State of California

THE RESOURCES AGENCY

Department of Water Resources

BULLETIN No. 159-65

CALIFORNIA FLOOD CONTROL PROGRAM 1965

FEBRUARY 1965

HUGO FISHER
Administrator
The Resources Agency

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
Director
Department of Water Resources

Discharge below partially completed Oroville Dam December 23, 1964

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STATE OF CALIFORNIA—RESOURCES AGENCY

WILLIAM E. WARNE, *Director*

DEPARTMENT OF WATER RESOURCES

P.O. BOX 388
SACRAMENTO

January 29, 1965

Honorable Edmund G. Brown
Governor of California
State Capitol
Sacramento, California

Dear Governor Brown:

During the floods of the Christmas week of 1964, you ordered a review of the events during that flood and the preparation of a strengthened and accelerated flood control program. This work has just been completed and I am pleased to submit herewith the full report.

The program set forth in this bulletin would increase our capability to prevent and to combat floods, would coordinate and strengthen the flood control activities of all participating agencies, and would provide a program on which all agencies could work to provide much needed additional flood protection.

This is planned to be the first in a series of bulletins presenting an annual flood control program for the State.

Sincerely yours,

William E. Warne

Director

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

EDMUND G. BROWN, Governor, State of California
HUGO FISHER, Administrator, The Resources Agency
WILLIAM E. WARNE, Director, Department of Water Resources
ALFRED R. GOLZE', Chief Engineer

This report was prepared by a special committee
consisting of

Robin R. Reynolds, Chairman . . . . . Division Engineer,
Division of Operations

and

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CHAPTER I. INTRODUCTION

In late December, 1964 the northwestern United States was struck by a great storm from the Pacific Ocean. There was widespread devastation. Unprecedented rainfall produced great rain floods in the Pacific Coast rivers and deep snow packs were laid down in the high mountains.

There was widespread flooding in the northern half of California, and damage was particularly severe on the North Coast. Most of the major rivers carried the peak flows of record. Twenty-four lives were lost in California. The total direct damage in California is estimated at over $140,000,000, although the full story of the damage is still unfolding, since one month after the flood communication with many areas in the North Coast is not yet reestablished.

The great lesson of this flood comes from the fact that where dams and levees exist there was little or no flooding but where the rivers are uncontrolled there was great damage and destruction. The most impressive performance was turned in by the unfinished Oroville Dam on the Feather River which reduced the record peak flow of that stream by 100,000 cubic feet per second, undoubtedly preventing much flood damage and probably averting a disaster similar to that from the Christmas flood of 1955. With some of the existing dams there was a very close margin of safety. We came within a hair's breadth of

having an uncontrolled spillover from Folsom Reservoir into the American River which would have put Sacramento at the mercy of torrential flows into full channels.

The December 1964 flood has brought into sharp focus the need to fully examine the State's flood control facilities and program and flood fight resources.

California has developed an economy and has settled its 18 millions of people in areas which, for the most part, are subject to natural flooding. Recognizing this situation, the Legislature has declared repeatedly that the people of California have a primary interest in the prevention of loss of lives, property, and services that occur as the result of floods. The importance of the flood problem in California also is dramatized by the many flood control facilities and by the hundreds of reclamation and flood control districts, state agencies, and by several federal agencies, notably the Corps of Engineers, that are engaged in flood mitigating programs. The recent and past flood experiences indicate, however, that actions to date fall short of need. Additional flood protection must be provided as rapidly as possible.

This report reviews this great flood and other recent floods, appraises the State's flood control and flood fight resources, and, from the lessons learned, recommends a strengthened flood control program.

CHAPTER II. RECENT FLOODS IN CALIFORNIA

Since the days of pioneer settlement the people of California have suffered great floods. The record begins with a diary note of a great flood in the Los Angeles River in 1769-70. Floods in 1772, 1780, 1805, 1821, 1825, 1832, and 1849 were followed by the near-legendary flood of 1861-62. This was followed by major floods in 1867, 1879, 1881, 1890, 1907, 1909, 1911, 1917, 1928, 1934, 1937, 1938, 1940, 1941, 1945, and 1950.

Since 1950 there have been eight major floods which have caused great suffering, loss of human life, and extensive damage to property and to the economy of California.

The recent floods of November-December 1950, December, 1955, February and April, 1958, October, 1962, January-February, 1963, and December, 1964, are described briefly in the following paragraphs with regard to storm occurrence, flood flows, and damages. Significant precipitation records are summarized in Table 1; and flow and stages for representative stations are listed in Table 2.

Floods of November and December, 1950

During two storm periods, November 12-20 and December 2-8, 1950, several series of weather fronts moved through Central and Northern California, bringing moist, tropical air to regions which had already received rainfall in excess of fifty percent of the normal total seasonal amounts. The November, 1950 flood is particularly significant since it was the first time in recorded history that major flooding had occurred so early in the season. This record was to be broken, however, in October, 1962.

TABLE I

SELECTED STORM PRECIPITATION

	Nov. 13-21, 1950 9-day total in inches	Dec. 1-10, 1950 10-day total, in inches	Dec. 15-28, 1955 14-day total, in inches	Feb. 17-26, 1958 10-day total, in inches
Eureka (Humboldt)	1.92	3.39	8.35	4.07
Crescent City (Del Norte)	5.71	6.73	13.24	7.11
Garberville (Humboldt)	3.42	7.44	-	11.11
Alderpoint (Humboldt)	2.49	6.58	16.81	9.50
Brush Creek (Butte)	16.39	13.10	29.67	7.56
Blue Canyon (Placer)	26.18	13.27	35.82	7.05
Shasta Dam (Shasta)	3.58	6.70	29.84	10.99
Grant Grove (Tulare)	13.89	6.90	22.53	5.43
Salinas (Monterey)	2.79	1.91	5.02	1.30

	Mar. 28-Apr. 7, 1958 11-day total, in inches	Oct. 7-14, 1962 8-day total, in inches	Jan. 29-Feb. 4, 1963 7-day total, in inches	Dec. 19-25 1964 7-day total, in inches
Eureka (Humboldt)	5.26	5.89	3.46	5.62
Crescent City (Del Norte)	9.15	9.04	4.94	8.04
Garberville (Humboldt)	10.94	-	9.09	23.07
Alderpoint (Humboldt)	10.25	13.95	8.80	17.28
Brush Creek (Butte)	12.94	26.01	14.97	24.54
Blue Canyon (Placer)	14.01	22.32	17.76	29.57
Shasta Dam (Shasta)	12.33	10.81	7.61	16.15
Grant Grove (Tulare)	13.30	1.75	10.07*	3.48
Salinas (Monterey)	4.40	.63	2.81	1.31

* Station not recording from February 1 to February 4.

TABLE II

SELECTED FLOOD FLOWS AND STAGES

Station	Nov. 1950		Dec. 1950		Dec. 1955		Feb. 1958	
	Stage, in feet	Flow, in cfs	Stage, in feet	Flow, in cfs	Stage, in feet	Flow, in cfs	Stage, in feet	Flow, in cfs
Feather R. nr. Oroville	--	92,100	--	51,800	--	203,000	--	102,000
Yuba R. at Englebright	541.68	109,000	--	68,100	544.66	148,000	536.30	50,900
Inflow, Folsom Reservoir	--	210,000	--		--	218,000	--	55,000
Inflow, Shasta Reservoir	--		--		--	201,000	--	115,500
Sacramento R. nr. Red Bluff		--		71,000	23.50		25.8	139,000
Sacramento R. at I Street	30.26	104,000			28.79		27.21	87,500
San Joaquin R. at Vernalis	--	--	32.81	79,000	31.95	50,900	20.18	9,500
Eel River at Scotia	--	--	37.37	160,000	61.9	541,000	40.35	197,000
Klamath R. nr. Klamath	--	--	--	--	49.7	425,000	33.8	236,000
Russian R. nr. Guerneville	--	--	--	53,600	49.7	90,100	42.95	69,600
Mad R. near Arcata	--	--	15.74	26,600	21.30	77,800	15.09	27,200
Walnut Cr. at Walnut Cr.	--	--	--	--	23.22	11,000	8.58	3,880
Alameda Cr. near Niles	12.5	15,100	--	--	14.9	29,000	8.61	6,540
Salinas R. near Spreckels	11.49	1,300	8.68	632	24.52	23,600	16.10	4,000
San Lorenzo R. at Big Trees	14.50	10,600	12.33	7,330	22.55	30,400	14.28	10,300

(Continued on next page.)

TABLE II (Continued)

SELECTED FLOOD FLOWS AND STAGES

Station	Apr. 1958		Oct. 1962		Feb. 1963		Dec. 1964	
	Stage, in feet	Flow, in cfs	Stage, in feet	Flow, in cfs	Stage, in feet	Flow, in cfs	Stage, in feet	Flow, in cfs
Feather R. nr. Oroville	--	31,000	160.13	136,000	165.37	191,000		250,000 1/
Yuba R. at Englebright	532.30	20,100	540.26	91,000	544.84	150,000	546.0	165,500
Inflow, Folsom Reservoir	--	59,200	--	89,945	--	240,200	--	280,000
Inflow, Shasta Reservoir	--		--	65,000	--	72,000	--	186,000
Sacramento R. nr. Red Bluff	17.50	79,000	16.2	49,500	20.5	71,600	27.7	170,000
Sacramento R. at I Street	27.62	88,900	24.64	76,600	28.52	98,100	29.4	99,600
San Joaquin R. at Vernalis	31.66	41,400	--	--	23.27	12,400	28.2	21,200
Eel River at Scotia	32.23	119,000	32.48	128,000	47,00	252,000	70.0	750,000
Klamath R. nr. Klamath	--	--	20.28	94,500	24.46	136,000	55.0	640,000
Russian R. nr. Guerneville	35.59	47,900	28.56	30,800	43.70	71,800	49.8	90,000
Mad R. near Arcata	--	--	12.40	26,000	9.71	15,000	24.0	71,000
Walnut Cr. at Walnut Cr.	20.24	12,200	13.68	10,900	12.55	9,180	16.24	28,000
Alameda Cr. near Niles	14.17	26,400	5.86	1,810	10.48	11,500	8.01	5,400
Salinas R. near Spreckels	23.1	32,000	--	--	15.22	7,570	--	--
San Lorenzo R. at Big Trees	17.76	17,200	12.10	7,390	15.80	13,000	10.50	5,800

1/ Estimated inflow to Oroville Reservoir.

Rio Dell, California - December 26, 1964
(Telephoto, courtesy U.P.I.)

Awaiting rescue. Eel River near Ferndale, California
December 23, 1964 (Telephoto, courtesy U.P.I.)

The November storm brought heaviest amounts of rainfall to the Sierra from the Kaweah River north to the Feather River, in amounts from 18 to 26 inches. During the December storm the heaviest rainfall occurred between the Tuolumne River and the Feather River in 8 to 12-inch amounts.

The storms during these two periods caused heavy runoff from the Sierra watersheds, resulting in river flow of record or near-record levels. The November storms caused the Cosumnes River to crest at 27,200 cfs* at Michigan Bar. The American River at Fair Oaks crested at 180,000 cfs. The Kings River at Piedra crested at 110,000 cfs, and the Kern River flow at Bakersfield was estimated to be nearly 47,000 cfs. Stream flows were generally less during the December storms.

Flood damage caused by the first flood runoff occurred in the lowlands from the Kern River to the Yuba River and near Clear Lake in Lake County. Olivehurst, suburban Sacramento, Fremont, Visalia, and Kernville, are among the many communities damaged by flood water from the November storms. During December 2-4, flooding was generally along the Stanislaus, Tuolumne, and American Rivers, and near Clear Lake. Flooding during December 5-9 occurred along the American River, the lower San Joaquin River, and in the upper San Joaquin Delta.

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*cfs - cubic feet per second

Crescent City, California, December 27, 1964
Harbor clogged with timber and debris. Lighthouse at lower left. (Telephoto, courtesy U.P.I.)

Klamath, California, December 25, 1964
Business district at left, residential area at right.
(Telephoto, courtesy U.P.I.)

Floods of December, 1955

The floods of December, 1955, which have been compared to the floods of 1861-62 because of the large volumes of water, were caused by a deep flow of warm, moist, tropical air from the central Pacific Ocean. The storms of December 17-26, consisted of alternating periods of heavy precipitation followed by intervening shorter periods of light precipitation. The area of heaviest rainfall was north of a line drawn from Santa Barbara to Bishop. Precipitation amounts for the storm period exceeded 30 inches in wide areas and a few stations recorded amounts greater than 40 inches. Although rainfall occurred as high as the 6,000-foot level, the snowmelt contribution to runoff was believed to be insignificant.

Peak flood runoff resulting from these storms exceeded maximum flow of record for most streams in the coastal areas north of Santa Barbara, in the Central Valley north of the Tule River Basin, in the Lahonton area north of the Walker River Basin and in the North Coast. Record flows of 148,000 cfs occurred on the Yuba River, 218,000 cfs on the American River at Folsom Reservoir, 541,000 cfs on the lower Eel River, 425,000 cfs on the lower Klamath River and 90,000 cfs on the lower Russian River.

Most of the damage from this flood occurred along streams which were unregulated by reservoirs. Flood damage was extensive along the Klamath, Mad, Eel, Russian, San Lorenzo, Feather, Yuba, Calaveras, and Kaweah Rivers. Levee failures

occurred along the Feather River and the design capacity of leveed channels was exceeded on the Feather, Yuba, and Bear Rivers. Nearly one million acres were inundated including highly developed areas in and near Yuba City, Stockton, Fresno, Visalia, Santa Cruz, Watsonville, Eureka, Klamath, Santa Rosa, Guerneville, and some tracts in the Sacramento-San Joaquin Delta. Sixty-four lives were lost.

Floods of February and April, 1958

The 1958 storms were significant because of their prolonged duration. From the first rains beginning in late January and extending almost continuously through early April the flood control works were subjected to high river stages. The stability of many levees was threatened by excessive saturation.

The February floods were preceded by a series of storms which primed most of the watersheds in the central and northern parts of the State. On February 18, the first of two flood-producing storms struck the North Coast. This warm air dropped heavy amounts of rain in this area but only moderate amounts in the Sierra Nevada. The next and more destructive storm struck the Central California coast near San Francisco on February 24. This storm brought heavy rain to all of Northern California with rainfall up to 8,000 feet in the Sierra Nevada.

Only light showers occurred during the remainder of February and early March, but a storm on March 16 brought

locally heavy rain to the Central Valley. During the period March 27 to April 5, a series of storms brought heavy precipitation to the already saturated watersheds of Northern and Central California.

The February storms caused record peak stages on streams along the west side of the Sacramento Valley, with the eastside streams well below record levels. Some high stages were experienced in the North Coastal area and only minor rises occurred in the remainder of Northern and Central California.

The March-April storms produced record peak flows in the Central Coastal area and on some streams in the Central Valley. Inflow to several Sierra reservoirs was estimated to be at record flows, and the regulated releases supplemented by local runoff produced record stages at some valley stations.

Flood damage resulting from the two storm periods occurred in February in the North Coastal area, in the northern Sacramento Valley, and near Clear Lake; and throughout most of Northern California in April. The later floods inundated areas in or near Hamilton City, Stockton, Walnut Creek, Brentwood, Mendota, Patterson, Mill Valley, Napa, and the Sacramento-San Joaquin Delta. Several locally-owned levees failed or were overtopped in the Central Valley and in scattered coastal areas.

Floods of October, 1962

The flood of October, 1962, was particularly significant because it broke all records for arriving early in the

Englebright Dam
December 25, 1964

Daguerre Point Dam on December 25, 1964
With floodwaters flowing around right abutment.

season. Since most flood control criteria for reservoir operation are based on a flood season starting on November 1, this storm could have caused uncontrolled reservoir spills, except for the fact that all of the watersheds were dry and absorbed most of the rainfall.

The storm of October 7-14, brought high-intensity rainfall generally confined to a 100-mile wide band extending diagonally across California from San Francisco to the Yuba River Basin. Heavy amounts of rain occurred at lower elevations as well as in the central Sierra Nevada.

Few stations on major streams experienced record-breaking flows, but at many points the flows were the highest since the floods of 1955. Local flooding and landslides occurred in the North Coastal area and in the San Francisco Bay area. Crops were inundated in the Sacramento Valley with local flooding occurring near Sacramento. There was substantial property damage, and the loss of 20 lives was attributed to the storm.

Floods of January-February, 1963

A foggy and relatively dry period occurred between the October storms in 1962 and the flood-producing rains of January 29 to February 1, 1963. These later storm systems brought warm, moist air to the snow-free, frozen mountainous areas of Northern and Central California. Heaviest rainfall

December 25, 1964
Site of the Feather River levee failure
that occurred on December 24, 1955.

December 27, 1964
Levee maintenance crew fights high tides and winds
to protect Twitchell Island.

occurred in the Clear Lake area, in the Santa Cruz and Santa Lucia Mountains, and in the Sierra Nevada from the Feather River to the Kings River.

New maximum inflows of 150,000 cfs and 240,000 cfs at Englebright and Folsom Reservoirs, respectively, were recorded during the January-February storms. Record flows also were experienced on several tributaries of the Feather, Yuba, and Bear Rivers, and in the Lahonton area.

The January-February storms caused flooding in Geyserville, Healdsburg, Napa, Gilroy, Alviso, Soquel, Portola, Quincy, Chester, Sierraville, and Bridgeport. Many major highways, municipal waterworks, levees, and small dams were damaged by the floodwaters. Property damage caused by the 1962-63 floods was less than that which resulted from the 1955 or 1958 floods.

Floods of December, 1964

The pattern of the December, 1964 storms was strikingly similar to that of December, 1955. Warm, moist air brought heavy rain to all of Northern California north of a line from San Francisco to Stockton. Rainfall amounts for the period December 19-27 in the North Coastal area ranged from 10 inches to 30 inches and in the northern Sierra Nevada from 20 inches to 40 inches.

Record-breaking flood crests occurred on many streams in the rainfall area. The crest on the Russian River near

December 23, 1964
Sacramento Weir and Bypass channel discharge floodwaters into Yolo Bypass above Sacramento.

Sacramento River at flood stage below confluence with American River, December 23, 1964.

Guerneville equalled the previous maximum, as did the crest on Redwood Creek at Orick. The Klamath and Eel Rivers far exceeded their previous maximum flows. On the east side of the Sacramento Valley, new maxima were recorded at Oroville on the Feather River (inflow to the reservoir behind Oroville Dam which is presently under construction), at Englebright Reservoir on the Yuba River, and at Folsom Reservoir on the American River.

Damage due to these storms occurred mostly in the North Coastal area where high water, heavy rain, high wind, and landslides created one disaster after another. Villages were wiped out; bridges, roads, and communication lines were demolished, and thousands of people were made homeless. In the Central Valley a few bridges were washed out, and Hell Hole Dam under construction on the upper American River collapsed.

Flooding in lower San Joaquin Valley from breaks along Stanislaus River levees southwest of Ripon.

Plate 2 shows the synthesized hydrograph of the Klamath River at Klamath for December 20-26, 1964. The peak flow of 650,000 cfs occurred early December 23. The previous maximum of 425,000 cfs occurred in 1955.

Plate 3 shows the hydrograph of the Eel River at Scotia for December 20-26, 1964. The gage became inoperative at 11 p.m. on December 22, therefore the remainder of the hydrograph is synthesized. The peak flow was 750,000 cfs occurring early December 23, surpassing the previous record flow of 541,000 cfs occurring in 1955.

