therefore, a small water sampling program was conducted in late March, 1977 along Coyote Creek from the south end of San Francisco Bay to Anderson Dam. Ten locations were visited and water quality samples were taken.

Grab samples were collected at ten stations previously described. These samples were analyzed for major parameters including pH, alkalinity (carbonate and biocarbonate), total hardness, chlorides, sulfates, nutrients (nitrates, nitrites, and ammonia), turbidity, and total coliform bacteria. In addition, dissolved oxygen, temperature and specific conductance were measured in the field.

Table 6-3 shows the water quality data for each of these ten stations. The purpose of this monitoring was to detect water quality gradients in Coyote Creek during dry weather. Several water quality problems are evident from this data. In most cases (except for the station at William Street Park) the water was very turbid with most values between 15 and 20 NTU. The water was also hard to very hard (but this is common for all Santa Clara County surface and groundwaters). The chloride concentration at the Dixon station was also high but this is due to tidal influence. Free ammonia concentrations ranged from 0.01 to 0.11 mg/1 with the highest value being at a downstream station. About half of these values are equal to or greater than the aquatic life beneficial use criteria for free ammonia (0.02 mg/1). The total coliform bacteria populations were also high at most of the stations. Fecal coliform populations may also be high at some of the stations. High phosphate and heavy metal (especially lead) concentrations are also expected at the downstream stations.

Figure 6-1 is a plot of concentrations by distance for selected parameters (specific conductance, turbidity, chlorides, ammonia and nitrites). It is evident that there was a marked increase in concentrations of these parameters as the creek passed through the urbanized area of the watershed. The water quality values for the stations located upstream of the urbanized areas were fairly consistent. The Dixon station is adversely influenced by the tidal action of the bay and the discharge from the sewage treatment facility,

Table 6-3. WATER QUALITY CONDITIONS FROM COYOTE CREEK STATIONS (March 31, 1977; Afternoon)

Station	pH	Spec. Cond. (μmhos/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Total Hardness (mg/l)	Total Alkalinity (mg/l)	CO_3 (mg/l)	HCO_3 (mg/l)	Cl (mg/l)	SO_4 (mg/l)	NH_3 (mg/l)	NO_3 (mg/l)	NO_2 (mg/l)	Total Coliforms (MPN/100 ml)
Urban:															
Dixon*	8.2	1600	14	170	6.7	440	400	48	195	280	70	2.1	1.1	0.042	350
Trimble	8.0	580	14	18	8.2	260	200	<24	98	60	65	0.95	0.80	0.035	>2400
Berryessa	7.7	750	14	13	4.8	300	320	<24	195	100	70	1.0	0.95	0.026	1600
William	7.6	700	14.5	5.5	6.8	340	360	<24	220	60	80	0.95	1.2	0.027	1600
Tully	7.6	215	13	18	7.2	140	120	<24	73	40	22	0.95	<0.01	0.012	1600
Hellyer	8.2	360	17.5	16	11	220	180	<24	85	30	38	0.90	1.25	0.020	≥2400
Non-urban:															
Tennant	8.3	325	14.5	6.6	9.3	240	200	24	98	<20	50	0.30	1.7	0.002	240
Coyote	8.6	300	14	14	9.4	200	120	36	37	<20	42	0.50	0.03	0.004	≥2400
Riverside	8.5	300	12	18	10.6	200	160	24	73	<20	38	0.45	<0.01	<0.002	≥2400
Cochran	8.2	280	11	33	10.6	220	160	<24	73	<20	40	0.05	<0.01	<0.002	350

*This urban Station is affected by the tidal bay waters and sanitary secondary wastewater treatment plant effluent.

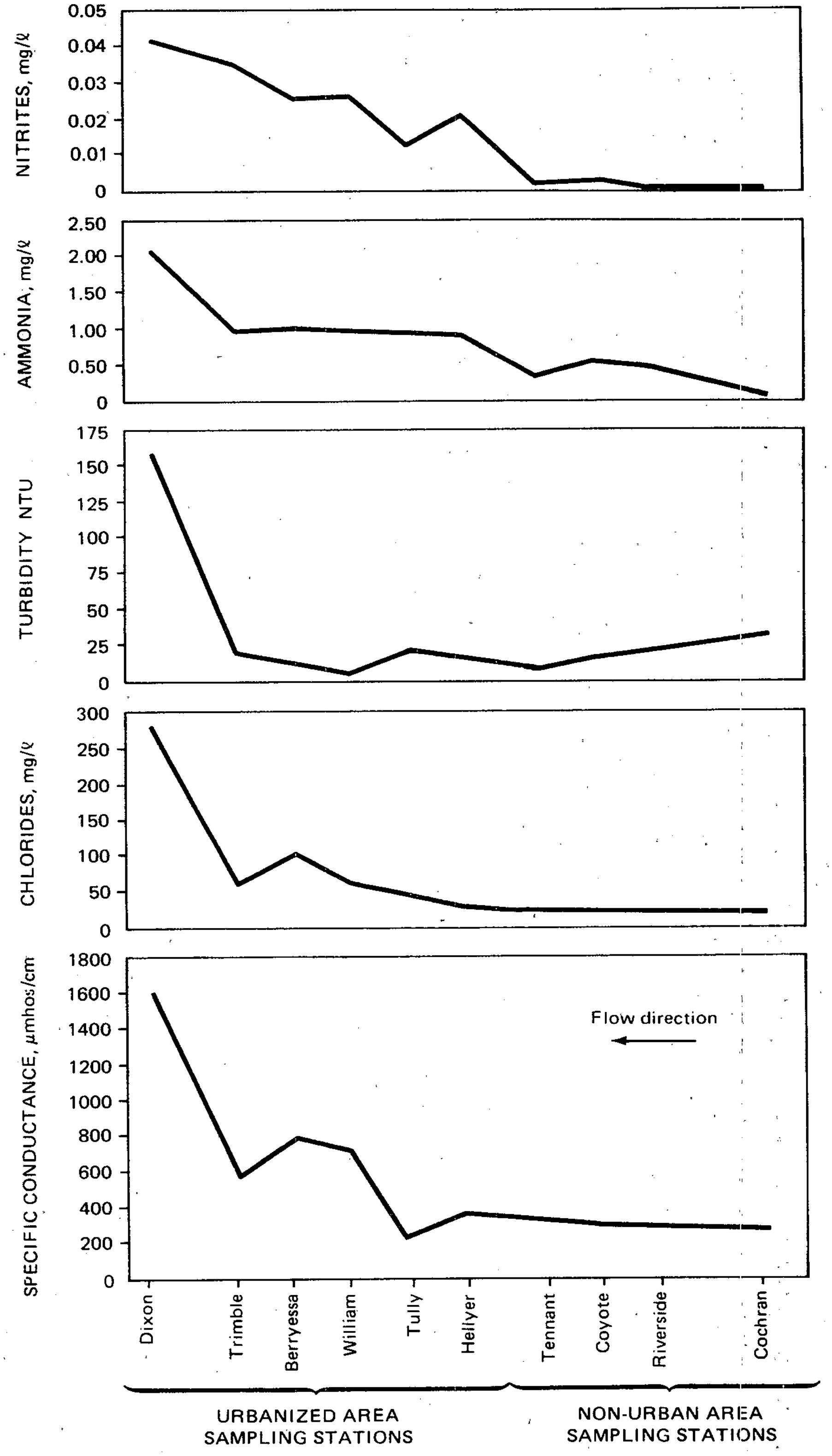

Figure 6-1. Water quality trends along Coyote Creek (March 31, 1977).

and characteristically shows the poorest water quality. The Trimble through Hellyer stations, however, were not influenced by these processes, but only from urban runoff discharges, and the water qualities at these stations is seen to be poorer than at the stations that were above the urban area. An exception in many cases is the Tully station, which is located in an urban area but has a large pool with little upstream flow contribution. The lower temperature and the better water quality measured at that location indicates that the source of water at that station was probably relatively clean groundwater. The turbidity levels were all fairly consistent (except for a higher value at the Dixon station) due to the turbid character of the water being discharged upstream from the stations from Lake Anderson. Because these measurements were made during a period of low flow following a 3-week dry spell, the water quality trends shown are expected to be less severe than what would be expected during or soon after an actual runoff event, as previously described.

Coyote Creek water quality, in the urban and non-urban areas during dry and wet weather is summarized in Table 6-4. This table is based on monitoring during this project, during the Santa Clara County "208" project (Metcalf and Eddy 1978), by the Santa Clara County Flood Control District and the California Dept. of Transportation. Additional data to be collected during the last phase of this project will be used to expand this table and will allow statistical comparisons of wet and dry, urban and non-urban water quality conditions.

SEDIMENT CHEMICAL QUALITY

Sediment samples were collected at each of the six sampling locations at the end of the field program during the first study phase. These samples were immediately frozen and transported to the laboratory for chemical, physical and organic analyses. Figure 6-2 summarizes the sediment quality trends that were observed for some of the major parameters. It is evident that orthophosphates, TOC, BOD_5, sulfates, sulfur and lead all increased in concentration in the sediments for the urban stations as compared to the upstream stations. The median sediment particle sizes significantly decreased at urbanized stations, reflecting an increased silt content. Figure 6-3 shows the particle size distributions for the sediment samples collected at the six stations. The urban sediment size distributions are quite different than for the non-urban sediments, especially in the size range from 100 to 1000 microns. The urban sediments have a much larger abundance of finer particles than the non-urban sediments.

