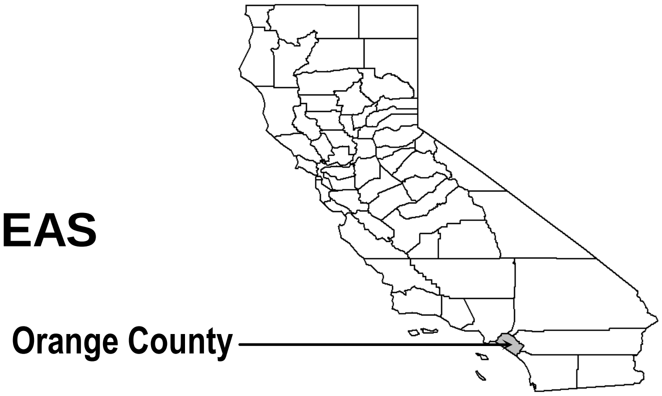
FLOOD INSURANCE STUDY

VOLUME 1 OF 3

ORANGE COUNTY, CALIFORNIA
AND INCORPORATED AREAS



COMMUNITY NAME	COMMUNITY NUMBER	COMMUNITY NAME	COMMUNITY NUMBER
ALISO VIEJO, CITY OF *	060770	LAKE FOREST, CITY OF	060759
ANAHEIM, CITY OF	060213	LOS ALAMITOS, CITY OF	060226
BREA, CITY OF	060214	MISSION VIEJO, CITY OF	060735
BUENA PARK, CITY OF	060215	NEWPORT BEACH, CITY OF	060227
COSTA MESA, CITY OF	060216	ORANGE, CITY OF	060228
CYPRESS, CITY OF	060217	ORANGE COUNTY	
DANA POINT, CITY OF	060736	(UNINCORPORATED AREAS)	060212
FOUNTAIN VALLEY, CITY OF	060218	PLACENTIA, CITY OF	060229
FULLERTON, CITY OF	060219	RANCHO SANTA MARGARITA, CITY OF	060769
GARDEN GROVE, CITY OF	060220	SAN CLEMENTE, CITY OF	060230
HUNTINGTON BEACH, CITY OF	065034	SAN JUAN CAPISTRANO, CITY OF	060231
IRVINE, CITY OF	060222	SANTA ANA, CITY OF	060232
LA HABRA, CITY OF	060224	SEAL BEACH, CITY OF	060233
LA PALMA, CITY OF[1]	060225	STANTON, CITY OF	060234
LAGUNA BEACH, CITY OF	060223	TUSTIN, CITY OF	060235
LAGUNA HILLS, CITY OF	060760	VILLA PARK, CITY OF	060236
LAGUNA NIGUEL, CITY OF	060764	WESTMINSTER, CITY OF	060237
LAGUNA WOODS, CITY OF	060768	YORBA LINDA, CITY OF	060238

*NOT PARTICIPATING IN THE NFIP

[1] NON-FLOODPRONE COMMUNITY

U.S. DEPARTMENT OF HOMELAND SECURITY

REVISED:

DECEMBER 3, 2009

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
06059CV001B

NOTICE TO FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current FIS components.

Initial Countywide FIS Effective Date: September 15, 1989

Revised Countywide FIS Dates:

February 5, 1992 – To add base flood elevations, to add special flood hazard areas, to update map format, and to reflect updated topographic information.

November 3, 1993 – To change base flood elevations, to change special flood hazard areas, to add roads and road names, to reflect updated topographic information, to incorporate previously issued letters of map revision, and to change floodway.

January 3, 1997 – To incorporate previously issued letters of map revision.

February 18, 2004 – To update corporate limits, to add special flood hazard areas, to change zone designations, to update map format, to incorporate previously issued letters of map revision, and to update roads and road names.

December 3, 2009 – To update corporate limits, to incorporate previously issued letters of map revision, to change special flood hazard areas, to update roads and road names and to reflect updated topographic information.

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FLOOD INSURANCE STUDY
ORANGE COUNTY, CALIFORNIA AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This countywide Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Orange County, California, including the Cities of Anaheim, Brea, Buena Park, Costa Mesa, Cypress, Dana Point, Fountain Valley, Fullerton, Garden Grove, Huntington Beach, Irvine, Laguna Beach, Laguna Hills, Laguna Niguel, Laguna Woods, La Habra, La Palma, Lake Forest, Los Alamitos, Mission Viejo, Newport Beach, Orange, Placentia, Rancho Santa Margarita, San Clemente, San Juan Capistrano, Santa Ana, Seal Beach, Stanton, Tustin, Villa Park, Westminster, and Yorba Linda, and the unincorporated areas of Orange County (hereinafter referred to collectively as Orange County).

Orange County also includes the City of Aliso Viejo, which is not participating in the National Flood Insurance Program.

This FIS aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This FIS has developed flood risk data for various areas of the county that will be used to establish actuarial flood insurance rates. This information will also be used by Orange County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP), and will also be used by local and regional planners to further promote sound land use and floodplain development. Minimum floodplain management requirements for participation in the NFIP are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for the FISs for the communities listed in Section 1.1 were performed under contract to the Federal Emergency Management Agency (FEMA). Additional information on the study contractors for each study is provided in Table 1, "Flood Insurance Study Contractors."

TABLE 1 – FLOOD INSURANCE STUDY CONTRACTORS

Community Name	Study Contractor[1]	Contract or Inter-Agency Agreement No.	Completion Date
City of Anaheim	HTA	H-4032	October 1978
City of Brea	HTA	H-4032	March 1978
City of Buena Park	HTA	H-4032	January 1978
City of Costa Mesa	USACE	IAA-H-19-74	April 1980
		IAA-H-19-76	
City of Cypress	--	IAA-H-2-73	
City of Fountain Valley	USACD	IAA-H-2-73	April 1980
City of Fullerton	VTN	H-3683	May 1975
City of Garden Grove	USACE	IAA-H-19-74	April 1980
		IAA-H-7-76	
City of Huntington Beach	TT	H-4543	April 1980
	USACE	IAA-H-8-71	
City of Irvine	HTA	H-4032	January 1978
City of Laguna Beach	HTA	H-4032	January 1978
	D&M	C-0970	1984
City of La Habra	HTA	H-4032	April 1978
City of La Palma[2]	--	--	--
City of Los Alamitos	--	--	--
City of Newport Beach	USGS	IAA-H-20-74	May 1977
		IAA-H-8-76	
City of Orange	HTA	H-4032	September 1978
City of Placentia	HTA	H-4032	March 1978
City of San Clemente	HTA	H-4032	November 1977
City of San Juan Capistrano	HTA	H-4032	February 1978
City of Santa Ana	HTA	H-4032	February 1978
City of Seal Beach	CH2M	H-1658	March 1975
	D&M	C-0970	1984
City of Stanton[2]	--	--	--
City of Tustin	HTA	H-4032	March 1978
Orange County (Unincorporated Areas)	VTN	H-3683	March 1973
City of Villa Park	HTA	H-4032	April 1978
City of Westminster	USACE	IAA-H-19-74	April 1980
		IAA-H-7-76	
City of Yorba Linda	HTA	H-4032	October 1978

[1] CH2M:	CH2M Hill, Inc.
USACE:	U.S. Army Corps of Engineers
D&M:	Dames & Moore
HTA:	Harris-Toups Associates
TT:	Tetra Tech, Inc.
USGS:	U.S. Geological Survey
VTN:	VTN Consolidated, Inc.

[2] Non-floodprone community

1.3 Coordination

Consultation Coordination Officer's (CCO) meetings may be held for each jurisdiction in this countywide FIS. An initial CCO meeting is held typically with representatives of FEMA, the community, and the study contractor to explain the nature and purpose of a FIS, and to identify the streams to be studied by detailed methods. A final CCO meeting is held typically with representatives of FEMA, the community, and the study contractor to review the results of the study.

The following were contacted for information pertinent to the individual FISs: California Department of Water Resources, USACE, Los Angeles District; Orange County Environmental Management Agency (OCEMA); USGS; and California Division of Highways. Private engineering and land development firms working within the unincorporated areas of Orange County contacted were the Mission Viejo Company; Raub, Bein, Frost & Associates; the Irvine Company; Coto de Gaza; the Emerald Bay Community Association; Leisure World; Boyle Engineering; and CST Engineering.

A technical coordination meeting was held on July 19, 1977, and was attended by representatives of FEMA; VTN Consolidated, Inc.; Orange County; USACE; Dames and Moore; and Toups Corporation. The purpose of the meeting was to make an assessment of the technical adequacy of the FIS for the unincorporated portions of Orange County. FEMA's Technical Evaluation Contractor (TEC) had the responsibility for updating this study, which was originally completed in 1975, to meet current Federal technical and mapping standards. The nature of the problems experienced by the TEC in revising this study and the potentially controversial nature of the proposed solutions required that prior consent be obtained from all concerned agencies. At the conclusion of the meeting, the consensus was that the TEC could proceed to update the original study and FEMA could then issue the results, with the understanding that future revisions will be required to reflect the final results of the studies of the incorporated areas of Orange County.

During the preparations of the initial FISs for the individual communities, FEMA representatives held coordination meetings with community officials, representatives of the study contractor for each study, and other interested agencies and citizens. The meetings, referred to as the initial, intermediate, and final community coordination meetings, were held at specified intervals during the preparation of the studies. The comments and issues raised at those meetings were addressed in the FIS for each community. The dates of the meetings for each community are provided in Table 2, "Initial and Final CCO Meetings."

TABLE 2 – INITIAL AND FINAL CCO MEETINGS

Community	Initial CCO Meeting	Intermediate CCO Meeting	Final CCO Meeting
City of Anaheim	May 10, 1976	July 12, 1978	February 27, 1979
City of Brea	May 10, 1976	--	October 5, 1978
City of Buena Park	May 10, 1976	--	November 8, 1977
City of Costa Mesa	November 26, 1979	February 1, 1980	September 16, 1980
City of Fountain Valley	November 26, 1979	February 1, 1980	September 16, 1980
City of Fullerton	July 1, 1974	--	March 18, 1975
City of Garden Grove	November 26, 1979	February 1, 1980	September 16, 1980
City of Huntington Beach	November 26, 1979	February 1, 1980	September 16, 1980
City of Irvine	May 10, 1976	February 1, 1980	September 16, 1980
City of Laguna Beach	May 10, 1976	--	--
City of La Habra	May 10, 1976	--	September 26, 1978
City of Newport Beach	May 10, 1976	--	October 12, 1977
City of Orange	May 10, 1976	--	December 12, 1978
Orange County (Unincorporated Areas)	July 19, 1977	--	June 12, 1978
City of Placentia	May 10, 1976	--	October 4, 1978
City of San Clemente	May 10, 1976	May 3, 1977	October 4, 1978
City of San Juan Capistrano	May 10, 1976	May 3, 1977	September 28, 1978
City of Santa Ana	May 10, 1976	--	September 28, 1978
City of Seal Beach	May 10, 1976	--	June 28, 1977
City of Tustin	May 10, 1976	--	September 27, 1978
City of Villa Park	May 10, 1976	--	October 3, 1978
City of Westminster	November 26, 1979	February 1, 1980	September 16, 1980
City of Yorba Linda	May 10, 1976	--	--

The sessions were attended by representatives of FEMA, the TEC, the OCEMA, and the study contractor performing the FIS for the unincorporated Orange County areas. Minor changes to the study were made in response to comments received at the meeting.

This study was revised in 1987 to incorporate new or revised hydrologic and hydraulic analyses for several flooding sources throughout the county. At this time, FEMA decided to include flooding information for the incorporated communities to provide the county with a more useable Flood Insurance Rate Map (FIRM).

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Orange County, California. The streams or portions of streams, studied by detailed methods are listed in Table 3, "Streams Studied by Detailed Methods." The areas studied by detailed methods were selected to include all known flood hazard areas and areas of projected development or proposed construction.

The streams or portions of streams that were studied by approximate methods are listed in Table 4, "Streams Studied by Approximate Methods." Approximate analyses were used to study those areas having a low development potential or minimal flood hazards.

TABLE 3 - STREAMS STUDIED BY DETAILED METHODS

Alameda Storm Channel
Aliso Creek
Alipaz Storm Channel
Anaheim-Barber City Channel
Agua Chinon Wash
Arroyo Salada
Atwood Channel
Barranca Channel
Bastanchurry Channel
Bee Canyon Wash
Big Canyon
Bitterbush Channel
Bluebird Canyon
Bonita Creek
Borrego Canyon Wash
Brea Canyon Channel
Brea Creek Channel
Buck Canyon
Buckeye Storm Channel
Canada Gobernadora
Canyon Acres Wash
Carbon Canyon Channel
Carbon Creek Channel
Carbon Canyon Diversion Channel
Cascadita Creek
Collins Channel
Como Storm Channel
Coyote Canyon Wash
Coyote Creek Channel
East Garden Grove-Winterburg Channel
East Richfield Channel
El Modena-Irvine Channel
English Canyon
Esperanza Canyon Channel
Facility No. J05
Fletcher Channel
Fullerton Creek Channel
Greenville-Banning Channel
Handy Creek
Hickey Canyon
Hicks Canyon Wash
Horno Creek
Houston Storm Channel
Huntington Beach Channel
Imperial Channel
La-Colina-Redhill Storm Channel
La Mirada Creek
La Paz Channel
Laguna Canyon
Lane Channel
Live Oak Canyon
Loftus Diversion Channel
Marlboro Channel
Marshburn Channel
Melrose Channel
Memory Garden Storm Channel
Modjeska Canyon
Niguel Canyon (Emerald Bay Channel)
Niguel Storm Drain (J03P01)

TABLE – 3 STREAMS STUDIED BY DETAILED METHODS-continued

(North Sulphur Creek)Narco Channel (J04)
North Tustin Channel
Oso Creek
Peters Canyon Wash
Placentia Storm Channel
Prima Deschaca Canada
Redhill Channel
Reservoir Canyon
Richfield Channel
Salt Creek
San Diego Creek
San Gabrial River
San Joaquin Channel
San Juan Canyon
San Juan Creek
Sand Canyon Wash
Santa Ana River
Santa Ana-Dehli Channel
Santa Ana Gardens Channel
Santa Ana River Overflow (Fountain Valley Channel)
Santa Ana-Santa Fe Channel
Santiago Creek
Santiago Creek (Upper)
Segunda Deschecha Canada
Segunda Deschecha Canada Tributary
Serrano Creek
Shady Canyon Wash
Silverado Canyon
Sulphur Creek
Talbert Channel(D02)
Tijeras Creek
Trabuco Creek
Upper Santiago Creek
Valencia Storm Channel
Veeh Creek (San Diego Creek Tributary 2)
Veeh Creek Tributary 1 (San Diego Creek Tributary 1)
Villa Park Storm Drain
Wila Park Storm Channel
Walnut Canyon Creek

TABLE 4 – STREAMS STUDIED BY APPROXIMATE METHODS

Agua Chinon Wash
Alameda Storm Channel
Alipaz Storm Channel
Atwood Channel
Bee Canyon
Bee Mud Canyon
Bitterbush Channel
Bluebird Canyon
Boat Canyon
Bolsa Chicago Channel
Bonita Creek
Bonita Creek Tributary 1
Bonita Creek Tributary 2
Brush Canyon
Buck Gulley
Buena Park Storm Channel
Capistrano Beach Storm Channel
Channel E04S01
Como Storm Channel
Culver Storm Channel
D-1 Channel
East Bra Channel
El Modena-Irvine Channel
Esperanza Canyon Channel
Facility No. L04
Federal Storm Channel
Hicks Canyon
Houston Storm Channel
La Veto Storm Drain
Laguna Road Wash Tributary 1
Live Oak Canyon
Los Alamitos Channel
Montecito Channel
Niguel Storm Drain
Park Avenue Wash
Peter Canyon
Prima Deschecha Canada
Prima Deschecha Canada Tributary
Rattlesnake Canyon
Reservoir Canyon
Richfield Channel
Rim Rock Canyon

TABLE 4 – STREAMS STUDIED BY APPROXIMATE METHODS - continued

Round Canyon
San Diego Creek
Santiago Creek
Serrano Creek
Serrano Creek Tributary 1
Southeast Anaheim Store Channel
Southwest Tustin Channel
Tuffree Storm Channel
Villa Park Storm Drain and Tributary
Walnut Storm Channel
Whitebrook Storm Channel

2.2 Community Description

Orange County is located southeast of Los Angeles County, within the south coastal basin of southern California.

The topography of the county includes the gently sloping alluvial fan of the Santa Ana River in the northwest; rolling hills along the southern coast; plateaus, foothills, and mountains in the east; and plains in the central and western parts.

The coastal climate of Orange County is characterized by light precipitation and mild temperatures that have relatively small daily and annual ranges. Inland temperature variations are greater and precipitation is heavier in the mountain regions. Average annual precipitation ranges from approximately 12 inches along the coast to approximately 30 inches in some of the higher mountain areas.

Northwestern Orange County is densely populated and has over 5 percent of the total State population. The more gently sloping areas in the central and western parts of the county continue to be converted from agricultural lands to residential and commercial developments at one of the fastest rates in the United States. Twenty-six cities have grown from small-town train depots of several decades ago into some of the largest in the State. As the cities have expanded by annexations, the unincorporated areas have decreased in size and, in many cases, remain as islands completely surrounded by cities.

Surface drainage features in Orange County vary widely, reflecting variations in rainfall, topography, watershed conditions, and manmade improvements. Brief descriptions of streams in the county are given below in alphabetical order.

Aliso Creek flows approximately 20 miles from its origin to the Pacific Ocean at the Aliso Beach County Park in South Laguna, south of the City of Laguna Beach. The creek is primarily an unimproved, natural watercourse except for a graded earth section, with two grade stabilization structures near the Narco Facility, a greenbelt reach through Leisure World in El Toro, and a 1-mile reach of improved channel upstream of the San Diego Freeway (Interstate Highway 5, or I-5). Approximately 1 mile from the ocean, the Aliso Water Management Agency proposed construction of a sewage treatment plant in July 1975. The treatment plant grading in Aliso Creek has been included in the analyses.

Arroyo Salada, west of the City of San Juan Capistrano and Tributary to Salt Creek, is a steep canyon except where it runs through the El Niguel Country Club as a narrow graded ditch within a grass swale. The floodplain is narrow.

Arroyo Trabuco, also called Trabuco Creek and O'Neill Arroyo Trabuco, located in central southeastern Orange County, runs through an active gravel mining operation, and further downstream occupies a flat-floored canyon with steep walls. It passes through O'Neill Regional Park as a leveed earth channel.

Bolsa Chica Channel runs southerly along the eastern corporate limits of the City of Seal Beach.

Buck Canyon is a narrow canyon east of, and flowing into the City of Newport Beach-Corona del Mar area from the east.

Canada Gobernadora, northwest of the City of San Juan Capistrano and Tributary to San Juan Creek, is flanked by a broad, gently sloping plain in some portions, and flows in a narrow gorge in other portions.

El Modena Irvine Channel runs from the foothills northeast of the El Modena community through the City of Orange, the unincorporated East Tustin community, the City of Tustin, and agricultural land, to the City of Irvine, where it joins Peters Canyon (F06).

English Canyon, tributary to Aliso Creek, has a shallow gulch configuration (within a residential area) that is planned to remain as a natural watercourse.

Facility No. J05 is an eroded swale that runs through agricultural land extending north from Aliso Creek to Paseo de Valencia. The floodplain is relatively narrow.

Handy Creek, tributary to Santiago Creek, is a rectangular concrete channel with up to 2-percent annual chance (50-year) capacity downstream of Orange Park Boulevard, where it is also referred to as the Alameda Storm Channel. Upstream, it is an unimproved earthen swale, with several undersized culvert and bridge road crossings.

The lower portion of Hickey Canyon, tributary to Arroyo Trabuco, is stabilized with pipe and wire revetment. It flows in a leveed earthen channel through the Trabuco Canyon community residential area, beyond which it continues as a narrow canyon.

La Paz Channel (L04), tributary to Oso Creek, is a flat, broad earth channel downstream of I-5, except for 0.25 mile of concrete channel and riprap. Upstream of I-5, the watercourse is between the base of a 30-foot slope and the high fill of the Atchison, Topeka & Santa Fe Railway (ATSFRR). Facility No. L04P07 is a designated greenbelt that joins L04 north of La Paz Road.

The downstream end of Laguna Canyon contains residential and commercial development in and along the watercourse. The watercourse varies from natural channel in the unincorporated area to a reinforced-concrete box drain and open-channel system within the City of Laguna Beach. The capacity of the drain and numerous crossing structures varies from less than 10-percent annual chance (10-year) flows to approximately 4-percent annual chance (25-year) flows. The watercourse meanders in and out of the City of Laguna Beach and borders the City of Irvine in the upstream segment.

Live Oak Canyon, tributary to Arroyo Trabuco, contains drainage that flows through O'Neill Regional Park. Upstream, the drainage is contained in a canyon, where it flows parallel to, and frequently crosses, Live Oak Canyon Road.

Los Alamitos Channel limits of the City of Seal Beach runs southerly along the western corporate limits of the City of Seal Beach.

Narco Channel, also called Sulphur Creek, is a tributary to Aliso Creek. It is an underground facility that runs from Laguna Niguel Park, through the Federal Building (formerly North American Rockwell) parking lot to upstream of La Paz Road at Oso Parkway. Beyond the underground facility, it is an incised, natural earth channel.

Niguel Canyon flows into the Pacific Ocean west of Laguna Beach. The canyon is developed as a private residential community near the ocean; as yet, the upper canyon areas are undeveloped.

Niguel Storm Drain, tributary to Sulphur Creek, is a double 78-inch pipe and open swale in a newly developed, hilly residential area.

Oso Creek, tributary to Trabuco Creek, has a graded earth trapezoidal channel from the San Juan Capistrano corporate limits upstream for approximately one mile, where it becomes a trapezoidal-channel with an earth bottom. The treatment on the side slopes varies from concrete to earth and/or riprap up to I-5. Upstream of I-5, the watercourse is an incised natural channel, except at the two golf courses, where it has been graded to a broad, shallow floodplain.

Salt Creek enters the Pacific Ocean between South Laguna and Dana Point. It is a narrow, steep canyon that branches to San Juan Canyon approximately 0.5 mile upstream of the confluence with Arroyo Salada.

San Diego Creek and its tributaries descend from the Santa Ana Mountains in central Orange County to a plain occupied by agricultural areas that are rapidly developing.

The San Gabriel River, located primarily in Los Angeles County, flows south through the western corner of the City of Seal Beach for a distance of approximately 1,000 feet, then to its mouth Pacific Ocean, 2.8 miles further downstream.

There are two unincorporated areas through which San Juan Creek flows, both upstream and downstream of the City of San Juan Capistrano. The lower San Juan Creek segment is unimproved between the Pacific Coast Highway and the Pacific

Ocean at Doheny State Beach, while the remaining segment (upstream of the Pacific Coast Highway) is a concrete-lined, earth-bottom, trapezoidal channel that passes through agricultural land, between two sewage treatment plants, and through a commercial development. The second area is upstream of the city, where the creek is an unimproved, natural watercourse with a few sand and gravel pits.

The Santa Ana River flows westerly, then southwesterly, through north-central Orange County to the Pacific Ocean. Much of the river is located within incorporated areas of Orange County. Its headwaters are located in San Bernardino and Riverside Counties. The Prado flood-control dam is located on the river approximately 3.8 miles upstream of the eastern county boundary and controls a drainage area of 2,225 square miles. Drainage through the hills into the City of Yorba Linda is channeled by well-defined washes. The streams flow in a general north-to-south direction to the Santa Ana River and are typical of the most streams in southern California. Since the climate is not supportive of continuous year-round runoff, the stream flow is negligible, except during and immediately following rains.

Santiago Creek, tributary to Santa Ana River, borders the City of Villa Park on the southeast for approximately 1.4 miles. This is a deep-cut natural watercourse, except for the numerous sand and gravel excavation operations along its south bank, adjacent to the City of Villa Park.

The Upper Santiago Creek floodplain in the area from Villa Park Dam upstream 3.5 miles to Santiago Dam is mostly developed county regional parklands. In the area upstream of Irvine Lake (Santiago Reservoir), it has a wide, irregular canyon bottom of boulders, gravel, and scattered trees, with a road along one side of the canyon floor.

Sulphur Creek, the natural course in the City of Laguna Niguel area, is well defined as it flows southwest along Crown Valley Parkway. It turns west of Central Park Drive and flows north in an incised, narrow earth ditch, with a broad over bank on the west side. It then enters Laguna Niguel Lake and the flow discharges from the dam through Laguna Niguel Regional Park to Aliso Creek.

Tijeras Canyon is a narrow canyon, tributary to Trabuco Canyon, near a gravel mining operation. The two canyons border the fertile Plano Trabuco agricultural plain, which is elevated from 30 to 100 feet above the creeks.

2.3 Principal Flood Problems

The Santa Ana River experienced the earliest flood of record in 1810, when adobe buildings were washed into the Santa Ana River. Other large floods occurred during 1862, 1884, 1889, 1916, 1926, 1938, and 1969. Of these, the most severe occurred in January 1862, with an estimated recurrence interval of greater than 200 years. The flood of March 1938 was the largest recorded on the Santa Ana River. It had a peak discharge of 100,000 cubic feet per second (cfs) at the gaging station downstream of Prado Dam. The estimated recurrence interval for this flood was approximately 140 years.

The largest peak flows occurring since the completion of the Prado Dam in 1941 were experienced in January and February 1969. These flows were 4,800 and 5,000 cfs, respectively, and represent the controlled outflow from Prado Dam. The recurrence intervals of these floods were estimated at 30 to 40 years, respectively, depending on location within the county. Although the Prado Dam helped to substantially reduce the flood damage, the 1969 storm caused the largest dollar loss in Orange County history as a result mainly of residential damage along Santiago Creek and agricultural and animal losses.

The historic floodplain of the Santa Ana River spreads from the bluffs of the City of Costa Mesa on the south, around the Huntington Beach bluffs on the north, to Anaheim Bay. In the early 1900s, the river was somewhat channelized by levees along the south side of the Talbert gap, between the Cities of Costa Mesa and Huntington Beach. During the 1938 flood, the river levees failed in the Huntington Beach/Fountain Valley area, inundating a vast area that is now substantially developed. The flood left 43 people dead and brought substantial damage to the county. The river levees have since been intermittently improved by the Orange County Flood Control District.

In the upstream portion of Brea Creek Channel within Buena Park the capacity is severely reduced just east of Dale Street. The resulting hydraulic jump elevates the water-surface elevation above the top of the wall, with resultant overflow to the south which is impounded by the levee containing the ATSFRR tracks. This impoundment reaches a maximum depth of 10 feet just upstream of the intersection of the ATSFRR and Brea Creek Channel and floods agricultural and vacant land. For a reach of approximately 1,000 feet on the east side of Dale Street, the overflow of 750 cfs to flow over the tracks during the 1-percent annual chance (100-year) flood, become sheet flow, and remain out of the channel. Downstream of Dale Street, obstructions caused by the double culvert at Beach Boulevard create a backwater situation for a distance of 1,200 feet. This backwater overtops the channel, causing shallow flooding in the overbanks. As before, the shallow flooding on the south side does not return to the channel. The floodwaters on the north, however, re-enter the creek downstream of Beach Boulevard.

Most of the flooding problem along Carbon Canyon Channel is associated with inadequate channel capacity with excessive debris accumulation, along with some poor alignment of the natural stream. However, the flooded area between Chapman Avenue and Palm Drive is in a non-developed section, with no structures involved.

Flooding problems along Carbon Creek Channel and Atwood Channel are associated with inadequate culverts and inadequate channel capacities. In the Cities of Anaheim and Buena Park, between Knott Avenue (upstream) and Holder Street (downstream), the 1-percent annual chance flood overtops the banks, but spreads out sufficiently so that the resulting depth of flooding is less than 1 foot.

The underground facility on Capistrano Beach Storm Channel has an approximate flow capacity of a 10-percent annual chance frequency storm. The flood flows from this channel begin at Camino Capistrano, flow south along Sepulveda Avenue, and then west through the commercial area until joining backwater from San Juan Creek. The flood flows do not follow the underground facility alignment because of a diversion caused by a block wall constructed at Camino Capistrano and Sepulveda Avenue.

On El Modena Irvine Channel, which flows through the City of Tustin to Peters Canyon Channel in the City of Irvine, the 1-percent annual chance flood flows exceed the capacity of the channel, particularly at road culvert crossings, thereby becoming sheetflow.

In the segment of Fullerton Creek Channel within the City of Buena Park, the Santa Ana Freeway-Southern Pacific Railroad (SPRR) crossing is a severe obstruction of flow causing a backwater situation that results in local shallow flooding. From the SPRR Bridge to Beach Boulevard, the channel cannot contain the 1-percent annual chance flow, and over bank flow less than 1 foot deep occurs for most of the reach. From Knott Avenue to Valley View Street, over bank flooding less than 1 foot in depth also occurs.

On Hickey Canyon a constriction of the watercourse at the Trabuco Canyon Road crossing causes ponding and resultant sheetflow at Trabuco Canyon Road and Trabuco Oaks Drive, where the U.S. Post Office is located.

The Houston Storm Channel, extending from Orangethorpe Avenue to Fullerton Creek, contains only half the 1-percent annual chance flood, resulting in shallow flooding of residential areas in the Cities of Fullerton and Buena Park.

On Horno Creek, located in the City of San Juan Capistrano, there is heavy growth in the channel upstream of Acjachema Street. This debris tends to choke bridge openings and cause channel breakouts. The backwater caused by the Ortega Highway crossing causes flooding of the commercial, residential, and school properties from Ortega Highway upstream to the I-5 crossing.

Both Modjeska and Silverado Canyons which are tributary to Santiago Creek, are densely developed by construction in the narrow, steep canyon bottoms. Many retaining walls have been constructed along one side of the canyon floor to provide room for house pads. A substantial debris problem exists which, coupled with flow velocities of 15 to 20 feet per second, may destroy the numerous footbridges spanning the watercourse. Significant property damage occurred in this canyon during the 1969 flood.

On Niguel Storm Drain, the poor trash rack inlet near Mirador Court will cause 1-percent annual chance flooding of adjacent downstream homes, with a resulting flood path heading north toward Crown Valley Parkway. Inlets within the area were found to be inadequate to alleviate the surplus flow.

Oso Creek flows through an orchard of large citrus trees. Flooding on this stream would cause damage to nearby trees and increase the debris load of Trabuco Creek. Flow separation occurs between the ATSFRR and Camino Capistrano upstream of Crown Valley Parkway because of the constriction at the railroad bridge.

San Juan Creek has been improved by the construction of concrete slope protection. However, the channel capacity is not adequate for large floods.

The history of flooding from Santiago Creek, the major tributary of the Santa Ana River in Orange County, closely follows that of the river. Flood damage occurred along the creek, either from inundation or erosion, in 1884, 1889, 1891, 1916, 1927, 1938, and 1969. The largest peak flow, estimated at 16,000 cfs, occurred during the storm of March 1884, when railroad bridges and several miles of track were washed away. Similar washouts occurred during each of the major floods. The large debris load carried by the creek was a contributing factor in many cases. The debris accumulated against bridge piers, causing floodwaters to rise and constrict bridge openings, resulting in destructive pressure against the piers. The SPRR bridges were washed out in 1916, 1927, and 1969. Culverts at Santiago Boulevard were washed out during the floods in 1969 and again in February 1978. Bank erosion has been a serious problem during periods of high runoff in Santiago Creek. In 1927, and again in 1969, much of the damage to properties adjacent to the creek was caused by bank erosion. The year 1969 was especially severe, with erosion occurring at Walnut Avenue and Mallard Street. Houses, swimming pools, garages, and dozens of backyards were washed away as the banks were widened by the streamflow. Sandbags and junked cars were used as emergency bank stabilizations to prevent further destruction.

Trabuco Creek has a dense growth of trees and brush in the main channel that may raise flood levels considerably. This debris tends to choke bridge openings and cause channel breakouts. The 1-percent annual chance flood breaks out of the channel at Del Obispo Street and the west bank levees return this flow from the main channel.