Plate 4 depicts the operation of partially completed Oroville Dam. The outflow occurred through the two diversion tunnels which discharged 157,000 cfs into the Feather River below the dam. This compares with the record inflow of 250,000 cfs, surpassing the March 19, 1907 record flow at Oroville of 230,000 cfs and the December, 1955 flow of 203,000 cfs. Peak inflow occurred in the early afternoon of December 22 and peak outflow occurred at noon on December 23, 1964.

Plate 5 shows the hydrograph of the Yuba River at Smartville. This includes the summation of "At Englebright Dam" and "Deer Creek near Smartville". The 171,800 cfs peak flow occurring late December 22, 1964, exceeded the previous record of 155,000 cfs established on February 1, 1963.

Plate 6 depicts inflow-outflow hydrographs of Folsom Reservoir for the period December 21-27, 1964. The record inflow of 280,000 cfs occurring late afternoon of December 23, surpassed the record established on February 1, 1963, of 240,200 cfs. Failure of partly constructed Hell Hole Dam on the Rubicon River contributed to the peak. Releases were increased to a maximum of 115,000 cfs at 11 a.m., December 23, and continued until noon on December 25, when over the next 24 hours, releases were reduced to 50,000 cfs.

Plate 7 is a comparison of 1964 maximum five-day precipitation with that of 1955. The amounts for Blue Canyon, Brush Creek, and Camptonville are not significantly different for the two years, but the amounts for Alderpoint and Klamath Glen exemplify the severity of the 1964 storm.

Plate 8 is a comparison of 1964 peak discharges with those of 1955. This bar graph tells much the same story as does Plate 7 with the Klamath River and Eel River surpassing the 1955 records by approximately 50 percent and the Feather, Yuba, and American Rivers experiencing record flows of from about 15 percent to 35 percent greater than 1955.

Plate 9 compares 1964 flood volumes with 1955. The period of December 20-26 was selected for both years on the North Coast and December 21-27 for both years for the Central Valley area.

CHAPTER III. EXISTING AND PLANNED FLOOD CONTROL WORKS

This chapter gives an account of existing and planned flood control works located throughout the length and breadth of the State. These are reported by hydrographic regions. It is to be noted, in comparing the current inventory of works with those recommended for construction in the Department's January, 1956 report on "Floods of December, 1955 in California", that a number of works have been built during the intervening nine-year period. However, this is no cause for complacency for during this same period millions of people have been added to the State's population and most of them live in areas subject to flooding.

North Coast

Most streams of the North Coast have no flood control works. This also is the area where the greatest damage has been suffered from the floods of recent years.

Russian River

The Russian River Basin drains approximately 1,500 square miles of Mendocino and Sonoma Counties and empties into the Pacific Ocean about 60 miles northwest of San Francisco. It is the southernmost major coastal river basin of Northern California. The plan of improvement contained in House Document 585, to alleviate damage due to major flooding which occurs on the average of every two years, provides for construction of two reservoirs and channel stabilization works in three phases.

Phase 1 consists of the construction of Coyote Valley Dam and Reservoir (Lake Mendocino) on the East Fork of Russian River for flood control and water conservation purposes and was completed in April, 1959. The total capacity of this reservoir is 122,500 acre-feet, 48,000 of which are for flood control.

Phase 2 will be construction of the Warm Springs Dam on Dry Creek, near Cloverdale. It was authorized by the Flood Control Act of 1962 and will provide flood protection for 20,500 acres of agricultural and recreation lands and supply 90,000 acre-feet of water to Sonoma and Marin Counties. The reservoir will have a capacity of 277,000 acre-feet of which 125,000 will be for flood control. Federal funds for preconstruction planning were provided in January, 1964 and studies are in progress for preparation of the detailed design memoranda.

Phase 3 provides for the enlargement of the storage capacity of the Coyote Valley Dam and Reservoir for water conservation.

In addition, this three-phase program includes channel stabilization and improvement works, some of which have been completed along the Russian River from Cloverdale to Healdsburg.

During the last ten years, local interests have spent an estimated one million dollars for additional construction of dikes, levees, training walls, groins, and bulkheads along the Russian River and Dry Creek.

The Central Sonoma Watershed Project, covering about 50,000 acres which drain into the Laguna de Santa Rosa and the

Russian River, is now under construction. Floodwater detention dams on Brush, Piner, Spring, and Matanzas Creeks have been completed and are in operation. The Santa Rosa Creek Reservoir complex, including three earthfill dams and two diversion structures with associated channels, is complete. Also completed are 0.5 mile of concrete box culvert and 1.6 miles of earth channel improvements on Brush and Piner Creeks. Construction is now in progress on about eight miles of earth and riprap-lined channel improvement on Santa Rosa Creek and its tributaries. This channel work is expected to continue for another two or three years.

The Sonoma County Flood Control and Water Conservation District has had a continuing program of improving upstream tributary channels to Santa Rosa Creek independently of federal or state aid.

Mendocino Coastal Streams

Between the mouth of the Eel River on the north and the mouth of the Russian River on the south there are a large number of relatively minor streams which drain in a westerly direction into the Pacific Ocean. Included in this group are Mattole, Ten Mile, Noyo, Big, Navarro, Garcia, and Gualala Rivers.

At the present time there is neither flood control works nor water conservation reservoirs on any of the coastal streams of Mendocino County. Generally the streams are all

characterized by deep narrow gorges with a limited amount of bottom land. These deep gorges have a confining influence on the streams and thereby protect the adjacent communities usually located on the broad terraces along the coast.

Eel River

The Sandy Prairie Project is a levee system in Humboldt County on the right bank of the lower Eel River at the mouth of the Van Duzen River. The levee extends from a point just upstream from the Highway 101 crossing, downstream to the vicinity of Fortuna and includes local private levees in the Eel River Delta. The project's purpose is to channel flood waters of the Van Duzen River into the Eel River without flooding lands in the vicinity of Fortuna. This project, constructed in 1959 by U. S. Corps of Engineers, is designed to pass a peak flow of 540,000 cfs in the Eel River.

The Blue Lake Levee is located in Humboldt County on the lower Mad River and extends from approximately two miles east of the town of Blue Lake to a point approximately one-quarter mile below the county road bridge. This levee, constructed in 1963 by U. S. Corps of Engineers is placed so as to permit the passage of a peak flow of 105,000 cfs.

Klamath River Basin

There are no significant flood control projects in the Klamath River Basin. However the accumulation of flood peaks is retarded to some extent by the storage capacity of

irrigation and hydroelectric power reservoirs on the Upper Klamath River. These include Upper Klamath Lake, Copco Lake and Iron Gate Reservoir.

Clear Lake Reservoir in Modoc County, constructed in 1910 by the U. S. Bureau of Reclamation on the headwaters of Lost River, a tributary of the Klamath River, has a capacity of 526,800 acre-feet. Control of flood water was an important part of the reclamation plan. Excess flood flows of Lost River are diverted into Klamath River by a flat-graded diversion channel. High stages in the Klamath River caused by the Keno Reef reduce the capacity of this channel. In addition, the levee system downstream has been designed to control damaging floods. The Tule Lake sump has been designed so that excess flood waters can be spilled into uninhabited but farmed sump areas, if the volume of flood waters exceeds the main sump capacity. Flood and drainage waters that enter Tule Lake sump must be pumped into Klamath River.

Trinity Reservoir, completed in 1962 by the United States Bureau of Reclamation provides some incidental flood control storage for flows of the Upper Trinity River.

The East Weaver Creek levee system at Weaverville in Trinity County, constructed in 1963 by U. S. Corps of Engineers, provides for the safe passage of a peak flow of 3,000 cfs.

In Scott Valley near Fort Jones a project to control flood flows of Hidden Creek by levees was undertaken by local

agencies. This project proved inadequate during the 1964 flood.

Except for the projects on the Russian River and the Trinity and Clear Lake Reservoirs none of the foregoing facilities within the North Coastal area should be considered to be parts of a final and fully developed flood control plan. They are stop-gap facilities offering protection only against moderate flows.

Sacramento Valley and Sacramento-San Joaquin Delta

Within the Sacramento River Basin there are a number of water control facilities that provide planned or incidental flood control and protection.

Flood Control Projects in Sacramento Valley

The Sacramento River Flood Control Project consists of a comprehensive system of levees, overflow weirs, drainage pumping plants, and flood bypass channels extending along the Sacramento River from Collinsville upstream to Ord Bend and along its principal tributaries to high ground near the base of the Sierra Nevada and the Coast Range foothills.

The project is a joint federal, state and local undertaking which was first approved for limited expenditure of federal funds in 1918. Federal legislation enacted in 1928, 1937, 1941, 1944, 1950, 1958, and 1960 modified the physical works of the project or increased the extent of federal participation. The project was first adopted by the State of California in 1911 and subsequent acts of the State Legislature generally paralleled the federal legislation.

Within the Sacramento Valley and Delta areas there are approximately 1,040 miles of river levees which are a part of the Sacramento River Flood Control Project and on which the State makes semiannual inspections. These levees include those enumberated in Section 8361 of the Water Code together with other

project flood control works which are the responsibility of public agencies other than the State of California. Units maintained and operated by the State of California include:

1. The east levee of the Sutter Bypass north of Nelson Slough.

2. The levees and channels of the Wadsworth Canal, Willow Slough Channel downstream from the Southern Pacific Railroad from Davis to Woodland except that portion of the north levee thereof lying within Reclamation District No. 2035.

3. Putah Creek downstream from Winters, the intercepting canals draining into them, and all structures incidental thereto.

4. The collecting canals, sumps, pumps and structures of the drainage system of Project No. 6 east of the Sutter Bypass.

5. The bypass channels of the Butte Slough Bypass, the Sutter Bypass, the Tisdale Bypass, the Yolo Bypass and the Sacramento Bypass with all cuts, canals, bridges, dams, and other structures and improvements contained therein and in the borrow pits thereof.

6. The levees of the Sacramento Bypass.

7. The channels and overflow channels of the Sacramento River and its tributaries within the Sacramento and San Joaquin Drainage District.

8. The Knights Landing ridge cut flowage area.

9. The flood relief channels controlled by the Moulton and Colusa Weirs and the training levees thereof.

10. The levee on the left bank of the Sacramento River adjoining Butte Basin, from the Butte Slough outfall gates upstream to a point four miles northerly from the Moulton Weir, after completion.

11. All weirs and relief structures.

12. The west levee of the Yolo Bypass, extending from the west end of the Fremont Weir southerly to the Cache Creek Settling Basin and from Willow Slough Channel to Putah Creek and the levee of the Yolo Bypass from Fremont Weir southerly two miles.

13. The levee on the west bank of Feather River extending a distance of about two miles southerly from the Sutter-Butte Canal headgate.

14. The levees of Cache Creek and the easterly and westerly levees of Cache Creek Settling Basin.

15. The flowage area of Western Pacific Intercepting Canal extending northerly for a distance of five miles from Bear River.

16. The levees of Tisdale Bypass from Tisdale Weir 4.5 miles easterly to Sutter Bypass.

The following levee systems are within the Sacramento River Flood Control Project but are the responsibility of local areas to operate or maintain or are the responsibility of the State through the establishment of maintenance areas: (1) American River, (2) Arcade Creek, (3) Bear River, (4) Butte Slough Bypass, (5) portions of the Cache Creek Settling Basin, (6) Cache Slough, (7) portion of Colusa Basin Drain, (8) Coon Creek Group Interceptor, (9) Deer Creek, (10) Elder Creek, (11) Elk Slough, (12) portions of the Feather River System, (13) Georgiana Slough, (14) Haas Slough, (15) Honcut Creek, (16) Knights Landing Ridge Cut, (17) Linda Creek, (18) Lindsay Slough, (19) Miner Slough, (20) Natomas Cross Canal, (21) Natomas East Canal, (22) North Dry Creek, (23) portions of the Sacramento River System, (24) Simmerly Slough, (25) South Dry Creek, (26) Steamboat Slough,

(27) portions of Sutter Bypass, (28) Sutter Slough, (29) Three-mile Slough, (30) Ulatis Creek Bypass, (31) Western Pacific Interceptor, (32) portions of Willow Slough Bypass, (33) Yankee Slough, (34) portions of Yolo Bypass, (35) portions of Yuba River System.

The Sacramento River and Major and Minor Tributaries Project of the U. S. Corps of Engineers also is a unit of the comprehensive plan for flood control and other purposes in the Sacramento River Basin. This project provides for levee construction and/or channel enlargement on the following minor tributaries of the Sacramento River: Chico and Mud Creeks and Sandy Gulch, Butte and Little Chico Creeks, Cherokee Canal, Elder Creek, and Deer Creek together with levee revetments for Sutter, Tisdale, Sacramento and Yolo Bypasses. Approximately 72 miles of channel improvements and about 107 miles of levees and bypass revetments as required for protection of bypass levee slopes against erosion also are involved in the project. This project is a modification and extension of the Sacramento River Flood Control Project and supplements reservoir units of the comprehensive plan by providing flood protection to certain unprotected or partially protected areas along Sacramento River. When completed the minor tributaries unit will provide protection from floods to about 8,000 acres of agricultural land and to the City of Chico and other communities. The bypass levee revetment work will provide

protection to flood plain lands adjacent to the bypasses and will decrease requirements for levee repairs under emergency conditions. Construction of the project was initiated in 1949 and suspended in October, 1950 following completion of improvements along Deer, Butte, and Little Chico Creeks. Construction was resumed in 1957. The Chico and Mud Creeks and Sandy Gulch Unit were completed in 1964. The active portion of the project is about 59 percent complete, with completion currently scheduled for December, 1970. Work remaining includes completion of the bypass levee revetments.

Flood control regulations of the Sacramento Valley Flood Control Project provides that the Federal Government will construct or finance the flood control features. The State provides land easements, rights-of-way and relocation of utilities, roads, and bridges and the State or local agencies assume responsibility for maintenance and operation.

The Chico Landing to Red Bluff Project of the U. S. Corps of Engineers to construct bank protection and minor channel improvements along Sacramento River between Chico Landing and Red Bluff was initiated in 1963 and completed in Tehama County in 1964. Authorized work in Butte and Glenn Counties has not been started because of failure of counties to provide suitable flood plain zoning.

In November, 1958, the U. S. Corps of Engineers completed construction of a levee along the right bank of the American River from Elvas Bridge to Carmichael Bluffs and pumping facilities for disposal of interior drainage.

The Sacramento River Bank Protection Project presently under construction by the U. S. Corps of Engineers is a long-range modification of the existing Sacramento River Flood Control Project to include construction of bank erosion control works and setback levees within the limits of the existing levee system. The initial 10-year phase consisting of approximately 430,000 lineal-feet of bank protection work at critical locations was initiated in June,1963 and is 7 percent complete. Completion of the initial phase is presently scheduled for December,1972.

Under study by the U. S. Corps of Engineers are channel improvements on Jack and Simmerly Sloughs. The Corps also has proposed channel improvements and levees on Thomes and Antelope Creeks, on Wilson, Walker, and Willow Creek and levees and a bypass system for Butte Basin but these proposals are presently inactive because of lack of local support.

Flood control works on the east side of the lower Sacramento Valley below the American River include levee systems along the lower reaches of Dry Creek, Cosummes, Mokelumne, and Calaveras Rivers and minor tributaries and Stockton Diverting Canal east of Stockton.

Farmington Reservoir constructed by the U. S. Corps of Engineers on Littlejohns Creek in the foothills east of Stockton provides substantial flood protection to

the area along Littlejohns Creek and Duck Creek. The reservoir has a capacity of 52,000 acre-feet, all for flood control. The project includes diversion of Duck Creek to Littlejohns Creek and channel improvement and clearing of Littlejohns Creek.

The Jackson Creek project of the Jackson Valley Irrigation District now under construction includes a 22,000 acre-foot reservoir which will provide no planned flood control, but will furnish some incidental protection.

Projects under construction or planned also include works on Duck Creek, Bear Creek, and Mormon Slough. Duck Creek Project now under construction by the U. S. Corps of Engineers intermittent channel enlargement in the lower reaches of Duck Creek east of Stockton to provide channel capadty for a 50-year flood. Completion is scheduled for this year. Flood control works are substantially complete. Bear Creek in San Joaquin County to carry a flood of 4,000 cubic feet per second and provide protection to about 30,000 acres of orchard, vineyards and row cropland and suburban areas near Stockton. This project of the U. S. Corps of Engineers comprises 38 miles of low levees and 22 miles of channel

The Mormon Slough Project of the U. S. Corps of Engineers to increase the capacities of Mormon Slough and Calaveras River downstream from Bellota in San Joaquin County by channel clearing, enlargement, and levee

construction has been authorized for construction. The improvements are designed to be coordinated with operation of New Hogan Dam and Reservoir for regulation of flood flows and will protect the city of Stockton and agricultural areas along Mormon Slough and Calaveras River.

Ulatis Creek Project of the U. S. Soil Conservation Service now under construction and about 18 percent complete provides for channel improvement along Ulatis Creek in Solano County on the west side of Sacramento Valley.

In the Sacramento-San Joaquin Delta numerous leveed islands are separated by major and minor stream channels leading from the Sacramento, San Joaquin, Cosumnes, Mokelumne, and Calaveras Rivers. Many of the main channel levees are part of the Sacramento River Flood Control Project and are joined to local levee systems which form and protect the islands, many of which are below sea level. No additional flood control features are now planned in the Delta area, although the U. S. Corps of Engineers has under consideration a long-range feasibility study of constructing flood control works as a part of a Delta master plan.

The U. S. Corps of Engineers are currently conducting a study on navigation in the Sacramento-River Basin and Delta and a re-examination of the Sacramento River Flood Control Project which will have appreciable bearing on flood control.

The U. S. Bureau of Reclamation has presented a plan of development and offstream storage on Kellog Creek in Contra Costa County which includes a reservoir with a

storage capacity of 135,000 acre-feet including a flood control reservation of 8,000 acre-feet for protection of the lower Kellogg Creek area. The Bureau is preparing a final feasibility report at this time.

Feather River

The most important flood control storage structure on the Feather River is the unfinished Oroville Dam which probably averted a disaster similar to that from the Christmas 1955 flood by temporarily impounding the record peak flow of the Feather River and substantially reducing that peak to safe downstream flows. When completed in 1967 the reservoir will have a capacity of 3,500,000 acre-feet of which 650,000 acre-feet will be available for flood control. There also are other reservoirs on the Feather River with an aggregate storage capacity of about 1,750,000 acre-feet, none of which is dedicated to flood control although some incidental control is provided. These reservoirs include those of Pacific Gas and Electric Company, the Oroville-Wyandotte Irrigation District and the Department of Water Resources. The largest reservoir is Lake Almanor on the North Fork with a gross storage of 1,308,000 acre-feet, owned by Pacific Gas and Electric Company and operated for irrigation and power purposes. The same company also owns Bucks Creek Dam on Bucks Creek, a tributary to North Fork Feather River the reservoir of which has a gross storage capacity of 103,000 acre-feet and Butt Valley Dam with a storage capacity of slightly less than

50,000 acre-feet which also receives water from Lake Almanor and makes releases to the North Fork Feather River. The other Pacific Gas and Electric reservoirs have capacities less than 6,000 acre-feet.

The Department of Water Resources has constructed Frenchman Dam on Little Last Chance Creek, tributary to Middle Fork of the Feather River. The reservoir has a gross storage capacity of 55,000 acre-feet. The water is used for irrigation and recreation but incidental flood control also is provided. The department also has constructed Antelope Dam on Antelope Creek tributary to Middle Fork Feather River. This reservoir has a gross storage capacity of 22,000 acre-feet. and being empty greatly reduced the flood peak on Indian Creek through Genessee and Indian Valleys.

