MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

TECHNICAL MEMORANDUM 88-03

# EVALUATION OF RESERVOIR SEDIMENTATION RATES IN THE UPPER CARMEL RIVER WATERSHED

FEBRUARY 1989

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## INTRODUCTION

Dams and the reservoirs they form have a number of significant impacts upon the environment. One of these, sedimentation within the reservoir, may have serious consequences both for storage capacity behind the dam, and for a variety of geomorphological and environmental characteristics downstream. Since all dams trap sediment to some degree, it is useful to attempt to estimate the rate of sedimentation and to design a reservoir with sufficient sediment storage capacity so that the planned yield is not affected during the life of the project. Reservoir sedimentation rates also provide the starting point for developing a sediment budget for a watershed and for evaluating some of the downstream environmental impacts of dams.

In the case of the Carmel River Watershed, reservoir sedimentation has had a significant impact on the existing reservoirs created by San Clemente Dam and Los Padres Dam, which have lost 78 percent and 38 percent respectively of their capacity upon closure. Additionally, the Monterey Peninsula Water Management District is in the planning stages of developing either an enlarged reservoir at one of these two sites, or a new dam and reservoir at a different location, perhaps on a tributary.

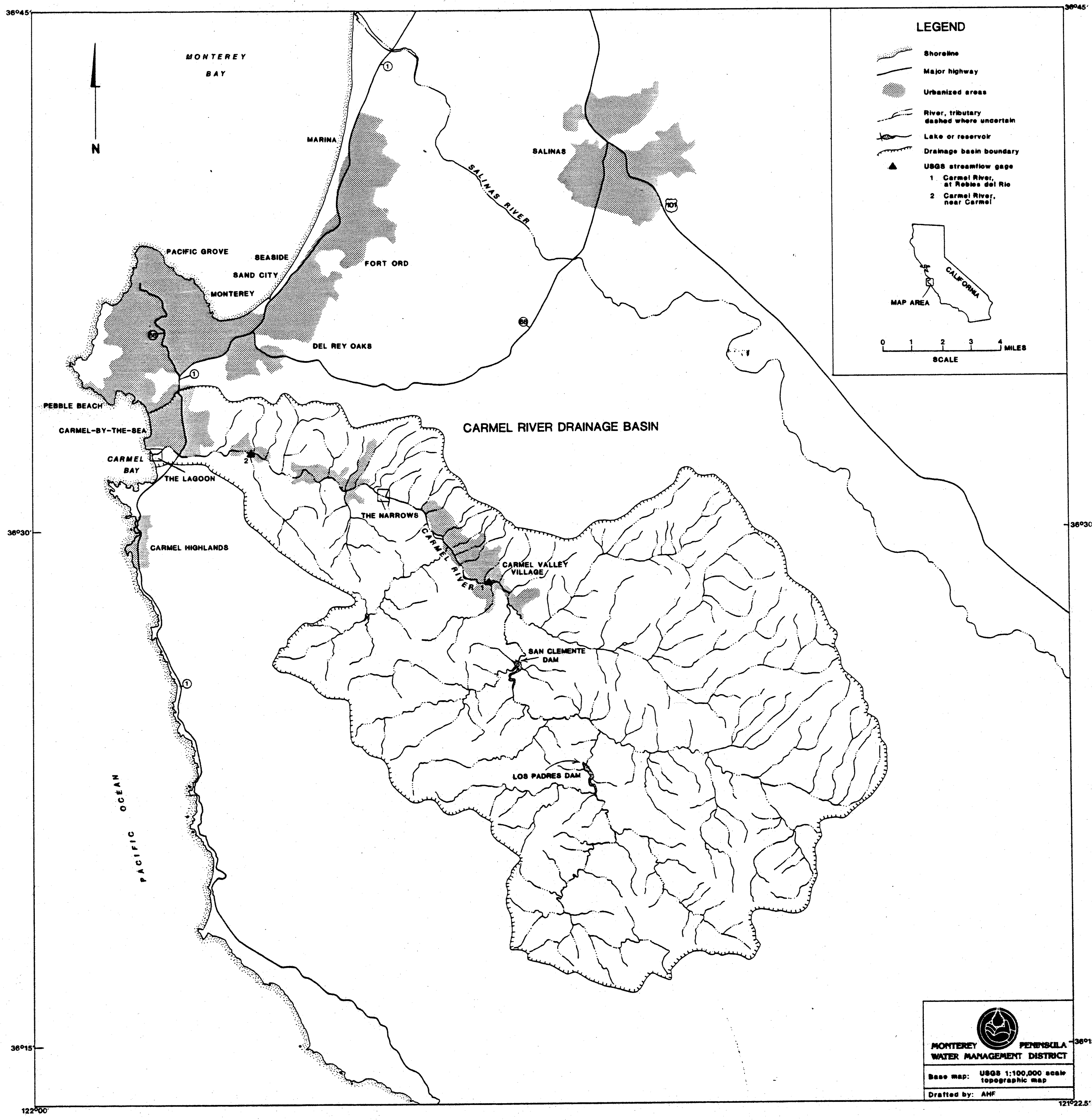
## OBJECTIVE

The objective of this technical memorandum is to present the existing data on reservoir sedimentation, to analyze the data to develop sediment yield and trap efficiency values, and to provide the basis for calculating sediment storage volumes in a proposed new reservoir.

## SETTING

The Carmel River drains a basin of 255 square miles ($mi^2$) on the Central California Coast, entering the Pacific Ocean at Carmel (Figure 1). The upper watershed is extremely rugged with peaks up to 5,000 feet above sea level. The upper 21 miles of the river pass through steep, narrow canyons before traversing an alluvial valley in its lower 15 miles. Orographic effects are

FIGURE 1: LOCATION MAP



pronounced; annual precipitation varies from about 16 inches at sea level near the river mouth, to over 40 inches in the high peaks of the southern part of the basin. Precipitation is almost entirely rain, with most falling from November through March. Streamflow is in response to this seasonal rainfall, and high flows capable of transporting sediment are restricted to these winter months.

Much of the sediment from the upper half of the basin (125 $mi^2$) has been trapped since 1921 by San Clemente Dam (rivermile 18.6). Los Padres Dam (drainage area of 44 $mi^2$) was closed in 1949 another 5 miles upstream. The upper basin with its steep slopes and a pre-1900 fire frequency of about once per 21 years (Griffen and Talley, 1981) undoubtedly produced the majority of the basin's sediment load. Downstream of San Clemente Dam elevations are lower and rainfall is much less. Sediment yields from other central California reservoirs support this concept, with the highest yields reported for reservoirs in mountainous headwater areas (Brown and Jackson, 1973).

## METHODOLOGY

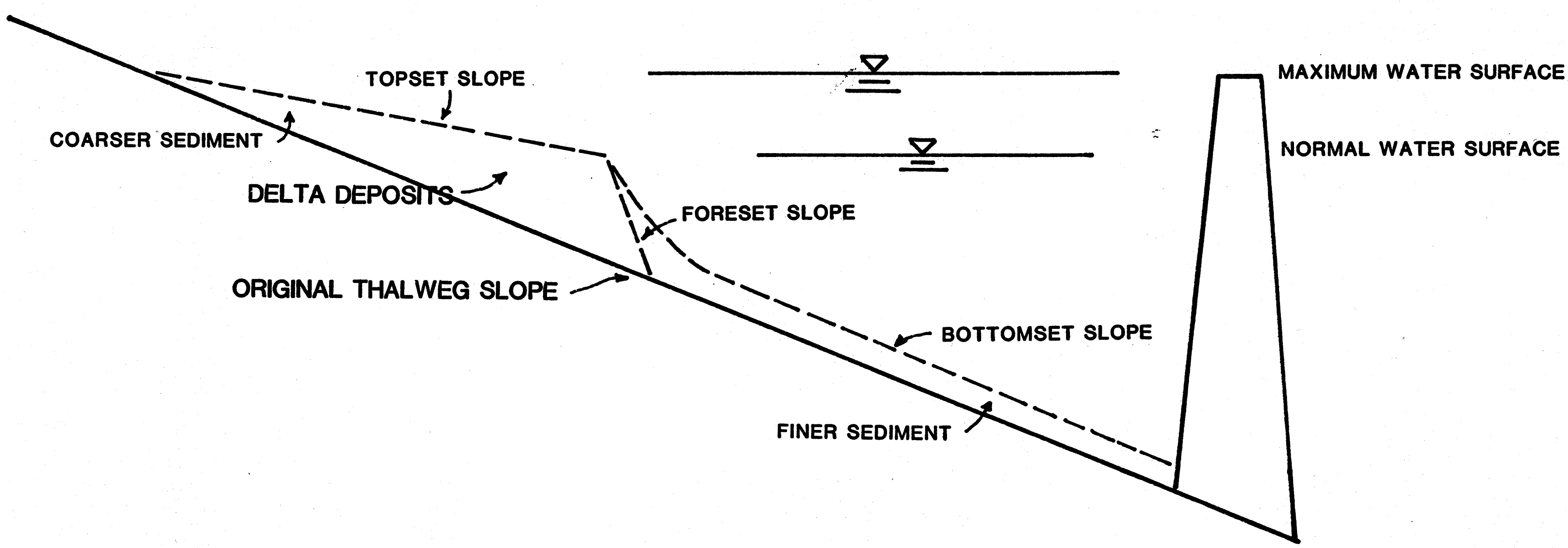
Measurements of sedimentation in reservoirs are generally made by periodic resurveys of the reservoir volume, although rates may be calculated by sediment transport measurements, if a sufficient number of these are made. Reservoir surveys are made with either a fathometer or a weighted line at a number of cross-sections through the reservoir. The methods for conducting these resurveys are described in detail by Gottschalk (1952). Accuracy is dependent upon the number of sections and the careful delineation of the active delta area at the upstream end of the reservoir. With a known volume loss over a given period of time, an annual rate may be calculated.

The next step in determining sediment yield is to calculate the trap efficiency. In all but the largest reservoirs, a percentage of the upstream sediment yield will pass through the reservoir, especially at flood stage. The trap efficiency of a reservoir is related to the characteristics of the incoming sediment and the detention storage time of the reservoir. The trap efficiency will vary over time depending on the inflow and outflow of the reservoir, with the lowest efficiency occurring at flood stage.

Sediment accumulates in a reservoir in a relatively predictable fashion (Figure 2). As the stream flow enters the reservoir, flow velocities are dramatically reduced, thereby decreasing the sediment transport capacity. Coarse-grained particles are deposited first, while the finer grains remain suspended and travel further into the reservoir until they progressively settle out or pass over the dam or through the outlets. The deposition of coarse material typically forms a delta at the upstream end of the reservoir.

FIGURE 2

## SCHEMATIC OF DELTA DEFINITIONS, RESERVOIR SEDIMENTATION



## SAN CLEMENTE RESERVOIR

(a) Existing Data:

The closure of San Clemente Dam in 1921 effectively trapped all of the bedload and a portion of the suspended load from the highest sediment production area in the basin. The existing data on reservoir capacity are presented in Table 1. The reason for the discrepancy in the initial capacity of the reservoir is unknown.

**TABLE 1**

**EXISTING DATA - RESERVOIR CAPACITY, SAN CLEMENTE DAM**

| YEAR | CAPACITY (AC-FT) WITH FLASHBOARDS ELEVATION = 537′ (a) | WITHOUT FLASHBOARDS ELEVATION = 525′, USGS (b) | WITHOUT FLASHBOARDS ELEVATION = 525′, CAL-AM (c) |
|---|---|---|---|
| 1921 | 2136 | 1377 | 1425 |
| 1960 | 1527 | 842 | 843 |
| 1970 | -- | 794 | -- |
| 1979 | 1226 | -- | -- |
| 1983 | 1156 | -- | 472 |
| 1984 | 796 | -- | 316 |
| 1986 | -- | -- | 316 |

Note: (a) San Clemente Reservoir has flashboards that may be raised or lowered, which allows the elevation of the reservoir to be raised from 525′ to 537′. The flashboards are usually raised in April and lowered in November prior to winter rains.

(b) Data from United States Geological Survey report dated May 1981, cited by U.S. Army Corps of Engineers, 1981 and Converse Consultants, 1986.

(c) Data from California-American Water Company or its consultants.

Combining the two sets of data allows a summary of the data to be prepared (Table 2). The capacity for 1979 at elevation 525′ was calculated by subtracting the same relative difference between capacity at 537′ and 525′ for 1983, from the measured 1979 capacity at 537′.

**TABLE 2**

**COMPILATION OF EXISTING DATA**

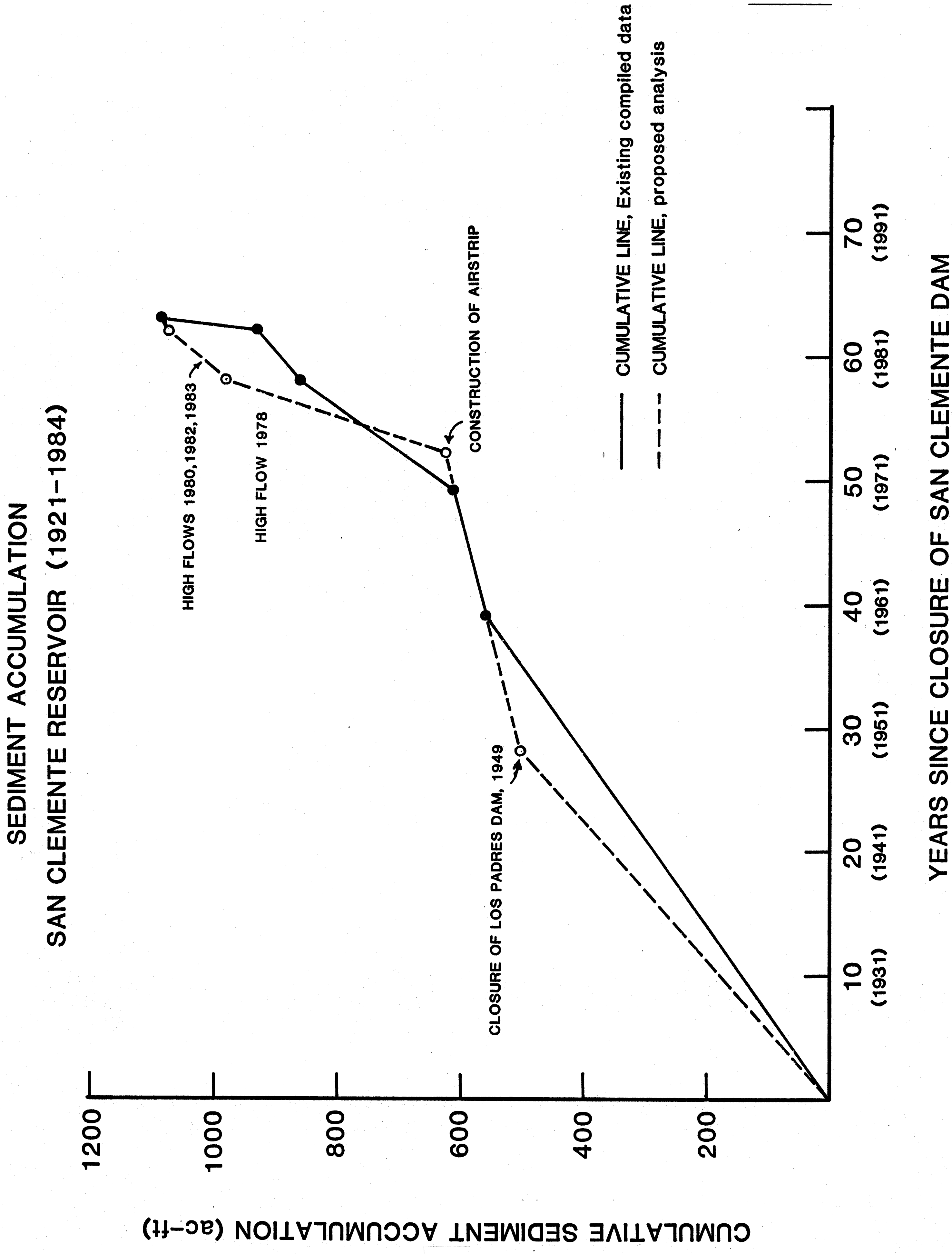
| YEAR | CAPACITY AT ELEV = 525′ (ACRE-FEET) | CAPACITY (ACRE-FEET) | CAPACITY (AC-FT/YR) | CUMULATIVE (AC-FT) SEDIMENT ACCUMULATION |
|---|---|---|---|---|
| 1921 | 1400 | -- | -- | 0 |
| 1960 | 843 | 557 | 14.3 | 557 |
| 1970 | 794 | 49 | 4.9 | 606 |
| 1979 | 542 | 252 | 28.0 | 858 |
| 1983 | 472 | 70 | 17.5 | 928 |
| 1984 | 316 | 156 | 156.0 | 1084 |

(b) Analysis:

These data are plotted in Figure 3, and are shown as solid circles connected by solid lines. Analysis of these data point out a number of flaws. First, Los Padres Dam was closed in 1949, five miles upstream. This would have cut-off the steepest and wettest portion of the drainage basin above the San Clemente Dam site, and thus the largest portion of the sediment yield. Second, in 1972 a rough airstrip was cut on Ponciano Ridge by the owners of Rancho San Clemente. In water years 1973, 1974 and 1975 (all above normal years in terms of flow) massive debris slides occurred on the slopes below the airstrip, and sufficient material entered the Carmel River just upstream of the reservoir to temporarily dam the river. A large debris fan at the mouth of this canyon is still present. Third, the Marble-Cone fire of 1977 did not burn any significant portion of the drainage basin below Los Padres Dam. Fourth, the relatively high flows of 1978, 1980, 1982, and 1983 would have caused an above normal accumulation of sediment in the reservoir. Fifth, the flows of water year 1984 had a recurrence interval of only 3-4 years, so that the extremely large change in capacity between 1983 and 1984 is considered unlikely.

Working with the constraints described above, the sedimentation data were reconstructed as shown in Table 3 below, which in the opinion of the author, is the most reasonable analysis.

FIGURE 3



SEDIMENT ACCUMULATION
SAN CLEMENTE RESERVOIR (1921-1984)
CUMULATIVE SEDIMENT ACCUMULATION (ac-ft)
1200
1000
800
600
400
200
10 (1931)
20 (1941)
30 (1951)
40 (1961)
50 (1971)
60 (1981)
70 (1991)
YEARS SINCE CLOSURE OF SAN CLEMENTE DAM
(DATE)
CLOSURE OF LOS PADRES DAM, 1949
CONSTRUCTION OF AIRSTRIP
HIGH FLOW 1978
HIGH FLOWS 1980, 1982, 1983
CUMULATIVE LINE, Existing compiled data
CUMULATIVE LINE, proposed analysis

## TABLE 3

## PROPOSED ANALYSIS OF SAN CLEMENTE RESERVOIR SEDIMENTATION DATA

| YEAR | CAPACITY AT ELEV = 525′ (AC-FT) | △ CAPACITY (AC-FT) | △ CAPACITY (AC-FT/YR) | CUMULATIVE SEDIMENT ACCUMULATION (AC-FT) |
|---|---|---|---|---|
| 1921 | 1400 | -- | -- | 0 |
| 1949 | 900 (a) | 500 | 17.9 | 500 |
| 1960 | 843 | 57 | 5.2 | 557 |
| 1970 | 794 | 49 | 4.9 | 606 |
| 1973 | 775 (b) | 19 | 6.3 | 625 |
| 1979 | 420 (c) | 355 | 59.2 | 980 |
| 1983 | 326 (d) | 94 | 23.5 | 1074 |
| 1984 | 316 (e) | 4 | 10.0 | 1084 |

Notes: (a) With the closure of Los Padres in 1949, the yield at San Clemente was greatly reduced, as the period from 1960 to 1970 indicates. The slope of this period was extended backward to 1949, to obtain this point.

(b) In the same manner as (a), the line was extended from 1970 to 1973 when the effects of the airstrip construction began to be seen.

(c) This value is back calculated after assuming that the 1984 value is correct, but that the 1983 value must be much lower given a reasonable accumulation for one year. The final value for 1979 was estimated given the series of wet years 1978-1983 and the gaps between 1973 and 1983.

(d) This value is obtained by subtracting 10 acre-feet from the 1984 value. Ten acre-feet was arrived at due to the 3-4 year recurrence interval of storms in 1983-84 and the likelihood of sediment being available for transport after the extremely wet winter of 1982-83.

(e) This value is assumed to be correct because the 1984 and 1986 estimates of reservoir volume computed by the California-American Water Company agree.

The data in Table 3 are also shown in Figure 3 as open circles connected by the dashed lines.

(c) <u>Calculation of Trap Efficiency</u>:

As previously discussed, the sediment trap efficiency of a reservoir depends on the characteristics of the inflowing sediment (its size distribution) and the detention-storage time of the reservoir. Trap efficiency could be calculated from measurements of sediment transport rates above and immediately below a reservoir.

However, these are generally not available. Instead, an empirical relationship was developed by Brune (1953) relating trap efficiency to the remaining reservoir capacity in respect to the annual inflow. Table 4 summarizes these relationships for San Clemente Reservoir.

**TABLE 4**
**SAN CLEMENTE RESERVOIR TRAP EFFICIENCY**

| YEAR | CAPACITY (AT ELEV=525´) (AC-FT) | AVERAGE ANNUAL-INFLOW[a] (AC-FT) | RATIO | TRAP EFFICIENCY %[b] |
|---|---|---|---|---|
| 1921 | 1400 | 70,500 | .020 | 60% |
| 1960 | 843 | " " | .012 | 47% |
| 1984 | 316 | " " | .004 | 21% |

Notes: [a]Annual unimpaired inflow based on reconstructed record developed by MPWMD for its simulation model, CVSIM for 1902-1987. Personal communication from D. Fuerst, October 1988.
[b]Brune (1953) developed a set of envelope curves for his data set. These values are based on the median curve.

Table 4 indicates that at present, according to the Brune (1953) methodology, about 79 percent of the sediment entering San Clemente Reservoir actually passes downstream. In part, this is due to the fact that most of the sediment arriving at San Clemente is suspended load because Los Padres Reservoir traps all of the bedload from the upper watershed, and the amount of bedload contributed by Cachagua, Pine, and San Clemente Creeks is significantly less.

(d) <u>Sediment Yield</u>:

The volume changes developed in the previous sections and the calculations of trap efficiency allow the determination of sediment yields for this location. Following Curry and Kondolf (1983) the conversion from AC-FT/YR to Tons/Year is made by using a specific gravity of 2.7 and a porosity of 20 percent.

The long-term average sediment accumulation rate from 1921 to 1984 is 17.2 AC-FT/YR. The following caclulations translates that value to Tons/Year:

$$\left(17.2\ \frac{\text{ac-ft}}{\text{year}}\right)\left(43{,}560\ \frac{\text{ft}^3}{\text{ac-ft}}\right)\left(62.3\ \frac{\text{lbs}}{\text{ft}^3}\right)\left(2.7\right)\left(.8\right)\left(\frac{1\ \text{ton}}{2000\ \text{lbs}}\right)$$

$$= 50{,}400\ \text{Tons/Year}$$

Given the drainage area at San Clemente of 125 $mi^2$, the yield per unit area is 403 $tons/mi^2/year$ (for additional data, see Table 8).

## LOS PADRES RESERVOIR:

(a) Existing Data:

Los Padres Dam was begun in 1947 and the reservoir was closed in 1949. The new reservoir trapped much of the sediment from that portion of the watershed with the highest yields. Existing data for reservoir capacities over time are summarized in Table 4.

**TABLE 4**
**LOS PADRES RESERVOIR - CAPACITY**
**(ACRE-FEET)**

| YEAR | CAL-AM DATA[a] ELEV = 1040.0 | USGS DATA[b] ELEV = 1040.0 #1 | USGS DATA[b] ELEV = 1040.0 #2 | USGS DATA[b] ELEV = 1040.8 #1 | USGS DATA[b] ELEV = 1040.8 #2 |
|---|---|---|---|---|---|
| 1949 | 3033 | 3100 | 3130 | 3165 | 3200 |
| 1977 | -- | -- | 2540 | 2580 | 2590 |
| 1978 | -- | 2015 | 1985 | 2050 | 2030 |
| 1980 | -- | 1960 | 1940 | 2000 | 1980 |
| 1983 | 2263 | -- | -- | -- | -- |
| 1984 | 2179 | -- | -- | -- | -- |
| 1986 | 2179 | -- | -- | -- | -- |

Notes: [a] California-American Water Company data summarized on a document provided to the MPWMD on 8/19/85. The 1986 value is a personal communication from M. Garrod of Cal-Am on 2/18/88.

[b] Data compiled in a report from the U.S. Geological Survey to the MPWMD dated 2/10/81. Nos. 1 and 2 refer to two different area-capacity curves included in this report. See text for description of the difference between elevations 1040.0 and 1040.8.

Obviously, significant discrepancies exist between the data compiled by Cal-Am and that developed by the USGS. The first issue that needs to be resolved is the spillway elevation. The USGS used 1040.8 as that datum in their investigation. However, Cal-Am uses 1040.0. A spillway discharge rating table prepared for California Water and Telephone Company gives the spillway lip as 1039.85. The discharge at 1040.0 is given as 12.3 cfs, while the discharge at an elevation of 1040.8 is 262 cfs. Based on this, it seems reasonable to use an elevation of 1040.0 for capacity calculations. The differences between the USGS data and Cal-Am's data undoubtedly lie in their respective methodology.

This author has seen the layout of the USGS cross-sections for the reservoir surveys, while the Cal-Am methodology has not been observed. For the purpose of this technical memorandum, the USGS data will be used. These data are presented in Table 5.

**TABLE 5**
**LOS PADRES RESERVOIR - PROPOSED ANALYSIS - SEDIMENTATION DATA**

| YEAR | CAPACITY (AC-FT) | △CAPACITY (AC-FT) | △CAPACITY (AC-FT/YR) | CUMULATIVE SEDIMENT ACCUMULATION (AC-FT) |
|---|---|---|---|---|
| 1949 | 3130 | -- | -- | 0 |
| 1977 | 2540 | 590 | 21.1 | 590 |
| 1978 | 1985 | 555 | 555.0 | 1145 |
| 1980 | 1940 | 45 | 22.5 | 1190 |

The data are plotted in Figure 4.

The most striking aspect of these data is the remarkable sedimentation following the Marble-Cone fire in 1977, which occurred at the end of the most severe drought in the historical record. According to the USGS data, 555 acre-feet or 17.7 percent of the original capacity of the reservoir was lost in one year. The Marble-Cone fire burned virtually all of the Carmel River watershed above Los Padres Dam. Griffen (1978) indicated that no extensive fires had occurred in the watershed in the last 50 years, and that the majority of the basin had not been burned for at least 76 years prior to the Marble-Cone Fire. Hecht (1984) studied the response of the upper Carmel River following the fire. His most significant finding was that at his study reaches several miles upstream from the reservoir, a major fill and scour cycle occurred, but that by the end of three years after the fire, the river channel had returned to within 10 to 20 percent of its pre-fire condition. Hecht attributed this rapid return to baseline condition to the lack of mass movement events triggered by the fire, which he believed was due to the stability of the underlying bedrock.

(b) Calculation of Trap Efficiency:

Using the same methodology as in the analysis of San Clemente Reservoir, Table 6 presents the change in trap efficiency over time for Los Padres Reservoir.

## TABLE 6
## LOS PADRES RESERVOIR - TRAP EFFICIENCY [a]

| YEAR YEAR | CAPACITY (AC-FT) | AVERAGE ANNUAL INFLOW (AC-FT) | CAPACITY / INFLOW RATIO | TRAP % |
|---|---|---|---|---|
| 1949 | 3130 | 54,500[b] | .057 | 79 |
| 1977 | 2540 | " " | .047 | 76 |
| 1980 | 1940 | " " | .036 | 72 |

Notes: [a]Trap efficiency computed from median curve of Brune (1953).
[b]Average annual unimpaired inflow based on reconstructed record developed by MPWMD for its simulation model CVSIM, for 1902-1987. Personal communication from D. Fuerst, October 1988.

It should be noted that the U.S. Army Corps of Engineers, in their 1981 study, "Feasibility Report on Water Resources Development", estimated the trap efficiency of Los Padres Reservoir to be 91 percent. This value seems high. For example, using the Brune method, a reservoir would need a capacity of over 9000 acre feet to have that large a trap efficiency. The methodology of the Corps of Engineers is not documented.

(c) Sediment Yield:

Sediment yields from the watershed above Los Padres Dam may be calculated using the methodology shown for analyzing San Clemente Reservoir data.

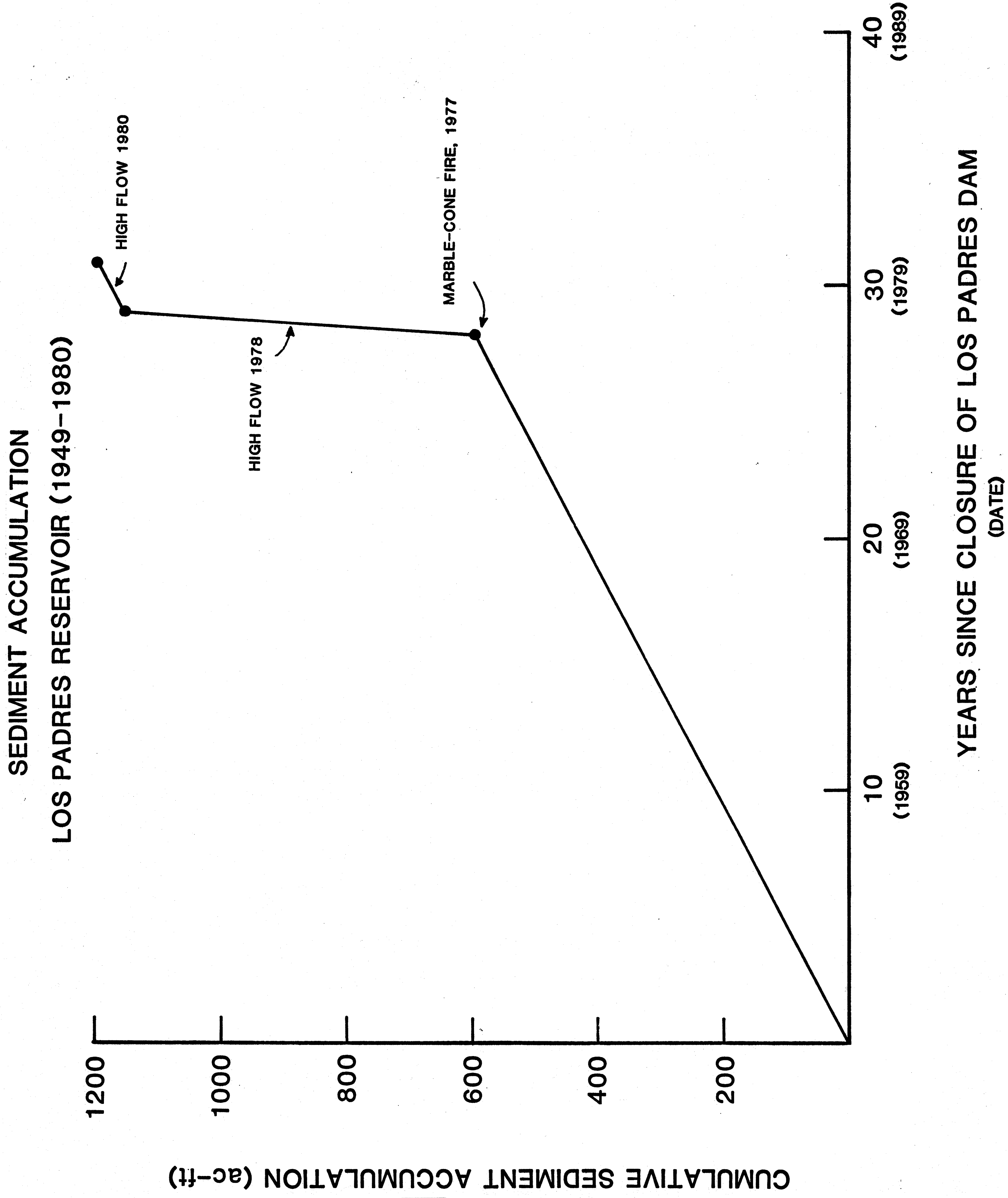
The long-term average sediment yield is 1190 acre feet divided by 31 years, or 38.4 AC-FT/YR. Calculations of the yield for each known period of the Los Padres record are shown in Table 7 below.

## TABLE 7
## LOS PADRES RESERVOIR - SEDIMENT YIELD

| YEAR | $\Delta$ CAPACITY (AC-FT) | YEARS | $\Delta$ CAPACITY (AC-FT/YEAR) | SEDIMENT YIELD[a] (AC-FT/MI$^2$/YEAR) |
|---|---|---|---|---|
| 1949 | 0 | -- | -- | -- |
| 1977 | 590 | 28 | 21.1 | .48 |
| 1978 | 555 | 1 | 555.0 | 12.70 |
| 1980 | 45 | 2 | 22.5 | .52 |
| AVG | 1190 | 31 | 38.4 | .88 |

Notes: [a]Drainage area above Los Padres Dam was measured with a planimeter as 43.6 mi$^2$.

FIGURE 4


SEDIMENT ACCUMULATION
LOS PADRES RESERVOIR (1949–1980)
HIGH FLOW 1980
HIGH FLOW 1978
MARBLE–CONE FIRE, 1977
CUMULATIVE SEDIMENT ACCUMULATION (ac–ft)
200
400
600
800
1000
1200
10
(1959)
20
(1969)
30
(1979)
40
(1989)
YEARS SINCE CLOSURE OF LOS PADRES DAM
(DATE)

It is instructive to note that the long-term rate was nearly doubled by one unusual event, the Marble-Cone fire. To convert to this value into tons/year:

$$\left(\frac{38.4 \text{ ac-ft}}{\text{year}}\right)\left(\frac{43{,}560 \text{ ft}^3}{\text{acre-ft}}\right)\left(\frac{62.3 \text{ lbs}}{\text{ft}^3}\right)(2.7)(0.8)\left(\frac{1 \text{ ton}}{2000 \text{ lbs}}\right)$$

= 112,500 Tons/Year or 2580 Tons/Mi$^2$/Year

Using the trap efficiencies calculated in the previous section, an estimate of the total yield may be made. Assuming the average trap efficiency for the 1949-1980 time period is 76 percent, the total yield may be calculated as follows:

$$\frac{112{,}500 \text{ Tons/Yr}}{\text{Total Yield}} = \frac{76}{100}$$

Or the total yield is 148,000 Tons/Yr and 3395 Tons/Mi$^2$/Yr.

COMPARISON OF LOS PADRES AND SAN CLEMENTE SEDIMENT DATA:

Table 8 presents a comparison of data for these two reservoirs.

**TABLE 8**
**SEDIMENTATION DATA LOS PADRES AND SAN CLEMENTE RESERVOIRS**

| | | YIELD | | | |
|---|---|---|---|---|---|
| Location | Period | (AC-FT/YR) | (AC-FT/Mi$^2$/YR) | (Tons/Mi/YR) | (Tons/YR) |
| Los Padres | 1949-1977 | 21.1 | .48 | 1,420 | 61,800 |
| | 1949-1980 | 38.4 | .88 | 2,580 | 112,500 |
| San Clemente | 1921-1949 | 17.9 | .14 | 420 | 52,500 |
| | 1949-1973 | 5.2 | .04 | 120 | 15,200 |
| | 1949-1984 | 16.7 | .13 | 390 | 48,900 |
| | 1921-1984 | 17.2 | .14 | 400 | 50,400 |

As would be expected, the yield at San Clemente for 1921-1949 is quite similar to the yield at Los Padres from 1949-1977. The difference lies in a combination of inaccuracies in the reservoir surveys, possible alluvial storage between Los Padres and San Clemente in the vicinity of Prince's Camp, and differing hydrologic conditions in the two periods. The yield at San Clemente decreased by 70 percent after the closure of Los Padres (1949-1973). The records for both reservoirs indicate that unusual events in each case greatly changed the long-term average yields. Both of these events are attributable to man's impacts, one by fire suppression, the other by airstrip construction.

SEDIMENT ROUTING:

A rough sediment routing through the two reservoirs may be made by using yield values and trap efficiency (Kondolf and Matthews, 1987). For this calculation, yields will be used that do not include the unusual events that affected the reservoirs.

Using data from Table 8, the yield based on reservoir accumulation at Los Padres (1949-1977) is 61,800 tons/yr. Adjusting for a trap efficiency of 75 percent gives a total yield 82,400 tons/year. Since all of the bedload from the upper watershed is trapped behind Los Padres Dam, the 20,600 tons/year must all be suspended load. This sediment load, combined with tributary inputs from Cachagua Creek, Pine Creek, and San Clemente Creek, provides the sediment input to San Clemente Reservoir, assuming no in-channel storage occurs. At San Clemente, for the period 1949-1973, the yield by reservoir accumulation is 15,200 tons/year. Using the trap efficiency of 48 percent, the total yield would be 31,700 tons/year. The tributary contribution is 31,700 tons minus 20,600 or 11,100 tons/year. This leaves 16,500 tons of suspended sediment output from San Clemente Reservoir. These figures reflect the characteristics of the time period 1949-1973, and would have to be adjusted to account for recent changes in order to estimate current yields.

CONCLUSIONS:

Analysis of reservoir sedimentation data provides insights into the sediment yields of the upper Carmel River watershed. These data provide the basis for estimating sediment accumulation in proposed reservoirs and evaluating their downstream effects.

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(rev2/89)

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# DRAFT

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

TECHNICAL MEMORANDUM 89-01

EVALUATION OF SEDIMENT TRANSPORT RATES
AT THE PROPOSED FISH SCREENING FACILITY
ON THE CARMEL RIVER AT PINE CREEK

MARCH 1989

PREPARED BY:
GRAHAM MATTHEWS

## INTRODUCTION

The Monterey Peninsula Water Management District (MPWMD) is in the planning stages of developing additional water supplies for the Monterey Peninsula. A variety of alternatives have been evaluated and the most practicable consist of a new dam either in the vicinity of the existing San Clemente and Los Padres Dams, or perhaps on a tributary. Of primary concern regarding the construction of a new dam on the Carmel River, is the potential to block or disrupt the anadromous fisheries resource of the river, from migration to and from some of its prime spawning habitat.

As a result, features are being considered for each project that would address this potential impact. In the case of the proposed dam and reservoir at the New San Clemente site, a fish screening facility would be constructed at the upstream end of the reservoir to trap downstream migrating steelhead and to allow them to be transported to a point below the new dam for release. In evaluating the conceptual design for such a facility, concern has been expressed about the volume of sediment transported by the Carmel River at this location, and how this could affect the operation of the facility.

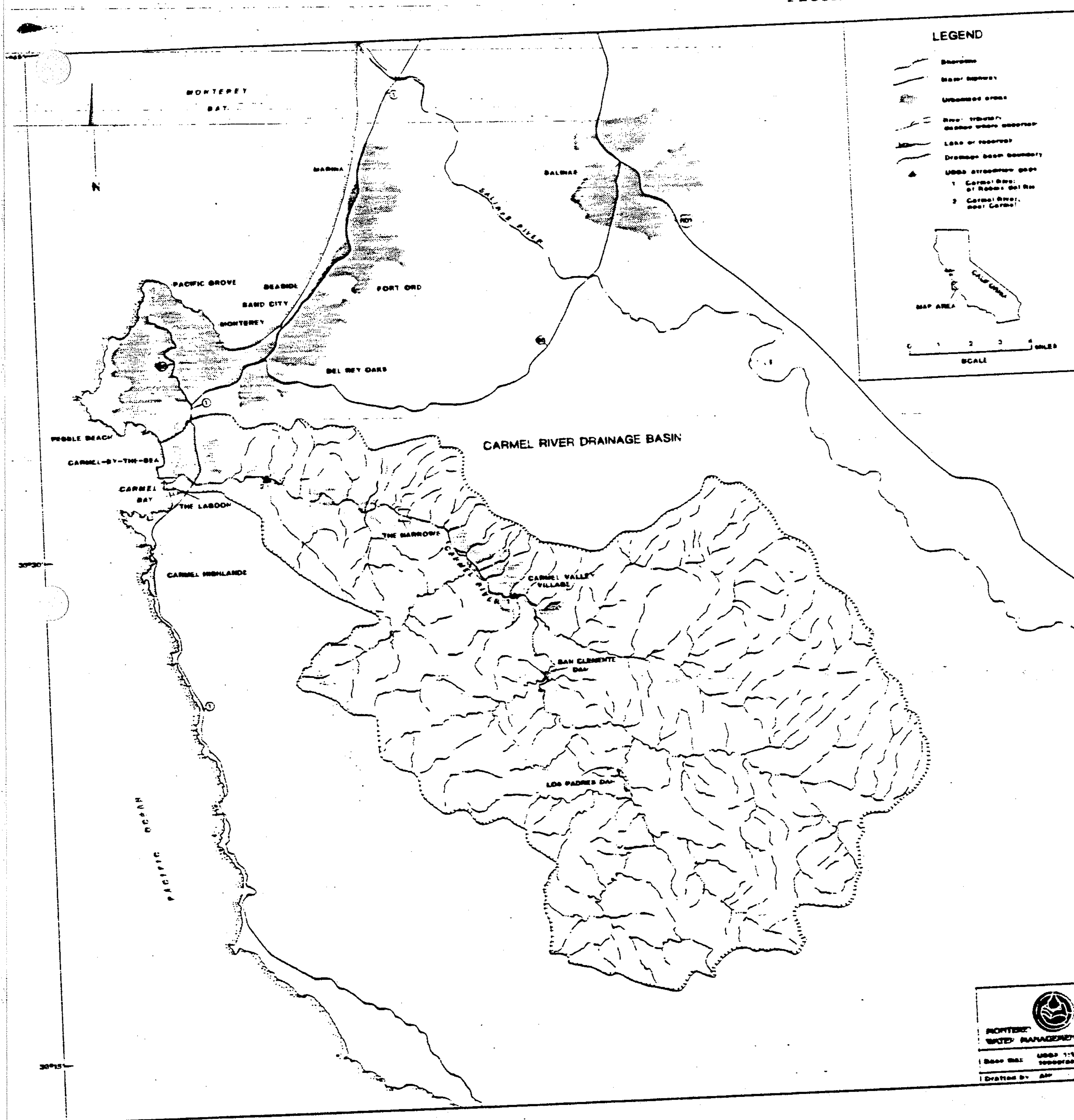
## OBJECTIVE

The objective of this technical memorandum is to estimate the existing sediment transport rates of the Carmel River at a location downstream of the confluence with Pine Creek. In addition, an evaluation of the size distribution of this sediment is presented.

## SETTING

The Carmel River drains a basin of 255 square miles ($mi^2$) on the Central California Coast, entering the Pacific Ocean at Carmel (Figure 1). The upper watershed is extremely rugged with peaks up to 5,000 feet above sea level. The upper 21 miles of the river pass through steep, narrow canyons before traversing an alluvial valley in its lower 15 miles. Orographic effects are

FIGURE 1: LOCATION MAP



pronounced; annual precipitation varies from about 16 inches at sea level near the river mouth, to over 40 inches in the high peaks of the southern part of the basin. Precipitation is almost entirely rain, with most falling from November through March. Streamflow is in response to the seasonal rainfall, and high flows capable of transporting sediment are restricted to these winter months.

Much of the sediment from the upper half of the basin (125 $mi^2$) has been trapped since 1921 by San Clemente Dam (rivermile 18.6). Los Padres Dam (drainage area of 44 $mi^2$) was closed in 1949 another 5 miles upstream. The upper basin with its steep slopes and a pre-1900 fire frequency of about once per 21 years (Griffen and Talley, 1981) undoubtedly produced the majority of the basin's sediment load. Downstream of San Clemente Dam elevations are lower and rainfall is much less.

Figure 2 is a reduced topographic map of the vicinity, showing place names, tributary creeks, and the site of the proposed fish screening facility. The proposed facility would be located about 2.5 miles above the existing San Clemente Dam at river mile 21 approximately, just downstream of the confluence of the Carmel River and Pine Creek.

