Monterey County Flood Control and Water Conservation District

Monterey County Master Drainage Plan
Canyon Del Rey Watershed Drainage and Erosion

MONTEREY COUNTY SURVEYORS, INC.
in joint venture with
KORETSKY KING ASSOCIATES, INC.
Consulting Engineers

June 1977

MONTEREY COUNTY SURVEYORS, INC. - KORETSKY KING ASSOCIATES, INC.

A Joint Venture

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ENGINEERS AND CONSULTANTS

June 30, 1977

Mr. Loran S. Bunte, Jr.
District Engineer
Monterey County Flood Control
and Water Conservation District
Post Office Box 930
Salinas, Ca 93901

Subject: Monterey County Drainage Master Plan - Canyon del Rey Watershed

Dear Loran:

In compliance with our contract for the subject study, we herewith transmit twenty (20) copies of the final report for the Canyon del Rey Watershed portion of the Monterey County Drainage Master Plan. The report recommends improvements to specific primary facilities for adequate protection of developed areas and major roads in the watershed from flooding by a 100-year return period storm. Estimated construction costs are presented, both in the drawings as well as in reduced form in the text, covering the primary facilities that require modifications for existing development and anticipated future development. A periodic updating of the Master Plan to reflect actual conditions, as development occurs, is strongly recommended as the basis on which to provide for future conditions.

We would like to recognize two of our specialist consultants that provided invaluable input to this report. Arvi Waananen, specialist on hydrology and Dr. Philip Williams, specialist on erosion and sediments.

We wish to express our appreciation to you and your staff for the assistance and cooperation we received during compilation of this report and look forward to continuing to be of service to the District in the future.

Repectfully submitted,

MONTEREY COUNTY SURVEYORS, INC./
KORETSKY KING ASSOCIATES, INC.

Sanford Koretsky

MONTEREY COUNTY MASTER DRAINAGE PLAN

CANYON DEL REY WATERSHED

Prepared for

MONTEREY COUNTY FLOOD CONTROL

and

WATER CONSERVATION DISTRICT

By Authorization of

MONTEREY COUNTY BOARD OF SUPERVISORS

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BY

MONTEREY COUNTY SURVEYORS, INC./
KORETSKY KING ASSOCIATES, INC.
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SECTION I

INTRODUCTION

A. GENERAL

This Master Drainage Plan for Canyon del Rey has been prepared to achieve the following objectives:

1. Ensure the future development and installation of associated flood control facilities within the study area proceed in an orderly and reasonable manner.

2. Establish design criteria so that future flood control works to be constructed within the study area are identified and sized to provide adequate flood protection with consideration of the mitigation of erosion and siltation.

3. Utilizing established criteria, assess the adequacy of the existing drainage and flood control facilities within the study area to pass design flows under present and future developed conditions, and their effects on erosion and siltation.

4. Determine the basic drainage patterns and indicate size, location, capacity, significant hydraulic characteristics, and the approximate costs of anticipated new or enlargement of existing major drainage facilities as well as erosion and siltation mitigation measures. Indicate parameters that should be considered in the proposed operational plan for Lakes Roberts and Laguna Grande now under study.

5. Recommend legal instruments necessary to implement, control and finance this Master Drainage Plan. These recommendations will include, where applicable, additions to the Ordinance prepared for the Santa Rita Creek Master Drainage Plan (Reference 1).

B. GENERAL SITE DESCRIPTION

Canyon del Rey Creek begins at an elevation of approximately 500 feet in coastal foothills and flows westerly along Highways 68 and 218, through Lakes Laguna Grande and Roberts in the City of Seaside to Monterey Bay. The tributary watershed (See Drawing 1) encompasses an area of 16.8 square miles. The north slopes of the watershed are mostly rolling hills covered by sandy soil, grass and scattered trees. Approximately 70 percent of this north slope area is within the U. S. Army Fort Ord Military Reservation and is undeveloped. Laguna Seca Ranch has already started development of some of the north slope between Highway 68 and Fort Ord.

The south slopes of the watershed are steeper, have some heavy brush cover, occasional rock outcroppings and soil with a higher content of sandstone, shale and clay. The south slopes rise to an elevation of over 1300 feet. Some light development has already taken place near the easterly end of the south slopes.

A high degree of urbanization is evident at the lower elevations at the west end of the watershed in the City of Seaside and in Del Rey Oaks. This urbanized area accounts for about 11 percent of the watershed (See Drawing 3).

The predominant geologic formation south of Highway 68 are Monterey siliceous shale and white diatomite shale (Reference 5). The shales generally lie above elevation 500 feet. Along Highway 68, quaternary alluvium exists in varying thickness. Clay is the most common soil type within the study area, varying among gravelly, sandy, silty and lean clays. A high erosion potential exists for the sandy or silty clays on steep slopes where there is little or no vegetation.

C. CANYON DEL REY WATERSHED

For the purposes of this study, the Canyon del Rey Watershed was subdivided into 28 independent subwatersheds (See Drawing 1). All the subwatersheds eventually drain into Canyon del Rey Creek and thence into Monterey Bay through the lakes in the City of Seaside (See Section IV for a detailed description of the subwatersheds).

The basic drainage from the south slopes of the watershed follows natural stream channels from the higher elevations to Canyon del Rey Creek. On the lower elevations, where areas containing sandy and silty clay are found, a substantial part of the runoff percolates into the pervious soils, while the balance eventually reaches Canyon del Rey Creek. During periods of high runoff, extensive erosion occurs and quantities of sand and silt are transported from the head water areas and side slopes deposited in the lower reaches on the valley floor where the velocity of flow is reduced. Such settlement occurs predominately in Laguna Grande and Roberts Lakes and in the area just east of the box culvert under the Monte Mart at Fremont Avenue.

SECTION II

HYDROLOGY

A. GENERAL

Hydrology considers the relationships between rainfall, watershed conditions, and runoff. The frequencies and magnitudes of flood damages are closely related to the frequencies and magnitude of the floods themselves. Peak discharge values where determined at critical points for several different storm recurrence intervals to evaluate the capacities of existing channels and structures. Values were also determined to establish requirements for future structure and channel improvements. The flow at each of these points varies with the storm intensity, the extension and timing of precipitation through the different watersheds, the hydraulic conditions of the creeks, channels, structures, the type of soil and subsoil comprising each subwatershed, and the extent of urbanization. The method used to determine these flows was based on the data available and the size, configuration and characteristics of the respective watersheds.

B. DATA AVAILABLE

Hydrologic determinations are dependent upon the availability of rainfall and stream flow records within and adjacent to the area under consideration. The hydrologic information available for Canyon del Rey Watershed includes precipitation data officially accepted and published by the Weather Bureau, U. S. Department of Commerce from the following gages:

1. Monterey Station - This rain gaging station has continuous records for the past 30 years.

2. Del Monte - This rain gaging station was located on the grounds bought for the Naval Post Graduate School and was relocated inside the camp at the end of 1954. At that time it had more than 20 years of records.

3. Monterey NALF (Relocated Del Monte) - This relocated rain gaging station inside the Naval Academy has now more than 10 years of continuous records.

The Monterey County Flood Control and Water Conservation District has operated a recording rain gage at Hidden Hill since 1968. Within the Canyon del Rey Watershed, there are more than 20 private rain gage stations. These stations are, however, concentrated in the lower urbanized sectors of the watershed.

The isohyetal maps developed for Lower Carmel Valley Watersheds and for El Toro Creek Watershed and the analysis of the precipitation records from the rain gages described resulted in the development of the isohyetal map for the study area shown on Drawing 2. This drawing also shows the location of the gages.

Recommendations for additional rain gages and stream gages within the study area are made later in this report.

Relationships between mean annual precipitation, precipitation depth, storm duration, and storm frequency were obtained from Reference 6, "Mean Annual Precipitation and Precipitation Depth-Duration-Frequency Data for San Francisco Bay Region, California" published by the U. S. Geological Survey, Water Resources Division.

Information contained in the report "Summary of Short-Duration Precipitation Frequency in Santa Cruz County" by J. Goodridge, Referency 7, was compared with the values for San Francisco Bay Region from the previous Reference 6, and found to be in close agreement.

A streamflow-measurement station at Del Rey Oaks City Park provides a record of runoff in Canyon del Rey Creek beginning in 1966 (U. S. Geological Survey Station 11143300). This is the only stream gage on Canyon Del Rey Creek.

Table II-A lists the mean annual precipitation in inches derived for each of the 28 subwatersheds in the basin (delineated on Drawing 1).

TABLE II-A

MEAN ANNUAL PRECIPITATION FOR

CANYON DEL REY SUBWATERSHEDS

Subwatershed	Area Acres	Average Mean Annual Precipitation (Inches)	Subwatershed	Area Acres	Average Mean Annual Precipitation (Inches)
1.	160	14.1	15.	263	13.6
2.	410	15.1	16.	228	13.7
3.	59	14.3	17.	388	13.8
4.	296	15.2	18.	302	13.9
5.	45	14.7	19.	153	14.3
6.	357	16.0	20.	124	14.4
7.	196	16.2	21.	140	14.5
8.	160	15.4	22.	141	14.7
9.	166	15.5	23.	185	15.0
10.	1018	16.5	24.	143	15.1
11.	332	16.1	25.	108	14.8
12.	469	16.4	26.	1130	14.2
13.	170	15.9	27.	350	13.8
14.	366	15.9	28.	840	13.2

C. METHODOLOGY

The peak discharge for a given return period may be estimated in several ways. The choice of method selected depends on the data available and the size and configuration of the watershed under study. The most frequently used methods are:

1. <u>Frequency Analysis of Recorded Peak Flows of the Stream Under Study</u>

   The most direct, and thus perferable, method of developing peak flows versus frequencies for a given stream is through statistical analysis of past floods on that stream. Long records are desirable for adequate analysis; a reliable analysis generally requires records more than 25 years in length. Records available for the one stream gage on Canyon del Rey Creek covers 9 years (through 1975). Accordingly, this method is not considered adequate or applicable.

2. <u>Correlation with Frequency of Recorded Peak Flows of a Nearby Stream</u>

   A stream gage record may be extended through correlation with a longer stream gage record from a nearby hydrologically similar watershed. Available stream gage data on nearby streams were reviewed and it was determined that there are no nearby streamgages suitable for correlation with Canyon del Rey Creek or any of its tributaries.

3. <u>Regional Frequency Analysis</u>

   A regional frequency analysis was presented in the U. S. Geological Survey Water Resources Division publication, "Suggested Criteria for Hydrologic Design of Storm Drainage Facilities in the San Francisco Bay Region, California " (Reference 8). This was based on the records of some 40 strem gaging stations in the San Francisco Bay Area. Extension of this study to the Canyon del Rey subwatersheds seems reasonable. Formulas are presented relating peak flow to watershed area and mean annual precipitation for return periods of 2, 5, 10, 25 and 50 years. Many characteristics important to the Canyon del Rey subwatersheds are not included in the formulas. Therefore, this method can be used only to obtain order of magnitude values. The reliability of results obtained for basins smaller than 5 square miles, such as those in this study area, is uncertain. Thus this method is of limited applicability.

4. <u>The Rational Method</u>

   A description of this method and an excellent discussion of the rational formula and its limitations is found in Reference 8. This mehtod is commonly used for small areas becuase of its simplicity but it is a more subjective procedure than the methods previously discussed. Accuracy depends on correctly estimating the time of concentration and the runoff factor "C".

The rational method is more reliable for small urbanized areas than for areas in their natural state. Its use in areas having a significant amount of highly porous soil is much more difficult because it requires modification of the runoff factor "C" to a much smaller value.

5. The Synthetic Unit Hydrograph

The unit hydrograph method, although more complex in application than the afore mentioned methods, has the advantage of providing a complete storm hydrograph rather than just the peak discharge. It is the most realistic method available as it considers the widest range of significant factors such as basin area, length, slope, configuration, cover, soil type and degree of urbanization. The Soil Conservation Service (SCS) method is of this type but it is oriented toward the entire United States rather than the central coastal region of California. A somewhat different approach is presented in Reference 8, based on an analysis of seven San Francisco Bay Region stream gages, one of which is in Santa Cruz County. This comprehensive synthetic unit hydrograph method is considered the most appropriate for analyzing the Canyon del Rey Watershed.

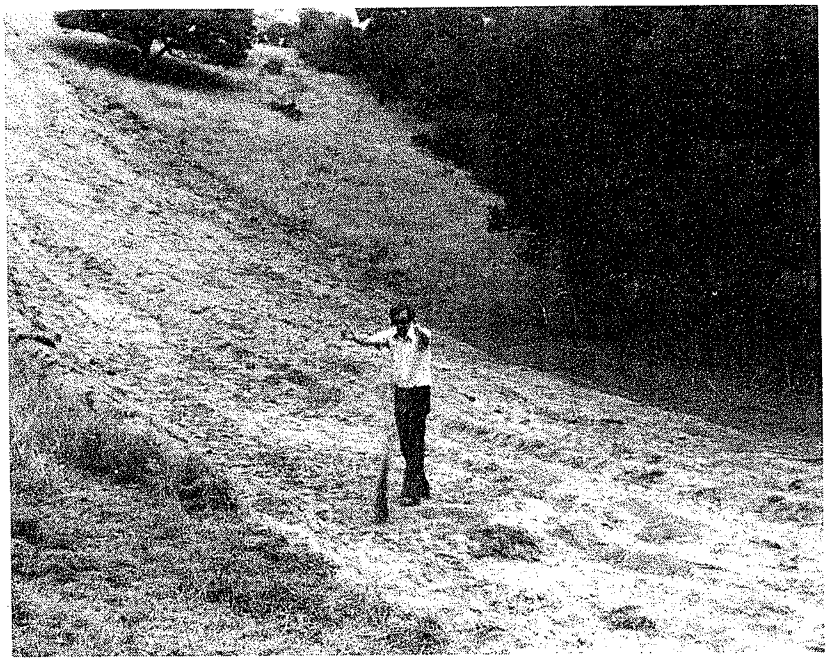
D. SELECTED METHOD

The synthetic unit hydrograph method selected is described in Reference 8. Only the general relationships comprising it and its generalized procedures are included in this report. The values in the tables and the formulas in Reference 8 are based on statistical analysis of San Francisco Bay region records. The data required to prepare the synthetic unit hydrograph for each tributary subwatershed are its area, its slope index, its percentage of urbanization, its mean annual precipitation, and the desired flood recurrence interval. (The slope index is the average slope of the main channel, expressed in feet per mile between points 10 and 85 percent of the distance from the lower to the upper end of the watershed). The following steps are needed for computing a triangular synthetic unit hydrograph for a watershed:

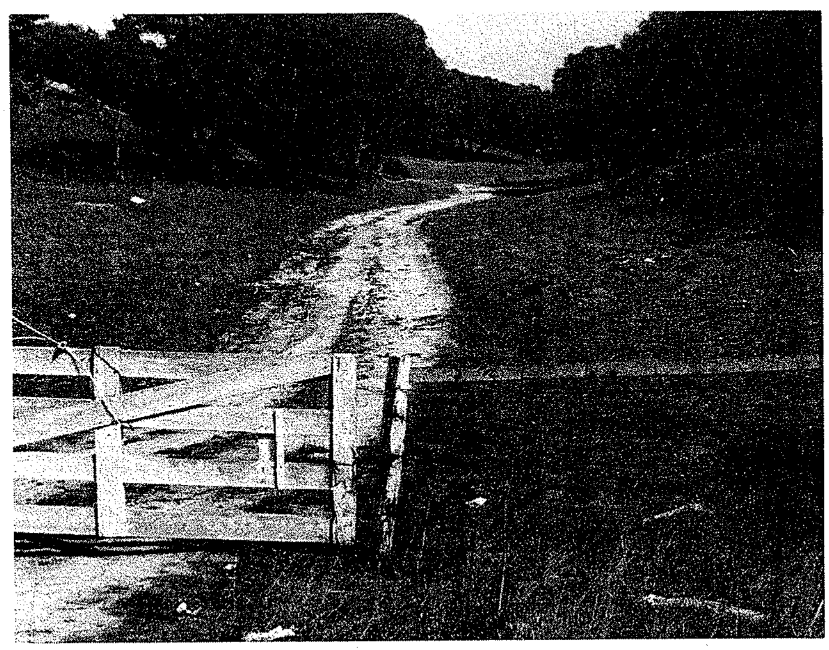
1. Prepare an Instantaneous Unit Hydrograph (IUH). Formulas have been developed for lag, time to peak, and base time. All of these are functions of the basin area and slope index.

