US Army Corps
Of Engineers
Los Angeles District

Ventura and Los Angeles Counties, California

CALLEGUAS CREEK

WATERSHED FEASIBILITY STUDY

HYDROLOGY APPENDIX

Prepared by: U.S. Army Corps of Engineers
Los Angeles District

February 2003

CALLEGUAS CREEK, VENTURA & LOS ANGELES COUNTIES, CA
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1. **Introduction**. The hydrology presented in this appendix is intended to be a part of the overall Calleguas Creek Feasibility Study, which is prepared in part by the Corps of Engineers, Los Angeles District, Ventura County Watershed Protection District (formerly Ventura County Flood Control District), Dr. Howard Chang, and Nolte Engineers.

The primary focus of the Calleguas Creek Watershed Feasibility Study is to determine the impact of sediment entering Mugu Lagoon and what environmental restoration measures might be implemented to minimize the impact. The challenge of determining the impacts of sediment entering Mugu Lagoon can best be accomplished using a watershed approach. The watershed approach is used because it considers all activities within the watershed that may or may not have an impact on sedimentation and the transport of this sediment to and through Mugu Lagoon. The focus of this study is to develop discharges for that area of Calleguas Creek from Hitch Blvd. to Mugu Lagoon, as well as the lower portion of Conejo Creek.

The hydrologic work effort for this study included a review of previous studies on the watershed. Streamgage data from the United States Geological Survey (USGS) and Ventura County was analyzed to determine flood frequency relationships. It also included developing rainfall-runoff models for the Calleguas Creek Watershed for estimating discharges at ungaged locations. Peak discharges and hydrographs for Existing, Future, and Natural Conditions were developed for key locations on Calleguas Creek and tributaries. The Natural Conditions presented in this study are meant to represent conditions in the watershed about the mid-1900s, i.e., prior to the current onset of urbanization.

2. **Purpose And Scope**. The purpose of the feasibility study is to investigate the environmental impacts on Mugu Lagoon associated with flood flows, sediment transport, and upstream land use practices in the Calleguas Creek Watershed, Ventura County, California. Figure 1 shows the general location of the study area.

3. **Prior Studies and Reports**.

Calleguas Creek Watershed Wetland Restoration Plan, David Magney Environmental Consulting, prepared for California State Coastal Conservancy and U.S. Environmental Protection Agency, October 2000,

Floodplain Evaluation Report, Naval Air Weapons Station, Point Mugu, Ca., U.S. Army Corps of Engineers, Los Angeles District, August 1998

Qualitative Assessment Report, Local Drainage, Point Mugu Naval Air Weapons Station, U.S. Army Corps of Engineers, Los Angeles District, June 1998.

Sediment Transport Modeling of Calleguas Creek, prepared by WEST Consultants, Inc., for Ventura County Flood Control District, May 1998.

Photo Summary of February '98 Storm Damage, Naval Air Weapons Station, Point Mugu, California, February 1998.

Calleguas Creek Watershed, Erosion and Sediment Control Plan for Mugu Lagoon, Ventura and Los Angeles Counties, California, U.S. Department of Agriculture, Water Resources Conservation Service, Davis, California, May 1995.

Calleguas Creek Watershed Erosion and Sediment Control for Mugu Lagoon, Natural Resources Conservation Service, May 1995.

Sand Loss Monitoring Program of Point Mugu Shoreline, U.S. Naval Air Weapons Station, Point Mugu, Moffat and Nichols, Engineers, February 1995.

An Overview of Historic Resources at the Naval Air Weapons Station, Point Mugu, California, Statistical Research Technical Series No. 50, 1994.

Point Mugu Seawall Repair Study, U.S. Naval Air Weapons Station, Point Mugu, Moffat and Nichols, Engineers, August 1992.

Reconnaissance Report for Calleguas Creek, California, U.S. Army Corps of Engineers, Los Angeles District, June 1992.

Development of Interim Sedimentation Control for Calleguas Creek, Simons, Li, and Associates, for Ventura County Public Works Agency, December 1989.

Tide Gate Structure, Point Mugu, California, Operation and Maintenance Manual, prepared by Lockman & Associates for U.S. Navy Pacific Missile Test Center, Point Mugu, California, October 1988, revised February 1989.

Calleguas Creek, Hydrology for Survey Report, Ventura County, U.S. Army Corps of Engineers, Los Angeles District, November 1987.

The Ecology of Mugu Lagoon, California, "The Onuf Report", U.S. Fish and Wildlife Service, July 1987.

Flood Hydraulics and Sediment Transport Study, Calleguas Creek, Ventura County, California, Dames and Moore Consulting Engineers, February 1986.

Oral History of Coastal Engineering Activities in Southern California 1930-1981, U.S. Army Corps of Engineers, Los Angeles District, January 1986.

Flood Hydraulic and Sediment Transport Study, Calleguas Creek, Ventura County, California, prepared by DMA Consulting Engineers, for U.S. Army Corps of Engineers, Los Angeles District, December 1985.

Calleguas Creek, Hydrology for Survey Report, U.S. Army Corps of Engineers, Los Angeles District, Los Angeles, CA, June 1985.

Urban Hydrology for Small Watersheds, U.S. Department of Agriculture, Soil Conservation Service, Technical Release Number 55, May 1985.

Sedimentation and Erosion of Calleguas Creek, Ventura County, California, Simon, Li & Associates, July 1984.

Sedimentation and Erosion of Study of Calleguas Creek, Ventura County, California, prepared by Simon, Li & Associates, Inc. for U.S. Army Corps of Engineers, Los Angeles District, November 1983.

Mugu Lagoon and Tributaries, Geology and Sediment, Soil Conservation Service, Lyle J. Steffen, April 1982.

Lower Calleguas Creek Watershed, Field Examination Report, Ventura County, California, U.S. Department of Agriculture, Soil Conservation Service, Davis, CA, January 1982.

Special Flood Hazard Study, Point Mugu, Missile Test Center, U.S. Army Corps of Engineers, Los Angeles District, March 1981.

Ventura County Hydrology Manual, Ventura County Flood Control District, County of Ventura, Public Works Agency, March 1979.

Report on Floods of February and March 1978, in Southern California, U.S. Army Corps of Engineers, Los Angeles District, November 1978

Hydrology for Special Flood Hazard Study, Calleguas Creek and Revolon Slough, Vicinity of Point Mugu, Ventura County, California, U.S. Army Corps of Engineers, Los Angeles District, August 1977.

Special Flood Hazard Study, Calleguas and Conejo Creeks, Vicinity for Camarillo, Ventura County, California, U.S. Army Corps of Engineers, Los Angeles District, May 1976.

Hydrology for Flood Insurance Studies, Simi Valley, Ventura County, California, Los Angeles District, U.S. Army Corps of Engineers, Los Angeles District, August 1974.

Calleguas Creek, Simi Valley to Moorpark Ventura County, California, Appendixes, Feasibility Report for Flood Control and Recreational Development, July 1974, U.S. Army Corps of Engineers, Los Angeles District, July 1974

Regional Flood Frequency Study, Calleguas Creek, U.S. Army Corps of Engineers, Los Angeles District, November 1971.

Standard-Project-Flood Peak Discharges for Calleguas Creek, California, U.S. Army Corps of Engineers, Los Angeles District, 17 March 1970.

Flood Plain Information, Calleguas Creek (including Conejo Creek and Arroyo Santa Rosa), Somis to Pacific Ocean, Ventura County, California, U.S. Army Corps of Engineers, Los Angeles District, September 1969.

Hydrology for Floodplain Information Studies, Calleguas Creek and Simi Valley, Ventura County, California, U.S. Army Corps of Engineers, Los Angeles District, August 1969.

Flood Control Needs Along Calleguas Creek, Corps of Engineers, Los Angeles District, 1943 (no file copy available).

4. Description of the Drainage Area.

4.1. General. The Calleguas Creek Watershed, which drains approximately 325 mi^2, is located in southern Ventura County with a small portion in Los Angeles County (see Figure 1). Calleguas Creek crosses Hitch Blvd. just downstream from the City of Moorpark. The creek in this stretch is known as Arroyo Los Posas. Ventura County Flood Control District (VCFCD) has operated and maintained a stream gage at this location since 1991.

The watershed is an elongated area with a maximum east-west length of 32 miles and a maximum north-south width of 14 miles. Elevations range from 3,700 feet in the upper watershed to sea level at the outlet to the Pacific Ocean at Mugu Lagoon. Major geographic borders of the watershed are the Santa Susana Mountains, Oak Ridge, and South Mountain to the north and the Simi Hills and Santa Monica Mountains to the south. Approximately half of the drainage area is mountainous, with steep, rocky ridges and numerous canyons. The remaining half consists of rolling hills, with well-defined stream courses, and relatively flat valley areas.

Numerous small tributaries draining the mountain portions of the watershed flow into Calleguas Creek in the upper two-thirds of the watershed. Conejo Creek and Revolon Slough, two major tributaries, enter Calleguas Creek in the lower one-third of the watershed. Calleguas Creek is also known as Arroyo Las Posas and Arroyo Simi in its middle and upper reaches, respectively.

Extensive urban development, farmland conversion, and the resulting redevelopment of orchards on steeper slopes has changed the geomorphology of the area and has led to accelerated erosion rates. Water now flows from the creek into the lagoon all year long due to urban runoff and discharge from wastewater treatment plants.

Ventura County supports a large urban population with residents working in the county as well as Los Angeles County. Cities directly adjacent to the Los Angeles County border, such as Thousand Oaks and Simi Valley, are considered bedroom communities to the Los Angeles Metropolitan area. Commuters begin their journey to Los Angeles from other parts of Ventura County and from as far away as Santa Barbara.

4.2. Calleguas Creek At Pacific Coast Highway. The confluence of Calleguas Creek with Revolon Slough is located just downstream from Pacific Coast Highway 1 (PCH). There is a set (two) of bridges crossing both Revolon Slough and Calleguas Creek; one each for northbound traffic and one each for southbound traffic. For Calleguas Creek at PCH, the channel bed width contracts from about 490 feet, at a distance 328 feet upstream of the bridges, to 230 feet at the bridges. The contraction slows down the flow at the bridge and sediment drops out, which induces aggradation of the channel; and thus, decreases the channel capacity. Futhermore, the inadequate capacity causes debris to get caught under the bridge, which further increases the flow restriction. The maximum capacity at the bridges is only about 15,500 ft^3/s. Overtopping at the bridges will, and has, occurred. Recent overtopping at the bridges occurred when flows of 26,600 ft^3/s in 1983 and 21,600 ft^3/s in 1998 were recorded at the stream gage at Calleguas Creek at California State University Channel Islands (CSUCI). (Caltrans EIR, Initial Study/Environmental Assessment for the Calleguas Creek Bridge Widening, February 2001).

4.3. Mugu Lagoon. Mugu Lagoon is located at the border of the Ventura and Los Angeles County coastline, at the Point Mugu Naval Air Weapons Station, California (see Figure 2). The Federal Government purchased the majority of the Mugu Lagoon area in 1950s and constructed the Point Mugu Naval Air Weapons Station. Major flood flows enter Mugu Lagoon from Calleguas Creek with lesser flows coming from smaller flood control ditches through the Naval Air Weapons Station. The PCH bridges provide a controlling hydraulic structure that maintains the same pattern of flow downstream from PCH. Calleguas Creek stays in a well-defined natural narrow channel (100 feet wide) for a distance of 2000 feet. Calleguas Creek then flows through a small bridge (pipeline), next to the sewage ponds, and then flows another 3000 feet to the Pacific Ocean. The total length of travel for Calleguas Creek from PCH to the Pacific Ocean is about 5000 feet, depending on the amount of closure of the mouth and its location.

Mugu Lagoon has three distinct coverage areas. The central branch is approximately 3000 feet long by 2000 feet wide located just south of the sewage ponds. The west branch is approximately 1000-foot wide by 5000 feet long and has remained essentially the same through recorded history. It should be noted that the north-south road that separates the west branch from the central branch has a couple of 48-inch culverts that allow tidal flow to enter the west branch during periods of high tide and allow surface runoff from portions of Revolon Slough drainage area to flow out to the Ocean. This road also acts as a effective control that prevents major sediment loads from entering the west branch. The east branch is approximately 500 to 800-feet wide by about 6000-feet long. Sedimentation in the east branch has caused scattered smaller ponding areas.

4.4. Runoff Characteristics. Streamflow is present in the lower portions of Calleguas Creek all year long due to urban runoff and discharge from wastewater treatment plants. However, the volume and peak of this flow are negligible compared to runoff generated during storm events. Runoff from storm events occurs during and immediately following rainfall. Meteorologic and physiographic conditions are not conducive to continuous runoff.

Streamflow increases rapidly in response to effective rainfall. High intensity rainfall, in combination with the effects of sparse vegetation, possible denudation by fire, and steep gradients in the upper watershed, result in intense, sometimes sediment-laden floods, with some debris in the form of trees and shrubs. These high-velocity flows generally produce channel scouring on unimproved channel reaches. Deposition of this sediment occurs in lower Calleguas Creek as stream gradients become flatter. The urbanization that is taking place in the valley areas of the Calleguas Creek Watershed tends to make the watershed more responsive to rainfall. Runoff from urban areas in the watershed is characterized by high flood peaks of short duration that result from high-intensity rainfall on areas that have a high percentage of impervious cover. The same rainfall occurring over an urbanized portion of the watershed will generate higher peak discharges with a shorter peaking time and a greater total volume than the natural watershed without urbanization.

4.5. Existing Water Related Structures. There are no Corps of Engineers flood control projects in the study area. The Calleguas Creek channel has undergone many structural modifications and improvements for the purpose of flood damage mitigation. The majority of the existing facilities were constructed by VCFCD. The Calleguas Creek mainstem channel improvements and the adjacent Revolon Slough were constructed during the 1950s by the Soil Conservation Service (SCS) to provide estimated 50-year flood protection to primarily agriculture land. The SCS channel improvements are located in the Simi Valley, Moorpark, and Camarillo areas. During the 1960s, VCFCD constructed concrete lined channels in the upper reaches of Arroyo Simi and some of its tributaries.

Numerous drop structures/bed stabilizers have been constructed along Calleguas Creek by VCFCD in an attempt to alleviate channel scouring and sediment deposition in the flatter Oxnard Plain. Most of the stabilizers have been installed in areas of high channel erosion between the Pleasant Valley Road Bridge and the Seminary Road bridge and between Grimes Canyon and just upstream of the Moorpark Road Bridge.

VCFCD has also constructed detention basins and debris basins on a number of tributaries to Calleguas Creek. These structures have little, if any, impact on peak flows on lower Calleguas Creek. The two largest structures located in the upstream watershed are Las Llajas Canyon Dam and Sycamore Canyon Dam. Neither structure is large enough to have any significant effect on peak discharge reduction as you move downstream into the lower reaches of the watershed to the study area. Both dams were completed in 1981; pertinent data for the dams are presented in Table 1. A list of VCFCD facilities in the Calleguas Creek Watershed is provided in Table 2.

4.6. Vegetation. The area encompassed within the Calleguas Creek Watershed includes several plant associations: riparian (stream-associated), oak chaparral and oak grassland, coastal sage scrub, and coastal salt marsh. Native vegetation in the undeveloped mountainous parts of the watershed consists primarily of chaparral species, including chamise, manzanita, toyon, scrub oak, sugarbush, buckwheat, and coyotebush. These species generally have deep root systems, which aid in maintaining soil and slope stability. On the lesser-sloped areas of the mountains, coastal sage scrub is predominant. It also is an effective soil protector, but to a lesser depth than chaparral. Due to its location in areas of moderate slope, urban development and the introduction of orchard agriculture has displaced considerable areas of it. The result has been increased runoff from these areas. The rolling hills within the valley areas are covered primarily with non-native grasses. In less-disturbed areas on lower slopes and in better-watered valleys stands of oak woodland exist. Heavier vegetal growth, however, is found along the undisturbed portions of the Calleguas Creek channel and tributaries.

Ventura County has been farmed since the late 1700s. Farming and ranching took place to support the Mission San Buenaventura. Irrigation on a large scale was introduced during the decade from 1880 to 1890, bringing change to the existing agriculture. Walnuts and apricots were introduced, and for a time they were the only major crops. Later, lima beans were grown extensively. Presently, the main money crops are lemons, strawberries, avocados and nursery stock. Much of the relatively flat plain upstream from the Point Mugu Naval Air Weapons Station (NAWS) is presently in field agriculture, mainly high value truck crops. As a result of rapid urban growth in valley floor areas, orchards of lemons, oranges, and avocados have been moved to areas with fairly steep slopes in the upper parts of the watershed.

4.7. Land Use. Land use within the Mugu Lagoon is continuously evolving. The earliest major land use has been agriculture. Various truck crops predominate in the Oxnard Plain, and in the steeper foothill areas, citrus and avocado orchards are common. Urbanization has occurred mainly within the last two decades. Major urban communities are Simi Valley, Thousand Oaks, Moorpark, and Camarillo. Portions of agricultural lands have been and are still being converted to urban development. The extent of present urbanization was based on USGS topographic maps, field investigations, and aerial photography.

4.8. Geology. The Calleguas Creek Watershed lies within a portion of the Transverse Range geomorphic province of southern California. The ranges and valleys in the study area conform geologically to the east-west trend of that province. The geology of the Calleguas Creek Watershed is dominated by the Ventura Basin, which extends westerly under the Pacific Ocean. This is an east-trending region that has been generally down-warped during the last 60 to 75 million years. Major deposition has occurred in this region, mostly from the sea, which has since receded from the eastern portion of the watershed. The resultant sedimentary rocks have been tectonically deformed and partly uplifted to form hills and mountains. The predominant rock types in the area are sedimentary, described as marine sandstone, conglomerate, and shales of Tertiary age. Older Quaternary rocks include the Santa Barbara and San Pedro Formations. Younger Quaternary deposits include terrace and floodplain deposits composed of clay, silt, sand, and gravel. Also found in the area are small exposures of volcanic rocks. All of the older units have been subjected to folding and faulting. The major faults in the area are the Simi (approximately 5 miles south of Simi Valley) and Santa Rosa Faults (approximately one mile north of Simi Valley). These faults have an east-west trend, which is characteristic of most faults in this area.

Tectonic activity has uplifted the terrain by as much as 2.5 feet per century, while erosion has lowered the terrain by as much as 0.75 feet per century (Scott and Williams 1978). The topographic rejuvenation through tectonic uplift and the prevalence of highly erodable sedimentary deposits have maintained conditions conducive to reasonably high rates of erosion and sediment yield. The Calleguas Creek Watershed sediments are found throughout the alluvial valleys, the delta plain, and the near shore system (Scott and Williams 1978, USDA-NRCS 1995).

The delta plain and the alluvial valleys have gone through periods of cutting and filling with rates of filling reaching 6 feet per century on the delta plain (USDA-NRCS 1995). The most recent sea level lowstand occurred during the late Pleistocene, approximately 18,000 years before present. During this period, streams were incised in valleys on the delta plain and it is likely that Calleguas Creek was connected to the Mugu Submarine Canyon. Sea level has risen steadily for the last 18,000 years, and incised stream valleys were filled and sediments deposited on the delta plain surface (Muto 1987, Muto and Blum 1989).

4.9. Soils. There are three predominating soil types in the study area. The first, Rincon-Huerhuer Azule Association, is found in the lower hills and consists of deep, well-drained clay loams overlying basic igneous rock (Hydrologic Soil Group C). The second, Hambright-Igneous rock consists of well-drained clay loams overlying basic igneous rock (Hydrologic Soil Group C). The third, Camarillo-Hueneme-Pacheco Association, found in valleys and plains, is deep, poorly drained loamy sands to silty-clay loams (Hydrologic Soil Group D).

There are twelve broad soil associations in the watershed. Each soil association is strongly correlated with one of three landforms: uplands; terraces; and alluvial fans, plains, and basins (Figure 11, Soil Associations in the Calleguas Creek Watershed, Edwards et al. 1970). Upland soils cover approximately 35 percent of the watershed. The primary parent materials are residium and colluvium. Slopes are moderately sloping to very steep. Soils are shallow to very deep, well-drained to somewhat excessively drained, various-textured deposits overlying sedimentary or igneous rock.

Terrace soils also cover approximately 35 percent of the watershed. The primary parent material is alluvium. Slopes are level to moderately steep. Soils are very deep, moderately well drained to well drained, very fine sandy loams overlying sandy clays with low to very low permeability. Alluvial fan, plain, and basin soils cover approximately 30 percent of the watershed. The primary parent material is alluvium. Slopes are level to moderately sloping. Soils are very deep, poorly drained to excessively drained, various-textured deposits.

5. Precipitation and Runoff.

5.1. Precipitation Records. There are over 40 active precipitation stations in and near the Calleguas Creek Watershed. Of these stations, 19 have non-recording gages, 11 have recording gages, and 10 stations have both recording and non-recording gages. The longest record station in the study area is the "Port Hueneme – USGS station, which has a period of record dating from 1891 to the present. Station locations in and around the Calleguas Creek Watershed are shown on Figure 3, and pertinent data is given in Table 3.