## METHODOLOGY

The sediment load of a river may be estimated in a number of ways; such as: (1) measurement of actual sediment transport rates and development of sediment rating curves, (2) usage of reservoir sedimentation data, (3) usage of regional values of existing data from comparative watersheds, or (4) estimation of watershed erosion and the delivery ratio of sediment. The methods above are listed in order of decreasing difficulty of implementation and increasing relative amount of error.

This study uses three lines of evidence, methods 1, 2, and 3 above, to produce estimates of sediment load. Although there have been no actual measurements of sediment transport rates at the proposed project site, measurements on tributaries allow the estimation of a sediment budget for this portion of the Carmel River watershed. Comparison of these estimates with actual measurements taken at a site about 7 miles downstream, and with actual reservoir sedimentation rates allows for double checking of each methods' accuracy.

The sediment load of a natural channel can be divided into suspended load and bedload. Bedload is defined as that portion of the total sediment discharge that moves by saltation (jumping, rolling, or sliding) on or in the bed of the river. In this study, bedload transport rates and volumes are the primary concern because it is this portion of the sediment load that could affect the operation and maintenance of a fish screening facility.

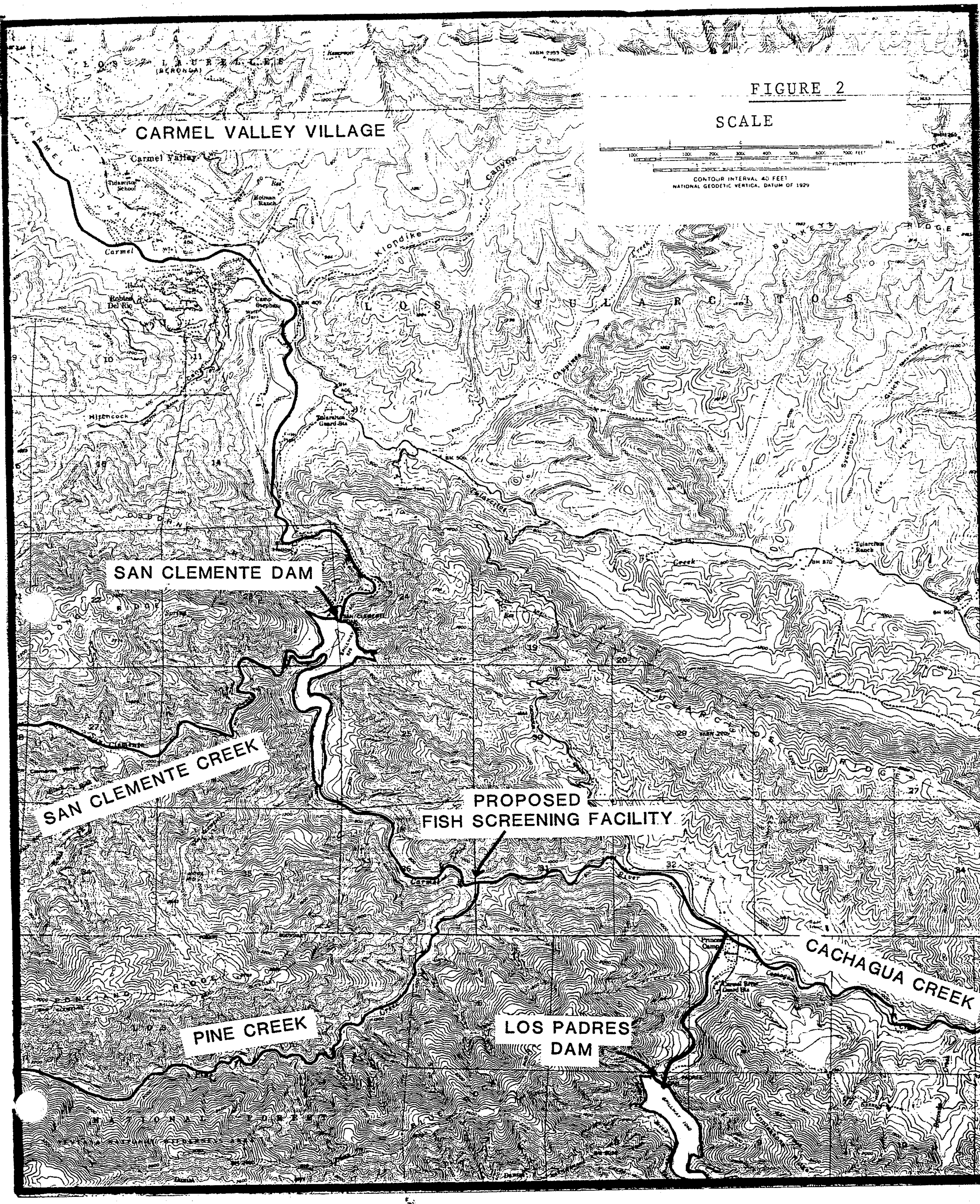


FIGURE 2
SCALE
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
CARMEL VALLEY VILLAGE
SAN CLEMENTE DAM
SAN CLEMENTE CREEK
PROPOSED
FISH SCREENING FACILITY
PINE CREEK
LOS PADRES
DAM
CACHAGUA CREEK
LOS TULARCITOS

That portion of the analysis dealing with reservoir sedimentation is based on a previous technical memorandum (# 88-03) prepared for the Monterey Peninsula Water Management District (Matthews, 1989). The interested reader is referred to that document for additional information.

ANALYSIS

(a) Using Reservoir Sedimentation Data:

The analysis of sedimentation in San Clemente reservoir presented in Technical Memorandum 88-03 indicated that the 1921-1949 sediment accumulation averaged nearly 18 acre feet per year (ac-ft/yr). After the closure of Los Padres Dam in 1949, the rate decreased dramatically to about 5 ac-ft/yr. It is appropriate to note at this point that averages are very misleading when discussing sediment transport rates because there exists an exponential relationship between sediment and discharge with the exponent generally varying between 1.5 and 3, at least for tributaries studied along the Carmel River (Matthews, 1983). The majority of sediment is thus transported at the highest flows.

The sedimentation rates noted above also include sediment transported by San Clemente Creek, a tributary with a drainage area of 15.6 $mi^2$, which is downstream of the proposed facility site. Table 1 presents drainage data for various portions of the watershed above San Clemente Dam.

**TABLE 1**

**TRIBUTARY DRAINAGE AREAS ABOVE SAN CLEMENTE DAM**

| TRIBUTARY | DRAINAGE AREA ($MI^2$) (a) | % AREA ABOVE SAN CLEMENTE |
|---|---|---|
| Above Los Padres Dam | 44.0 | 35.2 |
| Cachagua Creek | 46.3 | 37.0 |
| Pine Creek | 7.8 | 6.2 |
| San Clemente Creek | 15.6 | 12.5 |
| At San Clemente Dam | 125.0 (b) | 100.0 |

Notes: (a) Data from (Kapple, et al, 1984), or by planimetering.
(b) Individual areas do not match total because of drainage areas not included in these major tributary areas.

It is also instructive to note that based on some preliminary regression equations, the percentage of flow that each tributary produces for a given flow at Robles del Rio has been estimated by MPWMD staff. The watershed above Los Padres Dam, produces over 75% of the runoff reaching Carmel Valley Village. Five major tributaries (Cachagua Creek, Pine Creek, San Clemente, Tularatos

Creek, and Hitchcock Creek) produce the majority of the 25% remaining, with San Clemente Creek accounting for 57% of that amount. Cachagua Creek, despite its large drainage area, produces relatively little runoff because it is located in the rain shadow of the high peaks of the Santa Lucia's to the south and west. Even Pine Creek with a drainage area one-sixth the size of Cachagua Creeks', produces more runoff.

Technical memorandum 88-03 presented a preliminary sediment routing through the two reservoirs using sediment yields in tons/yr, which were calculated from average capacity changes by using a specific gravity of 2.7 and a porosity of 20 percent (Curry and Kondolf, 1983), and combining this with estimates of reservoir trap efficiency. For the period 1949-1973, it was estimated that an average of 20,600 tons of suspended load passed over Los Padres Dam and combined with 11,100 tons total load (both suspended and bedload), from the three major tributaries upstream to give a total yield at San Clemente of 31,700 tons/yr. A reasonable split of the 11,100 tons total load from tributaries would be 75% suspended load and 25% bedload. The bedload would therefore be 2,775 tons/yr. This amount needs to be split between the three tributaries. On the basis of the preliminary discharge regressions, San Clemente Creek would produce 64% of the sediment with Pine Creek at 19% and Cachagua at 17%. Thus the average bedload at the proposed facility would be 36% of 2,775 tons/yr or 1,000 tons/yr, or .34 ac-ft/yr on average. Again, it is worth remembering that in dry years, the bedload volume would be less than this figure, and in wet years considerably higher.

(b) Using Tributary Bedload Measurements

Very limited bedload measurements have been made on the three tributaries, with the exception of Pine Creek where no measurements have been made, by the MPWMD staff during the period 1982-1988. Two other tributaries further downstream also drain the wetter southern part of the watershed and may be included in this comparison. Table 2 presents the existing data.

**TABLE 2**

**SUMMARY OF CARMEL RIVER TRIBUTARY BEDLOAD MEASUREMENTS**

| TRIBUTARY | DRAINAGE AREA | NO. OF DATA POINTS | EQUATION OF BEST-FIT LINE |
|---|---|---|---|
| Cachagua | 46.3 | 12 | $y= 0.062\ X^{1.66}$ |
| Pine | 7.8 | -- | NA |
| San Clemente | 15.6 | 1 | NA |
| Hitchcock | 4.6 | 15 | $y= 2.001\ X^{1.02}$ |
| Robinson Canyon | 5.4 | 17 | $y= 0.307\ X^{1.43}$ |

Source: Unpublished data from MPWMD files.

The three bedload rating curves are shown in Figures 3, 4, and 5. The curves indicate that the tributaries transport relatively small amounts of bedload until flows exceed 100 $ft^3$/sec.

Since Los Padres reservoir traps all of the bedload from the upper portion of the watershed, any bedload transport occurring at the proposed site would come either from Cachagua Creek, Pine Creek, or from changes in channel-stored sediment such as bank or bar erosion. It is also likely that some portion of the sediment input by Cachagua Creek is deposited along the river before reaching the project site.

Previous unpublished work by the MPWMD estimated flood frequency data for the Carmel River at Pine Creek and for San Clemente Creek. These data for a number of recurrence interval storms are presented in Table 3.

**TABLE 3**

**FLOOD FREQUENCY DATA FOR SELECTED SITES**

**MEAN DAILY DISCHARGE, ANNUAL MAXIMA IN $FT^3$/SEC**

| RECURRENCE INTERVAL | CARMEL RIVER[(a)] AT PINE CREEK | SAN CLEMENTE[(a)] CREEK | PINE[(b)] CREEK | CACHAGUA[(c)] CREEK |
|---|---|---|---|---|
| 1.5 | 1,050 | 170 | 50 | 46 |
| 2 | 1,500 | 190 | 57 | 51 |
| 3 | 2,010 | 270 | 81 | 73 |
| 5 | 2,620 | 355 | 107 | 96 |
| 10 | 3,330 | 450 | 135 | 122 |

Notes: (a) Unpublished data from MPWMD analysis, April 1988.
(b) Calculated as 30% of San Clemente Creek using relationship established by preliminary regression estimates described earlier.
(c) Calculated as 27% of San Clemente Creek as per (b) above.

Mean daily discharges are used in these calculations so that instantaneous hydrographs do not have to be estimated and reduced for various sediment discharge categories. While mean daily discharges are known to underestimate the relationship between sediment load and discharge (Kondolf and Matthews, 1988), they are considered adequate for the purposes of this analysis. It should also be noted that the discharge estimates for the Carmel River at Pine Creek were prepared using published U.S. Geological Survey (USGS) records for the Robles del Rio gaging station and analysis by the MPWMD computer based simulation model, CVSIM. There is considerable disagreement between the USGS values and

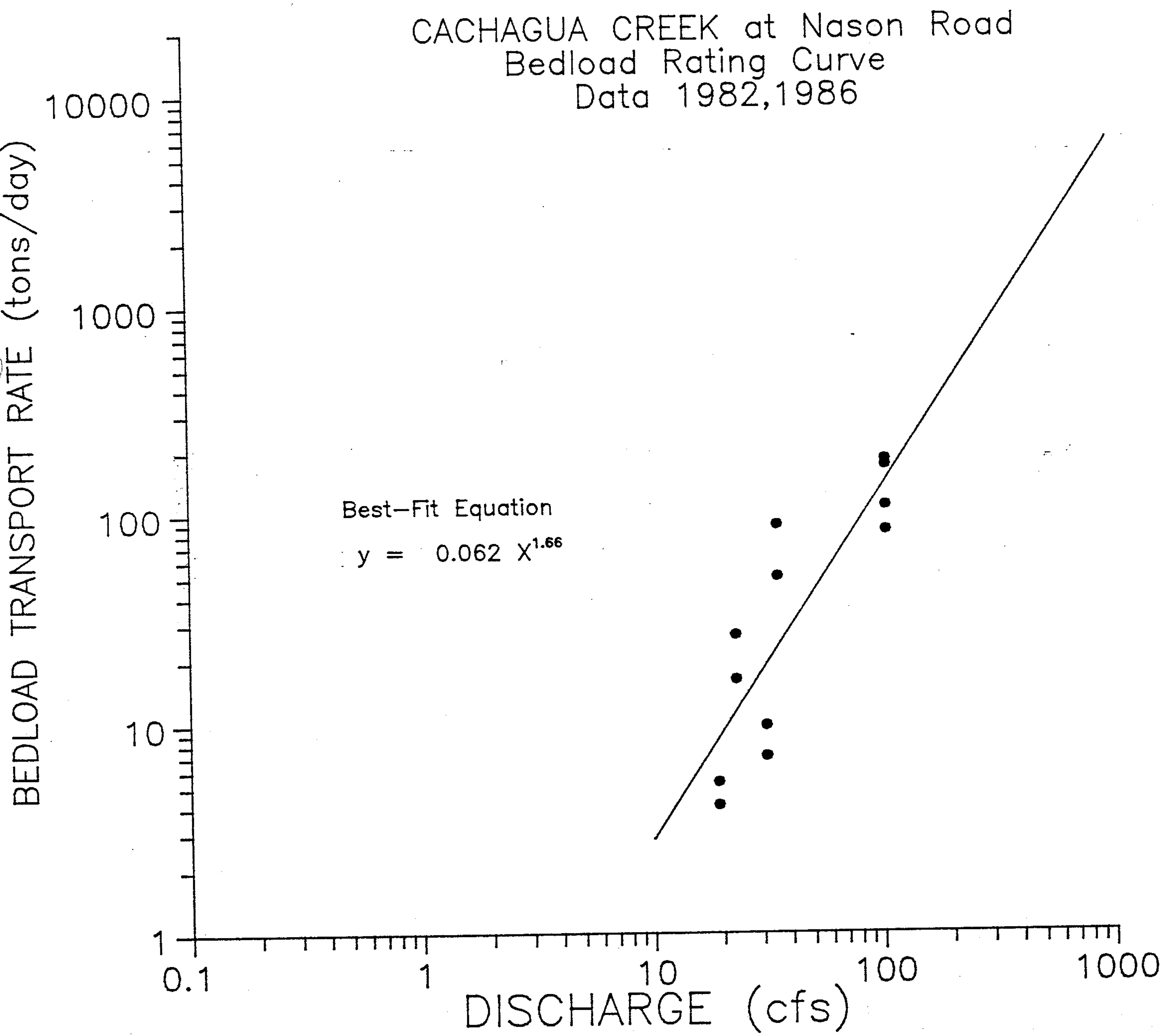

CACHAGUA CREEK at Nason Road
Bedload Rating Curve
Data 1982,1986
BEDLOAD TRANSPORT RATE (tons/day)
10000
1000
100
10
1
Best-Fit Equation
y = 0.062 X^1.66
0.1
1
10
100
1000
DISCHARGE (cfs)

FIGURE 4

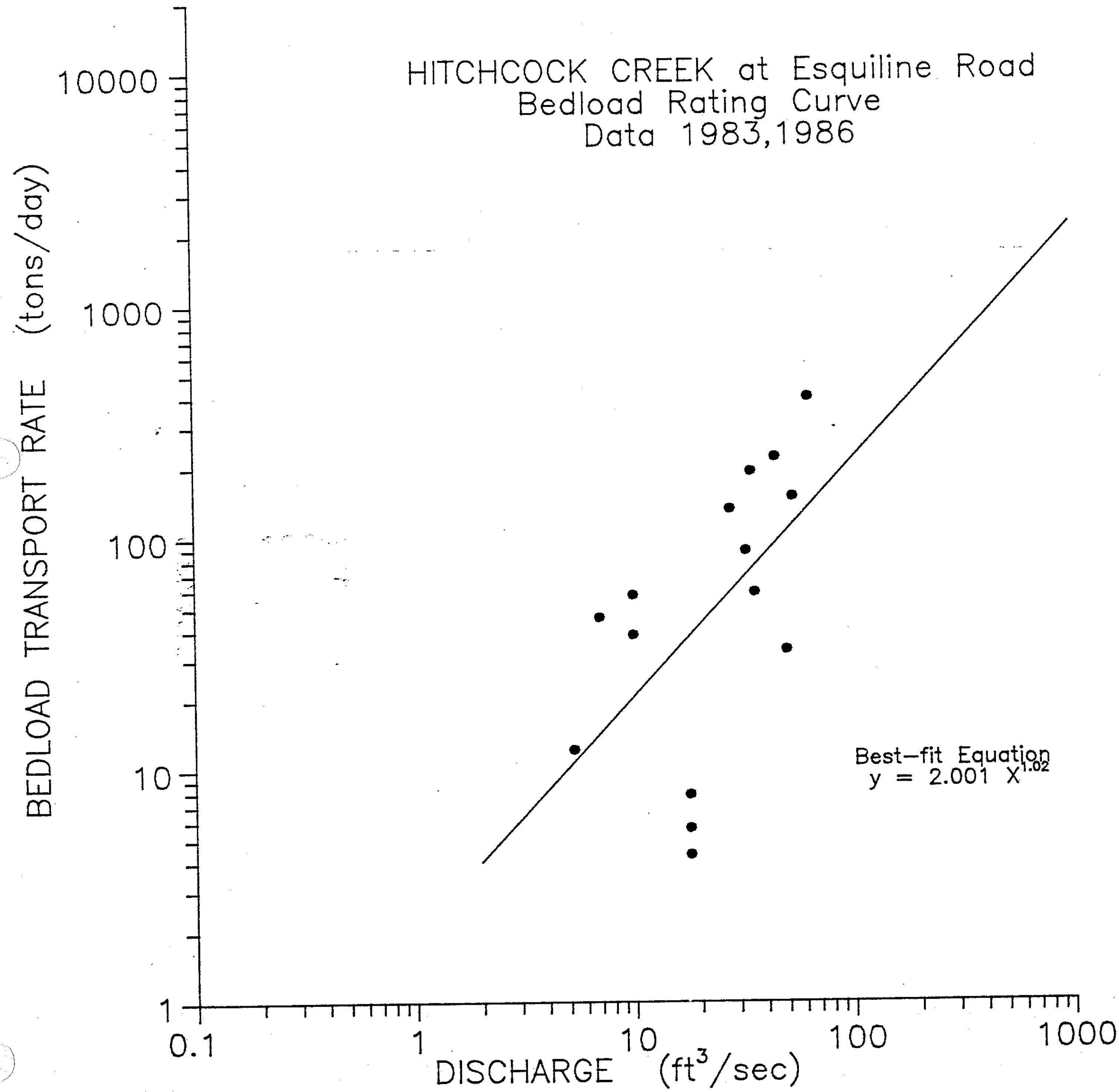
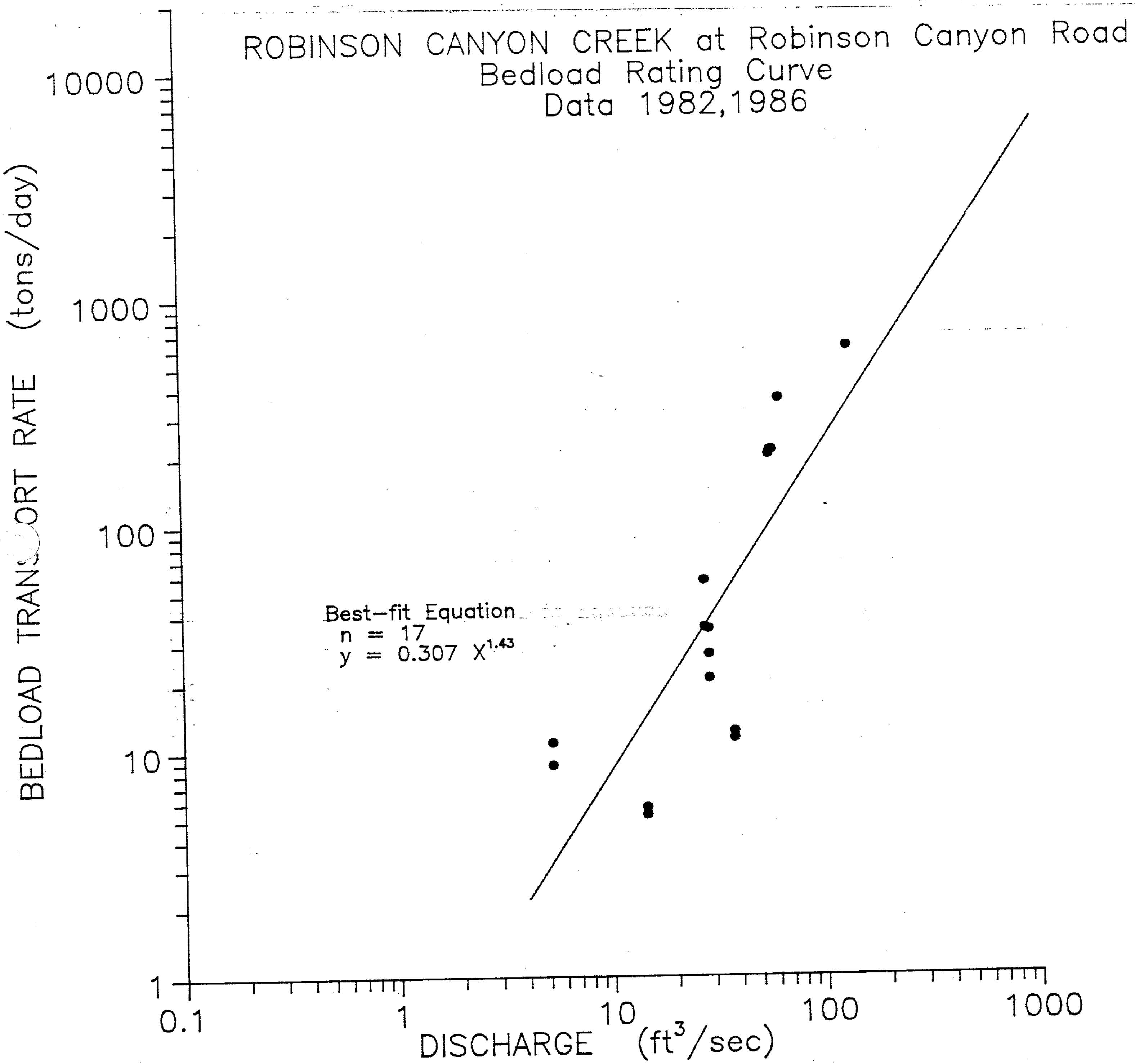

HITCHCOCK CREEK at Esquiline Road
Bedload Rating Curve
Data 1983,1986
BEDLOAD TRANSPORT RATE (tons/day)
10000
1000
100
10
1
0.1
1
10
100
1000
DISCHARGE (ft3/sec)
Best-fit Equation
y = 2.001 X1.02

FIGURE 5


ROBINSON CANYON CREEK at Robinson Canyon Road
Bedload Rating Curve
Data 1982,1986
BEDLOAD TRANSPORT RATE (tons/day)
10000
1000
100
10
1
Best-fit Equation
n = 17
y = 0.307 X^1.43
0.1
1
10
100
1000
DISCHARGE (ft^3/sec)

flood frequency estimates prepared by the U.S. Army Corps of Engineers (USACE) and the Federal Emergency Management Agency (FEMA), with USACE and FEMA having significally higher discharges; mostly, though, for the more infrequent storm events.

Using the mean daily discharges shown in Table 3, sediment loads can be estimated from the bedload rating curves (Figure 3 for Cachagua Creek and Figure 6 for Pine Creek). These data are presented in Table 4.

**TABLE 4**

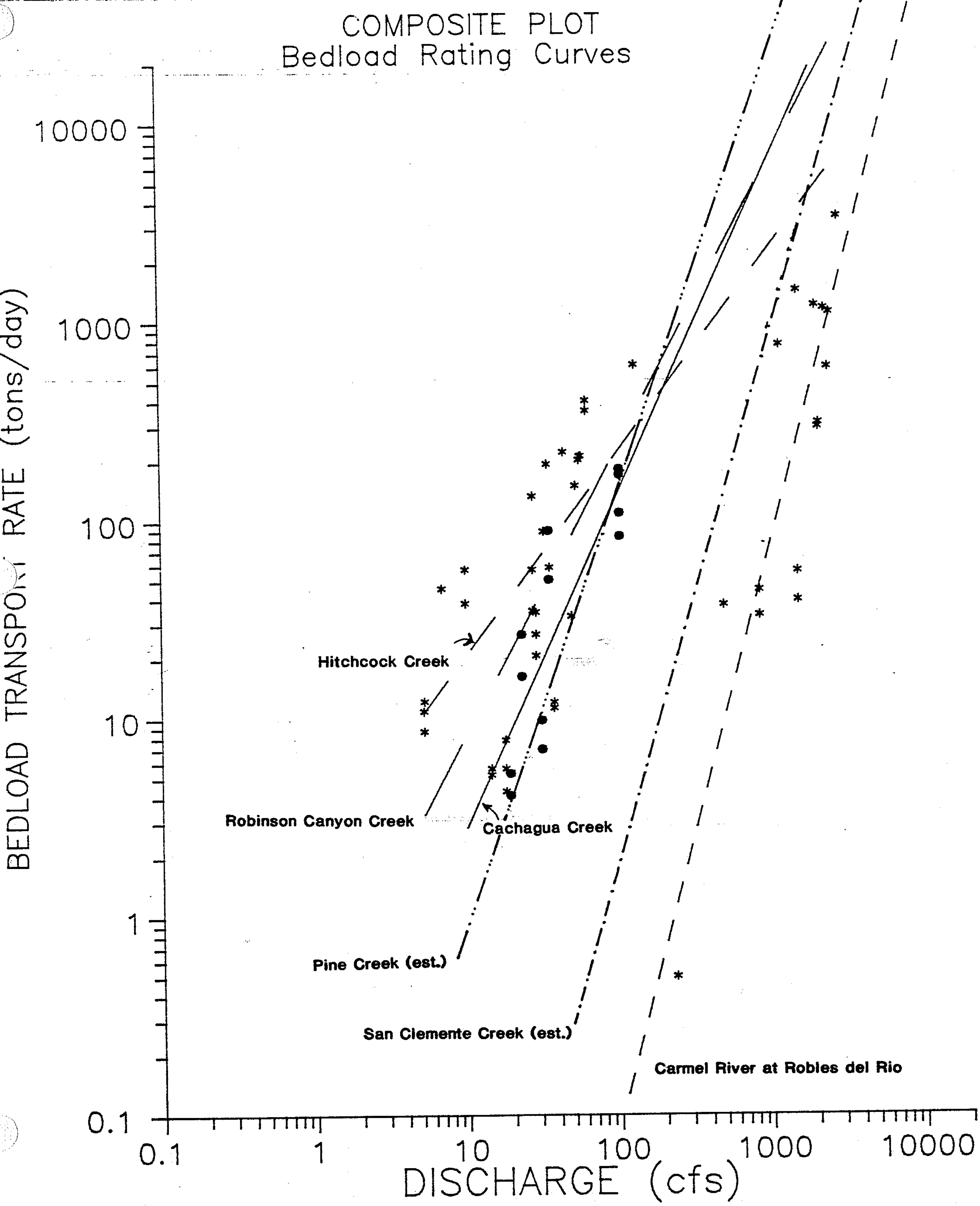
**TRIBUTARY BEDLOAD TRANSPORT DATA**

| | CACHAGUA CREEK | | PINE CREEK | |
|---|---|---|---|---|
| RECURRENCE INTERVAL (years) | DISCHARGE (cfs) | BEDLOAD RATE (tons/day) | DISCHARGE (cfs) | BEDLOAD RATE (tons/day) |
| 1.5 | 46 | 36 | 50 | 29 |
| 2 | 51 | 42 | 57 | 40 |
| 2.33 | 59 | 54 | 66 | 55 |
| 3 | 73 | 77 | 81 | 90 |
| 5 | 96 | 121 | 107 | 205 |
| 10 | 122 | 180 | 135 | 300 |

The estimates shown in Table 4 reflect only the one day of flow that included the peak discharge of the given recurrence interval. Flood frequency estimates by the annual maxima do not take into account lesser storm peaks within a given year, so that the estimates for the peak discharge only are definitely on the low side. Depending on how the other storms occurred, their number and duration, the actual bedload transported could be many times higher. Unpublished MPWMD data for the Carmel River at Robles del Rio show that the highest mean daily discharge may transport between 17% and 34% of the total annual load. Using an average of 25%, the following estimates are made:

| RECURRENCE INTERVAL (YEARS) | CACHAGUA CREEK BEDLOAD, TOTAL ANNUAL (TONS) | PINE CREEK BEDLOAD, TOTAL ANNUAL (TONS) | TOTAL TRIBUTARY INPUT (TONS) |
|---|---|---|---|
| 1.5 | 145 | 120 | 265 |
| 2 | 170 | 160 | 330 |
| 2.33 | 215 | 220 | 435 |
| 3 | 310 | 360 | 670 |
| 5 | 485 | 820 | 1305 |
| 10 | 720 | 1200 | 1920 |

FIGURE 6


COMPOSITE PLOT
Bedload Rating Curves
BEDLOAD TRANSPORT RATE (tons/day)
DISCHARGE (cfs)
0.1
1
10
100
1000
10000
Hitchcock Creek
Robinson Canyon Creek
Cachagua Creek
Pine Creek (est.)
San Clemente Creek (est.)
Carmel River at Robles del Rio

These estimates may be compared to the averages obtained by the first method of reservoir sedimentation as a means of checking their validity. The average estimate by reservoir sedimentation is 1,000 tons/year. The rating curve method gives 435 tons for the 2.33 recurrence interval storm or mean annual flow. The range of these values is reasonable given the methodology. The reservoir sedimentation method value is also known to be higher than the median value would be, biased as it would be by the few highest values for the period of record.

(c) Using Downstream Data:

A final method for estimating sediment transport at the ungaged proposed facility site near Pine Creek uses data collected at the USGS gaging station at Roble del Rio (River Mile 14.5). A bedload rating curve is shown in Figure 7. Both sites have armored beds, which are generally only mobilized at higher flows. The grain size at the Pine Creek site is larger, which would indicate additional resistance to the initiation of movement, however, the slope is much steeper there and the shear stress is greater which may balance out the larger grain size.

Using the bedload rating curve for a discharge of 1,670 $ft^3$/sec (2.33-yr flow at Pine Creek site) gives a transport rate of 280 tons/day. If it is assumed that this value represents 25% of the annual load, the total load would be 1,120 tons.

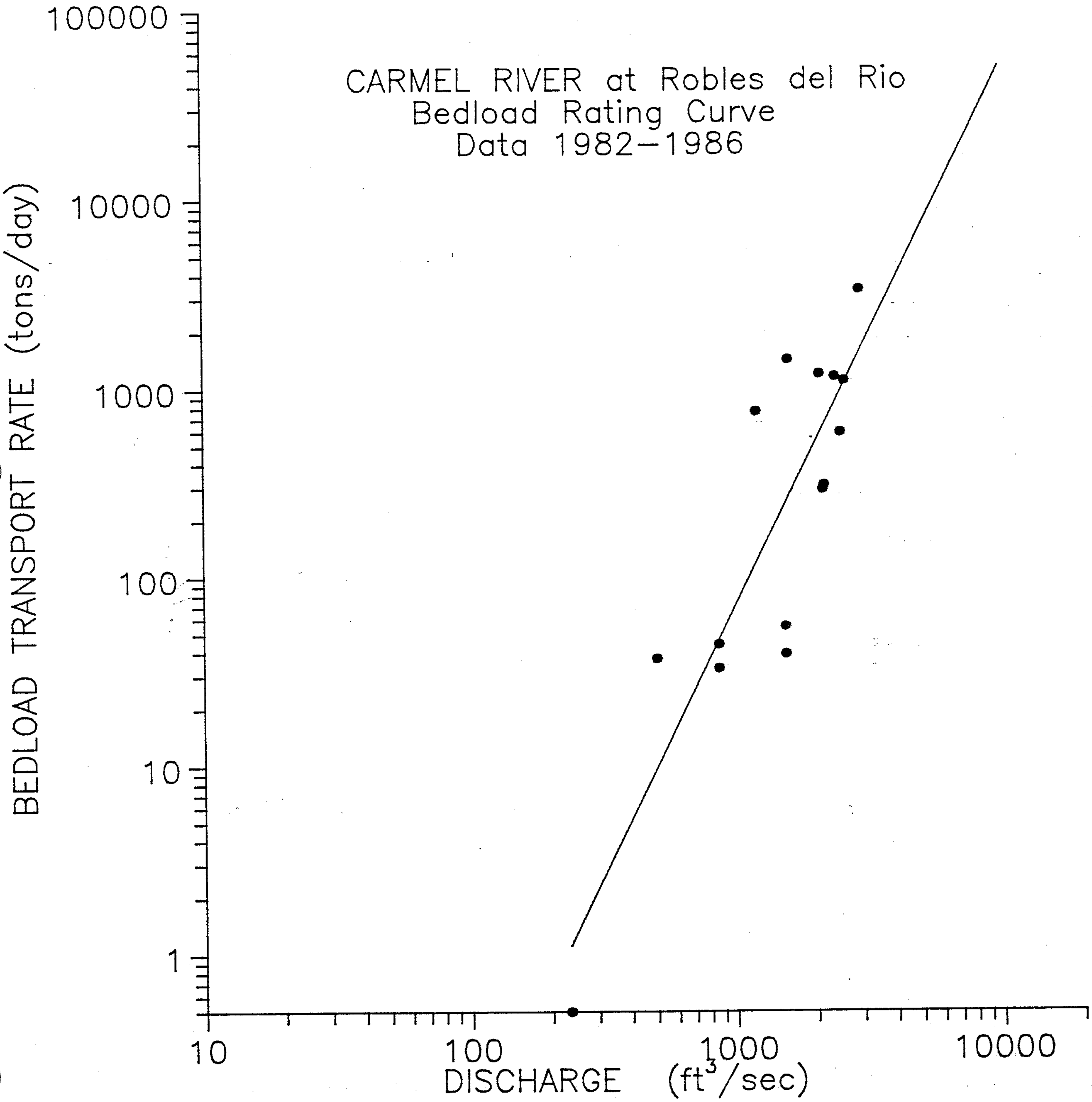
The three methods produce comparable values for total bedload transported at the proposed facility site. The volumes estimated would appear to be small enough to not appreciably affect the operation of a fish screening facility.

## SIZE DISTRIBUTION

The grain size distribution of the bedload transported at the proposed facility is also of interest. Once again, there is no actual data available of size analyses of bedload samples. However, MPWMD Staff made two pebble counts in the area on January 24, 1989. Cumulative percent finer curves are shown for these two pebble counts in Figures 8 and 9. The samples were made at locations that were interpreted to represent deposits made by storms comparable to bankfull discharge or the 1.5 year recurrence interval flow. The samples are reasonably similar, with the one made on Pine Creek slightly coarser overall.

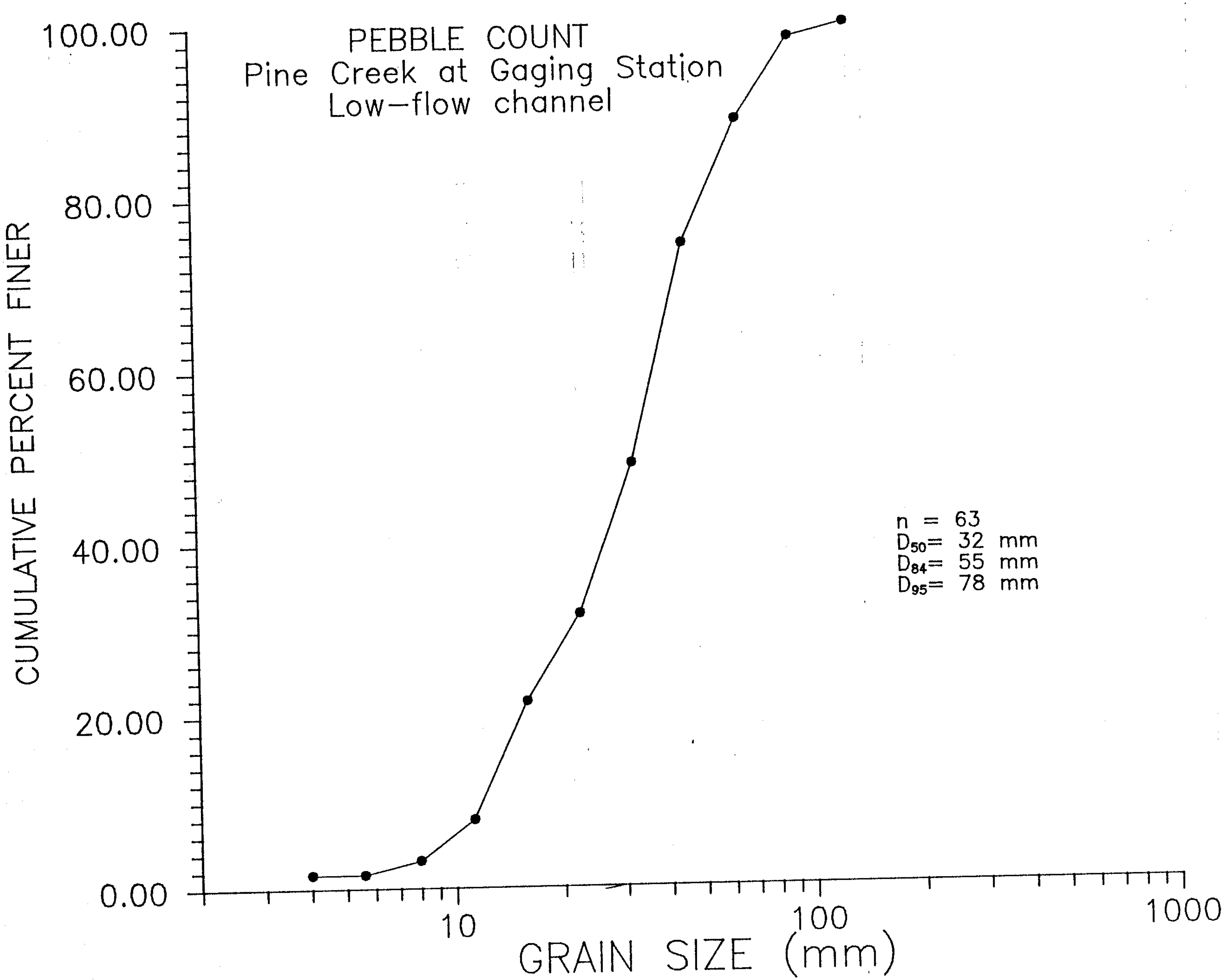
These limited data give a range for sediment transported by the Carmel River at flows up to about 2,000 $ft^3$/sec. This would appear to be similar to the case at Robles del Rio as discussed earlier, where the armored bed does not significantly mobilize without even higher discharges.

FIGURE 7



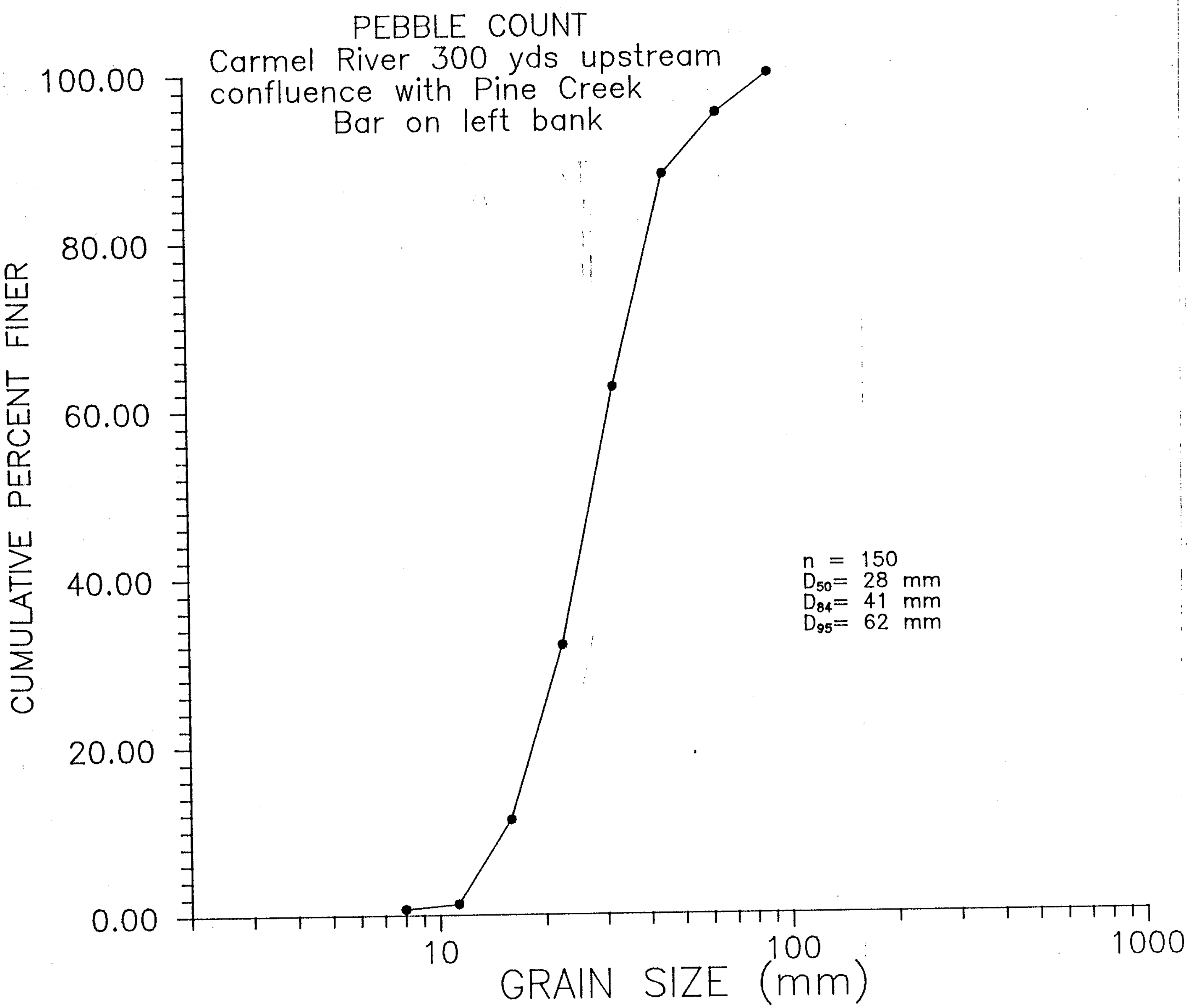
CARMEL RIVER at Robles del Rio
Bedload Rating Curve
Data 1982-1986
BEDLOAD TRANSPORT RATE (tons/day)
100000
10000
1000
100
10
1
10
100
1000
10000
DISCHARGE (ft³/sec)

FIGURE 8



PEBBLE COUNT
Pine Creek at Gaging Station
Low-flow channel
n = 63
D50= 32 mm
D84= 55 mm
D95= 78 mm
CUMULATIVE PERCENT FINER
100.00
80.00
60.00
40.00
20.00
0.00
10
100
1000
GRAIN SIZE (mm)

FIGURE 9


PEBBLE COUNT
Carmel River 300 yds upstream
confluence with Pine Creek
Bar on left bank
n = 150
D50= 28 mm
D84= 41 mm
D95= 62 mm
CUMULATIVE PERCENT FINER
100.00
80.00
60.00
40.00
20.00
0.00
10
100
1000
GRAIN SIZE (mm)

## CONCLUSION

Estimates of bedload transport rates on the Carmel River have been made for a proposed fish screening facility near the confluence with Pine Creek. Three methods were used to produce estimates. The values ranged from 435 tons to 1,120 tons for the 2.33-year recurrence interval flow. This represents a maximum of about .3 ac-ft of sediment accumulation in the backwater area of the facility during screening operations when the entire riverflow is diverted. At higher flows the radial gates would be opened and any accumulated sediment would be flushed out. Limited measurements of grain size distribution indicate that the size of the material being transported at this range of flows is much smaller than the very coarse cobbles and boulders which cover the river bed at the proposed site.

tm5/89-01.gm
(rev3/89)

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**MONTEREY PENINSULA WATER MANAGEMENT DISTRICT**

**TECHNICAL MEMORANDUM 95-01**

# HYDROLOGIC EVALUATION OF THE CARMEL RIVER AT THE LOS PADRES RESERVOIR REFERENCE SITE AND AT THE SAN CLEMENTE RESERVOIR MITIGATION SITE

## SUMMARY


The Monterey Peninsula Water Management District proposes to establish 46.5 acres of riparian habitat at the San Clemente Reservoir to mitigate for impacts from construction of the proposed 24,000 acre-foot New Los Padres Dam and Reservoir on the Carmel River. The mitigation site is located approximately six miles downstream of the New Los Padres Project. The San Clemente Reservoir site is inundated annually by the reservoir formed when the spillway elevation of San Clemente Dam is raised from an elevation of 525 feet to 537 feet by installing wooden flashboards. Completion of the New Los Padres Project would allow the permanent lowering of the flashboards, which would allow the District to establish a large riparian forest at the reservoir site.