Other major water storage features include those of the Oroville-Wyandotte Irrigation District which aggregates 165,000 acre-feet for irrigation, municipal, power and domestic use. These include: Little Grass Valley Reservoir on South Fork Feather River with a storage capacity of 93,000 acre-feet, Sly Creek Reservoir on Sly Creek with a storage capacity of 65,000 acre-feet and the Lost Creek, Ponderosa, and Miners Ranch Reservoirs with aggregate storage capacity of about 8,000 acre-feet.

Construction in the Feather River Basin includes Grizzly Valley Dam on Big Grizzly Creek which will provide 83,000 acre-feet of storage for recreation and conservation. Construction by the Department of Water Resources was initiated in the fall of 1964. Planned construction includes Dixie Refuge Dam on Last Chance Creek with a storage of 16,000 acre-feet and Abbey Bridge on Red Clover Creek with a storage of 11,000 acre-feet. These dams are authorized for construction by the department for recreation use but construction has not been scheduled.

Yuba River

Reservoirs on the Yuba River above Marysville provide approximately 490,000 acre-feet of storage capacity. These reservoirs are operated by Pacific Gas and Electric Company, Nevada Irrigation District, and Browns Valley Irrigation District. They include Jackson Meadows Reservoir on Jackson Creek tributary to the Middle Yuba River with a storage capacity of 68,000 acre-feet, Lake Spaulding on the South Fork Yuba River with a storage capacity of 74,500 acre-feet, Bowman Lake on Canyon Creek, 68,000 acre-feet, Scotts Flat on Deer Creek with a storage capacity of 52,000 acre-feet, Bullards Bar on the North Yuba with a storage capacity of 31,500 acre-feet, Fordyce on Fordyce Creek, 47,000 acre-feet, Englebright debris control dam on the Yuba River with a storage capacity of 70,000 acre-feet and Virginia Ranch Dam on Dry Creek tributary to Yuba River with a storage

capacity of 57,000 acre-feet. These reservoirs are operated for power and irrigation purposes and have no flood control reservations.

Marysville Reservoir on the Yuba River a few miles above Marysville has been proposed for flood control and water conservation by federal, state and local interests. As now planned the project would impound 1,000,000 acre-feet of which 260,000 would be for flood control. Recent studies by the Department and the Corps of Engineers show the project to be economically justified and the reservoir is urgently needed.

New Bullards Bar Dam on the Yuba River is planned as part of the Yuba County Water Agency project for power, conservation, flood control and recreation. A 930,000 acre-foot reservoir is planned with 170,000 acre-feet of flood control storage which would be operated in cooperation with Marysville Reservoir for flood control. Final formulation of a project is now being completed.

Bear River

Reservoirs on the Bear River have a total capacity of about 172,500 acre-feet including the 103,500 acre-feet Camp Far West Reservoir of South Sutter Water District and the 9,000 acre-foot Combie Reservoir and the recently completed 60,000 acre-foot Rollins Reservoir, both of Nevada Irrigation District. The Bear River system is operated for power and for irrigation with no flood control reservations.

since the volume of storage is relatively large in comparison with the runoff some incidental flood control is provided.

American River

Reservoirs on the American River have a total of about 1,460,000 acre-feet including Folsom Reservoir a unit of the Central Valley Project with 1,000,000 acre-feet storage capacity, and the Sacramento Municipal Utility District's Upper American River Project totaling 393,700 acre-feet including Loon Lake Reservoir 75,500, Gerle Creek Reservoir 1,200, Union Valley Reservoir 271,000,and Ice House Reservoir with 46,000 acre-feet. There also is the 20,000 acre-foot Stumpy Meadows Reservoir owned by Georgetown Divide Public Utility District and the North Fork Dam for debris control with a storage capacity of 14,600 acre-feet. Folsom Reservoir is the only one of these with a flood control reservation. Folsom Reservoir has a flood control reservation of 400,000 acre-feet and, together with the downstream levee system with a capacity of 115,000 cfs, provides protection from floods of the American River System.

The Middle Fork American River Project, including the 134,000 acre-foot French Meadows Reservoir and the 208,400 acre-foot Hell Hole Reservoir, is now under construction by the Placer County Water Agency. No flood control reservation is included. During the recent floods partially completed Hell Hole Dam was overtopped and washed out releasing

30,000 acre-feet of water and resulting in severe damage to roads and bridges, including destruction of the Highway 49 bridge near Auburn.

Auburn Reservoir on the North Fork American River has been proposed by the State for construction since 1931 when it was presented as a major unit of The State Water Plan. It was further considered and strongly recommended by the Department in 1957 as a key feature of the California Water Plan.

In 1959, the Bureau of Reclamation recommended construction of Auburn Reservoir with a storage capacity of 1,000,000 acre-feet as a unit of the Central Valley Project. The reservoir would be operated for flood control and hydroelectric power and to provide water for distribution southward through the proposed Folsom-South Canal. The State's comments on this proposal were favorable and congressional authorization was unsuccessfully attempted.

In 1961, the Bureau reconsidered Auburn Reservoir and recommended the storage capacity be 2,500,000 acre-feet. The State's comments again were favorable. Attempts to obtain congressional authorization have continued and are being actively pressed at this session of Congress.

Under the proposed plan of operation for Auburn Reservoir, 200,000 acre-feet of flood control storage in Folsom Reservoir would be transferred to Auburn Reservoir where a total of 450,000 acre-feet of flood control storage would be provided.

Shasta Dam

Folsom Dam on December 25, 1964

Cosumnes River

Sly Park Dam on the Cosumnes River with a gross storage capacity of 41,000 acre-feet is the only development on the Cosumnes River. There is no flood control reservation. The dam is owned and operated by the U. S. Bureau of Reclamation.

The Cosumnes River Project proposed by the U. S. Bureau of Reclamation is a multiple-purpose plan for water conservation, flood control, power, fish and wildlife enhancement, recreation and water quality control. If authorized, the project would consist of an initial and ultimate phase and be integrated with the Central Valley Project.

The primary storage features included in a initial phase are: (1) Nashville Dam and Reservoir, (2) Aukum Dam and Reservoir on South Fork Cosumnes River, (3) Pi-Pi Dam and Reservoir on Middle Fork Cosumnes River, and (4) Irish Hill Dam and Reservoir on Dry Creek. A total of 225,000 acre-feet of flood control storage at Nashville and Irish Hill Reservoirs would provide much needed flood protection to lands adjacent to Cosumnes River and Dry Creek.

Mokelumne River

Major water storage developments on the Mokelumne River System include recently completed Camanche Dam and Reservoir owned by East Bay Municipal Utility District with a gross storage capacity of 431,500 acre-feet, Pardee Dam and Reservoir also owned by East Bay Municipal Utility District with a storage capacity 210,000 acre-feet and Salt Springs Dam and Reservoir owned by Pacific Gas and Electric with a gross storage capacity of 139,400 acre-feet. None of these facilities has a flood control reservation, although the large storage capacity in relation to runoff provides some incidental protection. The Corps of Engineers now has a flood control project under advanced study.

Calaveras River

New Hogan Dam and Reservoir with a gross storage capacity of 325,000 acre-feet and a flood control reservation of 165,000 was recently completed by the U. S. Corps of Engineers and is operated for water conservation and flood control.

Putah Creek

Monticello Dam and Reservoir on Lower Putah Creek with a storage capacity of 1,600,000 acre-feet is operated by the U. S. Bureau of Reclamation for water conservation as part of the Central Valley Project. Although there is no flood control reservation in the facility, the large storage capacity does provide a large measure of flood protection on Putah Creek.

Cache Creek

Clear Lake Dam which regulates 420,000 acre-feet of capacity in Clear Lake controls flows from the drainage area tributary to Clear Lake. This storage capacity is operated for conservation but also provides some flood control on Cache Creek, although the lower 550 square miles of the drainage area are uncontrolled at the present time.

In the watershed tributary to Clear Lake the streams are substantially uncontrolled, although channel improvements, levees, and minor dams have been constructed in some areas. The Adobe Creek Project of the U. S. Soil Conservation Service to provide channel improvements on Adobe Creek is 85 percent complete.

The U. S. Corps of Engineers has nearly completed Middle Creek Project which provides for enlargement of existing levees, construction of additional levees, channel improvements along the lower seven miles of Middle Creek and tributary

streams, a pumping plant for disposal of interior drainage and construction of a 4,000-foot channel to divert Red Clover Creek flows around the town of Upper Lake. The project provides flood protection to the town of Upper Lake and to about 4,000 acres of highly developed agricultural land.

Lakeport Reservoir on Scotts Creek just west of Lakeport has been reported on favorably by the U. S. Corps of Engineers, and authorization from the Congress has been requested. This is a multiple-purpose project for water conservation and flood control with a gross storage capacity of 55,000 acre-feet, with 24,000 acre-feet reserved for flood control. Wilson Valley Dam on Cache Creek below the North Fork was planned, as part of a larger project by Yolo County Flood Control and Water Conservation District, to provide a gross storage capacity of 1,000,000 acre-feet, with 65,000 acre-feet of flood control reservation, but the project was rejected by the voters in 1964. The district is now conducting studies of a 300,000 acre-foot reservoir at Indian Valley on North Fork Cache Creek, with a flood control reservation of 40,000 acre-feet.

Lahonton Area

Existing storage on Truckee River tributaries includes the 40,000 acre-foot Boca Reservoir on Little Truckee River and the recently constructed Prosser Reservoir on Prosser Creek with a storage capacity of 30,000 acre-feet, both constructed by the

U. S. Bureau of Reclamation. Boca Reservoir has no flood control reservation but provides incidental protection to the downstream Truckee River area. Prosser Reservoir provides storage for 20,000 acre-feet of flood water and provides some protection to the Truckee River and Reno areas.

Interim channel improvement on the Truckee River and tributaries downstream from Lake Tahoe was made from 1959 through 1964 by the U. S. Corps of Engineers to provide for more rapid releases from Lake Tahoe during floods, thus alleviating damage to lakeshore properties.

In the Lake Tahoe area the U. S. Corps of Engineers has been authorized to construct Martis Creek Reservoir tributary to Truckee River below Truckee. This project, now in preconstruction planning, will create a 15,000 acre-foot flood control reservoir to decrease flood peaks in all reaches of the Truckee River below Martis Creek.

Stampede Reservoir on Little Truckee River above Boca Reservoir has been authorized for construction by the U. S. Bureau of Reclamation. This reservoir will have a total storage capacity of 225,000 acre-feet, including 30,000 acre-feet flood control space to furnish additional flood protection to downstream areas adjacent to the Truckee River and to the Reno area. Construction may start in 1967 if constructed prior to the Bureau's Watasheamu Project authorized for construction on the East Fork Carson River. If the projects are constructed

simultaneously, construction will probably begin about 1970. The Watasheamu Project will provide for a 160,000 acre-foot reservoir with 85,000 acre-feet of flood control space to furnish substantial flood protection to the Carson Valley.

The U. S. Bureau of Reclamation has completed a preliminary study of a reservoir on West Walker River with a gross storage capacity of 110,000 acre-feet and with a flood reservation of 30,000 acre-feet to provide substantial downstream protection.

San Joaquin Valley

This area extends from the Stanislaus River watershed and Sacramento-San Joaquin Delta southward to the Tehachapi Mountains. Many flood control works have been constructed on the waterways emanating from the base of the Sierra Nevada on the eastern side of the valley. However, considering that the valley is one of the important agricultural areas of the world and its population and industries continually are expanding, this great valley continues to need additional protection.

Lower San Joaquin River and Tributaries Including Tuolumne and Stanislaus Rivers, California

The Lower San Joaquin River Levees, New Melones Reservoir, and Tuolumne River Reservoirs are U. S. Corps of Engineers' projects which were authorized by the federal Flood Control Act of 1944, as modified by the Flood Control Act of 1962. These projects are described below.

Lower San Joaquin River Levees. This project provides for improvement by the Federal Government of the existing channel and levee system on the San Joaquin River from the Sacramento-San Joaquin Delta upstream to the mouth of the Merced River, and on the lower reaches of the Stanislaus and Tuolumne Rivers, by improvement of existing levees, construction of new levees, revetment of some river banks, and removal of accumulated snags in the river channel. The project is an integral unit of the U. S. Corps of Engineer's authorized plan for flood control and other purposes in the San Joaquin River Basin. It is designed to supplement the reservoir units of the overall plan, consisting mainly of flood control storage on the Tuolumne and Stanislaus Rivers and in the existing Millerton Reservoir at Friant Dam on the upper San Joaquin River, by providing channel capacities along San Joaquin River sufficient to safely pass regulated flows. The overall plan will provide flood protection to about 135,000 acres of agricultural land, to numerous commercial and public installations, and to a suburban area south of the City of Stockton.

Construction of the project was initiated in 1956 and as of January 1, 1965, was about 68 percent complete. Construction of the left bank levee along the San Joaquin River from the Tuolumne River to the Merced River has been classified as "inactive" since 1961 due to difficulties in arranging for local interests to accept maintenance responsibility.

Stanislaus River. Existing developments on Stanislaus River providing flood regulation are the Melones, Donnells, Beardsley, and Tulloch Dams and Reservoirs with an aggregate storage capacity of approximately 343,000 acre-feet. The protection afforded by these reservoirs, which are operated and owned by local irrigation districts, is not adequate; and the Corps of Engineers proposes to construct the authorized New Melones Dam and Reservoir which will increase the storage capacity at the Melones site from the existing 112,500 acre-feet to 2,400,000 acre-feet.

New Melones will provide flood protection to about 35,000 acres of highly developed agricultural land in the flood plain of the Stanislaus River and to the suburban areas of Ripon, Oakdale, and Riverbank. In conjunction with storage projects on the Tuolumne River and authorized levees on the lower San Joaquin River, New Melones will provide flood protection to about 50,000 acres of agricultural land along the San Joaquin River below the mouth of the Stanislaus River, to about 185,000 acres of intensively cultivated land in the

Sacramento-San Joaquin Delta, and to suburban areas south of the City of Stockton.

Preconstruction planning on the New Melones Project was initiated in January, 1964. The Corps of Engineers expects the project to be completed in 1974.

Tuolumne River. Developments on the Tuolumne River affording flood regulation are Hetch-Hetchy Reservoir, and Cherry Valley Reservoir owned by the City and County of San Francisco and Don Pedro Reservoir owned by the Turlock and Modesto Irrigation Districts. The three reservoirs have an aggregate storage capacity of approximately 918,000 acre-feet and, under agreement with the Corps of Engineers, will be operated for flood control by the local interests until the 2,030,000 acre-foot New Don Pedro Reservoir, which will inundate the existing 290,000 acre-foot Don Pedro Reservoir, is constructed and in operation. Upon completion, flood control regulation will be transferred to New Don Pedro. New Don Pedro will be constructed and operated by the Turlock and Modesto Irrigation Districts under a copperative arrangement with the City and County of San Francisco and the Federal Government.

The Federal Power Commission issued a license for the New Don Pedro Project on May 6, 1964. The Department of the Interior and the California Department of Fish and Game subsequently filed complaints on July 6, 1964, asking for a court hearing against the licensee and the Commission. Initiation of construction on New Don Pedro is dependent upon the court's decision.

Operation of the Tuolumne River reservoirs for flood control will provide flood protection to about 8,000 acres of agricultural lands and several communities along the Tuolumne River. The flood control afforded by the reservoirs is essential to the successful operation of the Lower San Joaquin River Levees.

Merced River

Development on the Merced River affording flood regulation is the Merced Irrigation District's 289,000 acre-foot Exchequer Reservoir. The reservoir is operated primarily for the storage of irrigation water and the development of hydroelectric power, but provides a considerable amount of incidental flood regulation.

At present, construction is well under way on the 1,000,000 acre-foot New Exchequer Dam and Reservoir, the first stage of the Merced River Development. The new reservoir will inundate existing Exchequer Dam. New Exchequer is being constructed by the Merced Irrigation District and will be operated for flood control under a cooperative arrangement with the Federal Government. The project is scheduled for completion by January, 1967.

New Exchequer will provide flood protection to about 50,000 acres of agricultural lands along the Merced River and will alleviate flooding on the San Joaquin River and in the Delta area. The flood control afforded by the New Exchequer project

will materially add to the effectiveness of the Corps of Engineers' project on the lower San Joaquin River and tributaries including Tuolumne and Stanislaus Rivers.

Merced County Stream Group

The principal streams in the Merced County Stream Group are Burns, Bear, Owens and Mariposa Creeks. The Corps of Engineers, in 1957, completed a flood control project on these streams consisting of channel improvements and retarding reservoirs on Burns, Bear, Owens and Mariposa Creeks with capacities of 7,000, 7,700, 3,600 and 15,000 acre-feet, respectively. The project provides flood protection to about 136,000 acres of agricultural lands, the City of Merced, the towns of Planada and Le Grand, other communities, and highway and railroad facilities.

The existing project is not adequate for protection against large floods and the Corps of Engineers is currently conducting studies to determine a plan of improvement. The tentative plan of improvement consists of new reservoirs, namely Castle Reservoir with a gross capacity of 11,500 acre-feet on Canal Creek; Haystack Mountain Reservoir with a gross capacity of 5,900 acre-feet on Black Rascal Creek; Aqua Fria Reservoir with a gross capacity of 66,000 acre-feet on Mariposa Creek; Marguerite Reservoir with gross capacity of 7,500 acre-feet, crossing both Deadman and Dutchman Creeks; the enlargement of the existing Burns, Bear and Owens Reservoirs to capacities of

21,000, 17,000 and 6,500 acre-feet, respectively; and, as an alternative to Aqua Fria Reservoir, enlarging existing Mariposa Reservoir to 30,000 acre-feet. The eight reservoirs would provide 70,000 acre-feet of flood control space, and would include recreation as a project purpose. Channel improvements would include 42 miles of channel enlargement, 85 miles of levee construction or enlargement, and 15 miles of minor channel improvement.

The Corps expects to complete its studies and submit a survey report thereon some time in 1965.

Mustang Creek

The Mustang Creek watershed is located mostly in northeastern Merced County. Mustang Creek, along with other smaller streams, discharges into the High Line Canal, an irrigation canal owned and operated by the Turlock Irrigation District. The District operates its canal system to control the flood flows of Mustang Creek, up to the capacity of its canals, by discharging them through wasteways into the Merced or San Joaquin River.

Additional flood protection is needed. The areas adjacent to the lower reaches of Mustang Creek have historically been subject to some degree of flooding in about one year out of three. The severe flood of 1938 inundated over 1,600 acres. Flood damages are primarily agricultural but significant damage has occurred to a county road and the canal system of the Turlock Irrigation District.

To alleviate the situation local interests are sponsoring a flood control project on Mustang Creek under provisions of Public Law 566, the Watershed Protection and Flood Prevention Act. The work plan is in preparation and should be completed in 1965. The proposed plan includes a flood retarding structure in the upper watershed of Mustang Creek, downstream channel improvement, and land treatment measures.

Chowchilla River

There is no development of any consequence on the Chowchilla River that affords flood protection. However, Buchanan Reservoir was authorized by the federal Flood Control Act of 1962. The project provides for construction of a dam on the Chowchilla River to create a reservoir with a gross storage capacity of 150,000 acre-feet for flood control and other purposes and approximately five miles of channel and levee improvements along Ash Slough, a distributary of the Chowchilla River. The project will provide flood protection to about 110,000 acres of urban and rural areas, including the City of Chowchilla.