Table 6-5 summarizes the parameters monitored in the sediments at the urban stations that were significantly greater in concentration than in the non-urban sediments. Sulfur, lead and arsenic are seen to be in substantially greater concentrations (4 to 60 times greater) in the urban sediments than for the non-urban sediments. Many minor elements also had higher concentrations in the urban sediments. Other important parameters in greater abundance in the urban sediments included organics and nutrients. In all cases, more parameters occurred at higher concentrations in the urban sediments as the sampling stations progressed downstream through the urban area. It is assumed that the parameters increasing by the greatest amounts are the most likely causes

Table 6-4. WATER QUALITY CONDITIONS IN COYOTE CREEK BY LOCATION AND SEASON

Parameter (mg/l, unless otherwise noted)	Urban Area		Non-Urban Area	
	Wet Weather	Dry Weather	Wet Weather	Dry Weather
pH (pH Units)	6.7	7.8	-	7.9
Temperature (°C)	16	15	-	15
Calcium (Ca)	13	-	-	40
Magnesium (Mg)	4.0	-	-	25
Sodium (Na)	0.01	-	-	19
Potassium (K)	2.7	-	-	1.9
Bicarbonate (HCO_3)	54	130	-	170
Carbonate (CO_3)	0.019	<24	-	3.0
Sulfate (SO_4)	18	55	-	37
Chloride (Cl)	12	60	-	15
Total Hardness	-*	250	-	200
Total Alkalinity	-	240	-	140
Total Solids	310	-	-	-
Total Dissolved Solids (TDS)	150	-	-	280
Suspended Solids (SS)	210	-	600	-
Volatile Suspended Solids (VSS)	23	-	90	-
Turbidity (NTU)	49	14	-	18
Specific Conductance (umhos/cm)	160	520	-	400
Dissolved Oxygen	8.0	7.6	-	11
Biochemical Oxygen Demand (BOD_5)	24	-	4	-
Chemical Oxygen Demand (COD)	200	-	-	-
Kjeldahl Nitrogen	7	-	2	-
Nitrates (NO_3)	0.7	0.84	-	1.2
Nitrites (NO_2)	-	0.024	-	<0.002
Ammonia (NH_3)	-	0.95	-	0.33
Orthophosphate ($O-PO_4$)	2.4	-	0.8	-
Total Organic Carbon (TOC)	110	-	-	0.6
Lead (Pb)	0.4	-	-	-
Zinc (Zn)	0.18	-	-	-
Copper (Cu)	0.03	-	-	-
Chromium (Cr)	0.02	-	-	-
Cadmium (Cd)	<0.002	-	-	-
Mercury (Hg)	<0.0001	-	-	-
Total Coliform Bacteria (MPN/100 ml)	>2400	>1900	-	>1300
Fecal Coliform Bacteria (MPN/100 ml)	>2400	-	-	-
Fecal Strep. Bacteria (MPN/100 ml)	>2400	-	-	-

*the blanks signify no data available

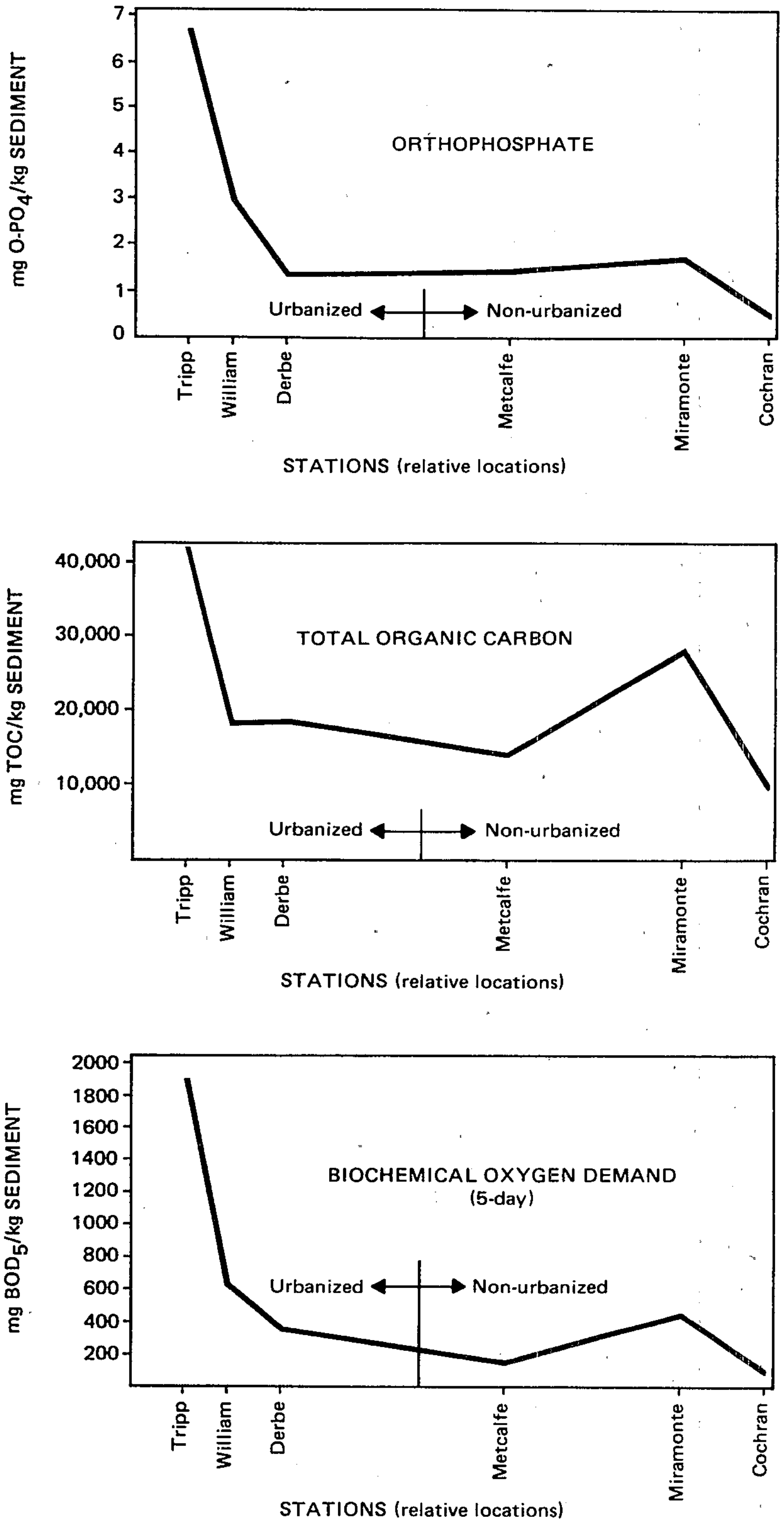

Figure 6-2. Sediment quality conditions along Coyote Creek.