The reach of the Carmel River that would be inundated by the New Los Padres Project has been designated as the reference site for use in preparing a mitigation and monitoring plan for the San Clemente mitigation site. Hydrologic analysis of the reference site and the mitigation site is presented in this technical memorandum. Field visits and analysis of aerial photographs, cross-sections, sedimentation rates, sediment data, and proposed daily flows for the Carmel River were used to study both sites.

The upstream portion of the mitigation site that is located on the main stem of the Carmel River appears to have recently changed from a metastable equilibrium (due to a large influx of sediment in 1973) to a steady-state equilibrium. Narrow canyon walls and rock outcrops are the dominant influence on channel configuration in this reach. The downstream portion of the mitigation site appears to have been strongly influenced by wave action in the reservoir, which has resulted in minimum topographic relief in the accumulated silt, sand, and fine gravel. No analysis of the San Clemente Creek portion of the mitigation site is presented.

Increased summer flows from the construction of the New Los Padres Project, elimination of wave action at the mitigation site, and planting activities proposed for the area should result in the development of a classic riparian forest at the site. Dense vegetation cover on streambanks and adjacent terraces will establish a stable threshold condition that should be disrupted only by catastrophic events such as large flows, "slugs" of sediment, or severe drought.

## I. INTRODUCTION

This report is a reference document for the revised "Riparian and Wetland Habitat Mitigation and Monitoring Plan for the New Los Padres Project, Carmel River, Monterey County, California, October 1994," which for this report, is referred to simply as the "Riparian and Wetland Habitat Mitigation Plan."

The Monterey Peninsula Water Management District (MPWMD) has proposed a comprehensive mitigation plan at the San Clemente Reservoir site to mitigate for impacts to 39.6 acres of riparian habitat from construction of the 24,000 acre-foot (AF) New Los Padres Dam and Reservoir (New Los Padres Project) on the Carmel River in Monterey County, California. The area currently inundated on an annual basis at the San Clemente Reservoir is proposed as the mitigation site. Each spring, wooden flashboards are installed at the San Clemente Dam to raise the spillway elevation by twelve feet. This creates additional storage in the main stem and in San Clemente Creek and approximately 46.5 acres of land owned by the California-American Water Company is inundated. The flashboards are removed in the fall, prior to the onset of winter rains. The San Clemente site will be available for restoration as a result of the permanent lowering of the flashboards at the dam after completion of the New Los Padres Project.

An interagency group inspected the San Clemente Reservoir site on March 29, 1994 and recommended that MPWMD conduct additional studies to assess the suitability of the site for work proposed in the Riparian and Wetland Habitat Mitigation Plan. The group recommended using the area that will be inundated by the New Los Padres Project as the reference site for monitoring the success of proposed mitigation activities at the San Clemente Reservoir.

This report focuses on the geomorphology of the two reservoir influenced areas (see Figure 1). The riparian area proposed to be inundated by the New Los Padres Project is briefly discussed and analyzed. A detailed description and analysis is presented of the area at the San Clemente Reservoir along the main stem that is inundated annually when the flash boards are raised. In addition, this report analyzes the potential for changes in the main stem at the San Clemente site after construction of the New Los Padres project.

## II. OBJECTIVES

This report provides answers to questions raised by the California Department of Fish and Game (CDFG) and the Army Corps of Engineers (Corps) at the March 29, 1994 field trip to the San Clemente Reservoir. Specific hydrologic questions raised at the March 29 meeting were:

1. What is the channel-forming flow or range of flows at the San Clemente site?

2. How can "year-round" flow be defined at the San Clemente site?

3. What are the effects of sediment deposition at the San Clemente mitigation site?

4. Is the San Clemente site stable?

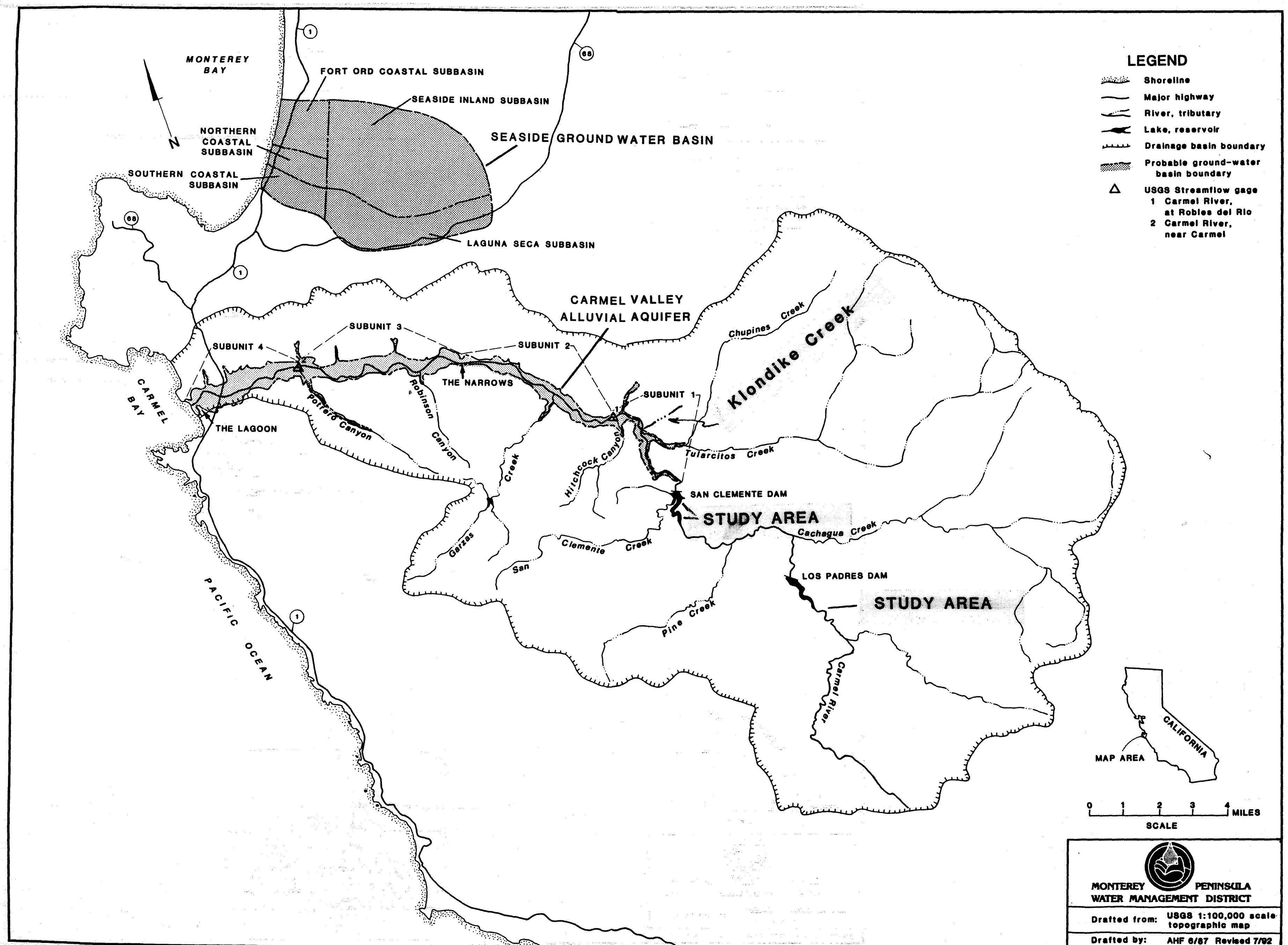
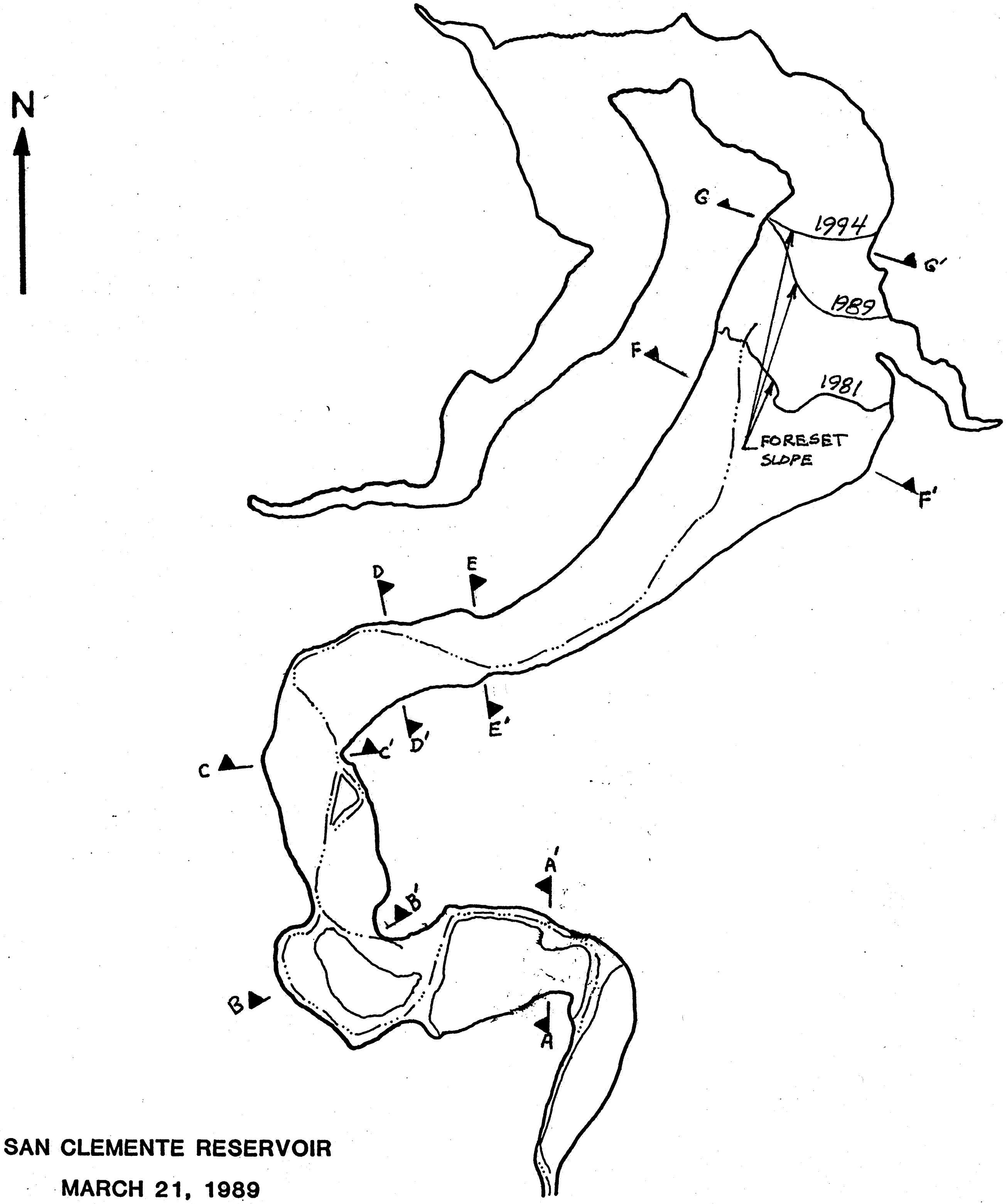

MONTEREY BAY
N
FORT ORD COASTAL SUBBASIN
SEASIDE INLAND SUBBASIN
NORTHERN COASTAL SUBBASIN
SOUTHERN COASTAL SUBBASIN
SEASIDE GROUND WATER BASIN
LAGUNA SECA SUBBASIN
CARMEL VALLEY ALLUVIAL AQUIFER
SUBUNIT 1
SUBUNIT 2
SUBUNIT 3
SUBUNIT 4
THE NARROWS
THE LAGOON
CARMEL BAY
Potrero Canyon
Robinson Canyon
Garzas Creek
Hitchcock Canyon
Chupines Creek
Klondike Creek
Tularcitos Creek
SAN CLEMENTE DAM
STUDY AREA
San Clemente Creek
Cachagua Creek
LOS PADRES DAM
STUDY AREA
Pine Creek
Carmel River
PACIFIC OCEAN
LEGEND
Shoreline
Major highway
River, tributary
Lake, reservoir
Drainage basin boundary
Probable ground-water basin boundary
USGS Streamflow gage
1 Carmel River, at Robles del Rio
2 Carmel River, near Carmel
CALIFORNIA
MAP AREA
0 1 2 3 4 MILES
SCALE
MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
Drafted from: USGS 1:100,000 scale topographic map
Drafted by: AHF 6/87 Revised 7/92

Figure 1




SAN CLEMENTE RESERVOIR
MARCH 21, 1989

## III. SETTING

For descriptions of regional geology, rainfall, runoff, and vegetation, the reader is referred to the Riparian Habitat Mitigation Plan and to chapters 6,7, and 9 in the Final EIR/EIS, March 1994.

The basin upstream of the San Clemente Dam at Rivermile 18.6 (miles upstream of the Pacific Ocean) is about 125 square miles and is extremely rugged, with peaks rising up to about 5,000 feet above sea level. The main stem in this upper basin passes through steep V-shaped canyons underlain by Sur Series metamorphic rocks and by Mesozoic granitic rocks. The channel through this reach is a gravel-cobble stream, with limited areas of sand and silt. Sediment thicknesses in the upper basin are not well documented, but are estimated to be five to fifteen feet thick except in the reservoir inundation areas, where the sediment thickness increases dramatically.

By comparison, downstream of San Clemente Dam near Klondike Creek at Rivermile 15.4, the river emerges from the steep upper basin and flows through alluvium in a wide valley, known as the Carmel Valley, to the Pacific Ocean. Alluvium in the lower portion of the Carmel Valley ranges in depth from about 50 feet at the Robles del Rio (Rosie's) Bridge, which is about one mile downstream of Klondike Creek, to 150 feet thick near the Pacific Ocean.

Most of the upper basin is densely vegetated with a Mixed Hardwood Forest. Development of the upper basin has been limited, due to steep slopes and designation of most of the basin upstream of Los Padres Reservoir (drainage area of 44 square miles) as part of the Ventana Wilderness in the Los Padres National Forest. Most of the upper basin is used for recreation, habitat, and watershed purposes. Grazing and cultivation for vineyards has occurred in a few areas of the Carmel and Cachagua Valleys on the less-steep slopes.

Annual rainfall at the study sites is about 24 inches per year. However, due to orographic effects, rainfall exceeds 40 inches per year at the headwaters (Hecht, 1981). The river rises quickly in response to moderate rainfall and significant flows have been recorded between late-November and early April. The main stem is unregulated upstream of the Los Padres Reservoir and flows year-round into the reservoir. Almost 70% of the annual flow from the Carmel River basin is generated in the 44 square mile basin upstream of the Los Padres Dam. Almost 90% of the annual flow in the drainage basin comes from the basin upstream of the San Clemente Dam (MPWMD 1992). During normal or better years, a minimum of five cubic feet per second (cfs) is released from Los Padres Reservoir under a Memorandum of Understanding between MPWMD, CDFG and the California-American Water Company (Cal-Am), the owner of the two reservoirs.

The area at the Los Padres Reservoir chosen as the reference site extends about 1.5 miles upstream of the upstream end of the reservoir inundation zone and includes the confluence with Danish Creek. In this reach, the river is confined in a narrow, steep canyon and channel slope ranges from 0.7 percent at Danish Creek to about 1.2 percent at the upstream end of the New

Los Padres Project. The river sustains a dense canopy of alders, willows, and cottonwoods along the channel. In places, the canopy completely shades the river. There is little fine sediment and sand in the channel bottom and flood debris tends to collect in transitional areas, such as in braided sections. Sediment at the upstream end of the reservoir ranges from small gravels to medium cobbles. Currently, there are large boulders (over 700 millimeters) present in the stream near Bluff Camp at the upstream end of the proposed New Los Padres Project.

A shown in Figure 2, the San Clemente mitigation site extends from approximately the 1994 foreset slope of the reservoir to the upstream end of the reservoir inundation zone (flashboards up) at Section A-A'. The mitigation site includes a portion of San Clemente Creek; however, this memorandum focuses on the main stem. The upstream half of the San Clemente site in the main stem reach is in a narrow, steep-sided canyon which restricts the river's meanders. Channel slope at the site ranges from 0.15 percent near the San Clemente Dam to one percent at the upstream end of the mitigation site. Aerial photographs from 1973, 1981, 1986, 1990, and 1995 show a meandering well-defined channel, even when the reservoir is partially filled.

At the upstream end of the mitigation site, the channel bottom is cobble-gravel, with a pool-riffle sequence that transitions to a wide, flat sand bed near the middle portion of the site. There are two deep pools, each over five feet deep at 10 cfs and each located at the base of a steep, rocky slope near Sections A-A' and B-B' respectively, in Figure 2. This area appears to have undergone significant changes during high flows between 1972 and 1986. The channel downstream of Section E-E' is composed primarily of sands and some silts. The low-flow channel in the downstream portion of the site appears to meander somewhat over the floodplain between Section E-E' and G-G'. The entire mitigation site is nearly devoid of vegetation downstream of Section B-B', but does support a limited growth of riparian vegetation near the upstream end of the reservoir in areas that are less frequently inundated.

## PREVIOUS WORK

The Carmel River has been studied extensively since the 1970's, when severe streambank erosion occurred and the steelhead population declined. A number of authors have contributed research papers and reports describing the hydrology and geomorphology of the river and the drainage basin. The focus has been on the portion of the river downstream of Klondike Creek. Fortunately, there are a few documents containing information specific to the Los Padres and San Clemente Reservoir sites.

Hecht (1981) determined bankfull discharge at the upstream end of the New Los Padres Project inundation area, near Bluff Camp. Matthews (1993) evaluated hydrologic and geomorphic impacts to the Carmel River downstream of the New Los Padres Project. Several authors have studied reservoir sedimentation rates, with the most recent being Matthews (February 1989). Sediment transport rates in the main stem at the San Clemente site were estimated by Matthews (March 1989).

## IV. SOURCES OF DATA AND METHODS OF ANALYSIS

Output from MPWMD's Carmel Valley Simulation Model (CVSIM), including mean daily inflows and outflows at both study sites for the period 1902 through 1992 was available. CVSIM is a computerized mathematical simulation of surface and groundwater resources within the District. Flow information prior to 1958 was reconstructed using various techniques to complete the record. Daily flow records at the Los Padres Dam from October 1957 to September 1992 were used in developing CVSIM output applied to this study. Output for the period 1958 to 1992 was used to determine expected flows in the San Clemente Reservoir after construction of the proposed New Los Padres Project.

Many of the aerial photographs of the San Clemente site yield little information about channel conditions, since they were taken with the reservoir full or nearly full (elevation = 537 feet). This was the case for the earliest aerial photographs of the Carmel River basin in 1939, at a time when the Los Padres Reservoir was not yet built. However, photographs taken in 1973, 1981, 1986, 1990 and 1995, with the reservoir partially filled, were studied to examine channel changes at the San Clemente site. Photographs from 1939, 1987, and 1994 of the Los Padres Reservoir site were used to study channel dynamics at that site.

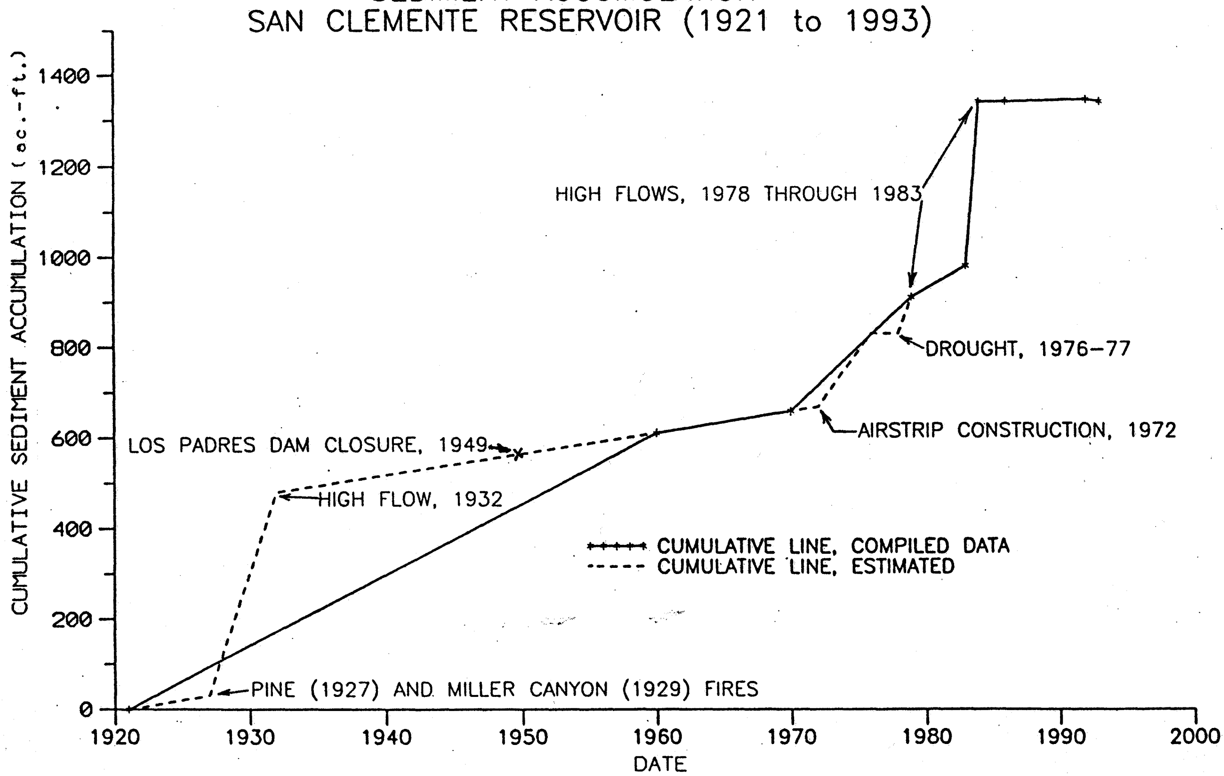
Topographic data in the vicinity of the two study sites were obtained from field surveys and through reservoir sounding. Many of the cross-sections presented were field-surveyed using a total station and data collector. Data for cross-sections E-E', F-F', and G-G' at the San Clemente Reservoir site were taken from the 1993 Cal-Am reservoir sounding. Elevations for field surveys were referenced to known reservoir levels.

Historical sediment transport rates were determined from reservoir sedimentation rates determined by sequential sounding and by direct measurement of sediment transport by Matthews (February 1989). Since Matthews' 1989 study, Cal-Am completed reservoir sounding at the San Clemente Reservoir in 1992 and in 1993. In addition to the sounding data, records of large fires in the Los Padres National Forest between 1909 and 1990 were used to reconstruct the rate of sedimentation in the existing main stem reservoirs (see Table 1 and Figure 3).

TABLE 1

| SAN CLEMENTE RESERVOIR CAPACITY (AC-FT) | | | | | | | |
|---|---|---|---|---|---|---|---|
| YEAR | EL.= 525 (U.S.G.S.) | EL.= 525 (CAL-AM) | EL.= 537 (CAL-AM) | DIFFERENCE EL. 537-525 (CAL-AM DATA) | CAPACITY EL. = 525 | SEDIMENT ACCUMULATION MEASURED | SEDIMENT ACCUMULATION ESTIMATED |
| 1921 | 1377 | 1425 | 2136 | 711 | 1425 | 0 | 0 |
| 1927 | | | | | | | 30 |
| 1932 | | | | | | | 479 |
| 1949 | | | | | | | 559 |
| 1960 | 842 | 843 | 1527 | 684 | 843 | 609 | 609 |
| 1970 | 794 | | | 684 | 794 | 658 | 658 |
| 1972 | | | | | | | 667 |
| 1979 | | | 1226 | 684 | 542 | 910 | 910 |
| 1983 | | 472 | 1156 | 684 | 472 | 980 | 980 |
| 1984 | | 316 | 796 | 480 | 316 | 1340 | 1340 |
| 1986 | | 316 | | 480 | 316 | 1340 | 1340 |
| 1992 | | 308 | | 480 | 311 | 1345 | 1345 |
| 1993 | | 339 | 796 | 457 | 339 | 1340 | 1340 |

FIGURE 3
SEDIMENT ACCUMULATION
SAN CLEMENTE RESERVOIR (1921 to 1993)




SOURCE: CAL–AM SOUNDING DATA AND MPWMD ANALYSIS

## V. ANALYSIS

### 1. A. CHANNEL-FORMING FLOW at the LOS PADRES RESERVOIR SITE

Historical Events

Black-and-white aerial photographs of the Los Padres site in 1939 show a moderate amount of vegetation at the study site (i.e. dense riparian cover alternating with open areas on gravel bars). In 1987, after the tumultuous period between 1976 and 1986, the site was nearly devoid of riparian vegetation. By July 1994, the site had developed a dense canopy adjacent to the main stem, with open areas on the gravel bars. It is apparent that this reach is subject to wide variations in the amount of riparian vegetation coverage, but the riparian habitat quickly recovers from high impact events.

In 1976, an unusual chain of natural events began that formed the present channel in the area proposed for inundation by the New Los Padres Project. The four "events" - two droughts, flooding and a large fire, were notable both for their impacts as well as timing. Initially, the driest two-year period in the historical record occurred in water years 1976 and 1977 (records have been kept on the Monterey Peninsula since 1897). This drought substantially depressed groundwater levels in many areas of Carmel Valley and was probably a major factor in the second event in the chain, which was the Marble-Cone fire.

In August 1977, the Marble-Cone fire burned nearly all of the basin upstream of the site. Immediately following the fire, the third major event in a series was several very wet years, punctuated with the record-setting 1983 runoff. In 1978 and 1980 high flows caused significant sedimentation in the Los Padres Reservoir. In the 1978 water year, the capacity of the reservoir was reduced by 18% (Matthews, February 1989). It is likely that much of the vegetation on the channel banks, which was severely stressed during the 1976-77 drought, was stripped away by high flows in subsequent years. Erosion and loss of vegetation occurred during 1982, 1983, and in 1986.

By 1987, aerial photographs show that many areas of the riverbottom had virtually no mature woody vegetation. However, spring flows in 1986 probably produced a good environment for seedling establishment. Between 1987 and 1991, the Carmel Valley experienced the last in an unusual series of events - an extended drought. At the Los Padres site, there was enough flow to encourage riparian vegetation, but not enough to scour seedlings. A minimal amount of flow allowed riparian vegetation to encroach into the channel in areas that normally would be scoured by frequent flows in the range of "bankfull discharge" (usually associated with the 1.5- to 3-year flow annual maximum series).

Flow Frequency Analysis

Table 2 shows the results of a flow frequency analysis based on data from CVSIM, reconstructed main stem and tributary streamflows, and from the U.S. Army Corps of Engineers 1981 study

# TABLE 2

## FLOW FREQUENCY ANALYSIS

| ALTERNATIVE | 1.5-YR | 2-YR | 2.4-YR | 3-YR | 5-YR | 10-YR |
|---|---|---|---|---|---|---|
| INFLOW TO LOS PADRES RESERVOIR | ANNUAL MAXIMUM MEAN DAILY FLOW (CFS) | | | | | |
| NO PROJECT (1) | 490 | 975 | 1,270 | 1,795 | 2,545 | 3,220 |
| MAINSTEM INFLOW TO SAN CLEMENTE RESERVOIR | | | | | | |
| 24 NLP (2) | 220 | 295 | 760 | 1,260 | 2,530 | 3,370 |
| NO PROJECT (2) | 555 | 1,095 | 1,430 | 2,025 | 2,865 | 3,625 |
| FLOW REDUCTION | 60% | 73% | 47% | 38% | 12% | 7% |
| INFLOW TO LOS PADRES RESERVOIR | ESTIMATED ANNUAL PEAK FLOW (CFS) | | | | | |
| NO PROJECT (3) | 900 | 1,540 | 2,100 | 2,500 | 4,100 | 6,200 |
| MAINSTEM INFLOW TO SAN CLEMENTE RESERVOIR (4) | | | | | | |
| 24 NLP (5) | 220 | 470 | 1,200 | 1,790 | 3,920 | 6,470 |
| NO PROJECT (6) | 960 | 1,740 | 2,260 | 2,870 | 4,440 | 6,960 |
| FLOW REDUCTION | 77% | 73% | 47% | 38% | 12% | 7% |

NOTES

1. 74% OF FLOW AT ROBLES DEL RIO, TABLE 7-8, FINAL EIR/EIS, MPWMD.
2. 83.5% OF FLOW AT ROBLES DEL RIO, TABLE 7-8, FINAL EIR/EIS, MPWMD. 1.5-YEAR FLOW ESTIMATED FROM INSTREAM FLOW REQUIREMENTS FOR STEELHEAD ATTRACTION EVENTS.
3. 74% OF PEAK FLOW AT ROBLES DEL RIO, PLATE C-14, U.S. ARMY CORPS OF ENGINEERS, "FEASIBILITY REPORT ON WATER RESOURCES DEVELOPMENT, CARMEL RIVER, APPENDIX C, 1981."
4. OUTFLOW FROM 24 NLP PLUS FLOW FROM CACHAGUA AND PINE CREEKS.
5. VALUES FOR THE 2-YEAR RETURN INTERVAL AND GREATER WERE CALCULATED USING THE PERCENTAGE REDUCTION SHOWN IN TABLE 7-8, FINAL EIR/EIS FOR THE ROBLES DEL RIO GAGING STATION. THE 1.5-YEAR RETURN FLOW WAS ESTIMATED BASED ON INSTREAM REQUIREMENTS FOR FISHERY.
6. 87% OF PEAK FLOWS AT SAN CLEMENTE DAM, PLATE C-14, U.S. ARMY CORPS OF ENGINEERS, "FEASIBILITY REPORT ON WATER RESOURCES DEVELOPMENT, CARMEL RIVER, APPENDIX C, 1981."

of the Carmel River basin. Annual maximum mean daily values for inflow to the existing main stem reservoirs were determined by multiplying flow values from MPWMD's Final EIR/S at Robles del Rio by a factor (based on annual runoff from streamflow measurements) appropriate for each reservoir. The same type of analysis was used to determine annual peaks from data in the Corps of Engineers report.

Bankfull Flow

As reported by Williams (1978), there are 11 different methods for defining bankfull flow. For this analysis, bankfull discharge was assumed to be near the edge of the lowest fully defined terrace. Normally, bankfull discharge is considered the dominant or channel-forming discharge. Curry (1981) cited a bankfull measurement by Hecht of 1,290 cfs (1.8-year flow) at Bluff Camp, which is just upstream of the reference site. Hydraulic analysis of a representative cross-section surveyed in July 1994 at the reference site (Figure 4) shows that bankfull is about 1,070 cfs (1.5-year flow). This value is based on channel conditions that may be somewhat different from those measured in 1977 by Hecht, especially with regard to the amount of woody vegetation growing below the level of the bankfull discharge. For hydraulic calculations at the reference site, a Manning's n value of 0.050 was used and the wetted perimeter was increased by 50% to account for the size of the boulders and cobbles along the section. Bankfull flow was computed at the edge of the active floodplain.

Inspection at the site in July 1994 showed that this reach of the river appeared to have changed little after a flow that was estimated to be a 5-year runoff event in January 1993 (flow at Robles del Rio). It is likely that the large flows between 1978 and 1986 established the current configuration of the channel at the Los Padres site and a dense growth of vegetation has prevented significant channel changes since the 1986 water year. Currently, low flows appear to be the force that is shaping the active channel by preventing further encroachment of woody riparian vegetation.

Figure 4 shows that an estimated flow of 650 cfs (1.2-year return interval) is associated with the level at which there is a change in vegetation from emergent wetland and seedling riparian species to more mature woody riparian vegetation. This flow level, which probably represents the maximum encroachment of mature woody riparian species, is lower at this site than the flow normally associated with bankfull (1.5- to 3-year event). It appears that streambank areas below the 650 cfs level are not conducive to willow and alder growth. Streambank vegetation above this level appears to be relatively stable.

The channel area between bankfull at 1,070 cfs and a flow of 650 cfs should experience active change as young willows and alders (1 to 3 years) are scoured from the banks. However, the relatively dry period between 1987 and 1991 allowed vegetation to encroach into the channel. Medium boulders (2 to 3 feet) and large cobbles (6 to 12 inches) discourage bed mobilization and a dense growth of maturing woody vegetation protects the banks from scouring. Absent a large, scouring flow, this area could fill in and result in a narrower channel.

TRANSECT 5, SITE 3 (ABOUT 4500 FT. U/S OF DANISH CREEK)
CARMEL RIVER SURVEY, JULY 1994
LOOKING DOWNSTREAM WITH ASSUMED DATUM

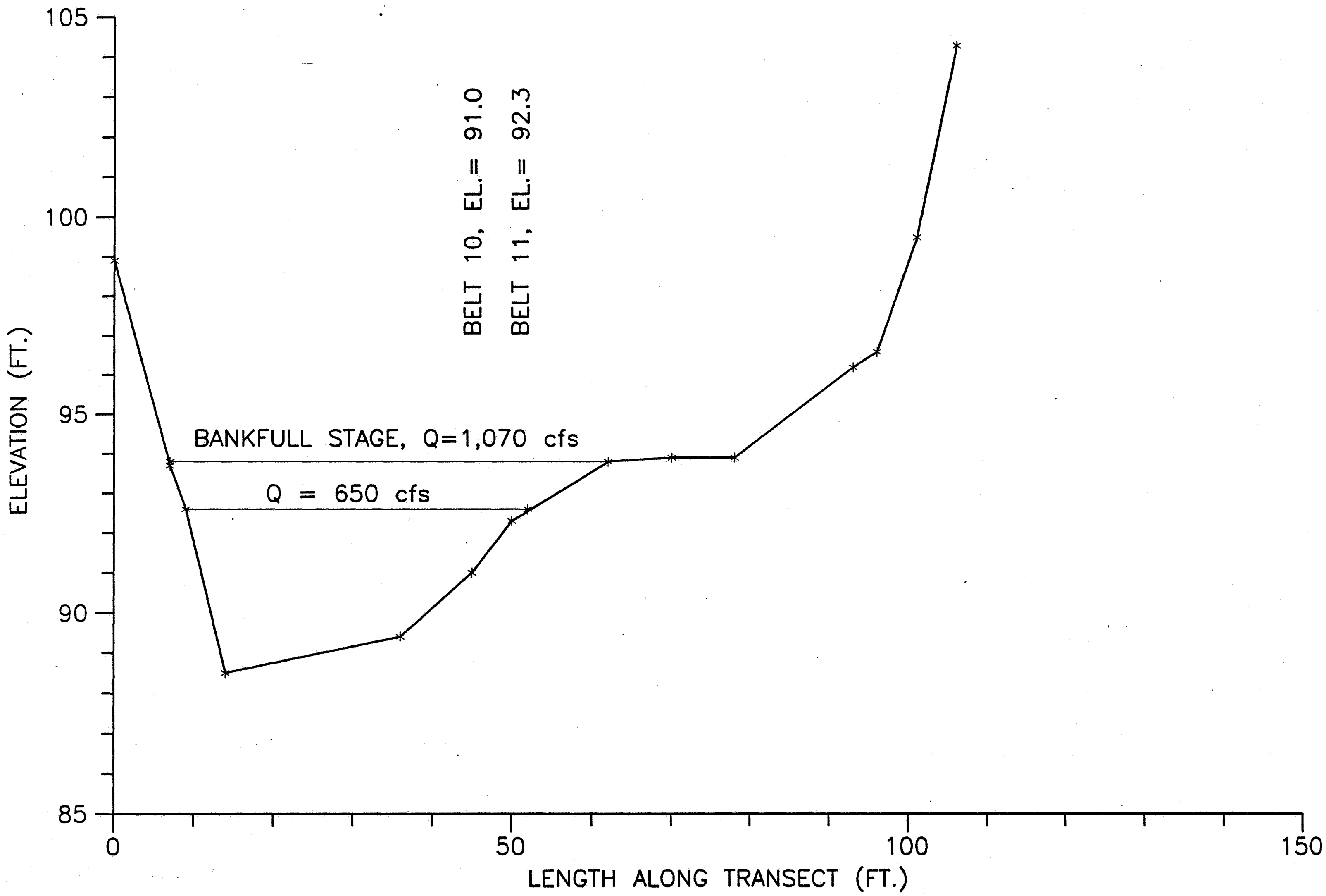



FIGURE 4

It is likely that a flow much greater than the 5-year event will be necessary to scour the banks, since streambanks along this reach resisted scouring during a flow of this magnitude in January 1993. It is worth noting that there were few mature trees on the channel banks and adjacent to the active channel. On the lower Carmel River, bank scour is common where large roots and overhanging branches from mature trees protrude into the channel, collect debris, and create turbulence within the flow. Turbulent flows can then scour the base of a streambanks and result in bank caving. Younger willows and alder trees, which dominate the streambanks at the Los Padres site, are less likely to contribute to this type of bank scour.

In mid-January 1995, Graham Matthews reported that little vegetation had been scoured in the river between the Los Padres and San Clemente Dams from a ten-year return flow on January 10, 1995 (preliminary estimate). It is possible that much of the vegetation upstream of the Los Padres Dam fared similarly.

In July 1994, it was observed that recent deposition of sediment and organic material was concentrated into relatively small areas near sudden changes in channel geometry. One could expect more debris, given the density of vegetation in the upper basin; however, the Marble-Cone fire in 1977 burned much of the supply of woody debris and several wet years followed the fire, which would have flushed much debris through the river. Flow between 1987 and 1994 probably was not high enough to move significant amounts of debris. It also appeared that no slides had occurred within the vicinity of the site to introduce sediment into the river.

As a result of the January 10, 1995 flow in the river, an enormous amount of debris was carried into the Los Padres Reservoir. It appears that approximately five acres of the reservoir area is covered with logs and debris, much of which is contained by a log boom. It is likely that a large amount of debris is now present at the study site.

It appears that two very different flows will shape the channel form in the near future. At present, a flow with a 1.2-year return frequency prevents further encroachment of vegetation into the channel. This is somewhat less than bankfull discharge. It remains to be seen if the large flow of January 10, 1995 mobilized the bed, scoured the banks, and created new terrace deposits. Until the conditions in the channel found in July 1994 change, the bankfull discharge may not be significant in shaping the channel. Should conditions in the streambed change, bankfull flows could become significant in defining the channel shape. The existing equilibrium of the stream could be changed if encroaching vegetation is removed by large flows or if the supply of sediment or debris increased (e.g., due to fire, landslides, or the maturing of vegetation adjacent to the channel).

## V.1.B. CHANNEL-FORMING FLOW at SAN CLEMENTE RESERVOIR

For existing conditions, bankfull flow at the site was assumed to approximate the flow as shown in Figure 7, an aerial photo taken on March 14, 1986. At the time of the photograph, flow was approximately 1,000 cfs (slightly more than the 1.5-year flow) and appears to be at about bankfull. Between Section F-F' and G-G', bankfull discharge is somewhat difficult to assess because of the effect of a natural levee on the reservoir backwater. This portion of the river channel appears to be fairly active even at relatively low flows, due to a lack of armoring and lack of stabilizing vegetation.

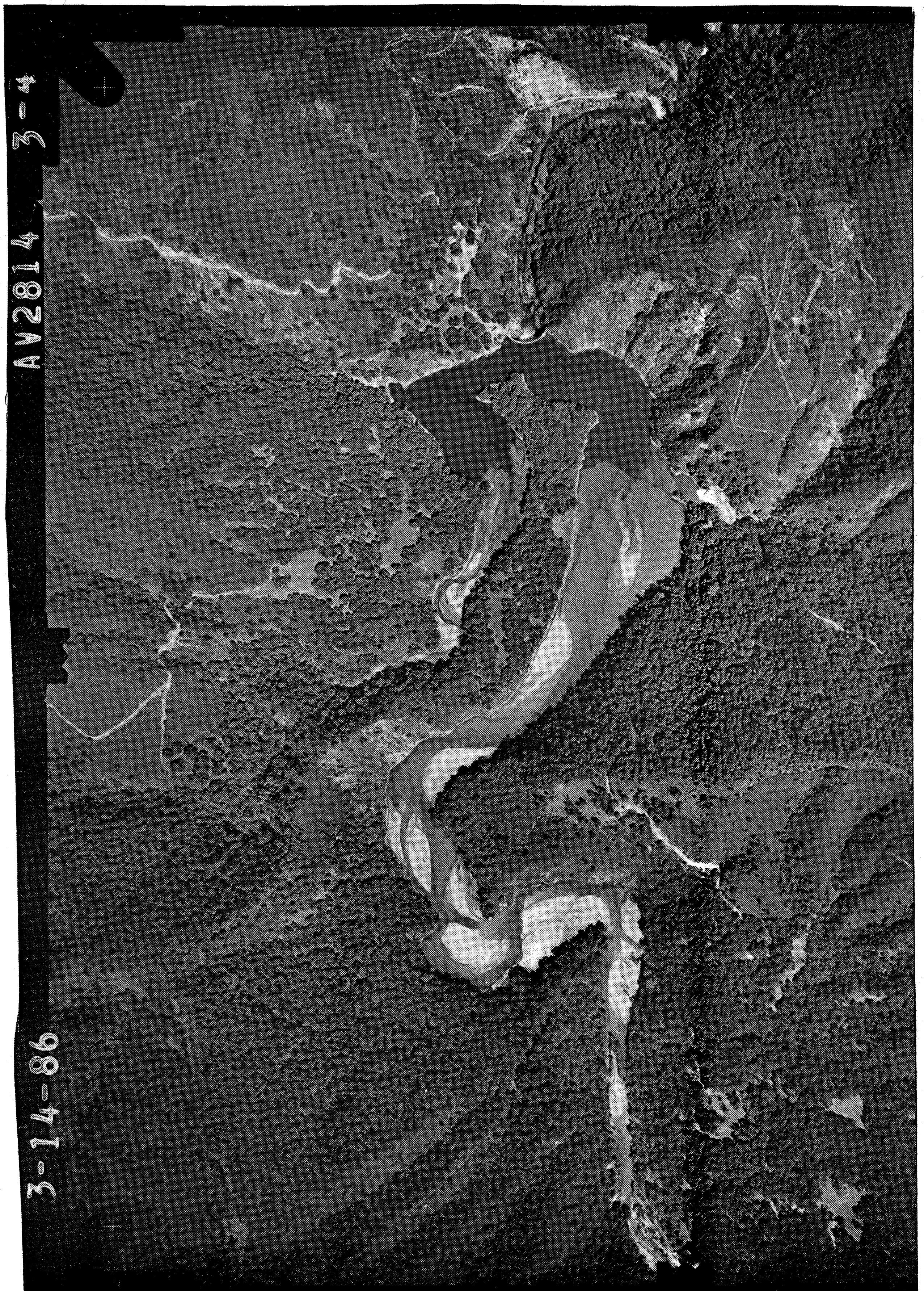
Table 2 shows that when the New Los Padres Project is completed, the 1.5-year return flow (annual maximum series) on the main stem at the San Clemente mitigation site could be reduced by up to 77%. This figure is somewhat higher than the 67% reduction shown in Table 7-8 of MPWMD's Final EIR/EIS for the New Los Padres Project, which is based on mean daily flows. For the 1.5-year flow, it was assumed that the New Los Padres Project would be operated to meet instream flow requirements of 200 cfs at the Carmel River lagoon for steelhead attraction events and that this would happen on a frequent basis (at least annually). This flow will likely define the lower bound for the development of mature woody vegetation along the active channel.