2.4 Flood Protection Measures

Structural flood protection measures in Orange County include levees, retarding basins, dams, and the channelization of many watercourses which provide partial or complete protection from 1-percent annual chance floods.

The Santa Ana River is continually being improved on a segment-by-segment basis to upgrade the river to contain the 1-percent annual chance flood. The banks of the river have been stabilized by the placement of rock riprap. In many locations, the channel capacity has been increased by the construction of levees protected by riprap material. The USACE completed Prado Dam, the major flood-control structure on the Santa Ana River, in 1941. The dam and channel combination, however, is not adequate for the safe conveyance of the 1-percent annual chance flood because of constrictions caused by several bridges, and by the lack of revetment on the upper portion of the levee. On the Santa Ana River floodplain, the OCEMA has channelized several major tributary watercourses to convey local runoff, but they will not materially reduce 1-percent annual chance flooding from the Santa Ana River.

Improvements have been proposed for Aliso Creek by the OCEMA from upstream of Muirlands Avenue through Second Street in the El Toro area. Some of these proposed improvements have not been included in the floodplain analysis. The Orange County Board of Supervisors (OCBOS) has also adopted an ordinance that establishes the Aliso Creek floodplain as an environmental corridor upon which development cannot encroach.

The Boat Canyon Storm Drain, extending from Hillcrest Drive to the Pacific Ocean in the City of Laguna Beach, has been designed to carry the 1-percent annual chance flood; however, a high debris factor causes local flooding at the inlet by Hillcrest Drive.

Brea Creek, from 250 feet east of Dale Street to the intersection of Gilbert Street and West Malvern Avenue, has been channelized and paved to convey the 1-percent annual chance flood.

Brea Canyon Channel was widened between Imperial Highway and the Pacific Electric Railway to convey the 1-percent annual chance flood.

There are two major flood protection structures on Carbon Canyon Channel: Carbon Canyon Dam and Miller Retarding Basin. Carbon Canyon Dam (capacity 7,030 acre-feet) was completed in 1961 and contains the 1-percent annual chance flood with a controlled outflow of 1,000 cfs. This outflow is contained in a rectangular concrete channel that extends from the dam 1.8 miles downstream to Palm Drive. The flow then travels through the Alta Vista Golf Course and an orchard in an unimproved section. It then enters a trapezoidal earth channel that extends from 500 feet upstream of Chapman Avenue into the City of Anaheim. Here it enters Miller Retarding Basin (capacity 360 acre-feet), designed and constructed to handle a 4-percent annual chance flood. The basin serves the dual function of storing water during very high flows to reduce the peak discharge downstream of the basin, and providing a means of percolating or spreading the imported water. During the 1-percent annual chance flood, most of the runoff is diverted along the Carbon Canyon Diversion Channel (E02) into the Santa Ana River. Miller Basin also overflows its external side spillway into Carbon Creek Channel (B01), which flows westerly and enters the City of Placentia.

Carbon Creek Channel is an improved channel near the boundary between the City of Placentia and the City of Yorba Linda. A concrete-lined rectangular channel has been constructed from Placentia Avenue (corporate limits) to Melrose Street. This reach has the capacity to convey the 1-percent annual chance flood from Placentia Avenue to Orange Freeway (State Route 57). A trapezoidal earth channel extends from Melrose Street to the Miller Retarding Basin.

Coyote Creek Channel is a trapezoidal earth channel from the southern corporate limits of the City of La Habra to Lambert Road. In this reach, there is a 683-foot-long double 20-foot by 12-foot reinforced-concrete box (RCB) culvert under Imperial Highway and a 324-foot long, triple 10-foot by 10-foot RCB culvert at Idaho Street. The trapezoidal earth channel has a 1-percent annual chance flood capacity up to the confluence with Imperial Channel, 3,800 feet upstream of the corporate limits of La Habra. From Lambert Road to La Habra Boulevard, it is a rectangular reinforced concrete channel and box culverts. From La Habra Boulevard upstream to Ramona Avenue, Coyote Creek Channel is an unimproved channel.

East Richfield Channel is a greenbelt channel from Brookmont Drive to Fairmont Boulevard and from Yorba Linda Boulevard to Avenidal Del Este. The channel in these areas will contain the 1-percent annual chance flood. Between Fairmont Boulevard and Yorba Linda Boulevard, the 1-percent annual chance flood would be contained in an underground pipe storm drain that was completed in 1978.

A 0.8-mile section of Esperanza Canyon Channel has been constructed to contain the 1-percent annual chance flood. This improved section is located 1,700 feet upstream of the corporate limits of the City of Yorba Linda and consists of a concrete-lined channel. Construction was completed on this section in 1979.

Imperial Channel is a trapezoidal earth channel from the confluence with Coyote Creek Channel to the corporate limits of the City of La Habra, except for a 1,000-foot concrete box culvert under the SPRR. The channel has the capacity to carry the 1-percent annual chance flood except for a 700-foot length of natural watercourse downstream of Imperial Highway.

La Mirada Creek, located in La Habra, has a 400-foot section of rectangular reinforced-concrete channel upstream of Whittier Boulevard that was designed to carry the 1-percent annual chance flood. Upstream from this improved channel, La Mirada Creek is an unimproved channel with trees and jungle-like growth and is flanked by houses on each side. Downstream of Whittier Boulevard is an eroded trapezoidal earth channel.

The Oso Creek Dam facilities constructed on Oso Creek provide a significant reduction of the peak 1-percent annual chance flood discharge for the 4-mile segment from the dam downstream to the confluence with La Paz Channel. Below the confluence, little flow reduction is experienced because of the large tributary area below the dam that contributes runoff at the confluence.

Placentia Storm Channel is a rectangular concrete channel that contains the 1-percent annual chance flood from its confluence with Carbon Creek Channel to the City of Placentia corporate limit at Placentia Avenue.

From the ocean outfall upstream to Avenida Vaquero, Prima Deshecha Canada, located in the City of San Clemente, has been improved by the construction of a 1-percent annual chance capacity, RCB conduit. A 1-percent annual chance capacity trapezoidal concrete channel extends upstream from Avenida Vaquero to 100 feet upstream of Calle Grande Vista. There are no flood protection measures through the Shorecliffs Golf Course other than the structures at the following street crossings:

Shorecliffs Golf Club Access Road – 11-foot by 19-foot concrete metal pipe arch

I-5 – 16-foot by 16-foot reinforced-concrete arch conduit

Avenida Vaquero – double 8-foot by 10-foot RCB conduit

Calle Nuevo – double 6-foot by 10-foot RCB conduit

On Salt Creek, a retarding basin and lake is proposed to retard the flows from three major drainage basins that converge immediately upstream of I-5.

The lower segment of San Diego Creek in Irvine, tributary to Upper Newport Bay, has been channelized by levee construction and will contain the 1- and 0.2-percent annual chance floods.

The USACE has completed channelization of the San Gabriel River.

Two dams in Santiago Creek reduce the peak flow from the mountainous areas: Villa Park Dam, a flood-control structure owned and operated by the OCEMA, and Santiago Dam, which creates Irvine Lake, a multiple-use recreational and water conservation facility with some flood control features. The two dams provide attenuation of the peak discharge from Santiago Canyon, which increases the protection level of the existing earth channel downstream of Villa Park Dam. This channel requires improvement to contain the 1-percent annual chance flood.

Seguna Deshecha Canada, located in the City of San Clemente, has been improved from the ocean outfall upstream to Avenida Pico, by the construction of a 1-percent annual chance capacity, rectangular reinforced concrete channel with a 20-foot bottom width. From Avenida Pico to El Camino Real, the Segunda Deshecha Canada channel has been improved by a 1-percent annual chance capacity, double 8-foot by 8-foot RCB conduit. The following is a list of the improvements by reach or crossing for Segunda Deshecha Canada:

El Camino Real arch conduit – 10-foot by 10-foot reinforced-concrete arch conduit

El Camino Real to 300 feet downstream of I-5 – 1-percent annual chance capacity, reinforced-concrete trapezoidal channel

Avenida Pico – double 10-foot by 10-foot RCB conduit

Calle de Los Mollinos – double 8-foot by 10-foot RCB conduit

I-5 – 17-foot by 17-foot reinforced-concrete arch conduit

From I-5 to Avenida Pico – reinforced-concrete trapezoidal channel, with an 8-foot bottom width and 10-foot depth

Avenida Pico (upstream of I-5) – 17-foot-diameter corrugated metal pipe

Proposed development immediately downstream from I-5 – double 10-foot by 10-foot RCB conduit

In addition to the structural measures described above, improvements have also been made to the following streams:

Alameda Storm Channel
Alipaz Storm Drain
Anaheim-Barber City Channel
Agua Chinon Wash
Atwood Channel
Barranca Channel
Bee Canyon Wash
Bitterbush Channel
Borrego Canyon Wash
Buckeye Storm Channel
Buena Park Storm Channel
Carbon Canyon Diversion Channel
Collins Channel
Como Storm Channel
Culver Storm Channel
East Garden-Grove Winterburg Channel
El Modena-Irvine Channel
Fletcher Channel
Fullerton Creek
Greenville-Banning Channel
Handy Creek
Hicks Canyon Wash
Horno Creek
Houston Storm Channel
La Colina-Redhill Channel
Laguna Canyon Channel
Lane Channel
Loftus Diversion Dam
Marlboro Channel
Marshburn Channel
Melrose Channel
Memory Garden Storm Channel
North Tustin Channel
Peters Canyon Wash
Redhill Channel
Reservoir Canyon
San Diego Creek
San Joaquin Channel
San Juan Creek
Sand Canyon Wash
Santa Ana-Delhi Channel
Santa Ana-Gardens Channel
Santa Ana-Sante Re Channel
Segunda Deschecha Canada Tributary
Serrano Creek
Southeast Anaheim Storm Channel
Southwest Tustin Channel
Trabuco Creek
Valencia Storm Channel
Whitebrook Storm Drain

Major structural flood protection measures have also been constructed along the 74 miles of coastline in Orange County. Over 50 miles of seawalls and revetments have been constructed to halt erosion and to absorb the impact of wave forces. In addition, 41 groins, breakwaters, and jetties have been constructed to serve a number of purposes, including flood protection (USACE, 1971; Scripps Institution of Oceanography, 1980).

The only major countywide nonstructural flood protection measure is the Public Warning System for severe weather conditions and tsunamis, operated by the National Oceanic and Atmospheric Administration through its National Weather Service, in cooperation with various State, county, and local officials (Diane Pierzinski, 1981). This system can provide some measure of flood protection by alerting coastal residents to take the necessary precautions in the event of a tsunami or major storm.

In addition, a NEXRAD radar system was installed in Orange County in the 1990s and is used to warn the public of severe weather conditions.

The continued urban growth of the county under a large number of local jurisdictions has left a multitude of unsolved drainage problems. Realizing the lack of planning of the drainage element throughout the county and the need to mitigate the potential flood threat that existed, the State legislature created the Orange County Flood Control District (OCBOS) in 1927. This district is now under the jurisdiction of the OCEMA. To augment the Flood Control Design Program in 1968, the OCBOS authorized a program for the preparation of local county drainage plans and the enactment of a drainage fee ordinance to finance local drainage facility construction. The master plans and the drainage fee ordinances make possible the logical planning and construction of necessary local drainage facilities and storm drains simultaneous with land development. Many of these master drainage plans have been completed and have been used in the preparation of this study (Toups Engineering, Inc., 1973; Raub, Bien, Frost & Associates, 1913; E. L. Pearson and Associates, 1969; VTN Consolidated, Inc., 1972; Williamson and Schmid, no date; Keith and Associates; 1970; Toups Engineering, Inc., 1969; Toups Engineering, Inc., 1971; VTN Consolidated, Inc., 1971; Toups Engineering, Inc., August 1971; Raub, Bien, Frost & Associates, 1971; Raub, Bien, Frost & Associates, 1973; Jennings-Halderman-Hood, 1973; Lowry Engineering-Science, 1969; Boyle Engineering Corporation, 1972; Boyle Engineering Corporation, 1973; Keith and Associates, 1974; Lampman and Associates, no date; VTN Consolidated, Inc., 1974; VTN Consolidated, Inc., August 1971).

In 1971, the OCBOS adopted an ordinance for floodplain zoning consistent with criteria of land management promulgated by FEMA. The ordinance provides for a floodplain overlay zone (FP-2) and a floodway overlay zone (FP-1). Subsequently, several areas in Orange County were designated as FP-2 zones. This overlay zone is included in development restrictions and criteria considered by Orange County in its land use administration.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the county, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this FIS. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1-percent chance of annual accidence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the county at the time of completion of this FIS. Maps and flood elevations will be amended periodically to reflect future changes.

The analyses reported here reflect flooding potentials based on conditions existing in the community and the watersheds at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

The settling ponds at the treatment plant upstream of Laguna Niguel Lake were assumed full during flood stage for the purpose of floodplain analysis of Sulphur Creek. The small footbridge near Laguna Niguel Lake was assumed to be washed out in early flood stage. The channel construction through the proposed park at Crown Valley Parkway and Central Park Drive was scheduled for completion in 1976 and was considered to exist for the analysis.

The analysis of Salt Creek was performed using tentative grading plans proposed as of December 31, 1974.

On Lower Santiago Creek, it was assumed that the numerous gravel pits operated within the floodplain were full prior to the occurrence of peak runoff, and that the culvert at Prospect Street was washed out. This prevents flow from entering the gravel pit upstream of Prospect Street, subsequently flooding houses south of the pit. Also, the gravel pit located downstream of the confluence with Silverado Canyon on Upper Santiago Creek was assumed to be filled, prior to the occurrence of peak runoff.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for the flooding sources studied in detail affecting the county.

The 10-, 2-, 1-, and 0.2-percent annual chance frequency-discharge rates determined in this study were calculated by a combination of methods. Discharge-frequency curves were established by determining the best fit of statistical analyses for the lower frequency storms and by computing and projecting the higher frequency storms.

A statistical frequency analysis, using the log-Pearson Type III method (U.S. Water Resources Council, 1967), was performed for each set of stream gage data. A discharge-frequency curve was plotted on log-probability paper to establish the flood flows for the lower frequencies.

Because stream gages have a relatively short period of record on the West Coast, the reliability of data is insufficient to accurately project 2- and 1-percent annual chance flood flows. The Standard Project Flood (SPF) generally corresponds to a recurrence interval of the 0.5- (200-year) to 0.2-percent annual chance flood for the southern California area. Thus, the SPF was used to adjust the projection of the discharge-frequency curve for the higher frequency flows. The SPF was computed using the USACE HEC-1 computer program (USACE, 1973). The SPF was plotted between the 0.5-percent annual chance and 0.2-percent annual chance flood frequencies on the same log probability paper that was used for the statistical analysis. The discharge-frequency curve was thus established by determining the best fit from the lower frequencies established by the statistical analysis and the higher frequencies established by the SPF analytical methods.

The stream gages that were used in the log-Pearson Type III analyses are listed in Table 5, "Stream Gages Used in Log-Pearson Analysis."

TABLE 5 – STREAM GAGES USED IN LOG-PEARSON ANALYSIS

Gage No.	Owner	Length of Record (Years)	Gage Location
11-0771	USGS	33	Alameda Storm Drain
11-0475	USGS	42	Aliso Creek at Second Street
11-0470	USGS	42	Arroyo Trabuco at Camino Capistrano Road
221	OCEMA	34	Peters Canyon Wash Near San Diego Freeway
11-0485	USGS	23	San Diego Creek Near Irvine
11-0465	USGS	44	San Juan Creek near San Juan Capistrano
11-0740	USGS	34	Santa Ana River below Prado Dam
122	OCEMA	33	Santa Ana River at Imperial Highway
11-0758	USGS	12	Santiago Creek at Modjeska Canyon
214A	OCEMA	10	Santiago Creek Below Villa Park Dam
11-0775	USGS	45	Santiago Creek at Santa Ana
207A	OCEMA	18	Westminster Channel at Beach Boulevard
152	OCEMA	35	Handy Creek Near Orange
11-475	USGS	41	Aliso Creek near Al Toro
11-470	USGS	44	Arroyo Trabuco near San Juan Capistrano
N/A	N/A	12	Brea Creek at Darlington Avenue
N/A	N/A	12	Brea Creek at Inflow to Brea Dam
N/A	N/A	13	Fullerton Creek at Richman Avenue
N/A	N/A	13	Fullerton Creek at Inflow to Fullerton Dam
11-757.4	USGS	36	Carbon Canyon Creek Near Yorba Linda

Many areas within Orange County do not have stream gages available and, therefore, correlation analyses were performed to determine the discharge rates of those streams. This was done by transferring the shape of a discharge-frequency curve determined from gage data to the location where a SPF was computed but no gage exists. Engineering judgment was used in selecting the most representative gaged curve shape. In addition, some of the discharge-frequency curves were modified to reflect recent urbanization and drainage characteristics. In some instances, an envelope curve, developed from 46 computed points and 12 existing stream gages, was used to establish a discharge rate.

The stream gages that were used in the correlation analysis are shown in Table 6, "Stream Gages Used in Correlation Analysis."

TABLE 6 – STREAM GAGES USED IN CORRELATION ANALYSIS

Facility No.	Stream Name	Location of Gage(s) Used
E01	Santa Ana River	Santa Ana River Below Prado Dam
E01S19	Bee Canyon[1]	--
E01S20	Brush Canyon[1]	--
E08	Santiago Creek	Santiago Creek at Modjeska Santiago Creek Below Villa Park Dam Santiago Creek at Santa Ana
E08S06	Handy Creek	Alameda Storm Drain (Handy Creek)
E17	Silverado Canyon	Santiago Creek at Modjeska Canyon
F01	Santa-Ana Delhi Channel	Westminster Channel at Beach Boulevard
F05	San Diego Creek	San Diego Creek Near Irvine
F18	Agua Chinon Wash	Aliso Creek at Second Street Peters Canyon Wash Near San Diego Freeway
	Round Canyon	Aliso Creek at Second Street
	Bee Canyon	Peters Canyon Wash Near San Diego Freeway
F19	Serrano Creek	Aliso Creek at Second Street
F06	Peters Canyon	Peters Canyon Wash Near San Diego Freeway
F26	Rattlesnake Canyon	Peters Canyon Wash Near San Diego Freeway
	Hicks Canyon	Aliso Creek at Second Street
F07	El Modena Irvine	Aliso Creek at Second Street Channel
G00P02	Buck Gulley[1]	--
H05	Emerald Bay Channel	Aliso Creek at Second Street
I02	Laguna Canyon	Aliso Creek at Second Street
J01	Aliso Creek	Aliso Creek at Second Street
J03	Sulphur Creek	Aliso Creek at Second Street
J03P01	Niguel Storm Drain	Aliso Creek at Second Street
J04	Narco Channel	Aliso Creek at Second Street
J05	--	Aliso Creek at Second Street
J07	English Canyon	Aliso Creek at Second Street
K01S02	Arroyo Salada	Aliso Creek at Second Street
L01	San Juan Creek	San Juan Creek near San Juan Capistrano
L01S02	Capistrano Beach Storm Channel	Alameda Store Drain
L02	Arroyo Trabuco	Arroyo Trabuco at Camino Capistrano Road
L02S03	Live Oak Canyon	Arroyo Trabuco at Camino Capistrano Road
L02S02	Hickey Creek	Arroyo Trabuco at Camino Capistrano Road
L11	Tijeras[1]	--
L03	Oso Creek	Aliso Creek at Second Street
L04	La Paz Channel	Aliso Creek at Second Street
L04P07	--	Aliso Creek at Second Street
L07	Canada Gobernadora	San Juan Creek near San Juan Capistrano

[1] Envelope Curve Used

The hydrology of the Oso Creek basin, including Lake Mission Viejo, is unique. A retention basin was constructed upstream of the dam on Oso Creek. The retention basin has an outlet pipe that bypasses the lake and a spillway that permits surcharge to enter the lake. An analysis was performed to determine the 1- and 0.2-percent annual chance floods by assuming that the bypass drain was obstructed and all flow was routed over the retention basin spillway into the lake, then over the lake spillway. The methodology used for this analysis was based on the Soil Conservation Service (SCS) method using gaged rainfall data (U.S. Department of Agriculture, 1964). Previously approved calculations prepared by the design engineer were used for the 10- and 2-percent annual chance floods. The flow rates were routed by the Muskingum Method downstream of the dam to the San Juan Capistrano corporate limits. Routed flows from the La Paz Channel were included in the Oso Creek analysis downstream of their confluence.

For Big and Bluebird Canyons, the peak flow rates for given recurrence intervals were computed using the multiple regression equation from Crippen and Beall (U.S. Department of the Interior, 1970):

$$A_n = aA^{b}1 \quad p^{b}2$$

where Q_n = Peak flow for recurrence intervals of n years
a,b1, b2 = Coefficients
A = Drainage area in square miles
P = Mean annual precipitation in inches

This equation regionalizes individual station frequency curves for the South Coast Hydrologic region that were developed using the log-Pearson Type III frequency distribution (USACE, 1973). Peak flow rates were determined for recurrence intervals of 50-, 20-, 10-, 4-, and 2-percent annual chance. The 1- and 0.2-percent annual chance recurrence interval flows were determined by logarithmic extrapolation of the frequency curve. A frequency curve of annual high tides was developed for the tide gage in Newport Harbor covering the station years from 1955 to the present, using a log-Pearson Type III distribution. The effects of urbanization on runoff were accounted for by using the results of a USGS study (U.S. Department of the Interior, 1974) that provided a digital simulation of the effects of urbanization on runoff in the Upper Santa Ana Valley.

The discharge-frequency relationships for the San Gabriel River were developed from release data on a system of dams located upstream from Seal Beach, and from gage data on the Coyote River.

The discharges for the Los Alamitos and Bolsa Chica Channels were estimated using regional rainfall-runoff relationships.

Synthetic hydrographs were developed for the Golf Course Retarding Basin using the Sherman method and information supplied by the Orange County Flood Control District.

The 1-percent annual chance flood discharge on the Santa Ana River were based on hydrology studies previously developed by the USACE for the survey investigation of the Santa Ana River (USACE, 1975). These discharges apply only to flow in the channel, and do not apply to overflow areas.

Peak discharges for Santiago Creek were taken directly from a USACE report (USACE, 1975).

Extensive USACE hydrologic studies (USACE, 1974; USACE, 1977), for streams within and adjacent to the City of Irvine provided the principal source of data used to determine peak discharges for streams within the city. Peak discharges for Agua Chinon Wash, Bee Canyon Wash, Borrego Canyon Wash, Serrano Creek, San Diego Creek, Veeh Creek (San Diego Creek Tributary 2) and Veeh Creek Tributary 1 (San Diego Creek Tributary 1), and Peters Canyon Wash were taken directly from the referenced studies. Peak discharges for some streams studied were computed by plotting an envelope curve based on peak discharges and drainage areas listed in the referenced studies. Specific discharges were determined for each study stream by locating the peak discharge on the envelope curve corresponding to the drainage area of the study stream.

Additional computations were performed on streams that have significant potential for retention of storm water due to reservoirs and embankments. San Canyon and Bonita Canyon Wash both contain sizable water-supply reservoirs. The effects of these structures were accounted for by using the USACE HEC-1 computer program (USACE, 1973) with the Modified Puls reservoir routing subroutine. Significant reductions in flows were computed. Ponding elevations within the reservoirs were also computed for floods of the selected recurrence intervals.

El Modena-Irvine Channel and Peters Canyon Wash are both intersected at right angles by the Santa Ana Freeway. The freeway is constructed with a concrete center barrier that has the effect of ponding upstream flows. The Modified Puls reservoir routing subroutine of the HEC-1 computer program was used on these streams to evaluate the effect of this barrier on the flows. The results indicated that the ponding was not of sufficient magnitude to reduce the peak discharge of high volume flows that occur during major storms.

Flood routing was also performed, by the Muskingum Method, along Brea and Fullerton Creeks below Brea and Fullerton Dams.

A summary of the drainage area-peak discharge relationships for all the streams studied by detailed methods is shown in Table 7, "Summary of Discharges."

TABLE 7 – SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
ALAMEDA STORM CHANNEL					
At confluence Santiago Creek	4.5	850	2,100	2,800	5,100
Approximately 800 feet downstream of Orange Park Acres Boulevard	4.1	800	2,000	2,700	4,800
ALIPAZ STORM CHANNEL					
At confluence Trabuco Creek	0.6	86	250	400	890
At Alpaz Street	0.3	50	140	220	490
ANAHEIM-BARBER CITY CHANNEL					
At Euclid Street	3.9	500	950	1,300	2,800
At Cerritos Avenue	1.8	300	550	750	1,600
At Ball Road	1.3	230	450	600	1,300
AGUA CHINON WASH					
At San Diego Creek	11.4	1,600	3,800	5,100	9,300
At Santa Ana Freeway	10.4	1,400	3,200	4,700	8,300
ATWOOD CHANNEL					
At confluence Miller Basin-Carbon Canyon Diversion Channel	9.4	1,700	4,000	5,500	11,000
Upstream of confluence Richfield Channel	4.8	750	1,700	2,300	4,700
At Taylor Street	4.3	690	1,600	2,100	4,300
At Imperial Highway	1.8	500	1,100	1,400	2,900
BARRANCA CHANNEL					
At confluence San Diego Creek	2.3	340	740	1,000	1,900
At Barranca Road	1.2	210	450	630	1,150
At Red Hill Avenue	0.7	150	330	400	850
BEE CANYON WASH					
At San Diego Creek	2.2	900	1,400	1,800	4,200
At Santa Ana Freeway	1.7	900	1,100	1,600	8,000

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
BITTERBUSH CHANNEL[1]					
At confluence Santa Ana River	1.5	1,000	1,700	2,000	3,900
Approximately 1,200 feet north of Chapman Avenue	1.3	920	1,500	1,800	3,300
Downstream of confluence Walnut Storm Channel	1.0	770	1,100	1,400	2,600
BLUEBIRD CANYON					
At confluence with San Diego Greek	5.0	1,100	2,500	3,750	7,000
Approximately 4,000 feet downstream of Bonita Reservoir	4.5	960	2,200	3,100	6,200
Approximately 3,500 feet downstream of Bonita Reservoir	4.0	900	2,000	2,900	5,800
At Bonita Reservoir	3.7	840	1,900	2,700	5,400
Downstream of confluence with Coyote Canyon	2.9	700	1,600	2,300	4,500
Downstream of confluence with Tributary 2	1.2	360	810	1,200	2,300
Downstream of Cress Street	0.9	200	440	640	1,400
BORREGO CANYON WASH					
Approximately 3,800 feet downstream of Trabuco Road	5.1	1,000	2,500	3,400	6,400
At Trabuco Road	5.1	1,000	2,500	3,400	6,400
BREA CANYON CHANNEL					
At the City of Brea-City of Fullerton corporate limits	21.5	1,700	5,600	8,300	18,000
At Imperial Highway	21.2	1,600	5,300	7,900	17,000
Downstream of Memory Gardens	20.8	1,600	5,200	7,800	17,000
At Central Avenue	18.8	1,500	4,800	7,200	16,000
At the City of Brea corporate limits	18.4	1,400	4,700	7,000	16,000

[1] Flows shown include 300 cfs from Walnut Storm Channel

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
BREA CREEK CHANNEL					
At confluence with Coyote Creek	33.3	1,700	3,700	7,900	21,000
At Beach Boulevard	33.1	1,700	3,700	7,900	21,000
At Atchison, Topeka & Santa Fe Railway (ATSF)	31.9	1,600	3,400	7,200	19,000
Approximately 2,000 feet downstream of CP 404	30.9	1,500	3,200	6,600	18,000
At the City of Buena Park corporate limits	30.3	1,500	3,000	6,200	17,000
At the City of Fullerton corporate limits at Magnolia Avenue extended	30.7	1,850	3,000	6,000	11,250
Downstream of confluence of Bastanchury Creek	28.4	1,250	2,550	5,000	10,600
Upstream of confluence of Bastanchury Creek	26.1	760	1,140	3,500	8,800
At intersection of Harbor Boulevard and Malvern Avenue	25.1	590	1,750	2,850	7,000
BUCKEYE STORM CHANNEL					
At Orange-Olive Road	1.5	630	1,200	1,500	3,000
At Shaffer Street	1.1	430	840	1,100	2,200
At Cambridge Street	1.0	370	770	990	2,000
CARBON CANYON CHANNEL					
At confluence with Miller Basin, downstream of Atwood Channel	32.3	2,500	5,600	7,700	16,000
Downstream of confluence with D-1 Channel	22.9	1,500	3,200	4,200	8,900
Upstream of confluence with D-1 channel	22.1	1,200	2,500	3,300	7,100
At Chapman Drive	22.0	1,200	2,500	3,200	6,900
Downstream of Palm Drive	21.5	*	*	2,110	*
Upstream of Palm Drive	20.9	680	1,600	2,100	4,500
At Yorba Linda Boulevard	20.7	530	1,200	1,700	3,700

*Data Not Available

TABLE 7 – SUMMARY OF DISCHARGES – continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
CARBON CANYON CHANNEL (continued)					
Approximately 2,000 feet downstream of Bastenchury Road	20.4	430	1,000	1,400	3,200
At Bastanchury Road	20.2	300	950	1,200	2,600
At Imperial Highway	20.0	200	950	1,100	2,100
At Carbon Canyon Dam Outflow	19.3	130	900	900	1,600
Upstream of confluence of Telegraph Canyon	13.1	730	2,600	4,000	9,300
Downstream of confluence of Soquel Canyon	11.9	720	2,600	3,900	9,100
Downstream of confluence of Sonome Canyon	7.4	450	1,600	2,500	5,800
Upstream of confluence of Sonome Canyon	5.3	310	1,100	1,700	4,000
Downstream of confluence of Liona Canyon	4.1	260	940	1,400	3,400
CARBON CANYON DIVERSION CHANNEL					
At confluence with Santa Ana River	33.2	2,000	2,500	4,600	8,000
Downstream of confluence with Miller Basin	32.3	1,900	2,400	4,300	8,000
CARBON CREEK CHANNEL					
At Southern Pacific Railroad	15.1	1,600	2,400	4,200	15,000
At Knott Avenue	13.8	1,400	2,100	3,800	14,000
CASCADITA CREEK					
At Via Cascadita	1.1	*	*	950	*
COLLINS CHANNEL					
Downstream of confluence with Santa Ana River	6.4	1,100	3,000	4,100	9,200
Upstream of confluence with Marlboro Channel	2.1	720	1,500	1,900	4,000

*Data Not Available

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
COMO STORM DRAIN					
At confluence with Peters Canyon Wash	1.7	480	1,100	1,600	3,100
Downstream of Walnut Avenue Wash	0.7	250	560	800	1,600
COYOTE CANYON WASH					
At confluence of Bonita Creek	1.6	460	1,100	1,500	3,000
Approximately 3,000 feet upstream of confluence of Bonita Creek	1.4	390	880	1,300	2,500
COYOTE CREEK CHANNEL					
Approximately 2,400 feet downstream of Beach Boulevard	11.7	3,000	6,300	8,100	17,000
Downstream of confluence of Imperial Channel	10.8	2,800	5,800	7,500	16,000
Upstream of confluence of White Brook	6.8	1,800	3,700	4,800	10,000
At confluence with Monte Vista Storm Drain	6.3	1,700	3,500	4,500	9,200
At Southern Pacific Railroad bridge	3.6	1,000	2,100	2,700	5,600
At Harbor Boulevard	3.2	880	1,900	2,400	5,000
At Palm Street	2.1	490	1,200	1,600	3,400
At Central Avenue	2.0	480	1,100	1,600	3,200
At Whittier Avenue	1.8	410	1,000	1,500	3,000
Approximately 1,300 feet downstream of La Habra corporate limits	1.2	230	640	930	1,900
At the City of La Habra corporate limits	0.7	120	360	530	1,100
EAST GARDEN GROVE-WINTERSBURG CHANNEL					
At Euclid Street	7.0	600	1,200	1,600	3,500
At Westminster Boulevard	5.9	500	950	1,300	3,100
EAST RICHFIELD CHANNEL					
At Santa Ana River confluence	2.5	720	1,800	2,600	5,300