5.2. Streamflow Records. Stream gaging stations have been operated at several points in the drainage area, with various periods of record from 1927 to date. Station locations in and around the Calleguas Creek Watershed are shown on Figure 3, and pertinent data is given in Table 4.

5.3. Climatology And Meteorology. The Calleguas Creek Watershed experiences a mild climate with a low variation in extreme temperatures. The summers are generally long and dry and the winters short and wet. Snow rarely occurs in the study area. Dry periods may be considerable, and extend over many months, or even years. The average annual temperature is around 60º Fahrenheit (F) in the Calleguas Creek Watershed with an average maximum of 70º to 80º F and an average minimum of about 40º F. Snow rarely occurs in this area. The prevailing winds are from the Pacific Ocean and are of light to moderate velocity. Mean annual precipitation ranges from 12 inches near the coast to over 20 inches in the Santa Susana Mountains. Isohyets of mean seasonal precipitation are shown on Figure 4. Nearly all precipitation occurs during the months of December through March.

5.3.1. Storms. Three types of storms produce precipitation in the Calleguas Creek Watershed:

5.3.1.1. General Winter Storms. General winter storms usually occur during the period from December through March. These storms usually originate over the Pacific Ocean as a result of the interaction between polar Pacific and tropical Pacific air masses and move eastward over the watershed. Often lasting several days, these storms reflect orographic influence and are accompanied by widespread precipitation.

5.3.1.2. Local Storms. Local storms can occur at any time of the year, either during general storms or as isolated phenomena. They occur rarely in the Calleguas Creek Watershed during the summer. Those that occur in the winter are generally associated with frontal systems. These storms cover comparatively small areas, but result in high intensity precipitation for durations of up to 6 hours.

5.3.1.3. General Summer Storms. General summer storms occur during the late summer or early fall months. These storms are usually associated with tropical cyclones and occur very infrequently. Because of this, and because these storms occur near the end of the dry season, they rarely result in any major flooding in the study area.

5.3.2. Storms And Floods Of Record. Little information is available concerning storms and floods in the Mugu Lagoon drainage area prior to 1918. Precipitation records indicate that moderate to heavy storms have occurred in the area in 1891, 1905, 1907, 1911, 1913, 1914, 1915, 1916, 1918, 1921, 1926, 1927, 1931, 1934, 1937, 1938, 1941, 1943, 1944, 1947, 1958, 1962, 1966, 1967, 1969, 1971, 1972, 1973, 1974, 1975, 1978, 1980, 1983, 1992, 1995, and 1998. Statements of local residents indicate that prior to 1918, major floods occurred in 1862, 1884, 1914, and 1916. Of these, the floods of 1862 and 1884 were probably the largest. A comparison of these floods with recorded flows is not possible, since historic floods are usually remembered by the damage caused rather than by an estimate of peak discharge. Brief descriptions of the storms and floods of 1918, 1938, 1943, 1969, 1978, 1980, and 1983 are given in subsequent paragraphs.

Storm and Flood of February 17-26, 1918. At Newbury Park (elevation 700 feet), the storm of February 17-26, 1918, produced a maximum 24-hour rainfall of 4.92 inches and a total storm rainfall of 9.73 inches. At Oxnard (elevation 51 feet), the maximum 24-hour rainfall was 2.67 inches and the total storm was 5.64 inches. No data are available regarding short-term rainfall intensities during this storm. However, 24-hour rainfall in excess of 2 inches was recorded at all stations in the area. No discharge estimates are available for points within the Calleguas Creek Watershed for this storm.

Storm and Flood of February 27-March 4, 1938. The effective duration of the storm of February 27-March 4, 1938, was 4 days, with two phases of high short-time intensities, the first occurring on February 28, and the second on March 2. The storm produced an average rainfall of 4.8 inches over the drainage area during the maximum 24-hours, and 8.3 inches for the total storm. A peak discharge of 4,100 ft^3/s occurred on March 2, 1938 at the gaging station near Moorpark, which has a drainage area of 115 mi^2. A peak discharge of 1,700 ft^3/s occurred at the gaging station near Simi, which has a drainage area of 67 mi^2.

Storm and Flood of January 21-24, 1943. The storm of January 21-24, 1943 which was in many respects the most severe of record in southern California, resulted when a series of warm Pacific cyclones moving generally eastward from the area north of Hawaii and combined with an intense, cold storm moving down the west coast of North America from British Columbia. The deep low pressure center which consequently developed over northern California and Oregon generated unusually strong southerly and southwesterly winds over southern California and produced very heavy precipitation over much of the area, with exceptionally large rainfall amounts in the mountain areas because of the powerful orographic uplift of these strong winds. Precipitation was continuous from about noon on January 21 into the morning of January 23, with two periods of very high intensity rainfall due, respectively, to the approach and subsequent recession of a cold front about midnight of January 21 and to the passage of a cold front about midnight of January 22. Rainfall generally tapered off on January 23 and 24, although certain mountain stations continued to receive substantial precipitation during these two days. Some record 24-hour rainfall totals were measured during this storm in the San Gabriel Mountains, including the State of California record of 26.12 inches in 24 hours at Hoegees. In the vicinity of the Calleguas Creek Watershed, approximately 8 inches of rainfall fell during this storm, but because this storm occurred after a dry period, there was no major flooding.

Storm and Flood of March 3-4, 1943. The local storm that occurred between 2200 hrs on March 3 and 0100 hrs on March 4, 1943 during three days of shower-type precipitation, resulted in short-period precipitation of near record breaking magnitude for the southern California coastal region. The storm apparently began over the southern part of Los Angeles and moved northeast at about 7 miles per hour toward the San Gabriel Mountains. Many automatic precipitation gages were in operation; as a result, the areal distribution of precipitation was well defined. The highest observed intensities were at the Sierra Madre-Carter (7-0-133B) precipitation station located in Sierra Madre, where maximum 15-, 30-, and 60-minute intensities of 5.5, 3.6, and 2.7 inches per hour, respectively, were recorded. Runoff was moderately heavy from local areas where high precipitation intensities occurred. However, no quantitative measurements of runoff are available for the vicinity of Sierra Madre where the highest precipitation intensities occurred. A peak discharge of 960 ft^3/s was recorded for the 2.5 square mile drainage area of the Broadway storm drain in Pasadena (about 6 miles southwest of storm center). This flow represented the greatest peak discharge per square mile (384 $ft^3/s/mi^2$) observed during the storm. This storm did not produce significant runoff in the study area.

Storm and Flood of January 18-27, 1969. A series of storms that began on January 18 and continued through January 27 was caused by a strong flow into southern California of very warm, moist air originating over the tropical Pacific Ocean south and east of Hawaii. This series of storms was interrupted by a brief ridge of high pressure which moved through the area on January 22 and 23 and caused a short break in the rainfall. Except for this lull, heavy precipitation occurred during most of the period January 18-26 and was climaxed by an intense downpour on January 25. Nine-day totals ranged from 10-20 inches in the lowlands and from 25 to more than 50 inches over mountain areas of southern California. Along Calleguas Creek, a peak discharge of 12,800 ft^3/s was recorded at the CSUCI stream gage. The peak discharge for the Madera St. stream gage was 5,040 ft^3/s.

Storm and Flood of February 22-25, 1969. The late February 1969 storm series was the climax of more than a month of extremely heavy, recurring rainfall in southern California. It occurred as a number of Pacific cyclones traveled southward off the west coast of the United States and then curved inland across California with copious quantities of moisture. Several cold fronts and other disturbances moved across southern California from February 22 through February 24, dropping moderately heavy amounts of precipitation. Early on February 25, a strong cold front moved slowly southeastward across southern California accompanied by strong low-level winds which, when lifted by the mountains, resulted in great quantities of orographic precipitation. As a result, rainfall was generally heavy everywhere and particularly heavy in the mountains. The February peak discharges on Calleguas Creek were slightly greater than those in January. The maximum peak discharge at the CSUCI stream gage was 16,300 ft^3/s, while the Madera St. stream gage recorded 6,330 ft^3/s, and the Moorpark stream gage recorded 6,500 ft^3/s. The maximum peak discharge on Conejo Creek at the stream gage above Highway 101 was 5,300 ft^3/s.

Storms and Floods of February 28-March 5, 1978. The storms and floods of February 28-March 5, 1978, were preceded by a series of storms in early February 1978. The later storms of February 1978 were a series of moderate-intensity storms rather than a single large storm. In the days preceding the storms, a large high-latitude block formed over the Bering Sea and Alaska. This block produced a very stable long-wave pattern, allowing the storm track to remain at low altitudes for several days. By March 3, the upper-level block had been displaced northwestward into the Bering Sea and replaced by a low over Alaska. A surface front, which proved to be the last one of the series, moved into southern California on the morning of March 4 and was accompanied by heavy rain, thunderstorms, and gale force winds. The maximum peak discharge on Calleguas Creek at the CSUCI stream gage was 18,700 ft^3/s, 7,730 ft^3/s at the Madera St. stream gage, 8,600 ft^3/s at the Moorpark stream gage, and 9,970 ft^3/s at the stream gage above Highway 101 all on March 4. The maximum peak discharge on Conejo Creek at the stream gage above Highway 101 was 9,830 ft^3/s.

Storm and Flood of February 13-22, 1980. A series of varying intensity fronts coming from the west soaked southern California with eight days of nearly continuous rain. The meteorological situation leading to the series of rainstorms was the result of a block that formed over British Columbia, causing a more southerly storm track. This blocking pattern allowed for a series of six storms to move through southern California during February 13-22. The strongest front passed the area midday on Saturday February 16, producing the second highest peak discharge of record on Calleguas Creek of 25,300 ft^3/s at the CSUCI stream gage, 9,310 ft^3/s at the Madera St. stream gage, and 14,000 ft^3/s at the stream gage above Highway 101. This storm caused a breach of the west levee of Calleguas Creek below Hueneme Road, with an estimated total of 24,000 acre-ft of water flowing through the breach before it was repaired. The maximum peak discharge on Conejo Creek at the stream gage above Highway 101 was 11,800 ft^3/s.

Storm and Flood of February 25-March 3, 1983. During the first part of 1983, there were several stormy periods but none in scope or duration to the storm that began February 25 and lasted through March 3. A strong flow of moist air from the southwest began producing precipitation on February 25 as the first in a series of frontal systems moved through California. This storm was characterized by two periods of moderate to heavy precipitation. With the ground wet from a January storm, heavy precipitation produced high flows in most creeks in southern California. On Calleguas Creek, at the CSUCI stream gage, Madera St. stream gage, and the stream gage above Highway 101, the peak discharges of record occurred, 26,600 ft^3/s, 10,570 ft^3/s and 17,200 ft^3/s, respectively. As in 1980, the Calleguas Creek levee was breached. The maximum peak discharge on Conejo Creek at the stream gage above Highway 101 was 14,000 ft^3/s.

Storm and Flood of February 10-15, 1992. On February 10, 1992, Southern California was hit by a major storm, which caused widespread damage and threatened the lives of many people, eventually claiming two in river torrents, and another two in a mud slide. The storm lasted through the 15th of February, leaving flood control structures damaged, full of debris, and vulnerable to future storms. Of primary concern in Ventura County was erosion of channels and removal of debris following flood flows. The greatest 24-hour precipitation totals were in the Santa Monica Mountains southwest to southeast of Woodland Hills, and from there northeast through the eastern Conejo and western San Fernando Valleys to the Big Tujunga Creek drainage of the San Gabriel mountains. Orographically favored locales received the heaviest rainfall on the 10th of February. The seven-day depths in Ventura County ranged from 6 to 13 inches, which represented about 60-65 percent of the mean annual rainfall. The peak flow on February 12th at the Calleguas Creek above Highway 101 gage was 12,560 ft^3/s and 14,700 ft^3/s at the Calleguas Creek at CSUCI gage. On February 10, Calleguas Creek overflowed downstream from the confluence with Conejo Creek (near Camarillo State Hospital) from a discharge less than 10,000 ft^3/s. The capacity was limited by debris, brush, and tress. The channel carried a larger flow on February 12th after being flushed out by the flood on the 10th. Although the peak flow in Calleguas Creek was estimated to be about a 10-year event, approximately one million cubic yards of sediment was deposited in the channel system. Conejo Creek contributed much of the sediment, as it was running higher than Calleguas Creek at the confluence of the two streams. On Calleguas Creek, the Lewis Street bridge abutments were undermined and required stone placement on them to prevent further damage.

Storms and Floods of January and March, 1995. Moist El Nino storms laden with tropical moisture occurred over Southern California during January and March of 1995. From January 3rd to the 10th, Southern California experienced a major storm event with high concentration of rainfall occurring. There were 11 deaths attributed to this storm and $1.34 billion in damages. This storm was the largest localized storm of record for the southern Los Angeles County and exceeded all National Weather Service predictions. Rainfall started on the 3rd with isolated high intensity rainfall occurring. On January 6th and 7th, there was very high intensity rainfall in the Camarillo area. On the 9th and 10th the majority of the county experienced high peak flows. Rainfall intensities in some locations were equivalent or greater than 100-year frequency precipitation. Significant local flooding occurred as a result of channels and local storm drains being overtaxed. On March 10, a cooler winter storm brought significant amounts of precipitation with damaging results due to the saturated soil conditions. The peak flow recorded on Calleguas Creek at the stream gage above Highway 101 was 9,120 ft^3/s and at the CCSUCI gage, it was 14,900 ft^3/s.

Storm and Flood of February 1998. In the "El Nino" winter season of 1997-1998, severe Pacific storms brought heavy rains to much of coastal Southern California. Widespread flooding occurred with these storms producing extensive property damage and several fatalities. California had the wettest February on record. In terms of precipitation, across California and the southwest, four weeks

> of nearly continuous storminess resulted in widespread flooding, mudslides, and agriculture disruptions. Late in the month a shift in the weather pattern brought some of that storminess out of the southwest and into the northern plains. February precipitation records were set at 19 stations in California. Santa Barbara, CA received an incredible monthly total of 21.74 inches, breaking the old record of 17.33 set in 1962 and establishing a record for any month. Records for that location date back to 1867. Oxnard, Simi Valley, and Lompoc received 17.80, 17.20, and 12.86 inches, respectively. After a near record drought–only a quarter inch of rain measured at Point Mugu between 1 February and 1 November 1997–soil moisture in the basin was very low. However, by the 23rd of February the area had received almost 23 inches of rain, with almost 15 inches of it in the preceding three weeks. Therefore, the soil was saturated. With the onset of heavy rains, streams swelled to peak levels within a few hours after the heaviest rain episode. The maximum flow in Calleguas Creek as recorded at the California State University Channel Islands was 21,600 ft^3/s, which caused overtopping of the bridges at Pacific Coast Highway.

6. Discharge-Frequency Analysis. Runoff records were available for 10 stream gages in the Calleguas Creek watershed. Six of the gages are located along the mainstem of Calleguas Creek, three gages along Conejo Creek, and 1 gage on Revolon Slough. Photographs at the stream gage locations are shown in Exhibit A. Discharge-frequency analyses for the 10 gaged locations were initially performed in accordance with Water Resource Council (WRC) guidelines outlined in Bulletin 17B.

The HEC-FFA computer program was used to perform flood frequency analyses on the 10 stream gages. A generalized skew of –0.4 from the skew figure in the back of Bulletin 17B was used to weight the computed skew as recommended in Bulletin 17B.

The period of record for the gage on Calleguas Creek above Moorpark was from 1934-1983. The rest of the gages had data up to present. It was decided the first thing to do was extend the period of record for the Moorpark gage using the peak flow data from the closest gage along Calleguas Creek using a regression analysis of peak flow versus peak flow. The period of record for the closest stream gage, Calleguas Creek at Madera Rd., was from 1933-present (2001). There were twenty annual peak values in the common period of record for these two gages that occurred during the same event. These peak flows for the common period of record for the two gages were plotted on log-log paper. An equation for converting from peak flow at Madera Rd. gage to flow peak at Moorpark gage was determined to be: $y = 1.1097x^{1.0235}$. The peak flow from 1984-2001 period of record from the Madera Rd. gage was used as x in the equation and peak flows for Moorpark gage, were estimated and included in the frequency analysis.

The computed results from the flood frequency analysis (HEC-FFA) indicated the discharges for the rarer events were significantly and consistently higher than the gaged data. Based on field reconnaissance and conversations with VCFCD staff, it was noted that higher flows were most likely impacted by sedimentation, insufficient channel capacity, and other factors, such as regulation (in the upper watershed), which affected the homogeneity and stationarity of the data. Subsequently, it was decided that a graphical analysis was more appropriate for the stream gages in this watershed.

The objective of the graphical approach was to create discharge-frequency curves for each of the gaged locations that were more consistent with the recorded data as well as consistent from a regional perspective (a family of curves with similar standard deviation and skew and consistent means). The annual peak discharges for each gage were plotted on log-probability paper using median plotting positions. A graphical curve was drawn to best fit the data. The six curves for Calleguas Creek were plotted on one sheet of log-probability paper. Since these six stream gages are along the Calleguas Creek mainstem, the frequency curves for these six should be relatively consistent with regards to mean, standard deviation, and skew. The same can be said for the three gages in the Conejo Creek subarea.

Statistics for each of the curves were calculated using the equations in Appendix 5 of Bulletin 17B. The computed mean discharge for the gages were examined first. The mean discharge for the six gages along Calleguas Creek were plotted versus drainage area. The mean discharge for the gages at Arroyo Simi at Royal Ave., at Madera Rd. and at Moorpark were adjusted to be consistent from upstream to downstream basis. The standard deviations for the six gages were also plotted versus drainage area. The standard deviations for the gage at Royal Ave., the gage at Madera Rd., and the gage above Moorpark were inconsistent with the other gages. The standard deviations were adjusted to be consistent from upstream to downstream. The skew coefficients for the six Calleguas Creek gages ranged from –0.231 to –0.049. The six skew values were averaged and a skew of –0.1 was adopted for the final curves for the gages along the Calleguas Creek mainstem.

The frequency curves for the three gages in the Conejo Creek watershed were also plotted on a single sheet of log-probability paper. The curve for Revolon Slough was included on this plot as the computed statistics were more in line with these three gages than the gages along the Calleguas Creek mainstem. It should be noted that Conejo Creek watershed is highly urbanized and is continuing to be developed, while Revolon Slough is primarily agriculture and no change in land use is anticipated in the near future. So, as more data from the Revolon Slough stream gage becomes available, the discharge-frequency results may need to be re-evaluated.

The computed mean discharge for the Conejo Creek below Conejo Blvd. gage was inconsistent with the other three gages from a discharge versus drainage area perspective; thus the mean discharge for this gage was adjusted upwards. The computed mean discharge for the other three gages were acceptable. The standard deviations ranged from 0.348 to 0.375, which were consistent and deemed acceptable. The skew values were averaged and a skew of 0.0 was adopted for the final curves for these four gages.

The annual peak discharges for each gage were re-plotted on log-probability paper using median plotting positions. The final curves were redrawn using the revised standard deviations, the adopted skews, and the adjusted means. A plot of the final curves for the six gages along Calleguas Creek mainstem are shown on Figure 5. A plot of the final curves for the three gages along Conejo Creek plus the one gage on Revolon Slough are shown on Figure 6. Discharge-frequency values for the gaged locations are shown in Table 5. Figures 7 through 16 represent the final frequency curves for the gaged locations along with the annual data plotted using median plotting positions. Preliminary statistics for the gages locations are shown in Table 6 and are included for comparison purposes only. The final statistics for the gages locations are shown in Table 7.

7. Rainfall-Runoff Analysis. Discharge-frequency values from previous studies by the Corps of Engineers for the Calleguas Creek Watershed were based on regional discharge-frequency relationships developed in 1971 and subsequently updated in 1985. By contrast, the current analysis uses rainfall-runoff models calibrated to the discharge-frequency relationships for the individual stream gage locations. The Hydrologic Modeling System (HEC-HMS), developed at the Hydrologic Engineering Center (HEC) at Davis, Ca., was used for the hydrologic modeling analysis. The HEC-HMS software uses a three-'model' approach, which includes a basin model, a meteorologic model, and a control specification model. Although the focus of this study was to develop discharges for that portion of Calleguas Creek from Hitch Blvd. to Mugu Lagoon, as well as the lower portion of Conejo Creek, the upper portion of the Calleguas Creek watershed was still subdivided and included in anticipation of any future expansion of the study area. A schematic flow diagram of the entire stream system is shown on Figures 17 and 18.