2. Modify the IUH to allow for any urbanization. The values for lag, time to peak, and base time are multiplied by a coefficient obtained from a table on the basis of percent of urbanization. For this study, these were determined for each subwatershed and are tabulated in Table II-B.

3. Obtain the unit hydrograph by selecting its time increment of rainfall duration which is used to modify the IUH time to peak and base times. The unit hydrograph's peak discharge may then be obtained from the area and the base time.



TYPICAL SUBWATERSHED AREAS WHERE PERVIOUS SOILS YIELD VERY LITTLE SURFACE RUNOFF



4. Intermediate unit hydrograph values are obtained by interpolation between the peak discharge at the time to peak and zero flow at time equals zero and at the end of the base time.

The rainfall excess is obtained through the following steps:

1. The storm duration is selected on the basis of the unit hydrograph's lag time or, where several sub-basins in series are being studied, the expected time from the beginning of the storm until the flow peaks at the bottom of the lowest basin.

2. The total storm precipitation for the desired duration and return period is obtained from a table on the basis of mean annual precipitation over the watershed. A convenient table of such data appears in Reference 8.

3. The total precipitation is broken down into time intervals using a table relating cumulative percentage of precipitation during the storm with cumulative percentage of time. Various relationships are given for different storm durations.

4. The loss rate (in inches per hour) for the watershed in its unurbanized condition is obtained from a table on the basis of return period and mean annual precipitation.

5. The loss rate is modified to account for any urbanization by multiplying it by a coefficient taken from a table on the basis of percent of urbanization.

6. The modified loss rate per time increment is then subtracted from the incremental precipitation values to obtain the rainfall excesses by increments.

The first value of rainfall excess is multiplied by the unit hydrograph ordinates and the products tabulated by time increments. The next excess value is then multiplied by the same ordinates but the products are recorded to lag one time increment behind those of the previous excess. This is repeated for the entire storm. The products for each time increment may then be added together to form the hydrograph. A constant value of discharge representing base flow may then be added to the hydrograph to obtain the total discharge.

Further modifications of the foregoing are possible in areas where special conditions exist. In parts of the Canyon del Rey Watershed, one such special condition is evident; i.e. unusually high soil permeability. The adaptation procedure to take this factor into account is described in "E" which follows.

E. ADAPTATION OF THE SELECTED METHOD

The selected method is based on greater San Francisco Bay Region watersheds ranging in area from 0.71 to 11.9 square miles and having soils with typical permeability as defined in Reference 6. Many of the Canyon del Rey subwatersheds are unusually permeable. Field reconnaissance and discussions with long-time residents disclosed very pervious channels throughout the study area. Portions of some of these channels are so pervious that they may have very little, if any, surface water flow, particularly during the smaller storms.

Special loss rates were developed for the several subwatersheds of the study area to allow for their higher than normal infiltration due to the permeable soil cover and depth to the water table. These special loss rates were determined after a systematic study of water losses for various storm recurrence intervals, observations in the field, records of past events, and discussions with local residents. The loss rates for the subwatersheds of Canyon del Rey Watershed are obtained by multiplying the average water loss coefficient included in Table 8 of Reference 8 by the Permeability Coefficient (K) in Table II-C of this report entitled "Permeability Coefficients for Canyon del Rey Subwatersheds." The resulting water loss rate is that for an unurbanized watershed; for urbanized areas the values need to be multiplied by the appropriate coefficients from Table II-D entitled, "Urbanization Coefficients for Rate of Water Loss in Canyon del Rey Subwatersheds."

F. CONDITIONS STUDIED

The individual subwatersheds were studies for both their present condition and the most intense state of development currently anticipated for the future. The present degree of development was evaluated on the basis of aerial maps flown in November 1976 and field reconnaissance. The pattern of anticipated future development was estimated on the basis of the proposed land use and anticipated population density as presented in "Monterey II", a plan for the Highway 68 area (Reference 5). This particular planning document presents the most realistic development approach for the study area available at this time. The plan is based on a community concept in its physical layout and is composed of several self-contained villages (See Drawing 3). These projected villages will exist to serve in coordination with the existing City of Monterey. This community concept process differs from the usual planning process in that it does not predict or project population by regions, but very specific areas. Land in the total planning area of Monterey II drains in five major directions but the drainage to Canyon del Rey Creek is the most important.

TABLE II-B

URBANIZATION COEFFICIENTS FOR TIME DIMENSIONS
CANYON DEL REY SUBWATERSHEDS

SUBWATERSHED	COEFFICIENT Present	COEFFICIENT Future	SUBWATERSHED	COEFFICIENT Present	COEFFICIENT Future
1	0.90	0.87	15	1.00	1.00
2	0.95	0.70	16	1.00	1.00
3	0.95	0.95	17	1.00	0.61
4	0.99	0.92	18	0.97	0.74
5	0.99	0.85	19	1.00	0.60
6	0.99	0.70	20	0.97	0.68
7	0.99	0.72	21	0.85	0.50
8	0.99	0.92	22	0.92	0.55
9	1.00	0.96	23	1.00	0.84
10	1.00	0.78	24	1.00	0.25
11	1.00	0.85	25	0.90	0.40
12	0.99	0.60	26	0.99	0.99
13	0.99	0.72	27	0.35	0.35
14	1.00	0.46	28	0.25	0.25

TABLE II-C

PERMEABILITY COEFFICIENTS FOR
CANYON DEL REY SUBWATERSHEDS

SUBWATERSHEDS	PERMEABILITY COEFFICIENT (K)	SUBWATERSHEDS	PERMEABILITY COEFFICIENT (K)
1	2.4	15	4.0
2	2.4	16	4.0
3	2.2	17	4.0
4	2.4	18	4.0
5	2.2	19	4.0
6	2.8	20	4.0
7	2.8	21	4.0
8	2.6	22	4.0
9	2.8	23	4.1
10	3.0	24	4.1
11	3.2	25	4.1
12	3.4	26	4.1
13	3.6	27	4.5
14	3.8	28	4.5

TABLE II-D

URBANIZATION COEFFICIENTS FOR RATE OF WATER LOSS
CANYON DEL REY SUBWATERSHEDS

SUBWATERSHED	COEFFICIENT Ø Present	COEFFICIENT Ø Future	SUBWATERSHED	COEFFICIENT Ø Present	COEFFICIENT Ø Future
1	0.92	0.90	15	1.00	1.00
2	0.97	0.80	16	1.00	1.00
3	0.95	0.95	17	1.00	0.74
4	0.99	0.95	18	0.98	0.82
5	0.99	0.90	19	1.00	0.76
6	0.99	0.80	20	1.00	0.75
7	0.99	0.81	21	0.90	0.65
8	1.00	0.95	22	0.95	0.65
9	1.00	0.98	23	1.00	0.90
10	1.00	0.85	24	1.00	0.50
11	1.00	0.90	25	0.94	0.65
12	0.99	0.76	26	0.99	0.99
13	0.99	0.81	27	0.55	0.55
14	1.00	0.66	28	0.50	0.50

To determine the projected future development, the Monterey II Plan divided the land into four main divisions as follows: conservation, low capability, medium capability and high capability, giving consideration to the quality of the soils, the slope, landslide areas, highly scenic areas, potentially active fault areas, and the proximity of lands to stream channels or drainage ways. Each village, according to this plan, would be a tight cluster of residential units with centrally located public services and shopping facilities, ranging from rather large lot homesites to garden apartments.

A Light Industrial Park of 285 acres is also projected in the Monterey II Plan. Research, light manufacturing, component assembly, office and some heavy commercial uses are envisioned for the park.

Special significance for future runoff is the concept in Monterey II of the "core shopping area." According to the plan, the core should be more than a regional shopping center. Transit buses, however, are included and given the opportunity to serve the retail areas directly. There might also be offices and the possibility of future multi-family housing in the core. The core thus would be a multi-use center which would serve the entire North Monterey County Trade Area in addition to Monterey residents. The Monterey II Plan estimates the range of number of dwellings in each of the projected villages for low density and high density as shown in Table II-E. The high density values were used for estimating the conditions of the future storm runoff within Canyon del Rey Watershed.

TABLE II-E

MONTEREY II PROJECTED VILLAGE DENSITIES

VILLAGE		LOW	HIGH
1		1167	1460
2		1249	1561
3		1200	1500
4		1057	1322
5		918	1148
A		160	200
B		240	300
C		240	300
	TOTAL	6231	7791

As more specific plans for new developments are formulated, they should be incorporated into the Master Drainage Plan. When implemented, each development will increase the peak discharge to be carried by all downstream drainage ways to which it is tributary. The significance of this increase will depend on the magnitude and location of the development. In recognition of this, each developer, as part of this overall plan, should be required to provide not only a complete drainage system within the development itself, but also to contribute financially to any downstream facilities required to handle the additional flows caused by the new construction. As recommended in Section VII of this report, the Master Drainage Plan should be subject to ongoing review and periodic updating to account for actual changes almost certain to occur within the watersheds.

G. SELECTION OF RETURN PERIOD

The primary purpose for providing flood control facilities is to protect the public from injury or death due to uncontrolled flooding. The secondary purpose is to protect property from damage when the value of the property justifies the cost of such protection. The magnitude of storm for which protection should be provided is also dependent upon the size, configuration and climatological characteristics of the watershed involved. Because hydrologic evaluation must be based on limited data, the projections and probabilities of storm occurrence and magnitude are subject to professional judgment and interpretation of many factors.

The decision as to what return period storm should be used for design must depend upon the potential consequences of that design. If the total volume of stormwater involved is large, life and property could be seriously threatened by undersized facilities. Under these conditions, a conservative approach must be taken. If, on the other hand, the total volume is relatively small, the threat to the public is much less severe and the use of shorter return period design storm is warranted. For this study a 100-year return period design storm for primary structures and a 10-year storm for secondary structures were selected. These are consistent with criteria established by other flood control districts in California and by the U. S. Department of Housing and Urban Development (HUD). HUD has sponsored the appraisal and mapping of flood-prone areas and through the Federal Insurance Administration has offered flood-plan insurance in those areas subject to periodic flooding that have met certain eligibility requirements. The 100-year flood has been established by the Federal Insurance Administration as the basis for flood-hazard evaluation and the determination of flood insurance rates. The 10-year storm for secondary structures is generally used as a criteria for the design of road and highway drainage facilities.

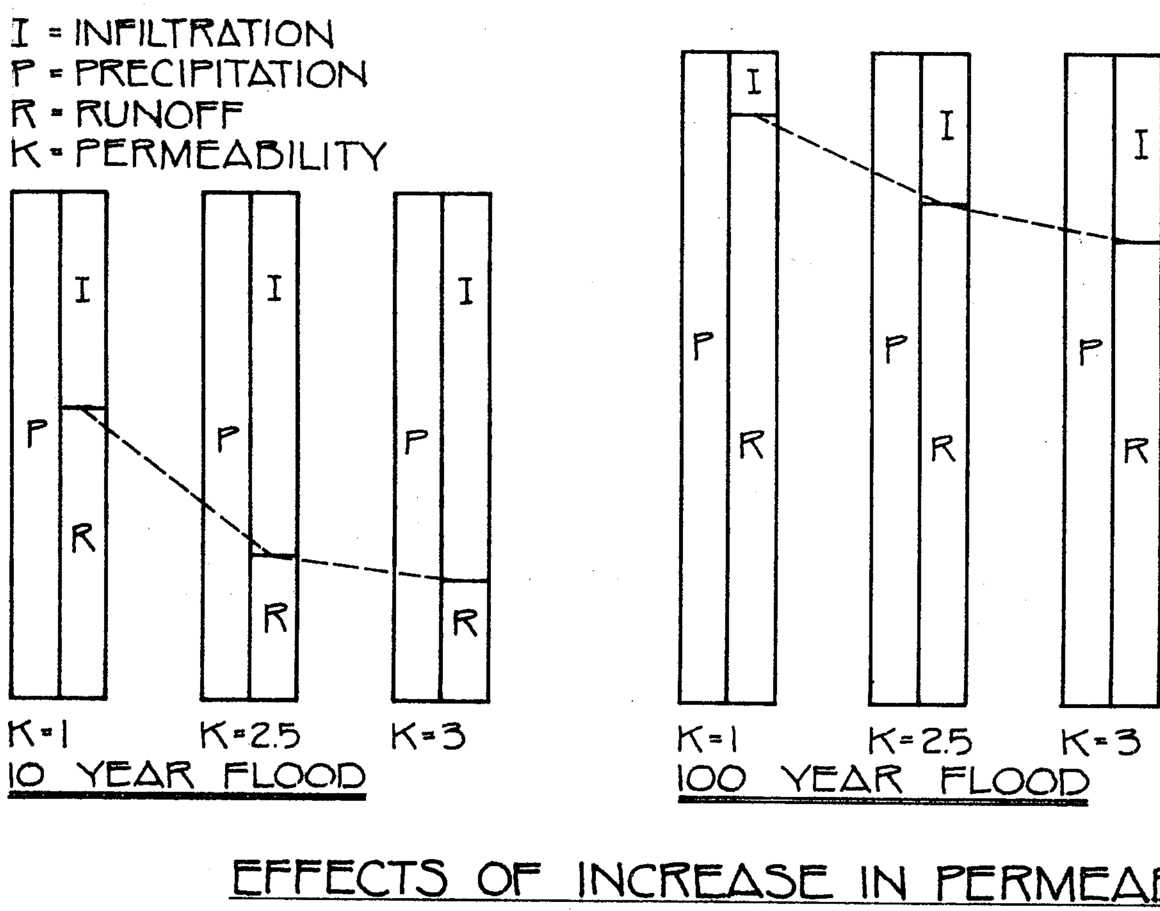
H. TEN AND ONE HUNDRED-YEAR PEAK FLOWS

The flows for the existing and projected future conditions for every subwatershed of the study area are shown in Table II-F, "Runoff by Subwatershed" for the 10-year and 100-year recurrence intervals. Each value is the peak discharge anticipated at the confluence with Canyon del Rey Creek (providing the drainage structures and conveyance facilities are adequately sized).