Preconstruction planning for the project was initiated in January, 1964, by the U. S. Corps of Engineers.

Fresno River

There is no development of any consequence on the Fresno River that affords flood protection. However, Hidden Reservoir

was authorized by the federal Flood Control Act of 1962. The project provides for the construction of a dam on the Fresno River, which will create a reservoir with a gross capacity of about 90,000 acre-feet for flood control and other purposes, and approximately seven miles of levee and channel improvement on the Fresno River downstream from the damsite. The project will provide flood protection to about 145,000 acres of urban and rural area, including the City of Madera.

Preconstruction planning for the project was initiated in January, 1964, by the U. S. Corps of Engineers.

The Lower San Joaquin River Flood Control Project

The State is currently constructing a project along and parallel to the San Joaquin River from the Merced River to a point west of Fresno. The project comprises a levee and bypass system for flood control which will permit the proper functioning of Friant Dam and Reservoir for flood control. The project was initiated in 1959. To date, contracts have been completed on about 100 miles of new levees, including appurtenant features, and on about 100 miles of existing levees which were refaced. The project is about 63 percent complete.

San Joaquin River Upstream from the Merced River

There are several reservoirs in the upper San Joaquin River watershed used primarily for power generation that provide some flood storage but the most important dam on the

river is Friant Dam located at the rim of the valley. The dam and 520,500 acre-foot reservoir were built by the U. S. Bureau of Reclamation as part of the Central Valley Project and are operated by the Bureau in accordance with flood control criteria which requires a flood control reservation of 390,000 acre-feet. The flood storage and regulation afforded by Friant Reservoir (Millerton Lake) alleviates flooding downstream along the San Joaquin River.

Big Dry Creek

Flood control facilities on Big Dry Creek consist of Big Dry Creek Reservoir and diversion facilities both upstream and downstream from the reservoir which were constructed by the U. S. Corps of Engineers in 1948. The reservoir has a gross storage capacity of 16,250 acre-feet, all of which is reserved for flood control.

By diverting the flows of Dog and Big Creeks to Little Dry Creek, and subsequently to the San Joaquin River, the project provides a high degree of flood protection to the Cities of Fresno and Clovis and their suburban areas.

Kings River

Courtright and Wishon Reservoirs, constructed in the upper Kings River watershed for power purposes by the Pacific Gas and Electric Company, afford some flood storage, but the principal development on the Kings River providing flood protection is the Pine Flat Project, constructed by the Corps of

Engineers in 1954. The project comprises (1) Pine Flat Dam and Reservoir which has an impounding capacity of 1,000,000 acre-feet and is operated primarily for flood control, and (2) downstream channel improvements on the Kings River and its distributaries on the valley floor to provide capacity to contain flood releases from the reservoir, to permit proper operation of the reservoir, and to assure proper division of flood flows through the several distributaries.

The channel improvements remain to be constructed. Current schedules call for initiation of construction of these remaining improvements in fiscal year 1965 and for completion in fiscal year 1966.

The project will protect some 80,000 acres of rich agricultural lands in the Kings River area and will provide protection against the flooding of 260,000 acres of excellent croplands in the Tulare Lake Basin.

Kaweah River

Flood protection on the Kaweah River is provided by Terminus Dam and Reservoir constructed by the Corps of Engineers in 1962. The reservoir has a gross storage capacity of 150,000 acre-feet and is operated primarily for flood control. The reservoir provides a high degree of flood protection to about 126,000 acres of agricultural and suburban lands in the Kaweah River Delta area, including the City of Visalia and adjacent urban and suburban areas and provides protection from

waters of the Kaweah River to 260,000 acres of highly productive land in the Tulare Lake Basin.

Tule River

Flood protection on the Tule River is provided by Success Dam and Reservoir constructed by the Corps of Engineers in 1961. The reservoir has a gross storage capacity of about 80,000 acre-feet and is operated primarily for flood control. The reservoir provides protection to about 60,000 acres of agricultural and suburban lands along the Tule River and distributaries, to the City of Porterville and suburban areas, and provides protection from waters of the Tule River to 260,000 acres of highly productive agricultural land in the Tulare Lake Basin.

Kern River

Flood protection on the Kern River is provided by Isabella Dam and Reservoir constructed by the Corps of Engineers in 1953. The reservoir has a gross storage capacity of 570,000 acre-feet and is operated primarily for flood control. The project also improves the irrigation water supply in the Kern River Delta area. The reservoir provides protection to about 350,000 acres of agricultural lands and oil fields in the Kern River Delta area, to the City of Bakersfield, and provides protection from waters of the Kern River to 260,000 acres of cropland in the Tulare Lake Basin.

The Corps of Engineers is currently investigating further water resources development on the Kern River in the interest of flood control, recreation, irrigation, and other purposes, and expects to complete a survey report in 1965.

Poso Stream Group

This stream group, located between the Tule and Kern Rivers, is composed of Poso and Deer Creeks and White River. Flooding on these streams results from rainstorms, and the flood flows are characterized by sharp peaks. Damage occurs to roads and bridges and, where the flood waters spread out, to cropland and local communities.

The Corps of Engineers is conducting studies of the stream group to determine whether provision for flood control improvements on the three streams is economically feasible. Consideration is being given to reservoir storage, levees, and channel improvement. The studies are being coordinated with the Bureau of Reclamation as that agency is proposing an 800,000 acre-foot dam and reservoir on Deer Creek as part of its proposed East Side Division of the Central Valley Project. The Corps expects to complete a survey report on its studies in 1965.

Central Coast and Bay Area

This embraces an area from Napa and Marin Counties on the north to Monterey County on the south. There are numerous flood control works in this area. However, there also are some important gaps or omissions as indicated herein.

Santa Cruz Area

The San Lorenzo River system drains about 120 square miles above the City of Santa Cruz and includes one dam which provides flood control only incidental to water conservation. The Loch Lomond Reservoir on Newell Creek has a total storage capacity of 8,400 acre-feet and controls only about ten percent of the total runoff.

Within the City of Santa Cruz the U. S. Corps of Engineers completed the San Lorenzo River Project in November, 1959. This project provides levees and flood walls along the lower 2.5 miles of the San Lorenzo River together with minor channel improvements for the purpose of providing flood protection to the city. There are also included channel improvements and rectification of Branciforte Creek. The improvements provide for design flows of 36,800 cfs in the San Lorenzo River above Branciforte Creek, 5,600 cfs in Branciforte Creek and 40,600 cfs below Branciforte Creek. This provides protection from a flood which is not expected to be equalled or exceeded on an average of once in 350 years. Flood peaks in Branciforte Creek normally do not occur at the same time as flood peaks in the San Lorenzo River.

Soquel Creek drains about 40 square miles and is a flashy stream with a peak being produced about four hours after the occurrence of a flood-producing storm. Channel improvement since the floods of 1955 includes channel clearing in the lower basin reaches made under provisions contained in Public Law 875. Existing flood control improvements constructed by local interests consist of noncontinuous bank protection work.

Pajaro River

The Pajaro River drains 1,300 square miles of the Coast Range of California. There are five dams which provide flood control only incidental to water conservation. These are: (1) Pacines Dam on a stream tributary to Tres Pinos Creek with a reservoir capacity of 4,500 acre-feet; (2) Hernandez Dam on the San Benito River with a reservoir capacity of 18,000 acre-feet; (3) North Fork Pacheco Creek Dam with a reservoir capacity of 6,150 acre-feet; (4) Chesbro Dam on Llagas Creek with a reservoir capacity of 7,630 acre-feet; and (5) Uvas Dam on Uvas Creek with a reservoir capacity of 10,000 acre-feet.

The existing federal flood control project, completed in 1949, consists of about 11 miles of levee along the lower Pajaro River and 2 miles of levee on Salsipuedes Creek immediately above its confluence with the Pajaro River. The levee maintenance is provided by the Santa Cruz County Storm Drain District and by

the Monterey County Flood Control and Water Conservation District. With the existing project the river channel has a capacity of about 19,000 cfs or a frequency of about once in 10 years.

Upstream from the Corps of Engineers' project on Corralitos Creek, bank-protection works have been constructed by private individuals and the Santa Cruz County Flood Control and Water Conservation District. The Counties of Monterey and Santa Cruz and the City of Watsonville have expended approximately $200,000 on channel clearing, levee maintenance and bank-protection works along Corralitos and Salsipuedes Creeks and Pajaro River in Pajaro Valley since completion of the federal project in 1949.

Monterey County

In the upper Salinas River basin there is an earthfill dam and reservoir on the Nacimiento River with a total storage capacity of 350,000 acre-feet of which 150,000 acre-feet is reserved for flood control.

At the present time there are no major flood control works on the lower Salinas River other than a few bank-protection works built by the County of Monterey, Southern Pacific Company, and individual land owners. The overall effectiveness of the protective measures have been greatly reduced because of the limited reaches over which the works extend.

There is also an earthfill dam on the San Antonio River now under construction and scheduled for completion by 1966. This dam and reservoir will have a total storage capacity of 350,000 acre-feet with 50,000 acre-feet allocated to flood control.

There are two small dams and conservation reservoirs on the Carmel River which provide some incidental flood control. These two reservoirs are the San Clemente and Los Padres Reservoirs with storage capacity of 3,100 acre-feet and 2,150 acre-feet respectively.

Marin County

The small federal flood control project on Coyote Creek consists of channel improvements in the community of Tamalpais Valley. The improvements which were begun in July, 1964 consist of a concrete-lined rectangular channel section for a distance of 2,900 feet and an enlarged earth channel section for 4,000 lineal feet. The project, as of January, 1965, is approximately 85 percent complete.

Residential areas along Novato Creek are afforded some protection from flooding by existing levees. Stafford Lake, a water supply reservoir, also contributes some protection. The only other works are local pumps and widening and clearing of the lower end of Novato Creek.

Water supply reservoirs of the North Marin County Water District and Marin Municipal Water Districts contain a gross capacity of more than 50,000 acre-feet. These reservoirs, although not utilized specifically for flood control, probably have an incidental effect on flood flows in the local streams.

Sonoma County

In that portion of southern Sonoma County that drains into San Pablo Bay, there is only a little more than 1,000 acre-feet of storage capacity in local conservation reservoirs. It is doubtful that this small amount of storage provides much incidental flood control to the area.

Napa County

The Napa River Watershed Project is currently in the initial stages of construction. The watershed work plan covers approximately 135,000 acres tributary to the Napa River. Channel improvements will run from Oakville Crossroad to Imola Avenue. This construction will include channel improvements on Napa River, a 3,000 acre-foot flood detention reservoir on Redwood Creek, one mile of channel improvements on Tulucay Creek which has been completed, and 2.4 miles of channel improvements on Conn Creek. A 31,000 acre-foot water conservation reservoir now exists on Conn Creek. The watershed work plan was designed for a ten percent chance flow in agricultural areas and a one percent chance flow in the urban areas.

There are almost 40,000 acre-feet of conservation storage capacity in Napa County reservoirs of which 31,000 is in Hennessey Reservoir on Conn Creek. Some degree of incidental flood control is obtained from this storage.

Solano County

The Green Valley Creek flood control project consists of channel realignment and enlargement for 4.3 miles along lower Green Valley Creek and Dan Wilson Creek. Channel works were constructed on Green Valley Creek from 12,000 feet above Fall Road down to Cordelia Slough, near State Highway 40. Construction on Dan Wilson Creek went from Rockville Road to its confluence with Green Valley Creek, a length of 2.6 miles. Project construction has recently been completed.

The Vallejo Sanitation and Flood Control District operates Chabot Reservoir to provide some flood control regulation. In addition, there are other channelization features. However, the facilities are overtaxed during a heavy storm.

In the southwestern portion of Solano County there is a total of about 20,000 acre-feet of storage capacity which probably provides some degree of incidental flood protection.

Contra Costa County

The Marsh-Kellogg Watershed Project of the U. S. Soil Conservation Service is now under construction involves an area of about 116,000 acres and is located in the vicinity of Brentwood. The plan includes construction of detention reservoirs on Marsh Creek and its principal tributaries, Dry and

Deer Creeks, and channel improvements on Sand Creek and Marsh Creek below the junction with Sand Creek. Improvements on Kellogg Creek include a flood water retarding structure and a side channel reservoir and diversion.

Construction has been completed on the Marsh Creek, Dry Creek, and Deer Creek floodwater detention dams and the Kellogg Creek side channel reservoir and diversion. Construction is in progress on 5.2 miles of earth channel improvements on lower Marsh Creek.

Detailed plans are being prepared for channel improvements on Deer, Dry, Sand, Middle, and Upper Marsh Creeks. The design of the Kellogg Creek flood water retarding structure is being deferred pending completion of feasibility studies by the U. S. Bureau of Reclamation on a large reservoir in the Kellogg Creek watershed.

The Walnut Creek Watershed Project of the U. S. Soil Conservation Service, consisting primarily of channel improvements, covers an area of approximately 72,600 acres. Channel improvements include drop structures, overpours, chutes, linings, enlargements, and levees. A total of about 33 miles of channel improvements on Grayson, Galindo, San Ramon, and Lafayette Creeks (tributaries to Walnut Creek), are included in the project. Work is essentially completed at this time.

Channel construction on the Corps of Engineers' Walnut Creek Project is presently underway on Reach 1 of Walnut Creek from Arnold Industrial Highway to Suisun Bay. Work involves utility and bridge relocations, together with channel widening and levees.

Approximately 1.5 miles of channel improvements were constructed on Rheem Creek from San Pablo Avenue to San Pablo Bay. Construction included 6,300 linear feet of trapezoidal earth channel and 1,500 linear feet of rectangular concrete channel. Rheem Creek drains approximately 1,400 acres. Channel designs were selected to carry flows from 600 second-feet at the upstream end, to 800 second-feet at the mouth of the creek. Construction was completed in November, 1960.

Alameda County

Local responsibility for flood control within Alameda County is lodged with the Alameda Flood Control and Water Conservation District. Since the formation of the District in 1949 various special zones have been authorized by the local electorate and the District presently is directing the planning, construction, and operation of flood control works in nine active zones embracing about 90 percent of the land area of the county. Not covered by special districts are the Berkeley-Albany area, the Piedmont area, the Alameda area and some East Bay Municipal Utility District property, all in the northern portion of the county.

A significant local flood control project is the downstream channel improvement works on San Lorenzo Creek recently completed by the U. S. Corps of Engineers in cooperation with the Alameda County Flood Control and Water Conservation District. The lower reach of the federal San Lorenzo Creek Flood Control Project extends from San Francisco Bay to Foothill Boulevard and

consists of leveed and riprapped channel extending about 1.4 miles upstream from the mouth, concrete channel for about 3.9 miles, and channel clearing and stabilization works for the balance of the 7.3 miles of the project. Construction of the upper portion of the project from Foothill Boulevard to "B" Street has not as yet been authorized.

Incidental flood control is derived from two small reservoirs on the upper reaches of San Lorenzo Creek. San Lorenzo Creek Dam, an earthfill structure 75 feet in height which can impound about 380 acre-feet of water, and Cull Creek Dam, another earthfill structure 55 feet in height which can impound 295 acre-feet of water, were recently completed by the District as multiple-purpose projects. While no flood control reservations are included, both reservoirs are kept at low levels during the first part of the stormy season to provide flood protection until the time necessary to fill for conservation and recreation purposes. The installations also serve as debris control facilities.

A flood detention dam and reservoir with a capacity of 130 acre-feet has been constructed on Ward Creek by the county district, in cooperation with the City of Hayward and the State Division of Highways.

The District has, since 1954, the date of the first flood control construction on San Lorenzo Creek, executed some 200 contracts and agreements, and has constructed 23 miles of concrete-lined channel, 112 miles of earth-lined channel,

45 miles of underground conduit, 52 miles of levees, and numerous structures consisting of dikes, tide gates, bridges, pumping plants, and culverts. As of July 1, 1964, local projects totaling about $75 million have been authorized, and expenditures on these projects have been about $25 million.

In addition to the flood control works provided by, and in cooperation with, the District, existing reservoirs of East Bay Municipal Utility District, City of San Francisco, the East Bay Regional Park District, and others assist in minimizing the effects of flood flows in Alameda County resulting from high runoff conditions.

Santa Clara County

The Santa Clara County Flood Control and Water Conservation District is divided into five zones which represent groups of watersheds within the County. A needed program for improvements through the developed urban areas has essentially been completed in the Northwest Zone with the exception of San Francisquito Creek.

In the North Central zone a bond financed program of improvements is presently underway and will be completed in the next two years.

The third zone is the Central Zone which includes the watershed of Los Gatos and Canoas Creeks and the Guadalupe River. Most of the improvements in this zone are on the Guadalupe River downstream from the Civic Center to the vicinity of the town of

Alviso. Work is proceeding on a pay-as-you-go plan. The City of Los Gatos receives some incidental flood protection from Lexington Reservoir which is located on Los Gatos Creek.

The East Zone has several small channel improvement projects but is an area in which very little work is undertaken annually because of the low income from a maximum tax rate.

In the South Zone there have been little if any construction of flood control works, except some local improvements along the Pajaro River and Llagas Creek.

San Mateo County

At the present time there are no existing flood control works in San Mateo County with the exception of some locally sponsored protective measures such as bank stabilization works and levees. In most instances, however, these works have been ineffective. Some incidental flood protection is probably realized on San Mateo, San Andreas, and Pilarcitos Creeks due to reservoirs of the City of San Francisco.

Southern California

Federal, state, and local agencies in Southern California have cooperated to construct many miles of channels and levees, and dams to protect residential and agricultural areas in Southern California. These existing flood control projects provide various degrees of protection to the area.

Central Coastal Area

The major existing flood control works in the Central Coastal area are the Arroyo Grande Creek Watershed Project, the Santa Maria River Levee Project, and the Santa Ynez River Watershed Project.

Arroyo Grande Creek Watershed Project. This project is in San Luis Obispo County starting at a point about two miles northeast of the City of San Luis Obispo and flowing about 25 miles to the Pacific Ocean near Oceano. The project provides for increasing the capacity of Arroyo Grande Creek, diversion of Los Berros Creek into Arroyo Grande Creek, control of Lopez Creek and Tar Canyon Creek with tidal gates and erosion control and stabilization of miles of sand dunes along the coast by planting. This project is operated by the San Luis Obispo County Flood Control and Water Conservation District.

Santa Maria River Levee Project. This project is located in Santa Barbara and San Luis Obispo Counties about

60 miles northwest of Santa Barbara. The project includes channel clearing and construction of intake levees at headwaters of Santa Maria River, construction of a 17-mile levee along the left bank from Fuglers Point to 600 feet downstream from State Highway Bridge at Guadalupe, construction of a five-mile levee along the right bank from 1.25 miles downstream from U. S. Highway 101 Bridge to 1.5 miles upstream of Southern Pacific Railroad Bridge at Guadalupe, and a 1.8 mile levee along Bradley Canyon. The project will provide flood protection for the City of Santa Maria and for agricultural lands in the Santa Maria Valley. The project is part of a comprehensive improvement which includes the multiple-purpose Twitchell Reservoir on the Cuyama River and was completed in 1958 by the Bureau of Reclamation. Construction of some parts of the project is complete. Construction of the final portions was initiated in 1961. This project is operated by the County of Santa Barbara.

Santa Ynez River Watershed Project. This project is in Santa Barbara County about 100 miles northwest of Los Angeles.