The most difficult and time-consuming part of the rainfall-runoff analysis was that of deriving flood hydrographs at a series of locations throughout study area for a range of frequency events. This problem requires the successive evaluation of many storm centerings upstream of each location of interest. The HEC-HMS computer program does not have a depth-area function wherein the peak discharge at multiple locations for a specific frequency can be determined with a single simulation. The previous rainfall-runoff model (HEC-1) developed by the Hydrologic Engineering Center at Davis, CA, addressed this issue by including a depth-area function, which consisted of generating index hydrographs, interpolating, and adding to other index hydrographs. The peak discharges for specific frequency events at many locations in the watershed could be generated from one computer run. The current version of the HEC-HMS computer software does not include this depth-area function yet.

Thus, separate basin models were developed for each concentration point (CP). In addition, meteorologic models were created for selected frequency events for each CP. Add to this two control specification models created for a 6-hour simulation and a 24-hour simulation. This resulted in an extensive list of HEC-HMS models and simulations. Calibration of the subarea parameters for each simulation proved to be prohibitive. Thus, the basin models were calibrated using an adjustment of the precipitation until the downstream discharge closely matched the discharge from the discharge-frequency curves. Calibration was performed at each of the stream gage locations within the study reach. The simulations for the ungaged locations included the precipitation ratio from the closest stream gage location for the appropriate frequency.

To expedite the analysis, meteorologic models were only developed for the 10-, 25-, and 100-year events. The results from these simulations for each CP were plotted on log-frequency paper alongside the discharge-frequency curve for the closest stream gage location. Graphical curves were then drawn through the three points and extrapolated on both ends using the stream gage frequency curve as a guide.

7.1. Subarea Delineation. For modeling runoff, the drainage area within the Calleguas Creek Watershed was divided into 75 subareas ranging in size from 0.1 mi^2 (Calleguas Creek below PCH) to 26.0 mi^2 (upper Revolon Slough) based primarily on subarea homogeneity, tributary boundaries, and critical points where discharge data was needed. The HEC-GeoHMS computer program, in conjunction with ArcView, was used with USGS 30-meter DEMs (Digital Elevation Models) to delineate the watershed and compute subarea characteristics. Subarea boundaries are shown on the USGS 1:24,000 topographic map on Figures 19 and 20. The subarea characteristics are listed in Table 8.

7.2. Precipitation. The total point-precipitation depths for the selected exceedance probability for durations from 5 minutes through the desired total duration of the hypothetical storm were used in the HEC-HMS models. Depths for various durations for a specified exceedance probability were obtained from NOAA Atlas 2 for the Western U.S., California. The 6-hr and 24-hr depths were determined from isopluvial maps included in the Atlas. The values for other durations were calculated using equations and nomographs also provided in NOAA Atlas II. The values were then plotted and smoothed prior to input to ensure that the storm hyetograph was reasonably shaped. The point precipitation values for the entire Calleguas Creek Watershed are shown in Table 9. The critical runoff-producing storm was determined to be of 6 hours duration for locations with less than 100 mi^2 of contributing drainage areas. This is dependent on the time of concentration at the location of interest. A sensitivity analysis was performed at a series of locations. The peak discharge for locations at or around 100 mi^2 was similar when using a 6-hour storm pattern or a 24-hour storm pattern. So, for areas with a contributing drainage area greater than 100 mi^2, a 24-hour frequency storm was used for simulation.

A depth-area-duration correction factor is applied in HEC-HMS, because intense rainfall is unlikely to be distributed uniformly over a large watershed. For a specified frequency and duration, the average rainfall depth over an area is less than the depth at a point. To account for this, the U.S. Weather Bureau (1958) derived, from averages of annual series of point and areal values for several dense, recording rain gage networks, factors by which point depths are to be reduced to yield areal-average depths. The factors, expressed as a percentage of point depth, are a function of area and duration. The depth-area-reduction curve is shown on Figure 21.

HEC-HMS interpolates to find depths for durations that are integer multiples of the time interval selected for runoff modeling. HEC-HMS uses linear interpolation, with logarithmically transformed values of depth and duration. The successive differences in the cumulative depths (the incremental precipitation depths) are calculated for each computation interval. The storm hyetograph is created using the alternating block method (Chow, Maidment, Mays, 1988) from the incremental precipitation values (blocks). This method positions the block of maximum incremental depth at the middle of the required duration. The remaining blocks are arranged then in descending order, alternately before and after the central block.

7.3. Precipitation Loss Rates. The initial-constant (or initial-uniform) loss rate method was utilized in the rainfall-runoff models to estimate the portion of rainfall that is “lost” to various factors including infiltration, interception, detention storage, evaporation, and transpiration. Based on previous studies in and around the Calleguas Creek Watershed, a constant loss rate of 0.20 in/hr was deemed applicable for valley subareas and 0.30 in/hr was deemed applicable for mountainous subareas. The percentage of valley and mountain for each subarea was estimated from previous studies and aerial photographs. A weighted constant loss rate based on the percentage valley and mountain was then calculated for each subarea. An initial loss rate of 1.20 inches was estimated for the valley areas and 1.50 inches for the mountain areas. Similarly, a weighted starting loss rate was calculated based on the percentage of valley and mountain for each subarea. Loss rates for each subarea are listed in Table 10.

7.4. Impervious Cover. An impervious factor was used to account for urbanization. The HEC-HMS models calculate 100% runoff from the impervious portion of the subareas. The percent impervious cover under Present Conditions was estimated for each subarea using previous studies, aerial photographs, and data provided by VCFCD. The percent impervious cover for each subarea under Present Conditions is presented in Table 10. The percent impervious cover for Future and Natural Conditions are also included. The basis for these conditions are discussed later.

7.5. Unit Hydrographs. The method used to develop synthetic unit hydrographs is the Los Angeles District procedures as described in the Department of the Army Technical Bulletin No. 5-550-3 entitled "Flood Prediction Techniques", dated February 1957. The procedure has its basis in an S-graph, which is the time distribution of runoff as a function of watershed lag time. Lag time is defined as the time in hours for 50 percent of total volume of runoff of the unit hydrograph to occur following the start of unit rainfall. The watershed lag time was approximated for all subareas using the lag relationship below. Figure 22 shows the relationship in graphical form.

$$Lag = 24 \cdot n \cdot \left(\frac{L \cdot L_{ca}}{S^{\frac{1}{2}}} \right)^{0.38}$$

The basin n-value is a variable in the lag equation that permits adjustment of lag time depending on the type of ground cover and other characteristics affecting watershed response to effective rainfall. Initial estimates for subarea basin n-values were based on the information in the 1987 Calleguas Creek, Hydrology for Survey report. The subareas delineated for the current study were overlain onto the 1987 subareas using ArcView GIS and n-values were proportioned using a ratio of subarea drainage area from the current study to the previous study. In defining the unit hydrographs for urbanized subareas, the basin n-values from the 1987 study were reduced in proportion to the degree of urbanization. This adjustment is necessary to account for the more rapid response of an urbanized watershed to rainfall excess and was carried through to the current analysis. Subarea characteristics including the basin n-values for Present, Future, and Natural Conditions are given in Table 8.

7.6. <u>S-Graph</u>. The S-graph applied in the Calleguas Creek Watershed is the Santa Clara S-graph. The Santa Clara S-graph, shown on Figure 23, is an average of 5 S-graphs; one determined for the Santa Clara River near Saugus and four S-graphs for the Santa Margarita River Watershed. (The Santa Margarita Watershed was found to have similar runoff characteristics).

7.7. <u>Base flow</u>. Base flow is now present in the lower portion of the Calleguas Creek Watershed on a year-round basis. This base flow is negligible however compared to the runoff generated during storm events and thus was not included in the rainfall-runoff models.

7.8. <u>Flood Routing</u>. Flood routing through both natural and improved channels was performed using the Muskingum method. The flood wave travel time in a reach, which approximates the Muskingum coefficient K, was determined by dividing reach length by average peak flow velocity. The peak flow velocity was determined in previous studies for the Calleguas Creek Watershed. Manning's formula for normal depth and an appropriate cross section was used to compute the average peak flow velocity for each reach. Cross sections were determined from USGS topographic maps and field investigations. The Muskingum K coefficient was set equal to the closest multiple of the computation interval (either 0.25 or 0.50) so the number of steps or subreaches (NSTPS in HEC-HMS model) would be equal to 1. The lone exception to this was along the lower part of Revolon Slough where the travel time through subarea REV-A3 was 1.41 hours, the K coefficient was set to 0.50, and the number of subreaches was set to 3. Muskingum X values were estimated according to the relative importance of channel storage. Values of X used in this study were estimated to range from 0.2 for reaches with limited channel capacity and wide cross sections and large amounts of channel storage to 0.4 for reaches with well-defined channels. Routing parameters for the various reaches in the study area are given in Table 11.

8. <u>Future Conditions</u>. On the basis of predictions of probable population increase and resulting urban and suburban development during the next 100 years, the estimate that 40 percent of the valley area would become all-impervious in that time was considered reasonable, except those areas where the subarea (or a portion of) would continue to be used for agriculture or is designated as an area that may not be developed (e.g., National Forest, etc.). Percentages of impervious cover for each subarea for Future Conditions are given in Table 8. Future Conditions frequency discharges were computed in an identical manner to Present Conditions using the HEC-HMS models. The estimated future impervious cover and revised basin n-values were changed for each subarea in the models. The models were executed using the same precipitation as Present Conditions.

9. <u>Natural Conditions</u>. An effort was made to estimate the frequency discharges at the same locations in the watershed that were calculated for Present and Future Conditions that represented a ‘Natural’ or undeveloped condition. History indicates there has been agriculture along with associated buildings for processing, residences, churches, etc. as far back as the late 1700s. The Natural Conditions presented in this study are meant to represent conditions in the watershed about the mid-1900s, i.e., prior to the current onset of urbanization. Natural

Conditions frequency discharges were determined by modifying the percent impervious cover and basin n-values for each subarea in the HEC-HMS models. The models were executed using the same precipitation as Present Conditions. Percentages of impervious cover for each subarea for Natural Conditions are given in Table 8.

10. Summary And Results. The approach selected, discrete event rainfall-runoff analysis, provided estimates of peak flows at selected locations in the watershed, and also made available flood hydrographs at these locations of interest. The basis of this approach -- frequency rainfall and subarea runoff calibrated to discharge-frequency relationships at gaged locations -- provided a sound basis for computation of frequency runoff. The dynamics of urbanization were quantified for Natural and Future Conditions by modifying the percent impervious cover and the basin n-values for each subarea. The discharges for larger events do not reflect the impacts caused by flow breaking out of the channel or re-entering the channel. These impacts will be quantified during the hydraulic portion of this study.

The frequency discharges for selected locations under Present, Future, and Natural Conditions are shown in Table 12. Note that the frequency discharges for CP-32 (Calleguas Creek at Pacific Coast Highway) are less than those at CP-140 (Calleguas Creek at Cal. State University Channel Islands -- CSUCI). This is due to the timing of the peak from the local inflow hydrographs (which occurs sooner) in relation to the peak coming down the main channel. The floodplain in this location in very flat and the hydrograph in the main channel is attenuated.

Hydrographs for the 100-year event for CP-141 (Calleguas Creek at Mugu Lagoon) and CP-28 (Conejo Creek above Calleguas Creek) under Present, Future, and Natural Conditions are shown on Figures 24 and 25, respectively. These hydrographs do not incorporate the impacts of flow breaking out or re-entering the channel.

A comparison was made with results from the previous Corps of Engineer Report for Survey for Calleguas Creek dated November 1987. The results were similar in some locations and significantly different at others. The Calleguas Creek watershed is becoming more urbanized and is now partially regulated by detention/debris basins, particularly in the upstream watershed. In addition, there has been an additional 15 years or more of data at the stream gages since the previous analysis. Therefore, an update to the discharge-frequency curves was necessary. When comparing the frequency discharges between the current analysis and previous study, a general trend can be seen, wherein the mean discharge at all locations has increased while the upper end of the curves or rarer events are slightly lower. The 100-year discharges were fairly close in most locations. A comparison of discharges is shown in Table 13.

Table 1: Elevation-Storage-Outflow Relationships
Las Llajas Canyon Dam and Sycamore Canyon Dam

Elevation (ft)	Storage (ac-ft)	Outflow (ft³/s)
Las Llajas Canyon Dam		
1,190	0	0
1,191	17	46
1,192	33	129
1,193	50	236
1,194	67	364
1,194.6	75	418
1,200	170	460
1,210	428	500
1,220	788	538
1,225	965	554
1,228	1,093	664
1,229	1,129	1,148
1,230	1,175	2,102
1,231	1,218	3,455
1,232	1,260	4,439
1,233	1,310	5,232
1,234	1,360	6,386
1,235	1,428	8,109
1,236	1,470	8,340
1,237	1,520	8,344
Spillway Crest = 1,229 feet Top of Dam = 1,240 feet		
Sycamore Dam		
782	0	0
783	47	32
784	73	88
785	102	137
786	130	141
788	197	159
790	287	162
792	375	172
794	483	181
796	603	186
797	670	190
798	745	428
800	892	1,502
802	1,070	3,043
804	1,270	4,926
806	1,482	7,111
808	1,690	9,568
810	1,920	12,420
Spillway Crest = 798 feet Top of Dam = 810 feet		

Table 2: Flood Control and Sediment Control Facilities
Calleguas Creek Watershed

Name	Type	Date	Maintained By	Notes
Adams Debris Basin	Debris Basin	9/2/1998	VCFCD	Existing
Arundell Barranca Dam & Debris Basin	Debris Basin	10/31/1996	VCFCD	Existing
Castro - Williams Debris Basin	Debris Basin	1/1/1955	NRCS	Existing
Cavin Road Debris Basin	Debris Basin		VCFCD	Existing
Coyote Canyon Debris Basin	Debris Basin	9/16/1998	VCFCD	Existing
Crestview Debris Basin	Debris Basin	1/1/1956	VCFCD	Existing
Dos Vientos-S Protrero Rd Debris/Detention/NPDES Basin	Debris Basin	9/26/1995		Existing
Edgemore Debris Basin	Debris Basin	8/27/1971	VCFCD	Existing
Erringer Road Debris Basin	Debris Basin	12/5/1997	VCFCD	Existing
Fagan Canyon Debris Basin	Debris Basin	5/23/1994	VCFCD	Existing
Ferro Debris Basin	Debris Basin	8/9/1995	VCFCD	Existing
Fox Barranca Debris Basin	Debris Basin	8/21/1992	VCFCD	Existing
Franklin Barranca (/Wasson) Debris Basin	Debris Basin	5/15/1995	VCFCD	Existing
Gabbert Canyon Debris Basin	Debris Basin	10/10/1995	VCFCD	Existing
Honda West Debris Basin	Debris Basin	4/1/1955	VCFCD	Existing
Jepson Wash Debris Basin	Debris Basin	9/11/1998	VCFCD	Existing
Las Posas Estates Debris Basin	Debris Basin	10/28/1991	VCFCD	Existing
Real Wash Debris Basin	Debris Basin	7/23/1964	VCFCD	Existing
Santa Rosa Road #2 Debris Basin	Debris Basin	4/1/1957	VCFCD	Existing
SCS Structure: C 15 f 1.2 (Fasshauer Est. R/W)	Debris Basin		NRCS	Existing
SCS Structure: C 17 d 1.3 (Brooker-Fox Barranca R/W)	Debris Basin			Existing
South Branch Arroyo Conejo Debris Basin	Debris Basin	2/19/1997	VCFCD	Existing
South Branch Hwy 101 bypass Basin	Debris Basin			Proposed
St. Johns Debris Basin	Debris Basin		VCFCD	Existing
Tapo Hills No. 1 Debris Basin	Debris Basin	10/27/1970	VCFCD	Existing
Tapo Hills No. 2 Debris Basin	Debris Basin	1/13/1978	VCFCD	Existing
Warring Canyon Debris Basin	Debris Basin	8/18/1992	VCFCD	Existing
West Camarillo Hills East Branch Debris Basin	Debris Basin	9/18/1992	VCFCD	Existing
West Camarillo Hills West Branch Debris Basin	Debris Basin	9/18/1992	VCFCD	Existing
Desilting Basin (Tract 3507-3) - Lindero Cyn.	Desilting Basin			Existing
Arielle Detention Basin	Detention Basin	6/3/1999	VCFCD	In Construction
Conejo Mountain Creek #1 Detention Basin	Detention Basin	10/22/1997		In Construction
Conejo Mountain Creek #2 Detention Basin	Detention Basin	10/22/1997		In Construction
Conejo Mountain Creek #3 Detention Basin	Detention Basin	10/22/1997		In Construction
Conejo Mountain Creek #4 Detention Basin	Detention Basin	10/22/1997		In Construction
Conejo Mountain Creek #5 Detention Basin	Detention Basin	10/22/1997		In Construction
Covington Detention Basin	Detention Basin	12/5/1997	VCFCD	In Construction

Table 2: Flood Control and Sediment Control Facilities
Calleguas Creek Watershed

Name	Type	Date	Maintained By	Notes
Detention Basin Site No. "0"	Detention Basin			Proposed
Detention Basin Site No. "1"	Detention Basin			Proposed
Detention Basin Site No. "2"	Detention Basin			Proposed
Detention Basin Site No. "3"	Detention Basin			Proposed
Erringer Detention Basin	Detention Basin	12/5/1997	VCFCD	In Construction
Gabbert Detention Basin MODIFIED SITE	Detention Basin			Proposed
Las LLajas Canyon Dam	Detention Basin	6/23/1980	VCFCD	Existing
Las Posas Estates Dam	Detention Basin	10/23/1956	VCFCD	Existing
Line "C"-Arroyo Simi Detention Basin	Detention Basin	8/12/1997		In Construction
Mission Oaks Drain Area Retention Dam	Detention Basin	9/1/1983	City of Camarillo	Existing
Mount Sinai Detention Basin "A"	Detention Basin	3/31/1999		Existing
Muirfield Detention Basin	Detention Basin	6/3/1999	VCFCD	In Construction
Oak Canyon Basin #1 Detention Basin	Detention Basin	6/18/1997		In Construction
Oak Canyon Basin #2 Detention Basin	Detention Basin	6/18/1997		In Construction
Peach Hill Wash Detention Basin	Detention Basin	11/13/1984	VCFCD	Existing
Ramona Dam & Debris Basin	Detention Basin	10/20/1992	VCFCD	Existing
Retention Basin - North of Hwy 126	Detention Basin		VCFCD	Existing
Rudolph Detention Basin	Detention Basin	12/5/1997	VCFCD	In Construction
Runkle Canyon Detention Basin	Detention Basin	3/11/1970	VCFCD	Existing
Sycamore Detention Basin	Detention Basin	12/5/1997	VCFCD	In Construction
Basin Number 2	Other	12/16/1997		Existing
Lang Ranch Dam	State Size Dam			Proposed
Sycamore Canyon Dam	State Size Dam	6/9/1980	VCFCD	Existing

Date refers to construction date
Data not available for blank cells
VCFCD = Ventura County Flood Control District
NRCS = Natural Resource Conservation Service

Table 3: Pertinent Data for Precipitation Stations
In and Around Calleguas Creek Watershed

Station ID	Station Name	Type	Latitude	Longitude	Elevation	Year Began
101	Piru-Camulos Ranch	RS	34.41	118.76	725	1929
121	Lake Sherwood-County Fire Station	RS	34.14	118.88	960	1935
128	Thousand Oaks-County Fire Station	S	34.22	118.87	800	1943
132	Saticoy-Buenaventura Lemon Co	S	34.28	119.14	170	1937
141	Moorpark-County Fire Station	S	34.29	118.88	525	1949
153	Ojai-Barrett Ranch	S	34.44	119.22	780	1952
154	Simi-County Fire Station	S	34.29	118.71	1,075	1948
163c	Sulphur Mountain	RS	34.41	119.17	2,610	NA
168	Oxnard Airport	RS	34.20	119.21	34	1957
169	Thousand Oaks-Weather Station	RS	34.18	118.85	805	1957
17	Port Hueneme – USN	RS	34.14	119.19	10	1891
171	Fillmore-Fish Hatchery	RS	34.39	118.88	465	1957
173	Santa Paula Canyon-Ferndale Ranch	RS	34.43	119.09	1,010	1957
175	Saticoy-County Fire Station	RS	34.29	119.16	185	1957
177	Camarillo-Pacific Sod	S	34.16	119.08	20	1957
18	Santa Paula-Limoneira Ranch	S	34.33	119.13	295	1905
187	Susana Knolls-County Fire Station	S	34.26	118.67	1,085	1956
188	Newbury Park-County Fire Station	R	34.19	118.93	640	1956
189	Somis-Deboni	R	34.28	119.07	520	1956
190	Somis-Bard	RS	34.28	119.01	460	1956
191	Moorpark-Downing Ranch	RS	34.33	118.90	1,040	1956
192	Moorpark-Everett	RS	34.25	118.84	635	1956
193	Santa Susana	RS	34.27	118.71	965	1956
194b	Camarillo-Sanitation Plant	RS	34.19	119.00	125	1956
196	Tapo Canyon	RS	34.33	118.72	1,390	1965
199	Fillmore-County Fire Station	S	34.40	118.93	435	1960
206	Somis-Fuller	RS	34.31	118.98	733	1961
215	Channel Islands Harbor	S	34.16	119.22	5	1964
219	Camarillo-Hauser	S	34.24	119.03	192	1965
222	Ventura-County Government Center	S	34.27	119.21	280	1926
223	Point Mugu-USN	S	34.11	119.12	5	1946
225	Wheeler Canyon	R	34.39	119.15	900	1966
227	Lake Bard	RS	34.24	118.83	1,010	1966
230	Ventura-Sexton Canyon	R	34.31	119.23	880	1972
231	El Rio-County Yard	S	34.24	119.18	79	1968
232	Santa Monica Mts-Deals Flat	RS	34.09	118.97	1,475	1969
234	Las Llajas Canyon	R	34.30	118.69	1,150	1969
235	Piru-L.A./Ventura County Line	PT	34.40	118.70	800	1971
238	South Mountain-Shell Oil	RS	34.33	119.01	1,630	1971