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
EAST RICHFIELD CHANNEL (continued)					
At Imperial Highway	2.4	700	1,700	2,400	5,000
At Brookmont Drive	2.2	630	1,600	2,200	4,100
Approximately 1,000 feet downstream of Fairmont Boulevard	2.0	500	1,400	2,000	4,100
Approximately 1,000 feet upstream of Fairmont Boulevard	1.1	310	810	1,200	2,400
Approximately 1,000 feet downstream of Yorba Linda Boulevard	1.0	290	750	1,100	2,200
EL MODENA-IRVINE CHANNEL					
Downstream of confluence with Browning Avenue Channel	10.1	1,700	3,900	5,400	10,000
At Browning Avenue	8.9	1,500	3,500	4,700	9,600
Downstream of confluence of Redhill Channel	8.5	1,400	3,300	4,400	9,000
Upstream of confluence of La Colima-Redhill Storm Channel	4.7	780	1,800	2,500	4,200
At Newport Avenue	4.5	750	1,700	2,400	4,700
Downstream of confluence of North Tustin Channel	3.8	600	1,400	2,000	3,700
At Fairhaven Avenue	1.8	490	680	720	2,200
Downstream of Jordan Avenue (Retarding Basin)	1.5	400	500	500	2,200
Intersection of Solana Drive and Marmon Avenue	1.5	400	770	990	2,200
Start of open channel downstream	1.3	340	670	870	1,900
FLETCHER CHANNEL					
At confluence with Santa Ana River	1.4	440	1,000	1,300	2,800
At Fletcher Street	1.3	570	1,100	1,400	2,800
At Glassell Street	1.0	450	860	1,100	2,200

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
FOUNTAIN VALLEY CHANNEL					
At Talbert Channel confluence	3.8	*	*	1,250	*
FULLERTON CREEK CHANNEL					
At Valley View Drive	20.6	1,500	3,900	6,200	14,000
Downstream of confluence of Buena Park Storm Channel	20.4	1,500	3,900	6,200	14,000
Downstream of confluence of Buena Park Storm Channel	19.3	1,500	3,700	5,900	13,000
Downstream of confluence of Melrose Channel	19.0	1,400	3,500	5,700	13,000
Upstream of confluence with Melrose Channel	17.5	1,300	3,300	5,300	12,000
At Manchester Avenue	17.0	1,300	3,300	5,300	12,000
At Dale Avenue	16.8	1,300	3,300	5,300	11,800
At confluence of Houston Channel	14.8	1,250	3,250	5,750	10,150
At ATSF Railway	8.92	750	1,900	3,000	7,000
At intersection of Bastanchury and Associated Roads	5.9	225	575	980	2,060
GREENVILLE-BANNING CHANNEL					
At Huntzinger Avenue	2.8	460	900	1,200	2,500
At Warner Avenue	1.6	150	300	850	2,500
At Edinger Avenue	0.8	100	150	450	1,000
HANDY CREEK					
At confluence with Santiago Creek	*	*	*	2,400	*
Upstream of Amapola Avenue	3.0	680	1,600	2,300	4,000
Downstream of Chapman Avenue	2.4	600	1,500	2,000	3,600
HICKS CANYON WASH					
At Culver Drive	3.0	730	1,800	2,700	4,800
Approximately 1.3 miles upstream of Culver Drive	2.6	700	1,700	2,400	4,600

*Data Not Available

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
HORNO CREEK					
At confluence with the City of San Juan Creek	4.5	350	1,100	1,700	3,800
At San Juan Capistrano corporate limits	3.4	350	1,100	1,700	3,800
HOUSTON STORM CHANNEL					
At confluence with Fullerton Creek	2.9	920	1,450	1,800	3,900
At the City of Buena Park corporate limits	2.1	660	1,100	1,300	3,000
HUNTINGTON BEACH CHANNEL					
At Talbert Channel confluence	4.5	*	*	1,480	*
IMPERIAL CHANNEL					
At confluence with Coyote Creek	3.3	740	1,600	2,100	4,400
At Euclid Street	2.4	530	1,200	1,600	3,300
At Harbor Boulevard	1.9	400	910	1,200	2,500
LA COLINA-REDHILL STORM CHANNEL					
At confluence with El-Modena Irvine Channel	1.3	230	580	780	1,500
LAGUNA CANYON					
At Pacific Coast Highway	9.0	1,300	3,100	4,500	7,500
Downstream of Canyon Acres Drive	8.1	1,200	3,000	4,300	7,300
Approximately 1.7 miles downstream of El Toro Road	7.3	1,200	2,900	4,100	7,000
Approximately 400 feet downstream of El Toro Road	5.4	1,100	2,600	3,700	6,300
At El Toro Road	3.9	720	1,800	2,500	4,200
Approximately 6,500 feet upstream of El Toro Road	2.9	430	1,100	1,500	2,500
Approximately 9,000 feet upstream of El Toro Road	1.4	230	580	800	*

*Data Not Available

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
LAGUNA WASH ROAD					
At San Diego Freeway	1.3	320	700	1,100	2,100
Downstream of confluence of Laguna Road Wash Tributary	1.1	240	510	730	1,500
LA MIRADA CREEK					
At the City of La Habra corporate limits	3.2	720	1,800[1]	1,800[1]	6,000
At Orange County limits	3.0	610	1,800	2,700	5,600
LANE CHANNEL					
At confluence with San Diego Creek	4.0	540	1,200	1,500	3,000
At Red Hill Avenue	2.2	310	660	850	1,700
LOFTUS DIVERSION CHANNEL					
At Imperial Highway	3.5	570	1,900	2,900	5,800
Downstream of confluence of Fullerton Creek	3.3	530	1,700	2,700	5,400
Upstream of confluence of Fullerton Creek	2.19	370	1,200	1,900	3,700
At Pacific Electric Railroad	1.74	290	950	1,500	2,900
At Kraemer Boulevard	1.52	250	800	1,300	2,500
Approximately 1,500 feet east of Kraemer Boulevard	1.47	240	770	1,200	2,400
Approximately 2,500 feet east of Kraemer Boulevard	0.85	140	450	700	1,400
MARLBORO CHANNEL					
At confluence with Collins Channel	3.5	590	1,100	1,700	4,200
At ATSF Railway	3.5	590	1,100	1,700	4,200
At Cambridge Street	3.4	570	1,100	1,700	4,100
Approximately 1,500 feet downstream of Tustin Avenue	3.3	530	1,100	1,600	4,000
At Newport Freeway	2.9	460[2]	840[2]	1,300[2]	3,400[2]

[1] Peak discharge reduced due to divergence of flow by streets

[2] Flows have been reduced to account for effects of upstream diversion channels

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
MELROSE CHANNEL (RIVERSIDE FREEWAY CHANNEL)					
At confluence with Fullerton Creek	1.5	320	612	830	1,800
At Stanton Avenue	1.2	250	480	650	1,400
MEMORY GARDEN STORM CHANNEL					
At confluence with Brea Canyon Wash	1.4	250	780	1,200	2,500
At Central Avenue	1.3	230	750	1,100	2,400
At Memory Garden Cemetery	1.2	210	710	1,100	2,300
Approximately 2,500 feet upstream of Memory Garden Cemetery	1.0	160	550	810	1,800
PETERS CANYON CHANNEL					
At confluence with San Diego Creek	*	*	*	14,660	*
At OCTA Metrolink	34.4	*	*	12,660	*
Downstream of El Modena-Irvine Channel	32.6	*	*	11,580	*
Downstream of Santa Ana Freeway	19.7	*	*	8,550	*
PETERS CANYON WASH					
Approximately 1,400 feet downstream of Peters Canyon Reservoir	0.24	*	*	320	*
Approximately 1,700 feet upstream of Lower Peters Canyon Reservoir	0.48	*	*	570	*
Approximately 1,300 feet upstream of Lower Peters Canyon Reservoir	0.77	*	*	840	*
At Lower Peters Canyon Reservoir	0.95	*	*	980	*

*Data Not Available

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
PLACENTIA STORM CHANNEL					
At confluence with Carbon Creek Channel	3.4	1,100	1,700	2,200	4,800
At ATSF Railway	3.1	960	1,600	1,900	4,200
At Placentia Avenue	2.7	760	1,200	1,450	3,200
PRIMA DESHECHA CANADA					
At El Camino Real	6.7	540	1,700	2,800	7,000
At San Diego Freeway	5.2	420	1,400	2,300	5,600
Downstream of confluence of Prima Deshecha Canada Tributary	4.0	360	1,100	1,900	4,600
RESERVOIR CANYON					
Downstream of I-5	1.0	130	360	570	1,300
Downstream of confluence of Deep Canyon	0.9	130	360	570	1,300
At Paseo Allegria	0.5	80	210	330	730
RICHFIELD CHANNEL					
At confluence with Atwood Channel	4.6	860	2,300	3,300	6,700
At ATSF Railway	4.3	830	2,200	3,100	6,500
SAND CANYON WASH					
At confluence with San Diego Creek	8.6	920	2,600	3,900	8,500
At Culver Drive	8.4	920	2,600	3,900	8,500
At Sand Canyon Spillway	7.0	860	2,400	3,600	7,800
At downstream side of Shady Canyon	5.7	1,100	2,600	3,700	7,400
At upstream side of Shady Canyon	2.5	500	1,200	1,700	3,300
SAN DIEGO CREEK					
At MacArthur Boulevard	123.8	4,300	9,700	18,500	27,500
Downstream of confluence with Sand Canyon	115.1	4,300	9,700	18,500	27,500
Downstream of confluence with San Joaquin channel	105.8	4,200	9,500	17,500	27,000
At San Diego Freeway	101.1	4,000	9,200	17,500	26,000
Downstream of confluence of Peters Canyon Wash	86.5	3,900	8,800	16,000	25,000

TABLE 7 – SUMMARY OF DISCHARGES – continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
SAN DIEGO CREEK (continued)					
At Sand Canyon Avenue	39.8	4,800	10,600	14,100	*
At Laguna Freeway	29.8	4,300	9,600	12,700	20,700
Upstream of confluence of Bee Canyon Wash	27.7	3,900	8,800	11,600	20,700
At San Diego Freeway	16.1	3,000	6,600	8,700	15,500
Approximately 2,000 feet downstream of confluence of Veeh Creek Tributary 1 (San Diego Creek Tributary 1)	14.7	1,700	3,900	5,800	11,000
Downstream of confluence of Veeh Creek Tributary 1 (San Diego Creek Tributary 1)	14.5	1,600	3,700	5,500	10,500
At Santa Ana Freeway	2.1	1,200	1,700	1,800	2,400
At Valencia Avenue	9.3	3,200	4,300	4,700	6,200
Downstream of confluence with Veeh Creek (San Diego Creek Tributary 2)	14.75	5,335	7,255	7,950	10,450
SAN JOAQUIN CHANNEL					
At confluence with San Diego Creek	4.9	910	2,100	2,650	5,900
Approximately 1,200 feet upstream of Culver Drive	3.3	720	1,600	2,050	4,600
Approximately 3,600 feet upstream of San Diego Freeway	1.2	360	810	1,250	2,300
SAN JUAN CREEK					
At the City of San Juan Capistrano corporate limits	173.7	8,200	30,000	42,000	80,000
Downstream of confluence of Trabuco Creek	171.1	8,000	29,000	41,000	79,000
At confluence of Horno Creek	116.8	6,200	22,000	32,000	60,000
At the City of San Juan Capistrano corporate limits	108.5	6,000	21,000	30,000	56,000

*Data Not Available

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
SANTA ANA-DELHI CHANNEL					
Upstream of confluence with Santa Ana Gardens Channel	4.2	580	1,100	1,500	3,200
At Flower Street	3.5	540	1,000	1,400	3,000
At Southern Pacific Railroad	2.9	470	880	1,200	2,600
At Warner Avenue	1.1	220	400	550	1,200
SANTA ANA GARDENS CHANNEL					
At Sunflower Avenue	5.7	560	1,100	1,400	3,100
At Alton Avenue	5.3	540	1,000	1,400	3,000
At Segerstrom Avenue	3.9	470	880	1,200	2,600
At Adams Avenue	3.0	430	820	1,100	2,400
At Edinger Avenue	2.5	400	750	1,000	2,200
At McFadden Avenue	1.4	260	400	650	1,400
SANTA ANA RIVER					
At mouth	2,447[1]	*	*	12,000[2]	*
At Katella Avenue in Orange	2,346[1]	*	*	50,000	*
At Imperial Highway in City of Anaheim	2,306[1]	*	*	50,000	*
SANTA ANA-SANTA FE CHANNEL					
At ATSF Railway crossing	4.2	500	1,300	2,000	3,700
At ATSF Railway junction	3.9	490	1,300	1,900	3,500
At Redhill Avenue	3.3	420	1,100	1,600	3,000
At Newport Freeway	2.3	290	760	1,100	2,100
Upstream of confluence of Southwest Tustin Channel	1.3	170	430	650	1,200
At Grand Avenue	0.8	100	260	400	730
SANTIAGO CREEK					
At Santa Ana River	102	1,500	4,000	12,000	27,000
At Atchison Topeka and Santa Fe Railway	96	1,500	4,000	12,000	27,000

*Data Not Available

[1] Approximately 2,225 square miles controlled by Prado Dam

[2] Reduction in discharge due to Santa Ana River overflow

TABLE 7 – SUMMARY OF DISCHARGES – continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
SEGUNDA DESHECHA CANADA					
At El Camino Real	7.4	590	1,800	3,000	7,600
At San Diego Freeway	6.9	560	1,800	2,900	7,300
Downstream of confluence of Segunda Deshecha Canada Tributary	6.4	520	1,700	2,800	6,800
Approximately 1.6 miles upstream of Pacific Ocean	5.0	430	1,400	2,300	5,500
Approximately 1.9 miles upstream of Pacific Ocean	4.7	410	1,300	2,100	4,800
Approximately 2.5 miles upstream of Pacific Ocean	4.2	380	1,200	2,000	4,800
SEGUNDA DESHECHA CANADA TRIBUTARY					
At confluence with Segunda Deshecha Canada	1.2	150	420	670	1,600
Approximately 1,584 feet upstream of confluence with Segunda Deshecha Canada	1.1	120	380	620	1,500
SERRANO CREEK					
At confluence with San Diego Creek	9.3	3,200	4,300	4,700	6,200
At OCTA Metrolink	6.3	850	2,200	3,000	5,600
Downstream of Tributary Junction	5.4	850	2,200	2,900	5,300
At Bake Parkway	4.9	*	*	2,800	*
Upstream of Tributary Junction	2.8	*	*	2,200	*
Approximately 12,500 feet upstream of Trabuco Road	1.7	*	*	1,700	*

*Data Not Available

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
SHADY CANYON WASH					
At confluence with Sand Canyon Wash	1.6	440	990	1,500	2,800
Approximately 2,200 feet upstream of confluence with Sand Canyon Wash	1.5	420	950	1,400	2,700
TALBERT CHANNEL					
At Huntington Beach Channel confluence	13.2	*	*	3,510	*
TRABUCO CREEK					
At Atchison, Topeka & Santa Fe Railway	35.46	*	*	13,000	*
At confluence with San Juan Creek	53.9	2,800	11,000	15,000	23,000
VALENCIA STORM CHANNEL					
At Harvard Avenue	1.0	*	*	915	1,174
Approximately 2,000 feet southeast of Culver Drive	0.7	250	560	760	1,600
VEEH CREEK (SAN DIEGO TRIBUTARY 2)					
At confluence with Veeh Creek Tributary 1 (San Diego Creek Tributary 1)	4.0	760	1,700	2,600	4,900
At confluence with San Diego Creek	5.4	2,540	3,490	3,810	5,030
VEEH CREEK TRIBUTARY 1 (SAN DIEGO TRIBUTARY 1)					
At confluence with San Diego Creek	5.4	900	2,000	3,100	5,800
Upstream of confluence of San Diego Creek Tributary 2	1.2	360	810	1,250	2,300
Approximately 4,400 feet upstream of confluence with San Diego Creek	1.0	310	700	1,100	2,000
Upstream of confluence with Veeh Creek (San Diego Tributary 2)	1.2	360	810	1,250	2,300

*Data Not Available

TABLE 7 – SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
VILLA PARK STORM DRAIN					
At intersection of Center Drive and Adams Ranch Road	0.1[1]	10	20	25	40
At intersection of Center Drive and Villa Park Road	0.1[1]	30	60	80	140
At intersection of Lemon Street and Villa Park Road	0.1[1]	55	95	125	230
At intersection of Center Drive and Santiago Boulevard	0.1[1]	40	75	100	170
At intersection of Lemon Street and Taft Avenue	0.2[1]	100	200	250	450
At Serrano Avenue	1.0	270	800	1,150	2,200
At Lemon Street	1.0	250	650	1,000	2,000
WALNUT CANYON CHANNEL					
At Riverside Freeway	2.8	820	1,800	2,500	5,200
At Santa Ana Canyon Road	2.6	710	1,700	2,300	4,800
At 1,000 feet upstream of Walnut Canyon Road	2.0	380	1,100	1,700	3,500
At 1,700 feet upstream of Walnut Canyon Road	1.8	340	1,000	1,500	3,100

*Data Not Available

[1] Due to divided flows at street intersections, flow concentrations are not combined and routed

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the source studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. For construction and/or floodplain management purposes, users are encouraged to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

For most streams studied by detailed methods, the USACE HEC-2 step-backwater computer program (USACE, October 1973) was used to compute the water-surface elevations. Analyses of various streams were updated to reflect developments, based on improvement plans submitted by the county and the additions of newly constructed levees and channel improvements. For those reaches not analyzed using the HEC-2 program, hand calculations were used in conjunction with published results of field investigations and improvement plan research and historic high water marks. Determination of input parameters for the hydraulic analyses is described below followed by summaries of methods and findings for individual streams.

For the analyses of the Santa Ana River, cross-section data from a previous USACE study of the river was used (USACE, June 1971).

Cross sections for most of the HEC-2 analyses were taken from topographic maps (E. L. Pearson and Associates, 1969; VTN Consolidated, Inc., 1972; Williamson and Schmid, No date; Keith and Associates, 1970; Toups Engineering, Inc., 1969; Toups Engineering, Inc., 1971; VTN Consolidated, Inc., 1971; Toups Engineering, Inc., August 1971; Raub, Bien, Frost & Associates, 1971; Raub, Bien, Frost & Associates, 1973; Jennings-Halderman-Hood, 1973; Lowry Engineering-Science, 1969; Boyle Engineering Corporation, 1972; Boyle Engineering Corporation, 1973; Keith and Associates, 1974; Lampman and Associates, no date; VTN Consolidated, Inc., 1974; VTN Consolidated, Inc., August 1971; USACE, 1973; Raub, Bien, Frost and Associates, 1972; USACE, June 1973; Toups Corporation, 1960; Orange County Flood Control District, 1959; City of Laguna Beach, 1960; Toups Corporation, 1977; Yorba Linda County Water District, 1966; City of San Juan Capistrano, 1967; Toups Corporation, 1976; The Irvine Company, 1960; Toups Corporation, April 1977; Toups Corporation, June 1977; Toups Corporation, 1972; City of San Clemente, no date; City of Brea, 1966; USACE, 1969; USACE, 1972). Cross sections for bridges were taken from bridge plans whenever available and/or augmented by field measurement. Cross sections were located at close intervals above and below bridges and culverts in order to compute the significant backwater effects of these structures in highly urbanized areas.

For San Diego Creek, from its mouth to MacArthur Boulevard, 11 field-surveyed cross sections were used. For Big Canyon from its mouth to a point above Jamboree Road, 15 field-surveyed sections were used.

In areas where there had been substantial changes caused by development not reflected on the existing topographic maps, aerial photos (Toups Corporation, 1977), improvement plans, and field reconnaissance were used to supplement the mapping.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the FIRM (Exhibit 2).

Starting water-surface elevations were determined by normal-depth calculations, through field investigations, or from streams studied previously. All elevations are referenced to the North American Vertical Datum of 1988 (NAVD 88).

Roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and were based on field observations of the streams and floodplain areas. Roughness factors for all streams studied by detailed methods are shown in Table 8, "Summary of Manning's "n" Values."

TABLE 8 – SUMMARY OF MANNING'S "n" VALUES

Stream	Channel "n"	Overbank "n"
Aliso Creek	0.015-0.045	0.032-0.100
Agua Chinon Wash	0.030-0.040	0.030-0.040
Arroyo Salada	0.030-0.065	0.030-0.080
Atwood Channel	0.014-0.040	0.022-0.070
Barranca Channel	0.025	N/A
Bee Canyon Wash	0.030-0.040	0.030-0.040
Bonita Creek	0.030-0.060	0.030-0.035
Borrego Canyon Wash	0.025-0.040	0.030
Brea Canyon Channel	0.025-0.040	0.025-0.100
Brea Creek Channel	0.015-0.060	0.020-0.120
Canada Gubernadora	0.030-0.045	0.050-0.100
Carbon Canyon Channel	0.014-0.125	0.022-0.125
Carbon Creek Channel	0.014-0.040	0.020-0.100
Cascadita Creek	0.013-0.060	0.040-0.055
Como Storm Channel	0.030	N/A
Coyote Canyon Wash	0.040-0.050	0.035-0.040
Coyote Creek	0.014-0.060	0.050-0.100
El Modena-Irvine Channel	0.035	0.030-0.035
English Canyon	0.035-0.065	0.045-0.100
Facility No. 505	0.030-0.080	0.030-0.080
Fullerton Creek Channel	0.015-0.060	0.060-0.140
Handy Creek	0.013-0.060	0.035-0.100
Hickey Canyon	0.035-0.065	0.045-0.100
Hicks Canyon Run	0.030	N/A
Horno Creek	0.020-0.060	0.060
Imperial Channel	0.014-0.100	0.020-0.100
Laguna Canyon	0.030-0.045	0.050-0.100
Lane Channel	0.025	N/A
La Paz Channel	0.035-0.065	0.045-0.100
Loftus Diversion Channel	0.025	0.030-0.080
Lower San Juan Canyon	0.030-0.045	0.050-0.100
Lower San Juan Creek	0.030-0.045	0.050-0.100
Lower Santiago Creek	0.030-0.045	0.050-0.100
Memory Garden Storm Channel	0.025	0.035
Modjeska Canyon	0.035-0.065	0.045-0.100
Niguel Canyon (Emerald Bay Channel)	0.030-0.080	0.030-0.080
Niguel Storm Drain	0.035-0.065	0.045-0.100
North Sulphur Creek (Narco Channel)	0.030-0.045	0.050-0.100
Oso Creek	0.035-0.065	0.045-0.100
Peters Canyon Wash	0.025-0.030	0.035

TABLE 8 – SUMMARY OF MANNING'S "n" VALUES - continued

Stream	Channel "n"	Overbank "n"
Placentia Storm Channel	0.014	N/A
Prima Deshecha Canada	0.020-0.050	0.035-0.050
Richfield Channel	0.014	N/A
San Diego Creek	0.025-0.050	0.025-0.035
San Juan Canyon	0.030-0.045	0.050-0.100
San Juan Creek	0.020-0.060	0.030-0.200
San Joaquin Channel	0.025-0.040	N/A
Sand Canyon Wash	0.030-0.060	0.025-0.050
Salt Creek	0.035-0.065	0.045-0.100
Santa Ana River	0.030-0.045	0.050-0.100
Segunda Deshecha Canada	0.015-0.060	0.030-0.060
Segunda Deshecha Canada Tributary	0.025	0.060
Serrano Creek	0.015-0.060	0.020-0.065
Shady Canyon Wash	0.035	0.035
Silverado Creek	0.030-0.045	0.050-0.100
Sulphur Creek	0.030-0.045	0.050-0.100
Trabuco Creek	0.013-0.070	0.014-0.080
Upper Santiago Creek	0.030-0.045	0.050-0.100
Valencia Storm Channel	0.040	0.030
Veeh Creek (San Diego Creek Tributary 2)	0.040-0.080	0.035-0.050
Veeh Creek Tributary 1 (San Diego Creek Tributary 1)	0.040-0.080	0.030-0.040

The following assumptions and criteria were used in performing the hydraulic analyses. These were coordinated with the USACE and the OCEMA.

1. Temporary separation of streamflow around island areas was analyzed by iteratively selecting different discharge rates in each side of the divided watercourse until the discharge rates with energy lines that balanced at common control points were found.

2. To simplify computer coding, circular culverts were coded as a hydraulically equivalent rectangular shape with some soffit elevations.

3. Major culverts were analyzed by bridge routines within the HEC-2 computer program (USACE, October 1973). To simplify computer coding of the numerous small culverts and bridges, a minor bridge or culvert was defined as having capacity less than two-thirds the capacity of the 10-percent annual chance frequency flood. For minor culverts, the culvert capacity was computed by the Manning's "n" equation and the flow over the roadway established the water-surface elevation of the resulting ponding area.

4. Debris blockage of bridges was discussed with the USACE and OCEMA. Some bridges have streamlined debris walls on the piers with an inclined curve slope, which permits debris to ride to the top of the water surface, thus reducing debris blockage. The depth of waterway blockage caused by debris was assumed to be equal to the depth of water and the width was based on the presence of a debris wall and the debris generation potential of the watercourses as indicated below. Bridges having no piers were assumed to have no flow area obstructed by debris. Obstructed areas were assumed as follows:

Type of Watercourse	Obstructed Area If Debris Wall Exists	Obstructed Area If No Debris Wall Exists
Heavily Wooded natural watercourse with high debris potential	3 Feet + Pier Width	4 Feet + Pier Width
Watercourse with intermediate debris potential	1 Foot + Pier Width	2 Feet + Pier Width

5. Ponded areas above roadway culverts were analyzed by subtracting culvert capacity (full pipe, with projecting entrance condition) from total discharge rate. The remaining flow was assumed to go over the roadbed at critical depth, and the backwater influence was extended upstream as a ponded condition.

   Channel spillover and breakout in urban areas results in several shallow flooding areas. The flooding limits were determined by coordinating with local agency data and field evaluation using engineering judgment based on the following criteria:

   a. Channel capacities were calculated freeboard, assuming normal-depth conditions.

   b. The overbank discharge rates were determined by subtracting channel capacity from the respective frequency flood peak-discharge rates.

   c. Flood depths in the street capacity charts.

   d. Trial-and-error computations solution of street flow depths were correlated with the given flow rate to determine limits of inundation if flood widths exceeded the street's rights of way, thus exceeding street capacity charts.

Approximate analyses were used to determine 1-percent annual chance flood limits in undeveloped or sparsely developed areas. Wherever possible, the flood limits were established by floodplain studies previously prepared by Federal or local agencies. Flood limits were also based on high-water marks found on physical features such as bridges, railroad trestles, and buildings. Aerial photographs (Toups Corporation, 1977) were utilized to plot flood limits of small reservoirs. Normal-depth analysis was used to establish flood limits at selected representative cross sections.

Coastal flood hazard areas subject to inundation by the Pacific Ocean were determined on the basis of water-surface elevations established from regression relations defined by Thomas (FEMA, 1984). These regression relations were defined as a practical method for establishing inundation elevations at any site along the southern California mainland coast. They were defined through analysis of water-surface elevations established for 125 locations in a complex and comprehensive model study by Tetra Tech, Inc. (Tetra Tech, Inc., 1982). The regression relations establish wave run-up and wave setup elevations in the City of Seal Beach for the 10-, 1-, and 0.2-percent annual chance flood events.

Wave run-up elevations were used to determine flood hazard areas for sites along the open coast that are subject to direct assault by deep-water waves. Run-up elevations range with location and local beach slope and were computed at 0.5-mile intervals, or more frequently in areas where the beach profile changes significantly over short distances. Areas with ground elevations 3.0 feet or more below the 1-percent annual chance wave run-up elevation are subject to velocity hazard.

Wave setup elevations determined from the regression equations on the basis of location along the coast were used to identify flood hazard areas along bays, coves, and areas sheltered from direct action of deep-water waves.

Coastal floodplain boundaries were delineated using the wave run-up or wave setup elevations computed at each 0.5-mile interval. Between these points, the boundaries were interpolated using topographic maps (U.S. Department of the Interior, 1975, et cetera; Abrams Aerial Survey Corporation, 1978). Structural modifications along the coast completed after the above-mentioned maps were not considered in the coastal analysis.

Computed elevations for wave run-up, wave setup, inundation hazard characteristics are shown in Table 9, “Summary of Pacific Ocean wave Elevations.”

TABLE 9 – SUMMARY OF PACIFIC OCEAN WAVE ELEVATIONS

	Wave Run-up Elevation (Feet)[1]			Wave Setup Elevation (Feet)		
Location	10-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance	10-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
Calle Ariana Extended	10.5	13.2	15.7			
At Allessandra Storm Channel	10.2	12.6	15.1			
At Segunda Deshecha Storm Channel	10.2	12.5	14.9			
At Camino de Estrela Extended	10.2	12.5	14.9			
At San Juan Channel	9.8	11.8	14.2			
At Island Way Extended	15.7	21.9	25.3			
At Dana Point Harbor				7.1	8.1	10.2
At Santa Clara Avenue Extended	12.0	15.9	18.7			
Approximately 750 feet southeast of intersection of Nautilus Isle and Niguel Shore Drive	11.6	14.9	17.7			
Intersection of Cabrillo Isle Street and Ports O Call Extended west approximately 1,150 feet	10.9	13.6	16.2			
At Salt Creek	11.9	15.3	18.1			
Approximately 260 feet southwest of intersection of Surf Breaker Drive and Crest Drive	13.1	18.0	20.3			
At Frederick Lane Extended south	14.4	19.5	22.7			
At La Senda Place Extended south	12.9	17.0	20.0			
At King John Lane Extended west	16.1	22.6	26.0			
At Vista Del Sol Extended southwest	11.7	15.0	17.8			
Approximately 600 feet west of intersection of Pacific Coast Highway and North Portola	15.9	22.2	25.6			
At Point Place Extended southwest	12.9	17.1	20.0			
At 9th Avenue Extended southwest	11.9	15.3	18.0			
Approximately 500 feet southwest of southern intersection of Circle Drive and Pacific Coast Highway	15.9	22.2	25.6			
At 5th Avenue Extended southwest	11.1	14.1	16.7			
At Seacliff Drive Extended southwest	12.9	17.1	20.0			
At West Street Extended west	10.5	13.1	15.6			
Approximately 100 feet northwest of Aliso Creek	11.0	13.9	16.5			

[1] Average elevation along coast in vicinity of each location

TABLE 9 – SUMMARY OF PACIFIC OCEAN WAVE ELEVATIONS - continued

Location	Wave Run-up Elevation (Feet)[1]			Wave Setup Elevation (Feet)		
	10-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance	10-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
Approximately 800 feet southwest of intersection of Pacific Coast Highway and Lagunita Lane	11.3	14.2	16.5			
At Upland Road Extended southwest	17.1	24.1	27.7			
At Diamond Street Extended	12.9	17.0	20.0			
At Mountain Road Extended	12.2	15.9	18.7			
At Park Avenue Storm Drain	11.8	15.2	18.0			
At Myrtle Street Extended southwest	12.0	15.4	18.3			
At Barranca Street Extended	14.4	19.4	22.7			
At McKnight Drive Extended south	12.8	16.8	19.8			
Approximately 700 feet south of intersection of Shamrock Road and Pacific Coast Highway	11.0	13.8	16.4			
At Niguel Canyon	11.3	14.4	17.1			
Approximately 450 feet southwest of intersection of Circle and Emerald Point Drives	10.8	13.5	16.1			
At Monte Carlo Drive Extended southwest	13.0	17.1	20.3			
Approximately 400 feet west of intersection of Riviera and Monte Carlo Drive	14.4	19.4	22.8			
At Cameo Shires Road Extended	13.5	18.1	21.1			
Approximately 400 feet south of intersection of Camden and Milford Drive	15.9	21.8	25.5			
At Shorecliff Drive Extended	11.3	14.4	17.1			
Approximately 450 feet southwest of intersection of Morning Canyon and Shorecliff Road	15.9	21.8	25.5			
At Beach Boulevard Extended south	11.0	13.9	16.5			
At Poppy Avenue Extended southwest	15.9	21.8	25.5			
At Larkspur Avenue Extended southwest	11.2	14.1	16.9			
At Newport Bay Entrance Channel				7.1	8.3	10.5
At G Street Extended southwest	10.6	13.1	15.7			
At Main Street Extended	10.6	13.1	15.7			

[1] Average elevation along coast in vicinity of each location

TABLE 9 – SUMMARY OF PACIFIC OCEAN WAVE ELEVATIONS - continued

	Wave Run-up Elevation (Feet)[1]			Wave Setup Elevation (Feet)		
Location	10-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance	10-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
At 6th Street Extended south	10.6	13.1	15.7			
At 9th Street Extended south	11.2	14.2	16.9			
Approximately 1,650 feet south of intersection of Lake Street and Atlanta Avenue	11.6	14.9	17.6			
At Lake Street Extended southwest	11.0	13.9	16.5			
At 20th Street Extended southwest	11.5	14.7	17.5			
Approximately 200 feet southwest of a point 200 feet northwest of intersection of 22nd Street and Pacific Coast Highway	12.6	16.5	19.4			
At Cherry Hill Drive Extended southwest	13.1	17.4	20.3			
Approximately 1,400 feet southwest of corner of Seaview Avenue	11.9	15.4	18.2			
Approximately 400 feet southwest of East Garden Grove Winterburg Channel Dam	11.9	15.4	18.2			
At Sceptre Lane Extended south	10.1	12.3	14.9			
At Weatherly Lane Extended south	10.8	13.6	16.2			
Approximately 1,200 feet southwest of intersection of Weatherly Lane and Warner Avenue	11.5	14.7	17.5			
At 6th Street Extended southwest	11.9	15.4	18.2			
At 14th Street Extended southwest	12.6	16.6	17.2			
At Anderson Street Extended southwest	11.4	14.5	17.2			
At Huntington Harbor				6.5	7.4	11.2
At intersection of Pacific Coast Highway and Warner Avenue				12.5	15.7	17.9
Philip Street Extended southwest	11.5	14.6	17.3			
At Dolphin Avenue Extended southwest	11.5	14.7	17.4			
At Anaheim Bay				7.2	8.5	10.6
At 10th Street Extended southwest	10.9	13.8	16.4			
At 5th Street Extended southwest	10.4	12.8	15.3			
Confluence with San Gabriel River				7.2	8.4	10.4

[1] Average elevation along coast in vicinity of each location

The most extensive hydraulic analyses in Orange County were carried out for the Santa Ana River. They included sediment transport analysis, channel capacity analysis, breakout analysis, and overflow analysis. The following is a brief discussion of the methods used in the analyses and the results obtained.