Applying a standard streamflow-routing method (the Muskingum Method, Reference 10), the flows shown by the complete hydrograph of every subwatershed were routed along the Canyon del Rey Creek in order to determine the peak flows at specific structures for 10-year and 100-year recurrence intervals for present and future conditions, and also to determine the volumes for routing and storage capacities. The peak routed flows at 16 significant crossings are shown in Table II-G, "Peak Stream Runoff Along Canyon del Rey Creek."

The values in Table II-G indicate peak runoff assuming that upstream drainage structures and waterways provide temporary flow detention and attenuation of peaks, as at present. The capacities of most of the present structures are too small to pass the full flood flows. However, ponding above these structures serves to reduce the magnitude of the peak flows passed downstream and to extend the period of flow. The short record at the gaging station downstream from point 29 precludes projecting flows for a specific return period. Flows projected on the basis of these records also are lower than calculated flows, partly because of attenuation of flows within the conveyance channels, undersized and clogged pipe structures and natural ponding areas within the subwatersheds.

FIGURE II-1



EFFECTS OF INCREASE IN PERMEABILITY ON FLOODFLOW VOLUME IN SUBWATERSHED 10

The large ratios of the 100- to the 10-year floods are a result of the low annual and strom participation and the pervious soils in the Canyon del Rey basin. Soils in the basin are highly pervious, particularly on the north slopes and the valley floor, and permit high percolation and infiltration rates. Most of the precipitation from the smaller, more frequent storms percolates into the soils, with little or no runoff.

For the larger, less frequent storms, the watershed is considered to be saturated because substantial antecedent precipitation usually causes saturation of the surface soils and a much larger proportion of the precipitation runs off as stream flow. The ratio of the 100- to the 10-year floods thus is usually much greater than in basins with less pervious soils and greater precipitation. As an example, the effect of increased perviousness on the runoff is demonstrated in Figure II-1 for subwatershed 10. This figure illustrates that the ratio in subwatershed 10 would be 2.0, however, the ratio of the 100- to the 10-year flood runoff for K-3 (high permeability existing in subwatershed 10) is 3.9.

The normal effects of urbanization includes sharp increases in the extend and degree of surface imperviousness, acceleration of runoff, and corresponding increases in peak flows for floods of all recurrence intervals. Flow increases usually are greatest for the smaller peak flows that have short recurrence intervals. The greater flows generally reflect basin-wide runoff after substantial saturation. The saturation effect, which occurs under natural conditions is similiar to the urbaniation effect in that both cause a reduction in infiltration and an increase in runoff. The magnitude of the urbanization effect thus is proportionately less for the greater floods.

TABLE II-F

RUNOFF BY SUBWATERSHEDS

	PRESENT				FUTURE			
	10 Year		100 Year		10 Year		100 Year	
Watershed Number	Peak (cfs)	Rate (cfs/ac.)	Peak (cfs)	Rate (cfs/ac.)	Peak (cfs)	Rate (cfs/ac.)	Peak (cfs)	Rate (cfs/ac.)
1	18	.114	50	.314	19	.120	53	.330
2	52	.127	135	.329	81	.198	182	.444
3	9	.153	25	.422	9	.153	25	.422
4	34	.115	95	.321	38	.128	102	.345
5	7	.156	19	.424	7	.156	19	.424
6	40	.112	112	.314	64	.179	153	.429
7	31 *	.158	83 *	.423	48 *	.245	108 *	.551
8	25	.156	66	.413	25	.156	72	.450
9	24	.145	67	.404	25	.151	69	.416
10	84	.083	265	.260	130	.128	346	.340
11	32	.096	100	.301	41	.123	117	.352
12	41	.087	133	.284	81	.173	211	.450
13	17	.100	54	.318	33	.194	72	.424
14	29	.079	100	.273	80	.219	194	.530
15	14	.053	63	.240	14	.053	63	.240
16	12	.052	61	.266	12	.052	61	.266
17	19	.049	92	.237	45	.116	150	.387
18	15	.049	70	.227	25	.081	93	.302
19	10	.065	45	.294	23	.150	73	.477
20	10	.081	46	.371	18	.145	64	.516
21	11	.070	47	.310	23	.150	79	.525
22	10	.064	42	.280	14	.095	57	.380
23	9	.049	41	.222	12	.065	48	.259
24	7	.046	32	.209	45	.294	96	.627
25	8	.075	31	.290	13	.120	43	.395
26	25	.022	184	.163	25	.022	184	.163
27	66	.189	150	.423	66	.189	150	.423
28	182	.222	385	.470	182	.222	385	.470

* Routed Peak Discharge From Dam @ Hidden Hills

TABLE II-G

ROUTED PEAK STREAM RUNOFF ALONG CANYON DEL REY CREEK

Structure Number	Description	PRESENT 10 Year (cfs)	PRESENT 100 Year (cfs)	FUTURE 10 Year (cfs)	FUTURE 100 Year (cfs)
7	Laguna Seca Road	75	235	112	286
10	Rangers Pond	124	408	155	464
14	Crossing Hwy 68	40	135	65	190
16	Crossing Hwy 68	97	194	146	260
21	Crossing Hwy 68	111	190	187	260
22	Crossing Hwy 68	125	173	194	225
25	48" CMP at Larkspur	150	230	231	313
26	Bridge (12' x 7')	135	296	209	391
27	Tributary Junction at Watershed No. 10	191	523	295	690
29	Crossing Hwy 68	196	583	302	757
30	Private Crossing Bridge (3.5 x 8.5)	209	668	318	852
31	Crossing Hwy 68	260	853	400	1088
38	Crossing Hwy 218	270	906	398	1129
40	Crossing Hwy 218	148	794	214	960
42	Under Market at Fremont Street	148	720	214	870
46	Laguna Grande-Roberts Lake	148	720	214	870

NOTE: 1. The flows indicated in Table II-6 as future were developed utilizing future anticipated urbanization and structures recommend to pass the future flow.

2. The structure numbers listed in Table II-G are structures where substantial flow changes occur due to inflow from the subwatersheds.

SECTION III

STORM DRAINAGE CRITERIA

A. GENERAL

These criteria are applicable to both primary and secondary facilities. A Primary Facility is a stormwater structure having a total usable waterway area of twelve (12) square feet or more. A Secondary Facility is a stormwater structure having a total usable waterway area of less than twelve (12) square feet.

B. JURISDICTION

"Primary Facilities" and those "Secondary Facilities" not within a county road right-of-way or easement should be under the jurisdiction of the Monterey County Flood Control and Water Conservation District. "Secondary Facilities" within a county road right-of-way or easement are under the jurisdiction of the County Department of Public Works or the Cities in which they occur. All "Secondary Facilities" within subdivisions should be closed conduits, except for those specifically planned and coordinated with the park and open-space areas within the subdivision as indicated in III-E below.

C. HYDROLOGY

1. Method

Stormwater runoff in main watercourses shall be calculated by either the Unit Hydrograph Method or the peak runoff equation derived for the study area subwatersheds (refer to C.4 hereinafter). The rational Method may be used for urbanized areas of less than 200 acres provided they are independent of the main watercourse. Each method shall be used as described in this section.

2. Design Storm Return Period

a. Primary Facilities

100-year frequency storm.

b. Secondary Facilities

1. 10-year frequency storm where no lot flooding will occur, as determined by the County Department of Public Works.

2. 25-year frequency storm where lot ponding and surface flow can occur, taking into account land use in the adjacent floodable area. Dedicated easements for surface water shall be provided.

3. Unit Hydrograph Method

Except as modified here, the Unit Hydrograph Method shall be as described in the latest edition of the U. S. Geological Survey publication, "Suggested Criteria for Hydrologic Design of Storm Drainage Facilities in the San Francisco Bay Region, California" by S. E. Rantz, 1971 (Reference 8). The mean annual precipitation shall be obtained from the latest edition of "Isohyetal Map for Canyon del Rey Watershed" included as Drawing 2 of the Master Drainage Plan Drawings. The method described in Reference 8 shall be adapted to the study area by multiplying the time dimension by the urbanization coefficients tabulated in Table II-B the water loss coefficient (Ø) by the permeability coefficient (K) listed in Table II-C The urbanization factors for use in the Unit Hydrograph Method to modify IUH have been determined for each subwatershed in the study area according to the actual percentage of urbanization and the projected future estimates of Monterey II Plan. Hydrographs may be routed from subwatershed to subwatershed by the Muskingum Method (Reference 10).

4. Peak Runoff

Due to the many variables affecting the storm runoff in each of the subwatersheds (such as mean annual precipitation, slope, area, elevation, urbanization and permeability) and the ability of the Unit Hydrograph Method to take these variable factors into account, this method was applied to the subwatersheds within the study area. Hydrographs and peak flows in cubic feet per second were developed for all subwatersheds. Values of peak flow per acre per subwatershed were developed for the 10- and 100-year storms. These values were developed for both present and anticipated future conditions and tabulated in Table II-F.

Utilizing the values in Table II-F the area of a subwatershed above a point of consideration, and the following Peak Runoff Equation, it is possible to determine the peak runoff at any point on the main watercourse of any subwatershed.

Peak Runoff Equation

$$Q = P \times A$$

where

Q = Peak runoff in cubic feet per second at the point under consideration.

P = Peak flow in cubic feet per second per acre for the appropriate subwatershed, return period and development conditions.

A = Subwatershed area above the point under consideration in acres.

The hydrographs of all the subwatersheds were used in routing the runoff in Canyon del Rey Creek, utilizing the Muskingum Method of routing. Additional hand routing was done at locations where undersized structures impeded flow and upstream ponding areas were available. Ponding was allowed as long as the future 100-year flows did not flood roadways or existing buildings. Values of peak runoff at various locations along the creek for 10- and 100-year storm runoff and present and anticipated future conditions, are tabulated in Table II-G. Peak flows for any location along Canyon del Rey Creek can be interpolated from this Table for the appropriate return period and development conditions.

5. Rational Method

The Rational Method formula shall be used only for Secondary Facilities independent of the main watercourse. The peak runoff for areas involving main watercourses shall be computed by the Unit Hydrograph Method or by using the rate of runoff tabulated for every subwatershed in Table II-F and routed by the Muskingum Method along the main creek of Canyon del Ray Watershed. The Rational Method shall utilize the figures and basic criteria presented below:

a. Runoff Coefficient (C)

Type of Area	Coefficient "C"
Rural, park, forested, agricultural, slope less than 30 percent	.20
Rural, park, forested, agricultural, slope greater than 30 percent	.40
Low residential density, single family	.40
High residential density, multiple family	.60
Schools	.70
Business and Commercial	.80
Impervious	.90

b. Duration (D)

The storm duration is equal to the time of concentration; that is, the time required for water to flow from the most remote point of the tributary area (from the standpoint of travel time) to the site under consideration. Minimum duration shall be 10 minutes.

c. Mean Annual Precipitation (Pma)

The mean annual precipitation shall be obtained from the latest edition of "Isohyetal Map for Canyon del Rey Watershed", (Drawing 2).

d. Precipitation Intensity (i)

The depth of precipitation shall be obtained from Table III-A by the duration (D) in hours.

e. Peak Runoff (Q)

$$Q = CiA$$

where

Q = Peak runoff rate in cubic feet per second.

C = Dimensionless runoff coefficient taken from paragraph "a" above.

i = Average precipitation intensity, in inches per hour taken from paragraph "d" above.

A = Drainage area in acres.

D. HYDRAULIC DESIGN

All drainage facilities shall be designed for the peak runoff from the design storm specified in C.2 above, taking advantage of any ponding that does not flood roadways or existing buildings. Any area to be utilized for ponding shall be subject to the approval of the Flood Control District. Manning's Equation (in most hydraulics texts or handbooks) shall be used to determine flows in pipes or channels. The following hydraulic factors and criteria shall be used, unless specifically authorized otherwise by the County Office having jurisdiction.

1. Manning's Roughness Coefficient (n)

Concrete Gutters	0.015
Corrugated Metal Pipe	0.024
Reinforced Concrete Pipe	0.015
Cast-in-Place Pipe	0.015

Lined Channels

Concrete	0.015
Air Blown Mortar	0.016
Grass	0.030
Placed Rock	0.035
Dumped Rock	0.040

Natural Channels

Clear	0.040
Clogged	0.060 to 0.100

Unlined Channels (man-made)

Maintained	0.025
Non-Maintained	0.040

2. Velocities

Minimum velocity in pipes at design flow shall be 2 feet per second unless controlled by minimum pipe size. Maximum velocity at design flow for unlined ditches and channels shall be 6 feet per second unless specifically authorized otherwise by the Monterey County Flood Control and Water Conservation District.

3. Use of Available Head

Available head governed by the permissible limits of upstream ponding may be used at culvert entrances. Entrance slope protection shall be provided to prevent scour when velocities exceed 10 fps.

4. Losses Other Than Friction

Proper allowances for losses through junction structures, inlets and manholes, and consideration of the water surface elevation of receiving waters shall be taken into account in determining the hydraulic grade line or water surface elevation.

5. Freeboard

a. The design of drainage pipe systems shall allow for a minimum freeboard of 0.75 feet between the top of inlet grate or manhole cover and the design water surface elevation.

b. Open channels shall have a minimum freeboard above design flow water surface of 2 feet or $v^2/2g$, whichever is greater, where V is the water velocity in feet per second and g is the acceleration of gravity (32.2 feet per second per second).

c. Gutter flow shall not extend more than 8 feet into the travelled way under 10-year design flow conditions.

E. STORM DRAINAGE FACILITIES

Drainage improvements within subdivisions should be constructed by the subdivider within dedicated streets or easements as necessary to prevent damage to lots within the subdivision and adjacent property, occurring as a result of surface water flow, sediment deposit, and erosion. The subdivider should coordinate and combine where appropriate, flood control facilities with park and open-space areas within the subdivision. All Secondary Facilities within subdivisions should be closed conduits, except for those specifically planned and coordinated with the park and openspace areas as indicated above.