Table 3: Pertinent Data for Precipitation Stations
In and Around Calleguas Creek Watershed

Station ID	Station Name	Type	Latitude	Longitude	Elevation	Year Began
239	El Rio-UWCD Spreading Grounds	S	34.24	119.15	105	1973
242	Tripas Canyon	RS	34.37	118.76	2,500	1972
245	Santa Paula-UWCD	RS	34.35	119.06	300	1961
246	Simi Sanitation Plant	PT	34.28	118.82	660	1975
249	Simi Hills-Rocketdyne Lab	RS	34.24	118.68	1,910	1959
25	Piru-Newhall Ranch	S	34.40	118.72	825	1913
250	Moorpark-Happy Camp Canyon	R	34.35	118.85	1,410	1977
259	Camarillo-PVWD	S	34.21	119.07	80	1982
261	Saticoy-Recharge Facility	S	34.28	119.12	145	1985
263	Camarillo-Leisure Village	S	34.22	118.99	115	1985
271	Lockwood Valley nr Seymour Creek	S	34.27	119.04	5,165	1992
32	Oxnard-Water Department	S	34.20	119.18	53	1875
36	Piru-County Fire Station	S	34.41	118.80	700	1926
49	Santa Rosa Valley-Worthington Ranch	S	34.25	118.94	445	1929
64	Upper Ojai-Happy Valley	RS	34.44	119.19	1,320	1901
65	Upper Ojai Summit-County Fire Statn	S	34.44	119.13	1,560	1925
85	Canada Larga	RS	34.38	119.23	760	1935
94	Fillmore-Fairview Ranch	S	34.39	118.86	640	1932
96	Bardsdale-Lander Ranch	S	34.36	118.95	390	1932

Type:
R: Recorder Gage
S: Standard Gage
RS: Recorder Standard
PT: Punch Tape

NA = Not Available

Table 4: Pertinent Data for Stream Gages In and Around Calleguas Creek Watershed

Station ID	Station Name	Type	Latitude	Longitude	Year Began
701	Hopper Creek near Piru	RG	34.40	118.83	1930
708	Santa Clara River at Montalvo	RG	34.28	119.14	1928
709	Santa Paula Creek near Santa Paula	RD	34.41	119.08	1927
710	Sespe Creek near Fillmore	RDT	34.44	118.93	1927
713	Pole Creek at Sespe Ave	RG	34.40	118.90	1974
731	Ellsworth Barranca at Foothill Rd	BC	34.32	119.14	1970
732	Harmon Barranca below Telegraph Rd	BC	34.28	119.20	1971
733	Oxnard West Drain below/above Bolker St	BC	34.18	119.20	1970
735	Fagan Canyon Drain below Harvard blvd	BC	34.34	119.08	1972
736	Real-Warring Drain above Pacific Ave	BC	34.40	118.80	1974
776	Revolon Slough at Laguna Rd	RG	34.18	119.10	1980
778	Nyeland Acres Drain	BC	34.23	119.13	1987
779	Rice Rd Drain below Wooley Rd	BC	34.19	119.15	1988
780	Beardsly Wash at Central Ave	RG	34.23	119.11	1995
781	Santa Clara Drain	RG	34.24	119.11	1996
782	Las Posas Estates Drain	RG	34.23	119.11	NA
800	Conejo Creek above Hwy 101	RGRD	34.24	118.96	1972
802	Arroyo Simi at Royal Ave Bridge	RGRD	34.26	118.74	1969
803	Arroyo Simi at Madera Rd Bridge	RGRDT	34.28	118.80	1938
805	Calleguas Creek at CSUCI	RG	34.18	119.04	1955
806	Calleguas Creek above Hwy 101	RGRD	34.22	119.01	1972
830	Arroyo Conejo S Brnch ab Ventu-Park Rd	BC	34.18	118.91	1970
831	Arroyo Simi above White Oak	NA	NA	NA	1971
832	Arroyo Tapo below Los Angeles Ave	BC	34.27	118.74	1970
833	Bus Canyon Drain above Los Angeles Ave	BC	34.27	118.78	1970
834	Sycamore Canyon Drain bl Tierra Rej Rd	BC	34.27	118.80	1971
835	Camarillo Hills Drain below Hwy 101	BC	34.22	119.07	1976
836	Arroyo Conejo below Conejo Blvd	BC	34.18	118.88	1976
838	Arroyo Santa Rosa bl Blanchard Rd Drain	BC	34.23	118.92	1984
839	Gabbert-Walnut Canyon Drain	BC	34.27	118.92	1987
841	Arroyo Las Posas at Hitch Blvd	RG	34.27	118.92	1991
931	Potrero Creek below Westlake Blvd	BC	34.14	118.84	1972

Type:

BC: Bristol Chart
RG: Recording Graphic
RGRDT: Recording Graphic Recording Digital Telemark
RGRD: Recording Graphic Recording Digital
RDT: Recording Digital Telemark

NA = Not Available

Table 5: Discharge-Frequency Results for Gaged Locations
Calleguas Creek Watershed

Closest CP/ *Gage Number*	Location	Drainage Area (mi²)	2-Year (ft³/s)	5-Year (ft³/s)	10-Year (ft³/s)	25-Year (ft³/s)	50-Year (ft³/s)	100-Year (ft³/s)	200-Year (ft³/s)	500-Year (ft³/s)
1 *831*	Arroyo Simi above White Oak	3.2	190	530	910	1,610	2,300	3,170	4,240	6,010
3 *802*	Arroyo Simi at Royal Ave.	32.6	1,020	2,570	4,130	6,790	9,330	12,400	16,000	21,700
5 *803*	Arroyo Simi at Madera Road	71.0	1,610	3,880	6,090	9,760	13,200	17,200	22,000	29,400
135 *801*	Arroyo Simi at Moorpark	115.0	2,180	5,140	7,970	12,700	17,000	22,100	28,000	37,200
139 *806*	Calleguas Creek above Highway 101	178.0	3,000	6,890	10,600	16,500	21,900	28,300	35,600	46,900
140 *805*	Calleguas Creek at CSUCI	248.0	4,450	9,900	14,900	22,900	30,100	38,500	48,000	62,600
19 *836*	Arroyo Conejo below Conejo Blvd.	14.2	1,230	2,520	3,680	5,500	7,130	9,000	11,200	14,400
22 *830*	Arroyo Conejo above Ventu Park	12.5	920	1,900	2,780	4,170	5,420	6,850	8,500	11,000
26 *800*	Conejo Creek above Highway 101	64.2	3,490	6,850	9,740	14,200	18,100	22,500	27,500	35,000
34 *776*	Revolon Slough at Laguna Road	46.0	2,130	4,190	5,980	8,730	11,100	13,900	17,000	21,700

Table 6: Preliminary Statistics from Graphical Frequency Curves for Gaged Locations in Calleguas Creek Watershed

Closest CP/ *Gage Number*	Location	Drainage Area (mi²)	Mean (X)	Standard Deviation (S)	Skew (G)	No. of Years of Record
1 *831*	Arroyo Simi above White Oak	3.2	2.235	0.550	-0.092	30
3 *802*	Arroyo Simi at Royal Ave.	32.6	3.102	0.463	-0.192	33
5 *803*	Arroyo Simi at Madera Rd.	71.0	3.116	0.552	-0.049	59
135 *801*	Arroyo Simi at Moorpark	115.0	3.190	0.511	-0.100	52
139 *806*	Calleguas Creek above Highway 101	178.0	3.459	0.460	-0.231	32
140 *805*	Calleguas Creek at CSUCI	248.0	3.640	0.419	-0.113	36
19 *836*	Arroyo Conejo below Conejo Blvd.	14.2	2.949	0.372	0.100	25
22 *830*	Arroyo Conejo above Ventu Park Rd. (South Branch)	12.5	2.962	0.375	0.044	31
26 *800*	Conejo Creek above Highway 101	64.2	3.546	0.348	0.029	31
34 *776*	Revolon Slough at Laguna Road	46.0	3.353	0.350	-0.059	22

Note: The values in this table were the preliminary estimates and are not used for the final frequency curves. They are included in this report for comparison purposes only.

Table 7: Adopted Statistics from Graphical Frequency Curves
for Gaged Locations in Calleguas Creek Watershed

Closest CP/ *Gage Number*	Location	Drainage Area (mi^2)	Mean (X)	Standard Deviation (S)	Skew (G)	No. of Years of Record
1 *831*	Arroyo Simi above White Oak	3.2	2.2627	0.550	-0.1[c]	30
3 *802*	Arroyo Simi at Royal Ave.	32.6	3.0000[a]	0.485[b]	-0.1[c]	33
5 *803*	Arroyo Simi at Madera Rd.	71.0	3.2000[a]	0.460[b]	-0.1[c]	59
135 *801*	Arroyo Simi at Moorpark	115.0	3.3300[a]	0.450[b]	-0.1[c]	52
139 *806*	Calleguas Creek above Highway 101	178.0	3.4693	0.436[b]	-0.1[c]	32
140 *805*	Calleguas Creek at CSUCI	248.0	3.6412	0.419	-0.1[c]	36
19 *836*	Arroyo Conejo below Conejo Blvd.	14.2	3.0890[a]	0.372	0.0[d]	25
22 *830*	Arroyo Conejo above Ventu Park Rd. (South Branch)	12.5	2.9636	0.375	0.0[d]	31
26 *800*	Conejo Creek above Highway 101	64.2	3.5425	0.348	0.0[d]	31
34 *776*	Revolon Slough at Laguna Road	46.0	3.3281	0.350	0.0[d]	22

a Adjusted Mean (see text)
b Adjusted Standard Deviation (see text)
c Average for 6 Calleguas Creek mainstem gages (see text)
d Average for 3 Conejo Creek and 1 Revolon Slough gages (see text)

Table 8: Subarea Parameters

Subarea	Drainage Area A (mi^2)	Length L (mi)	Length to Centroid Lca (mi)	Elevation Maximum Emax (ft)	Elevation Minimum Emin (ft)	Slope S (ft/mi)	Natural Conditions		Present Conditions		Future Conditions	
							N-Value	Lag (hrs)	N-Value	Lag (hrs)	N-Value	Lag (hrs)
CAL_A1	3.6	3.26	1.33	2,000	1,005	305.1	0.040	0.57	0.039	0.55	0.036	0.51
CAL_A2	3.5	3.70	1.96	2,646	1,003	443.7	0.040	0.64	0.039	0.62	0.036	0.58
CAL_A3	3.3	3.05	1.20	1,443	964	157.3	0.030	0.45	0.026	0.38	0.021	0.32
CAL_A4	3.9	4.36	1.80	1,676	910	175.8	0.026	0.51	0.017	0.34	0.016	0.31
CAL_A5	6.0	5.09	2.59	2,095	910	232.7	0.047	1.07	0.047	1.07	0.045	1.02
CAL_A6	1.6	2.76	0.98	1,010	860	54.3	0.047	0.77	0.047	0.77	0.045	0.74
CAL_A7	5.2	5.97	2.89	2,212	760	243.4	0.038	0.95	0.034	0.85	0.032	0.80
CAL_A8	3.0	5.21	2.66	1,757	685	205.7	0.038	0.90	0.034	0.81	0.032	0.76
CAL_A9	9.0	6.54	2.60	2,148	685	223.7	0.044	1.11	0.042	1.05	0.041	1.03
CAL_A10	3.3	5.06	2.89	1,469	635	164.9	0.048	1.21	0.047	1.19	0.046	1.16
CAL_A11	5.9	6.76	3.38	2,068	635	212.1	0.049	1.40	0.049	1.40	0.049	1.40
CAL_A12	2.1	3.08	1.12	1,042	589	147.3	0.044	0.65	0.043	0.64	0.042	0.62
CAL_A13	6.3	5.57	2.67	2,343	589	314.8	0.048	1.08	0.047	1.06	0.047	1.06
CAL_A14	4.2	5.34	2.98	1,930	548	258.9	0.046	1.10	0.045	1.08	0.045	1.08
CAL_A15	11.9	11.17	6.44	2,748	549	196.8	0.049	2.19	0.049	2.19	0.048	2.14
CAL_A16	5.0	5.74	3.32	1,263	417	147.4	0.040	1.14	0.040	1.14	0.035	1.00
CAL_A17	2.6	3.35	1.53	798	458	101.5	0.044	0.82	0.043	0.80	0.042	0.78
CAL_A18	1.6	3.31	1.70	924	397	159.4	0.041	0.72	0.040	0.71	0.036	0.64
CAL_A19	1.4	2.49	0.93	773	396	151.5	0.040	0.51	0.040	0.51	0.035	0.44
CAL_A20	5.1	7.55	4.11	1,811	397	187.2	0.040	1.31	0.040	1.31	0.035	1.15
CAL_A21	3.7	6.00	2.21	1,244	306	156.3	0.040	0.98	0.040	0.98	0.035	0.86
CAL_A22	4.7	7.37	4.45	1,843	307	208.3	0.040	1.31	0.040	1.31	0.035	1.15
CAL_A23	6.3	7.36	3.00	1,490	243	169.5	0.040	1.17	0.040	1.17	0.035	1.03
CAL_A24	5.5	7.69	4.51	2,259	245	261.9	0.044	1.41	0.044	1.41	0.041	1.31
CAL_A25	0.9	2.46	1.19	677	197	195.2	0.029	0.38	0.028	0.37	0.022	0.29
CAL_A26	0.5	2.01	0.98	680	183	246.8	0.029	0.32	0.028	0.31	0.022	0.24
CAL_A27	0.5	1.29	0.52	383	150	180.9	0.029	0.22	0.028	0.22	0.022	0.17
CAL_A28	0.5	2.07	1.12	215	136	38.1	0.029	0.48	0.028	0.46	0.022	0.36
CAL_A29	0.1	0.97	0.43	150	122	29.0	0.025	0.23	0.022	0.20	0.015	0.14
CAL_A30	0.4	1.67	0.74	129	92	22.2	0.025	0.36	0.022	0.32	0.015	0.22
CAL_A31	0.5	1.61	0.86	99	61	23.7	0.033	0.49	0.033	0.49	0.029	0.43
CAL_A32	1.3	2.65	1.61	1,222	63	438.1	0.033	0.43	0.033	0.43	0.029	0.38
CAL_A33	3.9	5.38	2.84	1,038	30	187.5	0.033	0.83	0.033	0.83	0.029	0.73
CAL_A34	0.6	2.07	0.81	547	11	259.4	0.033	0.33	0.033	0.33	0.029	0.29
CAL_A35	7.0	4.21	1.69	840	14	196.0	0.033	0.61	0.033	0.61	0.029	0.54

Table 8: Subarea Parameters

Subarea	Drainage Area A (mi^2)	Length L (mi)	Length to Centroid Lca (mi)	Elevation Maximum Emax (ft)	Elevation Minimum Emin (ft)	Slope S (ft/mi)	Natural Conditions		Present Conditions		Future Conditions	
							N-Value	Lag (hrs)	N-Value	Lag (hrs)	N-Value	Lag (hrs)
CAL_A36	1.0	1.81	0.91	1,444	9	792.7	0.033	0.27	0.033	0.27	0.029	0.24
CAL_A37	0.1	0.57	0.17	137	9	224.0	0.033	0.12	0.033	0.12	0.029	0.10
CAL_B1	6.8	7.06	3.79	3,627	1,126	354.5	0.050	1.37	0.050	1.37	0.049	1.34
CAL_B2	4.0	5.59	2.99	3,118	1,126	356.2	0.050	1.15	0.050	1.15	0.05	1.15
CAL_B3	0.6	2.88	1.53	1,534	964	197.6	0.027	0.42	0.019	0.29	0.017	0.26
CAL_C1	4.9	5.41	3.27	2,985	1,157	337.9	0.050	1.18	0.050	1.18	0.05	1.18
CAL_C2	11.6	7.07	3.55	2,751	1,157	225.6	0.050	1.46	0.050	1.46	0.05	1.46
CAL_C3	2.8	5.01	2.91	1,492	861	126.0	0.027	0.72	0.019	0.50	0.017	0.45
CAL_D1	2.7	4.81	3.14	2,149	830	274.1	0.043	1.00	0.040	0.93	0.039	0.90
CAL_D2	6.8	6.39	3.65	2,160	719	225.6	0.043	1.22	0.040	1.13	0.039	1.11
CAL_E1	3.8	5.40	2.73	1,936	520	262.1	0.044	1.02	0.043	1.00	0.041	0.95
CAL_E2	2.1	3.46	1.84	962	416	157.9	0.044	0.82	0.043	0.80	0.041	0.76
CAL_F1	3.6	6.29	3.91	2,262	309	310.7	0.044	1.20	0.044	1.20	0.041	1.12
CAL_F2	3.5	5.04	2.80	1,205	310	177.4	0.044	1.08	0.044	1.08	0.041	1.01
CAL_F3	0.6	2.20	1.15	503	245	117.1	0.044	0.61	0.044	0.61	0.041	0.57
CAL_G1	2.1	4.44	2.44	558	145	93.1	0.029	0.73	0.028	0.70	0.022	0.55
CAL_G2	2.5	4.17	2.00	214	92	29.2	0.029	0.82	0.028	0.79	0.022	0.62
CON_A1	2.4	3.74	1.66	2,164	978	316.9	0.029	0.47	0.025	0.40	0.021	0.34
CON_A2	2.7	2.88	0.95	1,579	801	270.0	0.029	0.35	0.025	0.30	0.021	0.25
CON_A3	3.0	3.70	1.14	1,547	703	228.4	0.029	0.43	0.025	0.37	0.021	0.31
CON_A4	5.2	3.95	1.24	842	529	79.2	0.029	0.55	0.025	0.48	0.021	0.40
CON_A5	2.1	4.31	1.34	688	260	99.3	0.030	0.59	0.026	0.51	0.023	0.45
CON_A6	8.0	7.26	3.63	1,288	260	141.5	0.030	0.97	0.026	0.84	0.023	0.75
CON_A7	2.6	4.07	2.34	834	210	153.3	0.030	0.65	0.026	0.56	0.023	0.50
CON_A8	3.8	3.54	1.79	817	158	186.1	0.031	0.56	0.030	0.54	0.026	0.47
CON_A9	7.8	4.80	1.51	1,030	109	191.9	0.031	0.58	0.030	0.56	0.026	0.49
CON_A10	2.1	3.46	1.43	1,787	105	485.9	0.031	0.42	0.030	0.41	0.026	0.35
CON_A11	3.8	4.36	1.26	332	92	55.1	0.031	0.66	0.030	0.64	0.026	0.56
CON_B1	2.8	3.54	1.59	2,103	1,026	304.4	0.029	0.45	0.025	0.39	0.021	0.33
CON_B2	3.6	5.64	3.34	1,405	703	124.5	0.029	0.85	0.025	0.73	0.021	0.61
CON_C1	2.4	2.99	1.25	1,114	710	135.1	0.030	0.47	0.027	0.42	0.023	0.36
CON_C2	3.9	2.97	0.48	1,119	720	134.3	0.030	0.32	0.027	0.29	0.023	0.25
CON_C3	5.1	3.64	1.37	991	633	98.2	0.030	0.55	0.027	0.50	0.023	0.42
CON_C4	1.9	2.86	1.70	1,528	530	349.4	0.030	0.43	0.027	0.39	0.023	0.33
CON_D1	9.1	8.13	5.19	1,289	247	128.2	0.032	1.27	0.032	1.27	0.027	1.07

Table 8: Subarea Parameters

Subarea	Drainage Area A (mi^2)	Length L (mi)	Length to Centroid Lca (mi)	Elevation Maximum Emax (ft)	Elevation Minimum Emin (ft)	Slope S (ft/mi)	Natural Conditions		Present Conditions		Future Conditions	
							N-Value	Lag (hrs)	N-Value	Lag (hrs)	N-Value	Lag (hrs)
CON_D2	3.8	5.04	1.96	1,075	246	164.5	0.032	0.70	0.032	0.70	0.027	0.59
CON_D3	1.8	2.97	1.30	852	210	216.3	0.032	0.46	0.032	0.46	0.027	0.39
REV_A1	26.0	10.82	3.72	2,151	64	192.9	0.028	1.01	0.027	0.97	0.019	0.68
REV_A2	13.7	7.15	3.33	850	44	112.7	0.028	0.91	0.027	0.88	0.019	0.62
REV_A3	21.2	12.12	5.62	116	9	8.8	0.028	2.21	0.027	2.13	0.019	1.50