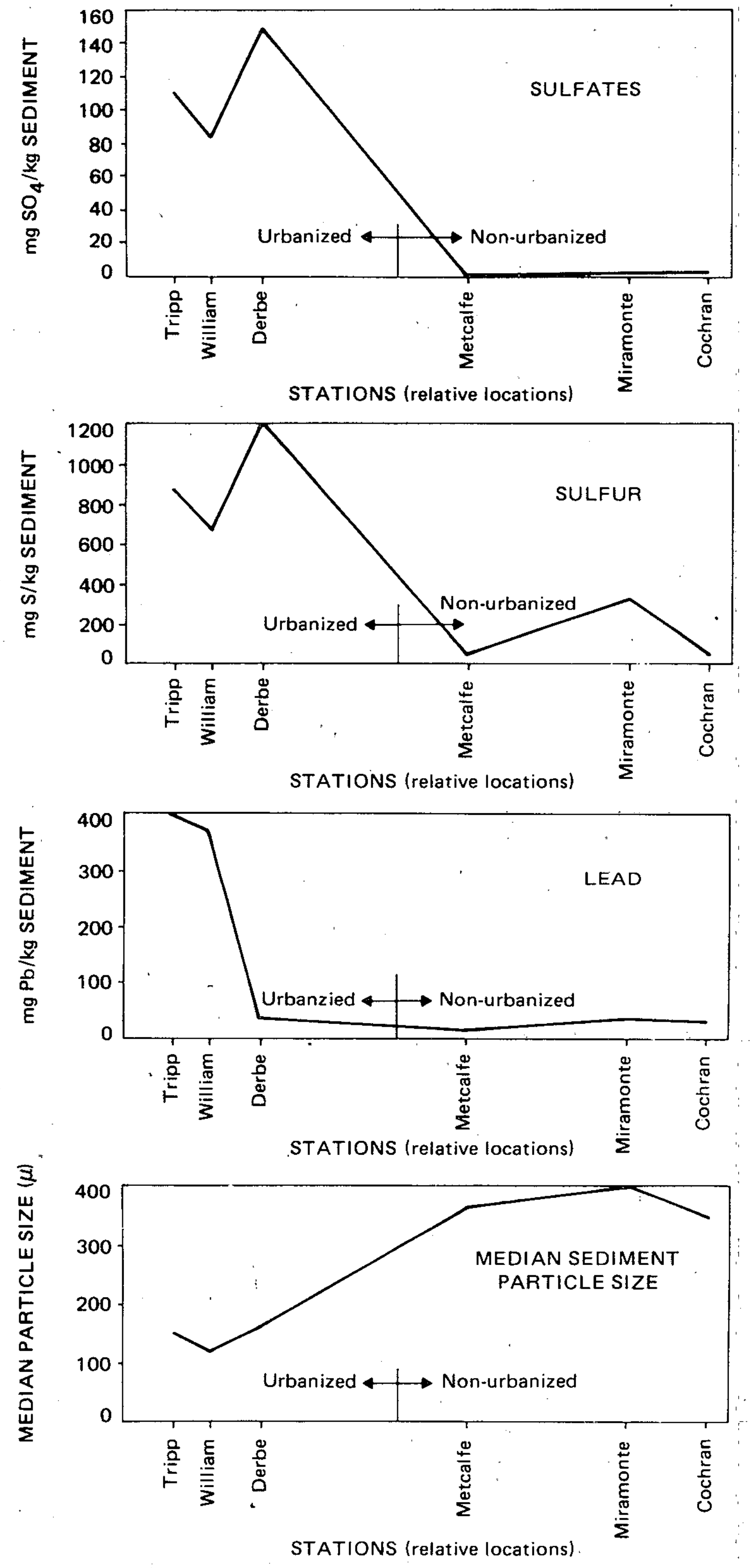

Figure 6-2. Sediment quality conditions along Coyote Creek (continued).

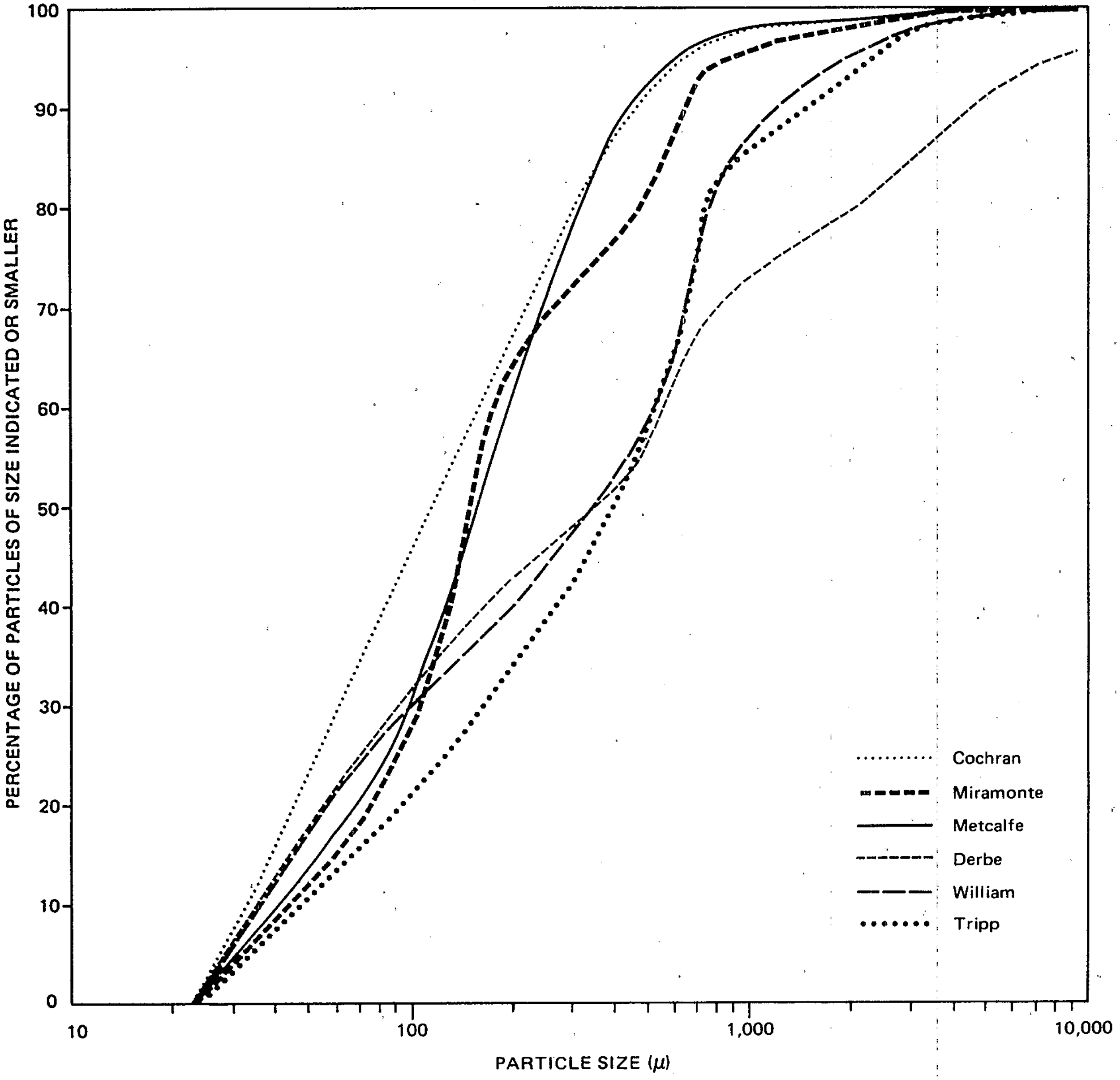

Figure 6-3. Particle size distribution of sediments.

Table 6-5. SEDIMENT CONCENTRATION INCREASES BETWEEN THE MIRAMONTE MONITORING STATION (NON-URBANIZED) AND DOWNSTREAM STATIONS

	Stations			
	Metcalfe	**Derbe**	**William**	**Tripp**
Greater than 10x Miramonte Station Values		Sulfate (60)	Sulfate (33) Lead (10)	Sulfate (44) Lead (11)
Between 3.0 and 10x Greater than Miramonte Station Values	Nickel (8.0) Chromium (6.5)	Sulfur (3.8)	Arsenic (8.7) Hafnium (4.7)	Arsenic (8.7) Thallium (4.8) Hafnium (4.7) BOD_5 (4.4) Praseodynium (4.4) Ortho PO_4 (3.9) Silver (>3.5) Erbium (3.5) Ytterbium (3.5) Tantalum (3.0)
Between 2.0 and 2.9x Greater than Miramonte Station Values	Cobalt (2.9) Manganese (2.6) Tantalum (2.3)	Hafnium (2.4) Chromium (2.0) Ytterbium (2.0)	Gallium (2.4) Tantalum (2.3) Thorium (2.3) Sulfur (2.1) Antimony (2.1) Niobium (2.1) Cadmium (2.0) Ytterbium (2.0) Yttrium (2.0)	Sulfur (2.7) Cadmium (2.6) Tungsten (2.6) Lanthanum (2.5) Bismuth (>2.4) Thorium (2.3) Yttrium (2.3) Antimony (2.1) Lutecium (2.1) Gallium (2.0)
Between 1.3 and 1.9x Greater than Miramonte Station Values	Scandium (1.9)	Erbium (1.9) Barium (1.5) Tantalum (1.3)	Chlorine (1.9) Erbium (1.8) Neodymium (1.8) Silver (>1.7) Zinc (1.7) Ortho PO_4 (1.7) Phosphorous (1.7) Europium (1.5) BOD_5 (1.5) Lanthanum (1.4) Thallium (>1.3) Holmium (1.3) Selenium (1.3)	Europium (1.9) Gadolinium (1.9) Niobium (1.9) Uranium (1.9) Chlorine (1.7) Germanium (1.7) Tin (1.7) Titanium (1.7) Mercury (1.6) TOC (1.5) Thallium (>1.3) Holmium (1.3) Selenium (1.3) COD (1.3)

for the degradation in observed biological quality. However, it must be assumed that other parameters only slightly increasing in concentration may also be important if their base concentrations are near critical levels. Beryllium, aluminum, iron, molybdenum, and silicon did not substantially change between the urban and non-urban sediments. These elements are in greater abundance in the natural erosion products in the watershed and urban activity does not significantly alter the receiving water loads. Appendix A lists the concentrations of all of the parameters monitored at each station according to their general concentration values.

Sediment samples were also analyzed for organics using a mass-spectrograph-gas-chromatograph (MSGC) in conjunction with an interfaced computer system. No volatile organic compounds were found in the supernatant water associated with the sediment samples. Because of the necessary sample preparation procedures, volatile organics could not be conducted on the sediment material directly. Sample sediment extracts were directly analyzed for non-volatile materials. Each sample contained a broad, undifferentiated peak at the upper end of the gas-chromatograph temperature program (275°C). The intensity level of this broad peak (and therefore total concentrations of components) was significantly higher in the urban sediment samples than in the non-urban sediment samples. Because of the "dirty" nature of the samples, specific compounds of this mixture could not be identified. Classes of compounds present in these broad peaks were identified as high molecular weight hydrocarbons (both aliphatic and aromatic) and high molecular weight oxygenated compounds. No pesticides, herbicides or PCBs were identified in the water associated with the sediments at the sampling locations. It is assumed that these volatile organics are more soluble and would be found in the runoff water during storm events and may not significantly accumulate in sediments away from the outfalls. This conclusion could vary substantially for other physical and chemical sediment conditions.