## V.2. LOW FLOWS AT THE SAN CLEMENTE MITIGATION SITE

The New Los Padres Reservoir will be operated conjunctively to maximize benefit to District water users and for aquatic habitat. Table 4-5A, page 4-25, Final EIR/EIS lists minimum instream flow requirements downstream of New Los Padres Dam. During low flow periods, there will be little or no tributary input from Pine and Cachagua Creeks, so that flow through the San Clemente mitigation site would be nearly identical to the releases from the New Los Padres Project (evapotranspiration will reduce streamflow slightly). For the months of June to December, a minimum of 20 cfs will be maintained in 75% of years. Output from CVSIM shows that in years with below normal or better runoff (75% of years), flow from the New Los Padres Reservoir should exceed this requirement and should be between 30 and 40 cfs in July, August and September. Flow in these years will gradually be reduced in October, November and December as the aquifers in the lower and middle Carmel Valley begin to recharge. During dry years (12.5% of years), flow releases will be cut to 10 cfs between June and December. During critically dry periods (12.5% of years), flows may drop to as little as 5 cfs for several months at a time. A detailed, graphical analysis of simulated daily flows is presented by Fuerst 1994 in MPWMD Technical Memorandum 94-01.

Technical Memorandum 94-01 shows that with the New Los Padres project, low flows during downstream of the project during wet periods will be substantially increased over the existing condition (30-40 cfs vs. 5 cfs - see pages titled "Carmel River Below LP Dam"). The 30 to 40 cfs flows will also be maintained for longer periods than the existing condition. It is likely that wetland species will develop above this flow level.

**Figure 7 - San Clemente Reservoir - March 14, 1986 at 10 a.m.**



## V.3. SEDIMENT DEPOSITION AT THE SAN CLEMENTE RESERVOIR MITIGATION SITE

It is striking to note that of 83 large fires listed between 1909 and 1990 in the Los Padres National Forest, only three were confirmed as being started from natural causes (lightning). Conditions in the upper basin (slopes, low population density, winds, and warm, dry summers) make fire suppression quite difficult.

Fire has played an important role in the supply of sediment to the Carmel River. Pre-1900 fire frequency has been estimated from tree ring studies at once every 21 years (Griffen and Talley, 1981). U.S. Forest Service records show that there were three major fires in the upper basin between 1909 and 1990. The Marble-Cone fire, started by lightning in August 1977, was the largest and reduced the capacity of the Los Padres Reservoir by 18% in the 1978 water year (Matthews, February 1989). In 1927, just a few years after the San Clemente Reservoir was completed, the Pine Canyon fire (man-made), burned nearly 66 square miles between Pine and Danish Creeks. Fred Nason, Jr., reported that the 1929 Miller Canyon fire was set by William Perris when Mr. Perris threw a cigarette from his porch. The fire raged for 68 days and burned 28 square miles (18,000 acres).

The Cachagua Valley, with a basin size of 53 square miles, contains most of the human settlements in the upper basin. As this area has developed, swift and effective fire protection has become crucial to the residents. In contrast, mechanized equipment, such as bulldozers and loaders, is discouraged in the Ventana Wilderness area upstream of the Los Padres Reservoir (basin area of 44 square miles). This reduces fire suppression activity in the wilderness area, but air support and ground crews are used to suppress fires when there is danger from a wildfire.

It is not clear from the records how much of the drainage basin was burned during the 1927 and 1929 fires, but fire-induced sediment runoff probably reduced the capacity of the San Clemente Reservoir significantly. Between the completion of the San Clemente Dam in 1921 and completion of the Los Padres Dam in 1949, all of the bedload and a portion of the suspended load from the 125 square mile basin upstream was trapped in the San Clemente Reservoir. Since 1949, all of the bedload and a significant portion of the suspended load from the drainage basin above the Los Padres Dam has been trapped in the Los Padres Reservoir. Matthews (February 1989) estimated the trap efficiency of the Los Padres Reservoir at 72%. Sediment accumulation at the San Clemente Reservoir between 1921 and 1993 is summarized in Table 1 and Figure 3.

The estimated accumulation rate at San Clemente Reservoir was developed by assuming that the there are periodic episodes of sediment accumulation. In between these episodes, sediment accumulation proceeds at a relatively slow rate. It was assumed that large fires in the basin would introduce significant quantities of sediment into the reservoir. In addition, it was also assumed that vegetation growth on and near sediment deposits within riparian areas would significantly reduce the movement of sediment in five to ten years. These assumptions are consistent with the normal cycle of drought, fire, flooding, and recovery.

Matthews (February 1989) estimated that between 1949 and 1972, the average sediment accumulation rate was about five acre-feet (AF) per year. Between 1973 and 1983, a tremendous amount of sediment entered the reservoir due to slides induced from the building of an illegal airstrip. Between 1984 and 1993, there was virtually no change in the volume accumulated sediment. It is estimated that the "normal" sediment accumulation rate is four to five AF per year, which is split between suspended sediment flowing over the Los Padres Dam and the total load from the three tributaries downstream of the Los Padres Dam (Pine, Cachagua and San Clemente Creeks).

Suspended load over Los Padres Dam was estimated by Matthews (March 1989) to be 20,600 tons or about 8.5 AF per year. The trap efficiency of San Clemente Reservoir was estimated to be 21% (Matthews, February 1989), which yields a figure of about 1.8 AF per year (using 110 pounds per cubic foot) for the main stem at San Clemente Reservoir. The New Los Padres Reservoir will likely have a trap efficiency of 95% (Matthews, February 1989), which will result in little or no suspended sediment in the main stem immediately downstream of the New Los Padres project. Total load from Pine and Cachagua Creeks was estimated by Matthews (March 1989) to be 1.4 AF per year. It is likely that the "normal" sediment transport rate in the main stem between the existing reservoirs will be less than 1.5 AF per year. Accumulation of one to two AF per year in San Clemente Creek is likely, based on Matthews figures.

Matthews (March 1989) reported that for Pine Creek, the median diameter of the pebbles counted was 32 mm, which characterizes Pine Creek as a cobble-gravel stream (ASCE Task Committee on Sediment Transport and Aquatic Habitat, May 1992). Less than 2% of the pebbles sampled were sand-sized. Because of its similarity with Pine Creek, Cachagua Creek is likely to be in the same cobble-gravel category. While this analysis represents past events, it is likely that sand input from these tributaries will be very low.

## V.4. STABILITY OF THE SAN CLEMENTE SITE

Many of the types of geomorphological features of the Carmel River can be found compressed into a little under one mile of the river at the San Clemente mitigation site. The site can be divided into two reaches, with the dividing line approximately halfway through the site at Section E-E', where the canyon of the reservoir begins to widen and rock outcrops become less dominant in shaping the channel configuration. Although the entire mitigation site is in a region where the river is primarily under bedrock control, the downstream portion of this site behaves much like an alluvial stream, due to alluvium that is up to 100 feet thick.

Stability of the mitigation site was analyzed using four approaches: 1) slope-discharge; 2) historical analysis; 3) comparison with other Central California coastal streams; and 4) river mechanics.

### Slope/Discharge

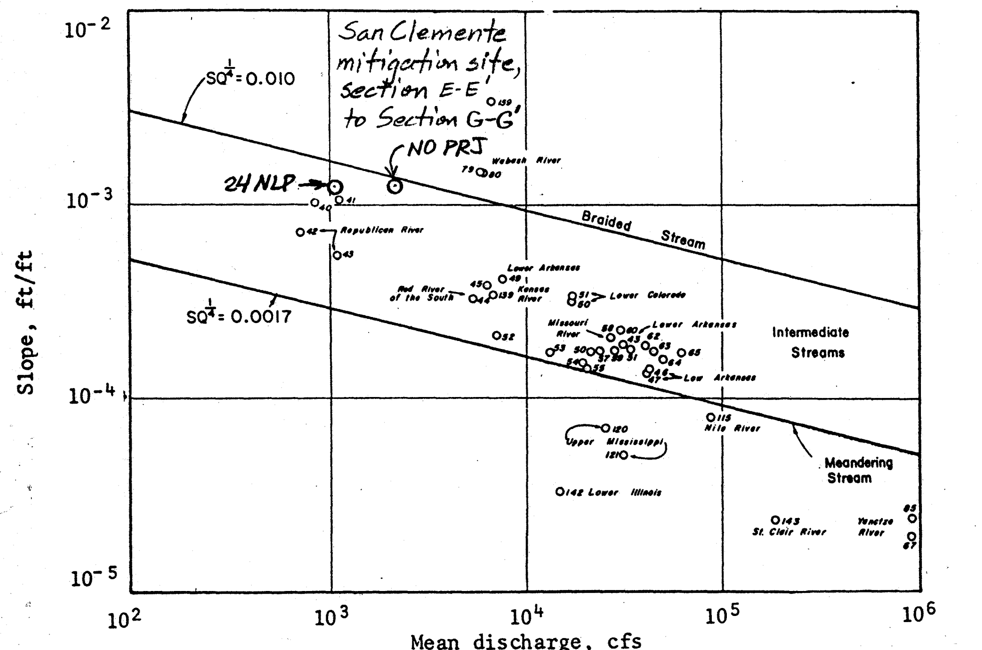
The downstream half of the site is sandy, broad (up to 600 feet wide) and shallow as the canyon floor in the inundation area has been filled in with silt and sediment from upstream. The gradient in the overbank area is about 0.001. Aerial photographs show a shallow main channel along the northeast side of the site; however, the area between the main channel and the western edge of the reservoir is somewhat braided. The fine gravels, sand, and silt present in this reach appear to be easily re-worked and the dearth of vegetation creates a dynamic environment for channel change in this reach. This portion of the channel plots in the intermediate streams portion of the graph in Figure 5 defining channel patterns for sandbed streams developed by Lane (1957) for both the existing (about 2,200 cfs) and proposed (1,100 cfs) mean annual discharge (2.33-year flow). The condition of this reach is similar to many reaches in the Carmel River downstream of Carmel Valley Village where healthy vegetation on the channel banks and terraces often makes the difference between a dynamically stable and unstable channel.

In the upstream portion of the site (upstream of Section E-E'), the channel is confined by several bedrock outcrops and exhibits some braiding. There is a pool-riffle sequence in this reach, which has a stream gradient of 0.001 to 0.002. Using the relationship cited by Kondolf and Curry (1986) for a bankfull flow of 1,000 cfs, the existing active channel plots in the meandering portion of the graph in Figure 6 showing channel patterns as a function of slope and bankfull discharge; however, the existing channel is near the line of transition to a meandering stream. For a predicted bankfull flow of 220 cfs after completion of the New Los Padres Project, the stream plots well into the "meandering" portion of the graph.

### Historical Analysis

Significant reservoir sedimentation after 1972 may have caused a temporary shift in the channel at the San Clemente Reservoir. In 1972, a rough airstrip was cut on Ponciano Ridge, above an unnamed drainage upstream of the San Clemente Reservoir. Matthews (February 1989) reported that in 1973, 1974, and 1975, so much debris from slides below the airstrip entered the stream that the river was temporarily dammed. Subsequently, high flows between 1978 and 1986 transported much of the debris from the slide into San Clemente Reservoir. Charles Page, a property owner adjacent to the reservoir, reported that more than six feet of sediment was deposited at the upstream end of the inundation area after construction of the airstrip (personal communication with Nikki Nedeff, MPWMD, July 1994).

The pattern of the upstream half of the mitigation site has been controlled by bedrock outcrops, except at Section B-B', where the river flowed toward an outcrop on the north side of the canyon in 1973. This configuration may have formed during high flows in 1958 or 1969, but was not stable due to the bedrock control and unconsolidated sediments in this reach. An aerial photograph from 1973 showed little detail, but did show that the main channel was in the early stages of adjusting to an aggradational event by incising into a sediment build-up and forming an oxbow at Section B-B'. By 1985, the shift to the south side of the canyon was complete. This represented a channel shift of about 300 feet. Today, a deep, off-channel pond is the only




Slope-discharge relation for braiding or meandering in sandbed streams (after Lane, 1957).

Figure 5. Slope-discharge relation for braiding or meandering in sandbed, figure from Richardson *et al.* (1975, page IV-20).

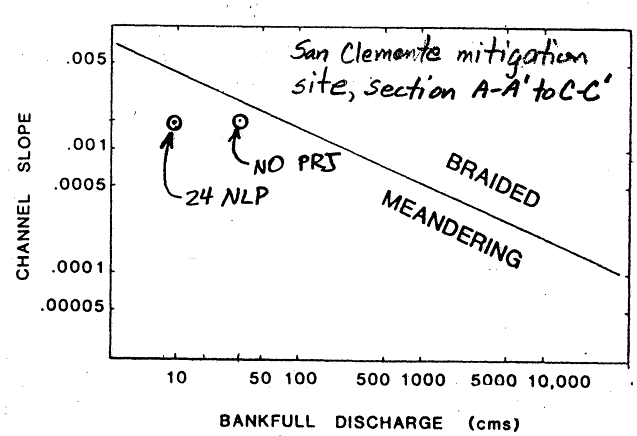



Figure 6. Channel patterns plotted by slope and bankfull discharge (after Leopold *et al.*, 1964, page 293). Figure from Kondolf and Curry (1986, page 312).

physical evidence of the former location of the main channel at Section B-B'. The main channel flows on the south side at Section B-B' currently. This basic configuration is evident, even after a large flow in January 1995.

### Comparison with Other Central California Coastal Streams

After construction of the New Los Padres Project, a reduction in bankfull discharge may result in channel narrowing in some areas after many decades. The active channel may slowly narrow as sediment (primarily from Pine and Cachagua Creeks) enters the mitigation site. Matthews and Associates (1993) predicts channel narrowing of up to 40% in the reach between Carmel Valley Village and the Pacific Ocean due to reductions frequent flows. At the San Clemente mitigation site, this process may occur over a very long period (many decades), due to the increased trap efficiency and concomitant dramatic reduction of suspended sediment in the main stem. The large overbank flow capacity at the San Clemente site and healthy riparian vegetation on the banks and terraces should make the difference between a major disruption and a dynamically stable channel during high flows.

If significant sedimentation occurs after construction of the New Los Padres Reservoir, e.g., from an upstream slide, braiding will quite likely follow in the upstream half of the site. The growth of vegetation along lower flow channels would be swift and would stabilize the streambanks. Incision and complete recovery in aggraded areas could be slow, perhaps two or three decades, due to the reduction of frequent flows. This should be compared with the 10 to 15 year period necessary for recovery from the large slug of sediment that entered the site after 1972. Pools in the vicinity of the prominent bedrock outcrops would likely be scoured out quickly. Over time, the stream would return to a meander pattern that is similar to the existing configuration.

### River Mechanics

Because of the changes that alluvial sandbeds undergo during storm flows (from ripples and dunes to flatbed), a reduction in the magnitude of frequent flows may not result in significant narrowing of the main channel after construction of the New Los Padres Project between the downstream end of the site at Section G-G' and the mid-way portion at Section E-E'. Resistance to flow in sandbed channels can vary by a factor of ten during passage of winter flows (ASCE 1975, p.115). An aerial photograph of the site from March 14, 1986 shows evidence of dunes in this reach of the river at a flow of approximately 1,000 cfs (or about the 1.5-year event). In addition, the effective slope of this area is similar to downstream portions of the Carmel River between the lagoon and the Rancho Cañada golf course area, where the river bottom changes from ripples and dunes to a flatbed and back to ripples during storm flows.

Flow velocity in the downstream portion of the site will be low, even during large flows. It is estimated that velocity will exceed five feet per second (fps) only during flows greater than the ten-year flow event. The 1.5-year mean daily flow of 220 cfs will move through this area of the site at one to two fps. Deposition of debris and finer sediments in and around channel vegetation will be the primary force that alters the shape of the channel. As discussed in section three, sediment input in this reach should be extremely limited by the New Los Padres Reservoir.

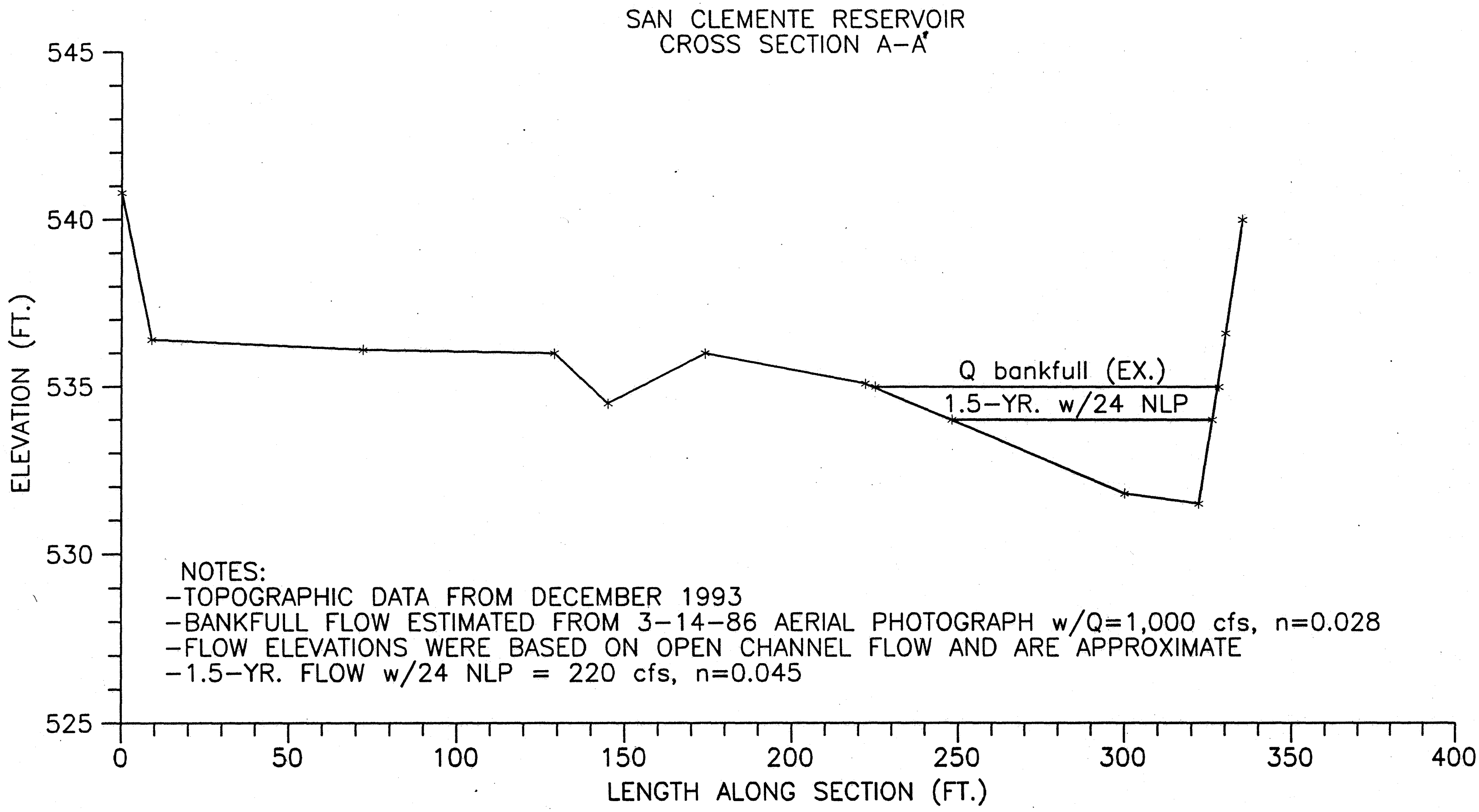
Upstream of Section E-E', grain size increases and bedload becomes well-graded, which reduces bank cohesion. Based on recent reservoir soundings, there is no longer a large supply of sediment from the slide that occurred in 1972. It is likely that the armored layer on the bed and banks will continue to coarsen, and the bed and banks in this is reach may begin to resemble reaches such as found just upstream of Schulte Bridge. The development of a coarse armor layer will be dependent on flow conditions and sediment supply, which are both difficult to forecast accurately. As the armor layer becomes more coarse, higher flows will be necessary to disturb the bed and banks.

## RECOMMENDATIONS

1. Prior to final design, a step-backwater analysis of the main stem reach within the mitigation site at the San Clemente Reservoir should be performed for several flows (i.e., low flow, 1.5-year, 3-year, 10-year, and 100-year events before and after construction of the New Los Padres Project). This information will enable final design of planting areas and provide data for use in the design of erosion protection measures.

2. Monumented cross-sections should be established at the mitigation site as soon as feasible to monitor the main stem and San Clemente Creek. Topography and sediment-size data should be collected after significant events. Suspended sediment and bedload transport data should be collected on San Clemente, Pine, and Cachagua Creeks and on the main stem. This data will assist in refining predictions of impacts due to the New Los Padres Project and in developing the final design of the mitigation plan.

*/u/larry/wp/eirs/wethyd2*


SAN CLEMENTE RESERVOIR
CROSS SECTION A-A'
545
540
535
530
525
ELEVATION (FT.)
Q bankfull (EX.)
1.5-YR. w/24 NLP
NOTES:
-TOPOGRAPHIC DATA FROM DECEMBER 1993
-BANKFULL FLOW ESTIMATED FROM 3-14-86 AERIAL PHOTOGRAPH w/Q=1,000 cfs, n=0.028
-FLOW ELEVATIONS WERE BASED ON OPEN CHANNEL FLOW AND ARE APPROXIMATE
-1.5-YR. FLOW w/24 NLP = 220 cfs, n=0.045
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200
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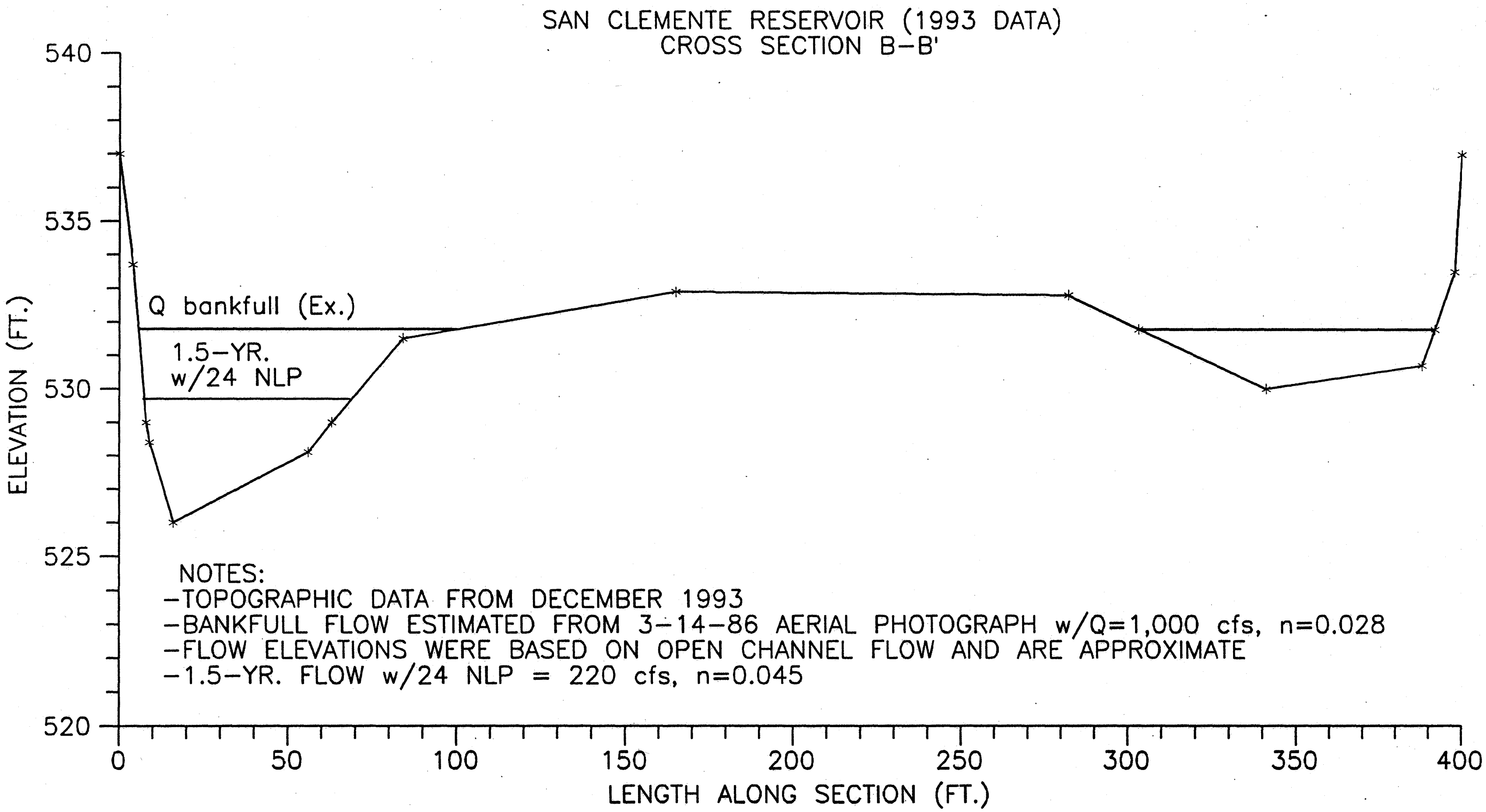
350
400
LENGTH ALONG SECTION (FT.)


SAN CLEMENTE RESERVOIR (1993 DATA)
CROSS SECTION B-B'
540
535
530
525
520
ELEVATION (FT.)
Q bankfull (Ex.)
1.5-YR.
w/24 NLP
NOTES:
-TOPOGRAPHIC DATA FROM DECEMBER 1993
-BANKFULL FLOW ESTIMATED FROM 3-14-86 AERIAL PHOTOGRAPH w/Q=1,000 cfs, n=0.028
-FLOW ELEVATIONS WERE BASED ON OPEN CHANNEL FLOW AND ARE APPROXIMATE
-1.5-YR. FLOW w/24 NLP = 220 cfs, n=0.045
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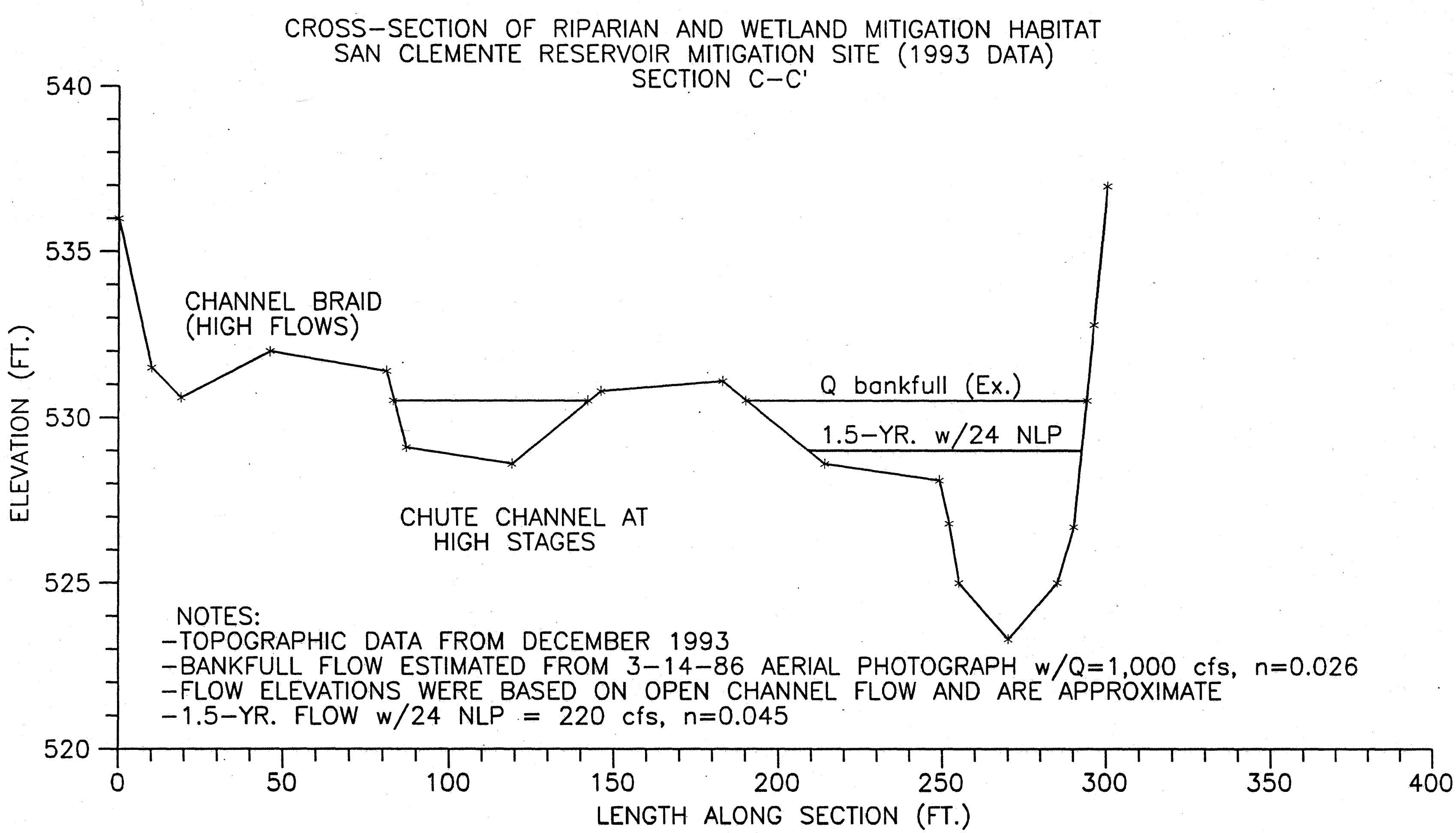
LENGTH ALONG SECTION (FT.)


CROSS-SECTION OF RIPARIAN AND WETLAND MITIGATION HABITAT
SAN CLEMENTE RESERVOIR MITIGATION SITE (1993 DATA)
SECTION C-C'
ELEVATION (FT.)
540
535
530
525
520
CHANNEL BRAID
(HIGH FLOWS)
Q bankfull (Ex.)
1.5-YR. w/24 NLP
CHUTE CHANNEL AT
HIGH STAGES
NOTES:
-TOPOGRAPHIC DATA FROM DECEMBER 1993
-BANKFULL FLOW ESTIMATED FROM 3-14-86 AERIAL PHOTOGRAPH w/Q=1,000 cfs, n=0.026
-FLOW ELEVATIONS WERE BASED ON OPEN CHANNEL FLOW AND ARE APPROXIMATE
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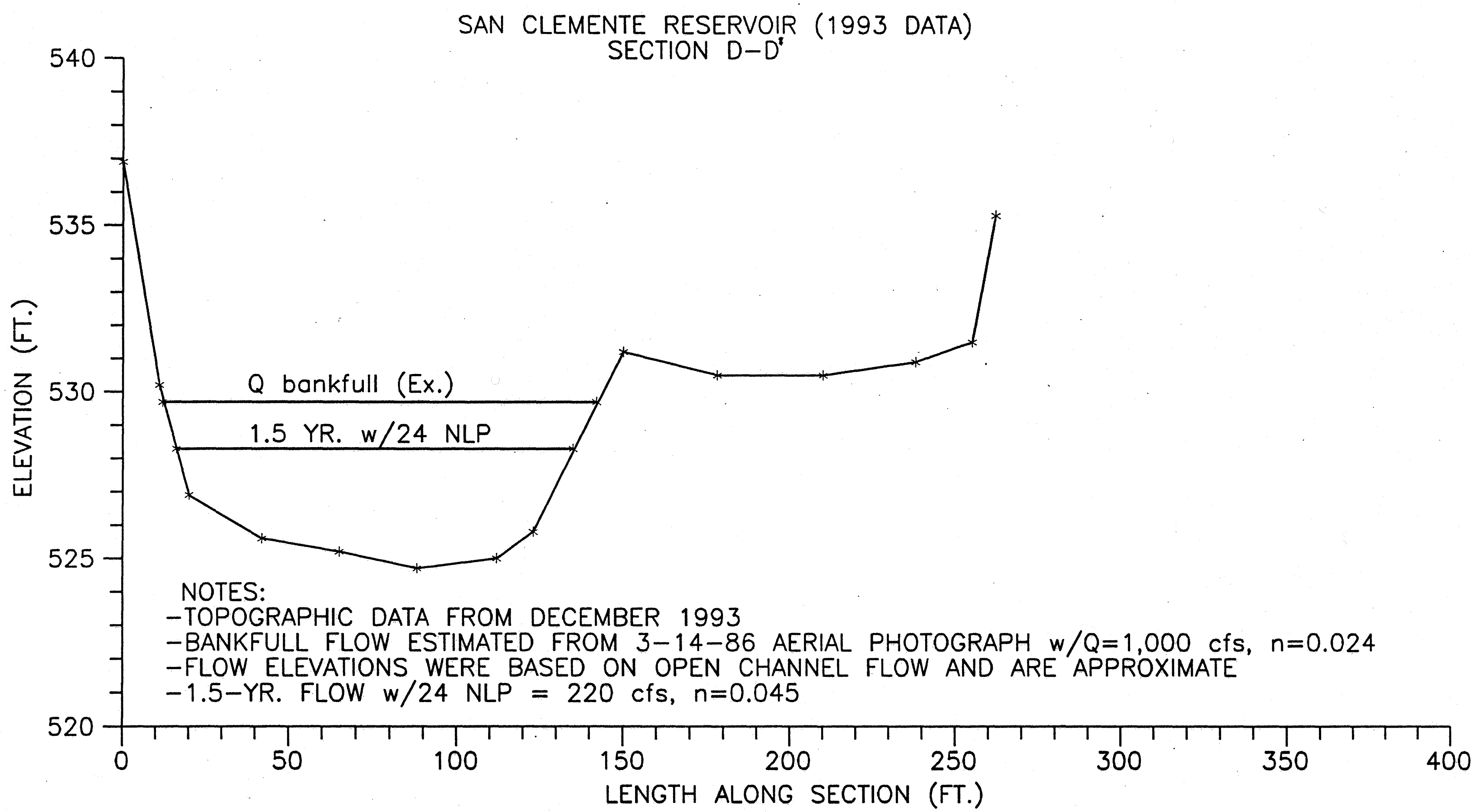
LENGTH ALONG SECTION (FT.)


SAN CLEMENTE RESERVOIR (1993 DATA)
SECTION D-D'
ELEVATION (FT.)
540
535
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525
520
Q bankfull (Ex.)
1.5 YR. w/24 NLP
NOTES:
-TOPOGRAPHIC DATA FROM DECEMBER 1993
-BANKFULL FLOW ESTIMATED FROM 3-14-86 AERIAL PHOTOGRAPH w/Q=1,000 cfs, n=0.024
-FLOW ELEVATIONS WERE BASED ON OPEN CHANNEL FLOW AND ARE APPROXIMATE
-1.5-YR. FLOW w/24 NLP = 220 cfs, n=0.045
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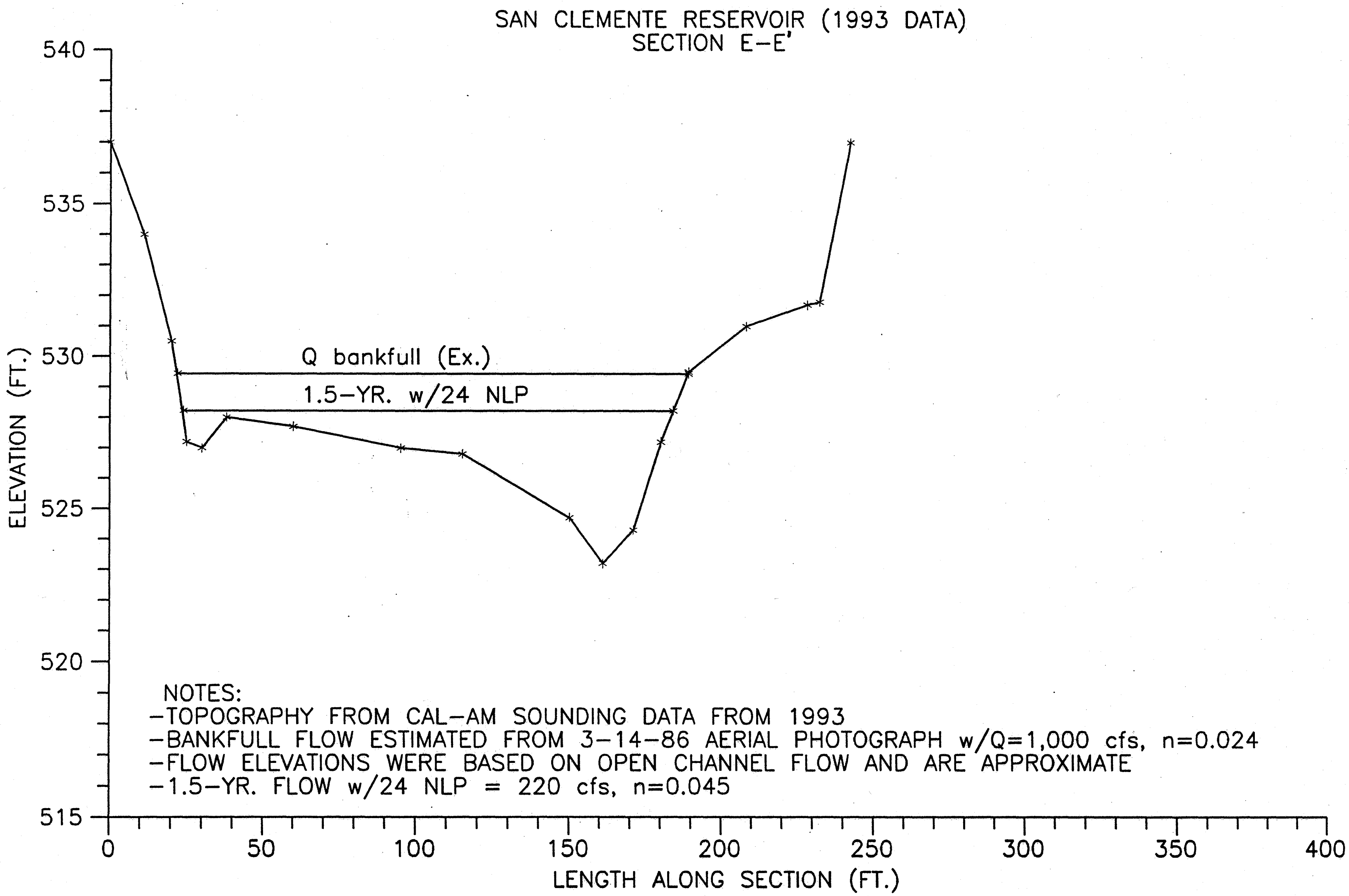
LENGTH ALONG SECTION (FT.)


SAN CLEMENTE RESERVOIR (1993 DATA)
SECTION E-E'
540
535
530
525
520
515
ELEVATION (FT.)
Q bankfull (Ex.)
1.5-YR. w/24 NLP
NOTES:
-TOPOGRAPHY FROM CAL-AM SOUNDING DATA FROM 1993
-BANKFULL FLOW ESTIMATED FROM 3-14-86 AERIAL PHOTOGRAPH w/Q=1,000 cfs, n=0.024
-FLOW ELEVATIONS WERE BASED ON OPEN CHANNEL FLOW AND ARE APPROXIMATE
-1.5-YR. FLOW w/24 NLP = 220 cfs, n=0.045
0
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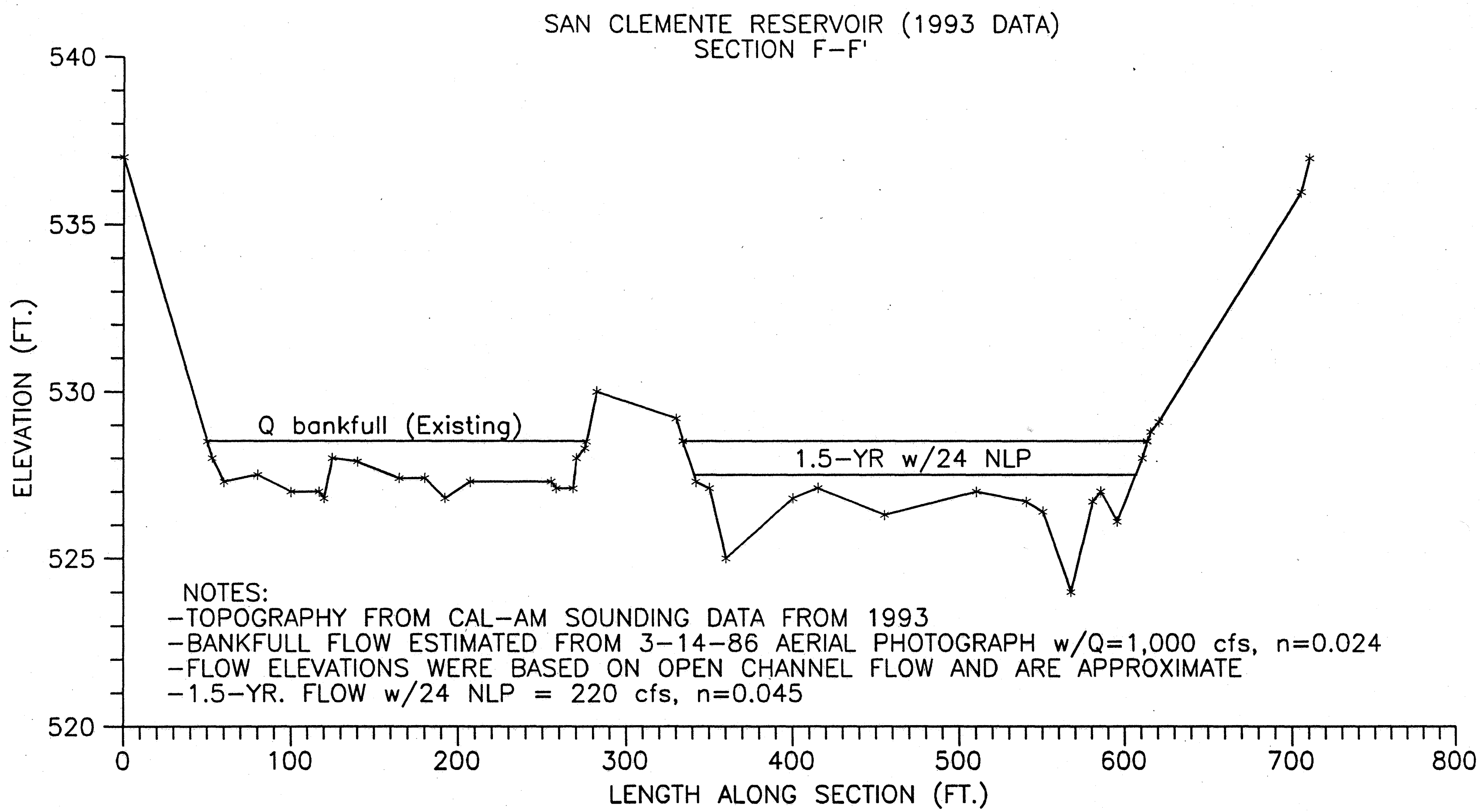
400
LENGTH ALONG SECTION (FT.)