Table 9: Point Precipitation Frequency For Calleguas Creek Watershed

Duration	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5-Min	0.19	0.27	0.32	0.38	0.43	0.47
10-Min	0.30	0.42	0.49	0.59	0.66	0.73
15-Min	0.38	0.53	0.62	0.75	0.84	0.93
30-Min	0.53	0.73	0.86	1.04	1.16	1.29
1-Hr	0.67	0.93	1.09	1.31	1.47	1.63
2-Hr	0.89	1.23	1.45	1.74	1.95	2.16
3-Hr	1.11	1.53	1.79	2.15	2.41	2.66
6-Hr	1.61	2.21	2.60	3.10	3.47	3.84
12-Hr	2.04	3.05	3.71	4.57	5.20	5.82
24-Hr	2.48	3.90	4.85	6.04	6.92	7.80

Location = Calleguas Creek at CP-141
Zone Number = 10
Latitude = 34.07
Longitude = 119.05
Elevation = 8

Table 10: Loss Rates and Percent Impervious Cover
Calleguas Creek Watershed

Subarea	Drainage Area (mi²)	Valley %	Mountain %	Loss Rate (in/hr)	Starting Loss (in)	Percent Impervious Cover		
						Natural	Present	Future
Calleguas Creek								
CAL_A1	3.6	40%	60%	0.26	1.38	3	10	19
CAL_A2	3.5	39%	61%	0.26	1.38	3	7	19
CAL_A3	3.3	82%	18%	0.22	1.25	4	15	34
CAL_A4	3.9	100%	0%	0.20	1.20	5	33	40
CAL_A5	6.0	13%	87%	0.29	1.46	2	4	10
CAL_A6	1.6	100%	0%	0.20	1.20	5	33	40
CAL_A7	5.2	50%	50%	0.25	1.35	3	15	23
CAL_A8	3.0	50%	50%	0.25	1.35	3	15	23
CAL_A9	9.0	23%	77%	0.28	1.43	2	11	13
CAL_A10	3.3	10%	90%	0.29	1.47	2	5	9
CAL_A11	5.9	3%	97%	0.30	1.49	2	5	6
CAL_A12	2.1	56%	44%	0.24	1.33	4	5	25
CAL_A13	6.3	9%	91%	0.29	1.47	2	8	8
CAL_A14	4.2	9%	91%	0.29	1.47	2	8	8
CAL_A15	11.9	5%	95%	0.30	1.49	2	5	7
CAL_A16	5.0	48%	52%	0.25	1.36	3	16	22
CAL_A17	2.6	22%	78%	0.28	1.43	3	6	13
CAL_A18	1.6	58%	42%	0.24	1.33	4	8	25
CAL_A19	1.4	42%	58%	0.26	1.37	3	5	20
CAL_A20	5.1	42%	58%	0.26	1.37	3	5	20
CAL_A21	3.7	42%	58%	0.26	1.37	3	5	20
CAL_A22	4.7	42%	58%	0.26	1.37	3	5	20
CAL_A23	6.3	42%	58%	0.26	1.37	3	5	20
CAL_A24	5.5	24%	76%	0.28	1.43	3	5	13
CAL_A25	0.9	72%	28%	0.23	1.28	4	17	30
CAL_A26	0.5	72%	28%	0.23	1.28	4	17	30
CAL_A27	0.5	100%	0%	0.20	1.20	5	14	40
CAL_A28	0.5	100%	0%	0.20	1.20	5	14	40
CAL_A29	0.1	100%	0%	0.20	1.20	5	14	40
CAL_A30	0.4	100%	0%	0.20	1.20	5	14	40
CAL_A31	0.5	44%	56%	0.26	1.37	3	6	20
CAL_A32	1.3	44%	56%	0.26	1.37	3	6	20
CAL_A33	3.9	44%	56%	0.26	1.37	3	6	20
CAL_A34	0.6	44%	56%	0.26	1.37	3	6	20
CAL_A35	7.0	44%	56%	0.26	1.37	3	6	20
CAL_A36	1.0	44%	56%	0.26	1.37	3	6	20
CAL_A37	0.1	100%	0%	0.20	1.20	3	6	20
CAL_B1	6.8	1%	99%	0.30	1.50	2	5	5
CAL_B2	4.0	20%	80%	0.28	1.44	3	8	12
CAL_B3	0.6	100%	0%	0.20	1.20	5	25	40
CAL_C1	4.9	0%	100%	0.30	1.50	2	5	5
CAL_C2	11.6	0%	100%	0.30	1.50	2	5	5
CAL_C3	2.8	44%	56%	0.26	1.37	5	27	38
CAL_D1	2.7	30%	70%	0.27	1.41	3	13	16
CAL_D2	6.8	30%	70%	0.27	1.41	3	13	16
CAL_E1	3.8	24%	76%	0.28	1.43	3	7	13
CAL_E2	2.1	24%	76%	0.28	1.43	3	7	13

Table 10: Loss Rates and Percent Impervious Cover
Calleguas Creek Watershed

CAL_F1	3.6	24%	76%	0.28	1.43	3	5	13
CAL_F2	3.5	24%	76%	0.28	1.43	3	5	13
CAL_F3	0.6	24%	76%	0.28	1.43	3	5	13
CAL_G1	2.1	72%	28%	0.23	1.28	4	17	30
CAL_G2	2.5	100%	0%	0.20	1.20	5	14	40
Conejo Creek								
CON_A1	2.4	75%	25%	0.23	1.28	4	15	31
CON_A2	2.7	75%	25%	0.23	1.28	4	15	31
CON_A3	3.0	75%	25%	0.23	1.28	4	15	31
CON_A4	5.2	75%	25%	0.23	1.28	4	15	31
CON_A5	2.1	67%	33%	0.23	1.30	4	15	29
CON_A6	8.0	67%	33%	0.23	1.30	4	14	29
CON_A7	2.6	58%	42%	0.24	1.33	4	8	25
CON_A8	3.8	58%	42%	0.24	1.33	4	8	25
CON_A9	7.8	58%	42%	0.24	1.33	4	8	25
CON_A10	2.1	58%	42%	0.24	1.33	4	8	25
CON_A11	3.8	58%	42%	0.24	1.33	4	8	25
CON_B1	2.8	75%	25%	0.23	1.28	4	15	31
CON_B2	3.6	75%	25%	0.23	1.28	4	15	31
CON_C1	2.4	67%	33%	0.23	1.30	4	15	29
CON_C2	3.9	67%	33%	0.23	1.30	4	15	29
CON_C3	5.1	67%	33%	0.23	1.30	4	15	29
CON_C4	1.9	67%	33%	0.23	1.30	4	15	29
CON_D1	9.1	52%	48%	0.25	1.34	4	6	23
CON_D2	3.8	52%	48%	0.25	1.34	4	6	23
CON_D3	1.8	58%	42%	0.24	1.33	4	8	25
Revolon Slough								
REV_A1	26.0	83%	17%	0.22	1.25	4	7	11
REV_A2	13.7	83%	17%	0.22	1.25	4	7	11
REV_A3	21.2	83%	17%	0.22	1.25	4	7	11

Percent Mountain & Valley estimated from 2001 aerial photos and values used in previous studies.

Table 11: Routing Parameters for HEC-HMS Models

Reach	Length (ft)	Velocity (ft/s)	Travel Time (hrs)	Muskingum K (hrs)	Muskingum X	No. of Subreaches
R1-131	8,749	7	0.35	0.25	0.40	1
R2-131	12,386	7	0.49	0.50	0.25	1
R131-3	9,041	8	0.31	0.25	0.30	1
R3-132	6,884	8	0.24	0.25	0.30	1
R4-132	20,752	18	0.32	0.25	0.35	1
R132-133	13,422	8	0.47	0.50	0.30	1
R133-5	8,358	7	0.33	0.25	0.25	1
R5-134	8,205	7	0.33	0.25	0.25	1
R134-6	9,540	8	0.33	0.25	0.25	1
R6-135	7,973	8	0.28	0.25	0.25	1
R135-136	21,863	11	0.55	0.50	0.25	1
R7-136	8,713	11	0.22	0.25	0.25	1
R136-8	3,095	11	0.08	0.25	0.30	1
R8-9	13,017	11	0.33	0.25	0.30	1
R10-137	4,352	11	0.11	0.25	0.30	1
R9-137	10,767	11	0.27	0.25	0.30	1
R137-11	10,222	12	0.24	0.25	0.30	1
R11-12	5,608	12	0.13	0.25	0.30	1
R12-139	6,118	12	0.14	0.25	0.30	1
R139-13	4,313	7	0.17	0.25	0.30	1
R13-14	6,826	7	0.27	0.50	0.30	1
R15-140	11,294	7	0.45	0.50	0.30	1
R16-17	11,893	12	0.28	0.50	0.30	1
R17-19	8,335	12	0.19	0.25	0.30	1
R18-19	25,160	12	0.58	0.50	0.30	1
R19-22	12,460	12	0.29	0.50	0.30	1
R20-21	14,455	12	0.33	0.50	0.30	1
R21-22	7,649	12	0.18	0.25	0.30	1
R22-23	15,398	12	0.36	0.50	0.30	1
R23-25	10,365	11	0.26	0.50	0.30	1
R24-25	8,381	11	0.21	0.25	0.30	1
R25-26	10,672	11	0.27	0.50	0.30	1
R26-27	15,415	11	0.39	0.50	0.30	1
R27-28	12,211	11	0.31	0.50	0.30	1
R140-29	7,584	7	0.30	0.50	0.25	1
R29-30	9,119	7	0.36	0.50	0.25	1
R30-31	9,103	7	0.36	0.50	0.25	1
R31-32	11,850	7	0.47	0.50	0.25	1
R32-141	1,569	7	0.06	0.25	0.25	1
R33-34	10,573	7	0.42	0.50	0.25	1
R34-35	35,646	7	1.41	0.50	0.25	3
R35-141	1,569	7	0.06	0.25	0.25	1

Table 12: Discharge Frequency Results at Selected Locations in the Calleguas Creek Watershed (With No Breakouts)

CP	Location	Drainage Area (mi^2)	2-Year (ft^3/s)	5-Year (ft^3/s)	10-Year (ft^3/s)	25-Year (ft^3/s)	50-Year (ft^3/s)	100-Year (ft^3/s)	200-Year (ft^3/s)	500-Year (ft^3/s)
135	Arroyo Simi at Moorpark	115.0	2,180	5,140	7,970	12,700	17,000	22,100	28,000	37,200
			2,510	*5,500*	*8,660*	*13,500*	*17,800*	*22,900*	*28,400*	*37,400*
			1,750	4,150	6,740	11,400	14,900	20,800	25,500	35,000
136	Calleguas Creek at Hitch Blvd.	126.6	2,550	5,900	9,210	14,700	19,000	24,800	31,500	40,500
			2,990	*6,600*	*10,100*	*15,600*	*19,900*	*25,700*	*32,500*	*42,500*
			2,050	5,000	7,820	13,200	17,400	23,300	29,000	39,000
139	Calleguas Creek Above Highway 101	178.0	3,000	6,890	10,600	16,500	21,900	28,300	35,600	46,900
			3,250	*7.410*	*12,100*	*18,200*	*23,500*	*30,000*	*37,500*	*49,000*
			2,490	5,800	9,060	14,900	19,000	26,600	32,500	42,500
140	Calleguas Creek at CSUCI	248.0	4,450	9,900	14,900	22,900	30,100	38,500	48,000	62,600
			6,600	*13,000*	*18,400*	*26,600*	*33,900*	*42,300*	*50,500*	*64,200*
			3,610	8,250	12,600	20,400	26,800	35,900	45,000	59,000
32	Calleguas Creek at Pacific Coast Highway	262.5	4,100	9,400	14,300	22,200	29,300	37,700	47,400	62,100
			6,300	*12,400*	*17,900*	*26,100*	*33,400*	*41,800*	*50,000*	*63,800*
			3,000	7,600	11,900	19,600	26,000	35,100	44,400	58,500
141	Calleguas Creek at Mugu Lagoon	323.4	5,100	10,700	15,200	23,600	31,000	41,700	50,000	64,300
			7,000	*13,800*	*19,100*	*27,800*	*35,500*	*46,200*	*54,000*	*69,200*
			3,700	8,400	12,700	20,800	27,500	38,800	47,000	61,900
26	Conejo Creek above Highway 101	64.2	3,490	6,850	9,740	14,200	18,100	22,500	27,500	35,000
			5,000	*8,960*	*12,400*	*16,700*	*20,800*	*24,800*	*29,200*	*36,100*
			2,150	5,500	8,350	12,900	17,000	21,300	26,700	34,200
28	Conejo Creek above Calleguas Creek	74.2	3,550	6,900	9,790	14,400	18,300	22,800	27,800	35,200
			5,250	*9,250*	*12,700*	*17,200*	*21,400*	*25,500*	*29,800*	*36,500*
			2,170	5,530	8,330	13,000	17,200	21,500	27,000	34,400
34	Revolon Slough at Laguna Road	46.0	2,130	4,190	5,980	8,730	11,100	13,900	17,000	21,700
			2,400	*4,520*	*6,440*	*9,200*	*11,400*	*14,300*	*17,400*	*22,000*
			1,980	3,990	5,630	8,400	10,800	13,600	16,700	21,400
35	Revolon Slough at Pacific Coast Highway	60.9	3,210	6,000	7,880	11,000	13,900	17,300	21,500	26,100
			2,900	*5,400*	*8,500*	*11,600*	*14,500*	*17,900*	*20,600*	*27,000*
			2,600	5,000	7,430	10,600	13,100	16,900	19,800	25,400

The upper discharge in each column represents Existing Conditions followed by Future Conditions and finally Natural Conditions.

Table 13: Comparison of Discharge Frequency Results at Selected Locations in the Calleguas Creek Watershed

CP	Location	5-Year		10-Year		25-Year		50-Year		100-Year		500-Year	
		Present (ft^3/s)	Future (ft^3/s)	Present (ft^3/s)	Future (ft^3/s)	Present (ft^3/s)	Future (ft^3/s)	Present (ft^3/s)	Future (ft^3/s)	Present (ft^3/s)	Future (ft^3/s)	Present (ft^3/s)	Future (ft^3/s)
135	Arroyo Simi at Moorpark	5,140	5,500	7,970	8,660	12,700	13,500	17,000	17,800	22,100	22,900	37,200	37,400
		3,100	3,500	5,700	6,500	11,000	12,000	16,000	18,000	23,000	25,000	45,000	46,000
136	Calleguas Creek at Hitch Blvd.	5,900	6,600	9,210	10,100	14,700	15,600	19,000	19,900	24,800	25,700	40,500	42,500
		3,100	3,500	5,700	6,500	11,000	12,000	16,000	18,000	23,000	25,000	45,000	46,000
139	Calleguas Creek Above Highway 101	6,890	7,410	10,600	12,100	16,500	18,200	21,900	23,500	28,300	30,000	46,900	49,000
		3,500	4,300	6,600	7,800	13,000	14,000	20,000	21,000	28,000	29,000	53,000	54,000
140	Calleguas Creek at CSUCI	9,900	13,000	14,900	18,400	22,900	26,600	30,100	33,900	38,500	42,300	62,600	64,200
		4,200	5,700	8,000	10,000	15,000	18,000	23,000	26,000	33,000	36,000	63,000	66,000
141	Calleguas Creek at Mugu Lagoon	10,700	13,800	15,200	19,100	23,600	27,800	31,000	35,500	41,700	46,200	64,300	69,200
		4,700	7,200	8,700	12,000	17,000	21,000	26,000	30,000	37,000	40,000	70,000	74,000

The upper value in each column for each location is for the current study. The lower value is from the 1987 Corps of Engineers Hydrology for Survey Report for Calleguas Creek.

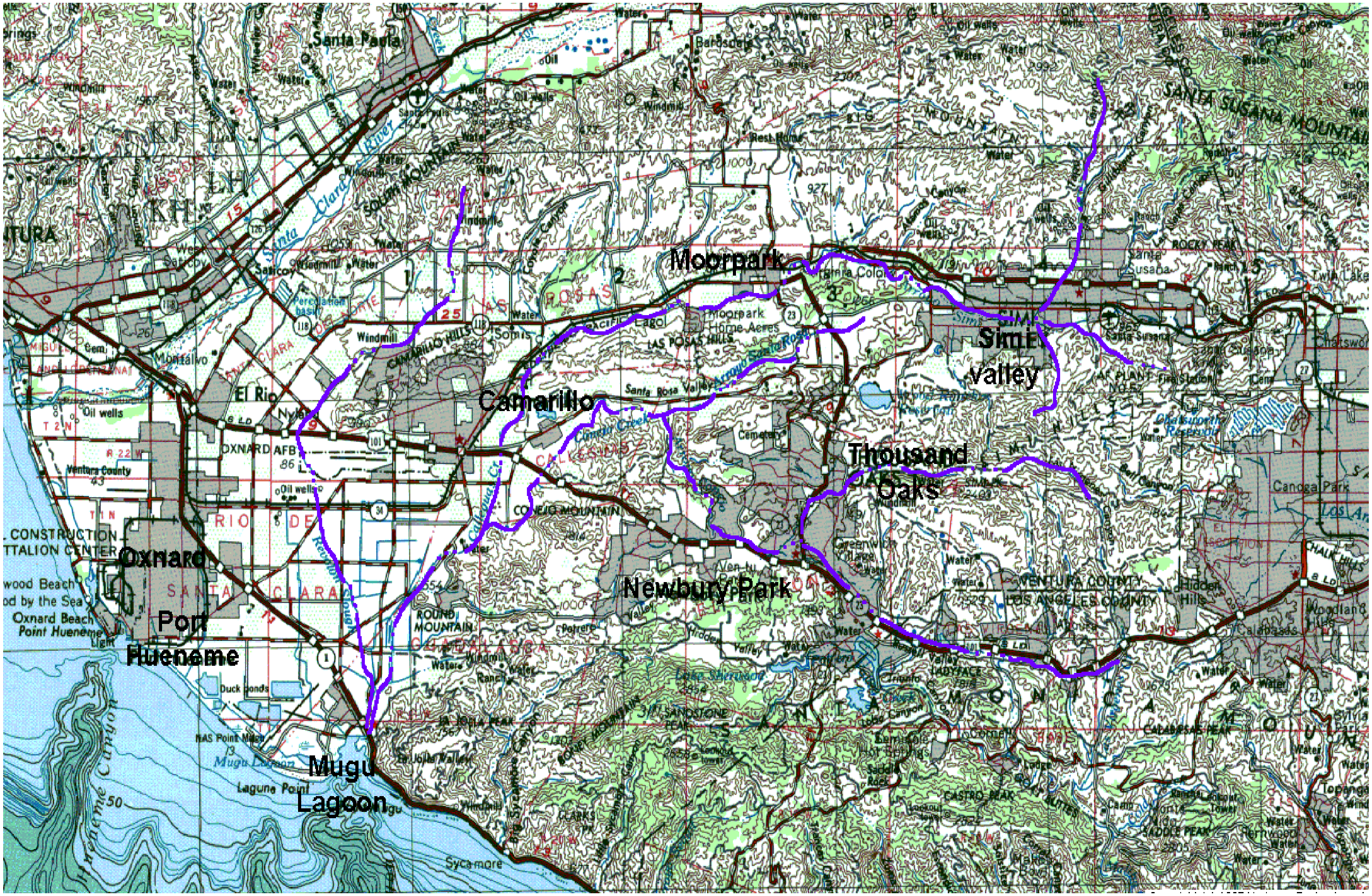

Figure 1: Location Map – Calleguas Creek Watershed, Ventura and Los Angeles Counties, CA