The watershed is about 900 square miles in area. The plan consists of (1) additional fire control and cover improvement measures on the forest lands and (2) structural measures; including grassed waterways, terraces and check dams to reduce erosion; cleaning and enlargement of existing channels and

construction of some additional channels, levees, culverts and bridges. The project was designed to function in conjunction with the existing Cachuma and Gibraltar Reservoirs. This project is operated by the County of Santa Barbara.

South Coastal Area

There are major existing flood control works in the South Coastal area as follows:

Ventura River Basin Project. This project is on the left bank of the lower Ventura River at Ventura. The levee is 2.64 miles in length. It gives protection to the City of Ventura against floods on the Ventura River by a rock-revetted earthfill levee. The area protected comprises about 1,500 acres of agricultural and commercial land. The levee was completed December, 1948. This project is operated by the Ventura County Flood Control District.

The Stewart Canyon portion of the project is on a tributary of the Ventura River and extends from the mouth of Stewart Canyon through the City of Ojai, about 14 miles above the mouth of Ventura River. The project provides for construction of a debris basin at the mouth of Stewart Canyon and a rectangular concrete channel and concrete-covered channel from the debris basin through Ojai. The project provides flood protection for residential and business districts in Ojai. This project is operated by the Ventura County Flood Control District.

Santa Clara River Levee Project. This project is on the lower Santa Clara River in Ventura County. The project provides for construction of 4.7 miles of levee along the left side of the lower Santa Clara River. It provides flood protection to Oxnard Plain, the City of Oxnard and the naval base at Port Hueneme. Construction of the Santa Clara River levee was completed in April,1961.

Santa Clara River Levee Project (Santa Paula Creek Channel) is on lower Santa Paula Creek in Ventura County. The project provides for construction of a concrete channel from near the mouth of Santa Paula Canyon to the Santa Clara River, a distance of approximately three miles. This improvement will protect the City of Santa Paula and nearby agricultural areas. The Santa Clara River Projects are operated by the Ventura County Flood Control District.

Calleguas Creek Watershed Project. This project is in southeastern Ventura County. There are two independent portions of the project. One includes the reach of Calleguas Creek between the Highway 101-A bridge and a point 860 feet upstream from the State Hospital bridge. The second portion includes the Walnut and Gabbert Canyons' watersheds west of Moorpark. It protects the City of Moorpark and rich agricultural lands from flooding and from damage by silt deposit. This project is operated by the Ventura County Flood Control District.

Los Angeles River Watershed Project. This project, in an area of about 150 square miles of the upper Los Angeles River basin in the western side of Los Angeles County, provides for improvement of runoff and water flow retardation and erosion prevention in aid of flood control on the watershed of the Los Angeles River.

Los Angeles and San Gabriel Rivers and Ballona Creek Project. This project is along the Los Angeles and San Gabriel Rivers, the Rio Hondo, and Ballona Creek, and tributaries thereof in Los Angeles County. The project provides for construction of five flood control reservoirs or basins, 29 debris basins, 101.3 miles of main channel, 179.4 miles of tributary channels, and two jetties. In general, standard project floods are used as channel-design floods.

Kenter Canyon Conduit and Channel. This project is in the southwestern part of Los Angeles County. It consists principally of a subsurface drain that begins near the intersection of Wilshire Boulevard and McClellan Drive in Los Angeles and extends 3.4 miles, for the most part beneath Broadway and Colorado Avenues in Santa Monica, to the ocean at Pico Boulevard. The improvement prevents serious flood damage to valuable residential and business properties in Santa Monica. The project was constructed as an emergency work-relief project and was completed in 1937.

The foregoing three projects are operated by the Los Angeles County Flood Control District.

Santa Ana River Basin Project. This project is on the Santa Ana River and tributaries and other streams in Riverside and San Bernardino Counties. It provides for construction of four levee and channel improvement projects: Devil, East Twin, and Warm Creek improvements and Lytle Creek levees, San Bernardino County; Riverside levees; Mill Creek levees near Redlands, San Bernardino County; and San Jacinto River levees and Bautista Creek channel near San Jacinto and Hemet, California, Riverside County. The project will provide protection for the City of San Bernardino and vicinity and nearby water supply wells. It also will provide flood protection to suburban areas located in the northwest part of Riverside, most of Rubidoux, to Redlands and Mentone, California, and valuable citrus orchards in the floodplain. This project is operated by the San Bernardino County Flood Control District and the Riverside County Flood Control and Water Conservation District.

The Santa Ana River Basin (and Orange County) Project also is on the Santa Ana River and tributaries and other streams in Orange, Riverside and San Bernardino Counties. It provides for construction of seven flood control dams, two flood control dams with downstream channels, and related flood control works for protection of metropolitan area of Orange County; control of floods on San Antonio and Chino Creeks; and the Lytle and

Cajon Creeks project to provide local flood protection at San Bernardino and Colton, California.

City Creek Levee Project. This project is about 5.5 miles east of the City of San Bernardino in San Bernardino County. The proposed project includes construction of about 2,550 feet of new levee, revetting of about 3,400 feet of existing levee and excavation of 4,600 feet of channel. This project is operated by the San Bernardino County Flood Control District.

Escondido Creek Watershed Project. This project is in the City of Escondido. The plans provide for construction of a 2,325 acre-foot capacity flood prevention and water management reservoir and realigning, enlarging, and lining existing natural channels through Escondido. This project will be operated by the City of Escondido.

Buena Vista Creek Watershed Project. This project is on Buena Vista Creek in San Diego County. The plan provides for the enlargement, realignment, and lining of portions of Buena Vista Creek and its principal tributaries through Vista. Construction was started in 1962. The project will be operated by the County of San Diego.

San Diego and Mission Bay Project. This project is on the San Diego River at San Diego. The project provides for

a leveed flood channel 800 feet wide from 0.4 mile above Morena Boulevard to the ocean (3.0 miles); dredging of entrance channel 20 feet deep into Mission Bay from the ocean; and construction of three stone jetties at entrance and other harbor improvements. The channel improvement on the San Diego River provides flood protection for the City of San Diego. The original flood control project provided for a levee system from Presidio Hill eastward for 6,700 feet and a cutoff levee of about 900 feet southward from the main levee. The flood control project was completed in 1959. This project is operated by the City of San Diego.

San Diego County Flood Hazard Investigation

A cooperative investigation was carried on by the Department of Water Resources and the County of San Diego in order to delineate areas of potential inundation along portions of the San Luis Rey, San Dieguito, San Diego, Sweetwater and Otay Rivers in San Diego County. This report was made available to the County for their use in flood control project planning and proper management of the flood plain.

Colorado Desert Area

The Tahchevah Creek Project is only the major flood control project in the Colorado Desert Area. This project is in the City of Palm Springs. It consists of an earthfill embankment at the mouth of Tehchevah Canyon creating a detention reservoir with a capacity of 900 acre-feet, a concrete-lined spillway in the right end of the embankment, a 1,200-foot stone dike to direct flows from the outlet works, a concrete-lined channel from the reservoir to Palm Canyon Drive, an underground conduit from Palm Canyon Drive to a point about 540 feet upstream from the junction of Tahchevah Creek and Baristo Creek, and an unlined, excavated earth channel from the downstream end of the conduit to Baristo Creek. This project will be operated by the Riverside County Flood Control and Water Conservation District.

Quail Wash Levee Project. This project is located in San Bernardino County about 0.5 mile southeast of the community of Joshua Tree and consists of a compacted earthfill levee about 2,660 feet long, with an average height of 9.5 feet and grouted-stone revetment on the channel side. The project is operated by the San Bernardino County Flood Control District.

Lahontan Area

Presently there are no existing flood control or watershed protection projects in the Southern California portion of the Lahontan area.

CHAPTER IV. FLOOD FIGHT RESPONSIBILITIES AND RESOURCES

In California there is no single agency responsible for flood fighting. Each local, state, or federal agency with statutory responsibilities for flood control work cooperate to the extent each has capability. The effort of each in Northern California are coordinated through the Flood Operation Center of the Department of Water Resources. By agreements with the Corps of Engineers, with the U. S. Weather Bureau, and with the Division of Forestry, the Department has developed plans and procedures to utilize the capabilities of these organizations.

In Northern and Central California all requests for local flood-fighting assistance are directed to the Department. If the resources of the Department are exhausted it will channel requests from local agencies to the Corps of Engineers. In other areas of the State, these local requests may be made directly to the Corps.

The Corps of Engineers is responsible for securing assistance from all other federal agencies such as the Sixth Army.

The California Disaster Office and its regional offices are responsible for coordinating mutual aid during natural disasters. The Department of Water Resources cooperates with the California Disaster Office in this coordinating effort.

The flood emergency resources available are broad and extensive and are discussed in detail later in this report by agencies. The declaration of a flood emergency by the Governor makes the entire resources of the State Government available to aid designated stricken areas. The Governor generally takes this action after local agencies have exhausted their resources or it is apparent that they soon will.

A declaration of national emergency by the President releases additional resources for flood fighting and for recovery. This makes available the resources of all federal agencies to the extent that they are needed. This includes the manpower and materials available to the Corps of Engineers either through its own resources, or from the Sixth Army, Navy, Air Force, or Marines. In addition, the Office of Emergency Planning initiates its program under prearranged agreements with the California Disaster Office.

The utilization of the resources of the State and of the federal agencies has been planned and organized in an orderly fashion so as to insure that when a flood emergency develops, the capabilities and resources of related local, state, and federal agencies are available to combat the emergency. The duties of the many involved agencies are described more fully in the following paragraphs.

California Department of Water Resources

In a flood emergency the Department provides services, funds, manpower, and equipment and supplies.

The Department provides flood emergency services before, during, and following the flood emergency. These services include: planning, execution, and coordination of flood fighting operations of local, state, and federal agencies through the Flood Operations Center; flood warning and river forecasts on the principal streams in Northern and Central California; training in flood fighting techniques for local, private, and public groups; and technical assistance in setting up flood fighting organizations to be operated by local entities. Also, the State Flood Emergency Operations Manual is prepared and made available to all persons and agencies who may be involved in a flood emergency.

Two sources of funds are available to the Department. Prior to the declaration of an emergency by the Governor, and under the Department's statutory authority, funds are available for operation of the Sacramento River Flood Control Project and for maintenance of portions of that project for which the Department has been assigned direct responsibility. Funds also are available for providing flood warnings and technical assistance in flood fighting for other areas of the State in addition to the Sacramento River Flood Control Project. Under emergency conditions, in addition to the funds appropriated to

the Department for its statutory responsibilities, there is available an emergency fund of one million dollars first appropriated by item 446.8 of the Budget Act of 1958. This appropriation is available without regard to fiscal years and when expended may be replenished by another appropriation.

The manpower of the Department is available for assignment to flood fighting duties by the Chief Engineer. These personnel provide liaison, technical assistance, flood fight supervision, flood fight duty, specific engineering knowledge and assistance, or any other duty necessary to avert, alleviate, restore or repair damage having a general public or state interest, or to protect the health, safety, convenience, and welfare of the general public of the State. An important part of this staff is the approximately 130 experienced supervisors in the operation and maintenance activities and personnel of the Sacramento and Sutter Maintenance Yards. Under emergency conditions the Department hires men to assist in flood fighting duties.

U. S. Army, Corps of Engineers

During flood emergencies the resources of the Corps of Engineers include the resources of the Army, Navy, Marines and the Air Force, in addition to the resources of other federal agencies. These resources are generally contingent upon the declaration of a national emergency, but are available under other conditions if it is necessary to protect life and

property. Under flood emergency conditions the Corps has resources available pursuant to Public Law 99 for emergency repairs to flood control works. In the recent flood the Corps acted quickly to restore transportation facilities and water supplies and to provide repairs in situations that were creating health problems. Cleaning up debris where navigation is involved also is a major activity.

U. S. Weather Bureau

The U. S. Weather Bureau's primary resource is its capability to provide weather and river forecasting service. Drawing upon the national and worldwide weather data-gathering networks and the weather radar installations, the Weather Bureau makes daily and other short-range forecasts and also makes thirty-day weather predictions. The Sacramento office of the Weather Bureau with the Department of Water Resources, through the Federal-State River Forecast Center, provides river warnings and forecasts for Central and Northern California. In other areas of the State, the Weather Bureau provides these services entirely with its own resources. Weather Bureau offices are located in Sacramento, Redding, Fresno, Eureka, San Francisco, Los Angeles, Bakersfield, Oakland and Santa Barbara.

The State Reclamation Board

The State Reclamation Board is responsible for securing lands, easements and rights-of-way for flood control purposes within its jursidiction. It is responsible for giving the necessary assurances to the Federal Government for construction of flood control projects. The Board also is the agency responsible for enforcing state laws and procedures governing the construction, operation and maintenance of flood control projects within the Sacramento-San Joaquin Drainage District; such district is confined to the valley floor of the Central Valley.

The duties and resources of the Reclamation Board are not necessarily affected by a flood emergency. However, their capabilities are available at the direction of the Board and the General Manager. The resources of the Board during a flood emergency generally consist of services that could be provided by its engineering and legal staffs.

California Disaster Office

The California Disaster Office coordinates the efforts of local and state agencies and coordinates federal assistance to local agencies during periods of flood disaster. This coordination is provided through six regional disaster offices and the disaster organizations in each city and county. The resources of most local agencies in California have been made available to their more distressed neighbors through "Mutual Aid" pacts established with the assistance of the Disaster Office. These pacts include provisions for furnishing manpower, equipment and supplies.

California Division of Forestry

The resources of the Division of Forestry during a flood emergency consist of manpower, equipment, and communica tions facilities. This well-trained fire control and fire fighting organization adapted quickly and effectively to flood fighting tasks. The Division and the Department of Water Resources executed an agreement in 1960 making available the manpower resources of the forestry conservation camps and the equipment and communication facilities when not utilized for fire fighting activities. The manpower consists of about 2,800 inmates of correctional institutions which have been assigned to the forestry conservation camps by the Department of Corrections. Forestry's equipment available for flood emergency activities

consists of 97 bulldozers, 300 light trucks, and other miscellaneous equipment. The statewide communications facilities of Forestry are an available and valuable resource.

California National Guard

Upon declaration of emergency by the Governor the entire resources of the California National Guard are available. This includes state funds to the extent necessary to activate the Guard and to carry out its work. Up to a full strength of some 24,000 men can be made available if needed. These men are trained in many skills and are dispersed throughout the entire State, from Yreka to Calexico. Present plans call for a restructuring of the National Guard, with the result that even more manpower and equipment would become available. With respect to equipment, thousands of motorized vehicles of all types with skilled operators are available, ranging from cross country multi-wheel drive trucks and amphibious trucks to buses and light passenger cars. Also, the facilities and personnel of the Air National Guard, with its 4-engine and 2-engine aircraft, are available. In this regard, the addition of helicopters is planned. Finally, the Guard has a limited quantity of supplies, such as emergency rations, gasoline and blankets. This agency has the largest aggregate amount of manpower and equipment available in an emergency of any state agency.

Non-Governmental Organizations Engaged in Public Assistance

During flood emergencies a number of private welfare organizations and associations minister exclusively to the individual and his family needs. These include the American Red Cross, the Salvation Army, church organizations, fraternal associations, and other nonpublic agency groups. In flood emergencies these organizations play an important part in view of the personal nature of their services. In varying degree, funds, manpower, and supplies needed for food, clothing and shelter are made available. Perhaps, the most important agency in this category is the American Red Cross. The Red Cross is the official volunteer disaster relief agency of the American people. The Red Cross, however, expects the locally constituted authority to assume total direction and leadership for the disaster situation in the community.

U. S. Office of Emergency Planning

Public Law 875, enacted in 1950, authorizes the President to furnish federal assistance to state and local governments in times of "major disasters". The Office of Emergency Planning exercises this authority on behalf of the President when he declares a state of disaster. Two important resources then become available -- federal funds and coordination of the disaster relief functions of all of the federal agencies. Federal funds for manpower, equipment and supplies

are made available on a reimbursable basis to local entities. Requests for federal assistance are made through the California Disaster Office.

U. S. Armed Forces

The resources of the armed forces, including the Army, Navy, Marine Corps and Air Force, consist of manpower, equipment and supplies of all kinds which may be used under certain conditions for protection of life and property, flood fighting, rescue and relief work. They are not available for rehabilitation. These resources are available following a declaration of a national emergency upon request through the Corps of Engineers or the Office of Emergency Planning.

California Highway Patrol

The Highway Patrol provides traffic control during flood periods. The Patrol assists citizens in the affected area and governmental agencies engaged in flood fighting, search and rescue, and other relief work. Direct assistance to state and federal organizations engaged in flood fighting includes the utilization of their communication facilities.

Local Law Enforcement Agencies

The county Sheriff's Offices and city Police Departments maintain law and order and provide for the public safety. These organizations are very active during flood emergencies and their participation is invaluable. The communication

facilities and other resources of these organizations are utilized to relay or obtain information. The local law authority can order evacuations of areas subject to imminent flooding or disaster.

Local Agencies

An important basis for flood fighting activities in California is the assumption that the flood fighting will begin at the local level. The local agency, the county, city, or district where the flooding occurs and which has responsibility for operation and maintenance of the flood protection facilities, has the first flood fighting responsibility. These local agencies have funds, manpower, equipment and supply resources which are brought into action before, during and following flood emergencies. When the local resources are exhausted or when it is apparent they soon will be the resources of higher levels of government are to be made available, generally by the declaration of an emergency by the Governor and the President.

U. S. Bureau of Reclamation

A primary contributary of the Bureau of Reclamation during a flood emergency is its operation of Reclamation reservoirs in accordance with pre-arranged flood control criteria and procedures. The Bureau does not generally have

available manpower, funds or equipment in excess of that necessary to carry out its statutory responsibilities except when requested to do so under a declaration of national emergency.

California Department of Employment

This Department's principal service is providing assistance in the recruitment of laborers and others needed during and after an emergency. The Department has about 100 field offices in principal towns and cities throughout the State.

CHAPTER V. AID PROGRAMS

State Emergency Flood Relief Law

The State Emergency Flood Relief Law provides state funds to assist local agencies in meeting the cost of repairing and restoring storm-damaged essential public real property to public use as soon as possible. When the Legislature concludes that damages incurred during a specific period were of sufficient magnitude to warrant state participation in the repair and restoration costs, an appropriation is made to the Department of Finance to finance the program.

Any city, county, or public district sustaining storm damage within the period specified by the Legislature is eligible for financial assistance under the law.

Emergency Powers of Director of Water Resources

Section 128 of the Water Code, added in 1956, authorizes the Director of the Department of Water Resources to designate the existence of an emergency in times of extraordinary stress and disaster resulting from storms and floods. On concurrence by the Governor, and the availability of funds, the Department is authorized to perform any work required or take any remedial measures necessary to prevent, to lessen, to repair, or to restore damage or destruction to property.

Public Law 875

The intent of Congress in enacting Public Law 875 is to provide an orderly and continuing means of financial assistance

to state and local governments in costs of measures required by them to prevent or alleviate suffering and damage caused by major disasters. The provisions of the law become operative upon concurrence by the President in the Governor's proclamation of a disaster area. Generally, federal financial assistance under this law is limited to protective work and other work for the preservation of life and property, and temporary replacement of essential facilities of local government. All cities, counties, public districts, and other units which qualify as legal government entities within the geographic area of the disaster are considered eligible local agencies.