SAN CLEMENTE RESERVOIR (1993 DATA)
SECTION F-F'
540
535
530
525
520
ELEVATION (FT.)
Q bankfull (Existing)
1.5-YR w/24 NLP
NOTES:
-TOPOGRAPHY FROM CAL-AM SOUNDING DATA FROM 1993
-BANKFULL FLOW ESTIMATED FROM 3-14-86 AERIAL PHOTOGRAPH w/Q=1,000 cfs, n=0.024
-FLOW ELEVATIONS WERE BASED ON OPEN CHANNEL FLOW AND ARE APPROXIMATE
-1.5-YR. FLOW w/24 NLP = 220 cfs, n=0.045
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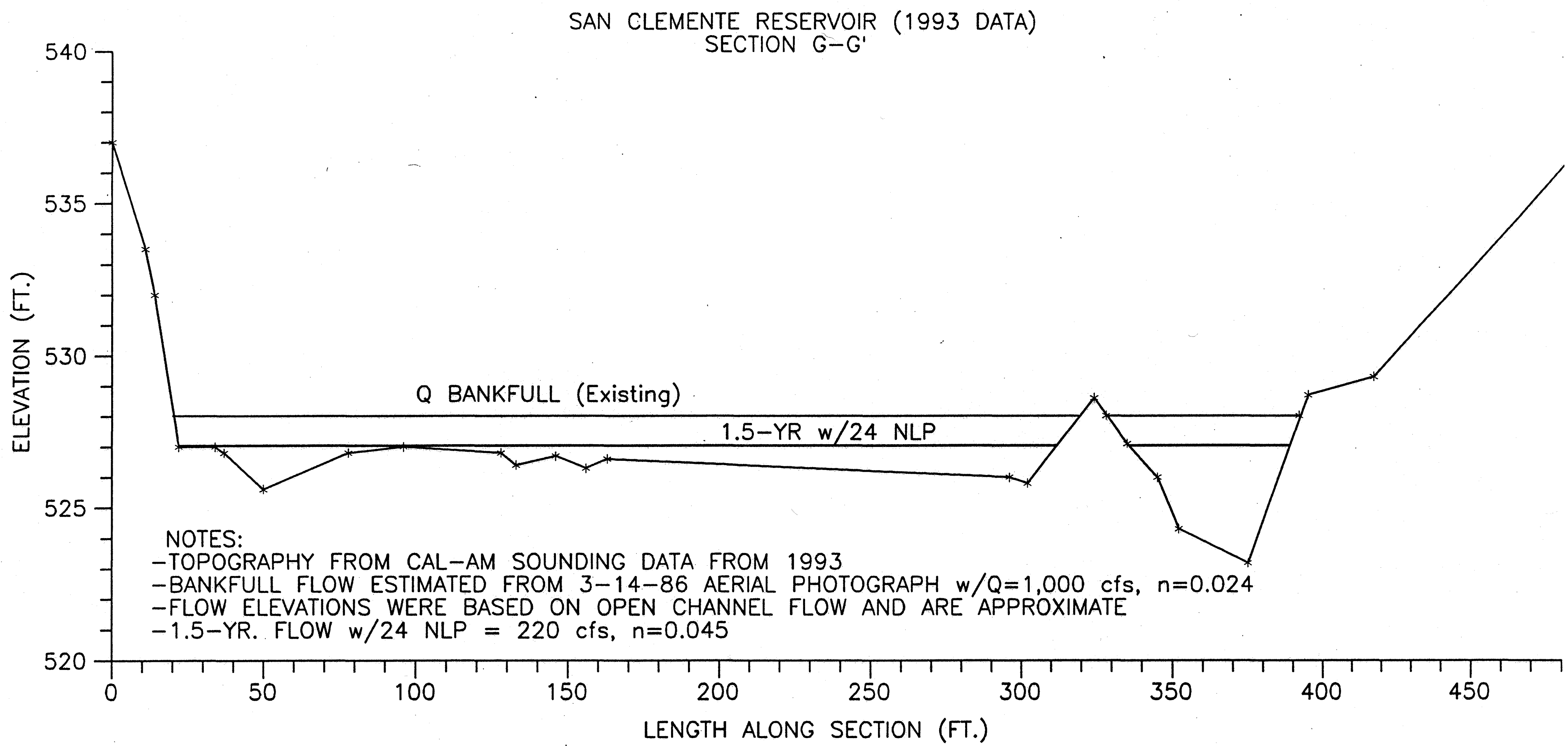
400
500
600
700
800
LENGTH ALONG SECTION (FT.)



SAN CLEMENTE RESERVOIR (1993 DATA)
SECTION G-G'
540
535
530
525
520
ELEVATION (FT.)
Q BANKFULL (Existing)
1.5-YR w/24 NLP
NOTES:
-TOPOGRAPHY FROM CAL-AM SOUNDING DATA FROM 1993
-BANKFULL FLOW ESTIMATED FROM 3-14-86 AERIAL PHOTOGRAPH w/Q=1,000 cfs, n=0.024
-FLOW ELEVATIONS WERE BASED ON OPEN CHANNEL FLOW AND ARE APPROXIMATE
-1.5-YR. FLOW w/24 NLP = 220 cfs, n=0.045
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300
350
400
450
LENGTH ALONG SECTION (FT.)

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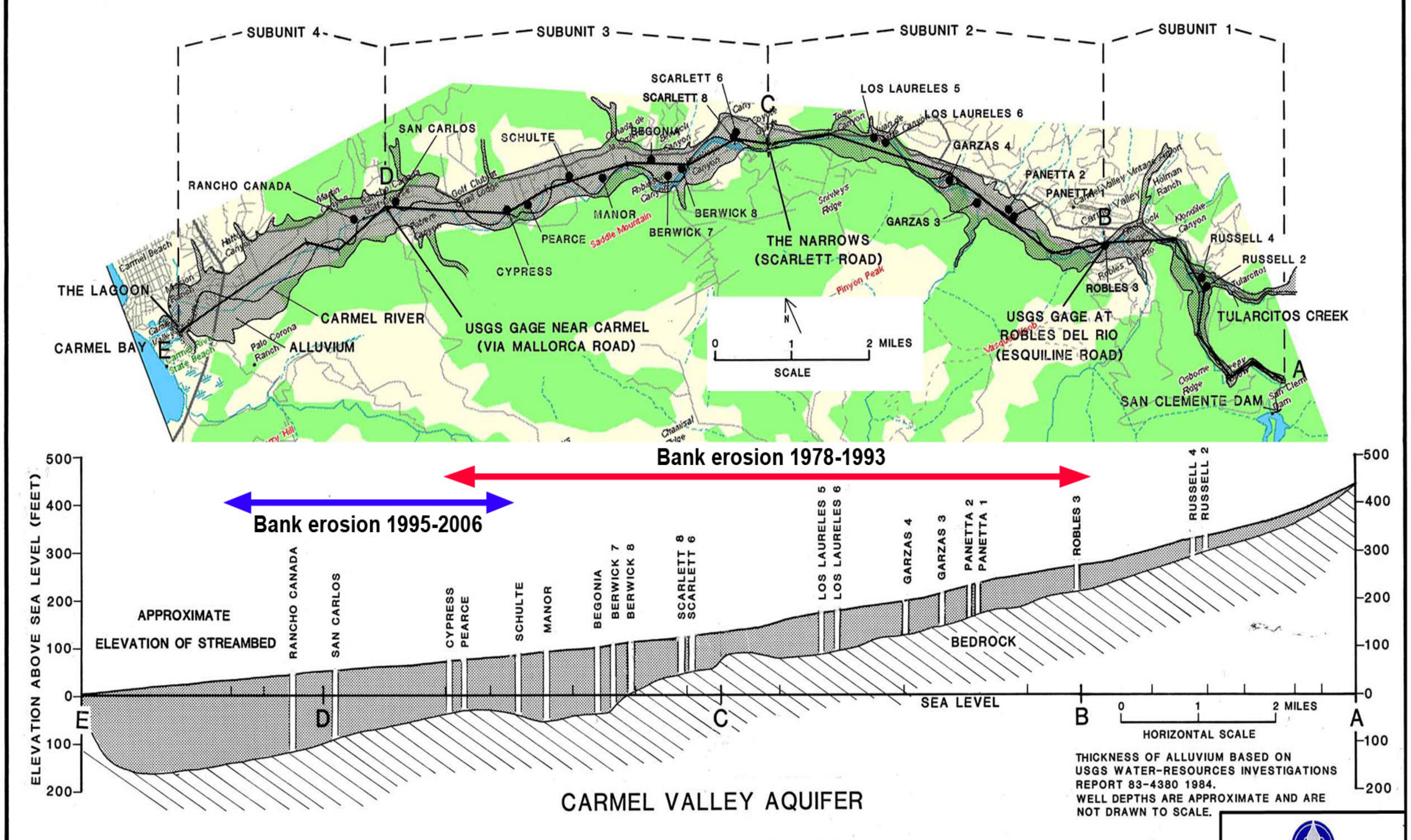
# FIGURE 1 - Map and Profile of the Carmel Valley Aquifer




MAP AND PROFILE OF ALLUVIAL AQUIFER SHOWING CALIFORNIA-AMERICAN WATER COMPANY PRODUCTION WELLS

JANUARY 1994

u:\larry\95-10\production-wells.tif

Revised 12-93

MONTEREY PENINSULA WATER MANAGEMENT DISTRICT
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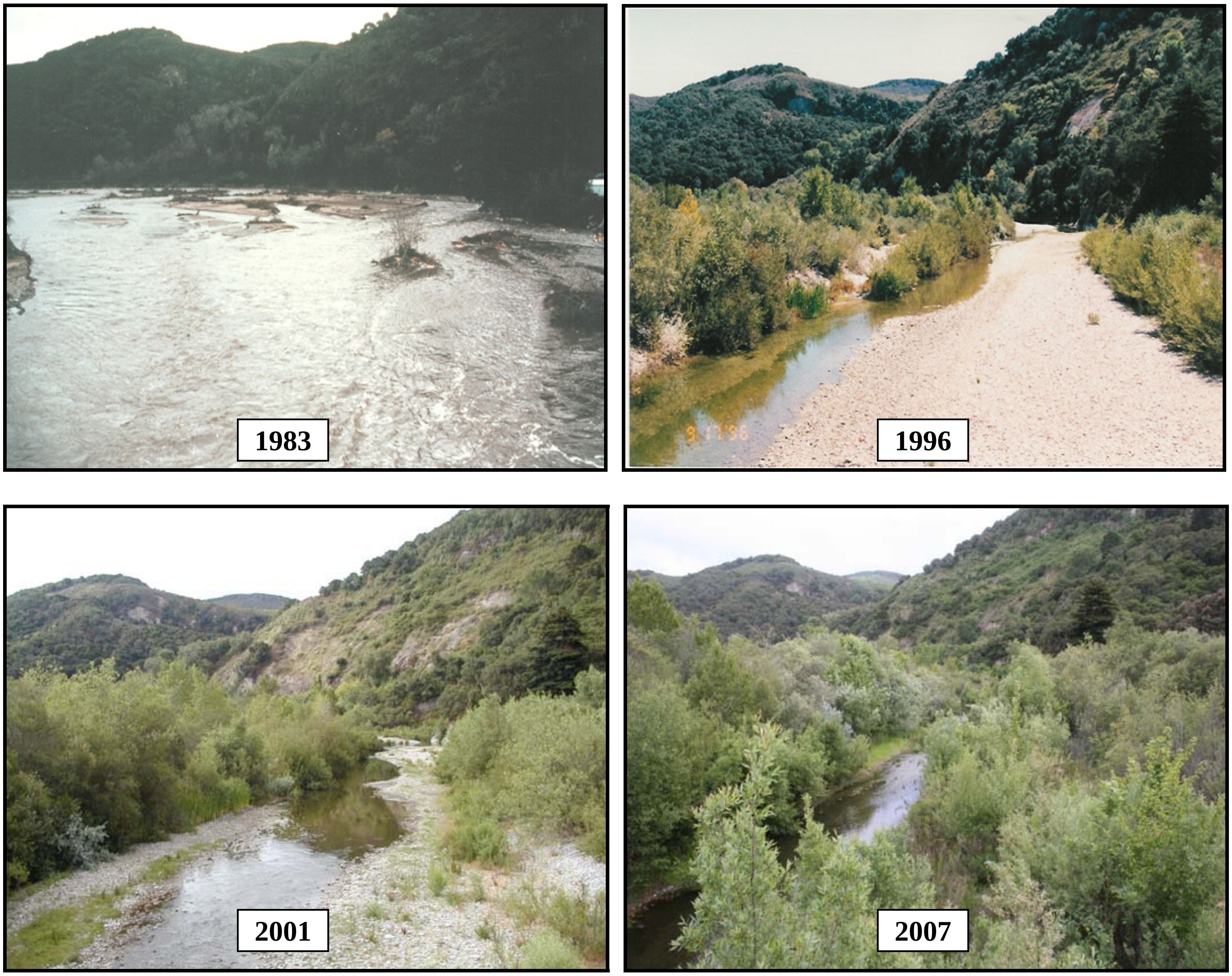
# 2007 CARMEL RIVER SURVEYS




**Views Upstream Schulte Road Bridge**

Prepared for:

**Monterey Peninsula Water Management District**
**P.O. Box 85**
**Monterey, CA 93942**

Prepared by:

**Graham Matthews & Associates**
**P.O. Box 1516**
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**February 2008**

# ACKNOWLEDGEMENTS

Graham Matthews & Associates
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Smokey Pittman – Senior Geomorphologist
Keith Barnard – Survey Manager
Logan Cornelius – Survey Technician II

Central Coast Surveyors:
Dave Edson, L.S.

The Gracious Landowners Who Allowed Us to Survey on Their Land:
Hacienda Carmel
Rancho Canada
Quail Lodge
Monterey Peninsula Regional Park District

MPWMD (Client):
Larry Hampson
Thomas Christiansen

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## APPENDICES

**Appendix A: Survey Control Report by Central Coast Surveyors**

# 2007 CARMEL RIVER SURVEYS

## INTRODUCTION

Graham Matthews & Associates (GMA) was retained by the Monterey Peninsula Water Management District (MPWMD) to collect longitudinal thalweg (the deepest continuous line) profile data and limited cross section data from the Carmel River for use in maintaining a long-term record and comparing to the past and future data.

## SCOPE

The scope of the project included the following tasks:

1. Survey the thalweg profile from the mouth upstream to the Robinson Canyon Bridge and in the Carmel Valley Village reach
2. Survey cross sections at the main bridges passed during the profile survey
3. Tie surveys into existing (from 1995) and/or new permanent benchmarks established by Central Coast Surveyors (CCS)
4. Compare 2007 surveys with previous longitudinal profile and cross section data as available

## METHODS

Standard survey techniques were used in this project and primarily involved total station surveying equipment. Topcon GTS-802 and APL-1A robotic total stations were used for the bulk of the thalweg and cross section surveys but using conventional two-person methods. Native riparian vegetation has encroached into the stream corridor in much of the channel rendering robotic or GPS one-person surveying impractical.

The initial total station setup and backsight used benchmarks (GPS1 and GPS2) that had been established on the Via Mallorca Bridge by CCS in 1995 to get on the NAD83 California State Plane Zone 4 horizontal and NAVD88 vertical coordinate system. From there, temporary control points were established in the stream corridor and the survey crew traversed downstream, averaging approximately 300' between turning points because of the dense vegetation and meandering channel. Thalweg shots were surveyed at each slope break to define riffle crests, pools, etc and at least every 50' where the profile was relatively flat. For the sake of efficiency, very little vegetation was cleared or trimmed during the surveys, and crews instead opted to set new turning points and/or use offset methods to project points horizontally and vertically into areas that were either inaccessible or not visible to the total station. The survey progressed downstream until reaching the pipeline crossing to the Carmel Area Wastewater District treatment plant. After completing the downstream reach, crews next surveyed upstream from Via Mallorca to the Robinson Canyon Bridge. Surveys were completed in October-November 2007.

The final reach surveyed was between the Boronda and Esquiline Bridges near the Carmel Valley Little League Baseball Park. Since no known control points were found at this site, the survey crew set a 5/8" rebar near the parking lot and set up a Trimble 4700 GPS base station over it for a real time kinematic (RTK) survey. The resulting four hour file was emailed to the National Geodetic Survey's OPUS website and they provided GMA with their coordinate solution for the point. Two RTK rover units were used to generate most of the thalweg points except in areas where riparian vegetation obscured the view of satellites. The total station was used conventionally to provide those data. To verify the OPUS generated elevation, an existing NGS benchmark along Carmel Valley Road was surveyed with the RTK rover.

At each major bridge crossing along those reaches where the profile was surveyed, a cross section was also surveyed along the upstream and downstream face of the bridge. The surveys extended from the top of the left bank to the top of the right bank. No effort was spent trying to locate old cross section benchmarks or to set new ones. Most of the bridges and their respective cross sections are more or less oriented perpendicular to the stream channel but in the case of the Robinson Canyon Bridge, the cross section did not follow the bridge face since the bridge orientation is skewed.

In 1995, CCS, under contract to MPWMD, established two control points at each of six bridges over the Carmel River. During the present survey, GMA survey crews tied into those benchmarks that they could locate in order to check in and correct their positions, if necessary. The Via Mallorca points were intact but one had been disturbed, perhaps by a Hacienda Carmel crew or contractor during sidewalk reconstruction for handicapped access. We shot to an NGS benchmark on the new Highway 1 Bridge with a published elevation (estimated horizontal coordinates). Next, when surveying upstream from Via Mallorca, the crew attempted to locate 1995 control points associated with Valley Greens Bridge but only found drill holes and brass plugs where the caps had been. At the next bridge upstream (Schulte Road), the 1995 benchmarks were intact but buried under gravel alongside the road. GMA did not survey past any of the other three bridges (Don Juan, Boronda, or Rosie's) with 1995 control.

During the last week on the ground (11/12-11/16/07), GMA coordinated with Central Coast Surveyors to have them set eight new control points: two at the most downstream golf cart bridge (#5) in the Rancho Canada Golf Course; two at the Rancho San Carlos Bridge; two at the Robinson Canyon Bridge; and replace the two missing caps at the Valley Greens Bridge. Since the GMA thalweg survey had passed these bridges before the new control was set, CCS surveyed to and established coordinates for six of the temporary points GMA had set in the riverbed during our traverse, which saved us substantial time, allowing us to correct our total station survey without having to reoccupy these points. The ability to check into and adjust our total station survey to known benchmarks spread along the way was invaluable and necessary due to the large number of instrument set-ups. Where the total station derived coordinates differed from the CCS GPS coordinates, adjustments were made by dividing the difference evenly by the number of turns and applying those corrections to the control points.

Total station surveys were recorded into Husky data collectors and downloaded into AutoCAD Land Desktop Development 2007 software. The resulting electronic fieldbook

(.fbk) files were separated into control and topographic point files. Control points were adjusted where necessary to agree with CCS established control at six bridges and NGS control at the Highway 1 Bridge and then the topographic .fbk files were imported.

Once the points were in AutoCAD, the next step in generating a thalweg profile was to determine the stationing of each point along the river channel. Since the thalweg changes course frequently within the active channel, the length also changes accordingly and makes comparison of the thalweg profile over time challenging. The best method is to establish a line up the river channel, such as a channel centerline, and conform the profile stationing to that. The MPWMD hand drew a centerline based on 1986 aerial photos and set river mile stationing on that beginning at the mouth of the Carmel River and proceeding upstream. Prior thalweg profiles by GMA in 1999 and 2001 used the stationing of the bridges from that effort and adjusted surveyed points to fit that stationing between bridges. For the present effort, GMA reconstructed a "centerline" using a 2005 National Agriculture Imagery Program (NAIP) ortho photo and then "adjusted" it as necessary by shortening or lengthening curves, etc., to match the stationing generated from the 1986 photo at the bridge locations.

Once in AutoCAD, the centerline was defined as an alignment and the thalweg points were assigned stationing by projecting each point orthogonally to the centerline. Since this centerline alignment method is somewhat different than that used by GMA in 1999 and 2001, we needed to reestablish the point stationing for those surveys, so we re-imported those older surveys into AutoCAD and assigned new stationing to them. Unfortunately, we did not have access to the previous MPWMD and FIS survey data in real world coordinates so we used the stationing derived in the 2001 report, but it should be noted that the comparison is not as correct as that between the 1999, 2001 and the present data.

## RESULTS

Thalweg profile data were available in various reaches from 1978 (FIS), 1984, 1994, and 1997 from MPWMD, and 1999, 2001, and the present 2007 (Figure 1). Between the Highway 1 Bridge and Via Mallorca, the only comparison is between 1978 and 2007 and the change shows considerable degradation of 2' to 3' over time. The reach between Via Mallorca and San Carlos Bridge has been the most frequently sampled (Figure 2). Relatively little change was evident between 1978 and 1984, while by 1994, the streambed had downcut or incised appreciably (about 2' on average), the bed texture (based on the GMA staff observations and discussions with MPWMD staff) had changed as a result, with much more gravel present, and there was much greater definition of pools. However, in 1999, after major floods in 1995 and 1998 along with significant bank erosion in upstream reaches, the channel had aggraded back towards the 1978 and 1984 elevations, and in the case of a 1000-foot reach downstream of San Carlos Road, was substantially elevated above these levels. Between 1999 and 2001, the material deposited by the 1998 floods had moved out and downcutting continued through the 2007 survey to the same level or lower than the 1994 channel.

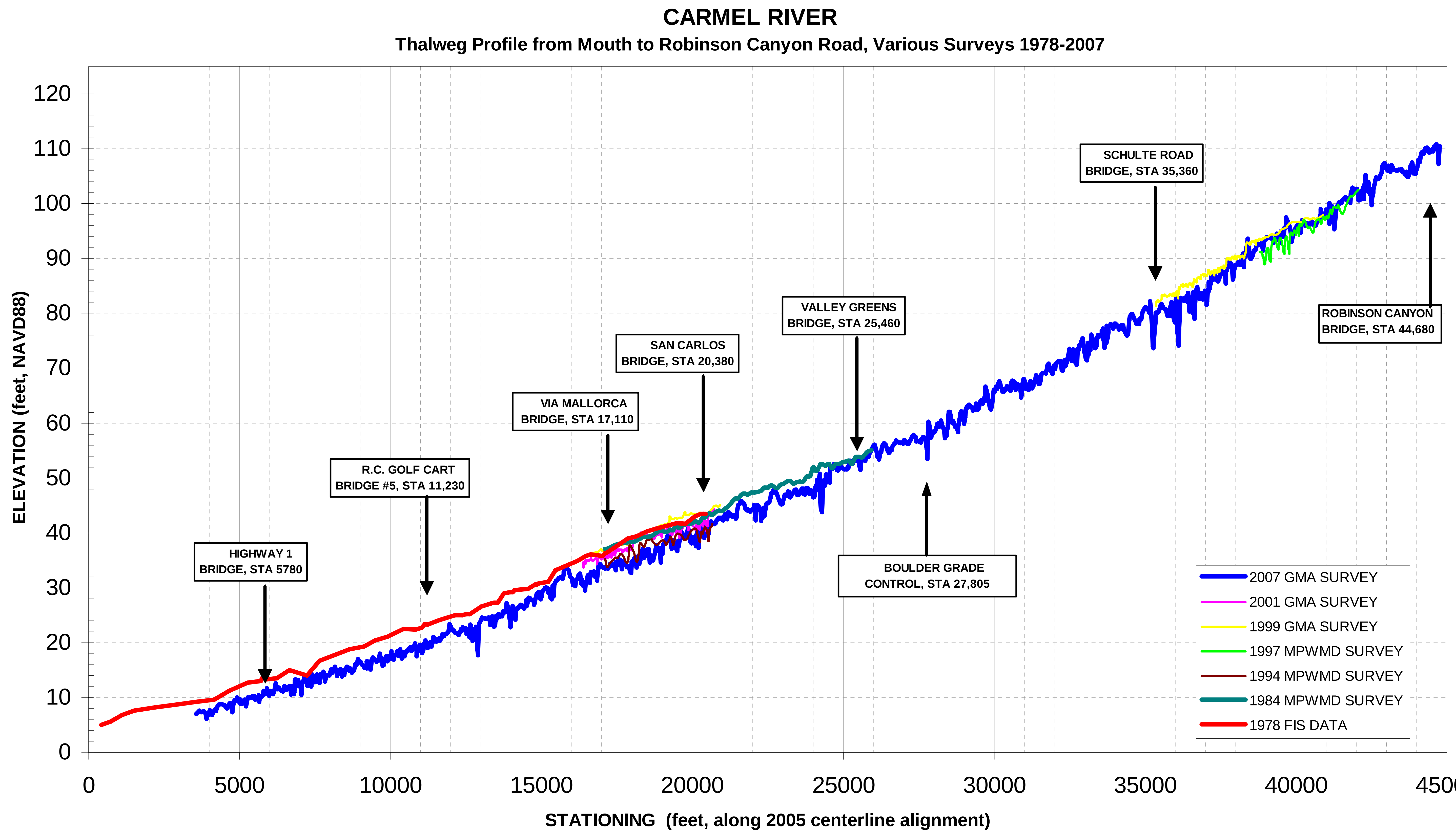
The only comparison from the data available to GMA between San Carlos Bridge and Valley Greens Drive Bridge is between 1984 and 2007 and shows general downcutting of approximately 2' until the profiles converge around Valley Greens Drive.

The reach upstream of the Schulte Road Bridge has been surveyed numerous times, including by GMA in 1999. Only data from 1997 and 1999 were available at the time this report was prepared and comparison between these surveys with the 2007 survey shows some, although less, channel lowering than in the downstream, lower gradient reaches (Figure 3). Beginning about 5000 feet upstream of Schulte Road Bridge, there is almost no difference between the present 2007 profile and that surveyed by MPWMD in 1997. Of particular interest is the reforming of several deep pools at the bridge and a short distance upstream at the weel-known bedrock outcrop. These pools are about 7-9' deeper than that surveyed in 1999 when a relatively planar bed existed post 1998 flood and upstream bank erosion.

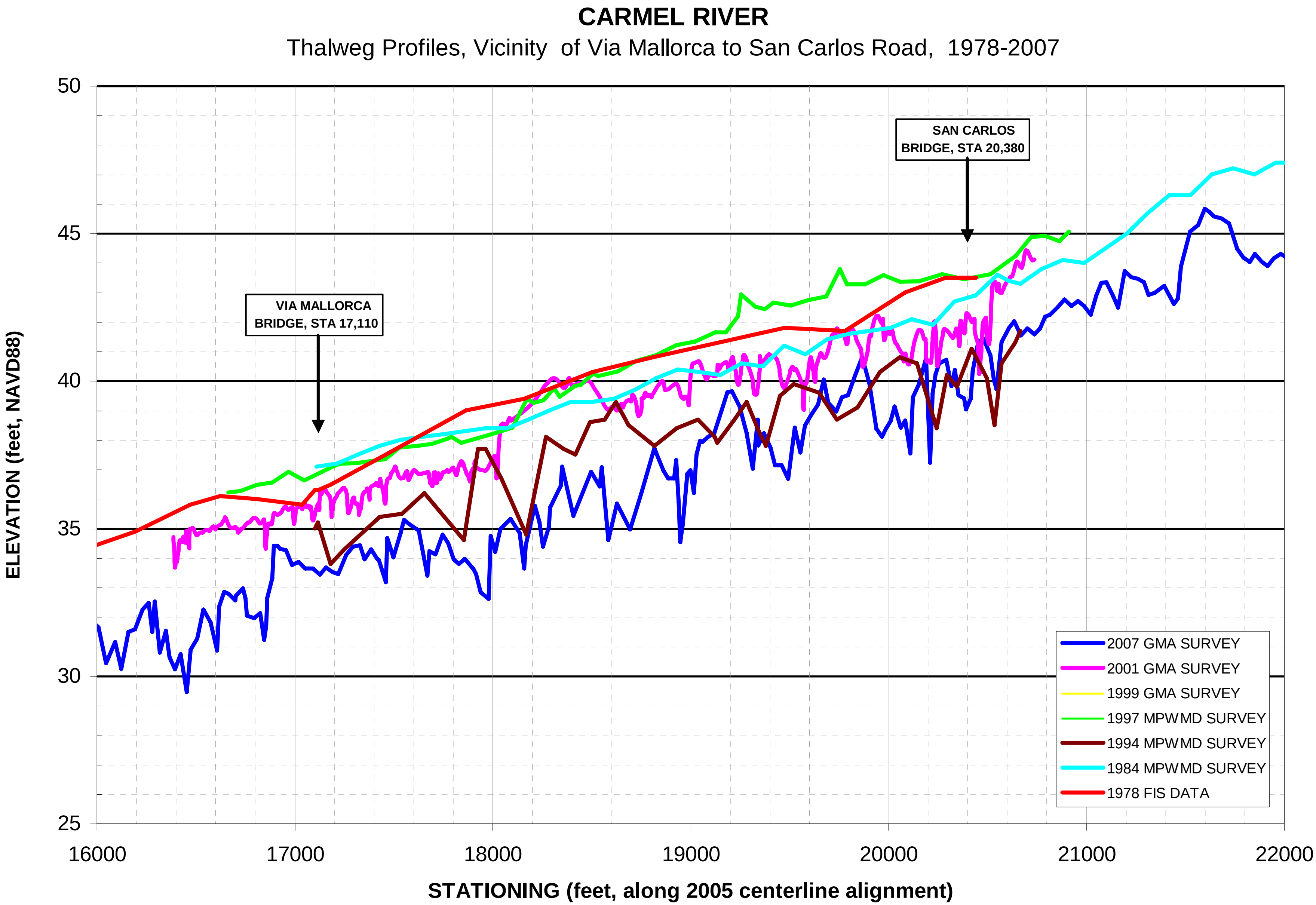
There were only three cross sections from 2001 that were comparable to those surveyed during the 2007 session. The 2001 cross sections 35 and 36 at the Via Mallorca Bridge were shifted to match the 2007 alignment and demonstrate between one and two feet of downcutting during that period, similar to that seen in the thalweg profile (Figure 4). At the San Carlos Bridge, cross section 3 from 2001 was approximately 15' downstream of the downstream face of the bridge. Similar downcutting is evident between 2001 and 2007.

## CONCLUSIONS

The present thalweg profile represents a good baseline for long-term monitoring of the lower 8 ½ miles of the Carmel River and appears to represent an incised, sediment-starved channel. The centerline developed from the 2005 aerial photos which matches the previous bridge stationing will provide a means of more accurately comparing future thalweg profiles with the present and recent past surveys. The effort fell short of the anticipated goal to carry the thalweg profile up to Klondike Creek, because of very difficult survey conditions. Surveys using RTK/GPS and/or robotic methods can be performed by one person and are therefore considerably more efficient, but the thick vegetative encroachment in and along the current channel of the Carmel River requires conventional two-person survey methods with extensive turning points (instrument set-ups) required. The establishment of new benchmarks and restoration of old benchmarks on all the major bridges in the lower section provides a good control network to assist in channel surveying for monitoring or restoration purposes using real world coordinates.




| 2007 CARMEL RIVER PROFILE SURVEYS | MONTEREY PENINSULA WATER MANAGEMENT DISTRICT | GMA GRAHAM MATTHEWS & ASSOCIATES Hydrology • Geomorphology • Stream Restoration P.O. Box 1516 Weaverville, CA 96093-1516 (530) 623-0520 | FIGURE 1 |
|---|---|---|---|

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GMA

**GRAHAM MATTHEWS & ASSOCIATES**

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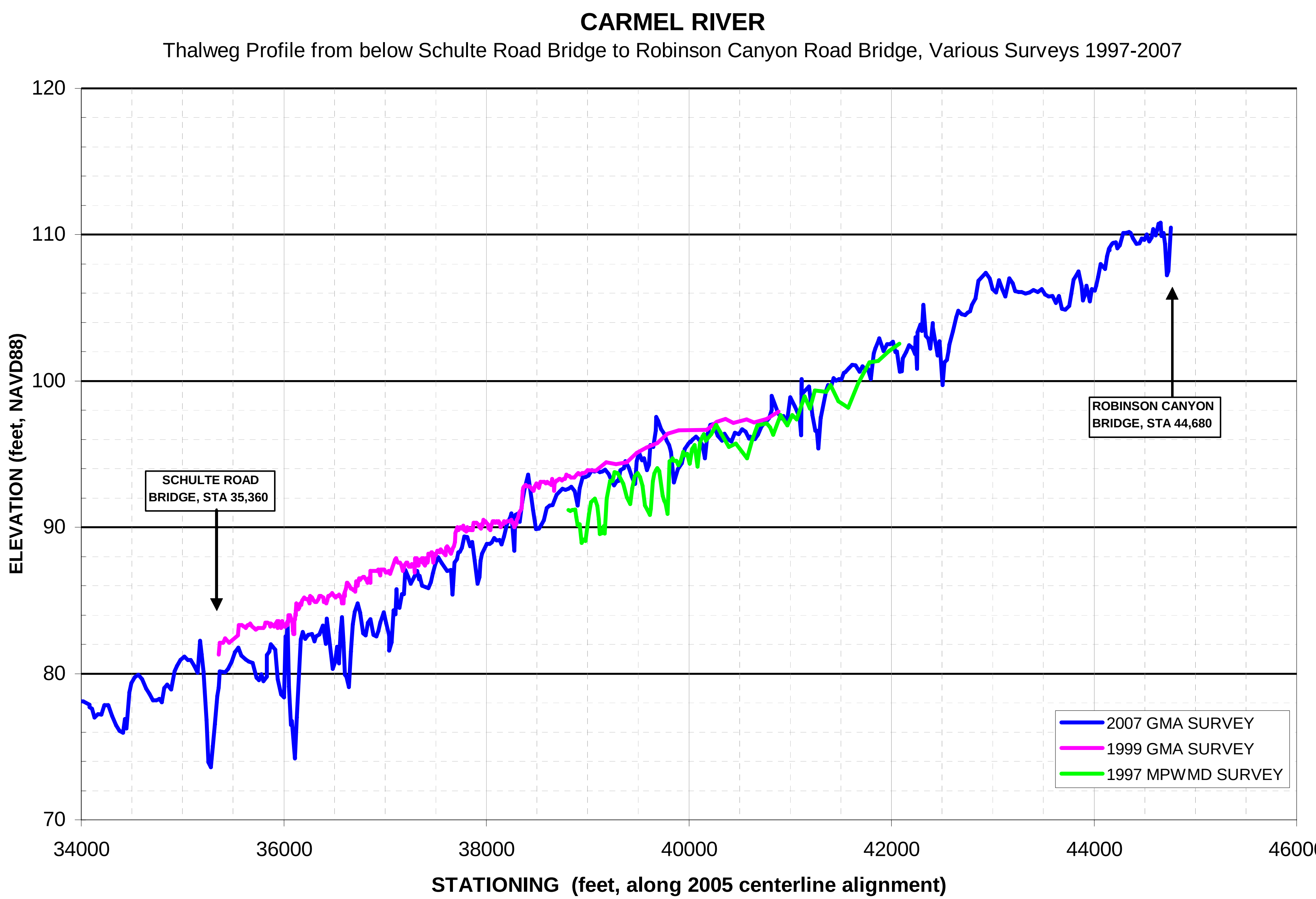
**FIGURE**

**2**

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GRAHAM MATTHEWS & ASSOCIATES
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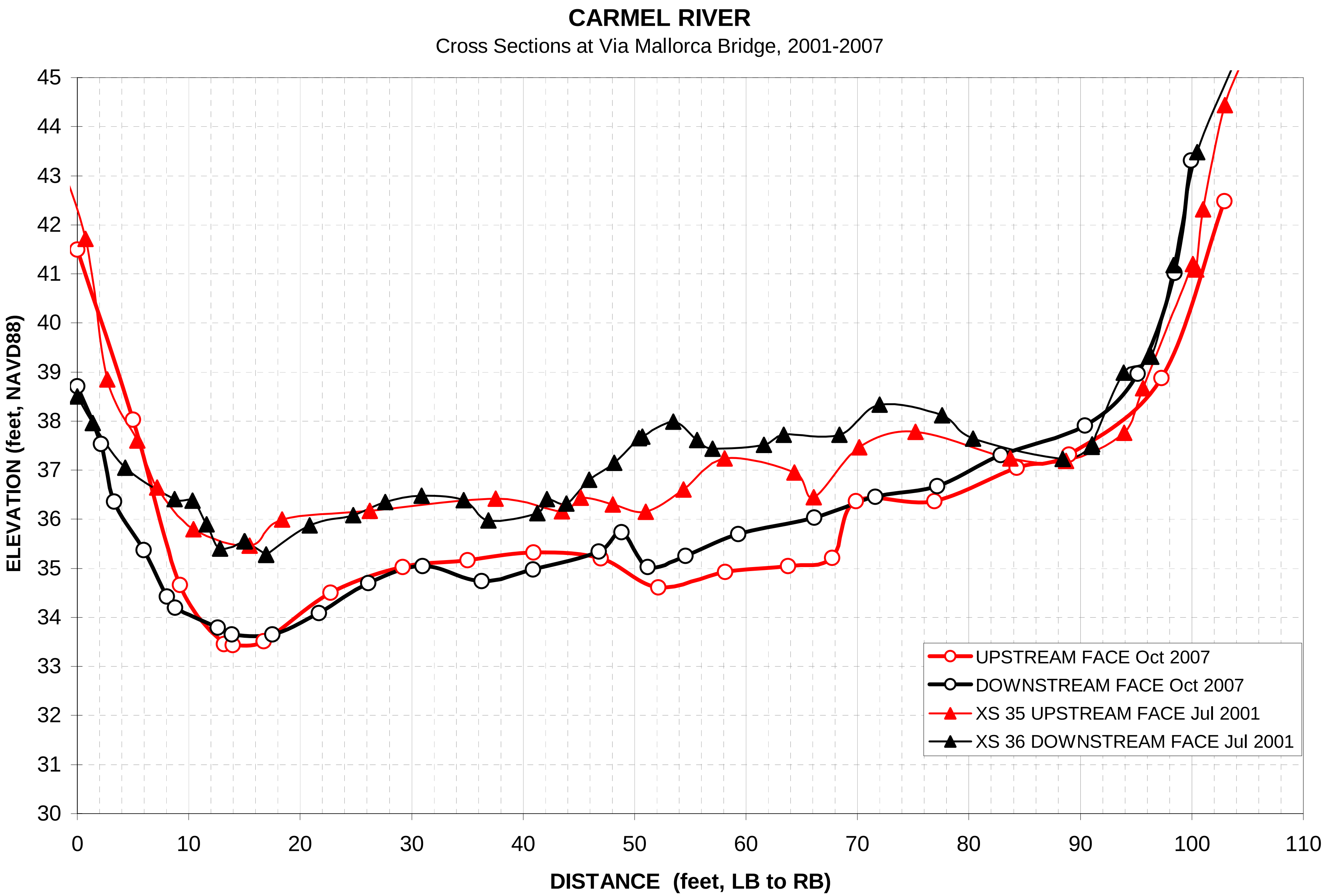
**FIGURE**

**3**




| MONTEREY PENINSULA WATER MANAGEMENT DISTRICT<br>2007 CARMEL RIVER PROFILE SURVEYS | GMA<br>GRAHAM MATTHEWS & ASSOCIATES<br>Hydrology • Geomorphology • Stream Restoration<br>P.O. Box 1516 Weaverville, CA 96093-1516<br>(530) 623-0520 | FIGURE<br>4 |
|---|---|---|

**APPENDIX A**

# SURVEY CONTROL POINTS
# ESTABLISHED WITH GPS METHODS

## LOWER CARMEL RIVER

PREPARED FOR

**GRAHAM MATTHEWS & ASSOCIATES**

**and**

**MONTEREY PENINSULA WATER MANAGEMENT DISTRICT**

By

**CENTRAL COAST SURVEYORS**

DECEMBER 2007 (EXPIRES 12/31/09)

## APPENDIX A

**Objective**:

The purpose of this project was to establish survey control points for use in subsequent surveys. This survey builds on a previous survey of twelve control points, two each at six bridge crossings, performed for the Water Management District in May of 1995. Two intervisible points have been set at each of the three addition bridge crossings along the Carmel River. A key criterion was to establish positions based on the State Plane Coordinates, allowing maximum flexibility for future use of the data, as well as suitability as Geographic Information System input data. The three new bridge locations are:

- Rancho Canada Golf Course
- Rancho San Carlos Road
- Robinson Canyon Road

In addition, it was noted that the two tablets set in 1995 at the Valley Greens crossing, set as “MPWMD GPS 3” and “MPWMD GPS 4” were sheared and missing from their shanks set in concrete. Two new tablets were modified and bonded to the concrete at these locations. Their slightly modified coordinates are reported herein.

Finally, at the Via Mallorca crossing, the tablet set as “MPWMD GPS 2” in the top of a rolled concrete curb return was noted as having been recovered from demolished concrete and recast into a new handicapped ramp installed at this curb return some three feet from its original location. The new coordinates are reported here as well.

**Methodology:**

The control points consist of 2” brass tablets with center-punch set in existing concrete. The points are numbered 101 through 108 as described on the attached tabulation. All tablets are stamped with the letters “M P W M D ”, along with their point number and year date (2007).

A Leica System 530 Global Positioning System (GPS) dual channel receiver equipped with “RTKMax” cellular telephone data modem for reception of a network-adjusted correction signal was used to establish a coordinate system congruent with the 1995 survey (California State Plane Coordinate System, Zone 4 (NAD83)).

**Conclusions:**

The attached table shows a listing of the State Plane Coordinates for all GPS-observed points, along with their orthometric height (calculated heights above sea level), expressed in feet and decimals thereof. A location description accompanies each control point. Coordinate data is also provided for key supplementary control points established and used by GMA in the course of their survey work.