1. Pipe Systems

   a. Minimum size pipe in easements - 15"

   b. Minimum size pipe in street right-of-way - 18"

   c. Energy dissipators and/or adequate slope protection shall be provided for outlets into natural drainage channels or unlined channels.

2. Ditches and Channels

   a. Man-made ditches and channels shall be lined if design velocities exceed 6 feet per second unless specifically authorized otherwise by the Monterey County Flood Control and Water Conservation District. To preserve the natural environment of the area, special consideration shall be given to the type and treatment of any lining to be incorporated into the design.

   b. Fences may be required along open channels in developed areas as determined by the County Department of Public Works.

F. RIGHT-OF-WAY AND EASEMENT DEDICATIONS

1. Minimum width of right-of-way or easement to be dedicated for watercourses shall be:

   a. Closed conduits up to 72-inch in diameter - 10 feet

   b. Closed conduits over 72-inch in diameter - Outside Diameter + 4 feet

   c. Earth channels (other than natural):

      1. Top width less than 30 feet - Top width + one 15-feet maintenance road + 4-foot berm on opposite side + necessary slope easements.

      2. Top width greater than 30 feet - Top width + two 15-feet maintenance roads + necessary slope easements.

d. Lined Channels - Top width + 4-feet berm on one side + necessary slope easements.

2. Drainage concentrated at the end of the channels or storm drains should be discharged into a watercourse acceptable to the jurisdiction in which it occurs, either directly or through an easement provided without cost to the jurisdiction.

TABLE III-A

Precipitation depth-duration-frequency data for the San Francisco Bay region

Duration	Recurrence interval (years) \ P_{MA}	Storm precipitation, in inches, corresponding to indicated values of mean annual precipitation (P_{MA}), in inches											
		10	12	14	16	18	20	30	40	50	60	70	80
5 minutes	2	0.08	0.10	0.11	0.12	0.13	0.14	0.16	0.19	0.21	0.23	0.26	0.28
	5	.12	.14	.15	.16	.17	.18	.21	.24	.27	.30	.33	.36
	10	.15	.17	.18	.19	.20	.21	.24	.28	.31	.35	.38	.41
	25	.17	.19	.21	.23	.24	.25	.29	.32	.36	.40	.44	.48
	50	.19	.21	.23	.24	.26	.27	.31	.35	.39	.43	.47	.51
	100	.21	.23	.25	.26	.28	.29	.33	.38	.42	.46	.51	.55
10 minutes	2	.13	.15	.17	.18	.20	.22	.25	.29	.32	.36	.40	.43
	5	.19	.21	.23	.25	.26	.27	.32	.37	.41	.46	.51	.56
	10	.23	.26	.28	.30	.32	.33	.38	.43	.49	.54	.58	.64
	25	.27	.30	.33	.35	.37	.39	.45	.50	.56	.62	.68	.74
	50	.30	.33	.36	.38	.40	.42	.48	.54	.61	.67	.73	.80
	100	.32	.36	.38	.41	.43	.45	.52	.58	.65	.72	.79	.86
15 minutes	2	.16	.19	.21	.23	.26	.27	.32	.36	.41	.46	.50	.55
	5	.25	.27	.29	.31	.33	.35	.41	.47	.52	.59	.65	.71
	10	.30	.32	.35	.38	.40	.42	.48	.55	.62	.68	.74	.81
	25	.34	.38	.42	.44	.47	.49	.56	.64	.71	.79	.86	.93
	50	.38	.42	.45	.48	.51	.53	.61	.69	.77	.85	.93	1.01
	100	.41	.45	.48	.52	.55	.57	.66	.74	.83	.91	1.00	1.08
30 minutes	2	.22	.26	.29	.32	.36	.38	.44	.51	.57	.63	.70	.76
	5	.34	.37	.40	.43	.46	.48	.57	.65	.73	.81	.90	.98
	10	.41	.45	.49	.52	.55	.58	.66	.76	.85	.94	1.03	1.12
	25	.47	.53	.58	.62	.65	.68	.78	.88	.99	1.09	1.19	1.30
	50	.52	.58	.62	.66	.70	.73	.85	.96	1.07	1.18	1.29	1.40
	100	.57	.62	.67	.72	.76	.79	.91	1.03	1.15	1.26	1.38	1.50
1 hour	2	.28	.33	.37	.41	.45	.48	.56	.64	.72	.80	.88	.96
	5	.43	.47	.51	.55	.58	.61	.72	.82	.92	1.03	1.14	1.24
	10	.52	.57	.62	.66	.70	.73	.84	.96	1.08	1.19	1.30	1.42
	25	.60	.67	.73	.78	.82	.86	.99	1.12	1.25	1.38	1.51	1.64
	50	.66	.73	.79	.84	.89	.93	1.07	1.21	1.35	1.49	1.63	1.77
	100	.72	.79	.85	.91	.96	1.00	1.15	1.30	1.45	1.60	1.75	1.90
2 hours	2	.45	.51	.56	.61	.66	.70	.85	1.00	1.15	1.30	1.45	1.60
	5	.67	.72	.76	.80	.84	.88	1.07	1.26	1.45	1.64	1.83	2.02
	10	.74	.79	.84	.89	.93	.97	1.18	1.39	1.60	1.81	2.02	2.23
	25	.90	.94	.99	1.03	1.08	1.12	1.34	1.56	1.78	2.00	2.22	2.44
	50	.98	1.03	1.07	1.12	1.16	1.21	1.44	1.67	1.90	2.13	2.36	2.59
	100	1.05	1.10	1.15	1.20	1.25	1.30	1.55	1.80	2.05	2.30	2.55	2.80
3 hours	2	.63	.68	.72	.77	.81	.86	1.09	1.32	1.55	1.78	2.01	2.24
	5	.78	.84	.89	.95	1.00	1.06	1.34	1.62	1.90	2.18	2.46	2.74
	10	.91	.97	1.03	1.10	1.16	1.22	1.53	1.84	2.15	2.46	2.77	3.08
	25	1.03	1.10	1.16	1.23	1.29	1.36	1.69	2.02	2.35	2.68	3.01	3.34
	50	1.14	1.21	1.28	1.34	1.41	1.48	1.82	2.16	2.50	2.84	3.18	3.52
	100	1.25	1.32	1.39	1.46	1.53	1.60	1.95	2.30	2.65	3.00	3.35	3.70
6 hours	2	.91	.99	1.07	1.16	1.24	1.32	1.73	2.14	2.55	2.96	3.37	3.78
	5	1.14	1.25	1.36	1.46	1.57	1.68	2.22	2.76	3.30	3.84	4.38	4.92
	10	1.30	1.42	1.54	1.66	1.78	1.90	2.50	3.10	3.70	4.30	4.90	5.50
	25	1.46	1.59	1.72	1.86	1.99	2.12	2.78	3.44	4.10	4.76	5.42	6.08
	50	1.60	1.74	1.88	2.02	2.16	2.30	3.00	3.70	4.40	5.10	5.80	6.50
	100	1.73	1.88	2.02	2.17	2.31	2.46	3.19	3.92	4.65	5.38	6.11	6.84
12 hours	2	1.04	1.18	1.33	1.47	1.62	1.76	2.48	3.20	3.92	4.64	5.36	6.08
	5	1.44	1.61	1.78	1.94	2.11	2.28	3.12	3.96	4.80	5.64	6.48	7.32
	10	1.70	1.88	2.06	2.24	2.42	2.60	3.50	4.40	5.30	6.20	7.10	8.00
	25	1.90	2.10	2.30	2.50	2.70	2.90	3.90	4.90	5.90	6.90	7.90	8.90
	50	2.15	2.36	2.57	2.78	2.99	3.20	4.25	5.30	6.35	7.40	8.45	9.50
	100	2.35	2.57	2.79	3.01	3.23	3.45	4.55	5.65	6.75	7.85	8.95	10.05

SECTION IV

EXISTING FACILITIES

A. GENERAL

The study area of the Canyon del Rey Watershed is made up of (28) subwatersheds. 14 are tributary to Canyon del Rey Creek from the south, 11 from the north, 3 almost parallel to Canyon del Rey Creek and also tributary from the north and 2 watersheds include the existing urbanized lower sectors. All these subwatersheds vary in size, length, elevation, type of soil cover, urbanization development and mean annual precipitation. The smallest subwatershed has a tributary drainage area of 45 acres and the largest 2.1 square miles.

The locations and sizes of both the existing and recommended future drainage facilities are shown on the Master Drainage Plan drawings, sheets 5 to 11. The structures are designated by boxed and circled numbers: (e.g., [5] for Primary Facilities and (3) for Secondary Facilities).

The 28 study area subwatersheds and their existing facilities are briefly described in this section. Where required, improvements to existing facilities are described in Section VI of this report and on Drawing 12 of the Master Drainage Plan Drawings.

B. EXISTING DRAINAGE FACILITIES

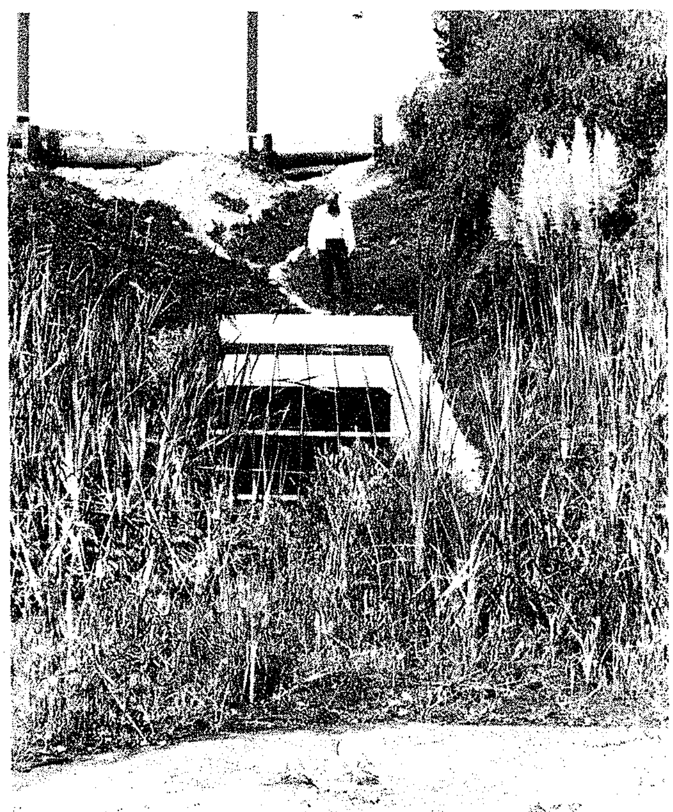
Subwatershed No. 1

This 165-acre subwatershed is located at the upstream limit of the study area. Its western ridge divides the runoff between the El Toro Creek Watershed and Canyon del Rey Watershed. It has no defined watercourse. Secondary culverts under paved residential roads by-pass the runoff down to Highway 68. Secondary Structure (1), a 12-inch reinforced concrete pipe (RCP), passes the runoff under Laguna Place Road. About 70% of the runoff goes under Highway 68 through an 18-inch RCP with a rounded entrance, Secondary Structure (2), and flows to the north side forming the upper reaches of Canyon del Rey Creek. In this location there is a side road ditch along Highway 68. The remaining 30% of the runoff moves as sheet flow paralleling Highway 68 along the south side until it reaches the next structure under Highway 68.

Subwatershed No. 2

This subwatershed has a tributary drainage of 410 acres and its southerly upper ridge divides the runoff between the Carmel and Canyon del Rey watersheds. The lower northern end of this watershed includes a sector of Highway 68. It has well defined watercourses in the upper reaches that combine with runoff flow down to Highway 68 along creeks and a side road channel paralleling Laureles Grade Road. The runoff is passed under Highway 68 through a protruding 18" x 28" corrugated metal pipe (CMP) arch, Primary Structure [3], which is the second hydraulic facility under Highway 68. At its inlet there is a flat ponding area and the outlet discharges directly into a Canyon del Rey side road ditch.

CANYON DEL REY CREEK BEGINS AS A ROADSIDE DITCH NEAR THE UPPER REACHES OF THE WATERSHED



INLET TO STRUCTURE 42 UNDER MONTE MART AT FREMONT AVE. NEAR THE LOWER END OF THE WATERSHED

Subwatershed No. 3

This subwatershed has a tributary drainage of 59 acres. It is steep and its lower part includes a sector of Highway 68. The runoff flows directly from the upper parts to the inlet of a 24" CMP, Secondary Structure (8). This is the third hydraulic facility crossing Highway 68. It has a flared inlet and a steeply sloped culvert which collects runoff from the side road ditch that flows under two private roads. It crosses the first private road through an 18" CMP, Secondary Structure (5), and the second private road to the SPCA through a 36" CMP, Structure (6).

Subwatershed No. 4

This subwatershed has a tributary drainage of 296 acres with very little development. It has a central watercourse that ends at a pond immediately at the south side of Highway 68. At the north side of Highway 68, the Canyon del Rey watercourse widens and ponds upstream from the ranger station. A culvert that carries the runoff from subwatershed 4 under Highway 68 ends at this pond. This is Secondary Structure (9), a 24" CMP that has no noticeable longitudinal slope. This hydraulic facility will pass water from one side of the highway to the other when the water surface is above the pipe invert flowing from the higher pond level to the lower.

Subwatershed No. 5

This is the smallest subwatershed of this study with a tributary drainage of only 45 acres. It is very steep and the north side includes a sector of Highway 68. There are three culverts under the highway to pass the runoff to Canyon del Rey Creek as follows:

Secondary Structure (11) - 24-inch CMP with flaired inlet
Crossing No. 5

Secondary Structure (12) - 18-inch CMP with flaired inlet
Crossing No. 6

Secondary Structure (13) - 16-inch CMP, Crossing No. 7

Subwatershed No. 6

This subwatershed has a tributary drainage area of 357 acres. It extends from the dividing ridge of the Carmel Watershed on the southside to Canyon del Rey Creek at the north side. At the north-easterly end of this watershed, Canyon del Rey Creek crosses Highway 68, flowing from the north side of the highway to the southside through a 36" CMP Primary Structure [14]. This is the 8th culvert under Highway 68. The lower portion of this watershed is flat and the rather well defined watercourses of the upper reaches disappear approaching the lower sector. When the amount of runoff is greater than the water losses by percolation the excess runs off to Canyon del Rey Creek.