ORGANIC TISSUE ANALYSES

Selected samples of fish (Gambusia affinis), filamentous algae (Cladophora sp.), crayfish (Procambarus clarkii) and cattail plant segments (Typha sp.) were collected at most of the six stations noted in Table 3-2. Each organism was chemically digested and analyzed for zinc and lead to indicate potential accumulations of these important urban runoff pollutants in common organisms. Tables 6-6 and 6-7 report these values on a milligram metal per kilogram dry tissue basis. Lead concentrations were not detected in many of the organic samples but did increase by a factor of 2 or 3 in the samples collected in the urban area for the algae, crayfish, and cattail specimens. The fish lead concentrations did not seem to increase in the urban area. Zinc concentrations were usually greater and were detected in most of the organic samples. Whole organism zinc concentrations increased by a factor of about 3 for the attached algae and the cattails, but stayed about the same for the crayfish and the fish specimens. Again, the urban area samples showed the higher concentrations.

When the organism tissue concentrations were compared with the sediment concentrations, some bioaccumulation of the metals was evident. The only

Table 6-6. LEAD CONCENTRATIONS IN BIOLOGICAL ORGANISMS*
(mg lead/kg dry tissue)

	Non-Urbanized Stations			Urbanized Stations		
Specimen	Cochran	Miramonte	Metcalfe	Derbe	William	Tripp
Fish	<40	-	-	<30	<40	<50
Attached Algae	<20	<30	<30	200	170	70
Crayfish	14	-	<30	29	<36	40
Higher Aquatics	<20	<30	<30	<30	<50	60
Sediment	28	37	16	37	370	400

*The lead concentration in the urbanized section of Coyote Creek during storms averaged about 0.4 mg/l. Dry weather and non-urbanized lead concentrations are expected to be much less.

Table 6-7. ZINC CONCENTRATIONS IN BIOLOGICAL ORGANISIMS*
(mg zinc/kg dry tissue)

	Non-Urbanized Stations			Urbanized Stations		
Specimen	Cochran	Miramonte	Metcalfe	Derbe	William	Tripp
Fish	135	-	-	100	120	130
Attached Algae	6.5	24	17	160	135	69
Crayfish	80	-	90	89	140	62
Higher Aquatics	9	78	26	40	150	210
Sediment	70	70	14	30	120	70

*The zinc concentration in the urbanized section of Coyote Creek during storms averaged about 0.2 mg/l. Dry weather and non-urbanized zinc concentrations are expected to be much less.

bioaccumulation factor noted for lead was for an algae sample in an urban area with a bioaccumulation factor of about 5. Bioaccumulation factors ranged up to 2 for zinc in the non-urban fish specimens and up to 3 in the urban fish specimens. A bioaccumulation factor for algae of about 5 for zinc was found in an urban specimen. A bioaccumulation factor of about 6 was found for a crayfish sample in the non-urban area and a maximum bioaccumulation factor of 3 in a crayfish sample in an urban specimen, even though the concentrations in the urban samples were greater. A bioaccumulation factor of about 2 for zinc was found in a cattail specimen in the non-urban sample and bioaccumulation factors up to 3 were found in the urban cattail specimens.

Bioaccumulation factors for the organisms compared to water concentrations were much higher. The bioaccumulation of zinc in the crayfish, attached algae, and fish was at least 300 when compared with the zinc concentrations in the water. The bioaccumulation of lead in attached algae in the urbanized area of Coyote Creek was at least 500 and for crayfish, at least 100 when compared to lead concentrations in the water.

FISH

The fish fauna currently known to exist in the Coyote Creek drainage system is comprised of 27 species, 11 of which are native California fishes, the remainder having been introduced through the stocking efforts of the California Department of Fish and Game and by the activities of bait dealers, fishermen, farm pond owners and others (Table 6-8). Both Lake Anderson and Coyote Lake reservoirs sustain warm water sport fisheries and about one third of the fish species reported from the Coyote Creek drainage are confined largely to the lentic habitat provided by those reservoirs. This includes such species as the threadfin shad, carp, golden shiner, brown bullhead, channel catfish, Mississippi silverside, pumpkinseed, redear sunfish and white crappie. In addition, the current distribution of two other fish species (the Sacramento squawfish and the riffle sculpin), is apparently limited to the upstream portions of Coyote Creek above Anderson Dam. Sacramento squawfish have not been encountered downstream of Lake Anderson since 1960 (Scoppettone and Smith 1978) and riffle sculpin generally prefer the cool, gravel-bottomed riffles of headwater streams (Moyle 1976). Of the remaining 16 species of fish known from the Coyote Creek system, 12 have been encountered during the present study.

Seine collections from the non-urbanized reach of the current study area have indicated the presence of 12 species of fish, half of which are native to the Coyote Creek system. Similar collections in the urbanized reach of the study area yielded only one native and three introduced fish species. As seen in Table 6-9, the non-urbanized section of the stream supports a comparatively diverse assemblage of fish which include such native species as the California roach, hitch, Sacramento blackfish, Sacramento sucker, threespine stickleback and prickly sculpin. Collectively, those species comprised over 60% of the 366 fishes collected from the upper reaches of the study area. In contrast, hitch, the only native fish collected form the urbanized reach of the study area, represented less than 1% of the 1124 fish captured in the lower section of the creek. Hitch generally exhibit a preference for quiet water habitat

Table 6-8. FISH SPECIES CURRENTLY KNOWN TO OCCUR IN THE COYOTE CREEK DRAINAGE SYSTEM

Petromyzontidae - Lampreys	
Pacific lamprey*	*Entosphenus tridentatus*
Clupeidae - Herrings	
Threadfin shad	*Dorosoma petenense*
Salmonidae - Salmon and Trout	
Rainbow trout*	*Salmo gairdneri*
Cyprinidae - Minnows and Carps	
Goldfish	*Carassius auratus*
Carp	*Cyprinus carpio*
California roach*	*Hesperoleucus symmetricus*
Hitch*	*Lavinia exilicauda*
Golden shiner	*Notemigonus crysoleucas*
Sacramento blackfish*	*Orthodon microlepidotus*
Fathead minnow	*Pimephales promelas*
Sacramento squawfish*	*Ptychocheilus grandis*
Speckled dace*	*Rhinichthys osculus*
Catostomidae - Suckers	
Sacramento sucker*	*Catostomus occidentalis*
Ictaluridae - Catfish	
Brown bullhead	*Ictalurus nebulosus*
Channel catfish	*Ictalurus punctatus*
Poecilidae - Livebearers	
Mosquitofish	*Gambusia affinis*
Atherinidae - Silversides	
Mississippi silverside	*Menidia audens*
Gasterosteidae - Sticklebacks	
Threespine stickleback*	*Gasterosteus aculeatus*
Centrarchidae - Sunfish	
Green sunfish	*Lepomis cyanellus*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Redear sunfish	*Lepomis microlophus*
Largemouth bass	*Micropterus salmoides*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Cottidae - Sculpins	
Prickly sculpin*	*Cottus asper*
Riffle sculpin*	*Cottus gulosus*

*Native species

Source: Present study, Aceituno et al. (1976), California Dept. of Water Resources (1978), Guzzetta (1974), and Scoppettone and Smith (1978).

Table 6-9. TAXONOMIC COMPOSITION AND RELATIVE ABUNDANCE OF FISH COLLECTED IN SEINE SAMPLES FROM COYOTE CREEK DURING FALL 1977 AND SPRING 1978

	Non-urbanized Reach		Urbanized Reach	
Species	Relative Abundance (%)	Length Range (mm)	Relative Abundance (%)	Length Range (mm)
Cyprinidae - minnows and carps				
California roach				
(*Hesperoleucus symmetricus*)	2.7	32 to 100	-	-
Hitch				
(*Lavinia exilicauda*)	3.6	78 to 292	0.4	48 to 142
Sacramento blackfish				
(*Orthodon microlepidotus*)	2.2	160 to 340		
Fathead minnow				
(*Pimephales promelas*)	3.8	27 to 66	1.2	35 to 65
Catostomidae - suckers				
Sacramento sucker				
(*Catostomus occidentalis*)	18.3	30 to 406	-	-
Poeciliidae - live bearers				
Mosquitofish				
(*Gambusia affinis*)	20.5	18 to 52	98.3	15 to 52
Gasterosteidae - sticklebacks			-	-
Threespine stickleback				
(*Gasterosteus aculeatus*)	33.1	34 to 50		
Centrarchidae - sunfish				
Green sunfish				
(*Lepomis cyanellus*)	9.0	36 to 123	0.1	30
Bluegill				
(*Lepomis macrochirus*)	4.4	35 to 96	-	-
Largemouth bass				
(*Micropterus salmoides*)	0.5	89 to 350	-	-
Black crappie				
(*Pomoxis nigromaculatus*)	0.5	64 to 219	-	-
Cottidae - sculpins				
Prickly sculpin				
(*Cottus asper*)	1.4	38 to 90	-	-
Total Number of Fish Collected	366		1124	

and are characteristic of warm, low elevation lakes, sloughs, sluggish rivers and ponds (Calhoun 1966 and Moyle 1976). In streams of the San Joaquin River system in the Sierra Nevada foothills of central California, Moyle and Nichols (1973) found hitch to be most abundant in warm, sandy-bottomed streams with large pools where introduced species such as green sunfish, largemouth bass, and mosquito fish were common. Likewise, within the present study, in the lower portions of Coyote Creek hitch were found to be associated with green sunfish, fathead minnows, and mosquito fish. However, mosquito fish completely dominated the collections from the urbanized section of the creek since they represented over 98% of the total number of fish captured. In foothill streams of the Sierra Nevadas, Moyle and Nichols (1973) found mosquito fish to be most abundant in disturbed portions of intermittent streams, especially in warm, turbid pools. The fish is particularly well adapted to live in extreme environmental conditions, including those imposed by stagnant waters with low dissolved oxygen concentrations and elevated temperatures.