## GPS CONTROL SURVEY - CARMEL RIVER - 11-16-07

| POINT ID | NORTHING | EASTING | ELEVATION | DESCRIPTOR |
|---|---|---|---|---|
| | (NAD 83 - CALIF. Z 4, FEET) | (NAD 83 - CALIF. Z 4, FEET) | (NAVD 88 DATUM, FEET) | |
| MPWMD 101 | 2091270.60 | 5711005.19 | 38.91 | BRASS TABLET IN A CART PATH INTERSECTION, APPROX. 65' NORTH OF THE NORTH END OF CART PATH BRIDGE LEADING TO THE 14TH GREEN AND 15TH TEEBOX, RANCHO CANADA WEST COURSE, 0.3' SOUTH OF THE NORTH EDGE OF A PERPENDICULAR CART PATH INTERSECTION. |
| MPWMD 102 | 2091058.78 | 5711201.90 | 36.80 | BRASS TABLET IN THE TOP OF A CONCRETE CURB, APPROX. 65' SOUTH OF THE SOUTH END OF CART PATH BRIDGE LEADING TO THE 14TH GREEN AND 15TH TEEBOX, RANCHO CANADA WEST COURSE, ON THE EASTERLY SIDE OF CART PATH 1.2' SOUTH OF THE BEGINNING OF A CONCRETE CURB. |
| MPWMD 103 | 2090915.31 | 5718497.00 | 66.58 | BRASS TABLET IN THE SOUTHEASTERLY CORNER OF A CONCRETE PAD, 8.5' SOUTH OF THE SOUTHWESTERLY CORNER OF RANCHO SAN CARLOS BRIDGE. |
| MPWMD 104 | 2090539.81 | 5718431.93 | 66.25 | BRASS TABLET IN AN ASPHALT CONCRETE DRIVEWAY APPROACH SERVING 26700 RANCH SAN CARLOS RD., APPROX 348' SOUTH OF THE RANCHO SAN CARLOS BRIDGE ALONG THE WESTERLY EDGE OF RANCHO SAN CARLOS ROAD. |
| MPWMD 105 | 2088620.39 | 5722015.24 | 83.31 | BRASS TABLET RESET OF "MPWMD GPS 3". |
| MPWMD 106 | 2088776.19 | 5722492.04 | 75.42 | BRASS TABLET RESET OF "MPWMD GPS 4". |
| MPWMD 107 | 2084936.65 | 5737273.55 | 147.38 | BRASS TABLET IN THE TOP OF AN ASPHALT CONCRETE CURB ALONG THE EASTERLY SIDE OF ROBINSON CANYON ROAD NEAR THE NORTHEASTERLY CORNER OF THE ROBINSON CANYON BRIDGE AND 1.6' NORTH OF THE BEGINNING OF THE ASPHALT CONCRETE CURB. |
| MPWMD 108 | 2084604.89 | 5737208.88 | 146.78 | BRASS TABLET IN THE TOP OF A ASPHALT CONCRETE CURB ALONG THE WESTERLY SIDE OF ROBINSON CANYON ROAD NEAR THE SOUTHWEST CORNER OF THE ROBINSON CANYON ROAD BRIDGE AND 1.3' SOUTH OF THE BEGINNING OF THE ASPHALT CONCRETE CURB. |

ALL BRASS TABLETS SET IN THIS SURVEY ARE STAMPED WITH THEIR POINT ID AND YEAR SET.

| | | | | |
|---|---|---|---|---|
| GMA CTRL 1 | 2091229.94 | 5711229.58 | 21.97 | WESTERLY SPIKE IN RIVER UPSTREAM OF RANCHO CANADA BRIDGE |
| GMA CTRL 2 | 2091295.60 | 5711391.07 | 20.84 | EASTERLY SPIKE IN RIVER UPSTREAM OF RANCHO CANADA BRIDGE |
| GMA CTRL 3 | 2091094.91 | 5718482.26 | 47.51 | SPIKE IN RIVER DOWNSTREAM OF RANCHO SAN CARLOS BRIDGE |
| GMA CTRL 4 | 2091072.91 | 5718686.57 | 42.98 | SPIKE IN RIVER UPSTREAM OF RANCHO SAN CARLOS BRIDGE |
| GMA CTRL 5 | 2088723.89 | 5722263.94 | 80.44 | CHISLED "X" ON VALLEY GREENS DR BRIDGE |
| GMA CTRL 6 | 2084713.53 | 5737232.21 | 148.86 | INK "X" ON ROBINSON CYN RD. BRIDGE |

| | | | | |
|---|---|---|---|---|
| MPWMD GPS 2 | 2091672.61 | 5715681.80 | 48.51 | NEW DATA FOR REPOSITIONED TABLET FROM 1995 SURVEY |

**BEFORE THE PUBLIC UTILITIES COMMISSION**

**OF THE STATE OF CALIFORNIA**

| | |
|---|---|
| In the Matter of the Application of California-American Water Company (U210W) for an Order Authorizing the Collection and Remittance of the Monterey Peninsula Water Management District User Fee | A.10-01-012<br>(Filed January 5, 2010) |

**DIRECT TESTIMONY OF LARRY M. HAMPSON**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Dated: August 22, 2011

BEFORE THE PUBLIC UTILITIES COMMISSION

**BEFORE THE PUBLIC UTILITIES COMMISSION**

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# DIRECT TESTIMONY OF LARRY M. HAMPSON

## I. INTRODUCTION

Q1. Please state your name, business address, and telephone number.

A1. My name is Larry M. Hampson. My business address is 5 Harris Court, Building G, Monterey, California 93940. My telephone number is (831) 658-5620.

Q2. By whom are you employed and in what capacity?

A2. I am employed by the Monterey Peninsula Water Management District (MPWMD or Water Management District) as District Engineer and have worked continuously for MPWMD since March 1991.

Q3. Please give a summary of your professional qualifications.

A3. My education includes a B.S. degree in Engineering Science from Colorado State University and an M.B.A. in Finance from the University of Colorado. I am a Registered Civil Engineer in the State of California (No. C 45763) and a licensed Professional Engineer in the State of Colorado (No. 25726). I have 28 years of experience in Civil Engineering, most of which has been related to water resource management. I am familiar with laws and regulations concerning environmental review, permitting, and construction of streamside restoration projects. I am familiar with principles of integrated water resources planning. I am knowledgeable regarding Monterey Peninsula water resource management issues in general and issues related to hydrology, erosion protection, and riparian habitat mitigation and river restoration in the Carmel River in particular.

Q4. Please briefly outline your current responsibilities at the Water Management District.

A4. As the District Engineer, I participate in planning, engineering, and environmental impact investigations for water supply projects to augment available supplies. Water supply projects include: evaluation of surface storage in the Carmel River watershed, such as the New Los Padres Dam and the Carmel River Dam and Reservoir; evaluation and initial planning for seawater desalination projects; and evaluation of wastewater recycling projects. My time for these tasks (approximately 35% or about 600 hours) is shown in the labor allocations to the Mitigation Program and to Capital Projects as shown in Exhibit DF-16.

I am responsible for planning, design, implementation, and monitoring of District-sponsored projects for erosion protection and river restoration and I supervise staff who work on riparian planting, irrigation, and monitoring of projects that affect the streamside environment of the Carmel River. I am responsible for reviewing and inspecting non-District sponsored projects that affect the channel of the Carmel River, such as the San Clemente Dam Removal and Carmel River Reroute Project. I am responsible for reviewing applications to alter the channel of the Carmel River and issue permits to implement proposed alterations. I am also involved in reviewing water rights applications for the Carmel River Basin. I am involved in planning level efforts to expand the Seaside Groundwater Basin Aquifer Storage and Recovery (ASR) and secure funds for the project. My time for these tasks (approximately 65% or about 1,100 hours) is included in the labor allocations to the Mitigation Program and to Capital Projects as shown in Exhibit DF-16.

I direct engineers, planners, hydrologists, and other technical and field staff in carrying out the Planning and Engineering Division (Division) duties and I am responsible for preparing the Division's budget and tracking its expenditures. The amount of time I spend in Management/Support of non-ASR activities is shown in Exhibit DF-13 (447 hours) and the time I spend in Management/Support for ASR is shown in Exhibit DF-15 (112 hours).

Since 2004, I have directed and coordinated efforts of MPWMD staff and many agencies to complete and update an Integrated Regional Water Management (IRWM) Plan for a planning region that comprises the Carmel River watershed, the six Monterey Peninsula cities, and unincorporated portions of Monterey County within the MPWMD boundary . The IRWM Plan for the region includes planning and implementation of projects that are directly related to the Mitigation Program and that will also augment the water supply for the region. My time for these tasks is included in the labor allocations to the Mitigation Program and to Capital Projects as shown in Exhibit DF-16.

Q5. Have you previously testified before the California Public Utilities Commission?

A5. No.

## II. PURPOSE OF TESTIMONY

Q6. What is the purpose of this direct testimony?

A6. The purpose of my testimony is to describe my involvement and responsibilities for several of the mitigation measures that were identified in "Final Environmental Impact Report, Water Allocation Program, Five Year Mitigation Program for Option V – 16,700 AF Cal-Am Production, Adopted by the MPWMD Board, November 1990, Prepared by MPWMD Staff" (hereinafter referred to as "Mitigation Program") to mitigate for the effects of Cal-Am diversions of the Carmel River. I describe my involvement and responsibilities associated with the following activities: 1) Aquifer Storage and Recovery; 2) Riparian Mitigation #2 and #3, which include preparing and overseeing a riparian corridor management plan for the Carmel River (#2) and implementing the plan (#3); and 3) Carmel River Lagoon Mitigation #1, #2, and #3, which include implementing the recommendations of the lagoon enhancement plan investigations (#1), expanding long-term monitoring at the lagoon (#2), and identifying feasible alternatives to maintain adequate lagoon volume (#3).

Q7. Please describe how this testimony is organized.

A7. My testimony is divided into seven parts. Section I, "Introduction" contains my qualifications to sponsor this testimony. Section II, "Purpose" provides context for the remaining sections of the testimony. Section III "Aquifer Storage and Recovery" (or ASR) discusses my involvement in planning level efforts for an expansion of the existing ASR Project and in seeking grant funds for the project. Section IV "Riparian Mitigation #2 and #3" describes the development and implementation of the Riparian Corridor Management Plan, with an emphasis on my direct involvement in the activities necessary to continue the restoration of the Carmel River restoration, protection, of the riparian corridor, and monitoring of the effectiveness of these activities. Section V "Lagoon Mitigation #1, #2, and #3" describes my involvement with implementing projects proposed in the Lagoon Enhancement Plan, monitoring physical changes to the lagoon over time, and determining an adequate volume of water to support plants and wildlife at the lagoon. Section VI "Changes in the Implementation of the Riparian and Lagoon Mitigation Measures" describes changes in the implementation of the Riparian and Lagoon mitigation measures over time, provides concluding remarks and describes additional activities that should be considered to improve the program to mitigate for Carmel River diversions. Section VII describes the 2009 Settlement Agreement between California American Water, NOAA Fisheries, and the California Department of Fish and Game to further reduce the impact of Cal-Am's operations in the Carmel River on steelhead and their habitat.

## III. <u>AQUIFER STORAGE AND RECOVERY (ASR)</u>

Q8. What are your responsibilities in relation to the ASR Project?

A8. My responsibilities focus on planning level efforts for an expansion of the existing ASR Project and I also help prepare, coordinate, and submit grant applications to request funds to implement this project. Planning level efforts for the ASR project include investigation of Cal-Am system limitations to an expansion of ASR and identifying potential improvements to expand the ASR project. In particular, I have worked with Joe Oliver, the Water Resources Manager, to focus on the limitations of the Segunda pipeline, the Cal-Am Carmel Valley facilities, and overall limitations of the Cal-Am system to provide flow from Carmel Valley to the ASR project. In addition, I have coordinated MPWMD efforts to prepare and I have filed grant applications to secure grant funds to expand the ASR project. The ASR Phase 1 Project (Water Project 1) received a small grant ($50,000) in 2006 from the IRWM grant program and the second phase of the project (Water Project 2) was one of the highest ranked projects in a subsequent grant application to the Department of Water Resources for $6 million from Proposition 84 bond funds for project implementation. The ASR portion of the grant request was $1.7 million. The 2011 grant request was not approved by DWR (note: the IRWM grant program has limited funds and includes a competitive selection process within the Central Coast hydrologic region that compares the quality of proposals submitted by six different regions eligible to receive funds. The Central Coast region is among the most competitive regions in the state. As shown in Exhibit DF-15, I estimate that over the next several years approximately 10% (112 hours) of the time I spend annually on the Mitigation Program will be required to continue these efforts to expand ASR.

## IV. <u>RIPARIAN MITIGATION #2 AND #3</u>

These two mitigation measures include preparing and overseeing the Riparian Corridor Management Plan (#2) and implementing the plan (#3). The two measures require a coordinated and comprehensive approach among staff in the Planning and Engineering Division and in the Water Resources Division to manage and improve on several of the District's programs that existed in 1990 to address the effects of diversions on the riparian corridor of the Carmel River. The RCMP focuses on the lower 15.5 miles of the river from the lagoon at River Mile (RM, measured from the Pacific Ocean) zero to Camp Steffani at RM 15.5 (a copy of the "Carmel River mileage survey" is shown in Table 1 of Exhibit LH1). Several MPWMD Carmel River-related programs conducted throughout the 1980s became part of the Mitigation Program, including the Conservation Program, the Interim Relief Program, the Carmel River Management Program (CRMP), the Irrigation Program, and the Emergency Irrigation Program. The latter three programs (the CRMP and the two irrigation programs) formed the initial basis of the Riparian Corridor Management Program.

Q9. What are your responsibilities to "Prepare and Oversee Riparian Corridor Management Plan" (Riparian Mitigation #2)?

A9. The District Engineer and Riparian Projects Coordinator are responsible for the preparation and oversight of the Riparian Corridor Management Plan (RCMP). The initial basis for the RCMP was the Carmel River Management Plan, which is the planning document for the Carmel River Management Program, the 1986 McNiesh study on the effects of groundwater pumping (see below reference), and MPWMD Rules and Regulations regarding activities within the streamside corridor. The Carmel River Management Program, Irrigation Program, and Emergency Irrigation Program were in place as early as Fiscal Year 1984 to carry out the recommendations contained in the plans and documents that initially made up the RCMP. The programs and their associated activities that were already in place at the time the Mitigation Program was implemented were all subsumed into the Mitigation Program. A detailed description of the basis for the Carmel River Management Program is contained in Exhibit LH-1 BACKGROUND – CARMEL RIVER MANAGEMENT PROGRAM. However, since 1990, management of the Carmel River has evolved considerably in response to changes in government regulations and policies and now relies on several documents and standards developed between 1984 and 2007 including:

1. Carmel River Management Plan (MPWMD, 1984);
2. Effects of Production Well Pumping on Plant Water Stress in the Riparian Corridor of the lower Carmel Valley (McNiesh, 1986);
3. MPWMD Rules and Regulations (primarily Rules 10 and 11 and Regulation XII);
4. Carmel River Lagoon Enhancement Plan, (State Parks et al, 1992);
5. U.S. Army Regional General Permit 24460S" (MPWMD, 2004)
6. Guidelines for Vegetation Management and Removal of Deleterious Materials for the Carmel River Riparian Corridor (MPWMD, 2004);
7. Clean Water Act Section 401 Water Quality Certification (Regional Water Quality Control Board, 2004)
8. Programmatic biological opinion 151422SWR00SR247 (National Marine Fisheries Service, 2004)
9. Biological opinion 1-3-F-45 (US Fish and Wildlife Service, 2004);
10. Study Plan for Long Term Adaptive Management of the Carmel River State Beach and Lagoon (MPWMD, 2007).

The standards and requirements contained in these documents are, in effect, the Riparian Corridor Management Plan for the Carmel River. Initially, the RCMP purpose was to coordinate the many riparian mitigation activities that MPWMD was carrying out along the river so that they could be effectively and efficiently implemented. MPWMD has found that the RCMP requires frequent requires revisions and additions due to changes in government regulations and policy, how those policies are applied (frequent personnel changes at regulatory agencies can precipitate changes in how policies are applied), and improved methods for river restoration activities.

The focus of the RCMP has changed over time as a result of changes in the river itself and changes in Cal-Am operations. In 1984, the Carmel River Management Plan identified more than eight miles of the river between about RM 5 and RM 15 that required intensive channel restoration work. In 1991, when the Mitigation Program began, the focus of the RCMP was on intensive restoration efforts in the reach of the river between RM 5 and RM 10 and between RM 12 and RM 13. Because of changes in Cal-Am operations as required under Riparian Mitigation #1 "Conservation and Water Distribution Management to Retain Water in River" (please see the Direct Testimony of Kevan Urquhart for an explanation of this mitigation measure), and the completion of many restoration projects in the 10-mile reach between RM 5 and RM 15, the focus of the RCMP now is in maintaining previously completed projects and focusing on restoration and protection of the lower fiver miles of the river where Cal-Am now concentrates its diversions.

In cooperation with the Riparian Projects Coordinator, my responsibilities include development of new or revised standards, methods, and approaches to managing the riparian corridor in response to these changes. Also in cooperation with the Riparian Projects Coordinator, I am responsible for obtaining programmatic authorizations to carry out the RCMP from several regulatory and advisory agencies with jurisdiction over the Carmel River (note: in addition to programmatic authorizations, individual permits are required for specific projects).

Because of the unique character and resources of the Carmel River, the degradation that has occurred to the river over the past several decades, and the intense interest and scrutiny of actions in the river by federal and state regulators, obtaining programmatic state and federal authorizations to carry out mitigation measures along the river can take a significant amount of labor. For example, between 1999 and 2004 MPWMD staff expended an estimated 1,250 hours and another $32,000 for outside consultant services to work with federal agencies to obtain Regional General Permit (RGP) 24460S from the U.S. Army Corps of Engineers for routine maintenance and restoration projects along the river. This RGP basically allows MPWMD to carry out the activities required under the

Mitigation Program. During the five-year period it took to obtain the RGP, I estimate that I spent nearly 1,000 hours of the total amount of staff hours to obtain the RGP, which must be renewed every five years. In addition to federal authorization, MPWMD also negotiates programmatic authorizations from two state agencies (California Department of Fish and Game and the Regional Water Quality Control Board). Looking forward to the next several years, during which MPWMD will need to continue to carry out mitigation measures in the channel of the river, the level of effort to obtain such authorizations may be as significant as past efforts have been and may take an average of as much as 80 hours of time annually for the District Engineer to maintain and secure these authorizations (please see Direct Testimony of Thomas Christensen for an estimate of the hours spent by the Riparian Projects Coordinator on these tasks).

Q10. What are your responsibilities for "Implement Riparian Corridor Management Program" (Riparian Mitigation #3)?

A10. I am responsible for carrying out the portion of the Carmel River Management Program (CRMP) that involves work to restore the physical alignment and stability of the Carmel River channel and streambanks to the condition that existed prior to increased Carmel River diversions (i.e., prior to the 1960s). A list of the CRMP activities I am responsible for is shown at the end of this answer.

I also supervise several MPWMD staff with responsibilities for implementing the portions of the RCMP associated with management, preservation, and enhancement of the riparian vegetation along the river that is integral to the restoration of the streamside corridor and dynamic stability of the Carmel River. The hours I spend supervising this staff is included as a portion of the time allocated for Management and Support staff as shown in Exhibit DF-13. Below is a discussion of my involvement in the Carmel River Management Program.

**Carmel River Management Program**

I am responsible for implementation of the Carmel River Management Program (CRMP), which began in 1984. The goals established for the CRMP were: 1) to coordinate private and publicly sponsored streambank stabilization projects implemented in response to widespread bank erosion; 2) restore streamside vegetation; and 3) enhance fisheries habitat. My direct involvement is with design and implementation of projects to attain these goals. I also coordinate with other MPWMD staff, such as the Riparian Projects Coordinator and the Senior Fisheries Biologist, to complete projects, monitor physical changes to these projects and evaluate their effectiveness.

The CRMP identified that more than eight miles of the river between about RM 5 and RM 15.5 required intensive restoration and management work. The CRMP was an existing MPWMD program in 1990 and is specifically referenced in the Mitigation Program on page 21 and in Riparian Mitigation #3 on page 30. The CRMP is intended to be carried out "...annually until a new water supply project that provides improved streamflow conditions is developed" (Mitigation Program p. 31). A description of the Carmel River Management Program history, including the reasons for implementing the program, specific tasks to accomplish program goals, and some of the results of the program are contained in Exhibit LH-1 BACKGROUND – CARMEL RIVER MANAGEMENT PROGRAM.

The CRMP came about as a result of extensive research by MPWMD and its consultants into the reasons for rapid and widespread degradation along the Carmel River streamside corridor during the late 1970s and early 1980s. It was determined that the river had been relatively stable for several decades prior to degrading and that increased demand for water on the Monterey Peninsula beginning in the mid-1960s resulted in an increase in Cal-Am diversions along the Carmel River in order to satisfy this demand. This increase led to an unprecedented episode of loss of streamside vegetation, streambank erosion, and degradation of the Carmel River streamside corridor between 1978 and 1983.

MPWMD Rules 120 through 127, which were adopted in 1983 under Regulation XII, established a riparian corridor along the lower 15.5 miles of the river, codified the rules concerning activities within that corridor, and required the development and promulgation of standards to prevent further degradation of the streamside corridor, restore degraded areas, and to preserve those areas that had not been impacted by Carmel River diversions. Between 1978 and 1983, the uncoordinated and often hasty responses of individual river front property owners to streambank erosion exacerbated the degradation. In order to As a result, MPWMD developed a set of rules and standards that require property owners to obtain a valid River Work Permit in order to carry out alterations within the streamside corridor. For those property owners who request help and as staff time allows, MPWMD provides technical assistance that includes on-site inspections, design recommendations, assistance with permit acquisition, and assistance with revegetation efforts. Because MPWMD has gained a significant amount of expertise with these types of projects, this type of assistance has been instrumental in the long-term success of bank restoration projects.

The link between Cal-Am's Carmel River diversions and effects on the streamside corridor was confirmed in both the 1990 Water Allocation Program Final Environmental Impact Report and the adopted Mitigation Program and in SWRCB Order 95-10. Both of these decision documents include continuation of the CRMP as a mitigation measure for Carmel River diversions. More recently, with continued erosion along the lower five miles of the river, it is clear that shifting and concentrating Cal-Am's diversions into the lower river has caused portions of the streambanks along this reach to become unstable, despite MPWMD efforts to mitigate for water diversions in this reach.

Methods to accomplish the program goals include regulation and coordination of activities within the streamside corridor (MPWMD Rules 120 to 127), restoration and maintenance of stable channel geometry, revegetation of streamside areas, extensive irrigation along the riparian corridor, selective in-channel vegetation management, extensive monitoring of MPWMD-sponsored projects, and surveys of the lower 15.5 miles of the river (photographic and topographic). Although not a specific activity or task within the CRMP, conjunctive use management of the surface and groundwater resources of Carmel Valley Aquifer has also proved to be an important tool in encouraging a natural recovery of portions of the streamside corridor (see Direct Testimony of Kevan Urquhart under Riparian Mitigation #1.

CRMP tasks include outreach, education, and providing technical assistance to riverfront property owners and other stakeholders; direct oversight of MPWMD-sponsored projects to restore and enhance the Carmel River; and coordinating design, review, construction, and inspection of non-MPWMD sponsored projects along the Carmel River.

Priorities for restoration work are developed in cooperation with the Carmel River Advisory Committee, which is a standing committee of the Water Management District that advises the Board of Directors concerning Carmel River management, and are presented to the MPWMD Board of Directors for approval. Most of the tasks associated with channel restoration projects are normally carried out by MPWMD staff, except operation of heavy construction equipment (e.g., bulldozers, loaders, excavators, backhoes, transport trucks, etc.), which is contracted out to the private sector. Tasks that MPWMD staff are responsible for include: initial problem assessment; development of preliminary and final designs; securing right-of-way agreements; securing funds for restoration projects; preparing environmental review and compliance documents; acquiring permits; preparing bid documents; managing construction contracts and on site construction activities; inspecting construction projects; monitoring and reporting.

MPWMD has designed, managed, inspected, and continues to monitor many stream restoration projects along the Carmel River.

Monitoring of the river includes studies about the condition of and changes to the channel and banks of the Carmel River between the ocean and the upstream limit of the Los Padres Reservoir at approximately RM 27. This includes topographic surveys, substrate analysis, maintaining a photographic record, and periodic inspections of the river. MPWMD also assesses problem areas and annually inspects the lower 15.5 miles of the river for erosion hazards.

MPWMD enforces the riparian corridor rules under a protocol that includes progressive actions by the agency to gain compliance. Most infractions are resolved by meeting with property owners on site, following up in writing with a River Work Permit for restorative actions, and inspecting the site for compliance with the conditions issued with a permit. However, difficult cases have required a lengthy involvement by MWPMD staff and District Counsel that have included actions in Superior Court to resolve infractions and follow-up actions by MPWMD to ensure enforcement of MPWMD rules.

Prior to 1984, repairs to public infrastructure and private property were not funded either by Cal-Am or by funds collected from users connected to the Cal-Am system. Instead, each property owner or responsible agency with property damage was required to fund repairs. A limited amount of funds were made available through a federal program for areas where structures were in imminent danger of falling into the river. Records show that there were only three federally funded restoration projects between 1978 and 1980 (near Garland Park, near Schulte Bridge, and at Via Mallorca Bridge). Since 1984, the cost for stabilizing and restoring the streamside corridor and for implementing the CRMP has been shared between river front property owners and Cal-Am users. Although there is a clear link between Cal-Am diversions and channel instability, funds collected for streambank restoration have not been adequate to fully address all areas of erosion along the river. In particular, a substantial amount of bank restoration work carried out in the mid-1990s in the lower five miles of the river was funded by river front property owners, with oversight and some technical assistance provided by MPWMD through the CRMP.

A list of tasks and estimated hours per staff member for implementing the Carmel River Management Program is as follows:

1. Restoration Project Design and Implementation

a) conduct comprehensive monitoring of the physical condition of the Carmel River including carrying out topographic surveys, substrate analysis, and maintaining a photographic record;

b) conduct assessment of problem areas, including inspections for erosion hazards;

c) conduct outreach, education, and present proposed projects to riverfront property owners and other stakeholders;

d) develop priorities for restoration work in cooperation with the Carmel River Advisory Committee; make recommendations to the MPWMD District Engineer and Board of Directors concerning project priorities;

e) develop preliminary and final designs, including using computer simulations as necessary;

f) secure right-of-way agreements;

g) secure funds for restoration projects;

h) prepare environmental review and compliance documents; acquire permits;

i) prepare bid documents; manage construction contracts and on-site construction activities; inspect construction projects;

j) design and implement revegetation plans, including installation of irrigation systems;

k) monitor projects and complete project reports.

2. Provide technical assistance to riverfront property owners

a) respond to erosion and streambank damage by conducting site assessments and making recommendations concerning streambank design and revegetation;

b) coordinate projects between property owners;

c) review and comment on project designs;

d) provide assistance with permit acquisition;

e) issue River Work Permits;

f) provide on-site expertise and technical assistance during construction, including assistance with revegetation and installation of irrigation systems.

3. Monitor physical changes along the Carmel River

a) conduct annual assessments for erosion hazards:

b) conduct periodic photo monitoring along the Carmel River, including photo documentation of MPWMD and non-MPWMD restoration projects; evaluate annual Carmel River aerial photographs for changes to the environment;

c) conduct periodic surveys of channel substrate, cross-sections, and thalweg profiles.

4. Complete portions of the Annual Mitigation Program Report

The tasks listed above are carried out by the following staff: Riparian Projects Coordinator (please see Direct Testimony of Thomas Christensen for an estimate of the hours that this position spends on these activities), District Engineer (400 hours), River Maintenance Specialist (approximately 100 hours), and River Maintenance Worker (approximately 100 hours). Note that during construction of restoration projects, the Senior Fisheries Biologist, Associate Fisheries Biologist, Assistant Fisheries Biologists and temporary field personnel may be required periodically to be on site to carry out measures required to reduce potential impacts to CRLF and steelhead. Their hours are described under the Fisheries Program (see Direct Testimony of Kevan Urquhart). Many tasks also involve a significant level of other staff support, including District Counsel, to carry out this portion of the Mitigation Program.

## V. <u>LAGOON MITIGATION #1, 2 AND #3</u>

Q11. What are your responsibilities for "Lagoon enhancement plan investigations" (Lagoon Mitigation #1)?

A11. I am involved in several of the recommended projects in the Lagoon Enhancement Plan. The lagoon and barrier beach are part of the Carmel River State Beach administered by the California Department of Parks and Recreation (State Parks). The Carmel River lagoon, located at the mouth of the Carmel River, is a seasonally brackish shallow lagoon perched a few feet above mean low low tide. The lagoon provides important habitat for feeding, rearing, and acclimatization of steelhead migrating to and from the ocean and can support several thousand steelhead during the dry season. California red-legged frogs have also been found in fringe areas of the lagoon. The lagoon forms in the lower one-half mile of the watershed when ocean tides block the mouth of the river with sand and form a "barrier beach" of approximately 800 feet across the mouth of the river.

When the Mitigation Program was adopted in 1990, a Lagoon Enhancement Plan was being developed. At the time, MPWMD participated in completing this plan, which consisted of several independent recommended projects. These were:

1) excavation of 2,000 lineal feet of the south arm;
2) creation of a 10-acre wetland around the south arm;
3) restoration of a riparian forest west of Highway 1; and
4) removal of the levee south of the river and west of Highway 1.

Other alternatives considered included:

5) a south bank flood by-pass channel;
6) a levee or floodwall along the northern portion of the lagoon and Scenic Road to protect low-lying homes and infrastructure; and
7) a north bank overflow channel to increase scouring flows toward the northern portion of the lagoon.

To date, projects 1 through 4 have been completed by State Parks. The other components of the plan continue to be pursued by MPWMD and other local agencies and non-profit organizations. The lagoon and State Beach is currently managed in part on a cooperative basis by the Lagoon Technical Advisory Committee (TAC), which is comprised of State Parks staff, plus other technical staff from local, state and federal agencies with functional responsibilities related to the Beach and Lagoon. MPWMD has facilitated meetings of this group between 2006 and 2011 and provides technical expertise on water quality and quantity.

In addition, MPWMD provides technical assistance to the Carmel River Watershed Conservancy (CRWC) and the Monterey County Water Resources Agency (MCWRA) for a project to study the feasibility of installing a barrier to protect homes and infrastructure on the north side of the lagoon (project 6 above). A barrier would also potentially result in a greater volume of fresh water in the lagoon at the start of the dry season and would reduce impacts to steelhead habitat from barrier beach manipulation in late fall and early winter. A $225,000 feasibility analysis for this project is moving forward and will be partially funded from Prop. 84 IRWM Planning Grant funds secured by MPWMD in 2011. MPWMD will continue to provide technical assistance and seek grant funding for implementation of the project, but the lead agency for this project is MCWRA.

The following is a List of Tasks and Staffing Requirements for Lagoon Mitigation #1:

1. Coordinate with the Lagoon Technical Advisory Committee and other project proponents concerning projects that could affect the lagoon environment.

2. Prepare and give public presentations describing the problems, issues and potential solutions at the lagoon.

3. Provide technical expertise and experience on hydraulic analysis, sediment transport, debris flow, and design issues.

4. Coordinate with project proponents on funding alternatives. Prepare grant applications.

5. Provide hydrologic and hydraulic information regarding lagoon and river inflows and levels.

6. Prepare grant applications.

MPWMD also provides technical assistance and grant coordination to the Big Sur Land Trust (BSLT) and the County of Monterey for project work at Highway 1 and in the floodplain east of Highway 1. MPWMD has entered into a Memorandum of Understanding with BSLT, Monterey County, and State Parks for project work that would reconnect the floodplain areas east and west of Highway 1. This project work would accomplish some of the goals for Lagoon Enhancement Plan projects 5 and 7, which were focused on reducing the need to raise levees north of the river, creating edge habitat within the lagoon and maintaining aquatic habitat in the lagoon with periodic scouring flows.

The tasks listed above are carried out by the District Engineer annually (80 hours) and relies, in part, on information provided by the MPWMD Hydrography Programs Coordinator.

Q12. What are your responsibilities for expanding long-term monitoring at the lagoon (Lagoon Mitigation #2).

A12. This measure consists of monitoring for changes in water quality, streamflow and sediment transport changes, vegetative mapping and soil surveys, and groundwater monitoring. Monitoring for changes in water quality is described in the Direct Testimony of Kevan Urquhart, the Senior Fisheries Biologist. Vegetative mapping and soils surveys are described in the Direct Testimony of Thomas Christensen, Riparian Projects Coordinator.

My responsibility under this measure is to update the stage-volume relationship for the lagoon and to understand the effect of changes in sediment transport delivery to and through the lagoon. The MPWMD Hydrography Programs Coordinator maintains a network of stream gages in the watershed, including gages in the south arm of the lagoon and at Highway 1 that provide real-time stage data at 15-minute intervals through a dial-up system. Surveys to map the entire lagoon were conducted in 1994 and 2007 (not every five years as described in the 1990 Mitigation Program). Table 1 and Figure 1 in Exhibit LH-2 show results of the two mapping surveys of the lagoon. In addition, MPWMD conducts an annual topographic survey of four cross-sections at the mouth of the lagoon to document trends in sediment transport into and through the lagoon. The cross-section data at the mouth indicate considerable variability in sand transport to and through the lagoon. But, these data and the two topographic surveys do not indicate a trend toward either more or less volume as a result of natural variations in sediment delivery. The significant increase in lagoon volume between 1994 and 2007 was due to dredging of the south arm as recommended and implemented as part of the Lagoon Enhancement Plan.

However, at present, the volume of sediment stored in gravels bars and in the active river channel upstream of the lagoon appears to be much less than in the two previous decades. In addition, the streambank stabilization program that began in the mid-1980s has effectively cut off the supply of sediment to the lagoon from streambank erosion. Periodic topographic surveys of the lagoon will be required to determine what effect a reduced supply of sediment has on lagoon volume and the barrier beach. Tasks associated with this mitigation measure and staff hours required are as follows:

1. Lagoon Mapping
    a. Annual Cross-Section Monitoring
    b. Periodic updates to stage-volume relationship (topographic mapping)
2. Lagoon and Highway 1 Stage Monitoring

3. Sediment transport assessment

The tasks listed above are carried out by the following staff: Hydrography Programs Coordinator (approximately 232 hours annually), and District Engineer (approximately 30 hours annually).

Q13. What is your involvement in identifying feasible alternatives to maintain adequate lagoon volume (Lagoon Mitigation #3)?

A13. The purpose of this measure is to determine "...the volume required to keep the lagoon in a stable situation that can adequately support plants and wildlife..." Using the information provided by expanding the long-term monitoring of the lagoon and by documenting changes at the beach and in the lagoon, some progress has been made in understanding and characterizing lagoon processes and in understanding how and when human activities most affect the lagoon. MPWMD has not been able to positively identify what level of inflow would be appropriate throughout the dry season to maintain an adequate volume for steelhead.

Annually, the lagoon goes through four distinct phases. In late spring or early summer when river inflow drops to a very low level, tides block the outlet for the last time with sand and the lagoon fills with fresh water – sometimes to very high level. When inflow drops below about 10 cubic feet per second (cfs), the lagoon water level starts to drop and when inflow ceases, the lagoon drains out through the beach over a period that is normally about six to twelve weeks and then reaches its low point for the dry season. Frequently, waves overtop the beach in late summer or early fall and the lagoon becomes brackish. In some cases, the lagoon can be nearly as saline as the ocean in late fall before the river begins to flow. In early winter, the Carmel River is normally flowing into the lagoon and the beach is breached to avoid local flooding. During the winter and late spring, the lagoon cycles between being nearly empty and nearly full in response to changing river inflows and tidal events.

Stage and inflow data, combined with stage-volume data, indicate that it is likely that a surface inflow of more than five cubic feet per second (cfs), which is about 3.2 million gallons per day, could be required to maintain an adequate volume. It appears that a level of five to six feet of water (all elevations in this discussion are on NGVD 1929) can provide "edge" habitat in vegetated areas and also increase access for aquatic species moving into and out of the south arm of the lagoon.

Lagoon stage varies between about one and ten feet, with the highest recorded level being 12.66 feet during an ocean swell event. When the river flows to the ocean, water levels in the lagoon frequently fluctuate diurnally in response to tidal action. Changes in the water level due to tidal action can be as much as six feet in a single day. When the barrier beach is breached – either naturally or mechanically – the water level can drop as much as nine feet in a few hours. Lagoon volume ranges from a little more than 10 acre-feet (AF) at very low stages to nearly 800 AF at flood stage as shown in Figure 1 in Exhibit LH-2). Aquatic habitat area ranges from as little as five acres at the lowest stage to more than 100 acres when the lagoon is full. Changes in the water level are a function of surface and groundwater inflows, ocean swell and tidal influence, the configuration of the beach and outlet channel, natural breaches of the barrier beach and mechanical or other artificially induced breaches of the barrier beach.

The barrier beach sands are highly porous and allow low outflows (i.e., below about 10 cfs) from the Carmel River watershed to the lagoon to pass through the beach when the lagoon is closed off. Based on daily measurements of inflow and stage changes, I estimate that 8 to 10 cubic feet per second can pass through the beach when the lagoon is full (equivalent to about 5 to 6.5 million gallons per day or MGD). However, inflow data from August 2011 while the lagoon was closed suggest that when the beach across the mouth of the river is narrow, there is an even higher flow rate through the beach (about 13 cfs). When surface and groundwater inflows exceed the porosity of the beach sands, the lagoon stage rises until it overtops the beach naturally or the beach is breached mechanically to avoid flooding of nearby low lying homes and infrastructure. The reverse occurs when inflows to the lagoon from the watershed are less than what can flow through the beach. Lagoon stage drops, the volume of aquatic habitat is reduced, and water quality can degrade. The lagoon typically reaches a low point within six to 12 weeks after final closure in late spring. The time to reach the lowest level depends both on the water level at final closure, the nature of the spring/summer recession of the river, and the volume of upstream diversions.

Between 2006 and 2010, State Parks took actions to increase the volume of the lagoon in the late spring by mechanically closing the lagoon while there is still freshwater surface inflow. This resulted in increased water quality and a higher water level to start the summer period. However, recent cutbacks in the State Parks budget have resulted in a suspension of this activity in 2011.

A significant problem at the lagoon is the seasonal drawdown in summer. This condition occurs as surface and groundwater inflows are reduced below the level that can flow through the beach. Water quality degrades during this period when temperatures increase and organic material and salty water are washed into the lagoon by ocean waves.

During the dry season, both Cal-Am and non-Cal-Am pumpers in the Carmel River Basin reduce the volume of fresh water that would otherwise flow into the lagoon. However, Cal-Am is by far the largest diverter and, historically, dry season daily demand has been as high as about 20 MGD. In recent years, peak Cal-Am production in the summer from the Carmel River Basin has dropped somewhat due to an aggressive water conservation program and the completion of the first phase of ASR, which allows Cal-Am to reduce production from the Carmel River Basin in the dry season. Even with this reduced production level and increases of releases from storage at Los Padres Reservoir, several miles of the lower Carmel River dry up and inflow to the lagoon normally ceases in early summer (this water year is a quite an exception).

Quantifying the effects of upstream diversions at the lagoon is complicated by a lack of knowledge about groundwater inflows (these are not measured) and it appears that successive wet years or successive dry years have considerable carryover effects in watershed baseflow from year to year. For example, recharge of the Carmel Valley Aquifer and subsequent surface flow in the dewatered portion of the river after successive dry years takes considerably more rainfall than after successive wet years. In dry cycles, Cal-Am diversions can exacerbate the problems associated with low lagoon levels by extending the time it takes between the annual low point in stage in August or September and the time the river begins flowing into the lagoon in late fall or early winter. During wet cycles, diversions may have a much more limited effect on the volume of inflow and water quality at the lagoon. Figure 2 in Exhibit LH-2 shows data from 1991 to 2011 concerning lagoon openings, aquifer depletion, and antecedent rainfall at the time of opening. These data confirm that the lagoon opens much later when the aquifer is significantly depleted (e.g., in 1991 and 1992) and much sooner when the aquifer is nearly full on October 1 (e.g., 1999).

Carmel River diversions likely affect lagoon volume and water quality more during the summer and early fall and appear to delay lagoon openings in late fall/early winter. It is apparent that diversions during the summer can dewater the aquifer and extend the time between the annual low point at the lagoon and re-filling by the Carmel River. In addition to water quality effects, when the lagoon drops to a low level, the confluence of the main stem and the south arm can become very shallow. Movement of steelhead in and out of the south arm, which offers some of the deepest habitat in the lagoon, may be affected. Because the lagoon stage normally drops to a very low level for extended periods prior to re-opening, there is an ongoing long-term management goal of finding additional sources of freshwater to maintain a higher lagoon volume throughout the summer and fall.

In early fall, ocean activity typically increases and waves overtop the beach, bringing with them large volumes of organic material and salt water into the lagoon. If there is little or no freshwater inflow, wave overtopping can have significant effects on water quality (e.g., increased salinity). Often, there is no freshwater surface flow to the lagoon for many months and the river may not flow into the lagoon until well after the beginning of the rainy season, normally in October, and after the Carmel Valley Aquifer is fully recharged by runoff after a summer of drawdown.

The extent and quality of habitat at the lagoon is also significantly affected by manipulation of the barrier beach by Monterey County to avoid floods in winter. This activity frequently reduces the habitat available to aquatic species. Additional work at the lagoon to monitor and analyze of the physical processes and changes at the lagoon throughout each season is essential to developing a set of alternatives that will provide an adequate long-term solution to improve lagoon habitat and meet the recommendations of the Lagoon Enhancement Plan.

In 2007, the lagoon TAC concluded that an insufficient body of technical knowledge exists regarding the complex physical interaction of the Beach and Lagoon, and its effect both on beach stability and the threatened fish and other species that use the Lagoon as habitat. The TAC developed an outline for studies to complete a Long Term Adaptive Management Plan (Carmel River Technical Advisory Committee, 2007). The studies include addressing environmental degradation due to mechanical breaching, upstream diversions, and sediment starvation.

The following tasks are carried out by the District Engineer in support of this measure (50 hours annually:

1. Monitor, document, and analyze stage, volume, and inflows to the lagoon.
2. Document and analyze changes in the Carmel River beach condition.

## VI. <u>CHANGES IN THE IMPLEMENTATION OF THE RIPARIAN AND LAGOON MITIGATION MEASURES</u>

Q14. Was the cost estimate for riparian mitigations shown in Exhibit 4 in the 1990 Mitigation Program (p. 25) reasonable?

A14. No. The costs for overseeing the Riparian Corridor Management Plan (Item 2) and implementation of the riparian corridor management program (Item 3) were significantly underestimated for the following reasons:

1) In 1990, when the Mitigation Program began, the processes for authorizing activities under the program were much more streamlined than they are today and the state and federal agencies that authorize projects had far fewer conditions and requirements to meet. For example, in 1992, I was able to call the local CDFG warden, describe what projects MPWMD was proposing for the river, arrange an afternoon meeting at the two project sites and obtain a Stream Alteration Agreement on site upon the conclusion of the field visit for a total of more than 7,500 feet of streambank restoration work along the river. This took a matter of hours. The same project today could take months of preparation and follow-up by MPWMD staff and several months for review through CDFG. In 1991, MPWMD could fill out a two-page permit application to the U.S. Army Corps (Corps), attach a simple project description, consult with federal agencies over the telephone, and expect to have a permit for a project in a matter of months. The listing under the Endangered Species Act of California red-legged frogs in 1995 and steelhead in 1996 have significantly raised the costs of securing permits and carrying out restoration

projects. For example, MPWMD expended about 1,250 hours and $32,000 in consultant costs between 1999 and 2004 to obtain a programmatic permit from the Corps for routine maintenance and restoration projects along the river.

2) One of the premises of the Carmel River Management Plan (developed for the Carmel River Management Program) to restore the river was to use little or no structural protection (such as gabions or rock riprap) and to rely instead on using riparian vegetation that would mature and protect the streambanks during high winter flows. The initial construction cost per foot of river in the early 1990s for this vegetative approach to restoration was in a range of $10-$50 per foot (depending on how much heavy construction equipment was used). It was recognized that this approach was low cost, but carried a relatively high risk of failure during extreme runoff events. The design standard for restoration projects was to provide erosion protection up to a 10-year recurrence interval. Initially (between 1986 and 1993), this approach was successful because winter river flows were relatively low and did not exceed the design standard. However, record high flow events in the mid-1990s caused extensive damage to MWPMD projects and proved that a more robust and significantly more costly approach would be needed that involved installation of structural protection to stabilize streambanks. The actual cost for restoration work using structural protection ranged from $100 to $200 per foot of river restoration or up to about four times more than the most costly approach initially envisioned with the 1990 plan.

3) In 1990, no intensive restoration work involving heavy construction downstream of RM 5.5 was proposed. However, in the early 1990s, this reach was destabilized after a significant amount of vegetation was lost along the streamside corridor. MPWMD has carried out a variety of actions to deal with this condition, including assisting river front property owners with projects, carrying out MPWMD-sponsored streambank restoration projects, installation and irrigation of riparian plantings, and installation of irrigation

systems to benefit existing vegetation. However, this portion of the river continues to be the most unstable along the river.

4) Since the mid-1990s, when measures in SWRCB Order WR 95-10 were implemented, streamflow in many years extends further downstream in the dry season than it did when the Mitigation Program began in 1990. This has resulted in improved habitat downstream of the Narrows and more stable streambanks upstream of RM 5, but additional streamflow in the dry season has also encouraged significant encroachment of vegetation into the active channel. Thus, the limits of the MPWMD vegetation management program have expanded by several miles and the frequency of vegetation management activities have increased over what was envisioned in 1990.

5) Since the adoption of the Mitigation Program in 1990 and in response to requirements under the Endangered Species Act, MPWMD has expanded the scope of mitigation activities associated with restoration projects to include protection of California Red-legged frogs, additional enhancement activities for steelhead, along with additional monitoring and reporting activities.

Q15. Have the Mitigation Program measures described above undergone additional changes since 2001, and if so, why?