Subwatershed No. 7

This subwatershed has a tributary drainage of 196 acres. It has a well defined creek channel that extends from the upper reaches, close to the dividing line with the Carmel Watershed, down to a gravity dam built close to Canyon del Rey Creek. A paved road, Hidden Hill Road, climbs to the upper part of this watershed where a substantial amount of earth work has already been done readying the land for subdividing. The dam discharges through a 24" CMP that ends in a concrete box energy dissipator. The dam also has a concrete spillway. Closer to Canyon del Rey Creek there is another 24" CMP, Secondary Structure (17), under a private unpaved road. The water passes through its outlet and joins the runoff from Watershed 6 before flowing to Canyon del Rey Creek. A short distance downstream, Canyon del Rey Creek crosses Highway 68 northbound. This is the 9th culvert under Highway 68 which is Primary Structure [16], a 48" CMP. Downstream from the dam there is a 12" CMP, Secondary Structure (18), under Boots Road through which local runoff passes to the west side road ditch. All runoff from this westerly part of the watershed finally flows to a drop inlet at the south side of Highway 68. Here, Secondary Structure (19), a 24" CMP, conducts the runoff to Canyon del Rey Creek on the north side.

Subwatershed No. 8

This subwatershed has a tributary drainage of 160 acres. The distance from the highway to the upper watershed reaches is shorter than its width. It is very steep and undeveloped. At the east sector of this watershed the runoff collected along the south road ditch of Highway 68 is conducted under the highway through an 18" CMP, Secondary Structure (20), to Canyon del Rey Creek, constituting the 11th crossing under Highway 68. At the inlet the water forms a rather large storage pond before it starts flowing. The soil is very soft and of granular nature. About 1200 feet west along Highway 68, Canyon del Rey Creek crosses the highway. The runoff flows southerly through a 54" CMP, Primary Structure [21], this being the 12th crossing under the highway. The only watercourse in this watershed disappears as it approaches Canyon del Rey Creek. Approaching the west limit of this watershed the water of Canyon del Rey Creek is conducted to the north side of the highway through a 48" CMP, Primary Structure [22], constituting the 13th crossing under Highway 68.

Subwatershed No. 9

This subwatershed has a tributary drainage of 166 acres and is very similar to the previous watershed (No. 8). Two culverts conduct the runoff northbound to Canyon del Rey Creek. The first culvert is a 24" CMP with a flared inlet, Secondary Structure (23), constituting the 14th crossing under Highway 68. The second sulvert is also a 24" CMP with a flared inlet, Secondary Structure (24), constituting the 15th crossing under the highway.

Subwatershed No. 10

This is a large subwatershed with a tributary of 1018 acres. The upper reaches begin at the dividing line with the Carmel Watershed. Its shape resembles a triangle with its base in the upper part and its vertex at Highway 68. The main watercourse is well defined and as it goes downhill the runoff concentrates in one channel and passes under the highway through a 6' x 3' foot reinforced concrete box, Primary Structure [27], constituting the 16th crossing under Highway 68.

Subwatershed No. 11

This bell-shaped subwatershed has a tributary drainage of 332 acres with its widest part at Highway 68. At the east sector of this watershed the runoff collected along the south road ditch of Highway 68 is passed under the highway through a heavily silted 18" CMP, Secondary Structure (28), this being the 17th crossing under the highway. About 1000 feet westward from Structure (28) Canyon del Rey Creek crosses the highway northbound. This is the 18th crossing under the highway. It is a triple 30" CMP, Primary Structure [29]. The excess runoff from this watershed flows directly to Canyon del Rey Creek located on the north side of Highway 68.

Subwatershed No. 12

This subwatershed has a tributary drainage of 469 acres. Its upper reaches extend to the Carmel watershed dividing line. As the runoff moves downstream the watershed becomes more and more narrow and the water concentrates in a single watercourse paralleling a private farm road. As the runoff approaches Canyon del Rey Creek it spreads out, funning as sheet flow. The water from Canyon del Rey passes under this private road through a 3.5-foot x 8.5-foot bridge, Primary Structure [30], which is located a few feet from and parallel to Highway 68.

Subwatershed No. 13

This is a 170-acre tributary drainage subwatershed extending to Watershed 12 on the east and Watershed 14 on the west. At its northerly end it connects directly with Canyon del Rey Creek. Runoff passes to Canyon del Rey Creek mostly as sheet flow.

Subwatershed No. 14

This subwatershed has a tributary drainage of 366 acres. it has one defined watercourse that joins Canyon del Rey Creek before crossing Highway 68. This is the 19th structure crossing under the highway. It is a double 48" RCP with a rounded entrance, Primary Structure [31]. Additional water moves down side road ditches of Highway 68. Past the outlet of this structure the channel becomes more shallow upon crossing the flatlands.

Subwatershed No. 15

This subwatershed has a tributary drainage of 263 acres and is located in the north-eastern sector of the study area. Although there are a few roads, it lies inside the Ford Ord military reservation and is basically unurbanized. Canyon del Rey Creek begins here as a small north side road ditch paralleling Highway 68. As the runoff flows in the channel it combines with water from Watershed 1 and Raceway Road through a 12" CMP, Primary Structure [4], parallel to Highway 68. About 300 feet downstream there is another branch of the Laguna Seca Raceway Road that has no apparent hydraulic facility for conveying this runoff; however, about 450 feet further downstream from this point, there is another connecting road to Highway 68 and the runoff is bypassed by way of it through a 48" CMP, Primary Structure [7], paralleling the highway.

Subwatershed No. 16

This subwatershed has a tributary drainage of 228 acres. About 95% of this area lies inside the military reservation. The upper reaches of the northerly side extend to the Laguna Seca Race Track. From this point the runoff flows downstream along two defined creeks. These watercourses combine along one single creek as the longitudinal slope decreases, with some check dams at the bottom. Finally, this runoff flows to the Canyon del Rey main watercourse and collects at a pond formed at the Laguna Seca Ranger Station. Located at this point is a 36" CMP, Primary Structure [10], which is an outlet for this pond, paralleling Highway 68. It has a drop inlet and at its outlet the water drops down about 5 feet and enters a true canyon.

Subwatershed No. 17

This subwatershed has a tributary drainage of 388 acres. The upper reaches are inside the military reservation and the lower part extends down to Canyon del Rey Creek. The creek crosses the highway southbound through a 36" CMP, Primary Structure [14]. A few roads already exist within this watershed and it appears that rather extensive development is planned for the future.

Subwatershed No. 18

This long and narrow subwatershed has a tributary drainage of 302 acres and is very similar in its characteristics to Watershed 17 but has some existing development. In the lower limit of this watershed is Canyon del Rey Creek which crosses the highway in a northbound direction through a 48" CMP, Primary Structure [16]. Runoff flowing along the north side road ditch is conducted to the creek through a 12" CMP, Secondary Structure (15), paralleling the highway under an uphill road.

Subwatershed No. 19

This subwatershed has a tributary drainage of 153 acres. Here the watercourse is more defined than those in the two previous watersheds. Canyon del Rey Creek, in the lower southerly limit of this watershed, crosses Highway 68 in a southerly direction through a 54" CMP, Primary Structure [21], the 12th hydraulic structure crossing under Highway 68.

Subwatershed No. 20

This subwatershed has a tributary drainage of 124 acres. It has one central watercourse and some existing development; more development appears to be planned for the future. It has one hydraulic structure, a 48" CMP, Primary Structure 22, at the crossing of Canyon del Rey Creek with Highway 68.

Subwatershed No. 21

This subwatershed is about the same in length and width, with a tributary drainage of 141 acres. The watercourse is not well defined as it approches the lower reaches of the watershed, where subdivisions already exist. There is only one hydraulic structure at the west limit of this watershed which is located under Larkspur Lane paralleling Highway 68. This is a 48" CMP, Primary Structure 25. Runoff ponds before being vented by the drop inlet of this structure.

Subwatershed No. 22

This subwatershed, very similar to the previous one, has a tributary drainage of 141 acres. It has a well defined watercourse at the east side of York School and has only one hydraulic structure which is in the westerly limits of this watershed under the road that goes to York School. This is a 12 foot x 7 foot bridge, Primary Structure 26, paralleling the highway.

Subwatershed No. 23

This subwatershed has a tributary drainage of 185 acres and a defined watercourse only in its lower reaches, and is undeveloped. It has only one structure, a triple 30" CMP, Primary Structure 29, to conduct all Canyon del Rey runoff under Highway 68 in a southerly direction.

Subwatershed No. 24

This subwatershed has a tributary drainage of 143 acres. It has only two watercourses, both of which are in the lower reaches joining together in a parallel ditch before reaching Highway 68. The runoff then flows west and is passed under Canyon del Rey Road to join the main runoff by a 6 foot x 6 foot reinforced concrete box, Primary Structure 32. This watershed is undeveloped.

Subwatershed No. 25

Subwatershed 25 has a tributary drainage of 108 acres. It has one defined watercourse which conducts the runoff southbound to the steeply sloped main channel under Canyon del Rey Road through an 18" CMP, Secondary Structure (33). About 1400 feet downstream from this junction all runoff from Canyon del Rey is conducted in a northerly direction under Canyon del Rey Road through a 6' x 8' RCB, Primary Structure 38 to the upper end of the "Frog Pond." At the entrance road to the Board of Education, three Secondary culvert pipes are located as follows:

(34) a 24" CMP under Canyon del Rey Road to conduct all local runoff to the main channel at the southside.

(35) a 12" CMP from uphill parallel to the entrance road.

(36) a 15" CMP parallel to Canyon del Rey Road under the entrance road.

Subwatershed No. 26

This is the largest subwatershed with a tributary drainage of 1130 acres. It extends totally inside the military reservation. Its upper reaches coincide with the higher reaches of Watersheds 18 and 19. It is long and narrow and for the most part parallel to Canyon del Rey Creek until it become tributary in the lower reaches at the entrance road to Fort Ord. This watershed has a well defined watercourse, is undeveloped and projected to remain in that condition.

Subwatershed No. 27

This subwatershed extends into the urbanized sector of the study area. It has a tributary drainage of 350 acres, all of which are tributary to Canyon del Rey Creek. Its limits are the airfield in the south and Plumas Avenue in the north and it extends downstream to the inlet of the existing 8' x 8' reinforced concrete box, Primary Structure [42], under Fremont Avenue. Primary Structure [37], a 90" CMP under Canyon del Rey Gardens Road, parallels Canyon del Rey Road (Highway 218) at the easterly end of the subwatershed. Canyon del Rey Creek then passes under Canyon del Rey Road and into the upper end of the "Frog Pond" through Primary Structure [38], a 6' x 8' RCB. The upper and lower ends of the "Frog Pond" are linked by Primary Structure [39] an 8' x 10' RCB under an entrance road to Fort Ord. The runoff flows from the "Frog Pond" crossing Canyon del Rey Road through a 7' x 6' reinforced concrete, Primary Structure [40], and continues along a well defined channel at the bottom of the creek. Several bridges cross this channel as private entrance to residences. At the crossing with Rosita Road the runoff is conduct through a 6' x 6' reinforced concrete box, Primary Structure [41].

Subwatershed No. 28

This last subwatershed has a tributary drainage of 840 acres of totally urbanized land. Its watershed boundaries are determined by the existing storm drainage system and all runoff is collected directly by Laguna Grande and Lake Roberts which are projected to act as a single body of water after the planned hydraulic improvements. Primary Structure [44], is the link between these two lakes. Primary Structure [43] is a 6' x 6' reinforced concrete box and conducts the flow under Kolb Ave. to Laguna Grande. Under Roberts Ave., the runoff from the lakes is passed through a damaged 48" CMP, Primary Structure [45] and finally the runoff flows to the beach through a 4 - 6' x 6' reinforced concrete box Primary Structure [46].

SECTION V

EROSION AND SEDIMENTATION IN THE CANYON DEL REY WATERSHED

A. INTRODUCTION

The Canyon del Rey watershed is divided into two dissimilar halves. The northern half, consisting of Fort Ord and the Town of Seaside consists of recent and older Pleistocene coastal sand dune fields (USGS 1974). The overlying these dune fields are therefore very permeable and, while erosion rates can occur on the steeper slopes, almost all of the material is deposited immediately downslope with very little sand being transported by significant distances or being washed into the Canyon del Rey itself.

The southern half of the watershed consists of Pleistocene alluvium exposed on steep slopes (the Paso Robles formation) and silacious and diatomite shales form the Miocene (the Monterey Shales). The soils on these geologic units are predominatly of the Santa Lucia and Santa Ynez series that have moderate to low permeability, high runoff rates and have erosion ratings of "very high" and "high" respectively. (S.C.S. 1975) (See attached erosion hazard map). Accordingly, it is expected that almost all sediment now being contributed to the creek derives from these steep sloping soils overlying the Monterey Shales in the southern half of the watershed. Eroded sediments from these soils are transported to the valley bottom and have created an extensive alluvial plain along the length of Canyon del Rey. Sediment has accumulated here because the slope and flow of the creek are insufficient to transport them further. However, in the recent past, the creek has degraded significantly incising a new channel approximately 5 to 10 feet below the old flood plain terrace. The juvenile stage of development of the new flood plain means that, during floods, large amounts of sediment will be eroded from the banks and from gully headcuts of tributaries. In these circumstances, the amount of sediment carried by the stream is limited, not so much by the supply from the upper watershed, but more by the transporting power of the flow.

B. METHODOLOGY

Predicting the sediment loads of watercourses is a complex and imprecise science. The best method is to obtain reservoir sedimentation rates or suspended sediment data for the creek in question over a wide range of flows. Data are not available for Canyon del Rey, nor are empirical methods such as the Universal Soil Loss Equation (Wischmeier & Smith 1960) and the Anderson equation set (Anderson 1975) applicable for this type of climate, watershed type and size. Accordingly, average annual and specific storm event sedimentation loads must be estimated by less direct methods.

1. Siltation in Laguna del Rey

The volume of sediment accumulated in Laguna del Rey is an integration over time of the annual sediment loads of Canyon del Rey. In the natural system, periodic large floods would break through the barrier beach to the ocean carrying with them large volumes of sediment from the lagoon. Since the 1930's man's activities has modified the overflow. Although unfortunately, no surveys have been taken of the lagoon, soil borings have been made that indicate that about 40 years ago, the lagoon bottom was about -2' MSL. The lagoon is now estimated to be about 7 feet deep which means the bottom is now at about 0 MSL.

This accumulation amounts to an average annual inflow of about 50,000 cubic ft./year or 2500 tons/year assuming 100 lbs./cubic ft. density. However, this volume includes large amounts of wind blown sand, sediment from construction activity and organic material and it is uncertain how useful this is as an indication of upstream erosion.