BENTHIC ORGANISMS

The taxonomic composition and relative abundance of benthic macroinvertebrates collected from both natural and artificial substrates in Coyote Creek are presented in Table 6-10. The benthos in the upper reaches of the Creek was shown to consist primarily of immature dipterans (midges and blackflies) along with certain clean water taxa such as mayflies and caddisflies. The benthos of the lower reaches of the creek was dominated exclusively by pollution tolerant oligochaete worms (tubificids).

In general, the abundance and diversity of taxa appear to be greatest in the non-urbanized sections of the stream. Figure 6-4 shows the trend of the overall decrease in the total number of benthic taxa encountered in the urbanized sections of the study area.

Crayfish were present throughout the study area and were collected in conjunction with the fish sampling effort. Two species of crayfish were encountered in Coyote Creek waters--_Pacifastacus leniusculus_ and _Procambarus clarkii_. Neither species is native to California waters. _Pacifastacus leniusculus_ was collected in the non-urbanized section of the study area. It is typically found in a wide variety of habitats including large rivers, swift or sluggish streams, lakes, and occasionally muddy sloughs (Riegel 1959). _Procambarus clarkii_ was collected in both the urbanized and non-urbanized sections of the stream. Riegel (1959) states that the species prefers sloughs where the water is relatively warm and vegetation plentiful; however, it is also found in large streams. Because of its burrowing activities _Procombarus clarkii_ often becomes a nuisance by damaging irrigation ditches and earthen dams.

ATTACHED ALGAE

Qualitative samples from natural substrates indicated that the filamentous alga, _Cladophora_ sp. was found throughout the study area. However, its growth reached greatest proportions in the upper sections of the stream. Table 6-11 presents the taxonomic composition and relative abundance of diatoms collected from artificial substrates placed at each sample location. The periphyton of the non-urbanized reaches of the stream was dominated by the genera Cocconeis and Achnanthes. The genera Nitzschia and Navicula, generally accepted to be more pollution-tolerant forms, dominated the periphyton of the urbanized reaches of Coyote Creek.

Table 6-10. TAXONOMIC COMPOSITION AND RELATIVE ABUNDANCE OF BENTHIC MICROINVERTEBRATES COLLECTED IN COYOTE CREEK DURING SPRING 1978

	Relative Abundance (%) of Each Taxon Within The Sample								
	Non-Urbanized Station								
	COCHRAN			MIRAMONTE			METCALFE		
Taxon	Ekman Dredge	Surber Sampler	Artificial Substrate[1]	Ekman Dredge	Surber Sampler	Artificial Substrate	Ekman Dredge	Surber Sampler	Artificial Substrate
Oligochaeta[2]	48.7	23.2	2.3	89.8	0.4	1.4	-	45.3	-
Hirudinea	0.7	-	-	2.2	0.4	-	-	-	-
Crustacea									
Amphipoda									
Talitridae									
Hyalella azteca	-	-	-	-	1.2	-	-	-	-
Insecta									
Ephemeroptera									
Baetidae									
Baetis sp.	-	10.8	0.9	-	4.9	5.2	-	4.7	-
Centroptilium sp.	-	-	-	-	1.2	-	-	-	23.5
Ephemerellidae									
Ephemerella sp.	-	-	0.6	-	6.1	3.8	-	15.1	-
Leptophlebiidae									
Habrophlebiodes sp.	-	4.5	-	-	-	-	-	-	-
Hemiptera									
Corixidae	-	-	-	-	1.7	-	1.1	-	-
Coleoptera									
Dytiscidae	-	-	-	-	0.4	0.8	-	4.7	-
Trichoptera									
Hydropsychidae							-	4.7	-
Cheumatopsyche sp.	-	-	-	-	-	-	-	-	-
Hydroptilidae	-	0.8	-	-	-	-	-	-	-
Diptera									
Ceratopogonidae	0.4	-	-	-	-	-	93.6	15.1	-
Chironomidae	46.8	2.7	36.0	0.7	2.4	18.7	1.1	-	-
Empididae	0.4	-	-	-	-	-	-	-	-
Muscidae	-	-	-	0.7	2.9	-	-	10.4	76.5
Simuliidae	-	56.4	59.9	-	70.2	27.9	4.2	-	-
Tabanidae	-	-	-	0.7	-	-	-	-	-
Tipulidae	-	0.8	-	-	-	-	-	-	-
Gastropoda									
Lymnaeidae									
Lymnaea sp.	0.4	-	-	0.7	0.4	-	-	-	-
Physidae									
Physa sp.	-	0.8	-	1.5	3.3	30.1	-	-	-
Planorbidae									
Promenetus sp.	0.7	-	0.3	3.7	4.5	12.1	-	-	-
Pelecypoda									
Sphaeriidae									
Pisidium sp.	1.9	-	-	-	-	-	-	-	-
Total Number of Organisms/m^2	5836	602	1428	2952	1323	555	2046	106	17

[1] Method of collection at each location.
[2] The majority of worms belonged to the family Lumbriculidae.

Table 6-10. (Concluded)

	Relative Abundance (%) of Each Taxon Within the Sample								
	Urbanized Stations								
	DERBE			WILLIAM			TRIPP		
Taxon	Ekman Dredge	Surber Sampler	Artificial Substrate	Ekman Dredge	Surber Sampler	Artificial Substrate	Ekman Dredge	Surber Sampler	Artificial Substrate
Oligochaeta[3]	100.0	99.1	79.7	100.0	94.5	54.3	100.0	99.5	34.9
Hirudinea	-	-	-	-	-	-	-	-	-
Crustacea									
Amphipoda									
Talitridae									
Hyalella azteca	-	-	-	-	-	-	-	-	-
Insecta									
Ephemeroptera									
Baetidae									
Baetis sp.	-	-	-	-	-	-	-	-	-
Centroptilium sp.	-	-	-	-	-	-	-	-	-
Ephemerellidae									
Ephemerella sp.	-	-	-	-	-	-	-	-	-
Leptophlebiidae									
Habrophlebiodes sp.	-	-	-	-	-	-	-	-	-
Hemiptera									
Corixidae	-	-	-						
Coleoptera									
Dytiscidae	-	-	-	-	-	-	-	-	-
Trichoptera									
Hydropsychidae	-	-	-	-	-	-	-	-	-
Cheumatopsyche sp.	-	-	-						
Hydroptilidae	-	-	-						
Diptera				-	-	-	-	-	-
Ceratopogonidae	-	-	15.5	-	-	-	-	-	-
Chironomidae	-	-	-	-	-	-	-	-	-
Empididae	-	-	-	-	5.5	45.7	-	0.5	65.1
Muscidae	-	0.1	4.8	-	-	-	-	-	-
Simuliidae	-	-	-	-	-	-	-	-	-
Tabanidae	-	-	-	-	-	-	-	-	-
Tipulidae	-	-	-	-	-	-	-	-	-
Gastropoda									
Lymnaeidae									
Lymnaea sp.	-	-	-	-	-	-	-	-	-
Physidae									
Physa sp.	-	-	-	-	-	-	-	-	-
Planorbidae									
Promenetus sp.	-	-	-	-	-	-	-	-	-
Pelecypoda									
Sphaeriidae									
Pisidium sp.	-	0.8	-	-	-	-	-	-	-
Total Number of Organisms/m^2	926	3432	84	1335	290	138	1787	3362	83

[3] The majority of worms belonged to the family Tubificidae.