1. Sediment Transport Analysis

Loss of channel capacity because of sedimentation has been recognized as a major problem on the downstream end of the lower Santa Ana River. Consequently, a sediment transport analysis was conducted to estimate the change in streambed profile associated with the 1-percent annual chance flood. Enough sedimentation data were available from the 1969 flood to make the analysis defendable. The USACE HEC-6 sediment-transport computer program was used to perform the computations (USACE, 1976). Because the channel is very inadequate, the HEC-6 program was used to obtain a starting condition fixed-bed mode for the determination of channel capacities.

Sediment samples were taken from the streambed at several locations to provide necessary input data to the program. Initial values of hydraulic and sediment transport parameters were computed and then calibrated using data from the 1969 flood, which constituted a 40-year flood. Acceptable reproduction of the stream profile observed after the flood was obtained for most of the study area. The calibrated parameters were then applied to the lap-year flood to determine the associated streambed profile.

The results of the analysis indicate that up to 4 feet of sediment will be deposited in the channel from Edinger Avenue to the Pacific Ocean. Deposition is also indicated between drop structures and in the vicinity of Imperial Highway. The analysis also predicts that as much as 2 feet of scour will occur between Garden Grove Boulevard and McFadden Avenue.

2. Channel Capacity Analysis

The USACE HEC-2 computer program (USACE, October 1973) was used to perform the computations required to determine the capacity of the existing channel. The HEC-2 computer program was operated in a fixed-bed mode, using the 1-percent annual chance sediment profile obtained from the HEC-6 computer program. The necessary data required to describe the existing channel configuration were taken from OCEMA construction plans. Bridge data were taken from construction plans provided by the Orange County Road Department and the California Department of Transportation.

A freeboard value of 1.25 feet was adopted for use in determining channel capacity. This value is one-half the standard used to design trapezoidal channels and, if exceeded, it is considered to represent a 50-percent chance of levee failure by overtopping. The freeboard value was applied to either the top of the revetment on the channel sides or to the general ground elevation outside the levee, whichever was higher. For most of the study reach, the upper portion of the channel levee is unprotected. Based on computations involving both permissible tractive force and maximum permissible velocity, it was assumed that the unprotected portion of the levee would erode when exposed to long-duration flows such as would occur during the 1-percent annual chance flood.

Roughness coefficients for the channel bottom were determined by an analysis of the predicted bed form. The values obtained for the channel bottom were combined with estimates for the revetment on the channel sides to obtain a composite value for the entire section. For the short stretch of river still unimproved (from near 17th Street to Garden Grove Freeway), the roughness coefficient was estimated using Cowan's Method. The resulting values ranged from 0.016 to 0.023 for the improved channel; a value of 0.030 was used for the natural channel. No refinement in values was made at bridges because the friction loss is negligible compared to pier losses and contraction and expansion losses.

The channel capacity was determined at all significant changes in conveyance and at all bridges. The capacities were determined using the HEC-2 computer program to compute a rating curve at each selected location based on a backwater analysis. Discharge values from 2,000 cfs to the peak 1-percent annual chance discharge of 50,000 cfs were used.

The result of the analysis indicate that the channel capacity ranges between 15,000 and 20,000 cfs from the San Diego Freeway to Garden Grove Boulevard; between 30,000 and 40,000 cfs from the San Diego Freeway to the Pacific Ocean; and between 40,000 and 50,000 cfs from Katella Avenue to the Santa Ana Freeway. The channel capacity is in excess of 50,000 cfs upstream of Katella Avenue.

3. Breakout Analysis

The location and magnitude of flows breaking out of the channel were determined using the results of the channel capacity analysis. It was assumed that the levee would fail at the water-surface elevation used to define the channel capacity and that the levee would erode sufficiently to allow all flow in excess of the capacity of the entrenched portion of the channel to break away from the river. Locations of breakouts that will result in damage during the 1-percent annual chance flood are listed in Table 10, "Santa Ana River Overflow Locations." In all cases, the floodplain slopes away from the channel, so that none of the excess flow will return to the river.

TABLE 10 – SANTA ANA RIVER OVERFLOW LOCATIONS

River Locations	1-Percent Annual Chance Discharge (cfs)	Breakout Direction
At Katella Avenue in City of Orange	5,000	Over West Bank
At Garden Grove Freeway (Upstream) in City of Garden Grove	19,000	Over West Bank
At Garden Grove Freeway (Downstream) in City of Garden Grove	1,000	Over Both Banks
At Santiago Creek in City of Santa Ana	4,000	Over East Bank
At Fairview Street in City of Santa Ana	3,000	Over West Bank
At Edinger Avenue in City of Santa Ana	3,000	Over Both Banks

4. Overflow Analysis

In general, a simplified overflow analysis was necessary because of the extremely large area involved; the complex flow patterns caused by several major obstructions; and the very dense development with a large number of streets available for conveyance.

The general approach used in the analysis was as follows:

a. Principal flow paths and major obstructions were identified using the results of the breakout analysis.

b. Hydraulic controls presented by the major obstructions were determined and the resulting flood depths upstream were computed. For example, rating curves were computed for weir flow over freeway embankments and flow at critical depth through constrictions presented by freeway underpasses.

c. The average inundation depth on the floodplain between major controls was determined by assuming normal depth, using gross cross sections obtained from USGS topographic maps (U.S. Department of the Interior, 1975, et cetera) and making allowances for obstructions presented by the dense development.

d. Allowance was made for interception of some of the flood by major local drainage channels and its loss as a result of peak attenuation of the flood wave caused by the large amount of storage available on the affected floodplain. The Modified Puls method of flood routing was used to estimate the peak attenuation of the overflow.

e. The block walls surrounding many areas in the floodplain were not designed to resist forces caused by ponding and will collapse before significant depths of flooding occur.

In computing the average flood depth between major obstructions, a base "n" value for flow in streets and between buildings was estimated at 0.1. To adjust for the obstruction caused by buildings, the following percentage reductions in effective flow width were estimated from aerial photographs of the subject area: for flow parallel to the general street direction, 50 percent; for flow perpendicular to the streets, 80 percent. The resulting adjusted values were determined to be 0.2 and 0.5, respectively.

The results of the analysis indicated that the 1-percent annual chance flood will inundate a large area from Katella Avenue to the Pacific Ocean. The average depth of inundation on the floodplain will be 3 feet, but localized depths in ponded areas or areas immediately upstream of major obstructions will range from 5 to 9 feet.

Profiles for the flow in the channel are provided only for completeness of the study. It should be emphasized that because the overflow is independent of the channel flow, the profiles should not be used to determine BFEs; instead, the FIRM (Exhibit 2) should be used for that purpose.

Alipaz Storm Drain was studied by approximate methods, and normal depth hand calculations were used to compute the elevations. The 1-percent annual chance flood is contained within the storm drain structures. The analysis indicated that the 1-percent annual chance flooding from San Juan Creek is more severe than the flooding from Alipaz Storm Drain.

On Anaheim-Barber City Channel, hand calculations indicated that the 1-percent annual chance flood flow is contained at all locations. Therefore, no further studies were undertaken.

Analysis of Agua Chinon Wash consisted of review of USACE hand calculations. Also, a weir analysis was made on the new center barrier along the Santa Ana Freeway. The analysis does not take into account the effect of basins constructed in the foothills.

A HEC-2 analysis provided both profiles for Atwood Channel. Hydraulic calculations were started at the confluence with Miller Retarding Basin, with storage capacity-discharge calculations used to determine the starting water-surface elevation. Between Miller Retarding Basin and Jefferson Street are areas of widespread 1-percent annual chance shallow flooding with flood depths from 1 to 3 feet. This reach of the channel is in the City of Anaheim and an unincorporated area of Orange County. Upstream of Jefferson Street, in the City of Placentia, the 1-percent annual chance flood discharge is confined to the valley adjacent to the channel.

For Bee Canyon Wash, the extent of shallow flooding was taken directly from a USACE Flood Plain Information report (USACE, 1972).

The 1-percent annual chance flood flow on Bitterbush Channel will be contained from the upstream corporate limits of the City of Orange to Sycamore Avenue. At the Sycamore Avenue crossing, hand calculations indicate that 260 cfs will escape the channel as a result of the constriction caused by the 12-foot by 6-foot culvert. The remainder of the channel will contain the 1-percent annual chance event, reduced by the overflow at Sycamore Avenue. No profiles have been plotted.

For Bluebird Canyon, the HEC-2 computer program was used to determine flood elevations from Glenneyre Street to 425 feet upstream of Cress Street. The 1-percent annual chance flood flow downstream of Glenneyre Street is contained within the existing storm drain. The flood limits for the reach, extending from the end of the HEC-2 computer program run to the study limits, were determined by approximate methods. The flow elevations were determined from normal-depth calculation, and the flood width was determined using contour maps (Toups Corporation, 1960; Orange County Flood Control District, 1959).

For Boat Canyon and Park Avenue Washes, the storm drain systems were analyzed by hand calculations; both contain the 1-percent annual chance flood.

Analyses of Bonita Creek consisted of two HEC-2 computer models (USACE, October 1973), one upstream and one downstream of Bonita Reservoir. The starting water-surface elevations upstream of the reservoir were determined by HEC-1 analysis (USACE, 1973). The small wooden farm bridge 1,000 feet upstream of MacArthur Boulevard was assumed to wash out, and the Coyote Canyon Road Bridge was assumed to have half its capacity plugged by debris and tree growth. Flow through the MacArthur Boulevard culvert was determined by hand calculations for the 0.2-percent annual chance flood flow because of the low accuracy obtained using the HEC-2 program for long culverts. The culvert flow, determined by hand calculations, was subtracted from the total. The remaining flow was used in the HEC-2 model with the culvert excluded.

It was found that Borrego Canyon Wash has 1-percent annual chance flood capacity. Because of the breakout at Astor Road, however, a large overbank flow continues downstream separate from the channel flow. The extent and depth of this shallow flooding was taken from a USACE report (USACE, 1977). The analysis does not take into account the effect of basins constructed in the foothills.

Hand calculations indicated that the 1-percent annual chance flood flow on Buckeye Storm Channel is contained from the upstream end to Shaffer Street. Downstream of Shaffer Street, the flow increases, exceeding the channel capacity. Approximately 400 cfs overflows between Shaffer Street and Orange-Olive Road. An additional 300 cfs escapes at Orange-Olive Road because of the small capacity of the conduits beneath the road. The entire overflow results in shallow flooding less than 1.0 foot deep; therefore, no profiles were plotted.

The Buena Park Storm Channel, a tributary of Fullerton Creek, was found to contain the 1-percent annual chance flood flow. Normal-depth calculations were performed in order to determine channel capacity.

Carbon Canyon Channel was studied from the Miller Retarding Basin to the Orange County limits at Brea. The HEC-2 program indicated that the 1-percent annual chance flood will overtop the channel in the vicinity of Miller Retarding Basin, resulting in shallow flooding less than 1 foot deep.

Hydraulic calculations were started at Miller Retarding Basin with storage capacity-discharge calculations to determine the starting water-surface elevations for the 10-, 2-, 1-, and 0.2-percent annual chance frequencies. The HEC-2 analysis was initiated at Miller Retarding Basin to reflect the changes in water-surface elevations resulting from the storage effect. The 1-percent annual chance flooding was found to be contained in the channel right-of-way from downstream of the City of Placentia to Chapman Avenue. The brick walls along both sides of the channel right-of-way were assumed to contain the 1-percent annual chance flood discharge without wall failure in this reach. The improved earth channel continues to a private road 500 feet upstream. The backwater effect from the Chapman Avenue culvert and a breakout upstream of the private road cause flooding west of the channel. Upstream of the private road the channel ends and a natural watercourse starts with heavy growth of trees and dense brush that cause flooding to be deep and widespread because of the increase in roughness coefficients. A HEC-2 analysis was continued upstream to Palm Drive, assuming the golf cart bridge in the Alta Vista Golf Course was destroyed in the flood.

The reach from Palm Drive to Carbon Canyon Dam was analyzed as supercritical flow and found to contain the 1-percent annual chance flood.

From the Carbon Canyon Flood Control Reservoir to the Orange County boundary, the stream is a natural watercourse with a poorly defined channel. Brush covers much of the invert as well as the sides of the canyon, with resulting high Manning's "n" values. The HEC-2 analysis indicated supercritical reaches at some locations along the channel. Because of erosive velocities and channel instability, critical depth was used at these locations.

On Carbon Canyon Diversion Channel, hand calculations indicated that the channel capacity just downstream of the Miller Retarding Basin is 3,770 cfs, compared to a peak 1-percent annual chance flood flow of 4,300 cfs. The excess is contained on the east side by a concrete block property wall, but it will flow to the west as shallow flooding less than 1 foot deep. Once this excess flow overtops the banks, it does not return to the channel. The channel can therefore adequately convey the remaining flow downstream from the breakout.

The HEC-2 program was used to determine flood elevations for Carbon Creek Channel. The program was run in the supercritical mode with normal depth as a starting water-surface elevation. The 1-percent annual chance flood is contained within the channel from Palm Avenue to upstream of Rose Drive.

Downstream of Glassell Street, hand calculations indicate that 340 cfs of the 1,900 cfs total flow on Collins Channel will overtop the channel banks, cause some shallow flooding, and then return to the channel just upstream of the SPRR tracks. Downstream of the confluence with Marlboro Channel, the increased flow exceeds the channel capacity, and approximately 700 cfs overtops the banks, resulting in shallow flooding less than 1 foot deep. Because banks are higher than the adjacent property, none of the overflow will return to the channel until after the peak flow has passed and the overflow reenters by way of the street drainage system.

Another breakout occurs between Katella and Struck Avenues. This is relatively small (200 cfs) and results in shallow flooding. Downstream from this point, the peak flow in the channel has been sufficiently reduced so that no further breakouts occur; therefore, no profiles were plotted. All calculations performed in analyzing this channel were done manually.

East Brea Channel, studied by approximate methods, was found to contain the 1-percent annual chance flood flow.

The capacity of East Garden Grove-Wintersburg Channel was checked at typical sections and at all crossings using normal-depth and energy equations. The channel was found to contain the 1-percent annual chance flood discharged at all points studied.

For East Richfield Channel, the HEC-2 program was used to determine flood elevations from the vicinity of Orangethorpe Avenue to Fairmont Boulevard. The reach consists of a small natural stream that passes through the Yorba Linda Golf Course from the City of Yorba Linda corporate limits to Brookmont Drive and then changes to a trapezoidal greenbelt channel to Fairmont Boulevard. The grading of the golf course is such that the overflow from the stream is channeled toward a box conduit beginning at the corporate boundary. The program was run in the subcritical mode using critical depth as the starting water-surface elevation.

The embankment for Imperial Highway acts as a dam reaching across the floodplain. A triple 6-foot by 4-foot box culvert and an 8-foot by 4-foot single box culvert, spaced approximately 80 feet apart, were designed to allow flow through the embankment. A 12-foot by 10-foot golf cart crossing 200 feet west of the triple box culvert is also effective in passing flow through the embankment. Because of spacing between the crossings, a normal bridge routine was used to model flow through the embankment for the 10-, 2-, and 1-percent annual chance floods. Weir flow over Imperial Highway during the 0.2-percent annual chance flood was modeled using a special bridge routine, with the three crossings modeled as one crossing of the same effective area. The rectangular box culvert that extends from the City of Anaheim corporate limits to Orangethorpe Avenue has the capacity to contain the 1-percent annual chance flood flow.

Hand calculations were used in analyzing flow through the underground storm drain from Fairmont Boulevard to Yorba Linda Boulevard. It was determined that the storm drain is capable of carrying the 1-percent annual chance flood with no overflow.

A series of normal-depth calculations were made for the greenbelt reach of channel upstream of Yorba Linda Boulevard. The 1-percent annual chance flood was determined to be contained in this reach.

For El Modena-Irvine Channel, a HEC-2 analysis was used along with a USACE Flood Plain Information report (USACE, 1969) and field investigation to determine the extent and depth of flooding on this channel. Extensive analysis was necessary to determine the extent of flow over the Santa Ana Freeway. This analysis consisted of normal-depth calculations, use of the HEC-1 computer program-weir flow analysis, and the use of another USACE Flood Plain Information report (USACE, June 1972).

The improved section of Esperanza Canyon consists of a concrete-lined channel designed to carry the 1-percent annual chance flood discharge. Normal-depth calculations verified that the 1-percent annual chance flow will be contained in the improved channel without overflow throughout its length.

Hand calculations show that the 1-percent annual chance flood on Fletcher Channel is contained at all points. Therefore, no further calculations were necessary, and no profiles were plotted.

On the upstream end of Greenville-Banning Channel, located in the City of Santa Ana, is a small, concrete-lined section with heavy bottom growth. At Dahl Lane, the crossing is insufficient to carry the 1-percent annual chance flood. A measured flow of 130 cfs overtops the road creating shallow flooding of less than 1 foot deep. Downstream of Edinger Avenue, the channel is larger, but without concrete lining. Hand calculations indicated that it is adequate to convey the remaining 1-percent annual chance flood at all points.

For Imperial Channel, the HEC-2 program was used for the entire reach, with starting water-surface elevations taken from its confluence with Coyote Creek Channel. The channel was found to contain the 1-percent annual chance flood discharge except for a small area at the Imperial Highway crossing where excessive debris downstream of the culvert causes shallow flooding. Flooding in this area is generally less than 1 foot deep.

La Colina-Redhill Storm Channel, a tributary of the El Modena-Irvine Channel, was evaluated using the HEC-2 program and was found to contain the 1-percent annual chance flood.

For Laguna Canyon, significant channel improvements in the area of Forest Street required a new HEC-2 model of the channel from the mouth to 0.56 mile above the mouth. The complex geometry of the channel and the length of the enclosed conduits required the use of hand calculations to supplement the HEC-2 model. Two reaches of the channel, one at Forest Street and the other from Beach Street to Pacific Coast Highway, are closed conduits of approximately 150 and 800 feet in length, respectively. The procedure followed for both conduits was to calculate the discharges through the conduits as a function of elevation difference upstream and downstream to the conduit. A HEC-2 model was used to determine the characteristic of overland surface flow above the conduit. A series of computer runs was made to balance the elevation difference upstream and downstream of the conduit with the calculated discharge through the conduit.

Loftus Diversion Channel was found to have 1-percent annual chance capacity upstream of the Associated Road crossing. Breakout of the 1-percent annual chance flood occurs downstream of Associated Road but does not affect any structures. This flooding is limited to the channel right-of-way and an adjacent greenbelt area. The hydraulic analysis was started at the channel mouth at Fullerton Flood-Control Reservoir.

Flood elevations for Los Alamitos Channel located in the Cities of Seal Beach and Los Alamitos were estimated by approximate methods. The Los Alamitos Channel and retarding basin have the capacity to contain the 1-percent annual chance flood.

Hand calculations revealed that the 1-percent annual chance flood flow on Marlboro Channel is contained at all points. Therefore, no detailed calculations were necessary, and no profiles were plotted.

Memory Garden Channel is hydraulically steep. Where the HEC-2 analysis indicated supercritical flow, critical depth was used. The underground RCB and trapezoidal earth channel reaches were found to have 1-percent annual chance flood capacity. The greenbelt channel reach contains the 1-percent annual chance flooding width to less than 200 feet. The hydraulic analysis for Memory Garden Channel was begun at the confluence with Brea Canyon Channel.

On Niguel Storm Drain, the inadequate trash rack inlet near Mirador Court and the El Niguel Country Club was analyzed for its capacity by trial-and-error calculation of static head and energy losses. Drop structures and the open swale were analyzed using the HEC-2 computer program.

North Tustin Channel was evaluated using the HEC-2 program and was found to contain the 1-percent annual chance flood.

For Lake Mission Viejo and Oso Creek Basin, at the upstream end of Oso Creek, the approximate 1-percent annual chance flood elevations of 702.3 and 731.0 feet, respectively, were determined from high-water marks.

On Peters Canyon Wash, the Navy Way bridge and the OCTA Metrolink bridge will carry less than the 2-percent annual chance flood. This creates ponding problems, which were analyzed using the HEC-1 computer program to determine the extent of ponding and channel breakout. Downstream from the Navy Way bridge, Peters Canyon Wash has 1-percent annual chance flood capacity. The undersized bridge, however, causes a breakout that continues southwest through the Marine Corps Air Facility and is picked up by Barranca Channel. The Santa

Ana Freeway bridge is also undersized, which restricts the flow and causes extensive ponding behind the freeway. The addition of a 3-foot-high center barrier on the Santa Ana Freeway changes the flood breakout pattern from that shown in the 1972 USACE Flood Plain Information report (USACE, 1972).

Richfield Channel is a concrete-lined channel throughout its improved reaches. Since the design capacity of the channel and the 1-percent annual chance flood discharges are approximately the same values, a series of normal-depth calculations was used to determine if breakout would occur anywhere throughout the improved reaches. Calculations made at all bridge crossings, transitions, and control points indicated flow elevations well below the top of the channel. The 1-percent annual chance flood will be contained from the City of Yorba Linda corporate limits to Imperial Highway. The 1-percent annual chance flood is also contained through the reach in the City of Placentia.

For Reservoir Canyon, normal-depth analysis was used to compute elevations. Upstream of I-5, the 1-percent annual chance flood depth is approximately 1 to 2 feet. Downstream of I-5, the 1-percent annual chance flood flow is contained within the storm drain structures.

San Diego Creek has 1-percent annual chance flood capacity from its confluence with Upper Newport Bay to approximately 500 feet upstream from Jeffrey Road. The remainder of the reach studied was modeled using data developed for the 1972 USACE Flood Plain Information report (USACE, 1972). These data were altered immediately upstream of the San Diego Freeway because of an approximately 2,000-foot reach that has been improved. A small breakout occurs at Harvard Avenue that leaves the channel and flows westerly to reenter the channel downstream. This flow was analyzed with the use of normal-depth calculations taken from field investigation and topographic maps (The Irvine Company, 1960; Toups Corporation, April 1977).

Data on the San Gabriel River and channel capacities were furnished by the USACE and the OCFCD. A profile was developed by the USACE as part of the General Design Memorandum for construction of a channel and levee system. Since work has been completed, 0.2-percent annual chance and lesser floods have been controlled.

San Joaquin Channel has 1-percent annual chance flood capacity from its confluence with San Diego Creek to Main Street and upstream from Culver Drive. The reach between Main Street and Culver Drive was analyzed using the HEC-2 computer model and hand calculations.

It was determined that the Santa Ana-Delhi Channel, located in the City of Costa Mesa, cannot contain the 1-percent annual chance flood.

On Santa Ana Gardens Channel, located in the Cities of Santa Ana and Costa Mesa, from the upstream end at McFadden Avenue to downstream of Alton Avenue, the channel is a graded earth section. Hand calculations demonstrated that minor amounts of flow (less than 150 cfs) escape from this reach at different points, but reenter downstream, where the channel capacity increases. The resulting overflow creates shallow flooding of less than 1 foot. Downstream of Alton Avenue, the channel is a reinforced-concrete section having a design discharge greater than the 1-percent annual chance flow.

For Santa Ana-Santa Fe Channel, the detailed study began at the ATSFRR, which parallels Moulton Parkway (Navy Way). A backwater condition exists upstream from this crossing caused by overflow from Peters Canyon Wash and El Modena-Irvine Channel. At this location, a BFE of 58 feet was determined by the USACE as reported in the Flood Plain Information report on San Diego Creek and Peters Canyon Wash (USACE, 1972). This BFE was used as the starting water-surface elevation for the 1-percent annual chance HEC-2 hydraulic analysis of Santa Ana-Santa Fe Channel.

On Santiago Creek, water-surface elevations for the 10-, 2-, 1-, and 0.2-percent annual chance floods were computed using the HEC-2 computer program. Computations were begun at the confluence with the Santa Ana River using water-surface elevations in the river immediately downstream from the confluence. These were derived by constructing a rating curve from elevations used in a Flood Plain Information report on Lower Santiago Creek (USACE, June 1973).

The 1-percent annual chance flood elevations at the mouth of Modjeska Canyon were computed by the OCEMA using study cross sections and discharges, but assuming washout of the north bank levee, based on an embankment stability study (Moore and Taber, 1977).

Segunda Deshecha Canada Tributary has minor flooding impact. The 1-percent annual chance discharge is contained by high canyon walls.

Serrano Creek was analyzed with the data developed for a 1974 USACE Flood Plain Information report (USACE, December 1974). The 1- and 0.2-percent annual chance flood limits and profiles were taken directly from the USACE report. The Standard Project Flood was found to have a recurrence interval of 500 years. The 10- and 2-percent annual chance profiles were determined with the use of the HEC-2 program. The two breakouts shown were determined to be shallow flooding.

For Tustin Channel, the design discharge was found to be greater than the 1-percent annual chance discharge determined for this study.

For Tijeras Canyon, the narrow floodplain was determined by an approximate normal-depth analysis.

Water-surface elevations for Tuffree Storm Drain and D-1 Channel, located in the City of Placentia, were determined by normal-depth analysis.

On Upper Santiago Creek, an approximate analysis was performed to establish the high-water surface on Villa Park Dam by estimating the backwater effect from the

1-percent annual chance flood discharge over the Villa Park Dam spillway. The flood elevations between the lakes on the creek were determined by normal-depth calculations.

Villa Park Storm Drain was studied by detailed hand calculations. The capacity of the arch conduit was calculated by reaches, using Manning's equation. Inlet flows were calculated along the storm drain alignment. Excess surface flows were routed, and breakouts determined, by use of normal depth and weir flow calculations, along with engineering judgment and extensive field review. The storm drain was found to flow full, with extensive overflow and breakout to the west during the base flood, in the reach upstream from Santiago Boulevard. The downstream portion was found to flow partly full, but, due to limited inlet capacity, resulted in major overflow to the west from Santiago Boulevard to Villa Park Road. The reach downstream from Villa Park Road was found to contain the remaining base flood flow.

A computer analysis was performed for Walnut Canyon Channel, tributary to the Santa Ana River, using the HEC-2 program. The analysis showed that the 1-percent annual chance flood is contained at all points.

Additional specific hydraulic information for streams in Orange County may be obtained from the previous FISs for the incorporated communities which were used in preparing this study (FEMA, December 1979; FEMA, 1980; FEMA, City of Costa Mesa, March 1982; FEMA, May 1982; FEMA, City of Garden Grove, March 1982; FEMA, August 1982; FEMA, City of La Habra, August 1979; FEMA, City of Placentia, August 1979; FEMA, 1985; FEMA, City of Westminster, March 1982; FEMA, 1981; U.S. Department of Housing and Urban Development, August 1978; U.S. Department of Housing and Urban Development, 1977; U.S. Department of Housing and Urban Development, January 1978; U.S. Department of Housing and Urban Development, March 1979; U.S. Department of Housing and Urban Development, March 1978; U.S. Department of Housing and Urban Development, City of Orange, June 1979; U.S. Department of Housing and Urban Development, City of San Clemente, June 1979; U.S. Department of Housing and Urban Development, City of San Juan Capistrano, March 1979; U.S. Department of Housing and Urban Development, City of Santa Ana, March 1979; U.S. Department of Housing and Urban Development, City of Tustin, March 1979; U.S. Department of Housing and Urban Development, City of Villa Park, June 1979).

3.3 Vertical Datum

All FISs and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum in use for newly created or revised FISs and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD 29). With the finalization of the North American Vertical Datum of 1988 (NAVD 88), many FIS reports and FIRMs are being prepared using NAVD 88 as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD 88. Structure and ground elevations in the community must, therefore, be referenced to NAVD 88. It is important to note that adjacent communities may be referenced to NAVD 88. This may result in differences in base flood elevations across the corporate limits between the communities.

For more information on NAVD 88, see Converting the National Flood Insurance Program to the North American Vertical Datum of 1988, FEMA Publication FIA-20/June 1992, or contact the Spatial Reference System Division, National Geodetic Survey, NOAA, Silver Spring Metro Center, 1315 East-West Highway, Silver Spring, Maryland 20910 (Internet address http://www.ngs.noaa.gov).

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS provides 1-percent annual chance floodplain data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent annual chance flood elevations; delineations of the 1- and 0.2-percent annual chance floodplains; and 1-percent annual chance floodway. This information is presented on the FIRM and in many components of the FIS, including Flood Profiles, Floodway Data tables, and Summary of Stillwater Elevation tables. Users should reference the data presented in the FIS as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent annual chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent annual chance flood is employed to indicate additional areas of flood risk in the community. For the stream studied in detail, the 1- and 0.2-percent annual chance floodplains have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at various scales and contour intervals (Raub, Bien, Frost & Associates, 1913; E. L. Pearson and Associates, 1969; VTN Consolidated, Inc., 1972; Williamson and Schmid, no date; Keith and Associates, 1970; Toups Engineering, Inc., 1969; Toups Engineering, Inc., 1971; VTN Consolidated, Inc., 1971; Toups Engineering, Inc., August 1973; Raub, Bien, Frost & Associates, 1971; Raub, Bien, Frost & Associates, 1973; Jennings-Halderman-Hood, 1973; Lowry Engineering-Science, 1969; Boyle Engineering Corporation, 1972; Boyle Engineering Corporation, 1973; Keith and Associates, 1974; Lampman and Associates, no date; VTN Consolidated, Inc., 1974; VTN Consolidated, Inc., August 1971; Raub, Bien, Frost & Associates, 1972; USACE, June 1973; Toups Corporation, 1960; Orange County Flood Control District, 1959; City of Laguna Beach, 1960; City of San Juan Capistrano, 1967; The Irvine Company, 1960; Toups Corporation, April 1977; Toups Corporation, 1972; City of San Clemente, no date; City of Brea, 1966; USACE, 1969; USACE, 1972; Raub, Bien, Frost & Associates, August

1972; Raub, Bien, Frost & Associates, Orange, California, 1972; E. L. Pearson and Associates, 1970).