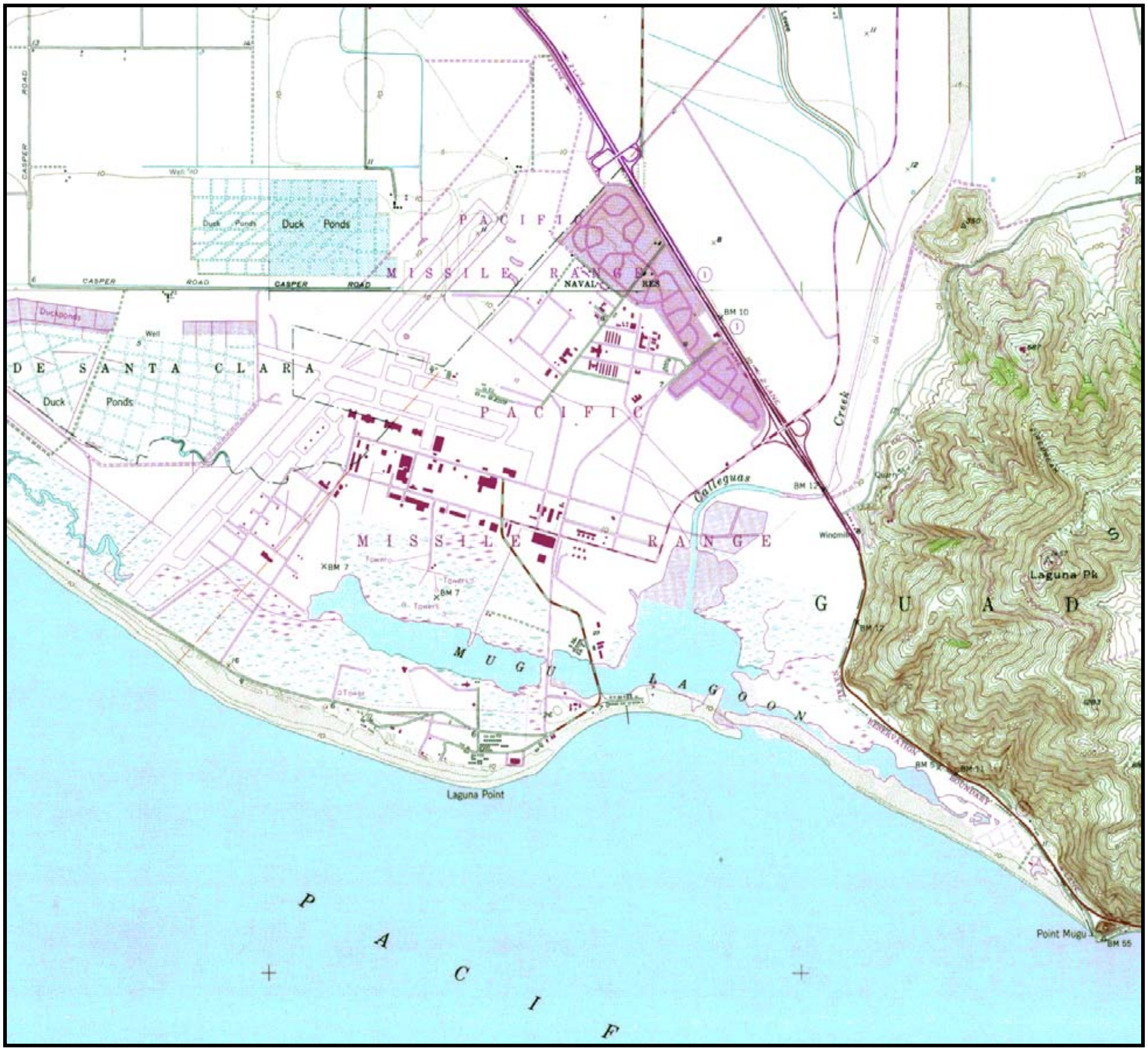

Figure 2: Location Map – Mugu Lagoon, Calleguas Creek Watershed, CA

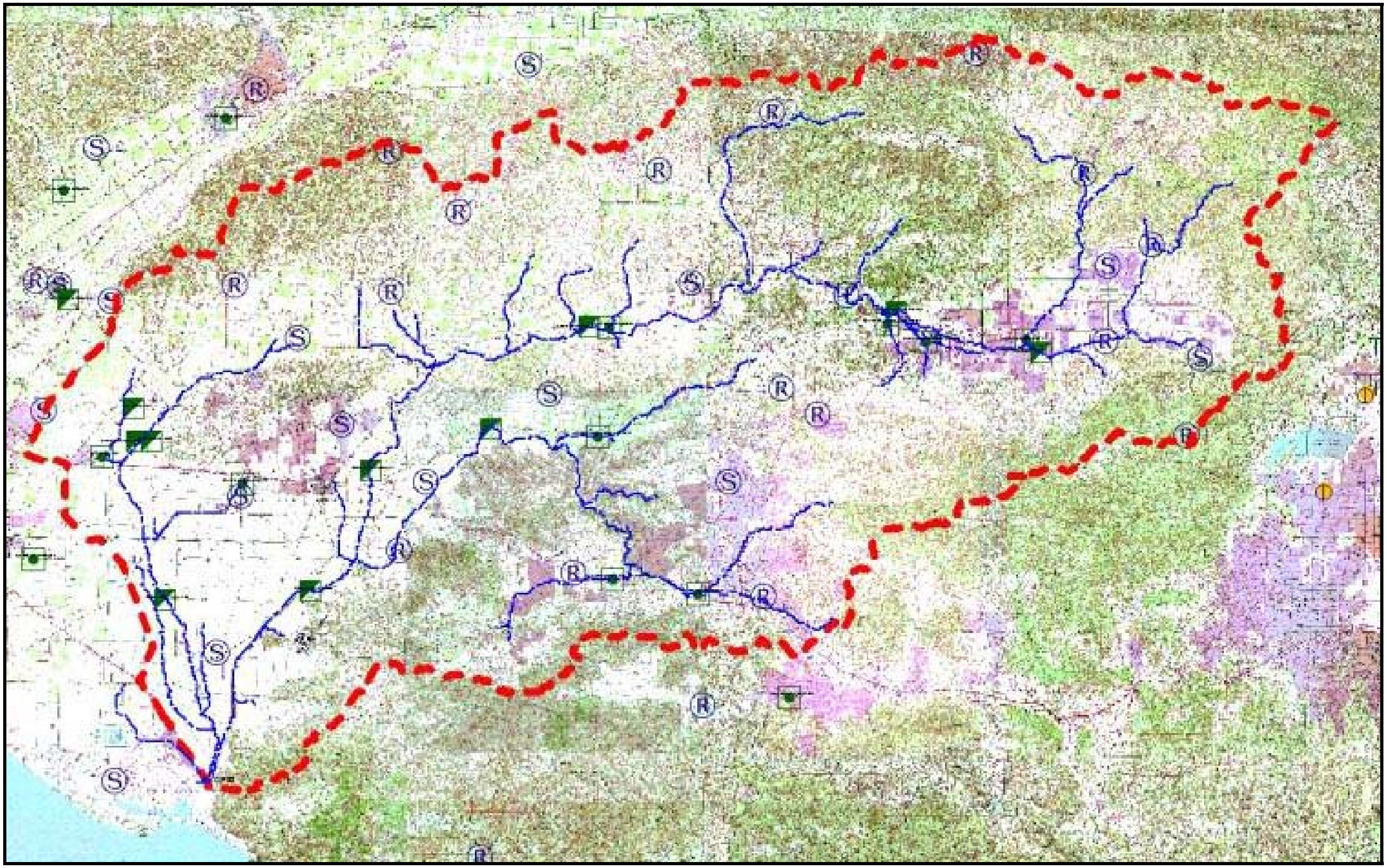

Figure 3: Precipitation and Stream Gage Locations
Calleguas Creek Watershed, CA

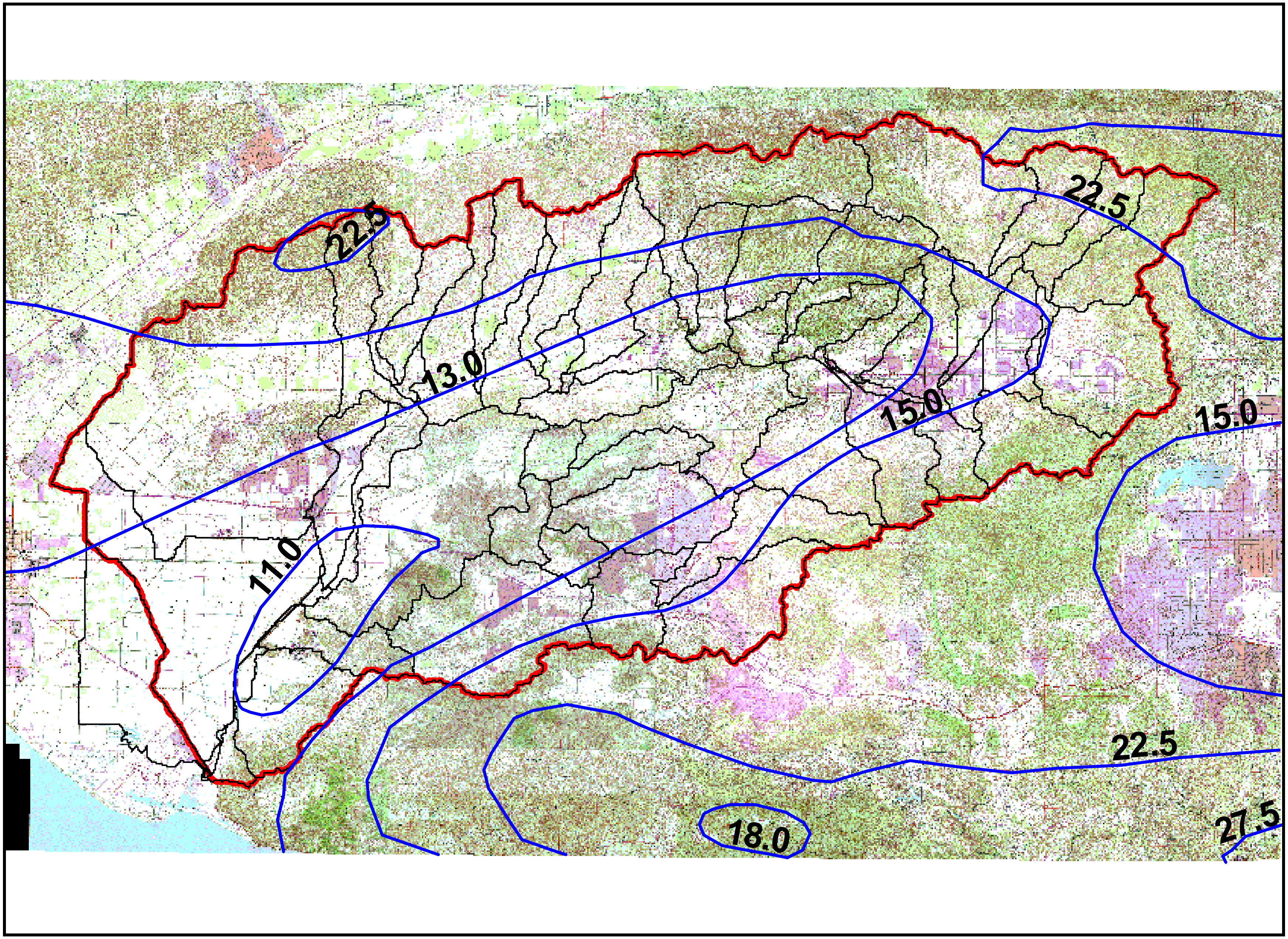

Figure 4: Average Annual Precipitation – Calleguas Creek Watershed

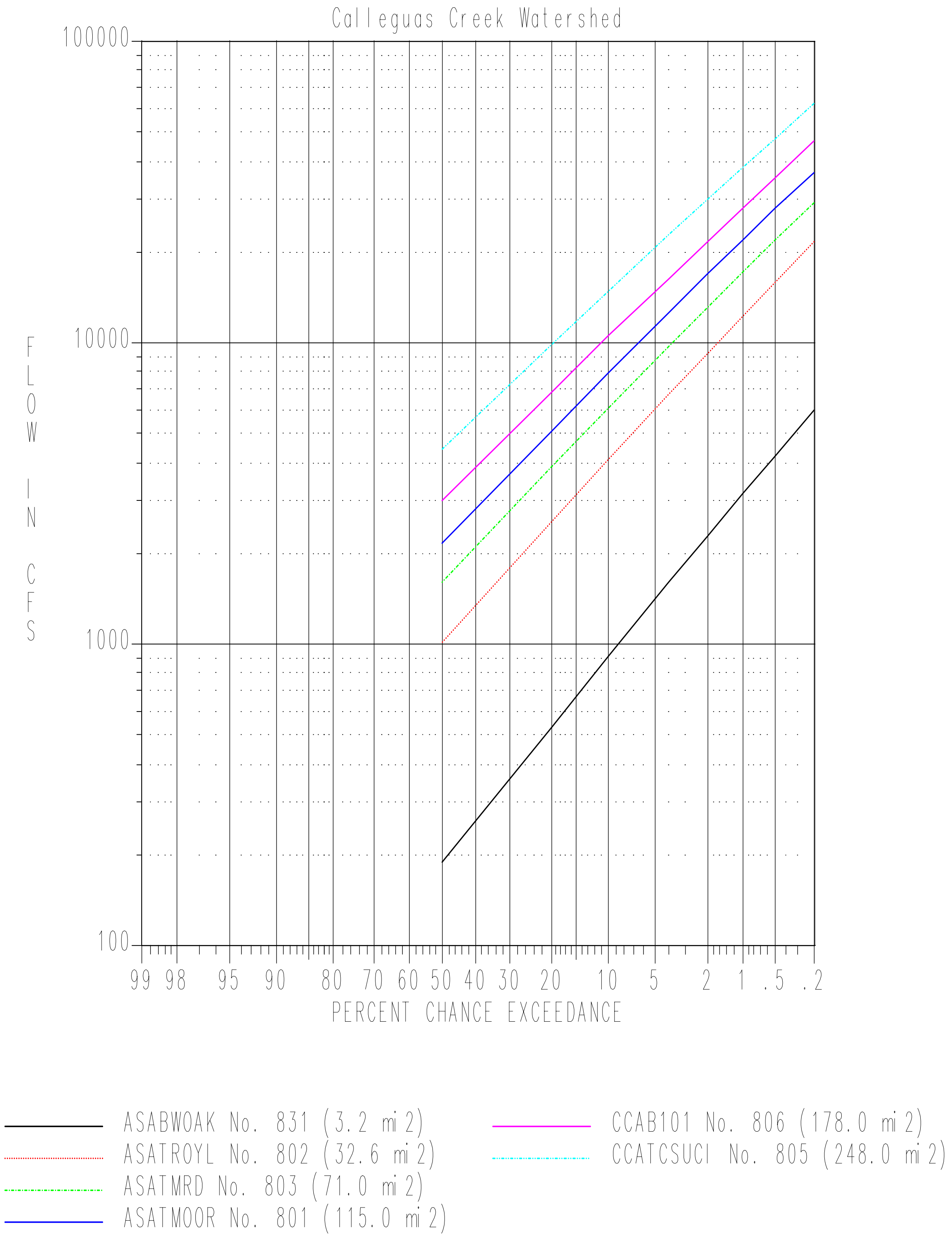

Figure 5: Discharge-Frequency Curves – Calleguas Creek Mainstem

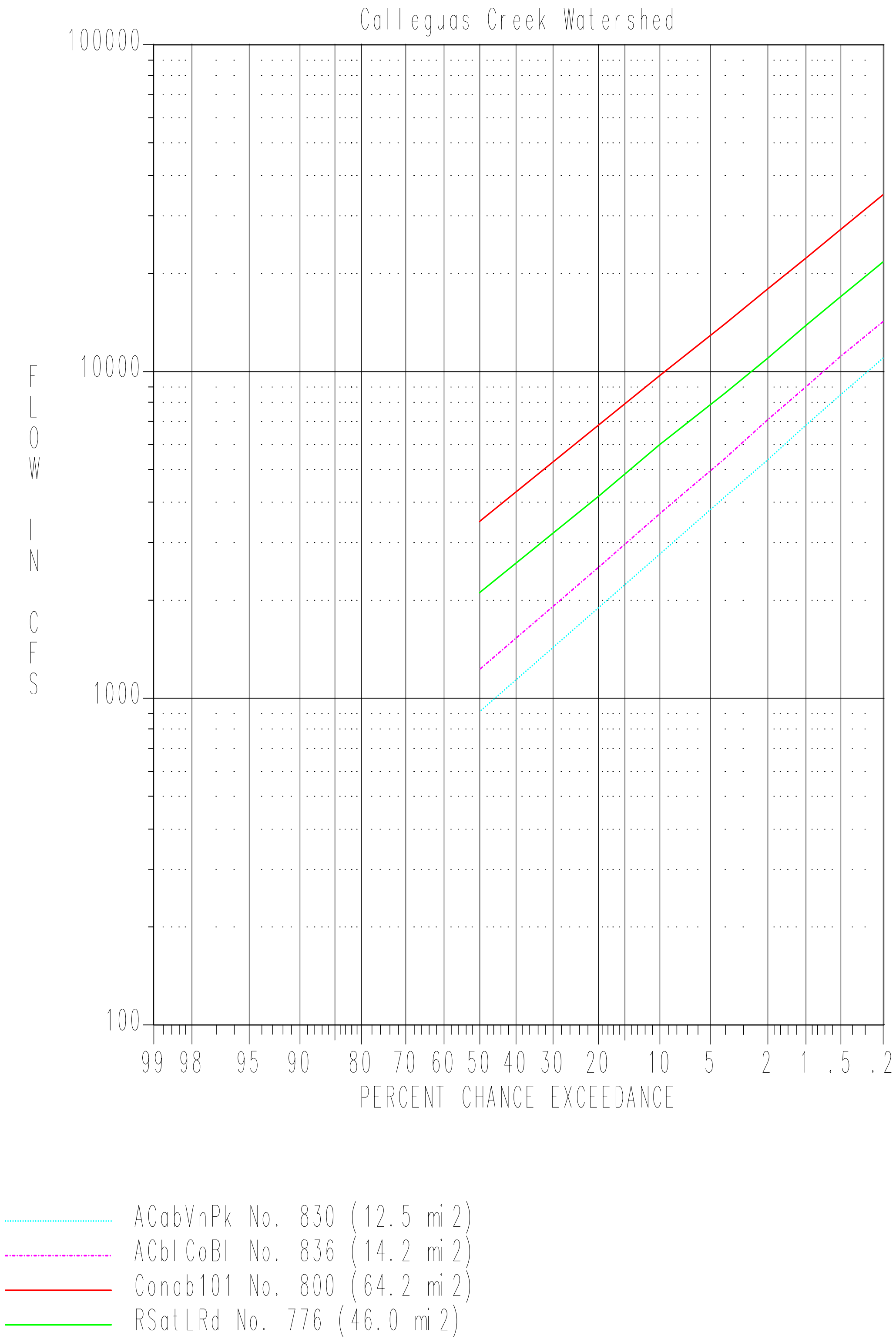

Figure 6: Discharge-Frequency Curves – Conejo Creek & Revolon Slough

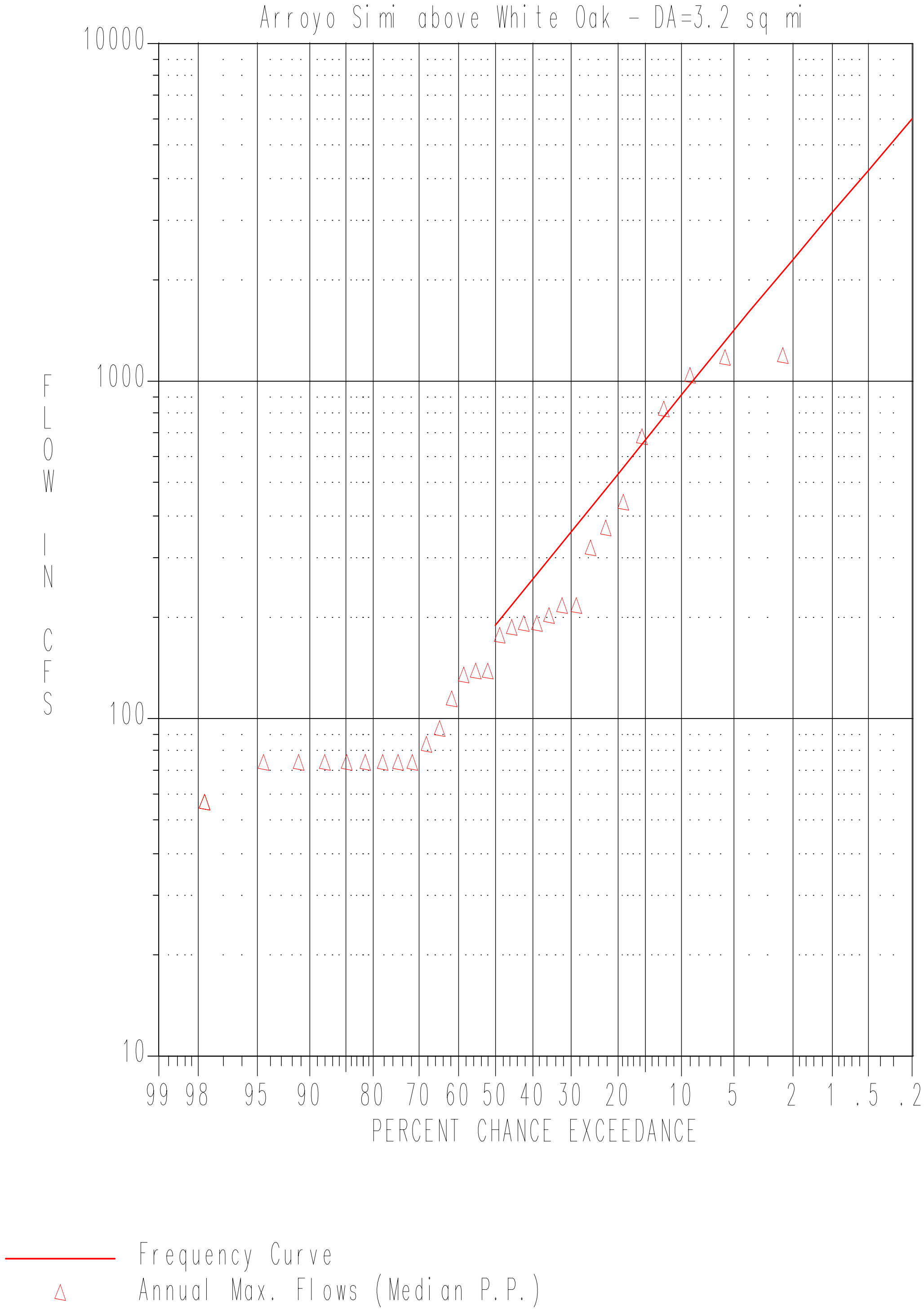

Figure 7: Discharge-Frequency Curve – Arroyo Simi above White Oak
Gage No. 831 - Drainage Area 3.2 mi²