Federal Aid Highway Act

Federal Emergency Funds - Federal Aid Highway Act provides federal funds to augment the funds of states and their subdivisions for the cost of emergency opening and permanent restoration of roads and bridges on federal aid highway systems damaged or destroyed during disaster conditions arising from natural disturbances of extraordinary intensity over a wide area.

Federal funds become available upon concurrence of the Secretary of Commerce in the Governor's emergency proclamation of flood conditions caused by storms or other natural disturbance.

Any state, city, or county having roads or bridges on the Federal Aid Highway System which have sustained storm damage during a proclaimed state of emergency is eligible for federal assistance under the Act.

Public Law 99

Federal Public Law 99 authorizes the expenditure of emergency funds by the U. S. Army Corps of Engineers in flood emergency preparation, in flood fighting and rescue operations, or in the repair or restoration of any flood control work threatened or destroyed by flood. Flood control operations are undertaken at the request of responsible local authorities when available local and state resources are inadequate.

Small Business Administration Loan

The Small Business Administration provides financial assistance to disaster victims in the form of direct loans in participation with banks or other lending institutions to restore or rehabilitate property damaged or destroyed as a result of natural disaster. Assistance also is available to small businesses for economic injury due to drought or excessive rainfall.

American National Red Cross

The American National Red Cross carries on a system of relief in mitigating the sufferings caused by pestilence, famine, fire, flood, and other disasters. Red Cross aid is not dependent upon a declaration of a disaster, nor does it duplicate relief provided by other agencies. Its major responsibilities are in the early stages of disaster emergencies, during which time its activities are closely coordinated with federal, state, and local governmental agencies to plan relief operations.

Any individual or family in need is entitled to assistance from the American National Red Cross.

A more detailed explanation of the foregoing program are available in the Department of Water Resources' report entitled "State and Federal Flood Relief and Disaster Laws".

CHAPTER VI. FLOOD DAMAGE AND PROBLEMS

Despite the existence of many flood control works in California, as described in Chapter II, the unprecedented flood of December, 1964 demonstrated conclusively that we still have a long way to go in securing adequate protection against floods, both in the construction of additional flood control facilities and in the effective management of lands along the flood plains of our rivers.

Damage from the Christmas 1964 floods was the worst in the North Coastal area where the storm was the heaviest and where flood control works are the fewest. For example, nearly two feet of precipitation fell on the Eel River watershed, sending new record flows rampaging through the basin with only a pitifully inadequate levee system in the Eel River Delta to provide protection to the local residents.

A similar catastrophe in the Sacramento Valley was avoided because of the comprehensive system of reservoirs, levees, and bypasses to control and contain the flows resulting from the flood. However, levees were put to a severe test by the extended duration of high flows, and extensive repairs and maintenance will be necessary. This is particularly true in the Sacramento-San Joaquin Delta where a combination of high flows, high tides, and winds acting against levees founded on organic soils and subject to sinking caused the near loss of several

islands and will necessitate major reconstruction of a number of levees.

While the recent storm did not cause flood in Central and Southern California, nowhere in the State can the overall flood control facilities be considered adequate. Flood problems are evident in varying degrees throughout the State.

In this chapter is a discussion of flood problems and flood damage in the various areas of the State followed by a discussion of certain general problems. This chapter describes those problems as manifested by the Christmas 1964 and other recent floods.

North Coastal Area

During heavy floods, such as those that occurred during the Christmas Season of 1964, the North Coastal Area characteristically sustains great damage in relation to its total economy. There are several reasons for this. In the first place, precipitation in California is characteristically the greatest in the North Coastal region and the virtual absence of snowpack to attenuate the discharges, coupled with the relatively steep topography of the area results in rapid runoff and accumulation of flood flows as they course to the ocean within a few hours, or, at the most, two or three days after the precipitation falls.

Secondly, the topography of the region confines the habitable areas to those relatively narrow bands of flat lands

along the channels where people have historically settled and developed a substantial portion of the economy of the region. The same forces that created those flat plains upon which the people live--namely floods--periodically go on a rampage and destroy virtually everything within their path.

Thirdly, the topography and particularly the geology of the region does not favor the construction of dams at a reasonable cost. This problem is compounded by the fact that the economy of the region generally is such that the present benefits to be realized from a flood control project are not sufficient to justify the relatively high expenditures.

Finally, all attempts at intensive investigation of the flood problems and of the feasibility of providing flood damage relief to the North Coastal area as a region have been thwarted by the obvious high cost of structures required and the low value of comparative benefits. Studies conducted to date have been limited both aerially and in scope. Flood control projects, constructed as a result of those studies, are few and the damages that they prevent, while important in the particular area they protect, are small in relation to the total economy of the region.

Smith and Klamath River Basins

Beginning in the most northerly areas, the Smith and the Klamath River Basins have no flood control facilities or flood control features of conservation facilities that would

provide material protection to the downstream areas where flood damage occurs. On the Smith River, the Christmas flood of 1964 spread out into various distributaries, flooding adjacent towns and causing damage to innumerable ranches and ranch buildings. The towns of Gasque and Fort Dick and the general flood plain north of Crescent City suffered road as well as public utility damage.

The Klamath River flooded in the Lower Klamath Lake area, Hornbrook, Seiad Valley, Happy Camp, Somesbar, Orleans, Weichepec, Martins Ferry, Pecwan, Klamath Glen, Klamath, and Requa. More than 150 homes were destroyed along the Klamath River, representing probably 50 percent of the total residences in the area. The communities of Klamath and Klamath Glen suffered the complete loss of all homes. Losses and damage on the Klamath River system extended to Etna in the Scott River Basin and to the Salmon River, a tributary. Tributary streams created local flooding problems in Shasta and Butte Valley and in the Tule Lake area in Siskiyou and Modoc Counties. Extensive damage also occurred along the Trinity River, particularly at Hoopa and Willow Creek. Flood stages within the lower Klamath Basin ranged from 10 to 12 feet above the 1955 flood level.

The operation of Ruth Dam and Reservoir for water conservation reduced the flood stages in the Mad River Basin to about one foot below the 1955 flood level. While the dam suffered damage, it was not rendered inoperative. However, Mad

River, Maple Creek, Corbel, Blue Lake, and the Arcata-Samoa area suffered damage.

Eel River Basin

Except for a levee project in the Lower Eel River Delta, there are no flood control facilities of significance within the Eel River Basin. As is the case in most of the North Coastal Area, the communities are concentrated along the flat lands comprising the flood plain of the river. Despite the fact that many people, and, in fact, major portions of some communities, moved up to higher land as a result of the devastating 1955 flood, the unprecedented Christmas 1964 floods, with stages of many feet higher than the former flood, wreaked much greater havoc and caused much greater destruction than did the former floods. A combination of flood control facilities, in conjunction with prudent flood plain management and broad scope area planning, holds the only answer to the future protection of the Eel River Basin from great flood damage.

Damage in the Eel River Basin occurred at Willits, Dos Rios, Island Mountain, Alder Point, Fort Seward, Myers Flat, Garberville, Weott, Shively, Scotia, Rio Dell Bridgeville, Alton, Fortuna, Fernbridge, Ferndale, and Loleta. The Christmas 1964 floods ranged from 2 to 20 feet above the previous 1955 record high water. Roads and railroads and public utilities accounted for approximately $42,000,000 damage in the Eel River

Basin within Humboldt and Mendocino Counties. The private damage in the two counties amounted to some $26,000,000. The town of Weott was approximately 75 percent destroyed, and Shively was completely destroyed, as were Pepperwood and Holmes. Business and manufacturing activities were disrupted.

The Sandy Prairie Levee Project at the junction of the Van Duzen and Eel Rivers near Fortuna was severely damaged. Because of extremely high flood stages in the Eel River, the simultaneous peak from the Van Duzen was prevented from entering the Eel River through the leveed channel. Waters from the Van Duzen were thus forced behind the Sandy Prairie levees and washed out stretches that could not resist flowing water on the back side. Extensive damage resulted to areas that depended on this project for flood protection.

The entire Eel River Delta suffered from the rapid rise of flood waters, the high stages, and the long period of inundation that accompanied the flood. Damage was compounded by the force of fast-flowing water that ripped through river banks, highway and railroad embankments, and public and private structures. Millions of board feet of both sawed lumber and cold-decked logs were carried away with the flood water. This along with the debris of fallen trees wiped out many buildings in the flood plain.

Dairy and livestock operations in the Eel River Delta were particularly hard hit by extensive loss of cattle

trapped in flooded areas. The rapidly rising water and the confusion in flood evacuation information hindered many from successfully moving their stock.

Russian River Basin

The flood control situation in the Russian River Basin is slightly better than that in the remainder of the North Coastal area and promises to improve in the near future with the construction of the Warm Springs Dam and Reservoir on Dry Creek, a major tributary to the Russian. Coyote Valley Dam and Reservoir on the East Fork of the Russian reduced the flood stages substantially during the Christmas 1964 floods. However, no one individual tributary to the Russian contributes a high percentage of the total flow in the river at Guerneville and considerably more storage will be needed on the system before the downstream communities can be assured full relief from flood damage.

The Russian River Basin is susceptible to damage to residential and agricultural areas in Ukiah and Hopland, as well as business establishments in Hopland. The community of Cloverdale is subject to flood damage from Big Sulphur Creek. The main channel of the Russian River has been cleared and improved from Calpella downstream, but heavy storms continue

to cause considerable damage. This emphasizes the point that channel improvement alone does not provide sufficient protection -- flood control storage on the several main tributaries is necessary.

The flooding southeasterly of Guerneville in the Laguna-De Santa Rosa area is caused principally by backwater from the Russian River with the Laguna acting as a ponding area. About 30 homes were flooded in Talmage in the Christmas 1964 flood from overflow of Mill Creek.

Mendocino Coastal Streams

Most of the developed land in the coastal area is located on the broad terraces along the Pacific Coastline. Streams draining the area have generally cut deeply into these terraces and do not overflow into local communities. A major exception is Anderson Valley and State Highway Route 128 along the Navarro River. Here the highway and valley lands are subject to flooding by the Navarro River and its tributaries.

In relation to other areas of the State, little demand for flood control or water development facilities has been expressed on the direct coastal streams. There is a general need however for a broad scope study in the area. In addition to possible flood control and water conservation, the study should investigate the potential for recreation and fisheries enhancement.

Sacramento Valley and Sacramento-San Joaquin Delta

Tremendous progress has been made in the Sacramento Valley toward the protection of life and property from flood damage. Shasta Dam and the Sacramento River Flood Control Project afford a high degree of protection. However, there remain flood problems which require additional reservoir storage and channel improvement for their correction or elimination.

Upper Sacramento Valley

The Upper Sacramento River, between Shasta and Red Bluff, receives the essentially uncontrolled inflow of a number of tributaries which, during floods, cause damaging stages in the river between Shasta and the head of the Sacramento River Bypass system. During the recent flood, damages were incurred in the communities of Anderson, Red Bluff, Los Molinos, Corning, Orland, Hamilton City, Willows, Chico, Butte City, Princeton, Richfield, and Colusa. These floods were generally of the same magnitude as the Christmas 1955 flood.

The west side tributaries to the Sacramento, between Shasta Dam and Red Bluff, contribute heavily during flood periods. They cause local damage to land and developments along the channels of these streams and add to high stages in the Sacramento River.

Extensive bank erosion, damage to state, county and private stream crossings, and damage to structures occurred

along many streams that enter the Sacramento River from both the east and west sides from Red Bluff to about the latitude of Chico. Thomes Creek caused serious damage when levees in the vicinity of Richfield failed to contain the large volume of flood water. At the heights of the flood highway travel was completely stopped on both U.S. 99W at Thomes Creek and U.S. 99E north of Vina from water from Mill Creek and Antelope Creek.

Irrigation structures suffered damage where diversion works were seriously eroded or where uncontrolled overflows entered canals and washed out the banks. The fish ladder and left abutment of the Stanford-Vina Diversion Dam on Deer Creek will need extensive repair as will the canal of the Anderson-Cottonwood Irrigation District.

Sacramento River Flood Control Project

The Christmas 1964 flood gave the Sacramento River Flood Control Project a severe test and disclosed the major problems which are current erosion, rather than inadequate channel capacity. The system carried amounts of water equal to the 1955 flood with greater efficiency and fewer trouble spots because of the high degree of channel and levee maintenance that has been exercised since that disasterous flood. The most serious erosion occurred on the right bank of the Feather River about one mile downstream from the Gridley Bridge. Here the river changed its course, eroding away the berm and

cut deeply into the levee section. Some 20,000 tons of rock were required on a 1,200-foot reach of this levee and berm to control the erosion and reinforce the levee.

Extensive berm and bank erosion also occurred on Butte Creek over a six-mile reach extending south from new U.S. Highway 99 Bridge to the Southern Pacific Railroad. Also, much log debris accumulated on the bridges in this area. Emergency repair necessitated the placement of about 10,000 tons of rock.

A survey of bank erosion is now being made on the west side of the Sacramento River north of Colusa and on the opposite (east) side of the river. The exact extent of damages cannot be determined until the water level recedes. However, it appears that several hundred feet of rock revetment will be required, at a cost of about $250,000. Encroachment in the channel has caused a problem in the City of Colusa. These encroachments should be removed and the levee should be reinforced with rock.

Butte Basin experienced overflows in areas where unauthorized levees were removed during 1964. There were no reports of serious flooding or damage as the result of this natural overflow into Butte Basin channels.

Additional problems in the project consist of silting in the Cherokee Canal below the confluence of Cottonwood Creek and damage to bridges over the borrow pits of the bypass.

There also are growing problems on relatively small streams and channels in areas that are being urbanized. Several

of these, such as Morrison Creek, are in the growing metropolitan area of Sacramento. Adequate planning is required now if large future costs are to be avoided.

Sierra Streams

During the Christmas 1964 floods, the Yuba River set a new record of peak discharge. There are essentially no major storage reservoirs on this river. Fortunately, sufficient control was provided on the Feather River by having completed the construction of Oroville Reservoir to an elevation of 605 feet, which reduced the peak inflow to the reservoir by more than 100,000 second feet. The possible tremendous damage which could have occurred by the concurrent peaking of both the Feather and Yuba Rivers at their confluence at Marysville was avoided by control of the Feather provided by Oroville Dam and Reservoir and by levee improvement and channel clearing that was done following the 1955 flood. There is an urgent need for sufficient flood control storage to control the Yuba River. The proposed Marysville Reservoir would provide this.

Spanish and Indian Creeks of the Upper Feather River Basin have experienced serious flooding during periods of high runoff of the Feather River. During recent years, a major

bridge over Spanish Creek was destroyed. Furthermore, there was danger of inundation and damage to the Airport at Quincy. As Indian and American Valleys are developed more intensively, damage from flooding can be expected to increase. There is a need to develop plans for providing flood control of these streams.

Incidental flood control on the Bear River is provided by operation of Camp Far West and Combie Reservoirs. Rollins Reservoir, currently under construction, will provide additional incidental flood control. There is a need for the Corps of Engineers to complete its current studies to develop a comprehensive plan for flood control of the Bear River.

While Folsom Reservoir controlled the flow in the American River through the Sacramento area, the flood storage reservation in that reservoir was very nearly fully committed during the recent flood. This "touch and go" situation strongly emphasized the need to expedite the authorization and construction of Auburn Reservoir to provide additional storage on the American River system to supplement the capacity of Folsom to more fully regulate flood flows on the American. An interim measure of increasing the flood control reservation also should be considered.

The Christmas 1964 storm was not as intense on the Cosumnes River Basin as on the American, Yuba and Feather River Basins to the north. However, this fortunate situation for the Cosumnes River Basin cannot always be expected to occur in the future. The Nashville site should be developed to provide adequate flood control for the Cosumnes River.

Sacramento River Seepage Problem

In many areas, the water level in the Sacramento River, particularly during flood flows, remains at a substantially higher elevation than the lands adjacent to the levee, causing water to seep through and under the levees with resultant damage. With seepage varying directly with the water stage, the persistence of high flows caused considerable damage to both agricultural and municipal economies. Typical agricultural damages are:

1. Inability to plant a given crop at the prescribed time.

2. Total or partial loss of established stands.

3. Inability to follow the first crop with a second crop.

4. Decreased yields and/or loss of perennial plants, including trees.

Seepage damage in municipal areas can be measured by the additional investment to assure that water levels are maintained below the foundation of structures, the cost of repair of roads, and extra pumping and maintenance costs to return the water to the river.

A study is currently in progress by the Department to evaluate average annual damages caused by seepage from the Feather and Sacramento Rivers to consider possible methods of seepage alleviation. The investigation also has as an objective the evaluation of the economics of various methods of providing such alleviation. This study should be accelerated.

Sacramento-San Joaquin Delta

Flood problems in the Sacramento-San Joaquin Delta fall under two categories. These are the natural and man-made problems that create or add to the severity of flooding and the physical problems of flood fighting. The first group includes:

1. The physical problem of constructing and maintaining levees on peat soils, particularly in old channel sections where the peat soil is quite deep, resulting in unstable sections of existing levees.

2. The necessity for relatively high levee sections on the landward side where much of the land is below sea level.

3. Levee subsidence and subsidence of land protected by the levees as a result of compaction and consolidation and stripping of peat soils.

4. High tides sometimes occuring during flood periods which restricts outflow of water from the Delta, creating high water stages.

5. High southerly and westerly winds during high flow periods which cause additional backup of flood flows and creates the danger of wave erosion of levee sections.

6. Control of floods by upstream works which effectively extends the duration of relatively high flows, resulting in a greater probability of high tides and winds occurring simultaneously with flood stages, thereby lengthening the probable time high stages are in contact with the levees.

The second problem in the Delta demonstrated by the recent floods concerns the problem of access to levees. In most cases, the impassable condition of the levees during wet weather permits access only by boat or by walking. Furthermore, sand for emergency levee repairs is generally not available within the Delta area. Therefore, peat or other unsatisfactory material sometimes must be used to fill sandbags. Also, increasing the height of the levee with sandbags or other construction materials during flood periods often results in additional subsidence.

In the past, levee design has been a major problem in that there have been many conflicting ideas as to what is necessary to provide a stable levee section.

In some areas, the recent flood demonstrated that there is need for improved communication between the State and local entities. With a number of people involved in flood fighting activities who are not normally involved in this field, there were some who did not have adequate knowledge of the responsibilities and authority of the various entities concerned.

In the Delta, the problem was again evident that project levees were endangered by areas protected by nonproject levees. This problem occurs where project levees protect the main channels and nonproject levees extend around various other islands.

San Joaquin Valley

Flood problems in the San Joaquin Valley are generally limited to the channel of the San Joaquin River between its major tributaries and the Delta. Certain levee problems and minor flooding in the uncompleted portions of the lower San Joaquin River Flood Control Project were noted during the December flood.

The flood problems of the San Joaquin Valley are of only an interim nature, as the existing flood control projects and those in the construction, implementation, and planning stages will essentially complete the degree of flood protection needed in the valley within the limitations of economic justification.

Central Coastal and San Francisco Bay Area

While considerable conservation and flood control works have been constructed in this area, both by the U. S. Army Corps of Engineers and local public agencies, flood problems still prevail on a number of streams. These problems are discussed herein, by county.

Santa Cruz County

Flood problems in the Santa Cruz County area are handled primarily by local agencies with the U. S. Corps of Engineers and the U. S. Weather Bureau providing valuable assistance.