The floodplain boundaries for the unincorporated areas of western Orange County were based on several approaches. Areas affected by potential failure of Santa Ana River levees were analyzed by correlation with the most recent USACE information. Other areas were studied by comparison of existing channel protection levels (per discussion with the OCEMA staff) to the 1-percent annual chance flood discharge. Master planned local drainage systems were field checked to verify existing facilities. In all situations above, judgment of topographic conditions by field inspection was an integral part of the study effort.

Several of the incorporated communities, such as the Cities of Anaheim, Buena Park, and Fullerton, are located on an alluvial plain with supplemental drainage provided by manmade channels. Because of these channels, the flood hazards are predominantly shallow in nature. Thus, the floodplain boundaries were determined by field investigations, in conjunction with computed breakout flow data and water-surface elevations. Barriers to sheet flow, such as railroad tracks and elevated or depressed roadways were the major factors considered in establishing floodplain boundaries.

Floodplain boundaries in the lower reaches of Canada Gobernadora were plotted from the master floodplain prepared by OCEMA (VTN Consolidated, Inc., August 1974). Due to the close correlation of discharge rates used for the report with those calculated for this study, the Laguna Canyon floodplain boundaries were obtained from the USACE Flood Plain Information report (USACE, 1969).

Floodplain boundaries for other approximate-study areas, except for the segment of Hicks Canyon adjacent to the City of Irvine, were determined by relating approximate flood elevations to available topographic mapping (Raub, Bien, Frost & Associates, 1913; E. L. Pearson and Associates, 1969; VTN Consolidated, Inc., 1972; Williamson and Schmid, no date; Keith and Associates, 1970; Toups Engineering, Inc., 1969; Toups Engineering, Inc., 1971; VTN Consolidated, Inc., 1971; Toups Engineering, Inc., August 1973; Raub, Bien, Frost & Associates, 1971; Raub, Bien, Frost & Associates, 1973; Jennings-Halderman-Hood, 1973; Lowry Engineering-Science, 1969; Boyle Engineering Corporation, 1972; Boyle Engineering Corporation, 1973; Keith and Associates, 1974; Lampman and Associates, no date; VTN Consolidated, Inc., 1974; VTN Consolidated, Inc., August 1971; U.S. Water Resources Council, 1967; USACE, June 1973; City of Brea, 1966; USACE, 1969; USACE, 1972).

The 1- and 0.2-percent annual chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent annual chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A and AE), and the 0.2-percent annual chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent annual chance floodplain boundaries are close together, only the 1-percent annual chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent annual chance floodplain boundary is shown on the FIRM (Exhibit 2).

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent annual chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent annual chance flood can be carried without substantial increases in flood heights. Minimum federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this FIS are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this FIS were computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain.

Unless otherwise described in this section, the floodways presented in this study were completed through a series of procedural steps that included:

1. Evaluation of equal conveyance reduction from each side of the floodplain.

2. Negotiation with agencies and coordination with local and regional agencies.

3. Review of existing hydraulic data.

4. Consideration of the topography and channel right-of-way.

Floodway encroachment policies of the OCEMA, which are more restrictive than Federal criteria, have been considered in determining location of encroachment boundaries. Accordingly, county guidelines do not allow encroachment where the mean stream velocity will be increased to above 10 feet per second (fps), except in shore segments. A maximum average water-surface rise of 1 foot is permitted where velocities do not exceed that amount.

A floodway is generally not appropriate in areas that produce hazardous velocities. In this study, floodway encroachment analysis was performed only for those watercourses with a mean stream velocity of 10 fps or less before encroachment. For those watercourses with mean velocities between 5 and 10 fps, encroachment will require protective works for bank stabilization. Velocities in excess of 10 fps before encroachment were generally considered hazardous, and no floodways were analyzed except where the floodplain contained a natural or manmade levee.

No floodways were developed for Coyote Canyon Wash, Hickey Canyon, Live Oak Canyon, Shady Canyon Wash, or upper reaches of Sand Canyon Wash and Veeh Creek Tributary 1 (San Diego Creek Tributary 1) because of the narrow flooding and hazardous velocities that exist. The 1-percent annual chance floodplain boundaries were adopted as the floodways for Coyote Canyon Wash, Shady Canyon Wash, and the upper reaches of Sand Canyon Wash and Veeh Creek Tributary 1 (San Diego Creek Tributary 1).

Except for some shallow flooding in the adjacent overbanks, for the El Modena-Irvine, Placentia Storm, Richfield, and Santa Ana-Santa Fe Channels, the 1-percent annual chance flooding is contained in the channel; therefore, the channel banks were adopted as the floodway. However, development along waterways is subject to approval from Orange County and to review by the OCEMA.

The OCBOS has adopted an ordinance based on the recommendations in a report entitled "Aliso Creek Forest to the Sea for Aliso Creek." These recommendations established the Aliso Creek floodplain as an environmental corridor upon which encroachment cannot be made; therefore, no floodway was computed.

No floodway was computed for Arroyo Trabuco because the canyon is a proposed environmental corridor.

No floodway was computed for Capistrano Beach Storm Channel because of its improved channel.

Along Facility No. J05, the master plan of the area proposes an underground facility, and encroachment, if any, would be minimal. Therefore, no floodway was computed.

No floodways were computed for Imperial Channel and La Mirada Creek because the 1-percent annual chance flood is contained within the channel.

No floodways were computed for San Diego Creek and Big Canyon within the City of Newport Beach because San Diego Creek flooding is confined within already constructed levees and the lower segments of Big Canyon are in a narrow, steep-walled canyon where a floodway would not be appropriate.

Because the Alameda Storm Channel is completely improved upstream of Hewes Avenue and the overbanks are fully developed, no additional encroachment on the watercourse is contemplated. Downstream of Hewes Avenue, the channel velocities are over 20 fps. Thus, any encroachment would increase these velocities. For these reasons, the floodway was set to coincide with the 30-foot channel right-of-way.

For Brea Canyon Channel, computed floodway boundaries are less than 100 feet apart, except for locations where backwater and weir flow conditions occur upstream of the Imperial Highway crossing.

Because of high flow velocities, the floodway in the upper portion of Carbon Canyon Channel can be considered to be coincident with the 1-percent annual chance floodplain boundary. Floodway and fringe areas are designated in the downstream portion of the canyon where velocities are lower and the flow cross section widens to several hundred feet. However, because development is precluded from the Carbon Canyon Dam and Regional Park, no floodway is shown within the park's boundaries.

For Coyote Creek Channel, the channel right-of-way is designated as the floodway because the 1-percent annual chance flood discharge is contained within the channel from the downstream La Habra corporate limits to the confluence with Imperial Channel. A floodway based on equal conveyance reduction was applied from the confluence was Imperial Channel to Lambert Road, the floodway was designated as the existing channel right-of-way. From Lambert Road to Palm Street the channel contains the 1-percent annual chance flood discharge; therefore, the channel right-of-way was designated as the floodway. Upstream of La Habra Boulevard, houses border both sides of the channel. A floodway based on equal conveyance reduction was determined but yielded unacceptable results. Therefore, the floodway was determined by trial considering the topography.

Downstream of Ortega Highway, Horno Creek flows in a channel designed to contain the 1-percent annual chance flood. The improved channel was adopted as the floodway. From I-5 upstream to Ortega Highway, Horno Creek flows in a line channel. The channel banks were adopted as the floodway. The floodway for all portions of Horno Creek was computed by equal conveyance reduction.

For Laguna Canyon, a floodway based on equal conveyance reduction was determined, but yielded unacceptable high velocities for some sections; therefore, the floodway was determined by trial considering the natural topography. Because of high velocities and the narrowness of the canyon, the 1-percent annual chance floodplain boundaries were adopted as floodway boundaries through the middle and downstream sections of the canyon. In the lower, highly developed section of Laguna Canyon, additional development would produce an unacceptable rise in flood elevations; therefore, the 1-percent annual chance floodplain boundaries were adopted as the floodway boundary.

For Loftus Diversion channel, the floodway was found to be within the existing channel right-of-way.

On Memory Garden Storm Channel, the 1-percent annual chance flow is a critical depth with high flow velocities along the entire study reach. Consequently, the floodway was set equal to the 1-percent annual chance floodplain boundary.

Along Oso Creek, a floodway was computed for those unimproved portions downstream of I-5; excessive velocities existed upstream of I-5, making a floodway designation inappropriate.

For Prima Deshecha Canada, upstream of Calle Grande Vista, a floodway was computed based on equal conveyance reduction. The 1-percent annual chance flood discharge is contained in a channel from Calle Grande Vista to the Pacific Ocean. Therefore, the channel banks were adopted as the floodway. The delineated floodway through this reach has a maximum width of 35 feet in its open-channel portions and a minimum width of 35 feet in its open-channel portions and a minimum width of 20 feet in its box culvert portions. Upstream of Cross Section Q, the 1-percent annual chance floodplain boundary was adopted as the floodway. Delineation of a floodway upstream of Cross Section Q is not appropriate because of the steep overbanks and high velocities in this area.

San Juan Creek has been improved with levees from the downstream corporate limits of the City of San Juan Capistrano to I-5. The channel banks or levee tops were adopted as the floodway. The delineated floodway in this reach ranges in width from approximately 200 feet to 280 feet wide.

The floodways presented for the Santa Ana River were developed by initially assuming that the floodway is contained within the river levees. The results of hydraulic analysis indicated that some modifications were required to achieve velocities and water-surface elevations consistent with the criteria established for equal-conveyance reduction floodways in Orange County. However, these modifications were only necessary in two areas. The area between the levees is shown as the floodway for most of the river.

From River Mile (RM) 7.50 to Prospect Street (RM 5.56), Santiago Creek flows through a series of sand and gravel excavations. Throughout this reach, the 1-percent annual chance floodplain boundaries were adopted as the floodway, with the exception of some ineffective flow areas.

For the Segunda Deshecha Canada, from Avenida Pico to the ocean, the 1-percent annual chance capacity, lined channel was adopted as the floodway. The delineated floodway in this reach has a maximum width of 40 feet in the trapezoidal channel portions and a minimum width of 20 feet in the box culvert portions.

For the Segunda Deshecha Canada Tributary, the 1-percent annual chance capacity lined channel was also adopted as the floodway.

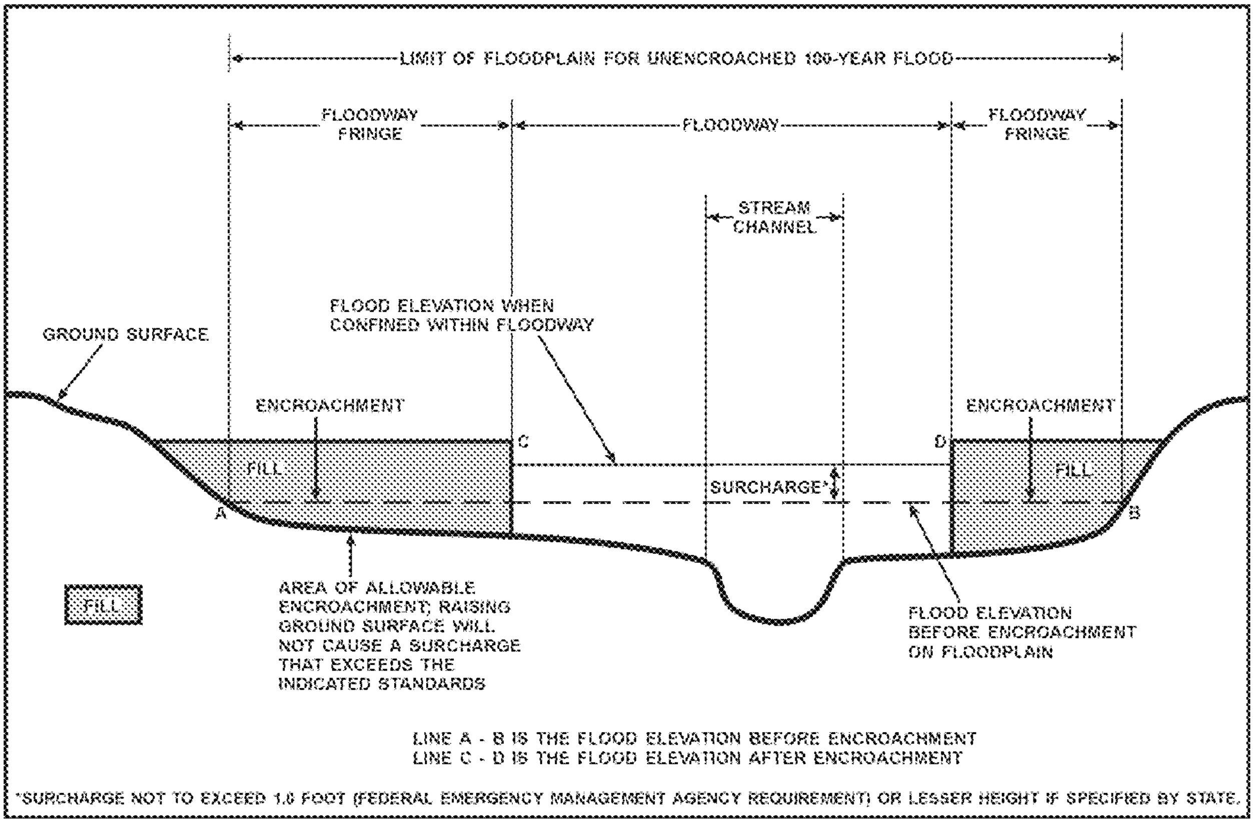
The floodway on Serrano Creek between I-5 and the OCTA Metrolink was computed by hand calculations.

Trabuco Creek, from the confluence with San Juan Creek to 2,000 feet upstream of Del Obispo Street, is contained in a 1-percent annual chance capacity lined levee. The top of levee was adopted as the floodway boundary. Where the channel had 1-percent annual chance flood conveyance capacity upstream of Del Obispo Street, the banks of the channel were adopted as the floodway boundaries.

Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (Table 11). The computed floodways are shown on the FIRM (Exhibit 2). In cases where the floodway and 1-percent annual chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

Encroachment into areas subject to inundation by floodwaters having hazardous velocities aggravates the risk of flood damage, and heightens potential flood hazards by further increasing velocities. A listing of stream velocities at selected cross sections is provided in Table 11, "Floodway Data." In order to reduce the risk of property damage in areas where the stream velocities are high, the community may wish to restrict development in areas outside the floodway.

The area between the floodway and 1-percent annual chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 1-percent annual chance flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1.



FLOODWAY SCHEMATIC Figure 1

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Aliso Creek								
A	74,991	81	673	4.5	616.4	616.4	616.4	0.0
B	75,266	58	252	11.9	619.1	619.1	619.1	0.0
C	75,515	65	309	9.7	621.6	621.6	621.6	0.0
D	75,863	52	243	12.3	626.9	626.9	626.9	0.0
E	76,080	45	232	12.9	631.4	631.4	631.4	0.0
F	76,296	68	316	9.5	635.9	635.9	635.9	0.0
G	76,507	51	304	9.9	638.1	638.1	638.1	0.0
H	76,676	50	340	8.8	639.8	639.8	639.8	0.0
I	76,787	91	496	6.1	641.3	641.3	641.3	0.0
J	76,940	81	313	9.6	641.7	641.7	641.7	0.0
K	77,109	58	252	11.9	644.7	644.7	644.7	0.0
L	77,268	82	479	6.3	649.1	649.1	649.1	0.0
M	77,495	63	339	8.8	650.8	650.8	650.8	0.0
N	77,843	66	347	8.6	655.4	655.4	655.4	0.0
O	77,975	73	369	8.1	657.3	657.3	657.3	0.0
P	78,287	35	213	14.1	664.8	664.8	664.8	0.0
Q	78,503	54	318	9.4	668.8	668.8	669.3	0.5
R	78,815	114	529	5.7	671.9	671.9	672.0	0.1
S	79,142	53	282	10.6	677.7	677.7	677.7	0.0
T	79,538	88	430	7.0	681.4	681.4	681.5	0.1
U	80,003	67	448	6.7	686.4	686.4	686.5	0.1
V	80,098	60	254	11.8	686.3	686.3	686.3	0.0
W	80,499	88	318	9.4	695.0	695.0	695.0	0.0
X	80,668	70	270	11.1	698.9	698.9	699.1	0.2
Y	81,043	84	282	10.6	702.9	702.9	702.9	0.0
Z	81,291	60	278	10.8	705.7	705.7	705.9	0.2

[1] Feet above mouth at Pacific Ocean

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

ALISO CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Aliso Creek (continued)								
AA	81,492[1]	69	394	7.6	708.7	708.7	708.8	0.1
AB	81,851[1]	115	413	7.3	710.7	710.7	711.0	0.3
AC	82,273[1]	130	574	4.5	711.9	711.9	712.0	0.1
AD	82,352[1]	246	652	4.0	712.4	712.4	712.9	0.5
AE	82,452[1]	66	240	10.8	715.1	715.1	715.1	0.0
AF	83,181[1]	68	262	9.9	728.2	728.2	728.2	0.0
AG	83,413[1]	66	239	10.9	737.8	737.8	737.8	0.0
AH	83,582[1]	108	411	6.3	741.4	741.4	741.4	0.0
AI	83,831[1]	69	243	10.7	744.0	744.0	744.0	0.0
AJ	84,132[1]	84	329	7.9	748.4	748.4	748.7	0.3
AK	85,177[1]	50	207	11.6	765.3	765.3	765.3	0.0
AL	86,275[1]	119	321	7.5	783.0	783.0	783.3	0.3
AM	83,476[1]	155	304	7.9	786.9	786.9	786.9	0.0
Atwood Channel								
A	5,100[2]	73	320	7.2	243.4	243.4	243.4	0.0
B	5,950[2]	85	482	4.8	246.5	246.5	246.5	0.0
C	6,450[2]	85	432	5.3	246.5	246.5	246.6	0.1
D	7,061[2]	115	497	4.6	246.9	246.9	247.4	0.5

[1] Feet above mouth at Pacific Ocean

[2] Feet above confluence with Miller Retarding Basin (Carbon Canyon Channel)

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

ALISO CREEK – ATWOOD CHANNEL

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Bluebird Canyon								
A	783	44	426	2.7	62.4	62.4	62.4	0.0
B	1,054	50	161	7.2	62.9	62.9	62.9	0.0
C	1,166	22	100	11.5	65.2	65.2	65.4	0.2
D	1,558	39	123	8.6	75.8	75.8	75.8	0.0
E	1,912	44	299	3.5	85.1	85.1	85.1	0.0
F	1,912	30	55	7.6	107.6	107.6	107.9	0.3
G	2,111	30	55	7.6	116.9	116.9	117.4	0.5
H	2,376	53	66	6.3	120.7	120.7	121.3	0.6
I	2,439	40	60	7.0	123.0	123.0	123.5	0.5
J	2,439	85	869	1.2	123.4	123.4	124.3	0.9
K	2,923	18	97	10.9	123.5	123.5	123.6	0.1

[1] Feet above confluence with Pacific Ocean

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

BLUEBIRD CANYON

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Bonita Creek								
A	3,150[1]	22	212	17.7	40.1	40.1	40.1	0.0
B	3,850[1]	52	283	13.3	45.3	45.3	45.3	0.0
C	4,550[1]	316	573	6.5	54.4	54.4	54.7	0.3
D	5,120[1]	440	670	4.6	61.4	61.4	61.4	0.0
E	5,720[1]	165	404	7.2	65.6	65.6	66.3	0.7
F	6,670[1]	116	339	8.6	79.5	79.5	80.0	0.5
G	7,590[1]	67	264	10.8	85.5	85.5	85.5	0.0
H	8,420[1]	87	269	3.2	92.9	92.9	92.9	0.0
I	11,200[1]	42	124	9.7	160.1	160.1	160.1	0.0
Brea Canyon Channel								
A	400[2]	100	1,080	7.3	302.6	302.6	302.6	0.0
B	1,980[2]	86	800	9.8	312.3	312.3	312.3	0.0
C	3,900[2]	86	796	9.9	324.1	324.1	324.1	0.0
D	4,915[2]	60	781	10.1	327.5	327.5	327.7	0.2
E	5,970[2]	80	617	12.6	332.0	332.0	332.0	0.0
F	7,005[2]	50	652	12.0	343.8	343.8	343.8	0.0
G	8,735[2]	60	698	10.3	356.4	356.4	357.0	0.6
H	10,215[2]	56	550	13.0	364.5	364.5	365.4	0.9
I	12,535[2]	60	580	12.0	380.3	380.3	381.2	0.9

[1] Feet above confluence with San Diego Creek

[2] Feet above mouth (at Brea Flood-Control Reservoir)

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

BONITA CREEK – BREA CANYON CHANNEL

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Carbon Canyon Channel								
A	1,933[1]	55	447	7.4	248.3	248.3	248.3	0.0
B	2,522[1]	160	1,092	3.0	250.3	250.3	251.1	0.8
C	2,918[1]	86	673	4.9	253.4	253.4	254.0	0.6
D	3,938[1]	51	354	9.3	259.5	259.5	260.5	1.0
E	4,938[1]	62	300	9.0	265.2	265.2	265.5	0.3
F	5,188[1]	148	490	5.5	268.4	268.4	269.4	1.0
G	5,758[1]	140	495	5.5	272.2	272.2	272.2	0.0
H	6,518[1]	66	243	11.1	275.8	275.8	276.5	0.7
I	6,918[1]	159	367	7.3	280.6	280.6	281.0	0.4
J	28,280[2]	100	570	7.4	499.5	499.5	499.7	0.2
Carbon Creek Channel								
A	65,356[3]	40	293	6.8	207.5	207.5	207.5	0.0
B	66,283[3]	40	293	6.8	208.5	208.5	209.5	1.0
Cascadita Creek								
A	605[4]	7	65	14.6	31.7	31.7	32.7	1.0
B	750[4]	7	53	15.7	34.2	34.2	34.2	0.0
C	895[4]	90	432	2.2	42.9	42.9	43.6	0.7
D	1,165[4]	28	88	10.7	43.2	43.2	43.7	0.5
E	1,665[4]	29	112	8.5	51.3	51.3	52.1	0.8
F	2,160[4]	30	148	6.4	63.7	63.7	63.7	0.0
G	2,660[4]	47	328	2.9	66.1	66.1	66.2	0.1
H	2,900[4]	26	91	10.4	74.1	74.1	74.5	0.4
I	3,140[4]	38	198	4.8	78.2	78.2	79.0	0.8
J	3,320[4]	16	99	9.6	79.3	79.3	80.2	0.9

[1] Feet above confluence with Miller Retarding Basin

[2] Feet above confluence with Carbon Creek Channel (Miller Retarding Basin)

[3] Feet above confluence with Coyote Creek Channel

[4] Feet above confluence with Prima Deshecha Canada

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

CARBON CANYON CHANNEL – CARBON CREEK CHANNEL –
CASCADITA CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Coyote Canyon Wash								
A	800[1]	84	210	6.2	155.3	155.3	155.3	0.0
B	1,300[1]	94	281	4.6	172.8	172.8	172.8	0.0
C	1,980[1]	48	154	8.4	179.6	179.6	179.6	0.0
D	2,380[1]	52	227	5.7	185.4	185.4	185.4	0.0
E	2,990[1]	23	106	12.3	198.8	198.8	198.8	0.0
F	3,770[1]	20	101	12.8	209.1	209.1	209.1	0.0
Coyote Creek Channel								
A	64,770[2]	72	558	8.6	226.4	226.4	226.4	0.0
B	65,220[2]	104	1,014	4.7	229.1	229.1	229.5	0.4
C	65,440[2]	92	872	5.5	229.4	229.4	229.9	0.5
D	66,520[2]	43	423	11.3	237.4	237.4	237.9	0.5
East Richfield Channel								
A	3,783[3]	178	378	6.3	309.3	309.3	310.0	0.7
B	4,060[3]	250	373	6.4	312.3	312.3	312.5	0.2
C	4,450[3]	249	822	2.9	323.9	323.9	323.9	0.0
D	4,790[3]	121	277	8.7	326.5	326.5	326.6	0.1
E	5,240[3]	114	268	9.0	338.8	338.8	338.8	0.0
F	5,790[3]	82	619	3.9	349.0	349.0	349.4	0.4

[1] Feet above confluence with Bonita Creek
[2] Feet above confluence with San Gabriel River
[3] Feet above confluence with Santa Ana River

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

COYOTE CANYON WASH – COYOTE CREEK CHANNEL – EAST RICHFIELD CHANNEL

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Handy Creek								
A	0.459	25	377	6.4	403.0	403.0	404.0	1.0
B	0.484	90	266	9.0	407.2	407.2	407.2	0.0
C	0.518	69	230	10.4	411.8	411.8	411.8	0.0
D	0.543	99	338	7.1	413.4	413.4	414.2	0.8
E	0.592	34	191	12.6	417.4	417.4	417.7	0.3
F	0.651	91	457	5.3	421.0	421.0	421.9	0.9
G	0.742	76	264	9.1	426.8	426.8	427.2	0.4
H	0.819	157	694	3.5	435.5	435.5	436.2	0.7
I	0.910	168	747	3.2	435.8	435.8	436.8	1.0
J	0.981	95	299	8.0	439.3	439.3	439.6	0.3
K	1.082	123	649	3.7	445.9	445.9	446.9	1.0
L	1.132	51	265	9.1	446.3	446.3	446.9	0.6
M	1.206	116	439	5.5	449.2	449.2	450.0	0.8
N	1.245	70	268	9.0	452.8	452.8	452.8	0.0
O	1.322	95	383	6.3	456.1	456.1	456.5	0.4
P	1.413	35	188	12.8	460.3	460.3	460.3	0.0
Q	1.494	45	200	12.0	467.6	467.6	467.6	0.0
R	1.573	185	644	3.7	474.8	474.8	475.7	0.9
S	1.611	68	252	9.5	476.4	476.4	476.4	0.0
T	1.778	72	230	10.4	482.4	482.4	482.4	0.0
U	1.913	99	295	8.1	489.4	489.4	489.4	0.0
V	2.091	39	146	11.0	498.3	498.3	498.3	0.0
W	2.180	85	418	3.8	507.3	507.3	507.3	0.0
X	2.270	220	839	1.9	510.1	510.1	510.1	0.0

[1] Miles above confluence with Santiago Creek

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

HANDY CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Horno Creek								
A	3,010	135	225	7.6	123.0	123.0	123.7	0.7
B	3,590	231	282	6.0	132.6	132.6	133.2	0.6
C	4,330	115	1,099	1.5	145.8	145.8	145.9	0.1
D	5,174	156	1,003	1.7	147.0	147.0	147.0	0.0
E	6,230	67	187	9.1	156.6	156.6	156.6	0.0
F	7,234	41	501	3.4	173.4	173.4	173.4	0.0
G	7,709	99	399	4.3	175.0	175.0	175.0	0.0
H	8,184	50	308	5.5	177.0	177.0	177.1	0.1
I	8,395	61	686	2.5	186.9	186.9	186.9	0.0
J	8,659	68	369	4.6	186.9	186.9	186.9	0.0
K	11,088	68	585	2.9	206.0	206.0	205.9	0.0
L	12,197	63	364	4.7	208.1	208.1	208.2	0.1

[1] Feet above confluence with San Juan Creek

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

HORNO CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Laguna Canyon								
A	929	183	1,223	7.4	19.3	19.3	19.6	0.3
B	1,039	206	1,081	8.0	20.1	20.1	20.1	0.0
C	1,105	160	897	8.2	20.7	20.7	21.0	0.3
D	1,332	130	840	8.4	24.4	24.4	25.3	0.9
E	1,433	169	406	7.7	26.0	26.0	26.6	0.6
F	1,754	164	401	7.7	31.5	31.5	31.9	0.4
G	1,888	100	552	9.1	33.4	33.4	33.8	0.4
H	1,976	220	623	3.9	34.3	34.3	35.2	0.9
I	2,045	175	322	7.6	35.1	35.1	35.5	0.4
J	2,097	145	301	8.1	36.2	36.2	36.3	0.1
K	2,549	85	244	9.7	43.4	43.4	43.5	0.1
L	2,875	66	226	10.5	48.0	48.0	48.3	0.3
M	3,468	75	238	10.0	55.1	55.1	55.8	0.7
N	3,515	85	247	9.6	55.5	55.5	56.3	0.8
O	3,537	85	317	7.5	56.2	56.2	57.1	0.9
P	3,814	98	259	9.2	58.8	58.4	59.2	0.8
Q	4,673	124	285	8.3	70.4	70.4	71.3	0.9
R	4,715	124	278	8.5	71.4	71.4	72.2	0.8
S	4,996	124	328	7.2	74.1	74.1	74.6	0.5
T	5,291	129	288	8.2	79.5	79.5	80.5	1.0
U	5,331	123	271	7.7	79.9	79.9	80.9	1.0
V	5,446	145	322	6.5	82.1	82.1	83.1	1.0
W	6,000	81	429	9.0	87.3	87.3	87.6	0.3
X	6,350	115	256	8.1	91.2	91.2	91.4	0.2
Y	6,713	108	228	8.0	96.6	96.6	96.8	0.2
Z	6,916	149	397	6.3	100.4	100.4	100.4	0.0

[1] Feet above confluence with the Pacific Ocean

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

LAGUNA CANYON

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Laguna Canyon (continued)								
AA	7,366	44	1126	11.1	107.9	107.9	107.9	0.0
AB	7,580	70	1286	5.6	109.4	109.4	110.4	1.0
AC	7,905	65	813	9.7	110.0	110.0	111.0	1.0
AD	8,407	95	538	7.7	117.0	117.0	118.0	1.0
AE	8,437	82	524	9.0	117.0	117.0	118.0	1.0
AF	8,730	125	293	7.3	120.1	120.1	120.3	0.2
AG	8,745	77	214	9.2	120.5	120.5	120.5	0.0
AH	8,762	58	196	10.0	120.5	120.5	121.5	1.0
AI	9,065	26	174	11.2	126.8	126.8	127.0	0.2
AJ	9,116	25	232	7.1	129.8	129.8	129.9	0.1
AK	9,241	25	137	12.1	130.2	130.2	130.2	0.0
AL	9,327	23	139	11.9	132.7	132.7	132.7	0.0
AM	9,509	38	192	8.6	135.6	135.6	135.8	0.2
AN	9,670	45	348	4.8	136.2	136.2	136.9	0.7
AO	10,060	53	154	6.2	136.3	136.3	137.0	0.7
AP	13,100	65	123	7.8	161.3	161.3	161.6	0.3
AQ	13,703	53	115	8.3	175.2	175.2	175.5	0.3
AR	13,817	49	239	12.6	175.3	175.3	175.3	0.0
AS	13,875	195	423	7.1	177.4	177.4	177.4	0.0
AT	13,935	160	404	7.4	177.8	177.8	177.8	0.0
AU	14,167	82	289	10.4	179.7	179.7	179.9	0.2
AV	14,608	53	260	11.5	182.6	182.6	182.8	0.2
AW	14,677	110	337	8.9	185.2	185.2	185.2	0.0
AX	14,798	76	306	9.8	186.4	186.4	186.4	0.0
AY	15,026	39	253	11.8	191.1	191.1	191.4	0.3

[1] Feet above confluence with Pacific Ocean

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

LAGUNA CANYON

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Laguna Canyon (continued)								
AZ	15,147	74	291	10.3	193.4	193.4	194.0	0.6
BA	15,441	59	266	11.7	197.0	197.0	197.2	0.2
BB	15,788	57	548	11.7	202.6	202.6	202.6	0.0
BC	15,974	57	588	9.4	204.5	204.5	205.5	1.0
BD	16,282	73	600	10.2	211.3	211.3	211.4	0.1
BE	16,484	110	454	8.2	213.6	213.6	213.8	0.2
BF	16,837	164	353	8.5	218.9	218.9	219.5	0.6
BG	17,065	86	363	8.3	220.1	220.1	220.7	0.6
BH	17,168	75	356	8.4	220.7	220.7	221.4	0.7
BI	17,315	161	810	3.7	221.8	221.8	222.8	1.0
BJ	17,581	148	480	6.3	222.2	222.2	223.1	0.9
BK	17,705	171	618	4.9	224.1	224.1	225.0	0.9
BL	18,154	150	385	7.8	229.1	229.1	229.6	0.5
BM	18,471	184	342	7.5	232.7	232.7	233.6	0.9
BN	18,505	203	346	7.4	234.3	234.3	235.2	0.9
BO	18,664	187	402	6.4	237.2	237.2	238.2	1.0
BP	18,841	140	328	7.9	239.5	239.5	240.5	1.0
BQ	18,913	182	398	6.5	240.7	240.7	241.7	1.0
BR	19,300	111	430	6.0	246.8	246.8	247.0	0.2
BS	19,426	114	309	8.3	247.0	247.0	247.4	0.4
BT	19,566	164	531	4.9	248.7	248.7	249.6	0.9
BU	19,933	138	339	7.6	250.2	250.2	250.8	0.6
BV	20,534	101	303	4.5	257.0	257.0	258.0	1.0
BW	20,700	68	195	7.0	258.9	258.9	259.5	0.6
BX	20,920	58	270	5.1	263.6	263.6	264.1	0.5