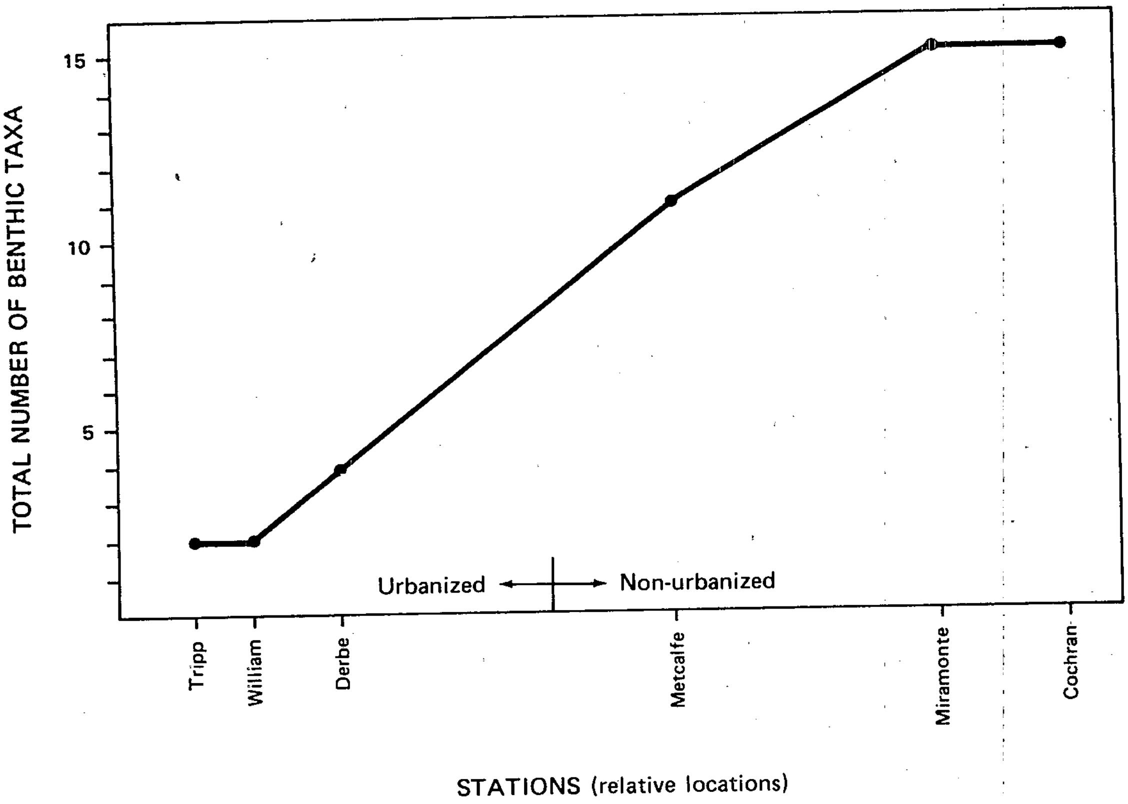

Figure 6-4. Abundance of benthic taxa collected from natural and artificial substrates in Coyote Creek during Spring of 1978.

TABLE 6-11. TAXONOMIC COMPOSITION AND RELATIVE ABUNDANCE OF DIATOMS COLLECTED ON GLASS SLIDES IN COYOTE CREEK DURING THE SPRING OF 1978

	Relative Abundance (%) of Each Taxon Within the Sample					
	Non-urbanized stations			Urbanized stations		
Taxon	Cochran	Miramonte	Metcalfe	Derbe	William	Tripp
Centrales						
Coscinodiscaceae						
Melosira spp.	0.4	-	-	-	1.2	0.8
Pennales						
Diatomaceae						
Diatoma vulgare	0.4	-	1.5	-	-	-
Fragilariaceae						
Synedra sp.	-	-	-	0.8	0.9	0.4
Achnanthaceae						
Achnanthes lanceolata	20.6	37.8	56.1	49.8	0.9	1.6
Rhoicosphenia curvata	0.4	-	-	1.2	-	-
Cocconeis pediculus	15.0	18.2	0.4	-	-	-
Cocconeis placentula	62.4	44.0	41.2	-	-	-
Naviculaceae						
Navicula spp.	-	-	-	-	10.5	23.8
Diploneis sp.	-	-	-	-	2.4	-
Frustulia rhomboides	-	-	-	-	0.4	-
Gyrosigma sp.	-	-	-	-	-	0.4
Gomphonemataceae						
Gomphonema spp.	-	-	-	2.8	6.9	0.8
Cymbellaceae						
Cymbella spp.	0.8	-	-	-	2.0	0.4
Rhopalodia spp.	-	-	-	-	-	0.4
Nitzschiaceae						
Nitzschia spp.	-	-	0.8	43.4	67.5	70.6
Denticula elegans	-	-	-	-	2.4	0.4
Surirellaceae						
Cymatopleura solea	-	-	-	-	0.9	-
Surirella spp.	-	-	-	2.0	4.0	0.4
Total Number of Frustules/mm^2	5545	4950	1874	4488	1189	4575

SECTION 7

CONTROL OF URBAN RUNOFF

REMOVAL GOALS

The degradation of conditions observed in Coyote Creek as it passed through San Jose may be due to several factors. These may include urban runoff, stream flows (both associated and not associated with urban runoff), and natural conditions (drought, stream gradient, groundwater infiltration, etc.). The preliminary conclusion is that urban runoff is the most important factor. Additional data collection and analyses to be conducted in Coyote Creek may help substantiate this conclusion and may help establish urban runoff control goals. The following discussion presents some preliminary urban runoff control goals.

Any urban runoff control program must be based upon control goals. Table 7-1 summarizes various removal conditions necessary to meet various goals for urban runoff quality and Coyote Creek conditions. These removal goals are based upon the earlier descriptions of beneficial use impairments and monitored biological conditions in the receiving water. The removal goals shown in Table 7-1 are all very high and will most likely not be obtainable by currently available urban runoff control procedures. These goals are not reasonable because they are not directly applicable to receiving water conditions except for those goals based on actual benefical use impairments in the receiving water. These goals are based on three conditions. The first is based on monitored conditions; the second set of goals corresponds to maintaining runoff water quality and receiving water quality during storms equal to beneficial use water quality criteria; and the third set of goals compares urban runoff to secondary sanitary sewage effluent conditions. The water quality criteria goals for lead and phosphate are quite high (up to 90% removal). These are not very reasonable because the criteria for these beneficial uses are designed for continuous discharge conditions. Intermittent storm discharges may have more important or less important effects on these beneficial uses depending upon the situation. Contact sports criteria would not be important for runoff water quality because of the lack of participation in these activities during storms. Aquatic life, however, may be more susceptible to short-term high concentrations of intermittent discharges than constant discharge conditions. Similarly, the sanitary wastewater effluent condition goal may not be reasonable. The secondary treatment requirements for sanitary wastewater are also based on continuous discharges and do not reflect the differences that slug discharges may impose on different types of receiving waters. The first criteria shown on Table 7-1 are based on actual field measurements made during these Coyote Creek studies and would be considered the

Table 7-1. VARIOUS URBAN RUNOFF CONTROL GOALS

		FOR RUNOFF TO EQUAL BENEFICIAL USE CRITERIA DURING STORMS FOR:				FOR RUNOFF TO EQUAL SECONDARY SANITARY WASTEWATER EFFLUENT:	
Parameter	Maximum Goal (Comparable To Background Condition)*	Livestock Use	Aquatic Life	Water Supply	Recreation	Concentrations During Runoff Events	Annual Yield
Suspended Solids	-	-	-	-	-	90%	40%
BOD$_5$	75%	-	-	-	-	10	-
COD	-	-	-	-	-	85	-
TOC	-	-	-	-	-	70	-
PO$_4$	75	-	-	-	90%	-	-
SO$_4$	95	-	-	-	-	-	-
Pb	90	75%	90%	90%	-	98	95
As	90	-	-	-	-	-	-
Cd	50	-	-	-	-	80	-
Cr	-	-	-	-	-	25	30
Zn	40	-	-	-	-	50	-

*Based on sediment measurements.

maximum removals necessary. These removals should bring the urbanized creek segments to non-urbanized conditions. Non-urbanized conditions may not be necessary before acceptable receiving water conditions are obtained. The continuation of the Coyote Creek studies will attempt to identify acceptable removal goals to meet major aquatic life criteria for Coyote Creek.

URBAN RUNOFF CONTROL MEASURES

The following discussion summarizes the costs, effectiveness and magnitude of potential uses for various urban runoff control measures. After urban runoff problems and source areas most responsible for the problem pollutants are identified, an appropriate urban runoff control program can be designed. Table 7-2 lists the various control measures that have been considered for controlling urban runoff for potential pollutant sources and source areas. As an example, street cleaning can only be applied to those impervious areas that street cleaning equipment has access to. Cleaning catch basins and storm sewerage systems can affect only that material that accumulates in them (mostly from adjacent street surfaces and erosion material from construction sites). Treatment of the urban runoff at the outfall, however, is capable of affecting pollutants originating from all of these sources. As noted previously, however, relative contributions and yields from these sources must be considered in designing an appropriate urban runoff control program. Table 7-3 summarizes the relative unit effectiveness of various control measures affecting each source area. Approximately 20 kilograms of a pollutant would have to be removed from vacant and landscaped areas to remove 1 kilogram of that pollutant from the runoff. However, only 1.3 kilograms of a pollutant would have to be removed from the street surfaces to control 1 kilogram in the runoff. These relative effectiveness values significantly affect the unit costs associated with removing pollutants from the different source areas.