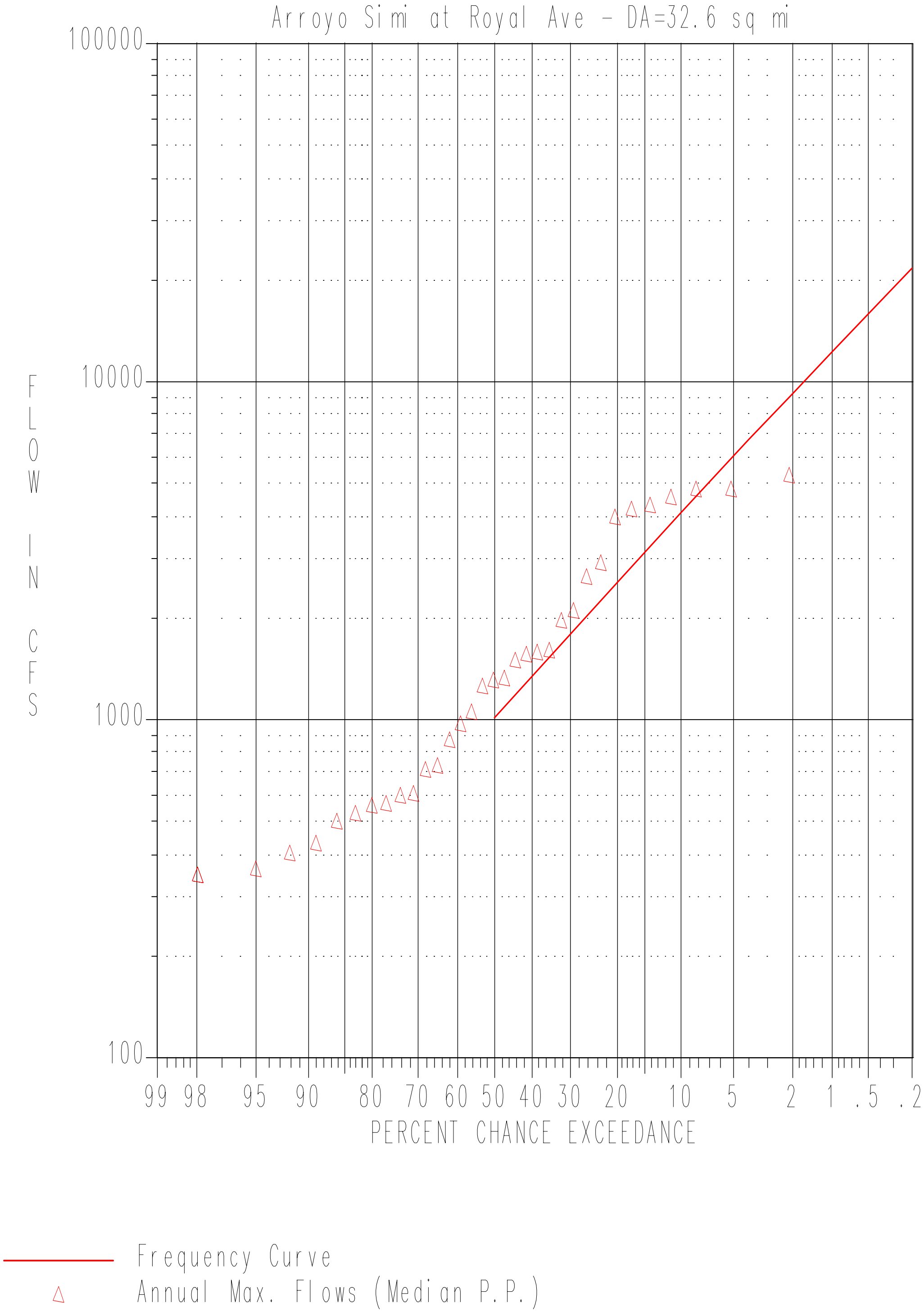

Figure 8: Discharge-Frequency Curve – Arroyo Simi at Royal Ave.
Gage No. 802 - Drainage Area 32.6 mi²

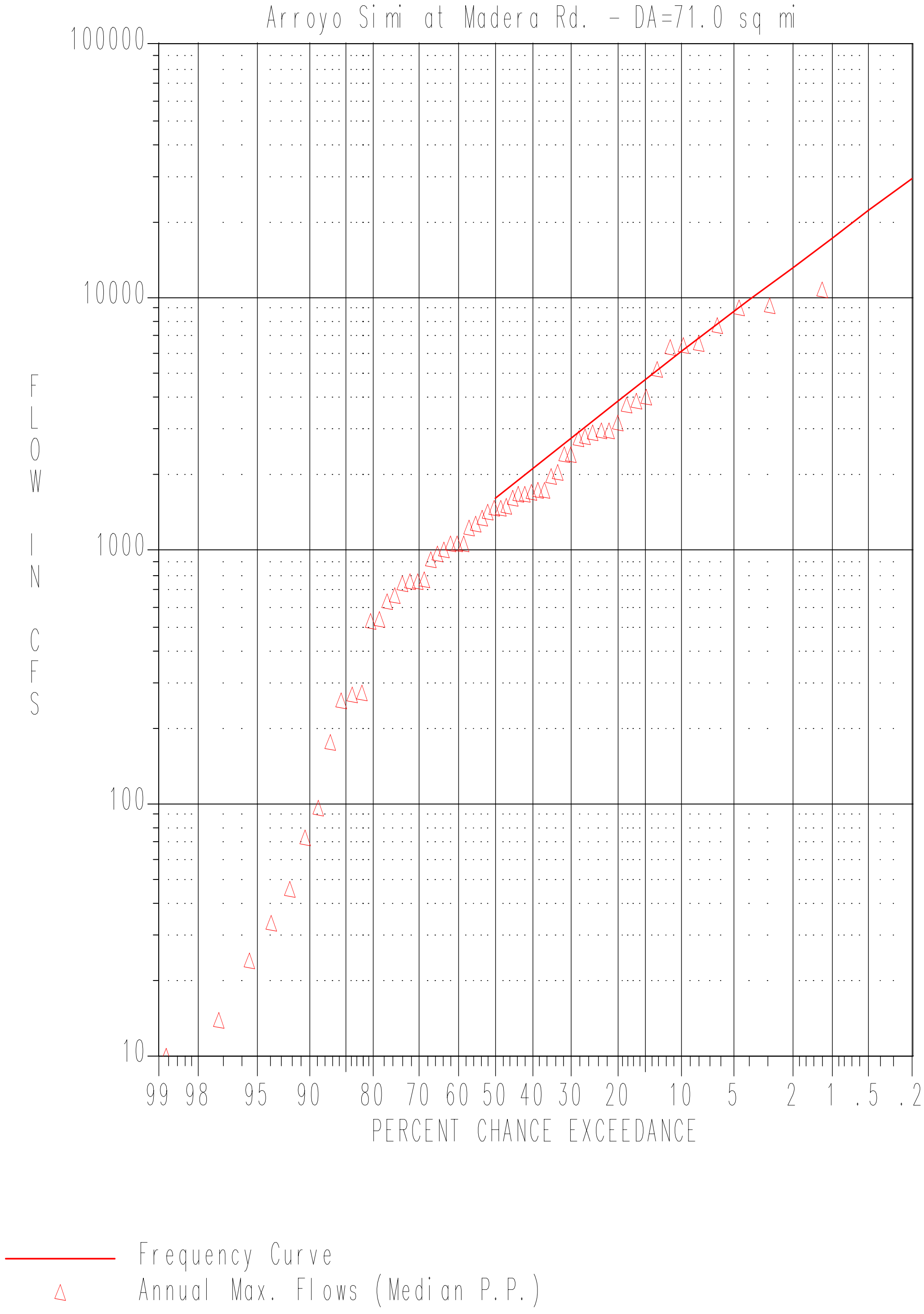

Figure 9: Discharge-Frequency Curve – Arroyo Simi at Madera Rd.
Gage No. 803 - Drainage Area 71.0 mi²

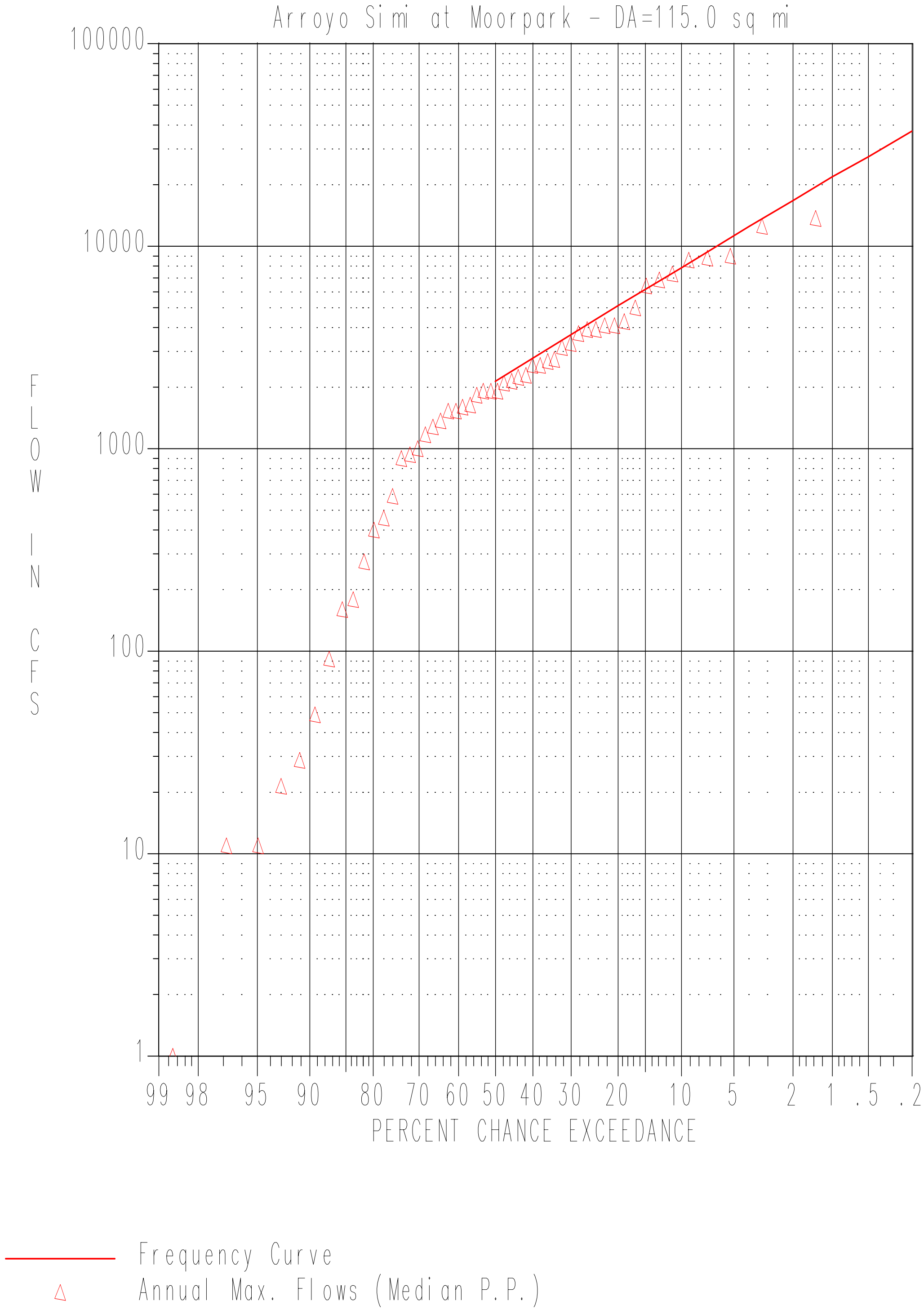

Figure 10: Discharge-Frequency Curve – Arroyo Simi at Moorpark
Gage No. 801 - Drainage Area 115.0 mi²

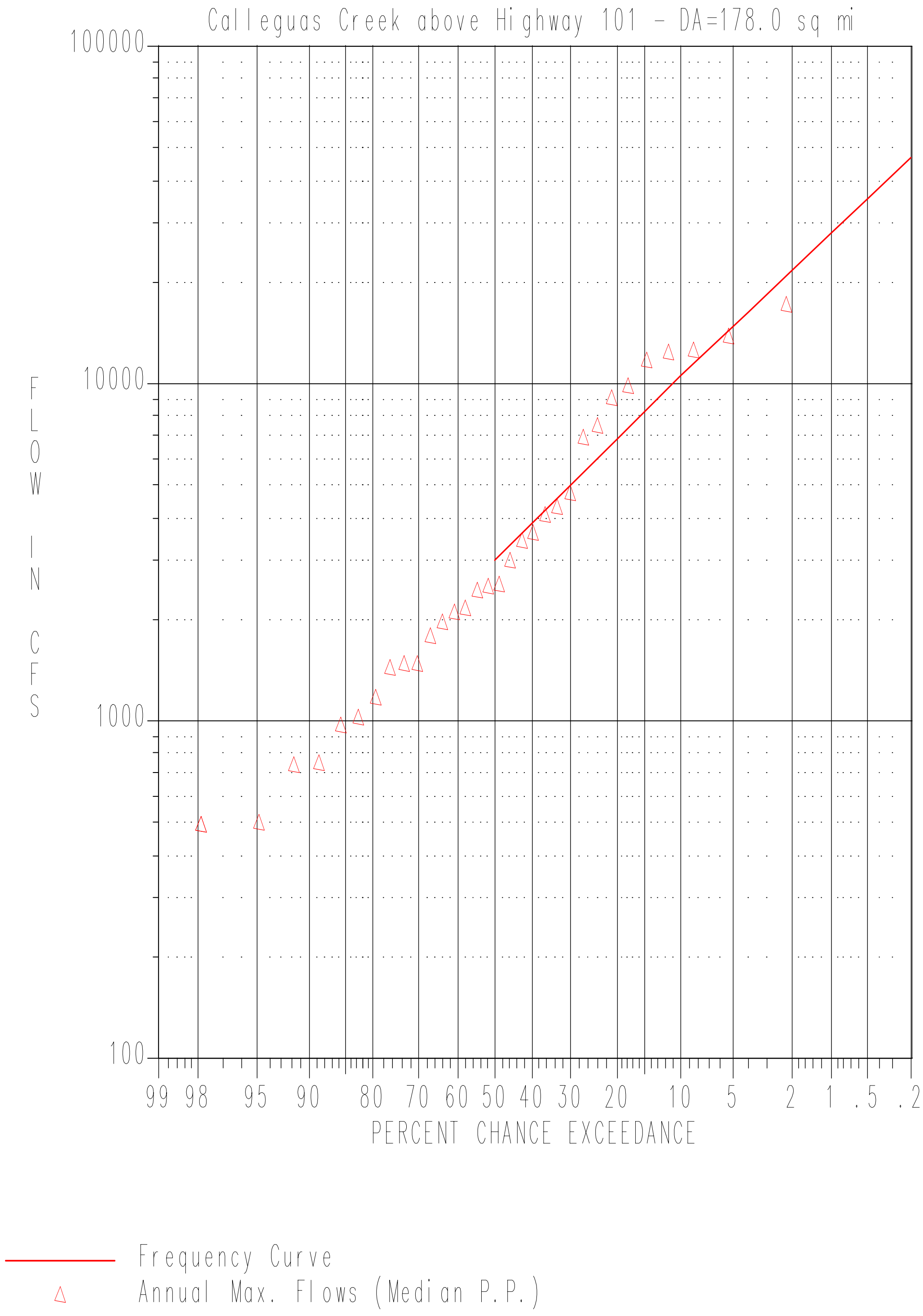

Figure 11: Discharge-Frequency Curve – Calleguas Creek above Highway 101
Gage No. 806 - Drainage Area 178.0 mi²

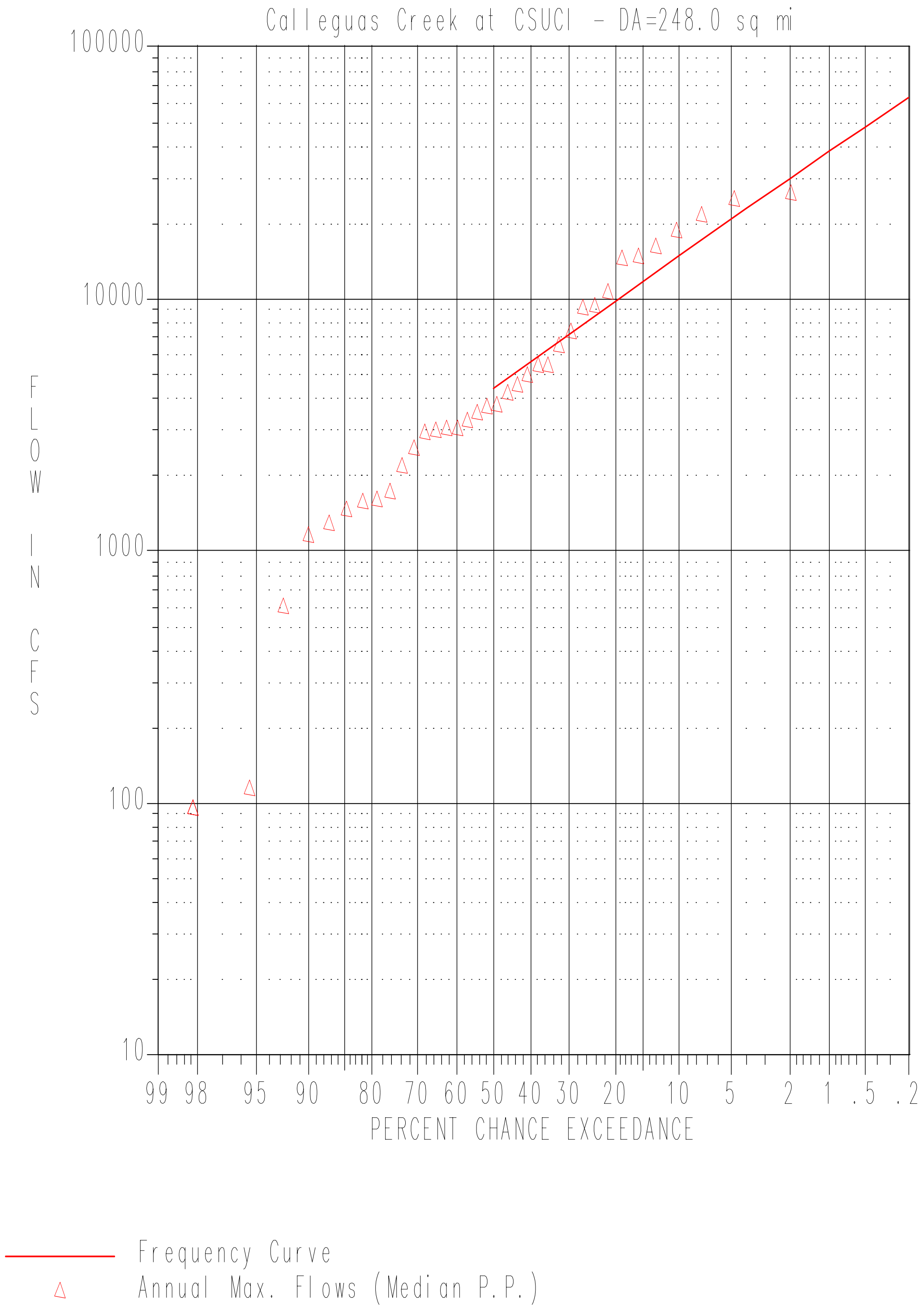

Figure 12: Discharge-Frequency Curve – Calleguas Creek at Hospital
Gage No. 805 - Drainage Area 248.0 mi²