2. Correlation With Reservoir Siltation in Other Watersheds

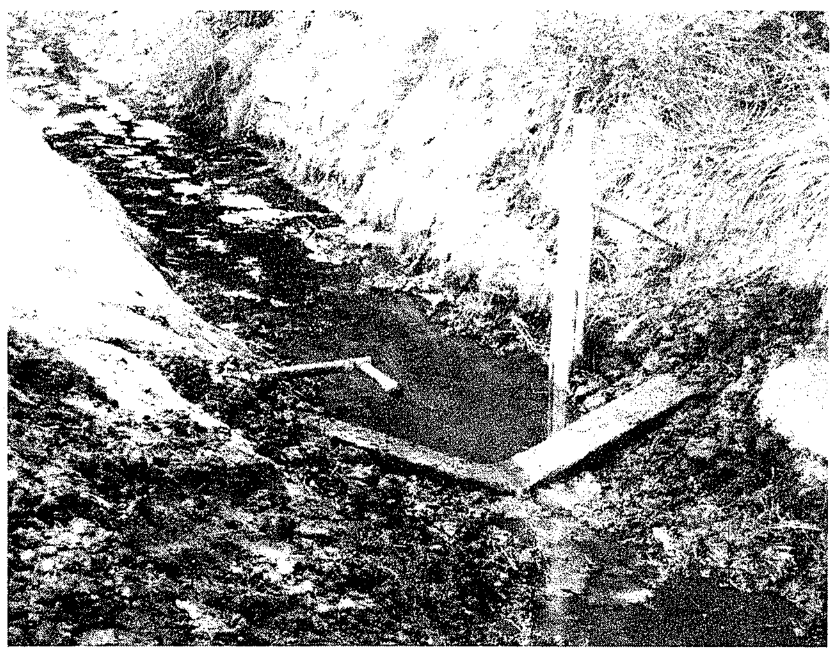
Erosion data has been collected for watersheds in the San Francisco Bay area based on sedimentation surveys of reservoirs (Brown & Jackson 1973). However, all of this information has been collected for larger watersheds with higher rainfall than the Canyon del Rey Watershed. The data is summarized in the attached Table V-A.

Based on this comparison, it would appear that Canyon del Rey has average annual suspended sediment loads of the order of 50 tons/square mile or about 700 tons at the stream gaging station in the park at Del Rey Oaks. It should be noted that sediment loads in the minor tributaries in the southern half of the watershed will be much greater than this value; however, they are not carried on into the main watercourse.

3. Calculation From Sediment Discharge Curves

Suspended sediment data has been collected for a number of creeks in the area. Of these, Colma Creek appears to be the most similar in watershed size, topography, soil erodibility and rainfall. Using sediment discharge relationships observed for Colma Creek (Knott 1973) (See Figure V-1) the sediment discharge for Canyon del Rey can be estimated from its own stream flow records. It is found that the average annual flood on Canyon del Rey (the 2.33 year flood) closely approximates the 1970 flood and that the 1970 water year was a typical "average" rainfall year. The 1970 flow record was therefore used to determine the sedimentation rate for an average year using the procedure outlined in the ASCE Sedimentation Engineering Handbook (ASCE 1975, P. 482). The total suspended load was calculated to be 14.5 tons as shown in Table V-B. The same method is used to determine the sediment load of the predicted 2.33 year, the 10 year and 100 year floods before and after urbanization based on the flood frequency diagram of Figure V-2. These are summarized on Table V-C.

TYPICAL SEDIMENTATION OF CULVERTS ON TRIBUTARIES TO CANYON DEL REY CREEK



U.S.G.S. STREAM GAGE IN DEL REY OAKS CITY PARK IMMEDIATELY AFTER REMOVAL OF ACCUMULATED SEDIMENT

The 1970 annual sediment load is expected to be lower than the average annual sediment load, because of a negative averaging bias in the daily flow records and in the period summation. Based on this information it is estimated for design purposes that the total average annual sediment load will be about 50 tons/square mile or 700 tons/year at the USGS gaging station.

4. Effect of Urbanization

The direct effects of urbanization on the suspended load, through its influence on the flood hydrograph, can be seen in Table V-C which shows that, because of the increase in runoff, the sediment production rate is increased 1.5 to 2 times. Two other processes that can greatly increase erosion rates are not reflected in these numbers.

Accelerated Erosion During Construction - The Colma Creek Study showed erosion rates of up to 2 orders of magnitude higher for several years after construction activity (Knott 1973).

Accelerated Gullying - The large alluvial valley deposits are extremely susceptible to gullying from the newly incised stream course. If runoff is concentrated or increased at certain points, gullying can start, contributing approximately 15 tons of sediment per foot of gully as it advances.

C. MITIGATION

To prevent additional erosion and consequent sedimentation downstream in Laguna del Rey, certain preventive measures should be taken:

1. Enforcement of erosion control ordinance for any new construction in the watershed.
2. Design of street drainage to maximize retention and minimize impervious surface area and street flooding.
3. Prevention of construction activity on unstable slopes.
4. Prevention of additional gullying of alluvial terrace by maintaining riparian vegetation.
5. Design the Del Rey Oaks "Frog Pond" as a sediment catch basin for large floods. This would require permanent dedication of this area for wetland, design of spillway at the highway 218 crossing, and provision of access to remove accumulated sediment. It is estimated that the 10-acre area will have a maximum of about 100 acre-feet of storage and a trap efficiency of about 85% (Brune 1953).

TABLE V-A

RESERVOIR SILTATION RATES

Reservoir Name	Watershed Area Mile^2	Average Runoff Acre Ft/Mile^2	Erosion Rate Tons/Mile^2	Comments
San Pablo	30.6	260	2700	Longest Available Records
Upper San Leandro	29.2	260	3300	Longest Available Records
Chabot	41.7	260	2100	Longest Available Records
Uvas	21.0	1000	970	
Pacheco	66.0	130	118	
Canyon del Rey	14.3	40	--	At Gaging Station

TABLE V-B

1970 ANNUAL HYDROGRAPH

Flow Range	(1) Flow Mid Point cfs	(2) Number of Days	(3) Sediment Rate Tons/Day	(4) Total Tons (2) + (3)
1-1.9	1.5	6	0.02	0.1
2-2.9	2.5	4	0.07	0.3
3-3.9	3.5	2	0.15	0.3
4-5.9	5.0	3	0.35	1.1
6-7.9	7.0	1	0.8	0.8
8-9.9	9.0	1	1.5	1.5
10-11.9	11.0	1	2.4	2.4
12-14.9	13.5	2	4.0	8.0
				14.5 Tons

NOTE: Values indicated are at the existing stream gage in the Del Rey Oaks City Park. (U.S.G.S. Station 11143300).

TABLE V-C

COMPARISON OF SEDIMENT TRANSPORT RATES AT DEL REY PARK

Storm Frequency	Watershed Conditions	Peak cfs	Qs Tons
10	Existing	148	210
10	Future	214	410
100	Existing	794	8,900
100	Future	960	14,300
2.33	1970	40	14

NOTE: Values indicated are at the existing stream gage in the Del Rey Oaks City Park. (U.S.G.S. Station 11143300).

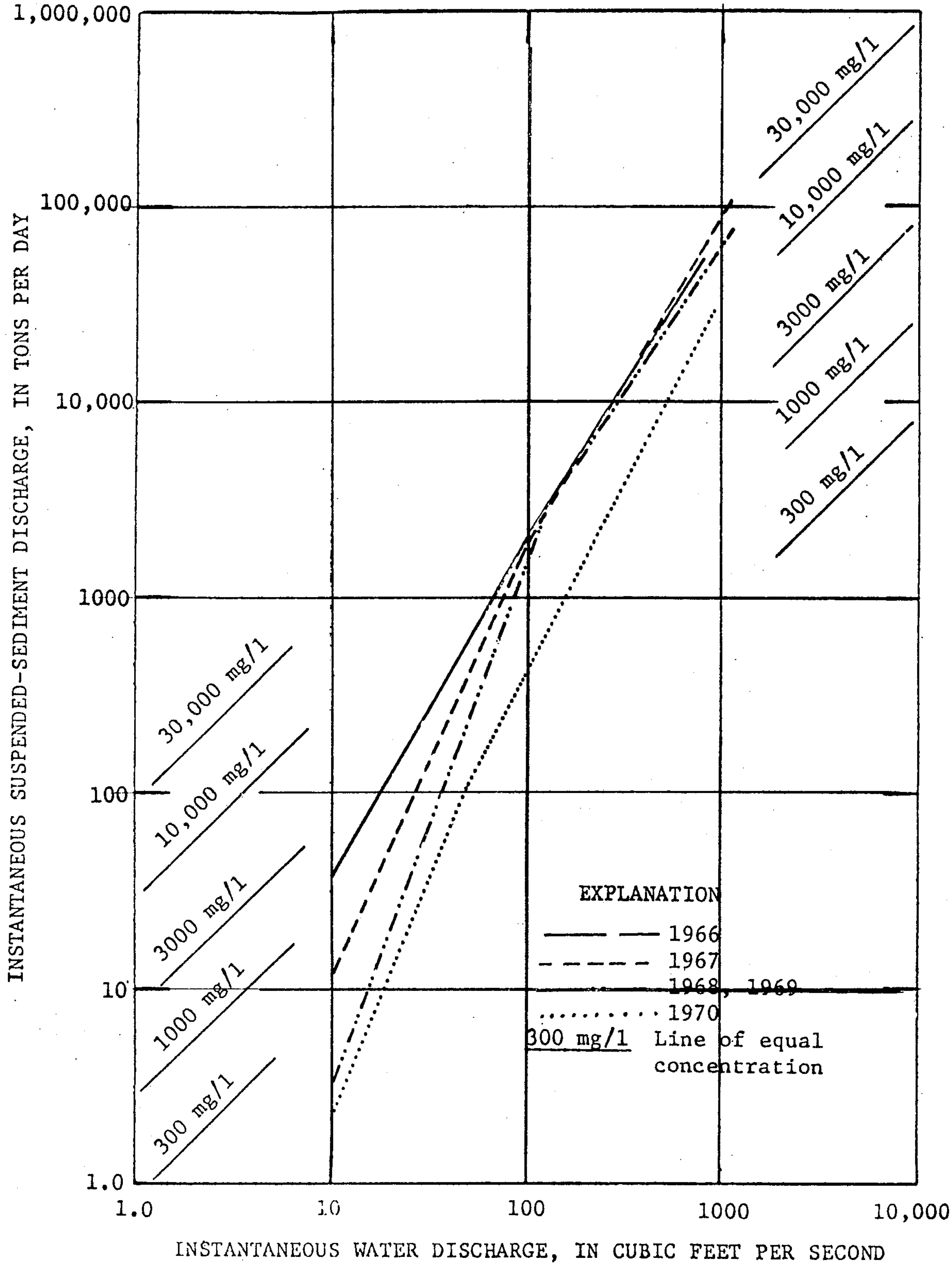
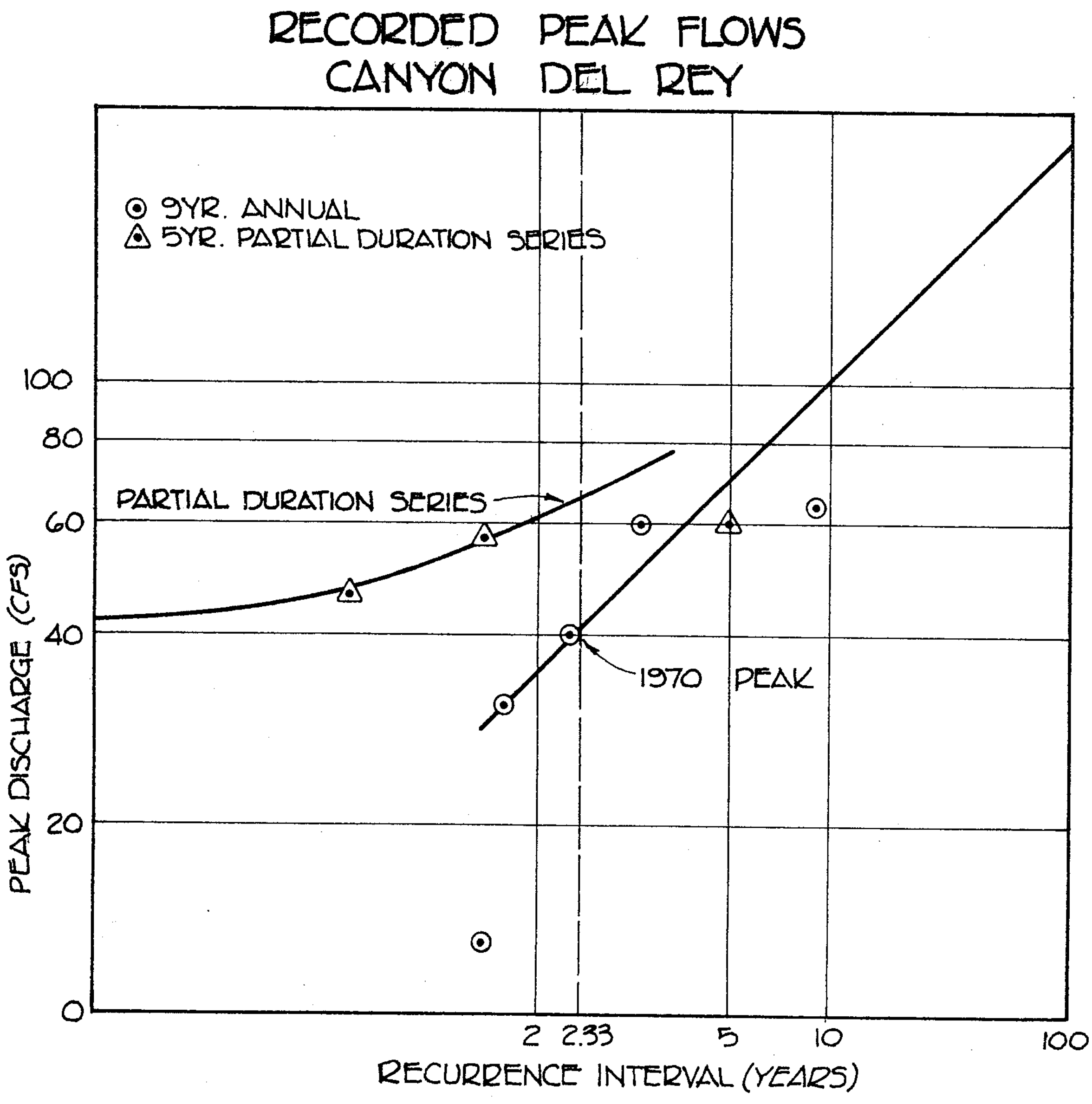


FIGURE 14.--Relation of suspended-sediment discharge to water discharge, Colma Creek at South San Francisco, 1966-70 water years. FROM KNOTTS, 1973.