The channel capacity of Soquel Creek is not adequate to safely pass flood waters without overflowing of the stream banks. Flood problems, resulting in damage to agricultural and residental property and to highways, roads, and bridges, are further aggravated by log jams that form in the channel obstructing the flow. Two bridges and a sharp bend in the channel further contribute to the flood problems. High velocity flows cause bank erosion and overflows, scour topsoil, deposit gravel and debris over a wide area. These flood problems occur primarily in the lower three miles of the stream, where the flood plain area is estimated to cover about 170 acres. Flood crests usually occur about 4 hours after the occurrence of intense rainfall.

Flood crests on the San Lorenzo River are reached within a few hours after the occurrence of intense rainfall. A serious problem is the occurrence of considerable debris, which causes jams in the river channel and higher flood stages. Associated with this problem is access to debris jams over private property in order to clear the channel. It is sometimes difficult to determine whether a specific jam actually presents a threat to life and property.

Though the City of Santa Cruz is protected, upstream flood problems along San Lorenzo River have occurred at Paradise Park, Gold Gulch, Felton, Ben Lomond, Boulder Creek, and Brookdale.

Flooding along Scott Creek has occurred during times of heavy precipitation. Flood crests occur very soon after the occurrence of intense rainfall. Areas subject to flooding are primarily agricultural. Flooding causes major damage to and loss of highly valued crops and some buildings.

Flood problems along the Pajaro River arise from a low degree of protection now afforded by the existing levees, and the high velocities of flood flows which cause severe bank erosion and levee damage. This has resulted in levee failure in past years and is a constant threat to the City of Watsonville and the Pajaro Valley area.

In the southernmost end of Santa Clara County, recurrent flooding is a threat to the intensively cultivated lands along the Pajaro River, where the flood plains of Llagas and Carnadero Creeks merge with the bottom land lake area, extending westward from San Felipe Lake to the vicinity of Sargent. This area is flooded by discharge of tributaries to Tequisquito Slough, as well as Llagas and Carnadero Creeks. In addition, the banks of the San Benito River are subject to severe erosion during periods of high runoff, such as that which occurred during the December 1955 flood.

Monterey County

Flood Problems arise principally from periodic damage to agricultural lands and utilities on the Salinas River flood plain below San Ardo, caused both by direct inundation and by channel bank erosion with consequent encroachment onto adjacent lands. Erosion damage begins when the flow in the Salinas River at Spreckels exceeds 15,000 cubic feet per second. Inundation will occur when the flow at Spreckels exceeds 20,000 cfs.

On the average, some damage is expected to occur once every two years with the present flood control system. When no major floods occur, the flood channels become constricted by growth of willows and deposits of silt. These constrictions increase the potential damage of small floods, causing a constant threat of inundation of the City of Salinas and other low lying urban areas.

There is also some danger of flooding on the Carmel River. The lower river has only a few privately-built levees to control flooding. There is always a danger of flooding along the lower river as silt is deposited at its mouth, backing up the water when the flow increases and causing localized flooding.

Marin County

Along Corte Madera Creek damaging floods have occurred in almost every flood year. About 1,500 acres of residential, commercial, and public development, having a total value of $45,000,000, is subject to flooding.

Richardson Bay, an arm of the San Francisco Bay, is surrounded by a highly developed suburban area which is also subject to recurring flood damage. Major storms in 1955 resulted in damage estimated to be in excess of $170,000.

The community of Tamalpais Valley, located about 10 miles north of San Francisco, is subject to recurring flood damage from Coyote Creek. And, continued residential development in the area of Novato Creek is causing increasingly serious flooding problems.

Sonoma County

Flood problems in the Sonoma Creek Basin arise primarily from inadequate channel sections on creeks, unstable levee sections adjacent to the Sonoma Creek channel, and inadequate openings under highway and railroad bridges. Tidal action in Sonoma Creek can aggravate the problem. Flooding in the lower reaches is nearly an annual occurrence. The City of Sonoma and Tubbs Island suffered damage from high flows on Nathanson Creek and Tolay Creek, respectively, during the flood of December,1955. Several homes were inundated in Sonoma.

Napa County

The flood plain in the Napa River watershed extends from 2 miles north of Calistoga to State Highway 48 near Vallejo. This encompasses the towns of Calistoga, the eastern part of St. Helena, the City of Napa, and coastal areas. Floods, such as

those which occurred during 1955, 1958, and 1963, have inundated up to 12,000 acres and caused damages ranging from $350,000 to $670,000. The majority of these damages occurred to commercial, industrial, and agricultural lands and roads and bridges. The most severe damages occurred in the vicinity of the City of Napa.

Solano County

In general, small streams cause extensive flooding of agricultural and urban lands. Local reservoirs and channel facilities are not sized to cope with even moderately heavy floods.

Overflow from a number of creeks which flow through the Fairfield-Suisun area and drain into Suisun Bay cause some damage to residential and agricultural areas. These floods are caused primarily by the inadequate channel facilities of local creeks and drainage canals, which are being further taxed by increased runoff, resulting from urbanization. Suisun City is also subject to occasional tidal flooding.

Contra Costa County

Flood damage in Contra Costa County can be expected to occur with each heavy rainstorm. Although the Contra Costa County Flood Control and Water Conservation District conducts an active flood control program, which includes several federal flood control projects now under construction, urban development of the area continues to proceed at a rapid pace and further aggravates the flood problem.

Heavy property damages were suffered in 1955 and 1958 by the flooding of Las Trampas Creek. It has been estimated that approximately 15 surface acres were lost through stream bank erosion in this channel. Other problems include excessive bank erosion on Las Trampas Creek and local flooding onto agricultural lands, subdivision developments, utilities, and roads.

In 1958, one of the major flood periods for the area, Las Trampas and San Ramon Creeks overflowed into the main street of Walnut Creek. A county bridge was completely washed out on Marsh Creek, and almost every creek in the area overflowed its banks.

Historic overbank flooding from Pine Creek has been intensified in recent years by encroachment of business and residential development. Severe damage has occurred to agricultural and urban land and improvements. Flooding occurred in the City of Concord from Pine Creek in December, 1955.

Alhambra Creek flows through the City of Martinez and causes serious flood damage to residences and commercial establishments.

Approximately 125 acres are subject to flooding from Pinole Creek, of which 70 acres are subject to severe damages. Flooding in the business district and a residential subdivision in Pinole occurred in 1955 and 1958.

The community of Rodeo is subject to recurring flood damage from Rodeo Creek. Flooding of residences and business establishments occurred in 1955 and 1958. Completion of the

freeway connecting other Bay Area cities has accelerated residential and commerical development.

Alameda County

Historic floods of the past have inundated relatively large areas of Livermore Valley and southern Alameda County. The principal areas subject to this flooding have been agricultural lands along the lower reaches of San Lorenzo and Alameda Creeks and in the western portion of Livermore Valley.

In 1963 the Oakland-Emeryville area, which suffered extensive damage in October 1962, authorized the formation of Zone 12. During 1964 local projects, costing about $21,500,000 were authorized. Zone 13, in the vicinity of San Leandro, was also formed in 1963 and local projects costing about $1,900,000 were authorized that same year. The District has requested the Corps of Engineers to undertake flood control projects in Arroyo Viejo, and on Temescal and San Leandro Creeks in these zones.

In the October 1962 storm, partially completed Cull Canyon Dam was damaged, as was the University of California's Botanical Gardens in Strawberry Canyon. Suffering and loss of property by private residents was also large.

Although no damage was reported in Alameda County as a result of the flood conditions in December, 1964, a number of significant problems remain unsolved. There is a need for local authorized projects to be constructed and federal plans

developed in the newly formed Zones 12 and 13 for the protection of life and property in the Oakland-San Leandro area. The upper reach of the San Lorenzo Flood Control Project must be authorized. Drainage at Oakland's Lake Merritt must be improved. Channel improvement on Alameda Creek must push steadily forward. Flood control protection for Livermore Valley is urgently needed. Construction of Del Valle Dam and Reservoir will assist in providing flood control protection for Livermore Valley, but the 1961 conclusion of the Corps of Engineers that channel improvements in Livermore Valley should not be authorized immediately, has left a decided gap in the necessary works.

Santa Clara County

In the Northwest Zone, San Francisquito Creek and the foothill areas above the present channel improvement on the other creeks are the major areas where future flood problems will probably occur. The North Central Zone likewise does not have any future flooding problems except in the foothill areas. In the Central Zone there remains at Alviso a channel alignment project and the closing of the levees, through this area, to the tidal channel. Until levees have been completed in this area, particularly where the railroad crosses the river, the City of Alviso can continue to expect flooding during periods of high tides and high runoff.

Another area of potential flooding problems occurs through the City of San Jose, where the Guadalupe River channel

needs improvement. In the East Zone, along Silver Creek and several other flat areas, there may be flood problems until improvements have been completed.

In the South Zone, Miller Slough in the City of Gilroy and Llagas Creek will continue to cause problems until the Llagas Creek Project can be completed.

San Mateo County

San Mateo County is hydrologically divided into two units, streams draining to the Pacific Ocean and streams draining into San Francisco Bay. Steep gradients in the area create floods characterized by rapid peaking and almost as rapid recession. Floods are of short duration, seldom being out of their banks more than a day or two. Damage on the coastside is principally agricultural in nature, including damage to crops and erosion of farmland. On the bayside, the major flood problem is due to the rapid expansion of residential and commercial development within the flood plains of the creek. Increased urbanization on the bayside and the expected growth in the coastal area indicates a need for flood control programs.

Southern California

From the standpoint of flood problems, Southern California can generally be described as consisting of a series of valleys and lowlands bounded by steep hills and mountains which, for the most part, are barren of vegetation with cover

limited principally to small trees and brush of various types. Due to steepness of terrain and limited ground cover in upper watersheds the many areas experience large runoff, heavy erosion, and debris production to the valleys as a result of wind, extreme temperature changes, and intense or continued rainfall.

The highly flammable types of cover in upper watersheds, coupled with increased populations, have aggravated the flood problem by greatly increasing the probability of fires of man-made origin, thereby reducing the vegetative cover and increasing the probability of erosion, flood, sediment, and debris damage to property.

Originally, development of Southern California was primarily agricultural. The rich valleys and lowlands of Southern California have become susceptible to floods and debris damage. Along with continuous expansion of agricultural development, there has been a continuous change in land use from agriculture to urban development. Inasmuch as the areas most susceptible to urban development are located in flatlands below the mouths of canyons that bound the valley areas, many urban areas are in danger of floods. Because of the rapid urbanization flood control problems often arise which must be solved immediately. Such problems develop usually after a severe burn in the upper watershed or become evident after a severe storm.

Flood control developments often lag behind urban development. This, however, does not mean that damage cannot

be prevented or curtailed. Urban development is taking place at a rapid rate. There is need for continuous studies, not only of known flood control problems, but also of potential flood problems resulting from either change in land use or in the hydrological factors contributing to runoff. There is need for physical works of improvement to keep pace with urban development; however, this is not always economically possible. During the interim, there is need for floodplain management in order to control development in the hazardous areas and keep flood damages to a minimum.

Temporary flood damage prevention works are needed after disastrous fires which occur frequently in Southern California. An example of this problem is in the Glendale, Burbank, and Santa Barbara areas where recent fires destroyed the watershed vegetation, resulting in mudslide problems after a high-intensity rain in November, 1964. Fortunately, in the Santa Barbara area, the Corps of Engineers, in cooperation with the county, have straightened and dredged the most critical channels, removed many substandard bridges, and constructed debris basins prior to the rainy season to minimize flood damage.

A step toward alleviation of flood problems in Southern California lies in comprehensive planning and management of floodplain lands that are subject to recurrent flooding by overflow of streams. Further steps are essential to encourage local

agencies to control use of floodplains in order to prevent loss of life and minimize damage to property from floods. In order to assist local agencies, the State acts as coordinator between the local agency and the U.S. Army Corps of Engineers in the conduct, by the Corps. of floodplain information studies under Section 206 of the Flood Control Act of 1960. These information studies provide a factual basis in planning the use of floodplains and in preparing zoning ordinances. In addition, the State can assist by making studies and information available to local agencies in support of their zoning activities, such as the Department's Bulletin No. 112, "San Diego County Flood Hazard Investigation".

Summary of Flood Damages

Information on areas inundated and economic damages during the floods since November, 1950 is summarized by major areas in Table III.

It will also be noted that Table III does not include Southern California. While a number of local flash floods have caused local damage, there has been no major flood in Southern California since 1941.

TABLE III

FLOODED AREAS AND FLOOD DAMAGE

Area	Nov. - Dec. 1950		Dec. 1955		Feb. - Apr. 1958		Oct. '62-Feb. '63		Dec. 1964	
	Acres	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars	Acres	Dollars
North Coastal	--	--	--	41,180,000	--	9,907,000[c]	--	2,550,000[e]	--	184,000,000
Sacramento Valley[a]	[b]	9,800,000	382,000[a]	66,100,000	386,000[a]	11,500,000	246,500[d]	10,400,000	325,000[a]	25,000,000
San Joaquin Valley	[b]	12,400,000	215,200	16,100,000	313,200	13,240,000	52,600	1,700,000	50,000	4,000,000
Central Coast	--	--	--	26,790,000	--	--	--	2,350,000[e]	--	--
Tulare Basin	[b]	9,400,000	183,300	16,600,000	72,200	3,380,000	7,600	400,000	--	--
Totals	[b]	31,600,000	780,500[a]	166,770,000	771,400[a]	38,027,000	306,700	17,400,000	375,000[a]	213,000,000

a/ Includes 75,000 acres in bypasses and floodways.
b/ Totals only - November, 320,000 acres; December, 145,000 acres.
c/ Totals only - February, $1,809,000; April, $8,098,000.
d/ 170,000 acres in October; 175,600 acres in February.
e/ Does not include October damage.

CHAPTER VII. THE CALIFORNIA FLOOD CONTROL PROGRAM--1965

It is apparent from the disastrous results of the December, 1964 flood and from the review contained in this report that construction of flood control works in California must be accelerated and that other actions need to be taken and certain studies need to be made. Actions to accomplish these steps constitute a flood control program for California. The "California Flood Control Program--1965", is set forth in this chapter. Using this report as a basis, the California Flood Control Program should be revised and up-dated each year.

The program set forth in this report will increase our protection against floods, will increase our capability to combat floods, will coordinate and strengthen the flood control activities of all participating agencies, will expand consideration of flood control in studies of multiple-purpose projects, and will provide a guide for all agencies in providing much needed flood control protection and flood damage prevention.

This chapter is divided into two parts. The first part summarizes actions which are needed to provide increased control of floods by reservoirs and levee systems. It includes information on (1) current multiple-purpose project studies requiring special attention, (2) authorized projects, (3) projects investigated but not yet authorized, and (4) basin-wide investigations which are needed. The second part of the chapter discusses the many actions and programs that are needed to

supplement and to make more effective the operation of flood control projects. The second part includes such subjects as (1) utilization and coordination of flood fighting resources, (2) flood forecast and flood warning systems, and (3) expanded approach to flood control, and (4) flood plain management.

Where specific recommendations are made they are emphasized by being underlined.

Needed Projects and Project Studies

Current Multiple-Purpose Project Studies Requiring Special Attention

1. Marysville Reservoir. This planned project is urgently needed for flood control on the Yuba River. Responsible agency: Corps of Engineers. Specific recommendation: Authorize and accelerate to construction as quickly as possible.

2. Auburn Reservoir. This planned project is urgently needed for added flood control of the American River. Responsible agency: Bureau of Reclamation. Specific recommendation: Authorize and accelerate to construction as quickly as possible.

3. Middle Fork Eel River Reservoirs. Spencer and Dos Rios Reservoirs on Middle Fork Eel River have been authorized as features of the California Water Resources Development System. Studies in progress are directed toward sizing of the reservoirs and selection of the export conveyance route. Responsible agencies: Department of Water Resources and Corps of Engineers. Specific recommendation: Both agencies should accelerate the current feasibility level investigations of these reservoirs and together they should develop a specific plan for flood control operation of the reservoirs. Consideration should be given to possible early construction of these reservoirs to provide flood control and in such a manner that they could perform their intended future purposes of providing water for export and for recreation.

4. English Ridge Reservoir. This reservoir would be an eventual feature of a state-federal project if water is routed through Clear Lake, or an independent federal or local project to serve Lake County, the North Bay Counties, and the Central Valley Project. Responsible agency: Bureau of Reclamation. Specific recommendation: That the Bureau of Reclamation initiate immediate studies at the feasibility level, comparable to those of the Department of Water Resources and Corps of Engineers at Dos Rios and Spencer, to evaluate the flood control features of English Ridge Reservoir and to develop a plan for early construction.

5. Butler Valley Project. This project on the Mad River, which would provide water supplies to the Eureka-Arcata area, offers one of the most favorable possibilities in the North Coastal area for early construction in the interests of flood control. Responsible agency: Corps of Engineers. Specific recommendation: Feasibility studies be initiated immediately for this project.

6. Knights Valley Project. This project on Franz Creek and Maacama Creek in the Russian River Basin has been studied by the Corps of Engineers and recommended for authorization. The project is being studied at the feasibility level by the Bureau of Reclamation. Responsible agency: Federal Government. Specific recommendation: Complete feasibility-level investigation and proceed to early construction.

7. Paskenta-Newville Project. A forthcoming report by the Department of Water Resources on the Upper Sacramento River Basin Investigation, as well as the published reports on the North Coastal Investigation, point out this project as favorable for early construction. It could provide complete flood control on Thomes Creek, in addition to the primary purposes of water conservation, recreation, and fishery enhancement. Responsible agency: Department of Water Resources. Specific Recommendation: The Department of Water Resources, or the Department of Water Resources in cooperation with the federal agencies, should expedite the feasibility-level investigation looking toward early construction.

8. Upper Sacramento River Tributary Reservoirs

Hulen Reservoir on Cottonwood Creek,
Dippingvat Reservoir on Cottonwood Creek,
Deer Creek Meadows Reservoir on Deer and Mill Creeks, and
Millville Reservoir on Cow Creek

These reservoirs have been found at reconnaissance level studies to be economically justified for multiple-purpose construction either as features of the California Water Development System or as locally constructed projects with state participation under the Davis-Grunsky program. They contain elements of flood control and would provide flood benefits to the downstream channels and would reduce flood peaks on the Sacramento River. Responsible agencies: Department of Water Resources and Corps of Engineers. Specific recommendation: The Department of Water Resources should expedite its program of feasibility investigations on these reservoirs looking toward early construction. The Corps of Engineers should participate cooperatively to provide technical assistance on flood control analyses.

Projects Already Authorized

Following are listed by geographic area flood control projects that are authorized. For these projects the general recommendation is that the Congress or the Legislature provide immediate new or additional funding and that construction be accelerated to the greatest possible extent. Specific recommendations are made for each project.

North Coast

1. Redwood Creek. Preconstruction planning is in progress. Authorized by P.L. 87-874, October 23, 1962. Responsible agency: Corps of Engineers. Specific recommendation: Reexamine in the light of new hydrologic data, replan if necessary, and accelerate construction.

2. Warm Springs Project on Russian River. Pre-construction planning is in progress and agreements have recently been reached with Sonoma County Flood Control District relative to a water supply contract. Authorized by P.L. 87-874, October 23, 1962. Responsible agency: Corps of Engineers. Specific recommendation: Accelerate construction.

3. Sandy Prairie Levee. This completed project was partially destroyed in the recent flood, which exceeded the design flood. Authorized by P.L. 85-500, July 3, 1958. Responsible agency: Corps of Engineers. Specific recommendation: Make immediate repairs. Reexamine in light of new hydrologic data, replan and reauthorize for construction as necessary.