[1] Feet above confluence with Pacific Ocean

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

LAGUNA CANYON

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Laguna Canyon (continued)								
BY	21,803	57	307	4.5	264.7	264.7	265.4	0.7
BZ	21,336	52	160	8.6	267.4	267.4	268.1	0.7
CA	21,498	56	283	4.8	271.0	271.0	271.9	0.9
CB	21,537	40	243	5.6	271.8	271.8	272.6	0.8
CC	21,630	46	267	5.1	272.1	272.1	273.0	0.9
CD	21,891	49	397	3.5	283.7	283.7	283.7	0.0
CE	21,920	73	579	2.4	283.8	283.8	282.8	0.0
CF	22,566	87	292	4.7	290.7	290.7	290.7	0.0
CG	23,054	43	142	9.6	301.1	301.1	301.2	0.1
CH	23,177	90	149	7.0	304.6	304.6	304.6	0.0
CI	23,351	63	448	2.3	305.5	305.5	305.5	0.0
CJ	23,469	100	152	6.9	308.8	308.8	309.8	1.0
CK	23,654	50	119	8.8	311.3	311.3	312.1	0.8
CL	23,851	33	119	8.8	315.2	315.2	315.8	0.6
CM	24,560	45	186	5.6	327.0	327.0	328.0	1.0
CN	24,722	52	144	7.3	329.2	329.2	329.6	0.4
CO	24,873	87	287	3.7	330.2	330.2	330.8	0.6
CP	25,004	151	672	1.0	330.3	330.3	331.0	0.7
CQ	25,324	281	1115	0.6	330.4	330.4	331.1	0.7
CR	25,483	205	339	2.1	330.4	330.4	331.1	0.7
CS	25,541	85	114	6.1	331.0	331.0	331.7	0.7
CT	25,607	86	126	5.6	332.6	332.6	333.2	0.6
CU	25,842	61	172	4.1	336.1	336.1	337.1	1.0
CV	25,970	58	109	6.4	339.5	339.5	339.9	0.4
CW	26,210	60	206	3.4	344.3	344.3	345.3	1.0
CX	27,192	70	165	4.9	360.0	360.0	360.5	0.5

[1] Feet above confluence with Pacific Ocean

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

LAGUNA CANYON

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Loftus Diversion Channel								
A	1,992[1]	62	500	5.4	314.7	314.7	315.6	0.9
B	3,205[1]	42	290	6.5	330.2	330.2	330.2	0.0
Oso Creek								
A-R*								
S	3.698[2]	254	699	9.5	284.0	284.0	285.0	1.0
T	3.792[2]	180	868	6.8	289.5	289.5	290.3	0.8
U	3.887[2]	185	951	6.3	294.3	294.3	295.1	0.8
V	3.982[2]	210	1,141	5.9	297.6	297.6	298.6	1.0
Prima Deshecha Canada								
A[3]	0.40[4]	70	175	13.2	48.8	48.8	49.4	0.6
B[3]	0.57[4]	54	216	10.7	58.1	58.1	58.2	0.1
C[3]	0.66[4]	54	211	10.9	69.0	69.0	69.1	0.1
D[3]	0.76[4]	70	333	6.9	72.5	72.5	73.5	1.0
E[3]	0.88[4]	52	206	11.2	76.7	76.7	77.2	0.5
F[3]	0.94[4]	17	139	16.5	82.9	82.9	82.9	0.0
G[3]	0.99[4]	13	165	14.0	88.6	88.6	89.0	0.4
H	1.03[4]	60	713	3.2	93.4	93.4	93.5	0.1
I	1.30[4]	37	223	10.3	94.4	94.4	95.4	1.0
J	1.34[4]	15	713	3.2	105.8	105.8	105.8	0.0

[1] Feet above mouth (at Fullerton Flood-Control Reservoir)

[2] Miles above confluence with Trabuco Creek

[3] Floodway contained in improved channel

[4] Feet above confluence with Pacific Ocean

*Floodway not computed

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

LOFTUS DIVERSION CHANNEL – OSO CREEK –
PRIMA DESHECHA CANADA

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Sand Canyon Wash								
A	700	108	513	7.6	24.9	24.9	24.9	0.0
B	2,430	410	686	5.7	33.4	33.4	34.2	0.8
C	3,375	491	665	5.9	42.3	42.3	42.3	0.0
D	4,030	405	699	5.6	48.9	48.9	49.9	1.0
E	4,815	794	4,805	0.7	63.1	63.1	63.1	0.0
F	5,850	407	672	5.4	64.7	64.7	65.4	0.7
G	6,450	384	641	5.6	68.6	68.6	68.9	0.3
H	7,380	287	555	6.5	76.2	76.2	76.9	0.7
I	8,720	170	564	6.4	85.0	85.0	85.4	0.4
J	9,400	119	584	6.2	88.0	88.0	88.3	0.3
K	10,540	60	276	12.3	96.4	96.4	96.4	0.0
L	11,180	150	944	3.6	100.2	100.2	100.5	0.3
M	11,520	129	403	8.4	100.8	100.8	101.1	0.3
N	12,120	103	340	10.0	108.5	108.5	109.0	0.5
O	13,000	165	495	6.9	116.6	116.6	117.6	1.0
P	14,000	86	311	10.9	127.1	127.1	127.8	0.7
Q	15,000	99	435	7.8	136.2	136.2	137.2	1.0
R	15,750	78	332	10.2	141.9	141.9	142.6	0.7
S	16,490	124	362	9.4	168.0	168.0	168.9	0.9
T	21,500	40	256	14.5	206.5	206.5	206.5	0.0
U	22,740	34	144	11.8	224.2	224.2	224.2	0.0
V	25,960	73	186	5.4	259.5	259.5	260.1	0.6
W	26,480	124	148	6.8	267.9	267.9	267.9	0.0
X	27,340	47	152	6.6	276.1	276.1	276.2	0.1
Y	28,220	52	116	8.6	290.1	290.1	290.1	0.0
Z	29,200	31	99	10.1	310.7	310.7	310.7	0.0

[1] Feet above confluence with San Diego Creek

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

SAND CANYON WASH

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
San Diego Creek								
A	35,740	120	728	14.0	116.1	116.1	116.1	0.0
B	36,345	333	1,478	6.9	123.9	123.9	124.9	1.0
C	36,945	452	1,415	7.2	125.7	125.7	126.1	0.4
D	38,300	136	1,237	8.2	129.6	129.6	130.6	1.0
E	39,090	109	700	14.6	133.7	133.7	133.7	0.0
F	40,240	141	1,480	6.9	138.7	138.7	139.1	0.4
G	40,690	228	2,272	4.5	139.5	139.5	139.9	0.4
H	41,305	100	683	14.9	141.4	141.4	141.4	0.0
I	47,600	146	1,372	9.3	173.8	173.8	174.2	0.4
J	48,113	131	1,180	10.8	174.8	174.8	174.8	0.0
K	48,815	269	2,006	8.3	176.8	176.8	176.9	0.1
L	49,344	66	536	16.2	185.9	185.9	185.9	0.0
M	49,984	318	1,236	4.7	190.5	190.5	190.5	0.0
N	50,624	384	1,584	3.7	191.8	191.8	191.8	0.0
O	51,514	374	1,286	4.5	193.5	193.5	193.5	0.0
P	52,324	315	1,318	4.4	195.5	195.5	195.5	0.0
Q	53,470	200	533	10.9	200.0	200.0	200.9	0.9
R	54,510	110	614	9.5	208.5	208.5	209.4	0.9
S	55,535	200	621	9.4	213.6	213.6	214.3	0.7
T	56,065	200	812	9.8	215.8	215.8	216.6	0.8
U	57,826	400	1,330	3.6	226.4	226.4	226.5	0.1
V	59,079	500	1,750	3.0	232.8	232.8	232.8	0.0
W	63,814	82	235	6.8	257.4	257.4	257.4	0.0

[1] Feet above confluence with Pacific Ocean

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

SAN DIEGO CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
San Juan Creek								
A	2.51	183	2,503	12.8	75.7	75.7	75.7	0.0
B	2.54	190	2,497	12.8	76.3	76.3	76.3	0.0
C	2.62	218	3,274	9.8	80.1	80.1	80.6	0.5
D	2.77	215	2,651	12.1	81.0	81.0	81.4	0.4
E	2.86	305	4,358	7.3	86.7	86.7	86.7	0.0
F	2.97	449	5,085	6.3	88.0	88.0	88.3	0.3
G	3.09	443	4,441	7.2	89.1	89.1	90.0	0.9
H	3.21	417	3,834	7.8	91.9/91.7[2]	91.7	92.5	0.8
I	3.34	573	3,722	8.1	95.2/94.7[2]	94.7	95.6	0.9
J	3.48	421	3,897	7.7	100.0/99.0[2]	99.0	99.5	0.5
K	3.57	356	3,451	8.7	102.2/100.5[2]	100.5	101.1	0.6
L	3.63	347	3,325	9.0	103.0/101.4[2]	101.4	102.1	0.7
M	3.71	217	2,421	12.4	105.1/106.1[2]	106.1	106.1	0.0
N	3.82	408	4,251	7.1	108.9/109.3[2]	109.3	109.3	0.0
O	3.92	441	3,341	9.0	112.0/110.0[2]	110.0	110.3	0.3
P	4.01	474	3,677	8.2	114.4/113.1[2]	113.1	113.1	0.0
Q	4.09	568	3,378	8.9	115.5/114.2[2]	114.2	114.3	0.1
R	4.17	554	3,631	8.3	116.6/116.2[2]	116.2	116.5	0.3
S	4.25	443	3,136	9.6	118.0/117.9[2]	117.9	118.1	0.2
T	4.32	615	3,929	7.6	120.2/120.3[2]	120.3	120.4	0.1
U	4.39	713	3,355	8.9	122.0	122.0	122.3	0.3
V	4.47	771	3,773	8.0	125.7	125.7	125.7	0.0
W	4.55	1,014	3,425	8.8	127.7/127.6[2]	127.6	127.7	0.1
X	4.62	832	3,323	9.0	131.8/131.4[2]	131.4	131.4	0.0
Y	4.70	550	2,425	12.4	133.5/132.7[2]	132.7	132.7	0.0
Z	4.78	296	2,176	13.8	134.3/133.8[2]	133.8	133.8	0.0

[1] Miles above confluence with Pacific Ocean

[2] River side/land side of levee

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

SAN JUAN CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
San Juan Creek (continued)								
AA	4.90	325	2,630	11.4	139.6	139.6	139.6	0.0
AB	4.98	342	2,892	10.4	141.4	141.4	141.4	0.0
AC	5.10	387	2,994	10.0	143.4	143.4	143.4	0.0
AD	5.19	340	2,316	13.0	145.1	145.1	145.1	0.0
AE	5.28	363	2,480	12.1	151.0	151.0	151.0	0.0
AF	5.37	323	3,707	8.1	155.8	155.8	155.8	0.0
AG	5.44	270	2,680	11.2	157.8	157.8	157.8	0.0
AH	5.51	227	2,417	12.4	161.3	161.3	161.3	0.0
AI	5.54	637	6,819	4.4	173.0	173.0	173.9	0.9
AJ	5.63	667	7,236	4.1	173.2	173.2	174.1	0.9

[1] Miles above confluence with Pacific Ocean

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

SAN JUAN CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Santa Ana River								
A-S*								
T	24.39	860	6,259	12.1	359.9	359.9	360.0	0.1
U	24.54	1,020	7,415	9.0	363.1	363.1	363.3	0.2
V	24.69	900	6,841	7.4	364.7	364.7	364.9	0.2
W	24.87	1,049	6,507	7.5	366.0	366.0	366.2	0.2
X	25.00	1,410	4,341	9.8	368.7	368.7	369.0	0.3
Y	25.15	1,520	8,594	7.1	374.7	374.7	375.2	0.5
Z	25.30	1,450	8,849	6.4	376.8	376.8	377.4	0.6
AA	25.45	1,260	9,137	6.0	380.3	380.3	380.7	0.4
AB	25.60	1,241	7,981	6.6	381.3	381.3	832.0	0.7
AC	25.75	990	6,151	7.8	382.7	382.7	383.2	0.5
AD	25.91	1,020	5,180	9.3	385.5	385.5	386.0	0.5
AE	26.06	913	5,625	8.6	389.0	389.0	389.6	0.6
AF	26.21	883	5,367	10.7	393.7	393.7	394.0	0.3
AG	26.36	867	4,830	11.5	397.4	397.4	397.6	0.2
AH	26.51	730	5,859	8.4	403.4	403.4	403.4	0.0
AI	26.66	832	7,827	6.1	405.2	405.2	405.2	0.0
AJ	26.82	593	3,838	8.8	410.1	410.1	410.1	0.0
AK	26.97	430	4,546	10.8	416.9	416.9	416.9	0.0
AL	27.12	574	6,309	8.8	419.2	419.2	419.2	0.0
AM	27.27	969	9,942	5.7	420.5	420.5	420.5	0.0
AN	27.42	972	6,568	9.7	420.6	420.6	420.6	0.0
AO	27.57	1,106	5,669	12.5	421.1	421.1	421.7	0.6
AP	27.72	1,070	7,435	8.9	423.5	423.5	424.2	0.7
AQ	27.87	900	6,255	10.6	424.5	424.5	425.2	0.7

[1] Miles above confluence with Pacific Ocean

*Floodway not computed

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA AND INCORPORATED AREAS

FLOODWAY DATA

SANTA ANA RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Santiago Creek								
A	972	90	770	10.4	115.0	115.0	115.0	0.0
B	1,901	102	814	12.3	119.2	119.2	119.3	0.1
C	3,210	80	805	12.4	126.7	126.7	126.8	0.1
D	3,823	85	829	12.1	129.4	129.4	129.7	0.3
E	4,921	113	1,256	8.0	134.5	134.5	134.6	0.1
F	5,407	74	608	16.4	135.3	135.3	135.3	0.0
G	6,748	185	1,541	7.8	143.8	143.8	143.8	0.0
H	7,302	135	1,306	9.2	146.3	146.3	147.0	0.7
I	8,559	86	935	12.8	150.6	150.6	151.4	0.8
J	9,187	115	1,002	12.0	153.4	153.4	153.7	0.3
K	10,006	148	1,347	8.9	158.4	158.4	159.0	0.6
L	10,745	191	1,661	7.2	162.4	162.4	163.2	0.8
M	11,363	150	1,291	9.3	165.1	165.1	165.9	0.8
N	11,848	231	1,353	8.9	167.0	167.0	167.7	0.7
O	12,482	101	1,145	10.5	173.6	173.6	173.6	0.0
P	12,904	165	1,254	9.6	177.4	177.4	178.4	1.0
Q	13,464	112	782	15.3	179.3	179.3	179.3	0.0
R	15,492	175	1,265	9.5	196.9	196.9	197.3	0.4
S	16,289	199	2,049	5.9	204.7	204.7	204.9	0.2
T	19,103	149	116	10.3	222.6	222.6	223.6	1.0
U	19,768	180	1,188	10.1	225.2	225.2	225.5	0.3
V	20,724	192	1,708	7.0	233.8	233.8	233.8	0.0
W	21,711	174	1,208	9.1	236.9	236.9	237.2	0.3
X	22,361	176	1,541	7.1	242.4	242.4	243.4	1.0
Y	23,723	159	877	12.5	250.9	250.9	250.9	0.0
Z	24,462	560	1,763	6.2	258.8	258.8	258.8	0.0
AA	25,312	263	1,473	7.5	266.1	266.1	266.1	0.0

[1] Feet above confluence with Santa Ana River

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

SANTIAGO CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Santiago Creek (continued)								
AB	29,547	296	1,581	7.6	304.9	304.9	305.1	0.2
AC	30,534	134	1,684	7.1	309.1	309.1	309.7	0.6
AD	31,427	910[2]	6,464	1.9	310.2	310.2	310.7	0.5
AE	32,567	2,064[2]	29,484	0.4	310.3	310.3	310.8	0.5
AF	33,713	241	4,185	2.9	310.3	310.3	310.8	0.5
AG	34,352	555	10,538	1.1	310.3	310.3	310.8	0.5
AH	36,374	506	3,474	3.5	330.5	330.5	330.6	0.1
AI	37,245	155	1,327	4.5	368.3	368.3	368.3	0.0
AJ	40,244	69	438	13.7	395.4	395.4	395.5	0.1
AK	41,295	123	1,070	11.2	413.0	413.0	413.0	0.0
AL	41,923	419	2,253	6.4	417.5	417.5	417.5	0.0
AM	43,386	286	1,977	6.1	430.0	430.0	430.8	0.8
AN	45,477	187	1,755	6.8	454.3	454.3	454.5	0.2
AO	47,604	354	2,642	4.5	474.7	474.7	475.4	0.7

[1] Feet above confluence with Santa Ana River

[2] Floodway width adjusted to updated waterlines, does not match model

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

SANTIAGO CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Segunda Deshecha Canada								
B-M[1]								
N	1.17[3]	20	160	18.1	73.0	73.0	73.8	0.8
O	1.28[3]	39	221	13.1	79.6	79.6	79.9	0.3
P	1.45[3]	44	415	6.7	89.4	89.4	90.3	0.9
Q	1.60[3]	42	432	5.3	92.1	92.1	92.7	0.6
Serrano Creek								
A[2]								
B	2,020[4]	43	227	13.2	251.7	251.7	251.7	0.0
C	2,420[4]	28	198	15.2	255.5	255.5	255.5	0.0
D	2,790[4]	112	355	11.4	262.1	262.1	262.1	0.0
E	3,990[4]	113	354	11.3	274.8	274.8	274.8	0.0
F	4,590[4]	55	317	9.5	280.1	280.1	280.1	0.0
G	4,990[4]	73	297	10.1	281.3	281.3	281.3	0.0
H	5,390[4]	70	268	11.2	285.3	285.3	285.3	0.0
I-V[2]								
W	14,234[4]	142	514	5.4	374.2	374.2	374.2	0.0
X	14,444[4]	217	791	3.5	374.7	374.7	374.7	0.0
Y	14,674[4]	132	316	8.9	375.0	375.0	375.0	0.0
Z	15,174[4]	99	516	5.4	382.7	382.7	382.9	0.2
AA	16,389[4]	63	357	7.8	395.0	395.0	396.0	1.0
AB	17,214[4]	55	246	11.4	401.6	401.6	401.8	0.2
AC	17,739[4]	86	497	5.6	408.4	408.4	408.8	0.4
AD	18,164[4]	60	240	11.6	412.0	412.0	412.0	0.0
AE	19,259[4]	45	223	12.6	436.9	436.9	436.9	0.0
AF	19,408[4]	46	223	12.5	440.4	440.4	440.4	0.0
AG	21,315[4]	86	394	7.1	486.3	486.3	486.3	0.0

[1] Floodway contained in improved channel

[2] Contained in channel

[3] Miles above confluence with Pacific Ocean

[4] Feet above confluence with San Diego Creek

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA AND INCORPORATED AREAS

FLOODWAY DATA

SEGUNDA DESHECHA CANYON – SERRANO CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Serrano Creek (continued)								
AH	22,251	65	248	11.3	511.2	511.2	511.2	0.0
AI	23,581	72	319	8.8	552.4	552.4	552.4	0.0
AJ	24,910	51	195	11.3	606.0	606.0	606.0	0.0
AK	25,347	40	180	12.2	626.7	626.7	626.7	0.0
AL	25,807	61	314	7.0	636.2	636.2	636.2	0.0
AM	26,232	64	212	10.4	646.8	646.8	646.8	0.0
AN	26,464	46	232	9.5	654.2	654.2	654.2	0.0
AO	27,309	58	208	10.6	670.6	670.6	670.6	0.0
AP	27,627	85	314	7.0	678.5	678.5	678.5	0.0
AQ	27,971	247	331	6.7	689.3	689.3	690.0	0.7
AR	28,128	130	553	4.0	690.0	690.0	691.0	1.0
AS	28,555	50	193	11.4	693.7	693.7	693.7	0.0
AT	29,336	60	206	10.7	713.2	713.2	713.2	0.0
AU	30,178	41	197	11.2	725.6	725.6	725.6	0.0
AV	30,744	57	343	5.5	731.7	731.7	732.0	0.3
AW	31,416	43	169	11.3	756.4	756.4	756.4	0.0
AX	31,566	47	259	7.3	758.4	758.4	758.4	0.0
AY	31,934	46	167	11.4	761.4	761.4	761.4	0.0
AZ	32,205	72	199	9.6	766.1	766.1	766.3	0.2
BA	32,935	62	191	10.0	775.4	775.4	775.4	0.0
BB	34,194	64	192	9.9	793.3	793.3	793.3	0.0

[1] Feet above confluence with San Diego Creek

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA AND INCORPORATED AREAS

FLOODWAY DATA

SERRANO CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Shady Canyon Wash								
A	200[1]	79	383	3.9	207.9	207.9	207.9	0.0
B	670[1]	51	145	0.6	210.0	210.0	210.0	0.0
C	1,330[1]	29	120	11.7	221.5	221.5	221.5	0.0
D	1,990[1]	95	143	9.8	230.3	230.3	230.3	0.0
E	2,590[1]	50	172	8.1	235.9	235.9	235.9	0.0
F	3,430[1]	35	127	11.0	251.8	251.8	251.8	0.0
Sulphur Creek								
A	0.000[2]	94	426	6.8	198.3	198.3	198.3	0.0
B	0.197[2]	114	608	4.9	203.8	203.8	204.3	0.5
C	0.266[2]	196	686	4.5	204.6	204.6	205.4	0.8
D	0.384[2]	76	281	11.1	209.6	209.6	209.7	0.1
E	0.446[2]	36	234	12.4	212.2	212.2	212.8	0.6
F	0.583[2]	154	1,045	2.8	217.7	217.7	218.7	1.0
G	0.723[2]	80	566	5.1	222.0	222.0	222.0	0.0

[1] Feet above confluence with Sand Canyon Wash

[2] Miles above Laguna Niguel Regional Park

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

SHADY CANYON WASH – SULPHUR CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Trabuco Creek								
A	2.24	186	2,100	6.2	159.8	159.8	159.8	0.0
B	2.33	191	1,462	8.9	162.3	162.3	162.3	0.0
C	2.44	138	1,263	10.3	166.8	166.8	166.8	0.0
D	2.54	109	967	13.4	170.2	170.2	170.2	0.0
E	2.65	117	1,196	10.9	179.6	179.6	179.6	0.0
F	2.71	163	1,994	6.5	181.7	181.7	181.7	0.0
G	2.76	70	696	18.7	191.0	191.0	191.0	0.0
H	2.89	117	1,051	12.4	198.6	198.6	198.6	0.0
I	2.94	77	733	17.7	202.9	202.9	202.9	0.0
J	3.00	81	889	14.6	207.9	207.9	207.9	0.0
K	3.05	99	1,103	11.8	211.3	211.3	211.7	0.4
L	3.11	59	686	18.9	211.3	211.3	211.3	0.0
M	3.21	84	989	13.1	218.4	218.4	218.4	0.0
N	3.33	106	1,264	10.3	223.6	223.6	223.6	0.0
O	3.44	87	886	14.7	231.0	231.0	231.0	0.0
P	3.55	76	865	15.0	235.1	235.1	235.5	0.4
Q	3.66	112	1,668	7.8	241.0	241.0	241.3	0.3
R	3.76	78	947	13.7	241.3	241.3	241.6	0.3
S	3.87	112	1,529	8.5	245.9	245.9	246.0	0.1
T	3.99	174	2,199	5.9	247.4	247.4	247.5	0.1
U	4.10	108	1,006	12.9	247.4	247.4	247.5	0.1
V	4.21	200	2,344	5.5	251.6	251.6	251.6	0.0
W	4.33	272	6,444	2.0	252.1	252.1	252.2	0.1
X	4.36	314	2,371	5.5	252.0	252.0	252.0	0.0
Y	4.42	313	2,473	5.3	252.4	252.4	252.7	0.3
Z	4.48	363	3,762	3.5	252.8	252.8	253.2	0.4

[1] Miles above confluence with San Juan Creek

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

TRABUCO CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Trabuco Creek (continued)								
AA	4.59[1]	587	2,211	5.9	254.0	254.0	254.5	0.5
AB	4.70[1]	559	3,903	3.3	255.1	255.1	256.0	0.9
AC	4.81[1]	806	3,654	3.6	256.0	`256.0	256.9	0.9
AD	4.91[1]	824	3,189	4.1	257.3	257.3	258.2	0.9
AE	4.97[1]	570	1,447	9.0	260.4	260.4	260.5	0.1
AF	5.02[1]	615	2,086	6.2	263.9	263.9	264.1	0.2
AG	5.13[1]	390	1,347	9.7	271.7	271.7	271.9	0.2
AH	5.19[1]	340	1,340	9.7	277.5	277.5	277.6	0.1
Upper Santiago Creek								
A	15.330	580	2,470	10.1	818.9	818.9	819.7	0.8
B	15.470	376	2,740	9.2	828.5	828.5	829.5	1.0
C	15.655	521	2,656	9.2	837.2	837.2	838.0	0.8
D	15.825	425	2,527	10.0	848.4	848.4	848.4	0.0
E	15.960	420	2,475	10.1	854.4	854.4	855.2	0.8
F	16.089	530	2,539	9.9	861.5	861.5	862.1	0.6
G	16.213	570	3,280	7.6	871.0	871.0	872.0	1.0
H	16.373	640	2,459	10.1	881.0	881.0	881.8	0.8
I	16.687	416	2,492	10.0	901.3	901.3	901.3	0.0
J	17.420	382	1,060	9.9	936.2	936.2	936.6	0.4
K	17.590	510	1,055	10.1	952.6	952.6	952.6	0.0
L	17.775	250	965	8.7	962.5	962.5	963.3	0.8
M	17.884	168	682	11.5	975.7	975.7	975.7	0.0
N	18.174	159	673	1.8	996.9	996.9	996.9	0.0
O	18.545	164	1,208	10.0	1,016.6	1,016.6	1,017.2	0.6
P	18.689	440	1,231	10.0	1,029.2	1,029.2	1,029.3	0.1
Q	18.845	620	1,408	10.4	1,039.1	1,039.1	1,039.4	0.3

[1] Miles above confluence with San Juan Creek

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

TRABUCO CREEK-UPPER SANTIAGO CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Upper Santiago Creek (continued)								
R	19.000[1]	658	1,650	9.8	1,049.9	1,049.9	1,050.0	0.1
S	19.128[1]	393	1,196	9.8	1,058.8	1,058.8	1,059.5	0.7
T	19.238[1]	335	1,280	9.7	1,065.8	1,065.8	1,066.4	0.6
U	19.346[1]	407	1,156	12.1	1,073.4	1,073.4	1,073.4	0.0
V	19.467[1]	370	1,378	10.0	1,080.8	1,080.8	1,081.6	0.8
W	19.620[1]	543	1,288	10.7	1,094.9	1,094.9	1,095.0	0.1
X	19.720[1]	320	946	10.2	1,103.1	1,103.1	1,103.6	0.5
Y	19.814[1]	190	855	12.6	1,113.3	1,113.3	1,113.3	0.0
Z	19.893[1]	243	999	10.0	1,120.3	1,120.3	1,121.1	0.8
AA	20.019[1]	180	804	10.0	1,129.6	1,129.6	1,129.7	0.1
AB	20.104[1]	261	793	10.0	1,136.5	1,136.5	1,136.6	0.1
AC	20.332[1]	155	725	10.9	1,148.7	1,148.7	1,148.7	0.0
AD	20.360[1]	160	723	10.9	1,158.6	1,158.6	1,158.6	0.0
AE	20.472[1]	272	933	9.9	1,163.9	1,163.9	1,164.3	0.4
AF	20.597[1]	186	711	11.2	1,174.0	1,174.0	1,174.0	0.0
AG	20.735[1]	242	840	9.8	1,184.5	1,184.5	1,184.7	0.2
AH	20.879[1]	310	1,111	10.1	1,196.7	1,196.7	1,196.7	0.0
AI	21.043[1]	201	716	11.0	1,211.8	1,211.8	1,211.8	0.0
Valencia Storm Channel								
A	1,530[2]	610	456	3.3	58.3	58.3	58.3	0.0
B	2,830[2]	400	360	4.2	64.1	64.1	64.1	0.0
C	3,880[2]	560	420	3.6	68.3	68.3	68.3	0.0

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[1] Miles above confluence with Santa Ana River

[2] Feet above confluence with Peters Canyon Wash

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

**ORANGE COUNTY, CA
AND INCORPORATED AREAS**

FLOODWAY DATA

UPPER SANTIAGO CREEK – VALENCIA STORM CHANNEL

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Veeh Creek (San Diego Creek Tributary 2)								
A	1,340[2]	210	358	7.7	227.7	227.7	227.7	0.0
B	1,720[2]	250	405	6.4	229.1	229.1	230.0	0.9
C	2,519[2]	87	443	5.9	241.8	241.8	241.8	0.0
D	3,666[2]	71	556	4.7	245.5	245.5	246.2	0.7
E	4,504[2]	92	500	5.2	247.5	247.5	248.3	0.8
Veeh Creek Tributary 1 (San Diego Creek Tributary 1)								
A[1]	50[3]	425	2,500	1.5	225.5	225.5	226.5	1.0
B[1]	485[3]	380	787	1.6	226.1	226.1	227.1	1.0
C	1,260[3]	150	152	8.2	233.1	233.1	233.7	0.6
D	1,720[3]	60	150	8.4	237.7	237.7	238.1	0.4
E	2,600[3]	67	148	8.5	245.8	245.8	245.8	0.0
F	3,200[3]	120	141	8.9	255.8	255.8	255.9	0.1
G	4,080[3]	80	119	10.5	264.5	264.5	264.7	0.2

[1] Cross Sections A and B on San Diego Creek Tributary 1 also cross Veeh Creek

[2] Feet above confluence with San Diego Creek

[3] Feet above confluence with Veeh Creek (San Diego Creek Tributary 2)

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

FLOODWAY DATA

VEEH CREEK – VEEH CREEK TRIBUTARY 1

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. The zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 1-percent annual chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent annual chance floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to the areas of 1-percent annual chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 1-percent annual chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the detailed hydraulic analyses are shown within this zone.

Zone AR

Area of special flood hazard formerly protected from the 1-percent annual chance flood event by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1-percent annual chance or greater flood event.

Zone A99

Zone A99 is the flood insurance rate zone that corresponds to areas of the 1-percent annual chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or depths are shown within this zone.

Zone V

Zone V is the flood insurance rate zone that corresponds to the 1-percent annual chance coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no base flood elevations are shown within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 1-percent annual chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2-percent annual chance floodplain, areas within the 0.2-percent annual chance floodplain, and to areas of 1-percent annual chance flooding where average depths are less than 1 foot, areas of 1-percent annual chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent annual chance flood by levees. No base flood elevations or depths are shown within this zone.

Zone D

Zone D is the flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 1-percent annual chance floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent annual chance floodplains. Floodways and the locations of selected cross sections used in the hydraulic analyses and floodway computations are shown where applicable.