FIGURE V-1



RECORDED PEAK FLOWS
CANYON DEL REY
9YR. ANNUAL
5YR. PARTIAL DURATION SERIES
PARTIAL DURATION SERIES
1970 PEAK
PEAK DISCHARGE (CFS)
100
80
60
40
20
0
2
2.33
5
10
100
RECURRENCE INTERVAL (YEARS)

FIGURE V-2

PREDICTED FLOOD FREQUENCY
CANYON DEL REY

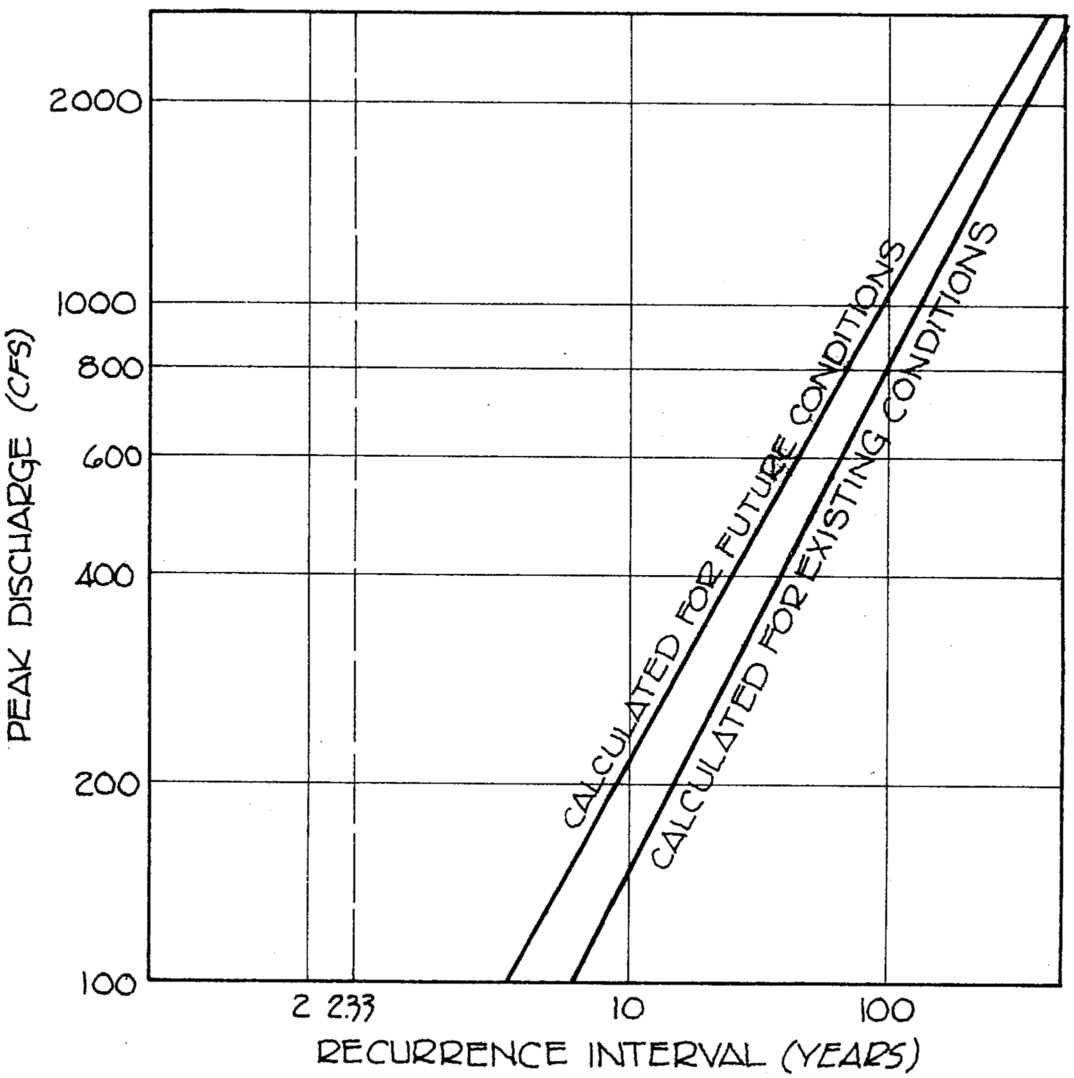


FIGURE V-3

SECTION VI

RECOMMENDED FACILITY IMPROVEMENTS

A. GENERAL

This section contains a brief description of recommended improvements to existing hydraulic structures, as well as a preliminary sizing of recommended new structures. The locations and sizes of both existing and recommended drainage facilities are shown on the Master Drainage Plan Drawings, Sheets 5 through 11. The existing structures not discussed herein are considered adequate or out of the scope of the authority of the County. Structures are designated by boxed numbers (e. g. [8]) for Primary Structures and circled numbers (e.g. (8)) for Secondary Structures. The following criteria were used as a basis for the recommendations:

- o All primary facilities shall pass the runoff from a 100-year storm without inundating permanent structures.
- o All secondary facilities shall pass the runoff from a 10-year storm without inundating permanent structures.
- o Traffic on the main roads shall not be disrupted by floodwaters.
- o Watercourses and ponding areas shall not be encroached upon and drainage structures should be maintained in as hydraulically efficient a state as possible.
- o Every attempt should be made to retain the area known as the "frog pond" and the area just upstream from the Monte Mart Market as retention basin areas.

A summary of recommended improvements and the estimated costs for the primary facilities are shown on Drawings 12 of the Drainage Master Plan Drawings.

B. RECOMMENDED IMPROVEMENTS

Throughout the study area, a number of private driveways and roads cross primary watercourses. Although the County has no jurisdiction over these private facilities, the private owners should be notified of the drainage requirements for their structures in order for them to take appropriate action to avoid flooding or damage to their private property. The anticipated peak flows which these structures should be capable of passing may be determined from the information contained in this report if not specifically noted.

Subwatershed 2

The existing roadside ditches along the lower portion of Laureles Grade Road near Highway 68 should be enlarged to carry the future estimated Q_{10} of 81 cfs. A new 42-inch CMP Secondary Structure (3A) should be installed under Laureles Grade Road to carry the flow from the easterly roadside ditch under Laureles Grade Road.

The existing 28" x 18" corrugated metal arch under Highway 68, Structure [3], is undersized and should be replaced with a 6' x 2.5' reinforced concrete box.

Subwatershed 6

The existing 48-inch CMP, Structure [16], will not pass the 100-year future storm runoff without flooding Highway 68. Since the existing culvert is very deep, provide a parallel 36-inch CMP above the existing culvert.

Subwatershed 10

Structure [27] requires a parallel 4' x 3' reinforced concrete box culvert with adequate slope to prevent silting.

Subwatershed 11

The existing bridge, Structure [30], is on a private road. It is 8.5' x 3.5' with very little freeboard. The road should be raised several feet and the structure increased to not less than a 72 square feet opening.

Subwatershed 14

Structure [31], a double 48" RCP, is very undersized and should be replaced by a triple 7' x 4.5' reinforced concrete box culvert. Replace Structure [37], a 90" RCP, with a 12' x 7.5' box or an equivalent structure with a cross-section of at least 90 SF.

Subwatershed 15

Structure [4] is totally inadequate and water will overtop the private road. Replace with double 42" CMP and raise the road 2 feet.

Subwatershed 16

Structure [7], a 48" CMP, has approximately one-half the capacity required. Provide parallel 48" CMP with rounded headwall entrance. Structure [10], a 36" CMP, requires a parallel 36" CMP. Raise the private road about 2 feet to avoid weir flow over the road during the future 100 year storm runoff.

Subwatershed 17

Structure 14, a 36" CMP, has about one-half the capacity required to pass the routed future 100 year storm runoff. To avoid flooding Highway 68, a parallel 36" CMP with rounded common headwall entrance should be provided.

Subwatershed 22

Structure 25 is a 48" CMP at Larkspur Drive. It requires a parallel 42" CMP with a drop inlet and clearing of the approach channel. Structure 26, a 12' x 6' reinforced concrete box culvert at York School Road, requires removal of the existing trees blocking free flow to the entrance of the structure.

Subwatershed 23

Structure 29 is a triple 30" CMP under Highway 68. It is undersized to pass the routed future 100 year storm runoff as the available head is very limited. Replace the existing structure with a triple 6' x 3' reinforced concrete box culvert.

Subwatershed 27

Structure 38 is a 6' x 8' reinforced concrete box culvert under Highway 218. A parallel 6' x 8' RCB with a common-headwall and rounded entrance should be constructed.

Existing Structure 40 is a 7' x 6' RCB at the outlet of the "Frog Pond." It is inadequate to pass the routed 100 year future peak runoff in spite of the large upstream ponding area. A parallel 6' x 8" RCB with common headwall and rounded entrance is required. The invert should be one foot below the invert of the existing culvert.

Structure 41, a 6' x 6' RCB at Rosita Road, is undersized and needs to be replaced by a double 6' x 7' culvert. The approach channel has numerous private bridges for the driveways of several houses built on the upper part of its southern bank. A minimum clear vertical distance to the invert of the creek of 5 feet and a channel cross sectional area of 90 square feet should be maintained at these driveway bridges to insure passing the 100 year storm flow.

Structure 42, an 8' x 8' box culvert, under Monte Mart and Fremont Avenue is adequate when the upstrem pond is 8 feet deep. The entrance to the culvert must be kept from clogging and no land filling must be allowed in the ponding area upstream.

Subwatershed 28

Structure 43 is a 6' x 6' box culvert under the filled area at the end of Kolb Avenue. It is undersized and the water will pond at its entrance and increase the elevation of the pond upstream from Structure 42 . Structure 43 should be replaced with an open channel to Laguna Grande or an extension of the existing 8' x 8' culvert, Structure 42 , to Laguna Grande if the filling area is to be used.

Structure 45 is a collapsed 48" CMP. It is presently the only outlet structure out of Roberts Lake. This structure should be replaced with a double 8' x 6' reinforced concrete box culvert. The inlet to the new culvert must be designed so that the lakes will maintain the desired operating elevation. During a future 100 year storm, consideration should be given to permit the lakes to rise 1 or 2 feet for a short period of time.

C. ADDITIONAL RAIN AND STREAM GAGES

All the existing rain gages within the Canyon del Rey Watershed are located at the westerm end of the watershed within the presently urbanized area. Therefore, locations for 4 additional rain gages are proposed.

1. At the northeastern edge of the watershed near Laguna Seca Race Track. Approximate elevation 750.

2. At the easterly end of the watershed at the Laguna Seca Ranger Station. Approximate elevation 400.

3. Near the center of the watershed near York School. Approximate elevation 370.

4. At the southwestern edge of the watershed south of the airport. Approximate elevation 530.

Records from the proposed rain gages will make it possible to precise the isohetal map for the watershed. See Drawing 2 for the location of the proposed gage sites.

The only stream gage on Canyon del Rey Creek is located in the park at Del Rey Oaks. This is near the lower (westerly) end of the watershed. Locations for 2 additional stream gages is proposed.

1. At the York Road Bridge.

2. Downstream of the Structure 20 crossing of Highway 68 in Subwatershed 18.

Stream gages at these locations will provide verification of flows anticipated in Canyon del Rey Creek and indicate flow changes due to future urbanization in the valley.

SECTION VII

RECOMMENDATIONS

A. IMPLEMENTATION OF MASTER DRAINAGE PLAN

To implement the Master Drainage Plan for the Canyon del Rey Creek Watershed as presented herein, the following procedures are recommended:

1. Complete all steps necessary for adoption by the County Board of Supervisors of this Master Drainage Plan.

2. Complete all steps necessary for the adoption of a Canyon del Rey Creek Watershed Zone. This should include the dissolution of any existing small service areas as well as agreements and arrangements with any existing entities, including cities, related to any drainage facilities which, upon adoption of this Master Plan will fall under the jurisdiction of the Monterey County Flood Control and Water Conservation District. Jurisdiction as defined in Section III, Paragraph B, of this report.

3. Establish a Watershed Zone Advisory Committee who's members are technically knowledgeable and represent the jurisdictions within the watershed, and who's function would include:

   a. Advising the District on priorities for the construction of primary drainage facilities.

   b. Advising the District on priorities for the construction of secondary drainage and sediment-mitigation facilities under their jurisdiction as defined in Section III.

   c. Scheduling the collection of charges for the Primary Facilities Updating Fund.

   d. Recommending an operation and maintenance program including sediment-mitigation works together with the necessary source of funding.

   e. Carrying out any requests of the District related to the Zone.

   f. Generally keeping the District informed of conditions in the Watershed Zone, including details of proposed sedimentation-mitigation works.

4. Complete all steps leading to the adoption of the recommended addition to the County Drainage Ordinance to cover the Canyon del Rey Creek Watershed presented in this report.

5. Upon recommendation by the Zone Advisory Committee, providing appropriate funds are available, contract for the design and construction of the required primary facilities.

6. Provide for regular ongoing review and updating of the Master Drainage Plan at intervals not to exceed five years. This updating should take into account new developments, pending new developments, changes in developments from those projected in the Master Drainage Plan, new approaches to the technical aspects of the Plan and additional information as it becomes available from rain gages, stream gages, and other records; all including siltation-mitigation.

7. Plans for all new construction in the Canyon del Rey Creek Watershed should be submitted to the District accompanied by a detailed delineation of erosion control measures proposed with back-up computations, including siltation retention works, prevention of construction activity on unstable slopes, design of street drainage to maximize retention and minimize impervious surface area and a program for maintaining riparian vegetation to prevent additional gullying of alluvial terraces. No construction shall be undertaken prior to District approval of such plans.

8. Since significant quantities of sediment will be generated in the watershed, unless adequate preventative steps are taken for its prevention and/or mitigation, the following measures should be taken:

   a. Plans for any new construction in the watershed including that by all levels of governmental agencies, should delineate a positive plan for erosion control and reduction of storm water runoff peak flows. These plans should include consideration of siltation retention works, percolation facilities, energy dissipators, prevention of construction on unstable slopes, minimization of impervious surfaces, maintenance of vegetation in the natural waterways and any other method of reducing runoff and erosion. All plans should be submitted to the District, and any other jurisdictional agency for review and approval.

   b. Although every effort should be made to reduce peak flows and erosion in the future developments further up the watershed, an agreement should be consummated (including arrangements for appropriate financial reimbursements) to reserve the Del Rey Oaks "Frog Pond" as a water and sediment catch basin. This area should be permanently dedicated as a "Wetland," an outlet designed at Highway 218, and provisions made to remove and dispose of any accumulated sediment.

   c. Any required agreements and arrangements should be consumated to retain and maintain the area just east of the box culvert under the Monte Mart at Fremont Blvd. for drainage retention and as a sediment catch basin.

B. SUGGESTED ADDITIONS TO COUNTY DRAINAGE ORDINANCE

The following should be added to the County Drainage Ordinance recommended in the Monterey County Master Drainage Plan - Santa Rita Creek Watershed Report, dated August 1972 (Reference 1):

<u>Canyon del Rey Creek Watersheds Area - Cost - Future Charges</u>

1. <u>Local Drainage Area Designated</u>

   A local drainage area to be designated as the Canyon del Rey Watershed Zone is hereby created. This Zone shall consist of all territory within the limits shown on the local drainage plan and maps included in the report entitled, "Monterey County Master Drainage Plan - Canyon del Rey Creek Watershed, Drainage and Erosion." Copies of the report are on file with the Monterey County Flood Control and Water Conservation District, hereinafter, referred to as the "District."