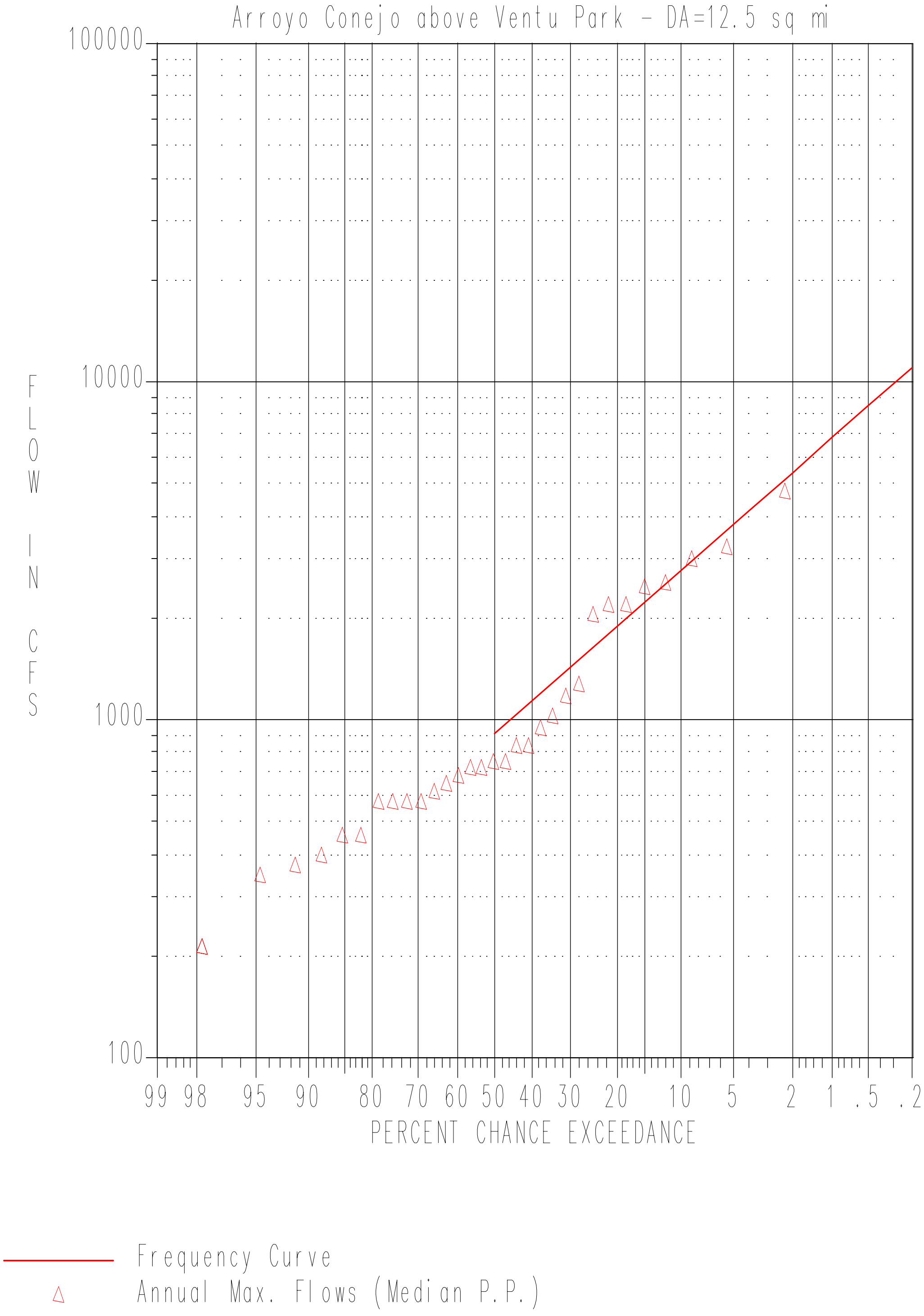

Figure 13: Discharge-Frequency Curve – Arroyo Conejo above Ventu Park
Gage No. 830 - Drainage Area 12.5 mi²

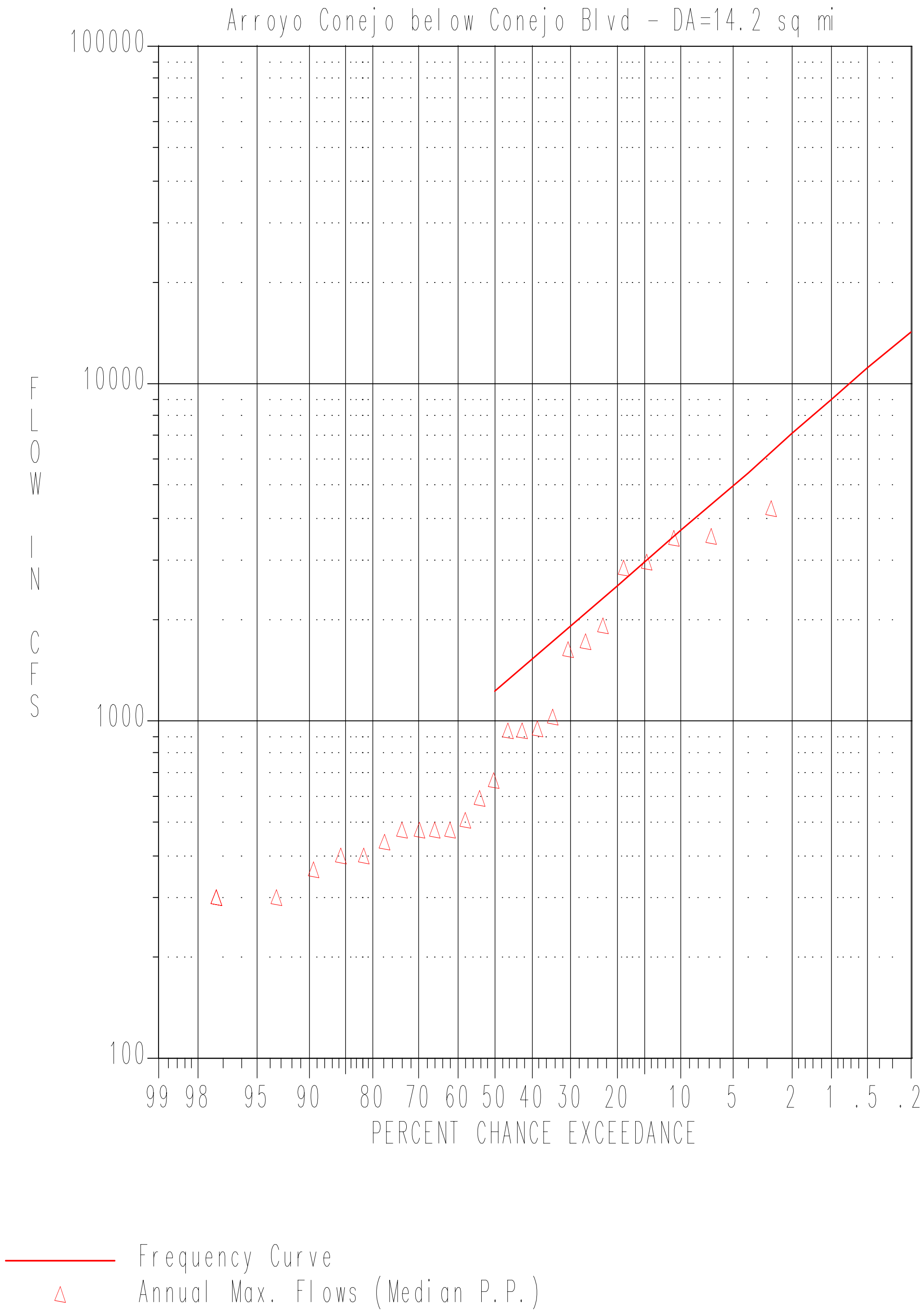

Figure 14: Discharge-Frequency Curve – Arroyo Conejo below Conejo Blvd.
Gage No. 836 - Drainage Area 14.2 mi²

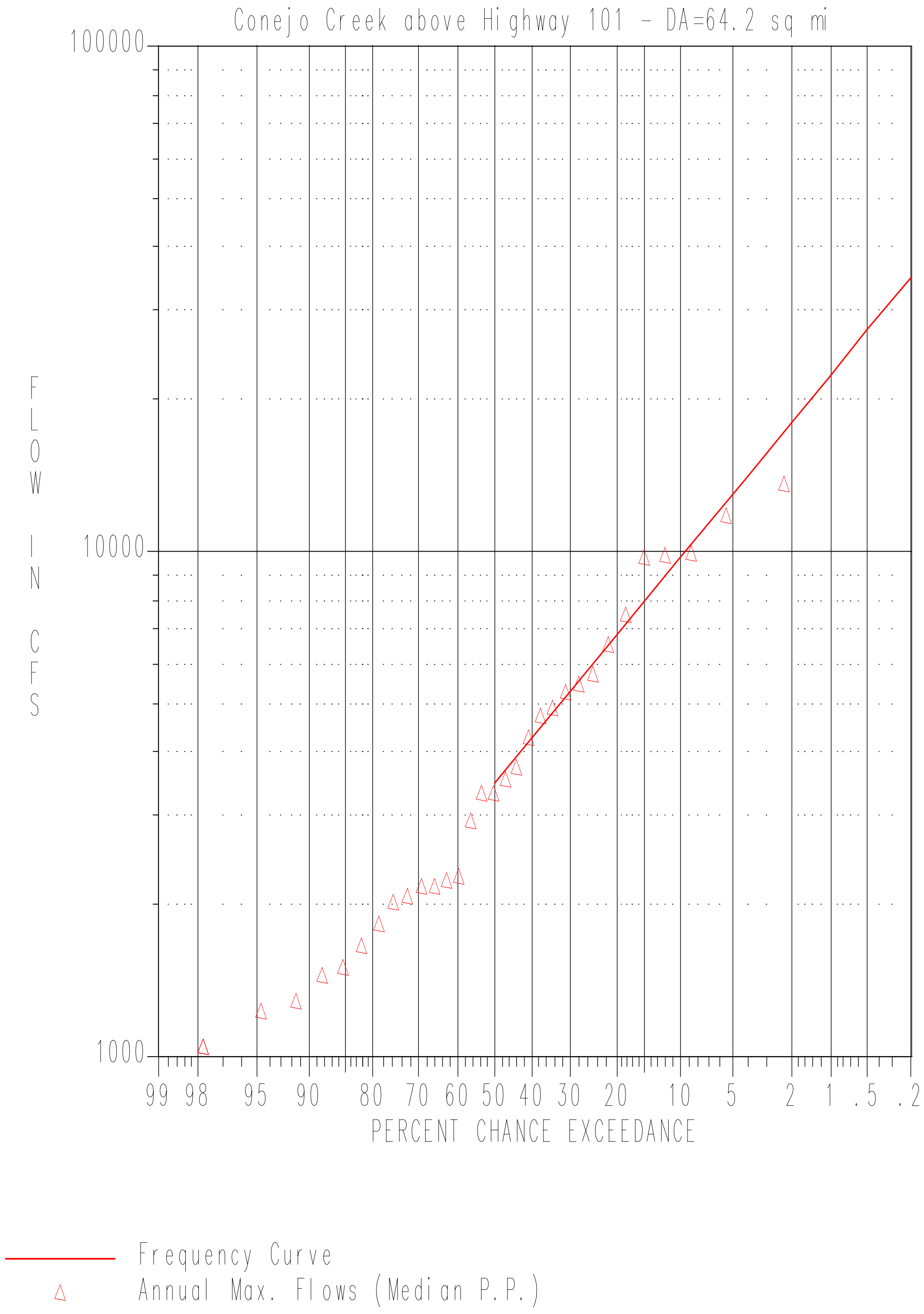

Figure 15: Discharge-Frequency Curve – Conejo Creek above Highway 101
Gage No. 800 - Drainage Area 64.2 mi²

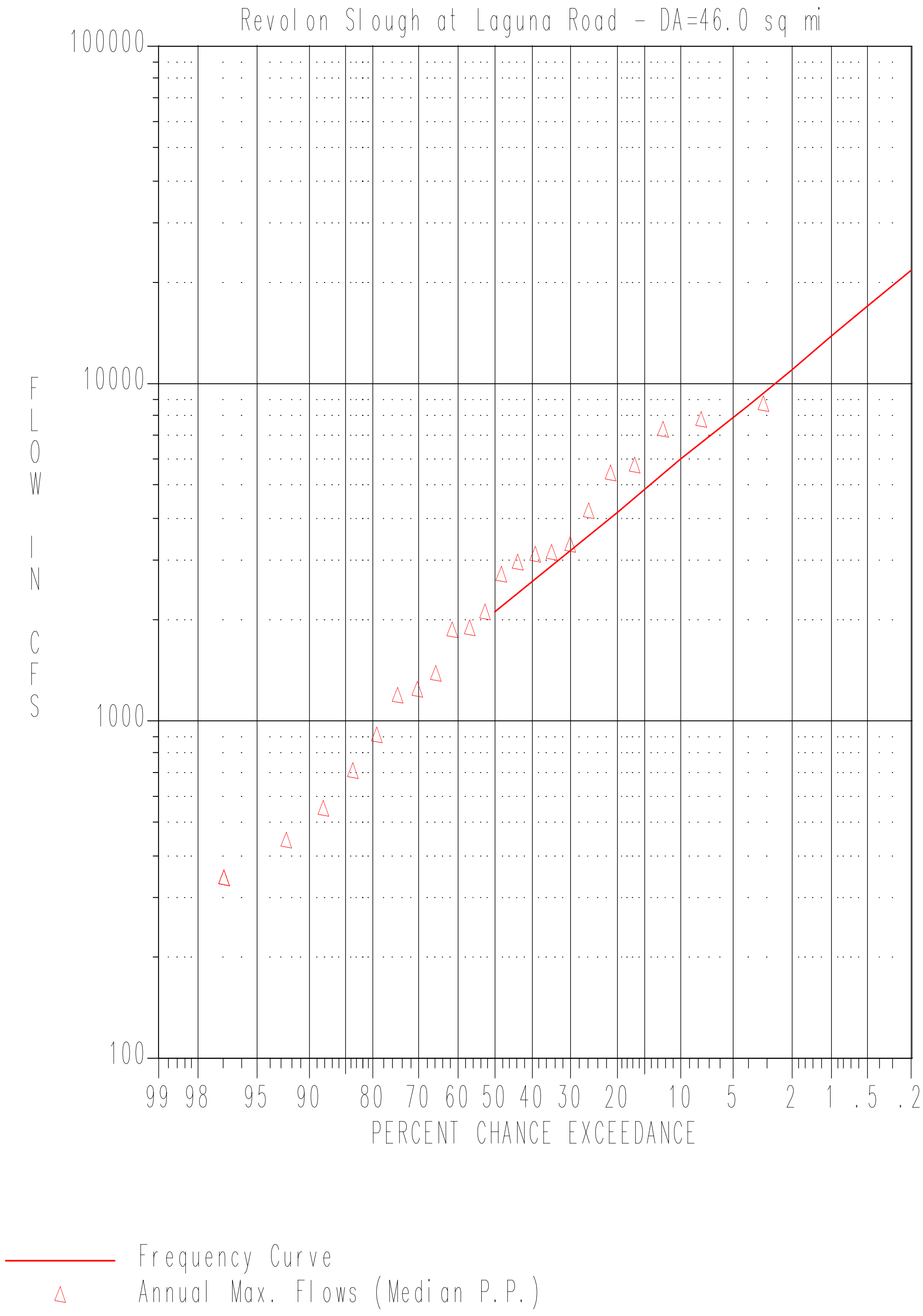

Figure 16: Discharge-Frequency Curve – Revolon Slough at Laguna Rd.
Gage No. 776 - Drainage Area 46.0 mi²

CALLEGUAS CREEK, VENTURA & LOS ANGELES COUNTIES, CA
WATERSHED STUDY

CALLEGUAS CREEK

WATERSHED FEASIBILITY STUDY

EXHIBIT A – Stream Gage Photographs

February 2003

Streamgage 776 - Revolon Slough at Laguna Road Looking Upstream

Streamgage 776 - Revolon Slough at Laguna Road Looking Downstream

Streamgage 800 - Arroyo Conejo above Highway 101 Looking Upstream

Streamgage 800 - Arroyo Conejo above Highway 101 Looking Downstream

Streamgage 802 - Arroyo Simi at Royal Avenue Looking Upstream

Streamgage 802 - Arroyo Simi at Royal Avenue Looking Downstream

Streamgage 806 - Calleguas Creek above Highway 101 Looking Upstream

Streamgage 806 - Calleguas Creek above Highway 101 Looking Downstream

Streamgage 830 - Arroyo Conejo above Ventu Park Road Looking Upstream

Streamgage 830 - Arroyo Conejo above Ventu Park Road Looking Downstream

Streamgage 831 - Arroyo Simi above White Oak Looking Downstream

Streamgage 836 - Arroyo Conejo below Conejo Boulevard Looking Upstream

Streamgage 836 - Arroyo Conejo below Conejo Boulevard Looking Downstream

Streamgage 803 - Arroyo Simi at Madera Road Looking Upstream

Streamgage 803 - Arroyo Simi at Madera Road Looking Downstream

Streamgage 805 - Calleguas Creek at CSUCI Looking Upstream

Streamgage 805 - Calleguas Creek at CSUCI Looking Downstream

CALLEGUAS CREEK, VENTURA & LOS ANGELES COUNTIES, CA
WATERSHED STUDY

CALLEGUAS CREEK

WATERSHED FEASIBILITY STUDY

EXHIBIT B – Watershed Photographs

February 2003

Calleguas Creek at PCH, looking downstream

Calleguas Creek at PCH, looking south

Calleguas Creek above PCH, looking downstream

Revolon Slough at PCH, looking downstream

Revolon Slough above PCH, looking downstream

Revolon Slough at PCH, looking upstream

Calleguas Creek and Revolon Slough above PCH, looking downstream

Calleguas Creek and Revolon Slough above PCH, looking upstream

Calleguas Creek at Camarillo Dr., near CSUCI, looking upstream

Calleguas Creek at Camarillo Dr., near CSUCI, looking upstream

Calleguas Creek at Camarillo Dr., near CSUCI, looking downstream

Calleguas Creek at Camarillo Dr., near CSUCI, looking downstream

Calleguas Creek at Camarillo Dr., near CSUCI, looking downstream

Calleguas Creek at Camarillo Dr., near CSUCI, at Stream Gage

Calleguas Creek at Old Dairy Rd. (Erosion), near CSUCI, looking upstream

Conejo Creek on right bank, near confluence with Calleguas Creek, looking downstream

Calleguas Creek and Conejo Creek at confluence

Calleguas Creek on left bank, near confluence with Conejo Creek, looking downstream

Calleguas Creek at Mission Oaks Blvd. and 101 Freeway, looking downstream

Calleguas Creek at Mission Oaks Blvd. (Bank Erosion), looking upstream

Calleguas Creek at Mission Oaks Blvd., looking downstream at 101 Freeway

Calleguas Creek at Mission Oaks Blvd., looking upstream

Calleguas Creek watershed at Box Canyon Rd. in Simi Valley

Calleguas Creek at PCH, looking downstream

Calleguas Creek at PCH, looking upstream

Wood Rd. Drain at PCH, looking north

Calleguas Creek at Pleasant Valley Rd., looking upstream

Calleguas Creek at Pleasant Valley Rd., looking downstream

Conejo Creek at Mary Smith Ranch Rd., looking upstream

Conejo Creek at Mary Smith Ranch Rd., looking downstream

Conejo Creek at Mary Smith Ranch Rd., looking upstream

Conejo Creek at Mary Smith Ranch Rd., looking downstream

Conejo Creek 0.5 mi. downstream from 101 Freeway, looking upstream

Conejo Creek 0.5 mi. downstream from 101 Freeway, looking upstream

Conejo Creek at Upland Rd. access at Leisure Village, looking downstream

Conejo Creek at Baron Bros. Nursery at Santa Rosa Ave., looking downstream

Calleguas Creek at Upland Rd., looking upstream

Calleguas Creek at Upland Rd., looking downstream

Calleguas Creek at Seminary Rd., looking upstream

Calleguas Creek at Seminary Rd., looking upstream

Calleguas Creek at Seminary Rd., looking downstream

Calleguas Creek at NE St. John's Seminary, looking downstream

Calleguas Creek at Hitch Blvd., looking upstream

Calleguas Creek at Moorpark WWTP, from right bank

Calleguas Creek at Moorpark WWTP, looking downstream

Calleguas Creek at Moorpark WWTP, looking upstream

Calleguas Creek at Moorpark WWTP, looking downstream

Calleguas Creek at Moorpark WWTP, looking upstream

Calleguas Creek at Moorpark WWTP, looking downstream