The current FIRM presents flooding information for the entire geographic area of Orange County. Previously, separate Flood Hazard Boundary Maps and/or FIRMs were prepared for each identified flood-prone incorporated community and the unincorporated areas of the county. This countywide FIRM also includes flood hazard information that was presented separately on Flood Boundary and Floodway Maps (FBFMs), where applicable. Historical data relating to the maps prepared for each community, up to and including the September 15, 1989 countywide FIS, are presented in Table 12, "Community Map History."

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Aliso Viejo, City of	January 10, 1975[1]	None	September 14, 1979[1]	September 15, 1989[1]
Anaheim, City of	July 26, 1974	April 16, 1976	June 4, 1980	September 15, 1989 September 16, 1982
Brea, City of	May 24, 1974	November 14, 1975	December 2, 1980	September 15, 1989
Buena Park, City of	November 1, 1974	April 9, 1976	February 1, 1979	September 15, 1989
Costa Mesa, City of	May 17, 1974	June 27, 1978 July 2, 1976	September 30, 1982	September 15, 1989
Cypress, City of	June 7, 1974	April 9, 1976	September 15, 1989	
Dana Point, City of	September 15, 1989	None	September 15, 1989	
Fountain Valley, City of	March 29, 1974	October 1, 1976 May 28, 1976	November 17, 1982	September 15, 1989
Fullerton, City of	June 28, 1974	July 2, 1976	July 5, 1977	September 15, 1989 April 5, 1983 April 20, 1982
Garden Grove, City of	June 14, 1974	May 7, 1976	September 30, 1982	September 15, 1989
Huntington Beach, City of	August 9, 1974	August 27, 1976	February 16, 1983	September 15, 1989

[1] This community did not have its own FIRM prior to the September 15, 1989, FIS. The land area for this community was previously shown on the FIRM for the unincorporated areas of Orange County, but was not identified as a separate NFIP community. Therefore, the dates for this community were taken from the FIRM for Orange County.

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Irvine, City of	June 21, 1974	July 12, 1977 February 20, 1976 September 1975	February 15, 1980	September 15, 1989
La Habra, City of	May 3, 1974	April 9, 1976	February 15, 1980	September 15, 1989
La Palma, City of	July 21, 1978	None	July 21, 1978	September 15, 1989
Laguna Beach, City of	July 21, 1974	July 9, 1976	September 28, 1979	September 15, 1989 September 18, 1985
Laguna Hills, City of	January 10, 1975[1]	None	September 14, 1979[1]	September 15, 1989[1]
Laguna Niguel, City of	January 10, 1975[1]	None	September 14, 1979[1]	September 15, 1989[1]
Laguna Woods, City of	January 10, 1975[1]	None	September 14, 1979[1]	September 15, 1989[1]
Lake Forest, City of	January 10, 1975[1]	None	September 14, 1979[1]	September 15, 1989[1]
Los Alamitos, City of	June 7, 1974	January 16,1976	September 15, 1989	
Mission Viejo, City of	September 15, 1989	None	September 15, 1989	
Newport Beach, City of	March 15, 1974	July 9, 1976	September 1, 1978	September 15, 1989
Orange, City of	March 28, 1978	None	December 4, 1979	September 15, 1989 September 30, 1982

[1] This community did not have its own FIRM prior to the September 15, 1989, FIS. The land area for this community was previously shown on the FIRM for the unincorporated areas of Orange County, but was not identified as a separate NFIP community. Therefore, the dates for this community were taken from the FIRM for Orange County.

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Orange County (Unincorporated Areas)	January 10, 1975	None	September 14, 1979	September 15, 1989
Placentia, City of	June 14, 1974	September 19, 1975	February 15, 1980	September 15, 1989
Rancho Santa Margarita, City of	January 10, 1975[1]	None	September 14, 1979[1]	September 15, 1989[1]
San Clemente, City of	June 14, 1974	November 14, 1975	December 4, 1979	September 15, 1989
San Juan Capistrano, City of	May 10, 1974	October 3, 1975	September 14, 1979	September 15, 1989
Santa Ana, City of	June 21, 1974	April 9, 1976	September 14, 1979	September 15, 1989 September 2, 1982
Seal Beach, City of	June 21, 1974	April 9, 1976	July 3, 1978	September 15, 1989
Stanton, City of	September 15, 1989	None	September 15, 1989	
Tustin, City of	June 21, 1974	July 16, 1976	September 14, 1979	September 15, 1989
Villa Park, City of	March 22, 1974	October 31, 1975	December 4, 1979	September 15, 1989
Westminster, City of	June 14, 1974	November 15, 1977 July 2, 1976	August 8, 1978	September 15, 1989
Yorba Linda, City of	August 9, 1974	August 6, 1976	August 1, 1978	September 15, 1989 May 12, 1981

[1] This community did not have its own FIRM prior to the September 15, 1989, FIS. The land area for this community was previously shown on the FIRM for the unincorporated areas of Orange County, but was not identified as a separate NFIP community. Therefore, the dates for this community were taken from the FIRM for Orange County.

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY

ORANGE COUNTY, CA
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

Data for segments of Laguna Canyon floodplain were obtained from a USACE Flood Plain Information report because of the close correlation of discharge rates used for this report as compared to those calculated for the present study (USACE, 1969).

The floodplains calculated for this study were in close agreement to those floodplains delineated for USACE Flood Plain Information reports (USACE, 1969; USACE, 1972; USACE, 1970; USACE, June 1971; USACE, March 1973). The few differences were reviewed with local agencies and generally resulted from changed topographic and/or land use conditions.

The analysis for the wide canyon area of the Santa Ana River utilized the USACE cross-section data from its previous study of the Santa Ana River (USACE, June 1971). In some stream areas, the Manning's roughness coefficients were adjusted to be consistent countywide. The 1-percent annual chance discharge rate and flood limits were the same for both the USACE study and this study. The 0.2-percent annual chance flood discharge rate and flood limits in this study exceeded the USACE Standard Project Flood. The USACE representatives confirmed that the selected recurrence interval discharges used in this study are consistent with the most recently developed data available at the time this study was prepared.

On Handy Creek, the discharge rates from Peters Canyon Reservoir used in the present study agree with the USACE data (USACE, 1972).

The floodplain boundaries delineated in this study in the area of San Diego Creek and its tributaries are coincident with the respective USACE studies, except where adjusted for recent grading for development.

The floodplain delineated for Canada Gobernadora was compared to that of the county's preliminary floodplain and master drainage plan prepared by the county (VTN Consolidated, Inc., August 1974). The floodplain shown in this study is narrower than that in the master plan in the Coto de Caza area. The chief reason is that the 1-percent annual chance discharge rate was based on current development density, while the master plan was based on future land use factors and on the Standard Project Flood.

The floodplain boundaries delineated for the study in the lower segment of Aliso Creek, with the exception of the revised grading at the treatment plant, were coincident with those of the USACE study (USACE, March 1973). Upstream of the freeway, the floodplain boundaries matched the USACE data where subsequent development grading had not occurred.

A USACE Flood Plain Information report for San Juan Creek (USACE, 1970) used the same assumed conditions of this study. In the lower study segment, the resulting floodplain includes a larger area east of the creek than that shown in the USACE report. The larger flooded area occurs because of floodwater overtopping the ATSFRR and because this study also analyzed the local inflow from Facility No. 101S02 and other areas; local inflow was beyond the scope of the USACE analysis. Upstream of San Juan Capistrano, close correlation to the USACE report was found by normal-depth analysis; therefore, the floodplain limits were adopted for this study.

The 1-percent annual chance flood profile and floodplain boundary for Santiago Creek between Modjeska Canyon Road bridge and Santiago Canyon Road bridge were developed by the OCEMA in July of 1977. A study of the north bank levee in 1977 (Moore and Taber, 1977) concluded that the levee, constructed in 1966 and 1969 by the Orange County Road Department, was inadequate to withstand the velocities of a 1-percent annual chance flood; the profile and mapping of this study reflect this conclusion.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this FIS can be obtained by contacting FEMA, Federal Insurance and Mitigation Division, 1111 Broadway, Suite 1200, Oakland, California 94607-4052.

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10.0 REVISIONS DESCRIPTION

This section has been added to provide information regarding significant revisions made since the original FIS was printed. Future revisions may be made that do not result in the republishing of this FIS report. To assure that any user is aware of all revisions, it is advisable to contact the community repository.

10.1 First Revision

The study dated February 5, 1992, incorporates an analysis of previously unstudied flood hazards along Cascadita Creek.

The hydrologic and hydraulic analyses for the study of Cascadita Creek in the City of San Clemente were performed by Schaaf & Wheeler for FEMA under Contract EMW-87-C-2843. This portion of the study was completed in March 1990.

On February 21, 1991, the results of the study were reviewed at a final community coordination meeting attended by representatives of FEMA, the study contractor, and the community.

Cascadita Creek was studied using detailed methods from its confluence with Prima Deshecha Canada to downstream of I-5. No changes have been made to any other watercourse in the City of San Clemente.

Cascadita Creek is a tributary of Prima Deshecha Canada. The confluence is located approximately 200 feet downstream of Avenida Vaquera and 400 feet upstream of the Pacific Coast Highway. The channel consists of an RCB with 1-percent annual chance capacity. Cascadita Creek changes to a rectangular reinforced-concrete channel approximately 550 feet upstream of the confluence. At Via Cascadita crossing the channel changes to natural earth. The crossing at I-5 consists of an 8-foot reinforced-concrete arch culvert.

Cascadita Creek can be found on the 7.5-minute quadrangle labeled "Dana Point, California" (U.S. Department of the Interior, 1975, et cetera). The drainage area is approximately 1.10 square miles. This watershed does not have any stream gages along the watercourse. Hydrology for this stream has been developed for the 1-percent annual chance storm using SCS Curve Number methodology as calibrated to local watersheds having stream gages.

Two watersheds with stream gage records in the vicinity of Cascadita Creek were used for calibrating the SCS model. Aliso Creek has a stream gage near Jeronimo Road in the City of El Toro (Bowers, McConaughy, Polinoski, and Smith, 1987). This basin drains approximately 7.95 square miles with 55 years of annual peak records. Las Flores Creek near Oceanside has a drainage basin of approximately 26.60 square miles with 27 years of annual peak records. Statistical analyses were performed on Aliso and Las Flores Creeks using USGS guidelines set forth in Bulletin 17B (U.S. Department of the Interior, 1981).

SCS Curve Number methodology was used to calibrate the Antecedent Moisture Condition (AMC) to the statistical frequency model. The drainage basin was determined from 7.5-minute quadrangle sheets along with length, centroid length, and average slope of the watershed. Soil parameters were obtained from the SCS and from the Orange County Hydrology Manual (Orange County Environmental Management Agency, 1986). Land use characteristics were determined from field investigations and aerial photos, and quadrangle sheets and curve numbers were selected accordingly from the Orange County Hydrology Manual. Rainfall pattern and depth characteristics for the 1-percent annual chance storm were developed from the Orange County Hydrology Manual. A 5-minute, 24-hour storm was used for the hydrograph settlement.

An AMC of 3 was determined from the calibration process. Aliso Creek produced an AMC of 2.25. Las Flores Creek produced an AMC in excess of 3. Differences are likely caused by period of record for each stream gage, the actual recorded values at each gage, and the soil characteristics found in each watershed. A comparative analysis using the Orange County Hydrology Manual and the SCS model found that the infiltration rates differ by 5 percent. This is attributed to using a maximum loss rate (Orange County Hydrology Manual) and minimum loss rate (SCS method). AMC 3 is a conservative estimate and was used for the SCS curve number methodology in determining the 1-percent annual chance peak discharge for Cascadita Creek.

The 1-percent annual chance discharge on Cascadita Creek is shown in the Summary of Discharges table (Table 7).

The detailed study to determine the 1-percent annual chance floodplain and floodway for Cascadita Creek was based upon HEC-2 analysis. Cross sections were obtained from field surveys. Topographic information obtained from the City of San Clemente was used to supplement field data and map the flood limits. Hydraulic structures in the vicinity of Via Cascadita were measured in the field.

The floodplain limits were delineated on topographic maps obtained from the City of San Clemente at a scale of 1:2,400.

Channel and overbank roughness factors (Manning's "n") used in the hydraulic computations were determined by engineering judgment and field inspection. The channel "n" values range from 0.013 to 0.06 and for the overbank areas from 0.04 to 0.055, as shown in the Summary of Manning's "n" Values (Table 8).

The downstream limit of this study for Cascadita Creek is approximately 550 feet upstream from the confluence with Prima Deshecha Canada where the channel changes from box culverts to rectangular channel.

At this point, the culvert and channel are the same size and the water is confined to the culvert downstream of the study area. This downstream portion of the channel flows as supercritical flow. Therefore, the starting water-surface elevation is based on critical depth.

10.2 Second Revision

The study dated September 30, 1993, incorporates a restudy of several streams in Orange County previously studied by detailed or approximate methods. The following streams were restudied by detailed methods: Aliso Creek from El Toro Road to Marguerite Parkway, Handy Creek from Santiago Canyon Road to Amapola Avenue, San Juan Creek from just upstream of the ATSFRR to Ortega Highway, Serrano Creek from Bake Parkway to approximately 12,500 feet upstream of Trabuco Road, and Trabuco Creek from the ATSFRR to approximately 2.9 miles upstream.

The hydrologic and hydraulic analyses for this restudy were performed by Schaaf & Wheeler for FEMA, under Contract No. EMW-89-C-2843. This restudy was completed in January 1992.

Revisions to the hydraulic analyses along a channel known as Channel No. 2A in the City of Orange, between Wanda Road and Newport Freeway, performed by Salkin Engineering Corporation for a Letter of Map Revision (LOMR) dated September 6, 1990.

Revisions to the hydraulic analyses along San Diego Creek involving the construction of a channel with soil-cement embankments from Laguna Freeway to Sand Canyon Avenue and a transition-earth channel extending for approximately 300 feet downstream of Sand Canyon Avenue. These revisions were performed by Simons, Li and Associates, Inc., for a LOMR dated January 20, 1992 (Case No. 91-09-104P).

Revisions to the hydraulic analyses to show the effects of the channelization project along Santiago Creek, which extends from approximately 500 feet downstream of the former SPRR to just upstream of Prospect Avenue. These revisions were performed by J. F. Davidson Associates, Inc., for a LOMR dated March 26, 1992 (Case No. 92-09-069P).

A revision to the FIRM to show the correct location of the O'Neil Retarding Basin and its 1-percent annual chance floodplain, located within the City of Mission Viejo. This revision is based on a topographic map entitled "Hydrology Map, L03-0S0 Creek Storm Drain, Mission Viejo-P.A. 24," revised October 1984, prepared by

Jack G. Raub Company, and a topographic map entitled O'Neil Retention Basin Flood Limits," dated October 24, 1984, used for a LOMR dated March 26, 1992 (Case No. 92-09-095P).

On February 19, 1992, the results of the study were reviewed at an intermediate community coordination meeting attended by representatives of FEMA, the study contractor, and the community.

The results of the study were reviewed at the final Consultation and Coordination Officer (CCO) meeting held on December 15, 1992. All problems raised at that meeting have been addressed in this study.

The 1-percent annual chance flow rates used in this restudy are shown in the Summary of Discharges (Table 7). All the flow rates were developed or taken directly from Section 3.1 of this report.

The 1-percent annual chance flow rates for Aliso Creek were determined from the Frequency-Discharge, Drainage Area Curves for Aliso Creek. Drainage areas were determined from USGS quadrangle maps (U.S. Department of the Interior, 1975, et cetera).

The 1-percent annual chance peak flow rates for Handy Creek were determined from the previous discharge values used for this stream.

The San Juan Creek 1-percent annual chance flow rates were obtained from Table 7.

The 1-percent annual chance flow rates for Serrano Creek were determined by plotting the drainage area versus peak discharge for the flow rates given in Table 7 (USACE, 1974; USACE, 1977) and additional information from the USACE by extrapolating this information for smaller drainage areas, the peak discharge within the study limits can be estimated. Drainage areas were determined from USGS quadrangle maps (U.S. Department of the Interior, 1975, et cetera).

The Trabuco Creek 1-percent annual chance flow rates were determined at the confluence with San Juan Creek by extending the frequency-discharge, drainage area curves for Trabuco Creek with the peak discharge given in Table 7. Drainage areas were also determined from USGS quadrangle maps (U.S. Department of the Interior, 1975, et cetera).

The hydraulic analyses for these restudied streams were performed using the USACE HEC-2 step-backwater program (USACE, October 1973).

The cross sections were obtained from field surveys and construction plans provided by the OCEMA. All construction plans used were for completed projects with the exception of the El Toro Road/Santa Margarita Parkway intersection improvements, Aliso Creek bridge improvement and landscape plan for Portola Parkway at Aliso Creek, and Facility No. J01 channel protection for the Portola Parkway bridge over Aliso Creek. These plans cover an approximately 3,900 foot reach of the creek. The projects are currently under construction and scheduled for completion in 1992.

The starting water-surface elevation was taken from the previous study profile. Channel and overbank roughness (Manning's "n") factors (Table 8) used in the hydraulic computations were determined by engineering judgment, field observation, and aerial photography.

Construction of a diversion to Santiago Creek (Handy Creek Storm Channel) has affected the floodplain and water-surface elevations. In addition, no floodway was delineated for the county portion of the stream. Upstream of Amapola Avenue, an existing detailed study exists within the City of Orange.

The cross sections were obtained from construction plans provided by the OCEMA for the Handy Creek storm channel and the Meads Avenue bridge; from field surveys for the transition area upstream of the storm channel box culvert; and from the existing HEC-2 model upstream of the transition area. The water-surface elevation for Santiago Creek at the Handy Creek storm channel confluence was used as the starting tailwater elevation for the hydraulic calculations of the storm channel box culvert. The resulting headwater elevation was used as the starting water-surface elevation for the HEC-2 analysis.

Channel and overbank roughness (Manning's "n") factors (Table 8) used in the hydraulic computations were determined by engineering judgment, field observations, aerial photography, and the existing HEC-2 model.

San Juan Creek was studied previously through the study reach up to RM 5.1. The reach was restudied because of natural and man-made changes in the channel. The cross-sectional information was obtained from topographical maps compiled from aerial photography (Harris-Toups Associates, no date, <u>Topographic Maps for the City of San Juan Capistrano</u>; Willdan Associates, 1979 and 1980; Pacific Air Industries, 1960; Raub, Bien, Frost & Associates, 1984; Keith Companies, 1987). As a result of a channel improvement project, sections upstream of the La Novia bridge crossing to the city limits have been modified. These changes were obtained from maps dated 1987. They were essentially the same 1984 topography with the improvements sketched in. Maps from the previous study for the City of San Juan Capistrano (Harris-Toups Associates, no date, <u>Topographic Maps for the City of San Juan Capistrano)</u> were utilized to obtain more information on portions of the right overbank of the reach downstream of La Novia. Additional mapping was also obtained from the City of San Juan Capistrano for the right overbank area between I-5 and the crossing at La Novia (Willdan Associates, 1979 and 1980). Further, extreme bank points for both the right and left overbank were obtained from the USGS quadrangle maps (U.S. Department of the Interior, 1975, et cetera). Since no adequate topographic information existed for the creek outside the city limits, cross sections were field surveyed. Topographic information (Pacific Air Industries, 1960) was used to supplement the field surveys for the extreme overbank areas. Field measurements were also obtained at all the bridges within the study reach. The starting water-surface elevation was taken from the previous study profile. It should be noted that the invert of the previous profile at station 13,229 is higher than the invert of the new profile. There is a continued difference in inverts throughout the study reach, which indicates severe erosion especially in the upper portion of the reach. Channel and overbank roughness (Manning's "n") factors (Table 8) used in the hydraulic computations were determined by engineering judgment and aerial photography and from photographs taken on a field visit. For portions of the extreme overbanks that were in very developed urban areas, the "n" values were adjusted according to the method suggested by H. R. Hejl and Lawrence Kans (USGS, 1977).

San Juan Creek was analyzed first assuming that the existing bank levees would hold and then assuming that they would fail. Since the available freeboard did not meet FEMA criteria, the limits of the floodplain were determined using the levee failure analysis. On the unprotected (river) side of the levee the maximum water-surface elevations were usually those with the levee holding. For the land side of the levee the maximum water-surface elevations were those without the levee. Hence a zone break was drawn on the levee, and the two different water-surface elevations were indicated. In a few instances the without levee case had a greater water-surface elevation for the river side than the with-levee case. In those instances the greater elevations were indicated on the maps.

Since a floodway existed for San Juan Creek, it is required that the new floodway limits not encroach on the previous floodway limits if possible. Therefore, the floodway analysis was started using the limits of the existing floodway for San Juan Creek from the previous study. The floodway limits were then checked to determine if they encroached within the bank points of the creek in its present condition. If this was the case, the floodway limits were adjusted to the bank points. In certain portions of the study reach the new floodplain and floodway limits fall within the limits of the original floodway. This is because of the difference in the inverts caused by erosion of the channel and to the changes in the creek and banks caused by the channel improvement project in the upper part of the study reach.

This reach of Serrano Creek was previously studied by approximate methods. Downstream of Bake Parkway, Serrano Creek was studied by detailed methods.

The cross sections were obtained from field surveys, construction plans of completed projects provided by the OCEMA, and aerial cross sections flown by Aelytek, Inc. In some areas, portions of the flow break out from the main floodplain and drain in a separate overbank flow path for a short reach. The main channel and the overbank flow path are separated by high ground at the channel bank. When this high ground is reduced the overbank flows return to the main channel. The amount of flow in the overbank was determined from the HEC-2 flow distribution option and weir calculations. The limits of flooding and water-surface elevations in the overbank were determined from hand calculations using Manning's equation. The flow rate in the main channel was not reduced by the overbank flow rate since the stability of the high ground separating the flow paths is unknown. If the high ground fails the overbank flows will drain unhindered to the main channel. The starting water-surface elevation was taken from station 12050 of the previous study profile. Channel and overbank roughness (Manning's "n") factors (Table 8) used in the hydraulic computations were determined by engineering judgment, field observations, and aerial photography.

Trabuco Creek was studied previously through the study reach and is included in the previous study. The reach is restudied because of more updated topographic information developed for the channel. The cross sections were obtained from topographic maps (Orange County Environmental Management Agency, 1986) and field surveys. For determination of the floodplain and floodway, the sand and gravel pits were not considered to be effective areas of flow. The pits have not been considered to be effective areas of flow. The pits have not been considered as part of the cross section. Channel and overbank roughness factors, Manning's "n" (Table 8), used in the hydraulic computations were determined by engineering judgment, aerial photography, and photographs taken on a field visit.

The floodplain boundaries for all the restudied streams were delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps (U.S. Department of the Interior, 1975, et cetera).

10.3 Third Revision

The study dated January 3, 1997, incorporates the effects of channel improvements from just upstream to approximately 3,900 feet upstream of East Nine Drive, construction of a 12- by 6-foot concrete box culvert from the confluence with Salt Creek to approximately 260 feet upstream of the confluence, construction of a 120-inch reinforced-concrete pipe from the upstream end of the concrete box culvert to just downstream of Camino Del Avion, and construction of a 10- by 8-foot concrete box culvert from the upstream end of the reinforced-concrete pipe to just upstream of East Nine Drive along Arroyo Salada. This study also incorporate the redesignation of the flooding along the Santa Ana River as Zone A99 and LOMRs, Letters of Map Revision Based on Fill (LOMR-Fs), and Letters of Map Amendment (LOMAs) issued previously for Orange County, California and Incorporated Areas.

The width of the SFHA, the area subject to inundation by the base (1-percent annual chance) flood, along Arroyo Salada increased in some areas and decreased in others. The SFHA is also known as the 1-percent annual chance floodplain. The base flood is contained in the culverts and the reinforced-concrete pipe along Arroyo Salada from its confluence with Salt Creek to just upstream of East Nine Drive. The BFEs have been removed and the zone designation changed to Zone A along Arroyo Salada from just upstream to approximately 3,900 feet upstream of East Nine Drive.

The zone designation of the 1-percent annual chance floodplain for the Santa Ana River has been redesignated Zone A99, based on the construction of the Santa Ana River Mainstem flood-control project, which includes two critical features: channel and bridge widening and channelization of the Lower Santa Ana River Channel Reaches 1 through 4, and construction of the Seven Oaks Dam. The Zone A99 designation is used to identify areas that are protected from the 1-percent annual chance flood by a Federal flood-protection system under construction, with no flood elevations determined.

The unincorporated areas of Orange County and the Cities of Anaheim, Costa Mesa, Fountain Valley, Garden Grove, Huntington Beach, Newport Beach, Orange, Santa Ana, Westminster, and Yorba Linda are affected by this construction. All communities have provided sufficient evidence of compliance with the adequate progress requirements of Paragraph 61.12(b) of the NFIP regulations, as well as with all other portions of Section 61.12.

The LOMR issued on June 15, 1990, for the City of Anaheim was based on the placement of fill and the construction of a levee along the south bank of the Santa Ana River, from approximately 600 feet to approximately 400 feet downstream of Weir Canyon Road.

The LOMA issued on April 22, 1993, determined that the property described as Lots 8-13, Tract No. 7284, Lots 47-48, Tract No. 5409, and Lots 35-48, Tract 5827, in the City of Anaheim would not be inundated by the 1-percent annual chance flood.

The LOMR issued on February 28, 1996 (Case No. 96-09-344P), for the Cities of Huntington and Westminster were based on the channelization of the Anaheim-Barber City Channel from its confluence with the Bolsa Chica Channel to just downstream of the San Diego Freeway. The width of the SFHA associated with the Anaheim-Barber City Channel decreased along the revised reach. The maximum decrease in SFHA width, 180 feet, occurred approximately 3,200 feet downstream of the San Diego Freeway. The 1-percent annual chance flood is contained within the identified channel banks of the Anaheim-Barber City Channel along the revised reach.

The LOMR issued on June 29, 1993, for the City of Yorba Linda (Case No. 93-09-076P), was based on the installation of underground conduits and channelization along Channel E04501 (also known as E04S02), Atwood Channel, and Bee Canyon Creek. As a result of this revision, the width of the SFHA decreased along the revised reaches of Channel E04501 and Bee Canyon Creek. As a result of this revision, the width of the SFHA decreased along the revised reaches of Channel E04501 and Bee Canyon Creek. Along Atwood Channel, an increase in SFHA width occurred at the intersection of Grandview Avenue and Alamo Lane. The width of the SFHA decreased along the remaining revised reaches of Atwood Channel. The 1-percent annual chance flood is contained within an underground conduit and/or streets along E04501 from the Yorba Reservoir to the Richard Nixon Freeway, and from approximately 350 feet downstream of Yorba Linda Boulevard to approximately 500 feet upstream of Hideway Avenue. The 1-percent annual chance flood is contained within an underground conduit or channel along Atwood Channel from approximately 500 feet upstream of Mountain View Avenue, and from Yorba Linda Boulevard to Del Caballo. The 1-percent annual chance flood is contained within an underground conduit along the entire revised reach of Bee Canyon Creek.

The LOMR-F issued on June 23, 1993, determined that the property described as Lot 94, Tract No. 7974, in the City of Yorba Linda would not be inundated by a 1-percent annual chance flood.

The LOMR issued on April 29, 1992, for the City of Anaheim was based on improvements and relocation of Esperanza Canyon Channel from its confluence with the Santa Ana River to the ATSFRR.

The LOMR issued on May 29, 1992, for the City of Yorba Linda was based on the construction of an underground box conduit along Esperanza Canyon Channel from the City of Yorba Linda corporate limits to Dominguez Ranch Road, and a concrete-lined channel from Dominguez Ranch Road to approximately 800 feet upstream of Felipa Road. The 1-percent annual chance flood is contained within the underground box conduit from the City of Yorba Linda corporate limits to Dominguez Ranch Road and the identified channel banks from Dominguez Ranch Road to approximately 800 feet upstream of Felipa Road.

The LOMR issued on July 14, 1992, for the City of Yorba Linda was based on updated hydrologic and hydraulic analyses along Richfield Channel from the City of Yorba Linda corporate limits to Buena Vista Avenue. The 1-percent annual chance flood is contained within the identified channel banks of Richfield Channel along the revised reach.

The LOMR-F issued on December 16, 1992, determined that the property described as Lot 4, Tract No. 12299, in the City of Orange would not be inundated by a 1-percent annual chance flood

The LOMR issued on July 10, 1996, for the City of Irvine (Case No. 96-09-738P) was based on channelization along San Diego Creek from the Laguna Freeway to just downstream of the San Diego Freeway, channelization along Agua Chinon Wash from its confluence with San Diego Creek to approximately 650 feet upstream of the confluence, construction of a RCB culvert along Agua Chinon Wash from approximately 650 feet upstream of its confluence with San Diego Creek to the existing culvert at Irvine Center Drive, and construction of a RCB culvert along Bee Canyon Wash from its confluence with San Diego Creek to the Santa Ana Freeway. The 1-percent annual chance flood is contained within the identified culverts along Agua Chinon and Bee Canyon Washes.

The LOMR issued on July 23, 1996, for the City of Irvine (Case No. 96-09-605P) was based on the construction of RCB culverts along Agua Chinon Wash from the Santa Ana Freeway to the ATSFRR; construction of a RCB culvert along Barranca Parkway from the culvert along Agua Chinon Wash to approximately 1,040 feet upstream of the culvert; and updated topographic information along Borrego Canyon Wash from Barranca Parkway to just upstream of the ATSFRR. The 1-percent annual chance flood is contained within the identified culverts along Agua Chinon Wash and Barranca Parkway.

10.4 Fourth Revision

The study dated February 18, 2004, converts the FIRM for Orange County and incorporated areas to digital format and to include mappable LOMRs, LOMR-Fs, and a floodplain study within the El Toro Marine Corps Air Station (MCAS). The newly studied flooding sources within the El Toro MCAS include Agua Chinon Wash, Bee Canyon Wash, Borrego Canyon Wash, and Round Canyon Wash.

The mapping has been prepared using digital data with new panel numbering. Previously published FIRM data produced manually have been converted to vector digital data by a digitizing process.

The El Toro MCAS has closed and the flood hazards within that area have been shown on the Orange County FIRM. The floodplain mapping for MCAS was based on the information contained in the report entitled "Flood Plain Information (FPI), Tributaries of Upper San Diego Creek, Orange County, California," prepared by the USACE, dated December 1974.

Bee Canyon, Round Canyon, Agua Chinon Wash, and Borrego Canyon Wash all have their headwaters in the foothills of the Santa Ana Mountains. The streams flow southwestward across an alluvial plain, eventually flowing into San Diego Creek and Newport Bay.

The LOMR issued on June 14, 2000, for the Cities of Anaheim, Fountain Valley, Garden Grove, Huntington Beach, Newport Beach, Orange, Santa Ana, Westminster, and Costa Mesa and the unincorporated areas of Orange County (Case No. 00-09-153P) was incorporated to show the effects of the completion and certification of the Santa Ana River Mainstem project from the Pacific Ocean to Imperial Highway. The zone designation within the levees along the Santa Ana River changed from Zone A99 to Zone A and the zone designation for the overbank areas changed to Zone X (shaded), an area protected from the base flood by construction of a levee, in those areas not affected by residual flooding. The residual floodplains along East Garden Grove-Wintersburg Channel, Ocean View Channel, Greenville Banning Channel, Fairview Channel, Gisler Channel, Santa Ana Gardens Channel, and Santa Ana Delhi Channel were completed by Orange County to show the underlying flooding that would remain upon completion of the Santa Ana River Mainstem Project. These floodplains are designated Zone A.

The LOMR issued on January 10, 2001, for the City of Fountain Valley (Case No. 01-09-266P) was incorporated to show the residual floodplain along Fountain Valley Channel. This study was prepared by West Consultants under FEMA contract No. EMF-96-CO-0100.

The LOMR issued on February 13, 2002, for the City of Huntington Beach (Case No. 00-09-825P) was incorporated to show the residual floodplains and effects of a levee system along Huntington Beach Channel, Talbert Channel, and Fountain Valley Channel. The study was prepared by West Consultants under FEMA Contract No. EMF-96-CO-0100. The tidal effects of the Pacific Ocean on the riverine flooding were evaluated. The remaining flooding along the Santa Ana River overbank areas changed from Zone A99 to Zone X (shaded), an area protected from the 1-percent annual chance flood by construction of a levee, in those areas not affected by residual flooding.