2. <u>Cost</u>

The estimated total cost of constructing the local drainage and sediment - mitigation facilities required within the Zone shall be as indicated in the latest updating of the "Monterey County Master Drainage Plan - Canyon del Rey Creek Watershed, Drainage and Erosion."

3. <u>Charges for Updating Present Primary Facilities</u>

The ad valorem tax per $100 assessed valuation to develop a fund for updating, operating and maintaining existing primary facilities, or for providing, operating and maintaining new primary facilities, or for providing, operating and maintaining sediment-mitigation works, which are required in the Zone in the opinion of the District to achieve protection to accommodate existing condition flows shown in the latest edition of the "Monterey County Drainage Plan - Canyon del Rey Creek Watershed Drainage and Erosion" will be determined by the following formula (chargeable to all property owners within the Zone):

$$\frac{C_{PF}}{V_A} = \text{Ad Valorem Tax}$$

where C_{PF} is the cost estimated by the District to improve the primary drainage and sediment mitigation facilities as required to provide protection from the 100 year flows under existing conditions as shown in the latest edition of the Master Drainage Plan for the Zone.

V_A is the total assessed valuation divided 100 for the Zone.

Charges collected as described in paragraph 3 shall be deposited in the County's Canyon del Rey Creek Watershed Zone Primary Facilities Updating Fund as described below.

4. <u>Charges for Future Development</u>

In addition to their pro-rata share of the charges for updating, operating and maintaining present primary facilities as described in paragraph 3 above, all future developments within the Canyon del Rey Watershed Zone will be charged a drainage fee as determined by the following method:

$$\frac{C_{PFF} - C_{PFM}}{A_{FD}} = \text{Drainage Fee Per Acre}$$

where C_{PFF} is the cost estimated by the District for all downstream primary drainage facilities required between the development and Monterey Bay to pass the 100 year peak discharge from all tributary areas under anticipated future development including the proposed development.

C_{PFM} is the cost estimated by the District for all downstream primary drainage facilities required between the development and Monterey Bay as shown in the latest edition of the Master Drainage Plan for the Canyon del Rey Creek Watershed for the then existing conditions.

A_{FD} is the number of undeveloped acres projected to be developed by the latest adopted Master or General Plan.

All drainage fees collected under this paragraph shall be deposited in the County's Canyon del Rey Creek Watershed Zone Primary Facilities Updating Fund as described below.

5. Deposit and Use of Funds

There is hereby created in the County Treasury "Canyon del Rey Creek Watershed Zone Primary Facilities Updating Fund." The ad valorem tax collected under paragraph 3 and the drainage fees collected under paragraph 4 shall be deposited in this fund. These monies shall be expended solely for drainage in the Canyon del Rey Creek Watershed Zone. These charges will be collected by the County under waterever method is legally advisable that the County deems to be appropriate.

C. EXPLANATION OF DRAINAGE FEES

The methods of collecting drainage fees and charges proposed in Section VI-B above, have been established in recognition of two separate requirements. The first requirement is to develop a fund to pay for upgrading inadequate existing primary facilities to protect against the 100-year return period storm runoff for present day conditions. The second requirement is to raise funds to pay for any facility enlargements over and above those required for present conditions necessitated by increased discharges caused by future development.

It is proposed that the first requirement be met by the ad valorem tax included in paragraph B-3 above. This tax would be charged to all property owners within the watershed. The drainage fee included in paragraph B-4 is proposed to meet the second requirement. This fee would be charged only to future developers and only if the proposed developments would increase runoff to the point where the improvements required for present conditions had to be enlarged.

This fee would be in addition to the owner's pro-rata share of charges for updating present primary facilities as per paragraph B-3. It would also be in addition to any in-tract or secondary facilities needed to satisfactorily discharge flow and to mitigate siltation from the development to a main watercourse.

As part of this study, hydrologic and hydraulic evaluations were made for both the present and anticipated future development conditions within the watershed. The estimated construction costs for Primary Facilities for the 100 year storm under present urbanization and under future anticipated development were developed and are presented hereinafter and as drawing 12 of the plans.

If future development occurs differently than now projected, and primary facilities need to be enlarged or reduced in size from those included in the Master Drainage Plan to accomodate increased discharges from future developments, the formula included in paragraph B-4 will still provide a means of collecting the differential cost between present required and future required facilities. These changed conditions or projections, if they occur, will be determined during the periodic updating of the Master Drainage Plan.

CANYON DEL REY WATERSHED
PRIMARY DRAINAGE FACILITIES

STRUCTURE NO.	SUB-WATERSHED	DESCRIPTION OF EXISTING STRUCTURE	PRESENT CAPACITY EXISTING STRUCUTE	PEAK DISCHARGE 100YR. STORM FUT. cfs	PEAK DISCHARGE 100YR. STORM PRES. cfs	PRIMARY FACILITY REQUIRED FUTURE	ESTIMATED COST FUTURE	PRIMARY FACILITY REQUIRED PRESENT	ESTIMATED COST PRESENT
3	2	28"x18" CMARCH UNDER HIGHWAY 68	30 cfs	182	135	REPLACE WITH 6'x2.5' RCB	$8,300	REPLACE WITH 5'x2.5' RCB	$7200
4	15	12" CMP UNDER LAGUNA SECA RD., EAST FORK	10	286	270	REPLACE WITH DBL. 42"CMP & RAISE ROAD 2' CLEAN OUTLET CHANNEL DOWN TO STRUC. 7	6,700	SAME AS FUTURE	6700
7	16	48"CMP UNDER LAGUNA SECA RD, WEST FORK	180	297	235	PROVIDE PARALLEL 48"CMP w/ ROUNDED ENTRANCE HEADWALL	3,800	PROVIDE PARALLEL 36" CMP w/ ROUNDED ENTRANCE HEADWALL	2900
10	16	36"CMP UNDER LAGUNA SECA RANGER STA. RD. IT HAS A DROP INLET & ROAD ACTS AS DAM.	90	170	170	PROVIDE PARALLEL 36" CMP w/ DROP INLET & RAISE ROAD 2'	10,400	SAME AS FUTURE	10,400
14	17	36" CMP UNDER HWY 68	100	190	135	PROVIDE PARALLEL 36"CMP w/ ROUNDED COMMON HEADWALL ENTRANCE	5,000	PROVIDE PARALLEL 24" CMP w/ ROUNDED COMMON HEADWALL ENTRANCE	3,400
16	6	48" CMP UNDER HWY 68	240	260	194	PROVIDE PARALLEL 36" CMP ABOVE EXISTING CULVERT	7,900	NO CHANGE	0
25	22	48" CMP UNDER LARKSPUR DR.	260	391	230	PROVIDE PARALLEL 42"CMP w/ DROP INLET. KEEP INLETS & APPROACHING DITCH CLEAR.	8,800	NO CHANGE	0
26	22	12'x6' RCB UNDER YORK SCHOOL RD.	500	391	391	REMOVE EXISTING TREES AT ENTRANCE OF STRUCTURE	1,000	SAME AS FUTURE	1,000
27	10	6'x3' RCB UNDER HWY. 68	200	344	265	PROVIDE PARALLEL 4'x3' RCB w/ LONGITUDINAL SLOPE OVER 1% TO REDUCE SILTING, CONSTRUCT COMMON ROUNDED HEADWALL ENTRANCE	8,200	PROVIDE PARALLEL 3'x3' RCB w/ LONGITUDINAL SLOPE OVER 1% TO REDUCE SILTING, CONSTRUCT COMMON ROUNDED HEADWALL ENTRANCE	6,900
29	23	TRIPLE 30" CMP UNDER HWY. 68	200	757	583	REPLACE WITH TRIPLE 6'x3' RCB w/ COMMON ROUNDED HEADWALL ENTRANCE	21,000	REPLACE WITH TRIPLE 5'x3' RCB w/ COMMON ROUNDED HEADWALL ENTRANCE	19,100
30	11	8.5'x3.5' BRIDGE AT PRIVATE DRIVEWAY	450	834	668	ENLARGE STRUCTURE TO MIN. 72 sq.ft. OPENING RAISE ROAD 2'.	3,900	ENLARGE STRUCTURE TO MIN. 60 sq.ft. OPENING RAISE ROAD 2'	3,200
31	14	DBL. 48" RCP w/ ROUNDED ENTRANCE HEADWALL UNDER HWY 68	300	1088	853	REPLACE WITH TRIPLE 7'x4.5' RCB w/ COMMON ROUNDED HEADWALL ENTRANCE	35,800	REPLACE WITH TRIPLE 6'x4.5' RCB w/ COMMON ROUNDED HEADWALL ENTRANCE	32,900
37	14	90" CMP UNDER CANYON DEL REY GARDENS ROAD	500	1120	898	REPLACE WITH 12'x7.5' RCB w/ ROUNDED ENTRANCE OR EQUIVALENT STRUCTURE w/ CLEAR OPENING OF 90 sq.ft. MIN.	16,400	REPLACE WITH 10'x7.5' RCB w/ ROUNDED ENTRANCE OR EQUIVALENT STRUCTURE w/ CLEAR OPENING OF 75 sq.ft. MIN.	10,200
38	27	6'x8' RCB UNDER HWY 218	600	1129	906	PROVIDE PARALLEL 6'x8' RCB w/ ROUNDED ENTRANCE	16,300	PROVIDE PARALLEL 3'x8' RCB w/ ROUNDED ENTRANCE	12,800
40	27	6'x7' RCB AT FROG POND OUTLET UNDER HWY 218	420	960	794	PROVIDE PARALLEL 6'x8' RCB w/ COMMON ROUNDED HEADWALL ENTRANCE. SET INVERT 1' BELOW EXIST. CULVERT INVERT	19,100	PROVIDE PARALLEL 4'x8' RCB w/ COMMON ROUNDED HEADWALL ENTRANCE. SET INVERT 1' BELOW EXIST. CULVERT INVERT	16,200
41	27	6'x6' RCB UNDER ROSITA RD.	400	960	794	REPLACE WITH DBL. 6'x7' RCB w/ ROUNDED ENTRANCE MAINTAIN U/S CHANNEL w/ 90sq.ft. MIN AREA & 5' MIN. VERT. CLEARANCE TO PRIVATE BRIDGES	26,900	REPLACE WITH DBL. 6'x6' RCB w/ ROUNDED ENTRANCE. MAINTAIN U/S CHANNEL w/75 sq.ft. MIN. AREA & 5' MIN. VERT. CLEARANCE TO PRIVATE BRIDGES	16,600
42	27	8'x8' RCB AT FREMONT AVE. & UNDER MONTE MART & FREMONT BLVD.	1800	870	720	PROVIDE MAINTENANCE CLEANING AT INLET & NO FILING OR ENCROACHMENTS OF U/S PONDING AREA	———	SAME AS FUTURE	0
43	28	6'x6' RCB AT END OF KOLB AVE.	780	870	720	REMOVE EXIST. STRUCTURE 43 & EXTEND EXIST. STRUC. 42 TO LAGUNA GRANDE IF FILLED AREA IS TO BE USED	107,200	NO CHANGE	0
45	28	COLLAPSED 48"CMP. LAKE ROBERTS OUTLET	0	200		REPLACE WITH DBL. 8'x6' RCB ENTRANCE TO ALLOW FOR DESIRED OPERATING ELEV. OF LAKE	24,300	SAME AS FUTURE	24,300

FUTURE TOTAL ESTIMATED COST $331,000

PRESENT TOTAL ESTIMATED COST $173,800

NOTES

1. PRIMARY FACILITIES NOT INCLUDED IN THE ABOVE LIST ARE ADEQUATE IN SIZE OR ARE LOCATED ON PRIVATE PROPERTY.

2. ALL PRIMARY FACILITIES, SUCH AS CULVERTS, BRIDGES, PONDING AREAS & CHANNEL IMPROVEMENTS ARE SUBJECT TO MODIFICATION DURING DESIGN.

3. ESTIMATED CONSTRUCTION COSTS ARE AT SPRING OF 1977 LEVELS & EXCLUDE COSTS OF ENGINEERING, ADMINISTRATION, RIGHTS OF WAY & EASEMENTS.

MONTEREY COUNTY SURVEYORS, INC.
KORETSKY KING ASSOCIATES, INC.
A Joint Venture
236 SALINAS STREET SALINAS

MONTEREY COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

MONTEREY COUNTY MASTER DRAINAGE PLAN

REVISIONS

DATE · JUNE, 1977

DRAWN KEM CHECKED LML

APPROVED

TITLE CANYON DEL REY WATER SHED

SCALE

DRAWING NO. 12

SECTION VIII

REFERENCES

1. "Monterey County Master Drainage Plan - Santa Rita Creek Watershed," prepared by Monterey County Surveyors, Inc./McCreary-Koretsky International, Inc., for Monterey County Flood Control and Water Conservation District, August 1972.

2. "Monterey County Master Drainage Plan - Carmel Valley Watersheds" prepared by Monterey County Surveyors, Inc./ Koretsky King Associates, Inc., for Monterey County Flood Control and Water Conservation District, June 1973.

3. "Monterey County Master Drainage Plan - El Toro Creek Watershed" prepared by Monterey County Surveyors, Inc./Koretsky King Associates, Inc. for Monterey County Flood Control and Water Conservation District, June 1974.

4. "Monterey County Master Drainage Plan - Lower Carmel Valley Watersheds" prepared by Monterey County Surveyors, INc./ Koretsky King Associates, Inc., for Monterey County Flood Control and Water Conservation District, June 1975.

5. "Monterey II - A plan for the Highway 68 area to the year 2000." An element of the City of Monterey, California General Plan, March 1976.

6. "Mean Annual Precipitation and Precipitation Depth-Duration-Frequency Data for San Francisco Bay Region, California" prepared by U. S. Geological Survey, Water Resources Division in cooperation with U. S. Department of Housing and Urban Development, by S. E. Rantz, 1971.

7. "Summary of Short-Duration Precipitation Frequency in Santa Cruz County" prepared by J. D. Goodridge for the Department of Water Resources, Division of Resources Development, State of California.

8. "Suggested Criteria for Hydrologic Design of Storm Drainage Facilities in the San Francisco Bay Region, California", prepared by U. S. Geological Survey, Water Resources Division in cooperation with U. S. Department of Housing and Urban Development by S. E. Rantz, 1971.

9. "Monterey County General Plan", Monterey County, State of California, Adopted by the Board of Supervisors of Monterey County, October 1968.

10. "Hydrology for Engineers", LInsley, Kohler and Paulhus, 1958.