Table 7-4 shows the suitability of various measures for controlling urban runoff pollutants. It combines the information presented in Tables 5-2 and 5-3 and also considers relative source strengths and approximate control measure effectiveness. Any one of the control measures shown is highly suitable for only a few of the pollutant groups, while many of the control measures can be partially suitable for many of the pollutants. Even if a potential problem is confined to a single pollutant, a combination of control measures will most likely be needed.

The most appropriate control measure combination can be selected knowing potential removals and unit costs for each control measure. Not considering other runoff control objectives or partial control of the other pollutants, one could simply start with the least costly control measure until the desired removal is obtained. If only a small quantity must be removed, the least expensive control option may be sufficient. However, if greater quantities must be removed, then a combination of control measures is needed. The selected mixture of control measures could vary, depending upon the parameters of concern and the total control needed.

Table 7-2. CONTROL MEASURES MOST SUITABLE FOR CONTROLLING POLLUTANTS FROM VARIOUS SOURCE AREAS

	Potential Pollutant Source Areas						
Control Measures	Rooftops	Street Surfaces	Parking Lots	Land-scaped Areas	Vacant Land	Con-struction Sites	Other (Industrial and Solid Waste Runoff)
Street Cleaning		X	X				
Leaf Removal			X	X			
Control Grass Types				X	X		
Repair Streets		X	X				
Control Fertilizer, Pesticide, etc.				X	X		
Control Use of Vacant Land					X		X
Control Litter		X			X		
Control Dog Litter		X		X	X		
Control Direct Discharge of Pollutants to Storm Drains	X						X
Eliminate Cross Connections with Sanitary Sewers							X
Clean Catchbasins		X				X	
Clean Storm Sewers and Drainage Channels		X				X	
Prevent Roof Drainage from Directly Entering Storm Sewer	X						
Direct Runoff Away from Contaminated Areas						X	X
Retain Runoff from Contaminated Areas						X	X
Regrade Disturbed Areas					X	X	X
Control Erosion at Construction Sites						X	
Store and Treat Runoff	X	X	X	X	X	X	X

Table 7-3. RELATIVE AREA CONTROL REQUIREMENTS TO IMPROVE RUNOFF QUALITY AT OUTFALL

Source Area	Annual Average Quantities to be Removed at Area to Control One kg at Outfall (kg)	Annual Average Percentage of Area Pollutant Deposition Yield to Outfall (%)	Percentage of Study Area (%)
Lawn and Landscaped Areas	20	5	44
Vacant Lots	20	5	4
Rooftops	3.3	30	19
Sidewalks	2.2	45	5
Parking Lots	2.0	50	7
Street Surfaces	1.3	75	21

Table 7-4. SUITABILITY OF CONTROL MEASURES FOR CONTROLLING COMMON URBAN RUNOFF POLLUTANTS

	Common Urban Runoff Pollutants								
Control Measures	Sediment	Oxygen Demanding Matter	Nutrients	Salts	Bacteria	Heavy Metals	Pesticides/ Herbicides	Oils and Grease	Floating Matter
Street Cleaning (with streets in good repair)	M*	L	L	M	L/M	H		M	M
Leaf Removal (seasonal use)		L/M	L/M		L	L	L	L	H
Control Grass Types	L	L	L				L/M		L/M
Repair Streets	L/M					L		L	L
Control Fertilizer, Pesticides, etc.			H				H		
Control Use of Vacant Land	L/M		L/M		L/M				
Control Litter		L	L		L/M			L/M	M
Control Dog Litter		L	M		M/H				L
Eliminate Cross Connections with Sanitary Sewers		L/M	L/M		M/H				
Clean Catchbasins	L					L/M		L	
Clean Storm Sewers and Drainage Channels	L/M					L/M		L	
Prevent Roof Drainage from Directly Entering Storm Sewer			L			L		L	
Direct Runoff Away from Contaminated Areas	M								
Retain Runoff from Contaminated Areas	M								
Regrade Disturbed Areas	M		L						
Control Erosion at Construction Sites	M							L/M	
Store and Treat Runoff	H	M/H	M	L	H	L/M	L	M	H

*L = Low suitability
L/M = Low-medium suitability
M = Medium suitability
M/H = Medium-high suitability

Table 7-5 compares the maximum pollutant removal potentials (as measured at the outfall) for four types of control measures. The four control measures illustrated are monthly street cleaning, twice weekly street cleaning, typical erosion control, and moderate runoff treatment. These removal potentials are a function of the removal efficiency of the specific pollutant by the control measure at the source and the effective yield of that source to the outfall yield. Therefore, erosion control for typical conditions (about 1% of an area under active construction) would not be highly efficient in controlling urban runoff yields for the whole area. Special circumstances, such as large construction activities, make erosion control practices a necessity in urban areas. Street cleaning is capable of removing significant portions of many of the pollutants but at potentially high costs. However, these costs are typically much less than the estimated runoff treatment costs when flow equalization and storage are considered. Two different cost values are shown for each control measure. The lower value is the unit cost (dollars per pound removed) for removal of a kilogram of pollutant from the source area. The second and higher cost value is the corresponding unit cost for removing an effective kilogram of the pollutant from the outfall yield. Even though the unit cost for controlling erosion at the source is quite low, the effective cost for removing pollutants at the outfall is substantially greater than for the other control measures. The two types of street cleaning programs illustrated have significantly different unit costs. Less frequent street cleaning is capable of removing a much greater quantity of pollutant per unit effort and cost than more frequent street cleaning. A condition is also reached with intensive street cleaning when the street surface cannot become any cleaner by street cleaning.

Table 7-5. CONTROL MEASURES AND UNIT REMOVAL COSTS

	MONTHLY STREET CLEANING			TWICE WEEKLY STREET CLEANING		
Parameter	Removal Potential (kg/ha/yr)* -Outfall Equivalent at 75%	Unit Cost at Source ($/kg Removed)	Unit Cost at Outfall ($/kg Removed)	Removal Potential (kg/ha/yr)* -Outfall Equivalent at 75%	Unit Cost at Source ($/kg Removed)	Unit Cost at Outfall ($/kg Removed)
Total Solids	56 (25%)**	0.13	0.17	130 (60%)	0.48	0.64
Suspended Solids	28 (20%)	0.26	0.35	67 (45%)	0.97	1.3
COD	5.4 (10%)	1.3	1.7	13 (20%)	4.9	6.5
BOD_5	2.8 (10%)	3.5	4.7	6.6 (20%)	10	13
Ortho PO_4	0.010 (<1%)	770	1000	0.023 (2%)	2900	3900
Kjeldahl N	0.12 (5%)	64	85	0.29 (10%)	240	320
Pb	0.22 (25%)	33	44	0.54 (60%)	120	160
Zn	0.028 (30%)	260	350	0.066 (75%)	1000	1300
Cr	0.022 (25%)	330	440	0.053 (60%)	1300	1700
Cu	0.040 (30%)	180	240	0.098 (80%)	660	880
Cd	0.00015 (20%)	44,000	59,000	0.00037 (40%)	180,000	240,000

*These unit area removal potentials refer to the complete watershed, not just street surface or construction site areas.

**The numbers in parentheses are the percentage removals of the total outfall yield for these conditions.

***Averaged from many candidate runoff treatment practices, including storage, capital and operating costs (Lager, et al., 1977)

REFERENCES

Aceituno, M.E., M.L. Caywood, and S.J. Nicola. Occurrence of Native Fishes in Alameda and Coyote Creeks, California. California Fish and Game 62(3): 195-206, 1976.

California Dept. of Water Resources. Anderson Reservoir Limnologic Investigation. California Department of Water Resources, Central District. 240 pp, 1978.

Calhoun, A.C., Ed. Inland Fisheries Management, California Department of Fish and Game. Sacramento, 546 pp, 1966.

Farmer, J.G. and T.D.B. Lyon. Lead in Glasgow Street Dirt and Soil. The Science of the Total Environment 8: 89-93, 1977.

Guzzetta, D.J. A Preliminary Survey of the Aquatic Habitat of Henry W. Coe State Park with Management Proposals. M.A. Thesis, San Jose State University, California. 75 pp, 1974.

Lager, J.A., W.G. Smith, W.G. Lynard, R.M. Finn and E.J. Finnemore. Urban Stormwater Management and Technology: Update and Users Guide. EPA-600/8-77-014. U.S. Environmental Protection Agency. Cincinnati, Ohio. 331 pp, September, 1977.

McKee, J., and H.W. Wolf. Water Quality Criteria, 2nd ed.: State Water Quality Control Board. Sacramento, California. 548 pp., 963.

McMullen, T.B. and R.B. Faoro. Occurrence of Eleven Metals in Airborne Particulates and Surficial Materials. Journal Air Pollution Control Association 27: 12: 1198-1202. December, 1977.

Metcalf and Eddy Engineers. Surface Water Management Plan for Santa Clara County - Technical Appendices, for Santa Clara Valley Water District. San Jose, California. December, 1978.

Moyle, P.B. and R.D. Nichols. Ecology of Some Native and Introduced Fishes of the Sierra Nevada Foothills in Central California. Copeia 1973(3): 478-490, 1973.

Moyle, P.B. Inland Fishes of California. Unversity of California Press, Berkeley, 405 pp, 1976.