A15. Yes. Streamside restoration activities (monitoring, planning, design, and implementation) have focused on the lower five miles of the river, including the lagoon, where effects of water diversions are the most pronounced. MPWMD has also taken the lead in developing the Integrated Regional Water Management Plan, which includes several restoration projects in the lower five miles of the river, as recommended in the Lagoon Enhancement Plan.

Q16. Do you have any concluding remarks about the MPWMD Mitigation Program?

A16. Yes. The Mitigation Program is focused on redressing impacts from Carmel River diversions that have benefitted the Monterey Peninsula. In my opinion, the public trust resources of the Carmel River may be partially recovered and sustained in the future by continuing to implement all aspects of this program. However, there are several other activities outlined below that may be necessary and should be considered in order to maintain the health of the riparian corridor.

**RECOMMENDED ADDITIONAL ACTIVITIES TO BE CONSIDERED FOR MITIGATING THE EFFECTS OF CAW DIVERSIONS ON RIPARIAN VEGETATION AND CHANNEL STABILITY**

1. Evaluate the feasibility of and schedule for using high volume overhead sprinkler irrigation along streambank areas in dewatered reaches. Implement a system for irrigating streambanks at the time a reach is dewatered.

2. Evaluate the feasibility of installing permanent irrigation systems in overbank (floodplain) areas located adjacent to dewatered channel areas. Implement a system for irrigating floodplain areas at the time a reach is dewatered.

3. Calibrate the existing sediment transport model of the Carmel River channel by developing a new digital terrain model (DTM). Compare the 2001 model developed by Mussetter Engineer, Inc. with a new DTM and determine the volume of sediment transported through the system since 2001. Develop channel modifications or a sediment management program to maintain the thalweg and channel bottom elevation in a condition that prevents further damage to public and private infrastructure and the riparian corridor of the Carmel River.

4. Develop an integrated surface and groundwater model for the Carmel Valley Aquifer that evaluates the effects of individual diversions on surface flow and

groundwater in the vicinity of diversions. Coordinate the volume and timing of diversions, irrigation of the riparian corridor, and management of the Carmel River lagoon such that impacts to the environment are minimized.

5. Fund a program to partner with local agencies to seek state and federal grants to purchase lands from willing landowners with riparian or overlying water rights in the Carmel River watershed. Retire water use on these lands.

6. Fund the local share of projects that benefit steelhead and increase the water supply as described in the Monterey Peninsula, Carmel Bay, and South Monterey Bay Integrated Regional Water Management Plan.

7. Carry out studies associated with improving habitat and volume of the Carmel River lagoon as outlined in the "Study Plan for Long Term Management of the Carmel River State Beach and Lagoon" by the Carmel River lagoon Technical Advisory Committee. Implement projects and activities to improve aquatic habitat and volume at the lagoon as recommended after completion of those studies.

## VII. 2009 SETTLEMENT AGREEMENT BETWEEN CALIFORNIA AMERICAN WATER, NOAA FISHERIES, AND CALIFORNIA DEPARTMENT OF FISH AND GAME

Q17. Please describe the Cal-Am 2009 Settlement Agreement.

A17. Beginning July 1, 2009, California American Water paid $3.5 million to the California Department of Fish and Game (CDFG) to establish a fund for projects to improve habitat along the Carmel River for threatened steelhead. Cal-Am will pay $1.1 million each July 1 up to $11.2 million (or until Cal-Am stops illegal Carmel River diversions). CDFG is charged with managing and monitoring the funds.

The agreement established a fund for projects "...to further reduce the impact of CAW's operations in the Carmel River on steelhead and their habitat pending CAW's development of a long-term water supply. CAW agrees that there are further interim measures that will benefit steelhead." The projects to be funded from this settlement are in addition to measures carried out by the MPWMD Mitigation Program.

At a meeting of Carmel River watershed stakeholders on April 14, 2011, Margaret Paul, the CDFG Grant Program Manager for the Settlement Agreement funds, announced that CDFG will no longer accept project applications for funds from this agreement until the following five projects have been fully funded and completed:

1) Sleepy Hollow Ford Removal and Bridge Replacement Project. MPWMD is the lead agency for design and implementation of this project, beginning in 2011-12.

2) Carmel Area Wastewater District Water Augmentation. CAWD is the lead agency for the design and implementation of this project, beginning in 2011.

3) Sleepy Hollow Intake Retrofit. MPWMD is the lead agency for the design and implementation of this project, beginning in 2011.

4) Lagoon Barrier Wall. This is a joint feasibility study with Monterey County Water Resources Agency as the lead in cooperation with the Carmel River Watershed Conservancy and MPWMD. The study will begin in 2011.

5) Old Carmel River Dam Removal. This project is being designed with the San Clemente Dam Removal and Carmel River Reroute Project that is jointly funded by the California Coastal Conservancy and Cal-Am. Implementation (deconstruction of the Old Carmel River Dam) of this project will be funded from Settlement Agreement funds.

This set of projects is likely to take up to five years to complete. CDFG anticipates that most of the $11.2 million in Settlement Agreement funds will be required to fund these projects. If there are funds available after completion of these five projects, CDFG may consider requests for funds to implement additional projects.

Q18. Does this conclude your direct testimony?

A18. Yes it does.

# EXHIBIT LH-1

**BEFORE THE PUBLIC UTILITIES COMMISSION**

**OF THE STATE OF CALIFORNIA**

| | |
|---|---|
| In the Matter of the Application of California-American Water Company (U210W) for an Order Authorizing the Collection and Remittance of the Monterey Peninsula Water Management District User Fee. | A.10-01-012<br>(Filed January 5, 2010) |

**EXHIBIT LH-1**

**BACKGROUND – CARMELRIVER MANAGEMENT PROGRAM**

**BY LARRY M. HAMPSON**

**DISTRICT ENGINEER**

**MONTEREY PENINSULA WATER MANAGEMENT DISTRICT**

__________ **x, 2011**

## BACKGROUND – CARMELRIVER MANAGEMENT PROGRAM

Testimony given by several participants at hearings for State Water Resources Control Board (SWRCB) Order Number WR 95-10[1] and testimony given by the Monterey Peninsula Water Management District (MPWMD) at subsequent hearings for SWRCB WR 2009-0060 described the history of Cal-Am diversions from the Carmel River in detail and the effects of these diversions on CarmelRiver channel stability and vegetation in the streamside (riparian) corridor. To sum up, it was found that annual Cal-Am diversions downstream of River Mile (RM, measured from the ocean) 15.5 (see **Table 1 – Carmel River Mileage Survey** and **Figure 1 – Map and Profile of Alluvial Aquifer**, attached) caused rapid dewatering of the alluvial aquifer and depressed groundwater levels for many months at a time, which led to vegetation stress and mortality. This culminated in an unprecedented episode of erosion between 1978 and 1983 that destabilized the channel and coincided with a dramatic decline of the steelhead population.

This exhibit outlines a brief history of the impacts to the lower 15.5 miles of the Carmel River from California American Water (Cal-Am) diversions; describes the development, funding, and implementation of a comprehensive program in the early 1980s to mitigate for those impacts (the Carmel River Management Program or CRMP); and describes some of the results of the program, which is currently a significant component of the MPWMD Mitigation Program.

**Overview of CarmelRiver morphology**

Historical aerial photographs from the 1930s to the mid-1960s show that after major floods in 1911, 1914, and 1918 and the completion of the San Clemente Dam in 1921, the lower

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[1]See 1992 oral and written testimony of Matt Kondolf, John Williams, and Graham Matthews. See also 1994 oral and written testimony by Larry Hampson.

Carmel River (from the ocean to RM 15.5) had developed in most places into a stable, meandering, single-thread channel fringed on both sides with a dense stand of riparian vegetation.

Riparian vegetation depends directly on access to adequate levels of surface and groundwater to become established and to maintain its health and vigor. Along the CarmelRiver, vigorous, mature streamside vegetation can resist erosion at average winter flow levels (frequent flows) and, when fully mature, may resist erosion during large magnitude flood events. Most of the streambanks along the alluvial section of the river are composed of non-cohesive sands and gravels and are easily eroded during frequent flow events when there is little or no vegetation to protect the streambanks. The presence or absence of healthy vegetation can make the difference between a streambank remaining stable or collapsing during high winter flows. Braided, unstable reaches of the river frequently do not have significant vegetative cover along the streambanks, whereas the more stable, single-thread channel reaches are associated with healthy streamside vegetation. Most of the alluvial section of the CarmelRiver lies in the transition zone between being a braided, unstable channel and a relatively stable, single-threaded channel. Studies conducted in the early 1980s showed that the lower 15 miles of the CarmelRiver is a potentially unstable system where the presence of a continuous corridor of healthy riparian vegetation can make the difference between a narrow, stable channel, and a wide, shifting channel.

Beginning in the mid-1960s, and in response to increased demand for water on the Monterey Peninsula, Cal-Am increased diversions from the well field downstream of San Clemente Dam in the Carmel Valley Aquifer. In addition, repair work at the base of San Clemente Dam reduced the amount of flow that leaked under the dam and went downstream, which at times resulted in an estimated flow downstream of the dam of less than 0.5 cfs. Because Cal-Am diverted up to about 15 cfs at the dam, there were extended periods during which most of the lower 15.5 miles went dry during the dry season. Mortality of healthy streamside vegetation between RM 5 and 15.5 culminated in the summer of 1977 after an intense two-year drought that saw groundwater elevations in the Carmel Valley Aquifer drop many feet below the root zone of streamside vegetation. The Marble-Cone fire in August of 1977 swept through the upper watershed burning 90% of the vegetation in its path, including hardwoods in the upper watershed. The intensity of the fire was apparently increased by the drought in 1976-77 and by a substantial amount of ground fuel.[2] In response to fears of streamflow "bulking" due to debris and sediment flow, dead vegetation was removed from portions of the channel prior to the winter of 1977-78 with bulldozers in order to increase channel conveyance in the lower river.

Lack of healthy vegetation compromised streambank stability and the full force of winter flows between 1978 and 1983 transformed the river from a narrow, single-thread channel fringed by a dense riparian forest to a wide, shifting channel nearly devoid of riparian vegetation. Peak flows during this episode did not exceed 10,000 cubic feet per second, or about a 10-year return event, and moderate to severe bank erosion occurred during lower magnitude, more frequent events. This episode of damage to streambanks was unprecedented in scope and magnitude.

**Response to Channel Degradation**

Many riverfront property owners reacted to property losses by dumping or placing erosion protection during emergencies caused by winter flows (for examples, see **Figure 2 through Figure 4**). In many cases, attempts to arrest streambank erosion included haphazard

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[2] Records indicate that a fire in the MillerCanyon fork of the CarmelRiver in 1927 was the fourth largest fire in the LosPadresNational Forest between 1909 and 1990. The MillerCanyon fire of 1927 appears to have been the last major fire upstream of San Clemente Dam prior to the Marble-Cone fire of 1977. U.S. Forest Service practice up until the 1970s was to carry out annual controlled burns in portions of the watershed, but the intensity of the 1976-77 drought probably caused extreme mortality of vegetation in the upper watershed. Also, Keith Vandevere, a former resident of CachaguaValley, reported that a heavy snowfall in 1974 tore off a substantial number of tree limbs that provided ground fuel. Mr. Vandevere said that the Marble-Cone fire was so hot that it ignited crown fires and destroyed hardwood trees in the upper watershed.

installations with a variety of undesirable or ineffectively designed and placed materials including auto bodies, car tires, large wooden "jacks," concrete rubble, plywood, concrete cubes, and poorly constructed gabions. These measures exacerbated the degradation of the river and in those instances where repairs were made in a piecemeal fashion, channel instability problems were often transferred downstream or were exacerbated.

In response to serious degradation of the streamside corridor and a precipitous drop in the numbers of returning adult steelhead, several groups became interested in halting streamside degradation and it was recognized that a more comprehensive approach was needed. MPWMD was asked to develop a plan to restore the river and in 1983, 83% of riverfront property owners along the lower 15.5 miles approved the formation of a benefit assessment zone with a tax for 10 years on lineal riverfront property footage to partially fund a restoration program. With the adoption of Regulation XII (in 1983), MPWMD Rules 120 through 127 codified the management of the streamside corridor and established a Carmel River Management Program. In 1984, MPWMD completed the Carmel River Management Plan that included recommendations and standards to restore the river.

Initial funding for the program was from a User Fee placed on Cal-Am bills, State grants, and from riverfront property assessments. The imposition of a User Fee by MPWMD in 1984 on connections to the Cal-Am system within the MPWMD boundary marked the first time that a fee was imposed on CarmelRiver diversions to mitigate for impacts and it was the first time all water users within the Cal-Am system were asked to fund these activities. However, it was not until the adoption of the MPWMD Water Allocation Program EIR in 1990 that a limit was imposed on diversions. In WRO 95-10, the State Water Resources Control Board confirmed the link between CarmelRiver diversions and impacts to the riparian corridor.

Impacts to vegetation and streambank stability associated with diversions can take many years to become evident and many years to mitigate. For example, during winter flows between 1978 and 1983, about eight miles of the lower 15.5 miles of stream were destabilized.

Most of this occurred between RM 5 and RM 15.5 at flows that did not exceed the 10-year return magnitude. A result of bank erosion upstream of RM 5 between 1978 and 1983 was the deposition of large amounts of sediment into gravel bars along the active channel. These bars migrated and reformed during very high flows, but generally it takes several years for large sediment deposits to translate through the system. For example, large gravel bars deposited between 1978 and 1983 in the active channel in a one-mile reach downstream of Schulte Road did not wash downstream until February 1998 – more than 15 years after they were formed. Episodes of streambank erosion are estimated to have added a total of between about 785,000 to more than one million cubic yards of sediment into the active channel downstream of RM 15.5 between 1978 and 1998[3]. Much of this material would not have entered the system had the vegetation along the streambanks remained healthy.

In the reach downstream of RM 5, the relatively slow migration of these gravel bar deposits, which can cause further instability, was coupled with a directive in the mid-1980s by MPWMD to Cal-Am to shift pumping to downstream wells in AQ3 and AQ4. The shift in pumping to downstream areas improved upstream conditions by extending the length of river that has surface flow. However, the pattern of increased groundwater pumping and subsequent

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[3] Curry and Kondolf (1983) estimated 490,000 cubic meters (641,000 cubic yards or CY) of bank material eroded in 1978 and 1980. Matthews (1987) estimated that 900,000 tons (or about 450,000 CY) of bedload material were stored in gravel bars in the late 1980s. Prior to floods in 1995 and 1998, a substantial portion of this material had either been stabilized or transported into the reach downstream of RM 5. After the 1995 floods, Monterey County submitted a permit application to the Corps of Engineers for emergency work to repair streambanks that described 262,500 CY of excavation in the channel to remove material and 51,400 CY of fill; however, it is unclear whether the excavation included eroded material or if there was a desire to remove gravel bars to increase the capacity of the river. After the 1998 flood, MPWMD (1998) estimated that there was a need for 93,000 cubic yards of fill – mostly downstream of RM 5 – to rebuild streambanks to pre-flood conditions.

channel degradation that occurred between 1978 and 1983 was repeated downstream of RM 5 in the mid-1990's after groundwater pumping and the effects of groundwater extraction were transferred downstream. Extensive bank erosion occurred in this reach between 1995 and 1998. Although the mid-1990's peak flows were much greater than those experienced during the previous episode of erosion, many areas upstream of RM 10, where flow in the summer had been increased after the shift in pumping in the early 1980s, were relatively stable in the mid-1990's. Recently, after more than 25 years of direct and indirect restoration activities, much of the streamside corridor between RM 5 and RM 15.5 shows improved stability. But the reach downstream of RM 5 continues to experience some erosion during frequent flow events.

**Carmel River Management Program**

When the CRMP began in 1983, approximately eight of the 15.5 miles in the lower Carmel River were considered degraded to the point that intensive restoration techniques involving placing structural protection and installing native plantings with heavy construction equipment in the river channel would be needed. The program was envisioned to take 10 years to complete and a portion of the program sunset in 1993 (the benefit assessment on river front properties stopped at that time). By 1993, MPWMD had completed about 25% of the stream restoration work that was recommended in 1983. Although 83% of riverfront property owners had approved of a program to restore the river, MPWMD initially found it difficult to obtain the support of river front property owners to allow work on their properties. This changed in the mid-1990s, when MPWMD was able to demonstrate the effectiveness of the streambank restoration program.

As of 2011, MPWMD had actively restored more than four miles of degraded sections between RM 5 and RM 15.5 (see **Table 2 - MPWMD Carmel River Restoration Projects**). Another four miles upstream of the Narrows improved naturally over a period of several years after MPWMD ordered Cal-Am in the mid-1980s to shift diversions downstream of the Narrows into sub-units AQ3 and AQ4. Maps of stream restoration projects carried out under the CRMP and Mitigation Program are attached as **Figure 5 –Map of Carmel River Channel Restoration**.

The combination of active and passive techniques appears to have been fairly successful in mitigating the effects of diversions upstream of RM 5 and restoring habitat and channel stability (see **Figure 6 - Berwick Restoration Project**). However, areas downstream of RM 5 have been impacted both by the propagation of channel instability that was introduced into the river system between 1978 and 1983 and by the shift in diversions in the mid-1980s to the furthest downstream wells (see **Figure 7 - Rancho Cañada**). In addition, it is clear that some of the potential impacts identified in 1984 from implementing the CRMP have also been realized. These impacts include channel degradation from RM 10 downstream (downcutting into the channel bottom) due to sediment starvation, which reduces aquifer storage and leads to degradation of infrastructure in the active channel, and vegetation encroachment into the active channel. Figure 5 and Figure 6 show periodic thalweg profiles indicating a trend toward degradation. Figures 7 through 12 are photographs showing channel degradation and exposed infrastructure.

Restoration of the streamside corridor has required a significant investment of both public and private resources to repair streambanks and improve streamside habitat. It is unknown how much money private property owners have spent on individual streambank restoration projects along the river since the late 1970's, but as much as one-third of the streambank restoration and armoring work has been carried out as privately-funded projects. Extensive river work was carried out by private property owners between 1978 and 1983 and between 1995 and 1999, approximately 10,000 lineal feet of streambank restoration work was carried out by private property owners at construction costs that ranged between about $100 to $500 per lineal foot of streambank. It is estimated that property owners spent between $2 million to $4 million in repair work during the 1995-99 period.

**Long-Term Effects of Water Diversions**

It should be noted that the 1976-77 drought and subsequent wet period did not result in an episode of erosion in the lower five miles of the river. This was a reach that did not contain Cal-Am production wells prior to the drought. However, in response to the drought of 1976-77, Cal-Am sought permits in 1978 to add four new wells between RM 3 and RM 6. Subsequently, a significant amount of production was shifted to these wells (Cañada, San Carlos, Cypress, and Pearce – see Figure 1). As a result of the 1987-91 drought, when these new wells were operational, a significant die-off of streamside vegetation occurred in the lower 6.5 miles of the river. During the mid-1990s, an episode of erosion occurred between RM 2 and RM 6.5 that was similar to the episode that occurred in the reach upstream after the 1976-77 drought. Essentially, by shifting diversions downstream, the impacts to the streamside corridor from water extraction were also shifted downstream. The need and expenses associated with work to carry out additional restoration projects in the reach downstream of RM 5 were not anticipated in the budget for the original Mitigation Program, but restoration of this reach is clearly consistent with the requirements of the program.

During the 1987-91 period, vegetation upstream of the Narrows (at RM 10) encroached so far into the active channel that MPWMD began a maintenance program to remove vegetation from the bottom of the channel. Since the mid-1990s, when measures in SWRCB Order WR 95-10 were implemented, streamflow in many years extends further downstream in the dry season than it did when the Mitigation Program began in 1990. This has resulted in improved habitat downstream of the Narrows and more stable streambanks upstream of RM 5, but augmentation of streamflow in the dry season from storage at Los Padres Reservoir has also encouraged significant encroachment into the active channel. Thus, the limits of the MPWMD vegetation management program have expanded by several miles over what was needed in 1990.

Secondary or "legacy effects" of water diversions and the response to channel instability includes degradation of the channel bottom (incision into the aquifer) and loss of aquifer storage. Adding structure to the streambanks to resist erosion (see **Figure 8 – Lower Carmel River Streambank Hardening**) has caused river flows to erode the bottom of the channel, instead of the sides (see **Figure 9 and Figure 10 – Lower Carmel River Thalweg Profiles and Figure 11**). This condition is exacerbated by a lack of sediment input from the upper watershed, where sediment is trapped behind both San Clemente Dam and Los Padres Dam. Incision into the lower Carmel River channel deposits has lowered the bottom of the channel and reduced the aquifer storage capacity. If this condition continues, it is possible that further channel instability could occur and be exhibited by collapsing streambanks, avulsion, and a significant increase in fine material in the channel bottom substrate, scour and deposition. Degraded habitat could be exhibited by vegetation stress, mortality, and a lack of diversity in both species and age class.Based on the experiences with dewatering of the river since the mid-1960's, it is reasonable to presume that streambank vegetation in areas near points of diversions will continue to be at risk from a depressed groundwater table and that this can lead to destabilization of streambanks.

## Table 1 – CARMEL RIVER MILEAGE SURVEY

| | Feet Upstream | Miles | Kilometers |
|---|---|---|---|
| **BRIDGES** | | | |
| Highway 1 | 5,780 | 1.09 | 1.76 |
| R.C. Golf Cart Bridge #5 | 11,230 | 2.13 | 3.42 |
| R.C. Golf Cart Bridge #4 | 12,530 | 2.37 | 3.82 |
| R.C. Golf Cart Bridge #3 | 13,450 | 2.55 | 4.10 |
| R.C. Golf Cart Bridge #2 | 14,030 | 2.66 | 4.28 |
| R.C. Golf Cart Bridge #1 | 14,780 | 2.80 | 4.50 |
| Via Mallorca | 17,110 | 3.24 | 5.21 |
| San Carlos | 20,380 | 3.86 | 6.21 |
| Valley Greens | 25,460 | 4.82 | 7.76 |
| C.V.G.C.C. Golf Cart Bridge | 27,430 | 5.20 | 8.36 |
| Schulte | 35,360 | 6.70 | 10.78 |
| Robinson Canyon | 44,680 | 8.46 | 13.62 |
| Randazzo | 53,470 | 10.13 | 16.30 |
| Don Juan | 56,940 | 10.78 | 17.36 |
| Boronda | 66,980 | 12.69 | 20.42 |
| Esquiline | 76,290 | 14.45 | 23.25 |
| Stonepine | 83,330 | 15.78 | 25.40 |
| **CREEKS** | | | |
| Hatton | 7,640 | 1.45 | 2.33 |
| Potrero | 20,510 | 3.88 | 6.25 |
| Robinson Canyon | 42,800 | 8.11 | 13.05 |
| Berwick Canyon | 42,950 | 8.13 | 13.09 |
| Buckeye | 44,750 | 8.48 | 13.64 |
| Coyote Gulch | 48,080 | 9.11 | 14.65 |
| Don Juan | 57,580 | 10.91 | 17.55 |
| Miramonte | 58,760 | 11.13 | 17.91 |
| Las Garzas | 65,910 | 12.48 | 20.09 |
| Hitchcock | 76,950 | 14.57 | 23.45 |
| Klondike Creek | 81,430 | 15.42 | 24.82 |
| Tularcitos | 83,710 | 15.85 | 25.51 |

**Table 1 – (continued) CARMEL RIVER MILEAGE SURVEY**

| MPWMD MONITOR WELLS | Feet Upstream | Miles | Kilometers |
|---|---|---|---|
| State Parks - Beach (Multiple) | 370 | 0.07 | 0.11 |
| State Parks - Wetlands (Multiple) | 1,637 | 0.31 | 0.50 |
| CAWD Observation | 3,432 | 0.65 | 1.05 |
| Odello West - Near CAWD (Multiple) | 3,802 | 0.72 | 1.16 |
| CAWD - Rio Road (Multiple) | 8,712 | 1.65 | 2.66 |
| Clark | 9,187 | 1.74 | 2.80 |
| Rancho Canada West | 11,246 | 2.13 | 3.43 |
| Druid Hills Ranch | 16,421 | 3.11 | 5.01 |
| Rancho Canada East - (Multiple) | 16,500 | 3.13 | 5.03 |
| Via Mallorca | 17,150 | 3.25 | 5.23 |
| Rubin | 18,780 | 3.56 | 5.72 |
| San Carlos- (Multiple) | 19,350 | 3.66 | 5.90 |
| Oppenheimer | 19,900 | 3.77 | 6.07 |
| Brookdale | 20,350 | 3.85 | 6.20 |
| Piezometer | 20,330 | 3.85 | 6.20 |
| Valley Greens | 20,400 | 3.86 | 6.22 |
| Sweeney (Okazaki) | 21,380 | 4.05 | 6.52 |
| Lake Place | 24,700 | 4.68 | 7.53 |
| Cypress | 28,580 | 5.41 | 8.71 |
| Williams North | 28,723 | 5.44 | 8.75 |
| Williams South | 29,430 | 5.57 | 8.97 |
| Vetter | 29,800 | 5.64 | 9.08 |
| Pearce- (Multiple) | 30,000 | 5.68 | 9.14 |
| Bernardi | 30,500 | 5.78 | 9.30 |
| Worth (Templeman) | 31,050 | 5.88 | 9.46 |
| Brown | 31,550 | 5.98 | 9.62 |
| Frumkin | 31,880 | 6.04 | 9.72 |
| Schulte | 34,500 | 6.53 | 10.52 |
| Carmel Valley High School | 35,376 | 6.70 | 10.78 |
| Reimers #1 | 35,482 | 6.72 | 10.81 |
| Mandelman | 38,700 | 7.33 | 11.80 |
| Dick | 39,430 | 7.47 | 12.02 |
| Center Road | 42,330 | 8.02 | 12.90 |
| Mid-valley | 42,330 | 8.02 | 12.90 |
| Carmel Valley Ranch #8 | 44,774 | 8.48 | 13.65 |
| Carmel Valley Ranch #5 | 44,880 | 8.50 | 13.68 |
| Coyote u s | 46,781 | 8.86 | 14.26 |
| Carmel Valley Ranch #1 | 47,203 | 8.94 | 14.39 |
| Hernstadt | 57,400 | 10.87 | 17.50 |
| Kurtz- 2 | 58,880 | 11.15 | 17.95 |
| Boronda | 66,130 | 12.52 | 20.16 |
| Little League #1 | 72,072 | 13.65 | 21.97 |
| Paso Hondo | 73,530 | 13.93 | 22.41 |
| Village Road | 74,300 | 14.07 | 22.65 |
| Via Helechos | 75,400 | 14.28 | 22.98 |

## Table 1 (continued) CARMEL RIVER MILEAGE SURVEY

| | Feet Upstream | Miles | Kilometers |
|---|---|---|---|
| CAL-AM PRODUCTION WELLS | | | |
| Rancho Canada | 16,500 | 3 13 | 5 03 |
| San Carlos | 19,500 | 3 69 | 5 94 |
| Cypress | 28,580 | 5 41 | 8 71 |
| Pearce | 30,000 | 5 68 | 9 14 |
| Schulte | 34,300 | 6 50 | 10 45 |
| Manor | 37,750 | 7 15 | 11 51 |
| Begonia | 41,030 | 7 77 | 12 51 |
| Berwick #7 | 42,600 | 8 07 | 12 98 |
| Berwick #8 | 43,400 | 8 22 | 13 23 |
| Scarlett #6 | 48,040 | 9 10 | 14 64 |
| Stanton (decommissioned) | 50,660 | 9 59 | 15 44 |
| Los Laureles #6 | 57,750 | 10 94 | 17 60 |
| Los Laureles #5 | 58,800 | 11 14 | 17 92 |
| West Garzas | 63,960 | 12 11 | 19 50 |
| Garzas Creek | 66,080 | 12 52 | 20 14 |
| Panetta | 68,210 | 12.92 | 20 79 |
| Robles | 76,290 | 14 45 | 23 25 |
| Russell #4 | 85,550 | 16 20 | 26 08 |
| Russell #2 | 85,800 | 16 25 | 26 15 |
| MISCELLANEOUS | | | |
| CAWD Ocean Outfall Pipeline | 3,550 | 0 67 | 1 08 |
| USGS - Near Carmel | 17,110 | 3 24 | 5 22 |
| USGS - Robles Del Rio | 76,200 | 14 43 | 23 23 |
| Sleepy Hollow Weir | 93,150 | 17 64 | 28 39 |
| Old Carmel Dam | 96,460 | 18 27 | 29 40 |
| San Clemente Dam | 98,270 | 18 61 | 29 95 |
| Los Padres Dam | 130,940 | 24 80 | 39 91 |

Notes

(1) Measurements for this survey were taken off of aerial photos taken in June 1986 The original photos were flown at a scale of 1 6000 The photos were enlarged by Towill, Inc to a scale of 1:1200 (i e , 1" = 100') A centerline of the river was drawn by District staff from a baseline at the mouth of the Carmel River to approximately 1.5 miles above San Clemente Dam Measurements were made on the Southside of the line noting both miles and kilometers Incremental measurement marks were made every 200 feet on the Southside of the line and at every tenth of a kilometer on the north side of the line Measurements for specific sites were rounded to the nearest ten feet before conversion Conversion factors a) 1 mile = 5,280 feet; b) 1 Kilometer = 3,281 feet

(2) The measurement for Los Padres Dam, 24 8 miles, was taken from the Feasibility Report on Water *Resources Development in the Carmel River, Monterey County, California*, prepared by the U S Army Corps of Engineers in May 1981 Specifically, Volume II, Appendix C, *Hydrology and Hydraulics Analysis*, Section III, *Present Condition Surface Water Hydrology*, Subsection B, *Existing Water Resources Development*, page C-2

Source Original by LS 8/88; revised by DHD 2/2000 and TLL 3/2000, edited by DWF 12/10/2002 and 3/5/2003

**FIGURE 1 - Map and Profile of the Carmel Valley Aquifer**

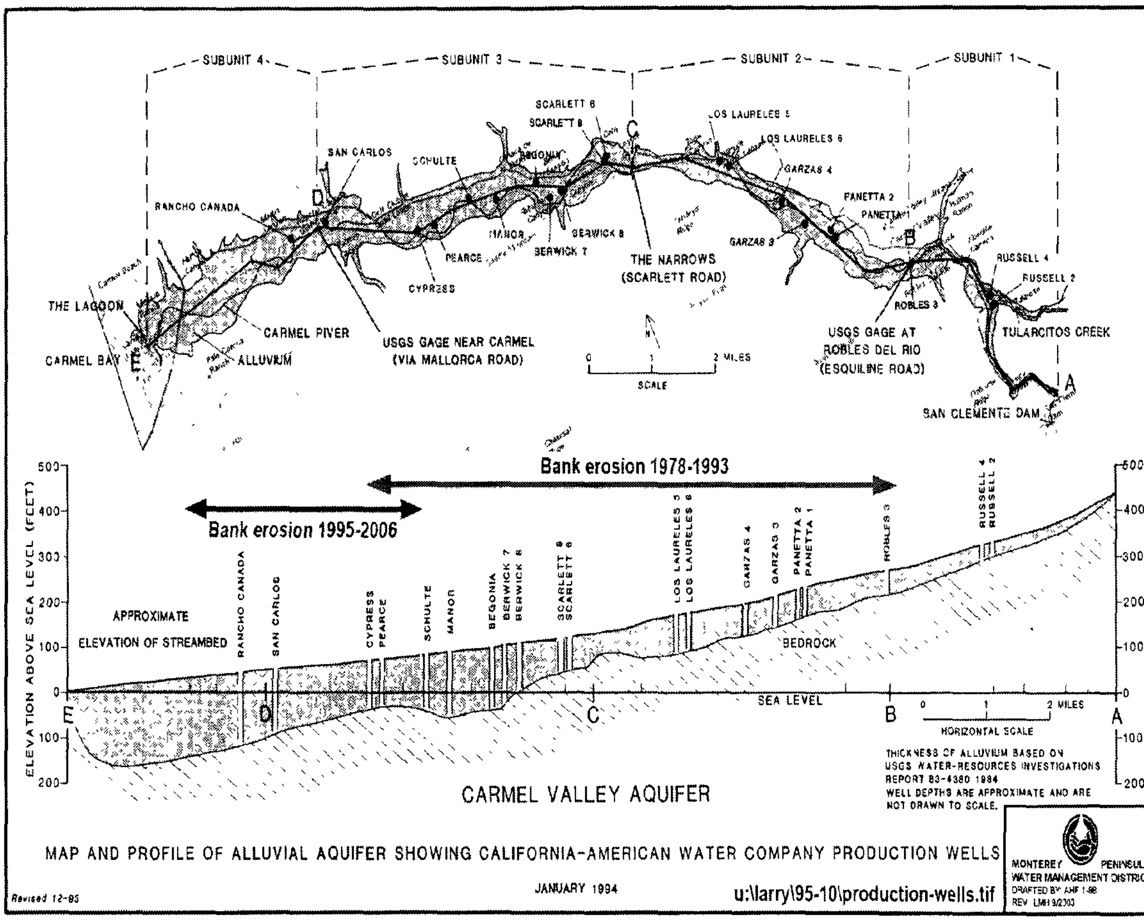
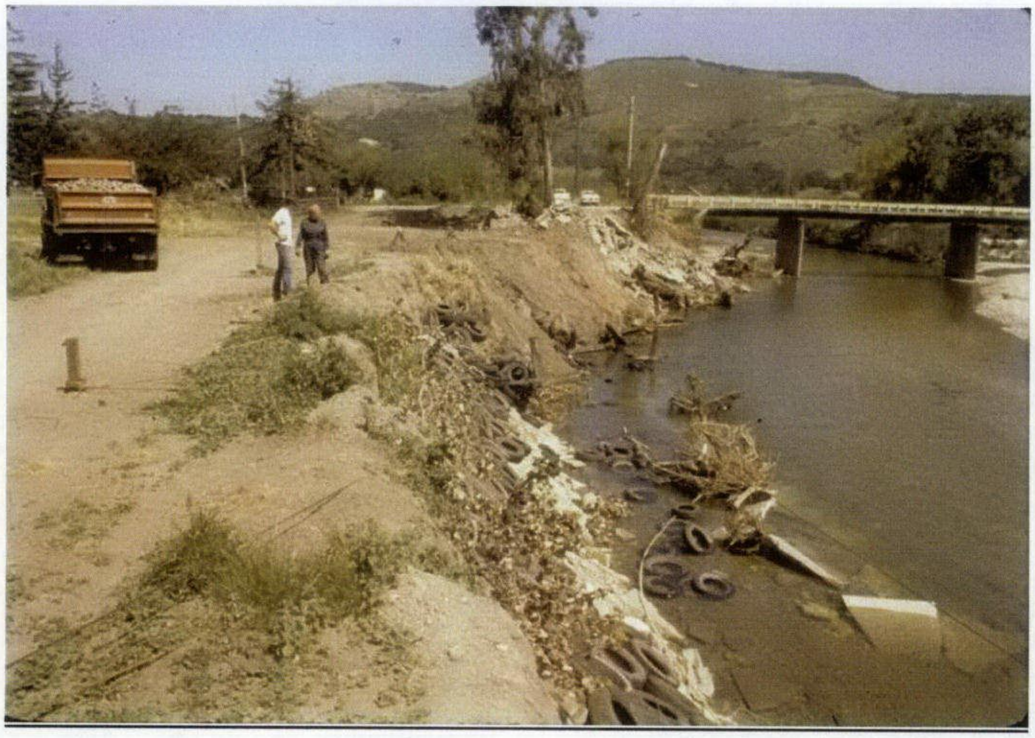


**Figure 2 – Drummond Property**

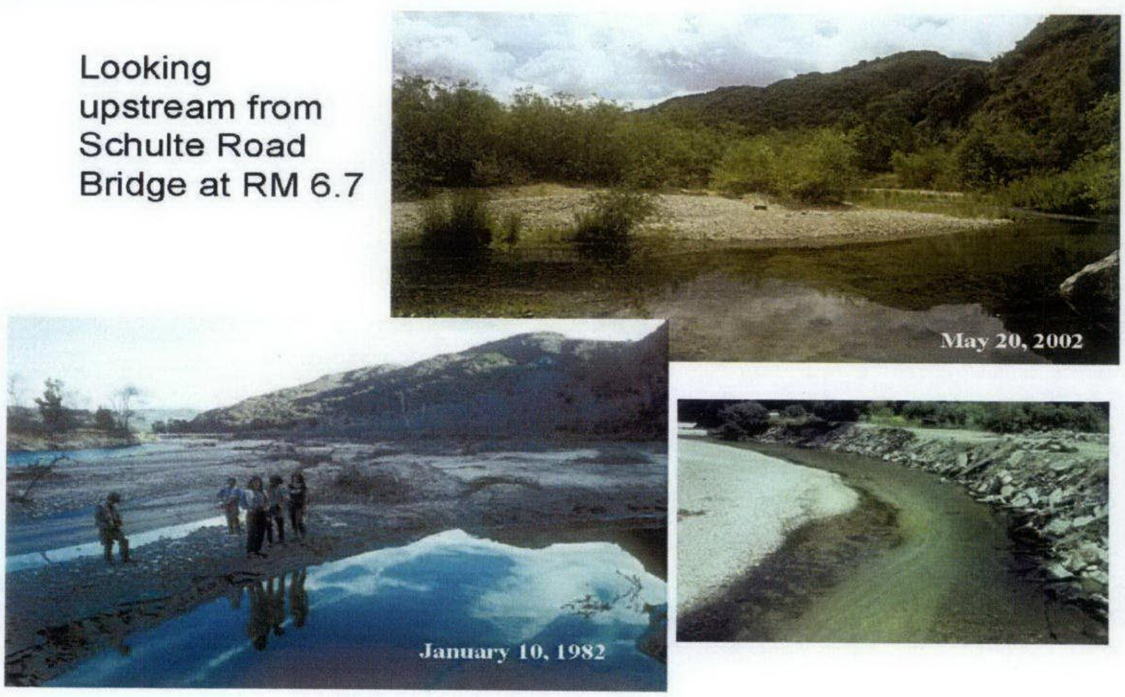
Above – ca spring 1982 – looking upstream along the Carmel River, near River Mile 6 at the remains of a back yard pool that was undermined. Note the use of car tires for streambanks protection (middle background).

**Figure 3 – Schulte Road Bridge Erosion**



MPWMD staff assess the condition of Carmel River streambanks at Schulte Road bridge in May 1982. This property owner dumped car tires and broken concrete onto the streambank in an effort to halt bank erosion.