The residual floodplains along Huntington Beach Channel and Talbert Channel and their overbanks were designated Zone AE, an SFHA with BFEs determined.

Table 13, "Letters of Map Change," has been included to show all LOMRs and LOMR-Fs that have been incorporated. In addition, changes established by those LOMRs and LOMR-Fs have been incorporated into Table 7, "Summary of Discharges"; Table 11, "Floodway Data"; and Exhibit 1, Flood Profiles, where applicable.

10.5 Fifth Revision

The restudy December 3, 2009, delineates the flood hazards for four stream reaches and their tributaries located within the City of Laguna Beach. Detailed hydrologic and hydraulic analysis of portions of Aliso Creek, Bluebird Canyon, Canyon Acres Wash, and Laguna Canyon were included in the study. The study area includes a combined stream length equaling approximately 7 miles and a contributing drainage area of approximately 45 square miles.

MAPIX-Mainland (MAPIX-M), a Joint Venture consisting of URS, Dewberry, Schaaf & Wheeler, Airborne 1, and TerraPoint, was contracted by FEMA Region IX to perform this flood insurance study under contract number EMF-2003-CO-0047, Task Order 014. The study was completed in March 2006.

The hydrologic methodology used to conduct the analysis was done following the procedures found in the *Orange County Hydrology Manual* (Orange County Environmental Agency 1996) and Addendum No. 1 to the *Orange County Hydrology Manual* (Orange County Environmental Agency 1995). Hydrologic analyses were carried out to establish peak discharge-frequency relationships at hydrologically significant locations for each flooding source studied.

To verify the computed peak discharges of the studied streams, a “comparison methodology” was utilized. This method compares another stream within the area, with effective FIS data and similar watershed characteristics. The following streams were utilized to compare the peak discharges of the study streams:

- Aliso Creek: Trabuco Creek (35 sq. mi.), San Diego Creek (30 sq. mi.), and Peters Canyon Wash (36 sq. mi.)
- Laguna Canyon: Coyote Creek (11 sq. mi.), Atwood Channel (9.4 sq. mi.), El Modena- Irving Channel, at confluence with Browning Ave. Channel (10 sq. mi.)
- Bluebird Canyon: El Modena-Irving Channel, at start of open channel (1.3 sq. mi.), Laguna Wash Rd (1.1 sq. mi.), Segunda Deshecha Canada Tributary (1.1 sq. mi.)

The comparison showed that the drainage areas and resultant discharges are within a reasonable range of each other.

Peak discharges for all the restudied streams were also calculated using USGS regression equations included in a report entitled, “Nationwide Summary of U.S. Geological Survey Regional Regression Equations for Estimating Magnitude and Frequency of floods for Ungaged Sites,” 1993.

Peak discharges per unit area curves were generated for the Aliso Creek, Laguna Canyon, and Bluebird Canyon watersheds and the results computed by the rainfall-runoff model and the regression equations. When a comparison of all the curves was made, it was determined that the discharges generated by the rainfall-runoff model were reasonable.

The new peak discharges were also compared to the effective peak discharges.
The new peak discharges for Aliso Creek and Bluebird Canyon were higher than the effective discharges, while the new peak discharges for Laguna Canyon were lower than the effective peak discharges. Canyon Acres Wash was previously

studied using approximate methods and does not have published peak discharges, thus a comparison could not be made.

The new peak discharges for Aliso Creek are likely attributed to an increase in drainage area. The effective discharges are based on a drainage area of approximately 28 square miles and the new peak discharges are based on a drainage area of approximately 35 square miles. The effective FIS indicates that the peak discharges for Bluebird Canyon were computed using a multiple regression equation. The regression equation did not account for basin slope. The contributing watershed for Bluebird Canyon is mountainous with steep slopes that can significantly reduce the time of concentration leading to increased peak discharges. In addition, new development in the Aliso Creek and Bluebird Canyon watersheds also can contribute to the increase in peak discharges.

The decrease in the peak discharges for Laguna Canyon can be attributed to the construction of the El Toro Toll Way, which has implemented a detention basin at the intersection of the El Toro Toll Road and El Toro Road, to attenuate the peak discharges of Niguel Creek (a tributary to Laguna Canyon). In addition, the effective peak discharges were previously determined through a correlation analysis using the stream gage for Aliso Creek. There are three lakes towards the upstream portions of the study area that provide storage that may not have been accounted for in the correlation analysis.

The peak discharges were calculated with HEC-1, which was developed with the aid of Geo-HMS and WMS. The input parameters were developed using the procedures outlined in the *Orange County Hydrology Manual.*

The calculated discharges were deemed reasonable when the peak discharges per unit area curves were compared to the peak discharges per unit area curves developed from the regression equations and other streams (with similar watershed characteristics) in Orange County that had published discharges in the previous Orange County FIS. In addition, the new peak discharges were deemed acceptable when compared to the effective discharges.

The scope of this revision stated that, for all revised streams, the water surface profiles for the 10%, 2%, 1%, and 0.2% flood discharges were to be computed. Therefore, where appropriate, the USACE's HEC-RAS (RAS), Version 3.1.1 (USACE 2003) step-backwater computer model was used to compute these profiles. The starting water surface elevations were based on the normal depth slope of the channel at the downstream limit of each study reach.

Aliso Creek is a large natural watercourse that has remained predominantly undisturbed. The total length of studied stream starts from its confluence with Pacific Ocean and concludes at a point approximately 5,210 linear feet upstream. A floodway was not developed for Aliso Creek as it is located along an environmentally sensitive area, which is regulated and prohibits any encroachment within the 1% annual chance floodplain. The floodplain mapping contained herein reflects a, 1%, and a 0.2% annual chance floodplain boundary. Base Flood Elevations are also included along the entire studied reach.

Bluebird Canyon is a small deeply incised channel that drains directly into the Pacific Ocean. The total length of studied stream starts from its confluence with Pacific Ocean and concludes at a point approximately 520 feet upstream of Cress Street for a total studied stream length of approximately 3,280 feet. There are three stream crossings in the model, which includes the extended storm drain at the downstream end, an extended culvert that passes underneath both Cress Street and Bluebird Canyon Park, and a private driveway just upstream of Cress Street.

The hydraulic modeling of Bluebird Canyon required the use of the split-flow optimization option to accurately balance the floodwater conveyance between an overland flow component and long continuous concrete pipes at two locations in the model. The first occurrence of this situation is at the downstream end of Bluebird Canyon. At the downstream limit of Bluebird Canyon there is an 84-inch diameter, reinforced concrete pipe, which conveys water from a point just upstream of Glenneyre Street and to a point downstream where it outlets on the beach at the Pacific Ocean. The Orange County Flood Control District provided as-built drawings for the large storm drain, titled "Bluebird Storm Drain – Ocean Outlet to Glenneyre Street", dated November, 1966, which allowed a hydraulic grade-line for the drain to be calculated. It was determined that this drain is under the influence of inlet control during the analyzed recurrence intervals. As a result, this permitted the drain to be analyzed as a single continuous pipe with a uniform slope in the HEC-RAS model. The stormdrain was modeled as an artificial stream that splits away from the normal stream centerline of Bluebird Canyon. The program automatically varies the discharge between the extended pipe and the overland flow area that spills over Glenneyre Street and travels overland until reaching the Pacific Ocean in the same location that the stormdrain outlets. The flow is varied until the elevations of the energy grade-lines are equal to each other. For example, the total peak 1% annual chance discharge predicted to runoff at the storm drain inlet is 1,153 cfs; however, when using the split-flow optimization function it is determined that only 795 cfs will convey through the storm drain itself while the remaining 358 cfs will spill over Glenneyre Street and travel overland until it reaches the beach at the Pacific Ocean. The energy-grade line for the overland flow component is developed through regular step-backwater calculations from cross sections that have been cut from the digital elevation model through this vicinity, while the energy-grade line for the piped component are developed through standard pipe inlet/outlet control computations. The program also splits flow for the 2% and 0.2% recurrence intervals at the Bluebird Canyon storm drain. The storm drain is able to fully convey the anticipated 10% peak flow so no overland flow is expected during this event. The overland flow area, downstream of Glenneyre Street, appears to be relatively shallow. As a result the mapping through this vicinity changes from a Zone AE to a Zone AO (2 foot depth).

Similar to the Bluebird Storm Drain, there is an extended 66-inch diameter, reinforced concrete pipe that extends from a point just upstream of Cress Street downstream approximately 560 feet to a point just south of Bluebird Park. Unfortunately, unlike the Bluebird Canyon Storm Drain, no as-built drawings for this pipe exist on record so the assumed pipe inverts were measured directly from the digital elevation model and the pipe orientation was also assumed. Based on the orientation of the inlet and outlet, it is anticipated that the extended culvert system includes a single bend of approximately 30-degrees. In an attempt to account for the small bend loss, the entrance loss coefficient was increased from the standard k_{ent}=0.5 to k_{ent}=0.7. The split flow optimization option is also applied at this location to distinguish between the anticipated amounts of floodwater traveling overland versus through the extended culvert. Based on the modeling results, all of the profiles are expected to include a fraction of overland flow. The mapping through the park's vicinity remains to be a Zone AE, connecting both the total combined flow at the upstream and downstream ends.

The HEC-RAS model for Bluebird Canyon includes three plans. Since the 10% flood discharge did not overtop Glenneyre Street at the downstream flow split, a separate run had to be developed specifically for the 10% annual chance flood event, where the split flow at this location was removed in order for HEC-RAS to properly execute. A second plan includes both flow splits at the Bluebird Canyon Storm Drain and Bluebird Canyon Park, which models the 2%, 1%, 0.2%, and floodway runs. The remaining plan was developed for mapping purposes only and uses "known water-surface elevations" at every cross section for each mapped recurrence interval. HEC-RAS was unable to successfully export the data to GIS using the plans that included the artificial flow split. Therefore, the mapping plan was prepared by removing the extended pipes (modeled as artificial stream splits in HEC-RAS) and using the computed water-surface elevations from the other two plans by manually inputting the known water-surface elevations at each cross section in the model. A floodway was also prepared for Bluebird Canyon. The floodway begins just upstream of Glenneyre Street at the Bluebird Canyon Storm Drain inlet and continues upstream to the upstream limit of detailed study at Bluebird Canyon Lane.

The 1% annual chance floodplain mapping along Bluebird Canyon provided with this study includes areas of shallow flooding Zone AO (depth 2 feet) along the Bluebird Canyon storm drain and Zone AE for the remaining studied limits. The 0.2% floodplain is also included in areas shown as shaded Zone X. In addition, Base Flood Elevations are also included along the areas mapped as Zone AE.

Canyon Acres Wash is a small tributary that drains into Laguna Canyon. The total length of studied stream starts from its confluence with Laguna Canyon to a point approximately 2,460 feet upstream, near the end of Canyon Acres Drive. A floodway was not developed for Canyon Acre Wash. The floodplain mapping contained herein reflects a 1%, 0.2% floodplain boundary. Base Flood Elevations are also included along the entire studied reach.

Laguna Canyon is a stream that has been impacted significantly by development. Beginning at approximately RS 13956 a manmade concrete lined channel has been constructed to alleviate flooding in the canyon. The channel extends downstream until it enters a box culvert at Beach Street and discharges into the Pacific Ocean. The starting water surface elevation was determined based on the slope-area method (normal depth).

The manmade channel has varying dimensions and has multiple cross-sectional shapes that transition from rectangular to trapezoidal and vise-versa. The channel has multiple road crossings, all of which have been modeled. In addition, there is a long (approximately one mile in length) box culvert that begins at approximately

360 feet upstream of Raquel Road to approximately 3,000 feet upstream of Canyon Acres Drive that also has varying dimensions and slopes.

Once the flow exits the culvert, it enters the manmade channel and flows downstream through the "Big Bend" area of Laguna Canyon. In this area, the channel has been constructed under numerous buildings. Neither the culvert nor the channel has the capacity to contain the 1% annual chance flood. In order to model the hydraulics of the stream, a HEC-RAS model was developed for the concrete channel from the "Big Bend" culvert to the Beach Street culvert. This model provides the amount of flow that can be carried by the concrete channel.

The discharges for the different flood frequencies from the hydrologic model between the "Big Bend" culvert and the Beach Street culvert were reduced by the amount of flow that can be carried by the concrete channel. A second HEC-RAS model was developed with the reduced flows for the area between the "Big Bend" culvert and Beach Street and the discharges from the hydrologic model for the areas upstream of the "Big Bend" culvert. The second HEC-RAS model was used to determine the flood profiles, floodway, and the floodplain boundaries.

Behind-Levee Analyses

Some flood hazard information presented in prior FIRMs and in prior FIS reports for Orange County and its incorporated communities was based on flood protection provided by levees. Based on the information available and the mapping standards of the National Flood Insurance Program (NFIP) at the time that the prior FISs and FIRMs were prepared, FEMA accredited the levees as providing protection from the flood that has a 1-percent annual chance of being equaled or exceeded in any given year. For FEMA to continue to accredit the identified levees with providing protection from the base flood, the levees must meet the criteria of the Code of Federal Regulations, Title 44, Chapter I, Section 65.10 (44 CFR 65.10), titled "Mapping of Areas Protected by Levee Systems."

On August 22, 2005, FEMA issued "Procedure Memorandum No. 34 – Interim Guidance for Studies Including Levees." The purpose of the memorandum was to help clarify the responsibility of community officials or other parties seeking recognition of a levee by providing information identified during a study/mapping project. Often, documentation regarding levee design, accreditation, and the impacts on flood hazard mapping is outdated or missing altogether. To remedy this, Procedure Memorandum No. 34 provides interim guidance on procedures to minimize delays in near-term studies/mapping projects, to help our mapping partners properly assess how to handle levee mapping issues.

While documentation related to 44 CFR 65.10 is being compiled, the release of a more up-to-date FIRM for other parts of a community or county may be delayed. To minimize the impact of the levee recognition and certification process, FEMA issued "Procedure Memorandum No. 43 – Guidelines for Identifying Provisionally Accredited Levees" on March 16, 2007. These guidelines allow issuance of the FIS and FIRM while levee owners or communities compile full documentation required to show compliance with 44 CFR 65.10. The guidelines also explain that a FIRM can be issued while providing the communities and levee owners with a specified timeframe to correct any maintenance deficiencies associated with a levee and to show compliance with 44 CFR 65.10.

FEMA contacted the communities within Orange County to obtain data required under 44 CFR 65.10 to continue to show the levees as providing protection from the flood that has a 1-percent annual chance of being equaled or exceeded in any given year.

FEMA understood that it may take time to acquire and/or assemble the documentation necessary to fully comply with 44 CFR 65.10. Therefore, FEMA put forth a process to provide the communities with additional time to submit all the necessary documentation. For a community to avail itself of the additional time, it had to sign an agreement with FEMA. Levees for which such agreements were signed are shown on the final effective FIRM as providing protection from the flood that has a 1-percent annual chance of being equaled or exceeded in any given year and labeled as a Provisionally Accredited Levee (PAL). Communities have two years from the date of FEMA's initial coordination to submit to FEMA final accreditation data for all PALs. Following receipt of final accreditation data, FEMA will revise the FIS and FIRM as warranted.

FEMA coordinated with the local communities and other organizations to compile a list of levees, based on information from the FIRM and community provided information. Levees along East Garden Grove – Wintersburg Channel, Talbert Channel and Santa Ana River are certified except in the City of Yorba Linda. Some of the levees along Fountain Valley Channel and Huntington Beach Channel are also certified.

Approximate analyses of "behind levee" flooding were conducted for the levees which were not certified, to indicate the extent of the "behind levee" floodplains. The methodology used in these analyses is discussed below.

Levee structure ID#s 284 and 285 are located on the San Gabriel River. A behind levee floodplain is recommended for these structures. These levees are operated and maintained by Los Angeles County. Please refer to the Los Angeles County and Incorporated Areas, California Flood Insurance Study for information on these levees and the computation of the behind levee floodplain.

Levee structure ID# 353 located on Huntington Beach Channel. Based on a review of the USGS 10m DEM topographic information and the BFEs on the effective FIRM, the area on the landward side of the structure is higher than the BFEs. No change in flood hazards is recommended.

Levee structures ID#s 358 and 377 are located on Huntington Beach Channel. Based on the flood hazards shown on the effective FIRM, these structures do not provide protection from the base flood. No change in flood hazards is recommended.

Levee structures ID#s 367 and 369 are located on Arroyo Trabuco Creek. Using the BFEs from the effective FIRM and USGS 10m DEMs topographic information, the behind levee floodplain was delineated on the landward side of the structures.

Levee structures ID#s 368 and 370 are located on San Juan Creek. For the northern segments of these levees, the behind levee floodplain was delineated using the BFEs from the effective FIRM and USGS 10m DEMs topographic information. For the southern segment of levee structure ID# 368 where there are no BFEs, an approximate hydraulic analysis was used to delineate the behind levee floodplain. A discharge of 42,000 cfs (from the effective FIS) and USGS 10m DEM topographic information was used in the approximate hydraulic analysis. For the southern segments of levee ID# 370, the levee does not provide protection from the base flood. Therefore, no change in flood hazards is recommended.

Part of levee structure ID# 383 is located in the City of Yorba Linda along the Santa Ana River. An A99 Zone was shown incorrectly at this location on the riverside of the levee. Based on a comparison of the USGS 10m DEM topographic data and BFEs which preceded the A99 Zone, there is a depression behind the levee. Using the BFEs that preceded the A99 Zone and the USGS 10m DEM topographic data the behind levee floodplain was delineated on the landward side of the levee.

Levee structure ID# 1361 is located on the San Diego Creek Channel. An approximate hydraulic analysis using the discharges from the effective FIS (17,500 cfs and 18,500 cfs) and USGS 10m DEM topographic information was used to delineate the behind levee floodplain.

TABLE 13 – LETTERS OF MAP CHANGE

Community	Flooding Source(s)/Project Identifier	Date Issued
CITY OF ANAHEIM		
Residual Floodplain Underlying Santa Ana River	Pond 1 and 2, Santa Ana River, South East Anaheim Channel	January 13, 2000
Santa Ana River Mainstream Flood Control Project	Santa Ana River	June 14, 2000
Santa Ana River	Santa Ana River	June 14, 2000
Atwood Channel	Atwood Channel	February 26, 2004
CITY OF BREA		
Unnamed Stream	Brea Canyon Channel	November 8, 1994
Coyote Canyon Creek	Coyote Canyon Creek Improvements	April 21, 2004
Study Update	Study Update	August 19, 2008
CITY OF BUENA PARK		
Tract 15359, Lots 1-9; Tract 15528, Lots 1-55; Tract 15529, Lots 1-33, and Tract 15530, Lots 1-26	Brea Creek Channel	October 5, 1998

TABLE 13 – LETTERS OF MAP CHANGE - continued

Community	Flooding Source(s)/Project Identifier	Date Issued
CITY OF COSTA MESA		
Santa Ana River Mainstream Flood Control Project	Santa Ana River	June 14, 2000
Residual Floodplain Study Gisler Channel	Gisler Channel	June 14, 2000
Residual Floodplain Study Greenville Banning and Fairview Channels	Fairview Channel, Greenville Banning Channel	June 14, 2000
CITY OF DANA POINT		
Wave Elevation Table Update	Wave Elevation Table Update	October 21, 2004
CITY OF FOUNTAIN VALLEY		
Santa Ana River Mainstream Flood Control Project	Santa Ana River	June 14, 2000
Santa Ana River Residual Floodplain	Fountain Valley Channel, Huntington Channel and Talbert Channel	June 14, 2000
East Garden Grove, Wintersburg, and Ocean View Channel Watershed	East Garden Grove Channel, Ocean View Channel, and Wintersburg Channel	June 14, 2000
FEMA Certification of Orange County Levees	Fountain Valley Channel and Talbert Channel	January 10, 2001
CITY OF FULLERTON		
Euclid Storm Drain Project	Unnamed Stream	February 21, 1992
Sheppard Drive Storm Drain	Zone AO at VA. Rd. Sheppard Dr.	January 6, 1997
Domingo Inlets Redondo Place To Terranza Place	Local Flooding	March 13, 1998
CITY OF GARDEN GROVE		
Santa Ana River Mainstream Flood Control Project	Santa Ana River	June 14, 2000
East Garden Grove, Wintersburg and Ocean View Channel Watershed	East Garden Grove Channel, Ocean View Channel and Wintersburg Channel	June 14, 2000

TABLE 13 – LETTERS OF MAP CHANGE - continued

Community	Flooding Source(s)/Project Identifier	Date Issued
CITY OF HUNTINGTON BEACH		
Santa Ana River Mainstream Flood Control Project	Santa Ana River	June 14, 2000
Santa Ana River Residual Floodplain	Fountain Valley Channel, Huntington Channel and Talbert Channel	June 14, 2000
Wave Elevation Table Update	Wave Elevation Table Update	October 21, 2004
Revisions of Base Maps	Revision of panel 06059C00227H	April 13, 2005
Talbert Channel	Talbert Channel Levee Certification Evaluation/TC	July 30, 2007
East Garden Grove, Wintersburg and Ocean View Channel Watershed	East Garden Grove Channel, Ocean View Channel and Wintersburg Channel	June 14, 2000
FEMA Certification of Orange County Levees	Fountain Valley Channel and Talbert Channel	January 10, 2001
FEMA Certification of Orange County Levees	Fountain Valley Channel, Huntington Beach Channel, Huntington Beach Channel Overbank, Talbert Channel, and Talbert Channel Overbank	February 13, 2002
CITY OF IRVINE		
Barranca Parkway Project	Marshburn Wash	March 4, 1994
Spectrums 2 and 3	Serrano Creek, Spectrums 2 and 3	March 30, 1995
Northwood 5 Interim Detention Basin	Hicks Canyon Wash	October 25, 1995
Valencia Channel Storm Drain	Valencia Channel	April 8, 1997
Agua Chinon Wash	Agua Chinon Wash	August 4, 1998
Atchison, Topeka and Santa Fe Railway/Metrolink Railroad Crossing	Bee Canyon Wash	August 20, 1998
Hicks Canyon and East Hicks Canyon Retarding Basins	Hicks Canyon Wash	October 19, 1998
Spectrum 2 Area	Serrano Creek	August 18, 1999
Marine Corps Air Station	Barranca Channel, Peter's Canyon Channel, Santa Ana-Santa Fe Channel	September 13, 1999
Lower Peters Canyon	El Modena-Irvine Channel, Hicks Canyon Channel, Peters Canyon Channel, and Rattlesnake Canyon Channel	December 29, 1999

TABLE 13 – LETTERS OF MAP CHANGE - continued

PROJECT	FLOODING SOURCE	LETTER
CITY OF IRVINE (continued)		
San Diego Creek From San Canyon Avenue to Jeffrey Road	San Diego Creek	January 27, 2000
Laguna Hills	Veeh Creek (San Diego Creek Tributary 2)	May 26, 2000
Mashburn Wash, Bee and Round Canyon	Mashburn Wash	July 2, 2002
Unnamed channel tributary to Central Irvine Channel	Northern sphere area, PA 9A, City of Irvine	June 23, 2005
Borrego Canyon Wash Channel	Borrego Canyon Wash Channel	October 16, 2006
San Diego Creek and Serrano Creek	San Diego Creek and Serrano Creek Channel improvements, September 2003	April 30, 2007
Channelization Fill	San Diego Creek Channel Improvements, Spectrum 5-Phase 3 Downstream	May 22, 2008
Reissuance	Reissuance of LOMR 98-09-899P	August 29, 2008
Addition of Culvert in Planning Area 17 (Pa 17)	Planning Area 17 (Pa 17)	October 28, 2008
Planning Area 6 (Pa 6)	Planning Area 6 (Pa-6) Phase 1 / Tract 16562	December 29, 2008
CITY OF LAGUNA BEACH		
Wave Elevation Table Update	Wave Elevation Table Update	October 21, 2004
CITY OF LAGUNA HILLS		
Laguna Hills	Veeh Creek (San Diego Creek Tributary 2)	May 26, 2000
CITY OF LAGUNA NIGUEL		
San Juan Canyon	San Juan Canyon Map Revision	May 05, 2005
CITY OF LA HABRA		
Coyote Canyon Creek	Coyote Canyon Creek Improvements	April 21, 2004
CITY OF LAKE FOREST		
Lake Forest Lakes 1A, 1B, and 2	Lake Forest Lake 1A, 1B, and 2	March 8, 1999
Spectrum 2 Area	Serrano Creek	August 18, 1999

TABLE 13 – LETTERS OF MAP CHANGE - continued

PROJECT	FLOODING SOURCE	LETTER
CITY OF MISSION VIEJO		
Ortega Channel	Ortega Wash and Wash 1	December 28, 1994
CITY OF NEWPORT BEACH		
Newport Business Center	Santa Ana-Delhi Channel	March 4, 1991
Santa Ana River Mainstream Flood Control Project	Santa Ana River	June 14, 2000
Residual Floodplain Study Gisler Channel	Gisler Channel	June 14, 2000
Residual Floodplain Study, Greenville Banning and Fairview Channels	Fairview Channel, Greenville Banning Channel	June 14, 2000
Wave elevation table update	Wave Elevation Table Update	October 21, 2004
ORANGE COUNTY (UNINCORPORATED AREAS)		
Barranca Parkway Project	Marshburn Wash	March 4, 1994
Unnamed	Borrego Canyon Wash	June 7, 1994
Northwood 5-Rattlesnake	Rattlesnake Canyon Wash	October 20, 1994
Unnamed	La Paz Channel	December 28, 1994
Tijeras Canyon Town Center	Tijera Canyon	July 11, 1995
Northwest 5 Interim Detention Basin	Hicks Canyon Wash	October 25, 1995
Coto De Caza	Canada Gobernadora	July 11, 1996
Foothill Ranch	Borrego Canyon Wash	September 5, 1996
Hicks Canyon and East Hicks Canyon Retarding Basins	E. Hicks Canyon Retarding Basin and Hicks Canyon Wash	October 19, 1998
Lower Peters Canyon	El Modena-Irvine Channel, Hicks Canyon Channel, Peters Canyon Channel and Rattlesnake Canyon Channel	December 29, 1999
Santa Ana River Mainstream Flood Control Project	Santa Ana River	June 14, 2000
Santa Ana River	Santa Ana River	June 14, 2000
Residual Floodplain Study Greenville Banning and Fairview Channels	Fairview Channel, Greenville Banning Channel	June 14, 2000
E. Garden Grove, Wintersburg and Ocean View Channel Watershed	East Garden Grove Channel, Ocean View Channel and Wintersburg Channel	June 14, 2000
San Juan Creek	San Juan Creek (PA-1)	August 31, 2006
Borrego Canyon Wash	Borrego Canyon Wash Channel	October 16, 2006
Peters Canyon Wash	Peters Canyon Wash	May 31, 2007

TABLE 13 – LETTERS OF MAP CHANGE - continued

PROJECT	FLOODING SOURCE	LETTER
CITY OF ORANGE		
Tract 14952	Santiago Creek	March 7, 1996
Santa Ana River Mainstream Flood Control Project	Santa Ana River	June 14, 2000
Santa Ana River	Santa Ana River	June 14, 2000
Santiago Creek-Reissuance of 96-09-427P	Santiago Creek	April 23, 1997
Peters Canyon Wash	Peters Canyon Wash	May 31, 2007
CITY OF PLACENTIA		
Carbon Canyon Channel	Carbon Canyon Channel	February 27, 1997
Carbon Canyon Channelization	Carbon Canyon Channel	June 9, 1999
CITY OF SANTA MARGARITA		
Tijeras Creek Bridge	Foothill Transportation Corridor - Tijeras Creek Bridge	March 30, 2004
Canada Chiquita Culvert	Foothill Transportation Corridor - Canada Chiquita Culvert	June 8, 2004
CITY OF SAN CLEMENTE		
Unnamed Stream	Camino De Los Mares	October 18, 1995
Tentative Tract 15706 (Monarch-Camino De Los Mares/Portico Del Sur)	Prima Deshecha Canada Tributary	March 29, 2000
Wave Elevation Table Update	Wave Elevation Table Update	October 21, 2004
Segunda Deshecha	Talega Village 4	May 03, 2005
Segunda Deshecha Canada	Plaza Pacifica	June 30, 2008
CITY OF SANTA ANA		
Residual Floodplain Study Gisler Channel	Gisler Channel	June 14, 2000
Santa Ana River	Santa Ana River	June 14, 2000
Santa Ana River Mainstream Flood Control Project	Santa Ana River	June 14, 2000
Residual Floodplain Study Greenville Banning and Fairview Channels	Fairview Channel, Greenville Banning Channel	June 14, 2000
East Garden Grove, Wintersburg and Ocean View Channel Watershed	East Garden Grove Channel, Ocean View Channel and Wintersburg Channel	June 14, 2000

TABLE 13 – LETTERS OF MAP CHANGE - continued

PROJECT	FLOODING SOURCE	LETTER
CITY OF TUSTIN		
Tustin Ranch Golf Course	Peters Canyon Wash	January 25, 1995
Marine Corps Air Station	Barranca Channel, Peter's Canyon Channel and Santa Ana-Santa Fe Channel	September 13, 1999
Lower Peters Canyon	El Modena Irvine Channel, Hicks Canyon Channel, Peter's Canyon Channel and Rattlesnake Canyon Channel	December 29, 1999
Peters Canyon Wash	Peters Canyon Wash	May 31, 2007
CITY OF WESTMINSTER		
Santa Ana River Mainstream Flood Control Project	Santa Ana River	June 14, 2000
East Garden Grove, Wintersburg, Ocean View Channel Watershed, Garden Grove and Wintersburg, Ocean View Channel Watershed	East Garden Grove Channel, Ocean View Channel and Wintersburg Channel	June 14, 2000
CITY OF YORBA LINDA		
Yorba Linda Pines South	Yorba Linda Pines South	July 28, 2008

TABLE 14 – INLAND FLOODING ELEVATIONS

	ELEVATION (feet NAVD)		
LOCATION	10-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
TALBERT CHANNEL – WEST BANK			
Between Ski Harbor Circle, Spencer Circle, and Magnolia Street	*	5.8	*
Between Adams Avenue, Yorktown Avenue, and Magnolia Street	*	9.9	*
Between Clipper Drive, Breakers Drive, and Estuary Lane	*	8.1	*
Between Yorktown Avenue, Brabham Drive, and Magnolia Street	*	7.2	*
TALBERT CHANNEL – EAST BANK			
Between Adams Avenue, Cape Cod Drive, and Gloucester Lane	*	9.7	*

*Elevation not computed

TABLE 14 – INLAND FLOODING ELEVATIONS - continued

LOCATION	ELEVATION (feet NAVD) 10-PERCENT ANNUAL CHANCE	 1-PERCENT ANNUAL CHANCE	 0.2-PERCENT ANNUAL CHANCE
HUNTINGTON BEACH CHANNEL – WEST BANK			
Between Brookhurst Street and Magnolia	*	8.0	*
Near Banning Avenue	*	7.9	*
Between Edison Avenue and Newland Street	*	7.7	*
Between Newland Street, Beach Boulevard, and Atlanta Avenue	*	7.8	*
Between Beach Boulevard, 4th Street, and Atlanta Avenue	*	6.6	*
Between Atlanta Avenue, Beach Boulevard, and Indianapolis Avenue	*	7.3	*
Between Atlanta Avenue, Delaware Way, and Beach Boulevard	*	6.5	*
HUNTINGTON BEACH CHANNEL – EAST BANK			
Between Banning Avenue, Magnolia Street, and Bermuda Circle extended	*	8.0	*
Between Levee, Newland Street, Hamilton Avenue, and Surveyor Circle	*	6.8	*
Between Hamilton Avenue, Newland Street, Atlanta Avenue, and Brenton Lane	*	6.6	*
Between Levee, Atlanta Avenue, and Newland Street	*	7.2	*
Between Atlanta Avenue, Newland Street, and Magnolia Street	*	6.5	*
Between Atlanta Avenue, Munster Drive, and Newland Street	*	7.7	*
Between Munster Drive, Adams Avenue, and Waterfront Lane	*	8.8	*
Between Waterfront Lane, Northport Drive, and Port Greenwich Lane	*	6.5	*

*Elevation not computed