Olson, K.W. and R.K. Skogerboe. Identification of Soil Lead Compounds from Automotive Sources. Environmental Science and Technology 9: 3: 227-230. March, 1975.

Pitt, R.E. and G. Amy. Toxic Materials Analyses of Street Surface Contaminants. EPA-R2-73-283. U.S. Environmental Protection Agency. Washington, D.C. 135 pp, August, 1973.

Pitt, R.E. Demonstration of Non-Point Pollution Abatement through Improved Street Cleaning Practices. EPA-600/2-79-161, 289 pp, 1979.

Riegel, J.A. The Systematics and Distribution of Crayfishes in California. California Fish and Game. 45(1): 29-50, 1959.

Sartor, J.D., and G.B. Boyd. Water Pollution Aspects of Street Surface Contaminants: EPA-R2-72-081, U.S. Environmental Protection Agency, Washington, D.C., November 1972.

Scoppettone, G.G. and J.J. Smith. Additional Records on The Distribution and Status of Native Fishes in Alameda and Coyote Creeks, California. California Fish and Game 64(1): 61-65, 1978.

U.S. Environmental Protection Agency. 1975 Interim Primary Drinking Water Standards: Subchapter D, Part 141, Subpart A, 1975.

_____. Proposed Criteria for Water Quality: Vol. 1. October, 1973.

_____. Water Quality Criteria, Environmental Studies Board: NAS-NAE, EPA-R3-73-033. March, 1973.

APPENDIX A

SEDIMENT QUALITY CONDITIONS

TABLE A-1. COMMON PARAMETER CONCENTRATIONS IN SEDIMENTS

Parameter	Station					
	Cochran	Miramonte	Metcalfe	Derbe	William	Tripp
Volatile Solids (%)	21.2	27.3	20.6	16.1	10.5	9.6
BOD_5 (mg/kg)	94	420	126	305	619	1850
COD (mg/kg)	37,000	98,000	67,000	46,000	62,000	131,000
TOC (mg/kg)	9600	28,000	14,000	28,000	18,000	42,000
NH_3 (mgN/kg)	120	310	110	40	79	150
NO_3 (mgN/kg) (dissolved)	<0.04	0.39	0.04	<0.03	<0.05	0.12
Kjeldahl Nitrogen (mgN/kg)	6000	29,000	9100	3900	8100	14,000
Organic Nitrogen (mgN/kg)	5900	29,000	9000	3900	8000	14,000
Ortho PO_4 (mgP/kg)	0.46	1.7	1.4	1.2	2.9	6.6
Sulfate ($mgSO_4$/kg)	4.4	2.5	0.84	150	83	110
Median Size ( )	350	400	370	160	120	150

Table A-2. PARAMETERS GENERALLY WITHIN 0.1 TO 1.0 mg/kg CONCENTRATION RANGE* IN SEDIMENTS

	Station					
Parameter	Cochran	Miramonte	Metcalfe	Derbe	William	Tripp
Beryllium	0.50	<0.48	0.53	<0.48	<0.48	0.48
Bismuth	0.52	<0.42	<0.42	<0.42	<0.42	1.0
Cadmium	0.48	0.54	<0.44	0.62	1.1	1.4
Erbium	0.57	0.57	0.44	1.1	1.0	2.0
Europium	0.83	0.83	0.35	0.41	1.2	1.6
Holmium	0.30	0.46	0.26	0.53	0.61	0.61
Lutecium	0.16	0.16	0.15	0.16	0.19	0.33
Selenium	0.37	0.82	0.47	0.36	1.1	1.1
Silver	<0.1	<0.1	<0.1	<0.1	0.17	0.35
Tantalum	0.51	0.20	0.45	2.6	0.45	0.60
Tellurium	<0.20	0.17	<0.20	<0.20	<0.12	0.10
Terbium	0.44	1.7	0.38	0.66	0.66	1.9
Thallium	0.76	<0.76	0.76	<0.76	0.96	0.96
Thullium	0.27	0.23	<0.19	0.23	0.23	1.1
Tungsten	0.56	0.58	<0.46	0.66	0.66	1.5

*Parameters less than 0.1 mg/kg at all stations:
Gold, Iridium, Osmium, Palladium Platinum, Rhodium, Ruthenium.

Table A-3. PARAMETERS GENERALLY WITHIN 1.0 TO 10 mg/kg CONCENTRATION RANGE IN SEDIMENTS

	Station					
Parameter	Cochran	Miramonte	Metcalfe	Derbe	William	Tripp
Antimony	1.4	1.4	0.30	1.2	3.0	3.0
Arsenic	6.1	1.5	<1.0	1.5	13	13
Bromine	6.0	28	6.9	2.4	14	14
Cesium	4.3	4.3	0.43	1.6	3.2	1.8
Chlorine	6.0	25	14	6.0	47	42
Dysprosium	2.2	2.7	0.72	1.3	1.4	3.1
Gadolinium	2.1	2.1	1.1	1.9	1.9	4.0
Gallium	5.4	2.3	1.1	2.0	5.4	4.6
Germanium	1.0	0.60	0.60	0.52	0.60	1.0
Hafnium	4.0	1.7	1.7	4.0	7.9	7.9
Iodine	7.0	16	6.2	1.6	7.0	12
Lanthanum	7.1	5.7	3.8	3.8	8.1	14
Mercury	1.1	8.4	1.6	6.6	4.3	13
Molybdenum	0.98	1.1	0.98	1.1	1.1	1.3
Neodymium	9.0	5.1	1.8	2.6	9.0	6.0
Niobium	3.2	3.6	3.6	3.6	7.7	6.8
Praseodymium	2.7	2.7	1.2	1.2	2.7	12
Samarium	4.3	5.4	1.1	2.6	4.3	5.4
Thorium	6.0	6.9	1.6	4.8	16	16
Tin	2.3	2.3	0.53	2.3	2.3	4.0
Uranium	2.3	2.3	0.99	2.3	2.0	4.4
Ytterbium	2.0	0.85	0.74	1.7	1.7	3.0
Yttrium	6.1	6.1	5.4	5.4	12	14

Table A-4. PARAMETERS GENERALLY WITHIN A 10 TO 100 mg/kg CONCENTRATION RANGE IN SEDIMENTS

	Station					
Parameter	Cochran	Miramonte	Metcalfe	Derbe	William	Tripp
Cerium	20	23	11	23	23	23
Copper	42	42	24	42	48	48
Lead	28	37	16	37	370	400
Lithium	43	86	29	-	57	-
Rubidium	37	66	13	20	28	37
Scandium	14	14	27	7.2	7.2	7.2
Strontium	59	140	59	120	69	120
Sulfur	69	320	69	≃1200	660	870
Zinc	70	70	14	30	120	70
Zirconium	40	40	17	35	40	37

Table A-5. PARAMETERS GENERALLY WITHIN A 100 TO 1000 mg/kg CONCENTRATION RANGE IN SEDIMENTS

	Station					
Parameter	Cochran	Miramonte	Metcalfe	Derbe	William	Tripp
Barium	270	480	270	740	400	580
Boron	170	91	59	33	83	91
Chromium	130	120	780	240	130	120
Fluorine	260	820	260	300	530	450
Manganese	750	500	≃1300	250	150	380
Nickel	560	150	≃1200	98	120	120
Vanadium	130	126	71	71	71	71

Table A-6. PARAMETERS WITH CONCENTRATIONS GENERALLY GREATER THAN 1000 mg/kg IN SEDIMENTS

	Station					
Parameter	Cochran	Miramonte	Metcalfe	Derbe	William	Tripp
Aluminium	≃3000	>10,000	>10,000	>10,000	>10,000	>10,000
Calcium	≃4700	>10,000	>10,000	>10,000	>5000	>5000
Cobalt	≃4400	31	89	16	31	18
Iron	>10,000	>10,000	>10,000	>10,000	>10,000	>10,000
Magnesium	>10,000	>5000	>10,000	>10,000	>10,000	>10,000
Phosphorus	≃1600	690	480	690	≃1200	690
Potassium	≃4000	>10,000	≃2700	≃3400	>5000	>5000
Silicon	>10,000	>10,000	>10,000	>10,000	>10,000	>10,000
Sodium	≃2800	>10,000	≃3200	≃2800	>10,000	>5000
Titanium	≃1500	≃1300	≃1300	≃1100	≃1500	≃2200

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6. ABSTRACT

This preliminary report describes the characteristics of urban runoff affecting Coyote Creek, sources of urban runoff pollutants, effects of urban runoff and potential controls for urban runoff. Local urban runoff characterization information is summarized, and sources of urban runoff pollutants are being investigated and include sampling from source areas such as street surfaces, parking lots, landscaped areas and rooftops.

Various biological sampling techniques were used to evaluate the fish, benthic macroinvertebrates and attached algae conditions in the creek, above and within the urban area. Creek water and sediment samples were also obtained and analyzed for a broad list of parameters. In most cases, very pronounced gradients of these creek quality indicators were observed, with the urbanized portion of the creek being significantly degraded. Current additional monitoring is being conducted to identify the urban runoff control goals necessary to improve creek quality to adequate levels.

7. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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