**Figure 4 – Schulte Restoration Project**



## Table 2- MPWMD Carmel River Restoration Projects

### MPWMD Restoration Project Summary - Alluvial Section (lagoon to Camp Steffani) (revised 06-12-2007)

| Project / Location River mile (from ocean) | Date | Length (lineal ft ) | RSP or structural protection (lineal ft ) | Area (ac ) | No of Properties | Method | Notes |
|---|---|---|---|---|---|---|---|
| Rancho Canada/ RM 2 6 | 1988 | 600 | 0 | 2 8 | 1 | gravel bar relocation/ bank stabilization | construction costs funded by Rancho Canada ($26,000) |
| | | | | | | revegetation | native vegetation + irrigation |
| Hacienda Carmel / 3 3 | Nov '94 | 200 | 200 | 0 9 | 2 | grading/RSP/revegetation/irrigation | 600 tons RSP to repair 1993 levee damage |
| | Jan '95 | 50 | 50 | | | repair | *60 tons rip rap-Jan 10, 1995 flow caused slumping of bank* |
| | Jan 2005 | 400 | 120 | 0 5 | 3 | emergency streambank stabilization | 300 tons of rip-rap in three groins |
| | Apr 2006 | 150 | 150 | 0 5 | 2 | emergency streambank stabilization | 100 tons of RSP placed in between three groins |
| Valley Hills / 5 2 - 5 6 | Aug '92-Nov '92 | *1,500* | *300* | *6 9* | *7* | channel realignment/floodplain restoration/post and wire/vegetation/irrigation | 300' post & wire +1,000 tons rip rap to create a rock grade structure<br>vegetation + irrigation system for more than 3 acres of vegetation |
| | Jan '93 | | | | | vegetation/irrigation | 1500 willow cuttings |
| | Aug '93 | 400 | 400 | | | repair post and wire, add RSP | post & wire repair, rip-rap installed 3 ft up bank |
| | Nov '93 | 500 | 500 | 2 3 | | extended | post & wire + rip rap near Quail lodge maint bld , Last date post and w |
| | Nov '97 | 100 | 100 | | | repairs | 200 tons rip rap stock pile used to repair bank near Cypress Well |
| | *97 '98* | | | | | vegetation | Goals = species diversification in microhabitats |
| Herbert/ RM 5 7 | 1988 | 300 | 0 | 1 4 | 2 | gravel bar relocation/ bank stabilization | large debris jam in center of channel relocated |
| All Saints / 6 | 1995 | 600 | 600 | 2 8 | 5 | emergency streambank repair | streambank repair in cooperation w/ NRCS, MCWRA 4 400 tons rip-ra |
| | *1999* | *1,500* | *1,200* | *6 9* | *19* | *channel realignment/floodplain restoration* | 870 willow cuttings,95 cottonwoods + 99 other plants mult species |
| | | | | | | vegetation/irrigation/large wood | 36 logs installed for steelhead habitat |
| Clark / 6 8 | fall '89 | 250 | 250 | 1 1 | 1 | RSP/vegetation/irrigation | rip rap illegally placed by owner was redesigned, permitted and modifi |
| | early '90 | | | | | | entire slope planted, drip irrigation installed |
| Schulte / 6 7 | 1987 | 3,200 | 3,200 | 14 7 | 9 | channel realignment/floodplain restoration | post & wire, concrete rubble Schulte road bridge vicinity |
| | complete Jan '88 | | | | | vegetation/irrigation | 6 000 willow cuttings |
| | Feb '98 | | | | | repairs | 150 tons of rip rap, '95 damage, Manor Well |
| Red Rock / 7 2-7 7 | Oct - Dec '97 | 1,800 | 1 800 | 8 3 | 16 | channel realignment/floodplain restoration/RSP/vegetation/irrigation | 2 500 tons rip rap |
| | Feb '98 | | | | | repair | 150 tons rip rap, downstream end, by owner |
| | spring '98 | | | | | vegetation | *upstream end, revegetation willows & cottonwoods* |

### MPWMD Restoration Project Summary - Alluvial Section (lagoon to Camp Steffani) (revised 06 12 2007 )

| Project / Location River mile (from ocean) | Date | Length (lineal ft ) | RSP or structural protection (lineal ft ) | Area (ac ) | No of Properties | Method | Notes |
|---|---|---|---|---|---|---|---|
| Berwick / 8 | June, Aug '87 | 800 | 600 | 3 7 | 5 | channel realignment/floodplain restoration/RSP/vegetation/irrigation | concrete rubble + filter cloth |
| | Aug '87 | | | | | | drip irrigation allows for planting in dry season |
| Scarlett / 9 1 | Oct - Dec '89 | 1,800 | 1,000 | 8 3 | 4 | channel realignment/floodplain restoration/RSP/vegetation/irrigation | concrete rubble, filter cloth |
| | Feb '90 | | | | | | first project to use willows along the toe, drip irr '90 '93 |
| | Jan '96 | | | | | repair | rip rap |
| | June '96 | | | | | vegetation | |
| Garland Park/11 | 1985 | 500 | 0 | 2 3 | 1 | first willow trenching project | |
| DeDampierre / 13-14 | Sept '92 | 6,000 | 2,600 | 27 5 | 26 | channel realignment/floodplain restoration/post and wire/vegetation/irrigation | 2,600 ft post & wire<br>10,000 willow & cottonwood cuttings |
| | Sept '93 | 1,000 | 1,000 | | | streambank repair | 1,000 ft post & wire repair |
| | Sept '93 | | | | | vegetation | 4,000 willows and cottonwoods |
| | Nov - Dec '95 | 700 | 700 | 3 2 | 3 | emergency streambank repair | streambank repair in cooperation w/ NRCS, MCWRA 4,400 tons rip r |
| | Oct 2002 | 300 | | | 1 | install five large rock/log deflectors | partially funded with CDFG grant |
| Cozzens / 14 6 | fall '91 | 60 | 60 | 0 3 | 1 | vegetation | first willow mattress- willows laid on the slope every 2 ft extending dov<br>ground water and the lower willow covered with 1-2 ft of channel mater |
| **Subtotal** | | **22,710** | **14,830** | **94 3** | **108** | | |
| Total in miles | | 4 30 | | | | | |
| Average per year (15 years) | | 1,514 | 989 | | | | *Approx 33% of streambanks stabilized w/structural materials* |
| **Other Projects** | | | | | | | |
| Lagoon to Narrows | 1988-1992 | 50,000 | | 229 6 | > 200 | emergency irrigation | 500,000 lin ft of irrigation maintained/operated |
| San Carlos / 4 | 1989 to present | 2,000 | | 9 2 | | vegetation/irrigation | 500' up from San Carlos Bridge<br>*willow transplants in chevron rows i e use vegetation to redirect water* |
| Lemos / 7 5 | ca 1987 | 400 | | 0 7 | 1 | vegetation/irrigation | planting through concrete rubble placed by owner in '83-'84, irrigation provided and maintained by property owner |
| deDampierre/13.5 | October 2003 | 700 | 200 | 3 2 | 1 | fish habitat enhancement | log/rock structures funded by CDFG grant |

Compiled by Jessica Wheeler from MPWMD annual reports, additional comments and editing by Larry Hampson
Last updated June 12, 2007, LMH

Figure 5 – Map of Carmel River Channel Restoration

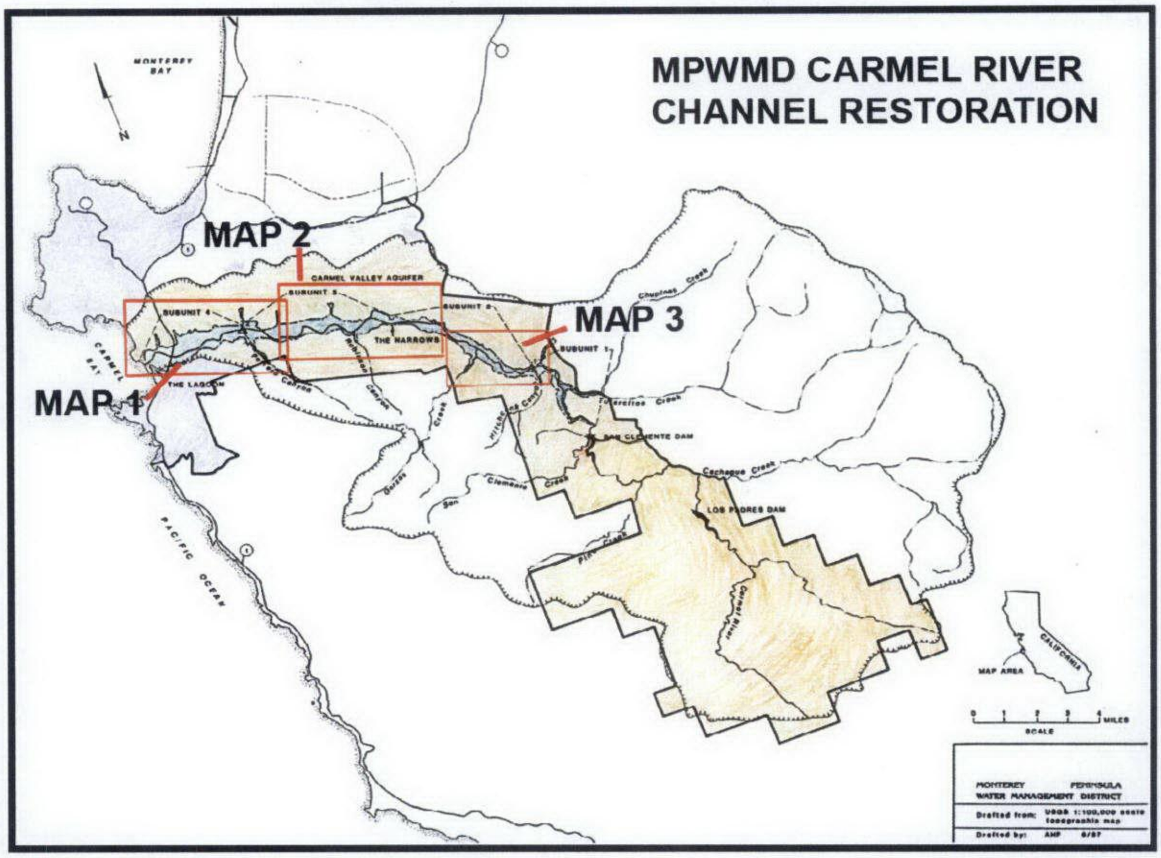
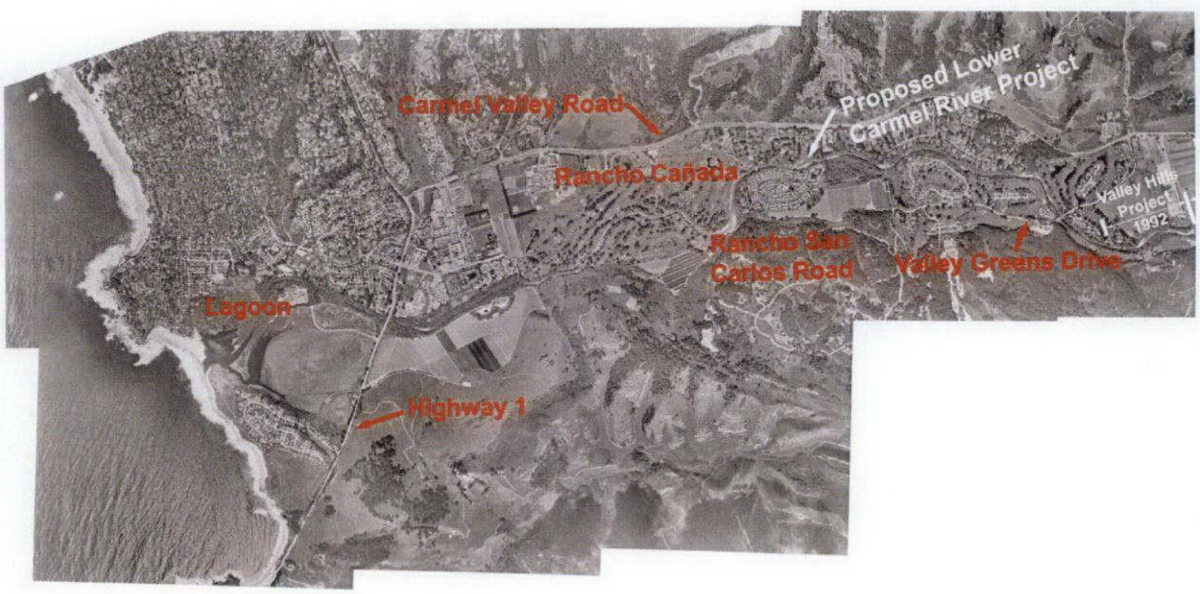
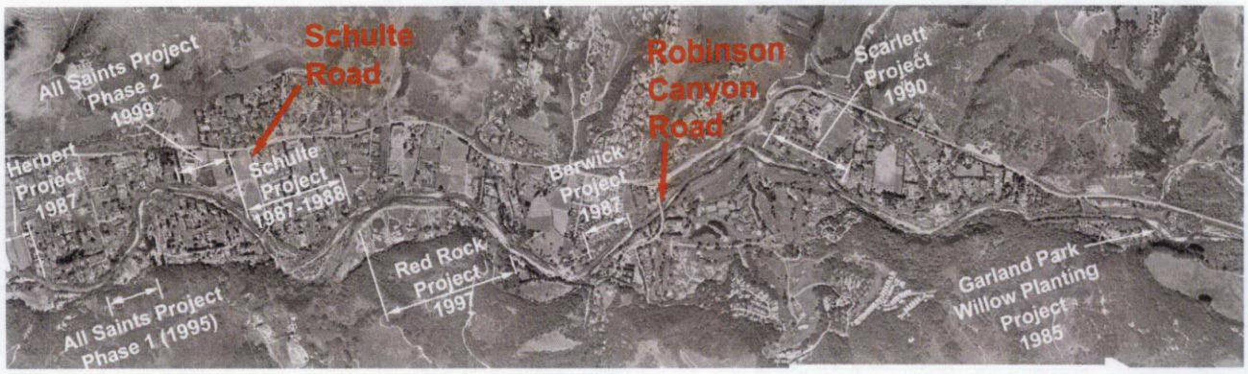



Figure 5 (continued) – Map of Carmel River Channel Restoration



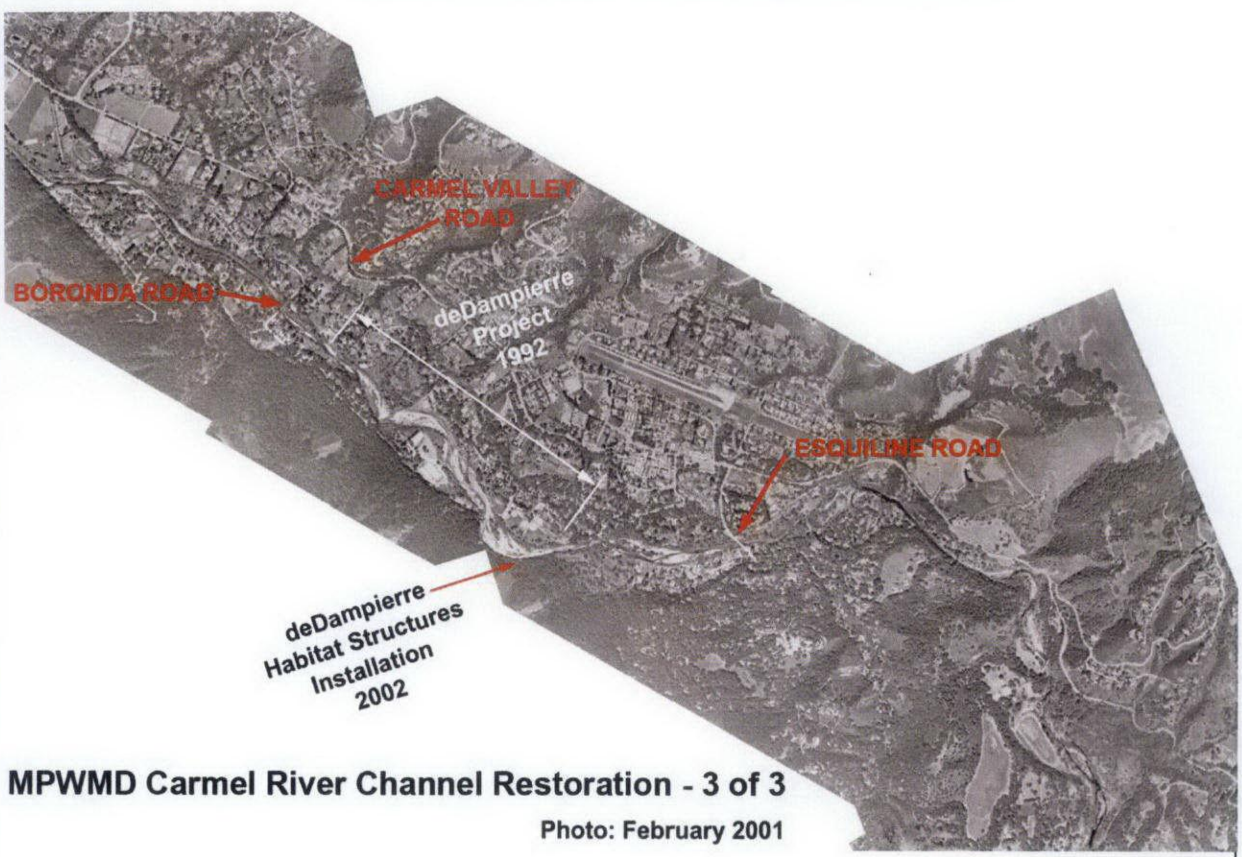

MPWMD Carmel River Channel Restoration - 1 of 3

**Figure 5 (continued) – Map of Carmel River Channel Restoration**




**MPWMD Carmel River Channel Restoration - 2 of 3**

**Figure 5 (continued) – Map of Carmel River Channel Restoration**



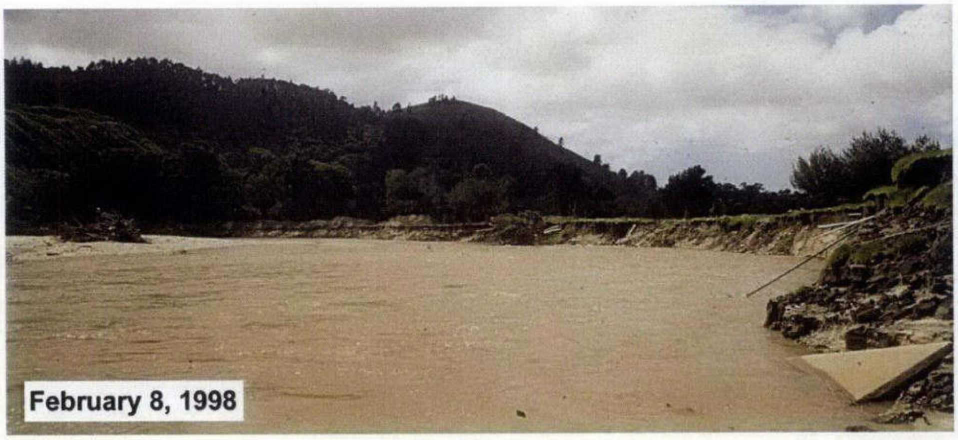

**MPWMD Carmel River Channel Restoration - 3 of 3**

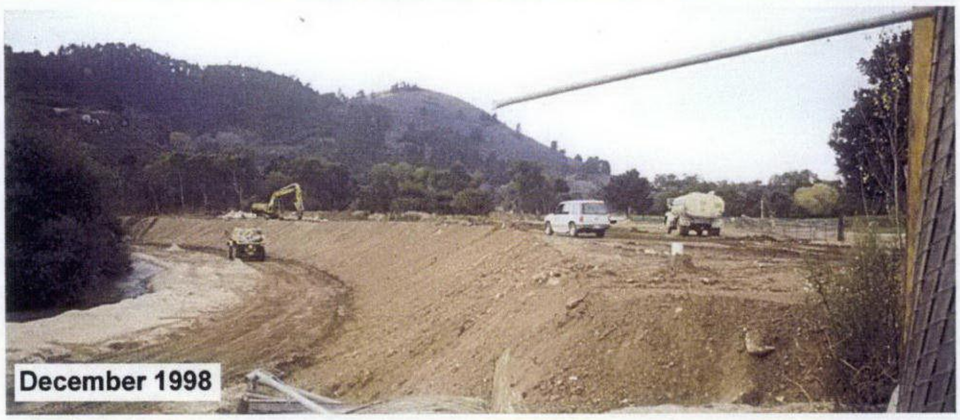
**Photo: February 2001**

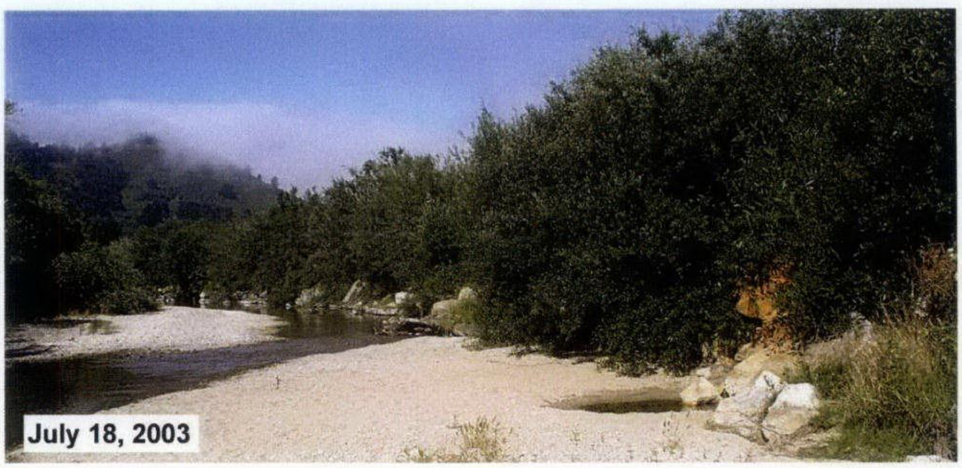
**Figure 6 - Berwick Restoration Project at RM 8.2**


Top – Looking upstream to one of Cal-Am's Berwick wells (shown with arrow) with Robinson Canyon Road bridge in the background. Middle – after stream restoration work was completed. Bottom – 15 years after restoration work was completed.

<u>**Figure 7 – Rancho Cañada**</u>

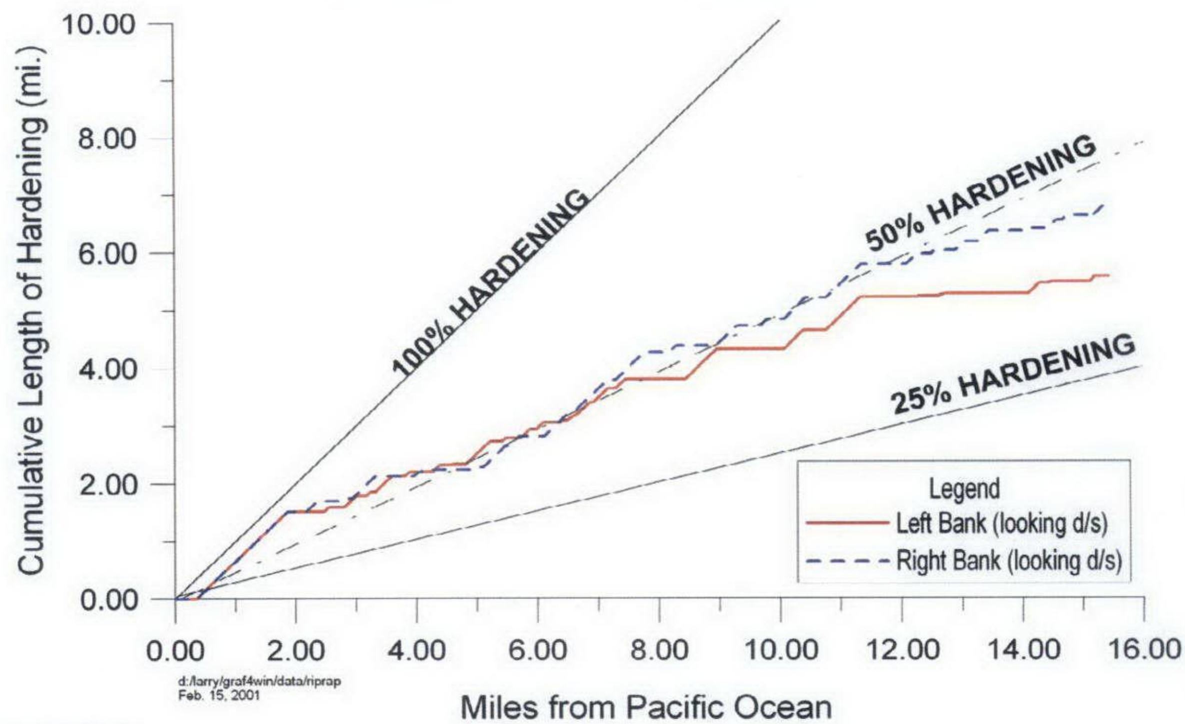


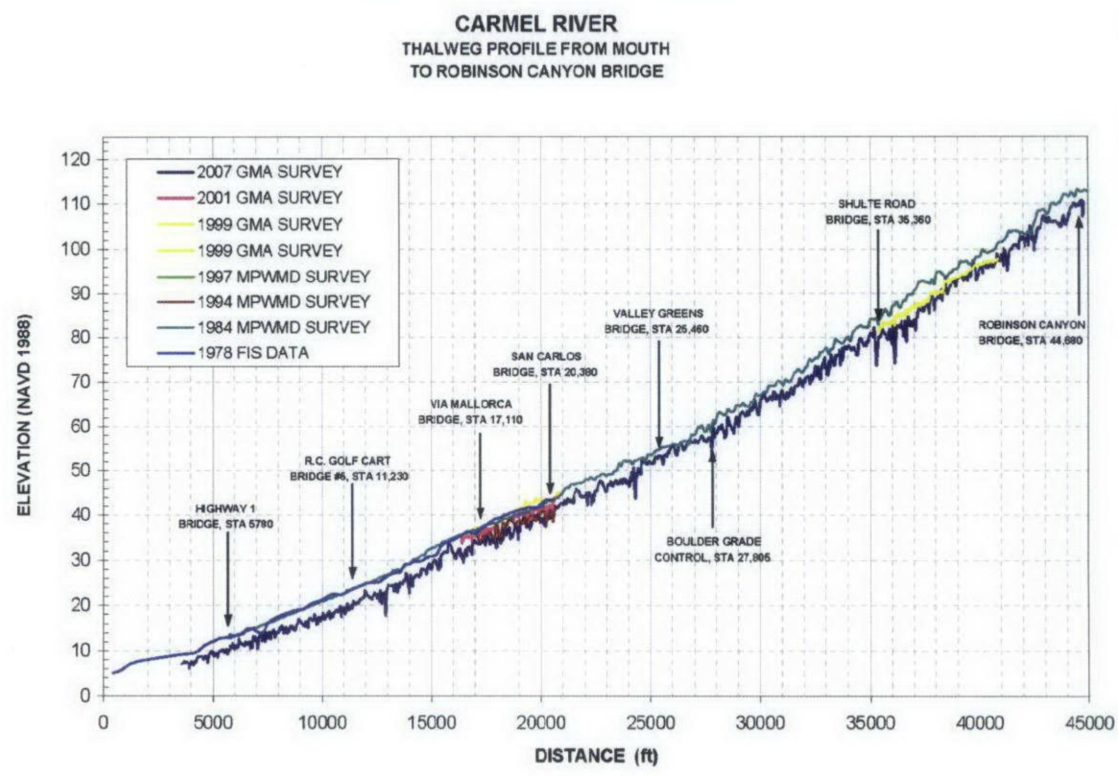

Top – Carmel River, looking downstream at RM 3, adjacent to Cal-Am Cañada well. Middle – during stream restoration work. Bottom – five years after completion of restoration work. Note stained boulders just above the bottom of the channel at the right of picture. This is from well blow-off water that contains iron-loving bacteria.

**Figure 8 – Lower Carmel River Streambank Hardening**




Source: MPWMD

**Figure 9 – Lower Carmel River Thalweg Profiles (1 of 2)**




Source: Matthews, Graham and Associates (February 2008), 2007 Carmel River Surveys, Prepared for Monterey Peninsula Water Management District.

**Figure 10 – Lower Carmel River Thalweg Profiles (2 of 2)**

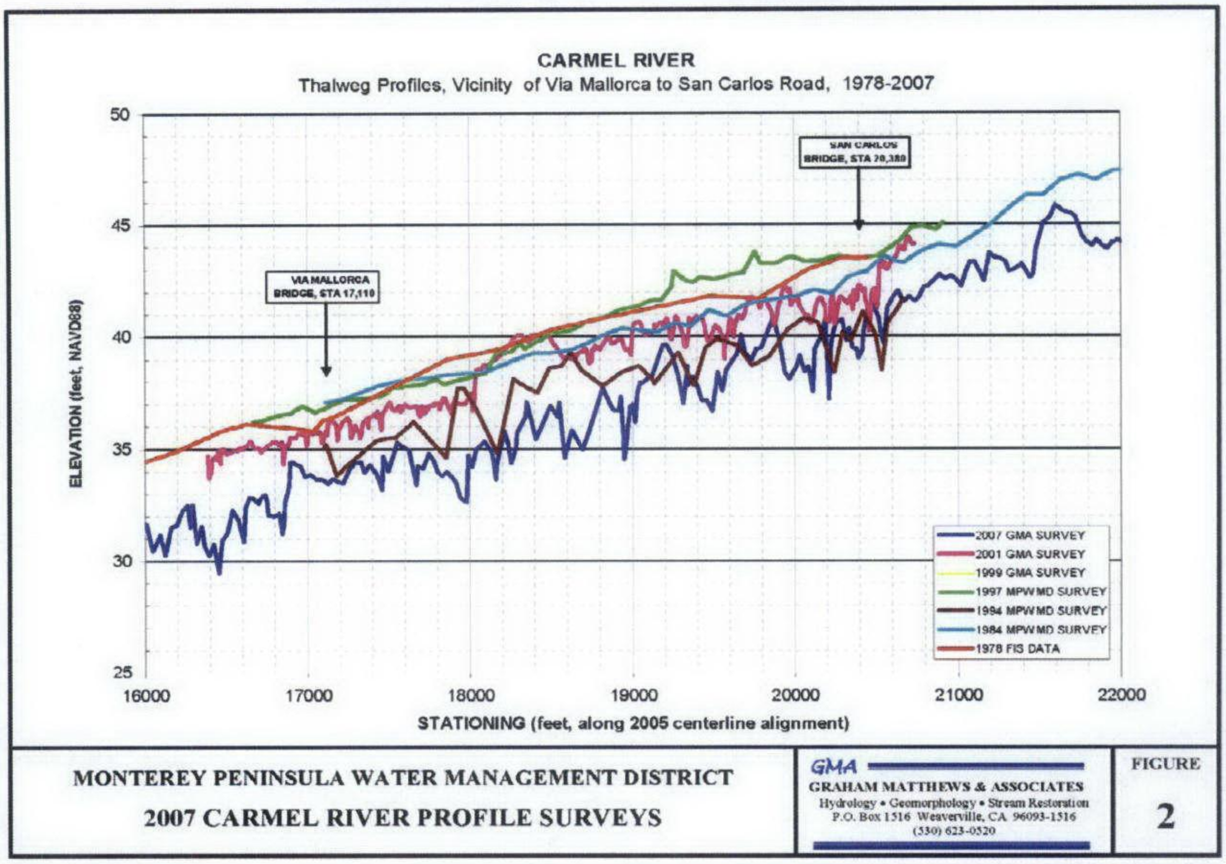



**Figure 11 – Channel Degradation (1 of 4)**

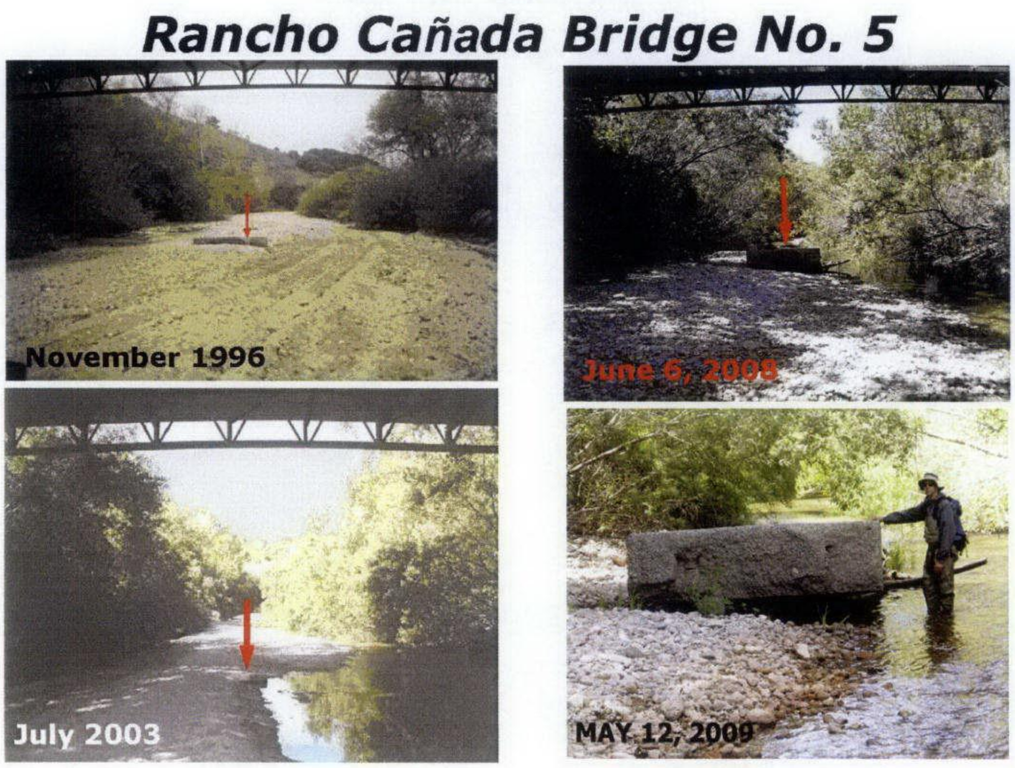


**Figure 11 – Channel Degradation (2 of 4)**

## *Rancho Cañada Bridge No. 2*

2007 (left)

1994 (below)

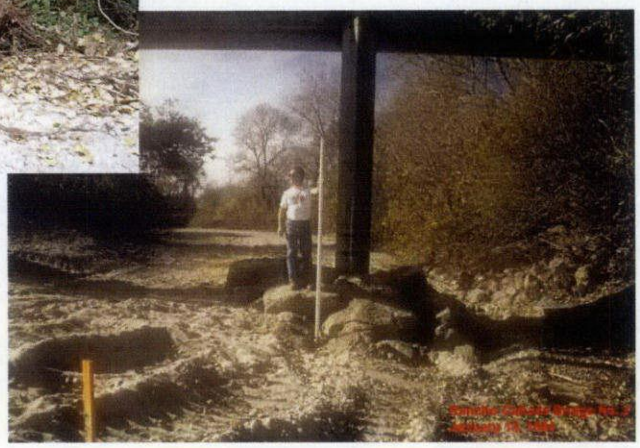


**Figure 11 – Channel Degradation (3 of 4)**

## *Valley Hills Grade Control*

***Looking upstream***
***Left – July 2004***
***Bottom – September 2007***

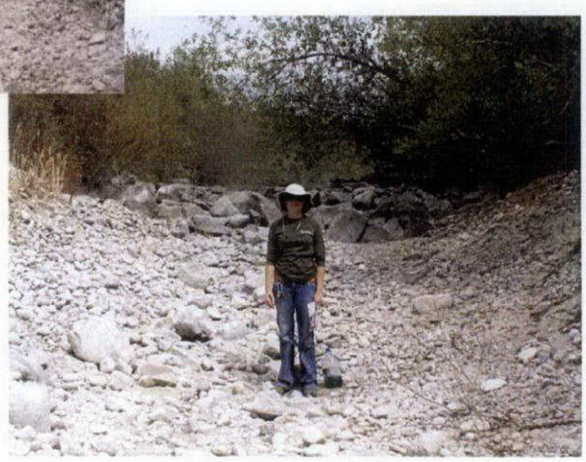
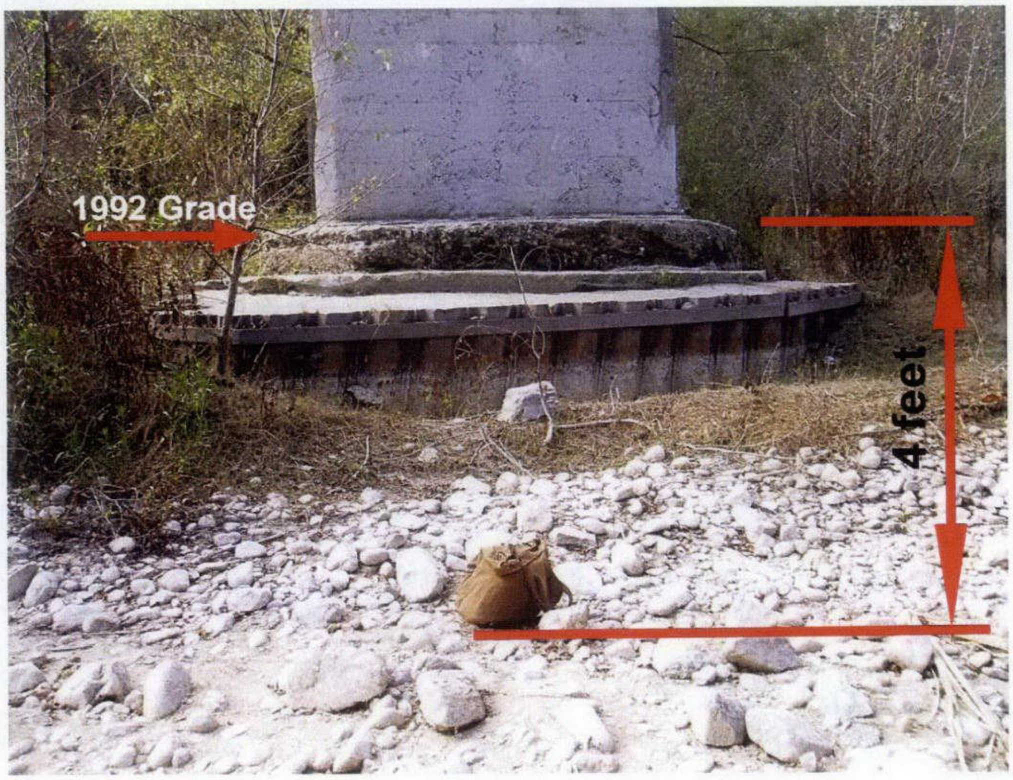


**Figure 11 – Channel Degradation (4 of 4)**

# Schulte Road Bridge - Nov 2007

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U:\Larry\MitProgram\UserFee\LHampson Draft Testimony\Exh-LH1-22August2011.docx

# EXHIBIT LH-2

**BEFORE THE PUBLIC UTILITIES COMMISSION**

**OF THE STATE OF CALIFORNIA**

| | |
|---|---|
| In the Matter of the Application of California-American Water Company (U210W) for an Order Authorizing the Collection and Remittance of the Monterey Peninsula Water Management District User Fee. | A.10-01-012<br>(Filed January 5, 2010) |

**EXHIBIT LH-2**

**CARMEL RIVER LAGOON TABLES AND FIGURES**

**BY LARRY M. HAMPSON**

**DISTRICT ENGINEER**

**MONTEREY PENINSULA WATER MANAGEMENT DISTRICT**

**__________ x, 2011**

## Table 1 – Carmel River Lagoon Stage-Volume Relationship

| Elevation NGVD 29[a] (ft) | Incremental Stage Volume acre-ft | Cumulative Volume (acre-feet) |
|---|---|---|
| -2.0 | 1.5 | 1.52 |
| -1.0 | 1.2 | 2.76 |
| 0.0 | 1.8 | 4.61 |
| 1.0 | 3.3 | 7.90 |
| 2.0 | 5.8 | 13.68 |
| 3.0 | 10.6 | 24.31 |
| 4.0 | 16.8 | 41.12 |
| 5.0 | 23.2 | 64.36 |
| 6.0 | 35.6 | 99.98 |
| 7.0 | 49.4 | 149.35 |
| 8.0 | 62.9 | 212.25 |
| 9.0 | 76.3 | 288.58 |
| 10.0 | 93.9 | 382.48 |
| 11.0 | 117.9 | 500.39 |
| 12.0 | 140.8 | 641.19 |
| 13.0 | 162.8 | 803.96 |
| 14.0 | 187.8 | 991.80 |
| 15.0 | 225.3 | 1,217.14 |

[a] All survey data were originally in NAVD 88. The VERTCON conversion calculator provided by the National Geodetic Survey (NGS) recommended a shift of -2.736 feet to convert from NAVD 88 to NGVD 29.

**Table 3: 1997 Stage-Volume Analysis[a]**

| Elevation (ft, NGVD 29) | Cumulative Volume (acre-feet) |
|---|---|
| -2.00 | 0.002 |
| -1.00 | 0.04 |
| 0.00 | 0.19 |
| 1.00 | 0.50 |
| 2.00 | 1.50 |
| 3.00 | 4.57 |
| 4.00 | 12.55 |
| 5.00 | 30.18 |
| 6.00 | 60.58 |
| 7.00 | 103.31 |
| 8.00 | 155.77 |
| 9.00 | 217.25 |
| 10.00 | 285.77 |

[a] Source: MPWMD Technical Memorandum 05-01, "Surface Water Dynamics at the Carmel River Lagoon. Water Years 1991 through 2005" (October, 2005).

Source: RMC Water and Environment (2007), Carmel River Lagoon Hydrographic Survey and Stage-Volume Relationship, prepared for Monterey Peninsula Water Management District

**FIGURE 1. – Lagoon Storage Volume**

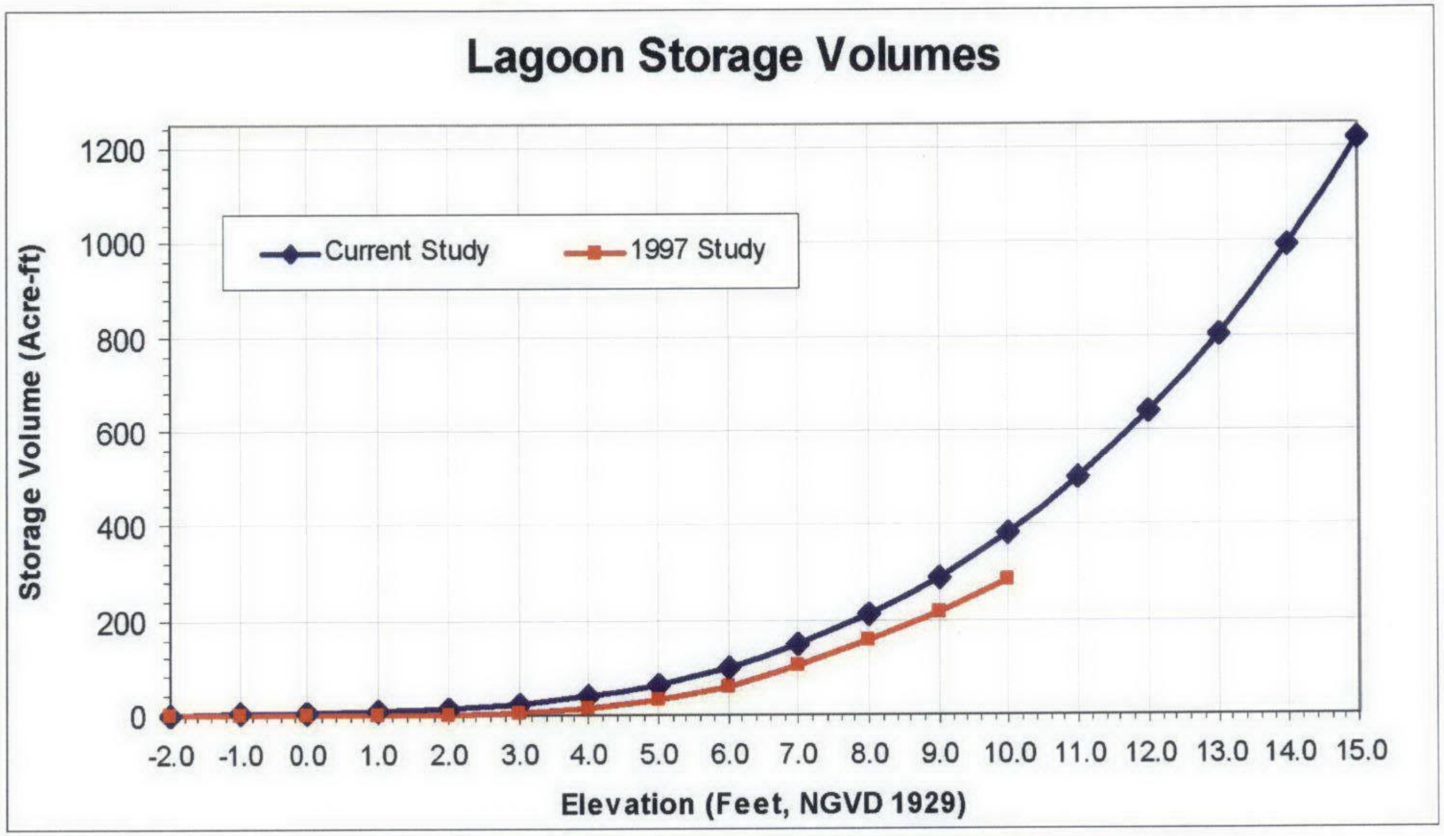
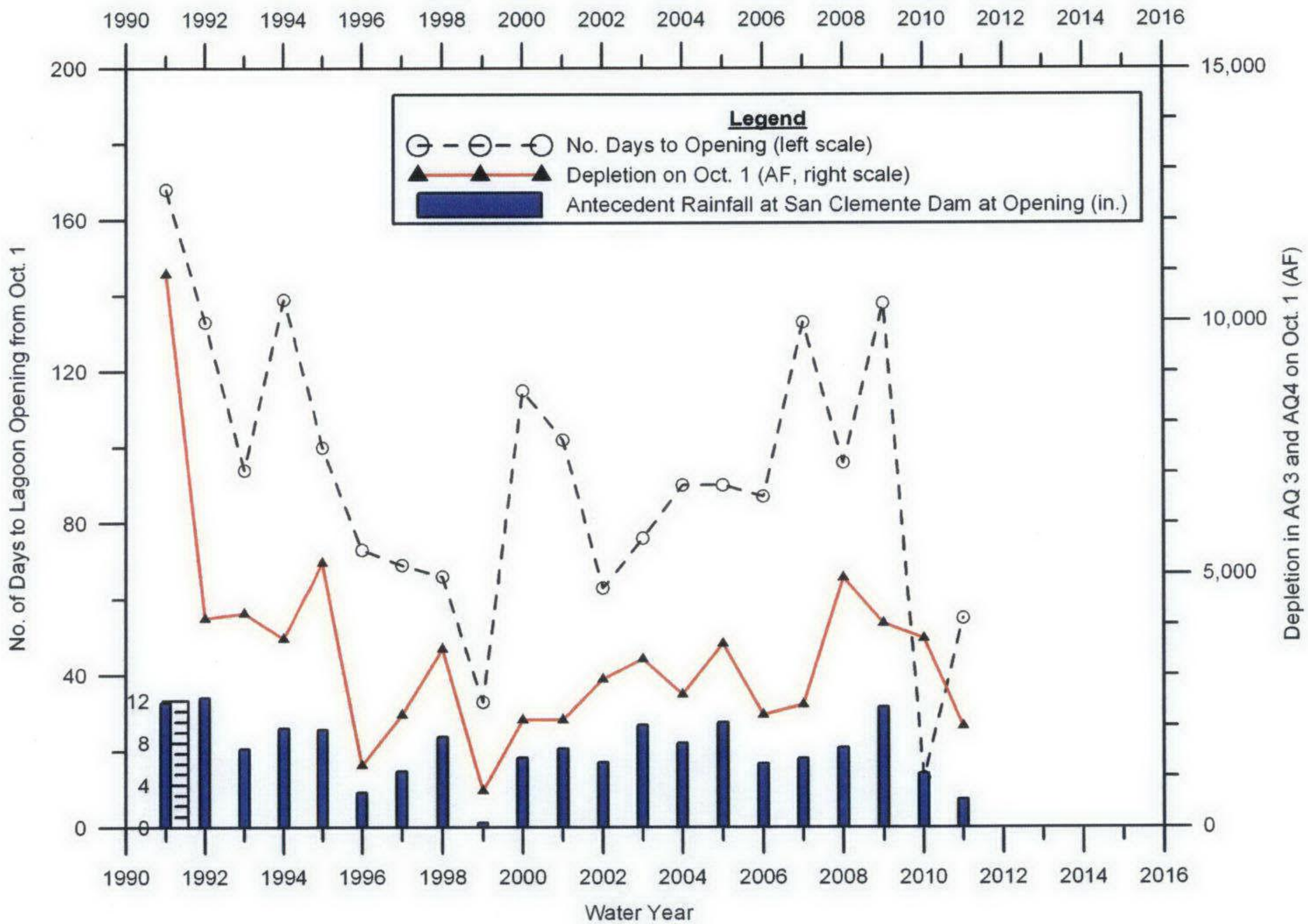



**Figure 1: Comparison of the 1997 and Current Stage-Volume Analysis**

Source: RMC Water and Environment (2007), Carmel River Lagoon Hydrographic Survey and Stage-Volume Relationship, prepared for Monterey Peninsula Water Management District

**FIGURE 2.**

**Comparison of Carmel River Lagoon Openings with Aquifer Depletion and Antecedent Rainfall**




Source: Data from Monterey Peninsula Water Management District and California American Water