Sacramento Valley and Sacramento-San Joaquin Delta

1. Oroville Dam and Reservoir. Construction is proceeding under the tightest possible schedule. Federal contribution toward construction is authorized by P.L. 85-500, July 3, 1958. Responsible agency: Department of Water Resources. Specific recommendation: Maintain construction schedule and urge the Congress to make appropriations to keep the federal contribution current.

2. New Bullards Bar. Project will be advertised in June, 1965. No federal authorization yet; a study by the Corps of Engineers is underway to determine whether flood control storage should be included in the project. Responsible agency: Yuba County Water Agency. Specific recommendation: Encourage early construction.

3. Sacramento River Flood Control Project (Old Project). Construction is 99 percent complete but final completion has been delayed somewhat because of levee stripping controversy. Last contract is scheduled for spring, 1965. Initially authorized by Flood Control Act of 1917, and modified by Act of 1928, 1937, and 1941. Responsible agency: Corps of Engineers and State Reclamation Board. Specific recommendation: Maintain construction schedule.

4. Sacramento River Major and Minor Tributaries. Construction of active portions is about

67 percent complete. Thomes and Antelope Creeks are being restudied with project funds. Federally authorized by P.L. 534, 78th Congress, 2d Session, as amended by P.L. 516 of May 17, 1950. Responsible agency: Corps of Engineers and State Reclamation Board. Specific recommendation: Accelerate completion of active units and accelerate restudy of Thomes and Antelope Creek Units.

5. Sacramento River Bank Protection. Construction is about 12 percent complete. Authorized by P.L. 86-645 of July 14, 1960. Responsible agency: Corps of Engineers and State Reclamation Board. Specific recommendation: Accelerate construction and seek additional funding.

6. Sacramento River, Chico Landing to Red Bluff. Work in Tehama County started June, 1963 and was completed March 1964. Work in Butte and Glenn Counties is "inactive" due to failure of local agencies to establish flood plain zoning. Authorized by P.L. 85-500, July 3, 1958. Responsible agency: Corps of Engineers and State Reclamation Board. Specific recommendation: Urge adoption of necessary zoning ordinances to assure early completion.

7. Duck Creek. Construction is presently scheduled to start in spring of 1965. Authorized by Section 205 of the 1948 Flood Control Act, as amended by P.L. 685, 84th Congress, 2d Session. Responsible agency: Corps of Engineers. Specific recommendation: Construct as scheduled.

8. Mormon Slough. Preconstruction planning was started in fiscal year 1964. Authorized by P.L. 87-874, October 23, 1962. Responsible agency: Corps of Engineers and State Reclamation Board. Specific recommendation: Accelerate planning and construction.

9. Ulatis Creek. Construction is about 13 percent complete. Authorized under P.L. 566, 83d Congress, 2d Session. Approved for construction August 17, 1961. Responsible agency: U. S. Soil Conservation Service. Specific recommendation: Construct as scheduled.

10. Adobe Creek. Construction is about 85 percent complete. Authorized under P.L. 566, 83d Congress, 2d Session. Approved for construction by USDA

July 31, 1958. Responsible agency: U. S. Soil Conservation Service. Specific recommendation: Accelerate to completion.

11. Table Mountain (Iron Canyon). The project is classified "deferred" because of lack of agreement among local interests and federal and state agencies concerning fisheries and values of lands to be inundated. It is recommended the project remain in deferred status pending improvement in economic justification. This project was initially authorized by P.L. 534, 78th Congress, 2d Session, December 22, 1944. Responsible agencies: Department of Water Resources and Corps of Engineers. Specific recommendation: Investigate transfer of flood control aspects of proposed Iron Canyon Project to reservoir projects on Sacramento River tributaries, and improvement of Sacramento River Flood Control Project.

12. Butte Basin. The Butte Basin Bypass Project was authorized by the 1944 Flood Control Act and in modified form was adopted by the State Reclamation Board in 1964 as a master plan for Butte Basin to maintain the integrity of the Sacramento River Flood Control Project. Responsible agencies: Corps of Engineers and Department of Water Resources. Specific recommendation: Accelerate studies to determine long-range features and priorities for construction.

Central Coastal and Bay Area

1. Alameda Creek. Channel improvement work is scheduled to begin in 1965. Authorized by P.L. 87-874, October 23, 1962. Design of Del Valle Dam, by the State, is continuing with construction scheduled to begin in late 1965. Responsible agencies: Corps of Engineers and Department of Water Resources. Specific recommendation: Construct as scheduled.

2. Walnut Creek. Channel improvement work is about five percent complete. Authorized by P.L. 86-645, July 14, 1960. Responsible agency: Corps of Engineers. Specific recommendation: Continue construction on schedule.

3. Pinole Creek and Rodeo Creek. Channel improvement work is scheduled for construction in 1965.

Authorized under authority of Section 205 of the Flood Control Act of 1948 as amended by Section 205 of the 1962 Flood Control Act. Responsible agency: Corps of Engineers. Specific recommendation: Begin construction as scheduled.

4. Corte Madera Creek. Preconstruction planning is in progress. Authorized by P.L. 87-874, October 23, 1962. Responsible agency: Corps of Engineers. Specific recommendation: Additional funds be immediately provided for completion of planning and design, leading to early construction.

5. Napa River. Construction of the Tulucay Creek portion of the project is complete and detail plans for construction of Redwood Creek Dam are in preparation. Authorized under P.L. 566, 83d Congress, 2d Session. Approved for construction June 27, 1962. Responsible agency: U. S. Soil Conservation Service. Specific recommendation: Accelerate construction.

San Joaquin Valley

1. Bear Creek (San Joaquin County). Construction is about 58 percent complete. Final construction contract is scheduled for this spring. Authorized by P.L. 534, 78th Congress, 2d Session, December 22, 1944, as part of the Calaveras River and Littlejohn Creek and tributaries project. Responsible agency: Corps of Engineers and State Reclamation Board. Specific recommendation: Maintain construction schedule.

2. New Melones Reservoir. Preconstruction planning is in progress. Authorized by P.L. 534, 78th Congress, 2d Session, December 22, 1944, as modified by P.L. 87-874 of October 23, 1962. Responsible agency: Corps of Engineers. Specific recommendation: Accelerate design and construction.

3. New Don Pedro Reservoir. Planning is in progress by local interests. Construction is dependent on court resolution of fishery problems. Federal contribution toward flood control portion of projects authorized by P.L. 534, 78th Congress, 2d Session. Responsible agency: Turlock and Modesto Irrigation Districts. Specific recommendation: Urge early resolution of controversy so that construction can proceed.

4. New Exchequer Reservoir. Construction started June 1964 and is proceeding under a tight schedule. Federal contribution toward flood control portion of project authorized by P.L. 86-645, July 14, 1960. Responsible agency: Merced Irrigation District. Specific recommendation: Maintain construction schedule.

5. Buchanan Reservoir. Preconstruction planning was initiated in January, 1964. Authorized by P.L. 87-874, October 23, 1962. Responsible agency: Corps of Engineers. Specific recommendation: Accelerate design and construction.

6. Hidden Reservoir. Preconstruction planning was initiated in January, 1964. Authorized by P.L. 87-874, October 23, 1962. Responsible agency: Corps of Engineers. Specific recommendation: Accelerate design and construction.

7. Lower San Joaquin Flood Control Project Above Mouth of Merced River. Construction is scheduled for completion in 1966. Authorized by P.L. 534, 78th Congress, 2d Session, December 22, 1944, as modified by P.L. 327, 84th Congress, 1st Session. Responsible agency: State Reclamation Board. Specific recommendation: Maintain construction schedule.

8. San Joaquin River below Merced River. Construction of active portions is about 68 percent complete. There are two inactive units that are delayed until local interests accept maintenance responsibility. Authorized by P.L. 534, 78th Congress, 2d Session, December 22, 1944. Responsible agency: Corps of Engineers and State Reclamation Board. Specific recommendation: Urge resolution of controversy and accelerate completion of the project.

9. Kings River Channel Improvement. Preconstruction planning for the levee and channel improvement has been completed. Construction will be scheduled as soon as required rights-of-way assurances are provided by local interests. Authorized by P.L. 534, 78th Congress, 2d Session, December 22, 1944. Responsible agency: Corps of Engineers. Specific recommendation: Accelerate construction.

Southern California

1. Los Angeles County Drainage Area. Construction is continuing. Authorized by various flood control acts between 1936 and 1960, inclusive. The basic comprehensive plan was authorized by the 1941 Flood Control Act. Responsible agency: Corps of Engineers. Specific recommendation: Maintain current construction schedule.

2. West Fork Dam, Mojave River. Preconstruction planning is in progress. Authorized by P.L. 86-645, July 14, 1960. Responsible agency: Corps of Engineers. Specific recommendation: Initiate construction as soon as possible.

3. Escondido Creek Watershed. Detailed plans are being prepared with construction to begin in the summer of 1965. Authorized under P.L. 566, 83d Congress, 2d Session. Responsible agency: U. S. Soil Conservation Service. Specific recommendation: Accelerate construction.

4. Santa Paula Creek. Authorized by Flood Control Act of 1948, as amended. Responsible agency: Corps of Engineers. Specific recommendation: Obtain planning funds.

5. Banning Levee on White Water River. Project is being designed and early construction is anticipated. Authorized by Section 205 of Flood Control Act of 1948, as amended. Responsible agency: Corps of Engineers. Specific recommendation: Proceed to early construction.

Projects Investigated But Not Yet Authorized

The following list includes some of the projects which have reached the final planning stage and have been reviewed by the State. It is recommended that these projects, which have been found to be economically justified and financially feasible and which will provide significant flood control benefits, be authorized by the Congress or the Legislature and that construction

funds be provided as soon as possible. Specific recommendations also are made for each project.

Sacramento Valley and Sacramento-San Joaquin Delta

1. Marysville Reservoir. This planned project is urgently needed for flood control on the Yuba River. Responsible agency: Corps of Engineers Specific recommendation: Authorize and accelerate to construction as quickly as possible.

2. Auburn Reservoir. This planned project is urgently needed for added flood control of the American River. Responsible agency: Bureau of Reclamation. Specific recommendation: Authorize and accelerate to construction as quickly as possible.

3. Cosumnes River Division. This planned project, particularly Nashville Reservoir, is urgently needed for flood control on the Cosumnes River. Responsible agency: Bureau of Reclamation. Specific recommendation: Authorize and accelerate to construction as quickly as possible.

4. Lakeport Reservoir. This planned project is needed for flood control of Scott Creek above Clear Lake. Responsible agency: Corps of Engineers. Specific recommendation: Expedite authorization and construction.

5. Wilson Valley Reservoir. This planned project is urgently needed for flood control of Cache Creek. Responsible agency: Local agency with State and/or federal participation or federal agency. Specific recommendation: Expedite authorization and construction.

North Coast

1. Eel River Delta Levee Project. This project is urgently needed; it would provide effective flood control to an area which experienced some of the worst devastation in the 1964 floods. Responsible agency: Corps of Engineers. Specific recommendation: State and local interests give full support to immediate congressional authorization.

Central Coast

1. Sonoma Creek Project. This planned channel improvement project is being finalized for submittal to Congress. Responsible agency: Corps of Engineers. Specific recommendation: Expedite authorization and construction.

2. Napa River Project. This planned project provides for channel improvements along the lower reach of the Napa River. If authorized, this project will replace the lower portion of the presently authorized Napa River Watershed Project of the U. S. Soil Conservation Service. Responsible agency: Corps of Engineers. Specific recommendation: Expedite authorization and construction.

Southern California

1. Lytle and Warm Creeks. This project will provide for flood control along Lytle and Warm Creeks in the cities of San Bernardino County and Colton. The proposed plan provides for the construction of a concrete-lined channel along the West Branch of Lytle Creek, and continuous levees along Warm Creek, and includes a channel along a portion of the Santa Ana River. Responsible agency: U. S. Soil Conservation Service. Specific recommendation: Expedite authorization and construction.

2. Beardsley Watershed. This planned project in Ventura County will provide improvement of existing channels and upgrading of three debris basins for sediment control and flood protection to agricultural land and the town of Nyland Acres. Responsible agency: U. S. Soil Conservation Service. Specific recommendation: Expedite final approval and construction.

3. Revolon Watershed: This planned Soil Conservation Project in Ventura County will provide enlargement and realignment of channels to provide flood protection for agricultural lands near the City of Oxnard. Responsible agency: U. S. Soil Conservation Service. Specific recommendation: Expedite final approval and construction.

4. San Gabriel River Watershed (Western Area). This planned Soil Conservation Service Project will

provide construction of numerous check dams, three debris basins and channels, and control of sediment and flood runoff in the San Gabriel Mountains. Responsible agency: U. S. Soil Conservation Service. Specific recommendation: Expedite final approval and construction.

5. San Diego River Mission Valley: This planned project will provide channel improvements on the San Diego River in Mission Valley. It will consist of concrete lining on the main stream and on a portion of three of its principal tributaries. Responsible agency: Corps of Engineers. Specific recommendation: Expedite authorization and construction.

6. Tijuana River Basin (International Project). This planned project will provide construction of a concrete-lined channel on a new alignment of the Lower Tijuana River. The project will reduce the flood threat created by the improvement of the upper portion of the river by Mexico. Responsible agencies: International Boundary Commission and Corps of Engineers. Since justification of this project is generally based on substantial land enhancement benefits resulting from flood control, it would be appropriate for local interests to assume a share of the necessary right-of-way costs. On this basis the project should be accelerated to early construction.

Comprehensive Basin-Wide Investigations

In addition to the many individual project investigations which have been made or are proposed, there is an urgent need for several comprehensive basin-wide studies, particularly in Northern and Central California. These studies should take into account several factors that have developed in recent years. For example, the effects of the December, 1964 storm require a new evaluation of flood control criteria. Further, the roles of recreation, and of the preservation and possible enhancement of natural resources, have been undergoing major conceptual changes almost overnight.

Also, the Federal Government, through the Area Redevelopment Act, the Accelerated Public Works Act and other programs complementary thereto, is making financial assistance and other aids available to designated counties in California. Many of these counties are located in Northern and Central California. This factor, together with the fact that in certain river basins, particularly in the North Coastal area, local economies could profit substantially not only from construction projects, but also from the industrial and recreational developments which will follow such construction, should have very favorable impacts on such economies. In such situations, an increased need and justification for flood damage abatement programs would follow. A list of needed basin-wide investigations includes:

1. Sacramento Valley and Sacramento-San Joaquin Delta. The Corps of Engineers presently has authorization, but only limited funds, for a comprehensive re-evaluation of the entire basin. Important sub-basins or areas which need further study, in the light of recent developments, include (a) the Sacramento-San Joaquin Delta; (b) the Sacramento River Basin above the mouth of the Feather River, including Stony Creek, Thomes Creek, Cottonwood Creek, Cow Creek, Antelope Creek, Mill Creek, Deer Creek, Chico Creek, Butte Creek, and Butte Basin; (c) Cache Creek Basin, including Wilson Valley Reservoir and Scotts Creek and Kelseyville Reservoirs; (d) Upper Putah Creek Basin; (e) Bear River; and (f) Upper Feather River Basin including Spanish and Indian Creeks and North Fork Feather River above Lake Almanor. The entire Yuba River Basin should also be restudied, particularly Marysville Reservoir; in addition, in the event the Yuba County Water Agency is unsuccessful in securing satisfactory bids for its project on the Yuba, the project should be reexamined in the light of possible state or federal

construction or financial aid. It is recommended that adequate funds be secured for acceleration and completion of the Corps of Engineers' authorized basin-wide investigation in Northern California streams, and the Sacramento River and Sacramento-San Joaquin Delta and that these studies include consideration of flood plain management.

2. San Joaquin Valley. The Corps of Engineers presntly has authorization, but only limited funds, for a comprehensive reevaluation of the entire San Joaquin Valley. This is scheduled as a five or six-year investigation. The study should be kept on schedule. It is recommended that adequate funds be provided for completion, as scheduled by the Corps of Engineers, of the authorized investigation in the San Joaquin Valley and that these studies include consideration of flood plain management.

3. Eel River Basin. The Department of Water Resources, the Corps of Engineers, and the Bureau of Reclamation all have investigations in progress on the Eel River. Although comprehensive to a significant degree, the foremost objective of these studies is to develop plans for water development for both local use and for the export of surplus water to water-deficient areas of the State. It is recommended that these studies be reexamined on a comprehensive basin-wide basis in the light of the recent flood events with an eye to bolstering the economy of the region, and giving special attention to the possibilities of early construction and to flood plain management.

4. Klamath River Basin. With the exception of the Trinity River, which will be treated separately, there appears to be no possibility of developing a practicable plan for flood control on the lower Klamath River, until major conservation reservoirs are needed for water supply. It is recommended that flood control be given strong consideration as a purpose in any studies of the Klamath River Basin by any agency. It is further recommended that flood plain management studies be initiated in this basin.

5. Trinity River Basin. As with the Eel River Basin, the Trinity River Basin is being studied by both the Department of Water Resources and the Bureau of Reclamation, primarily for water development. In view of new hydrologic data, flood control should be more than an incidental purpose. It is recommended

that consideration be given to flood control as a primary purpose in investigations presently being conducted.

6. Mad River Basin. This basin is being studied by the Department of Water Resources and the Corps of Engineers, primarily for additional water supplies. It is recommended that flood control be considered a primary purpose in investigations presently being conducted and that attention be given to flood plain management.

7. Smith River Basin. The Corps of Engineers is authorized to study the Smith River Basin, but has had no funds made available. Flood plain management and channel improvement appear to be important in the solution to this problem. It is recommended that early funding be provided to the Corps of Engineers for this authorized study and that attention be given to flood plain management.

8. Russian River Basin. Construction of the authorized Warm Springs Reservoir on Dry Creek will provide substantial new flood protection in the Russian River Basin. Nonetheless, in view of new hydrologic data, it is recommended that the entire basin be restudied by the Corps of Engineers.

9. Minor Northern California Basins. Numerous flood problems occur in several sub-basins including Lost River-Tule Lake, Butte Valley, Shasta Valley, Scott Valley, South Fork Pit River, Susan River, and the North Fork of the Feather River above Lake Almanor. It is recommended that the Department of Water Resources and the Corps of Engineers undertake, at a reconnaissance level, reviews of flood control projects in connection with multiple-purpose water developments for these areas. The timing of these studies should be coordinated with possible water projects for other needs and to take advantage of possible broadened economic concepts.

Needed Actions and Other Studies

There are several important subjects, in addition to specific projects, which have a significant bearing on the solution of flood problems. Some of these subjects have been considered before, some may be new; but this review of California's flood problems indicates that their consideration is urgent.

Utilization and Coordination of Flood Fighting Resources

It is apparent not only from reading Chapter IV, "Flood Fight Resources and Responsibilities", but also from the experiences of recent floods that almost unlimited resources are available in flood emergencies. The problem is to assure that these resources are utilized in the most expeditious and timely manner and to the fullest extent possible. The way to do this is to assure coordination among the various agencies, making certain that the responsibilities and communication channels of each are fully understood. The Flood Control Center in Sacramento has operated in such a satisfactory manner during past floods that it has set a pattern for similar centers elsewhere. It is recommended that the Department of Water Resources, the Corps of Engineers, the Weather Bureau, and the California Disaster Office establish a task force with the objective of studying and setting up and staffing three other area flood control centers; one in or near Eureka, the second in the San Francisco Bay area, and the third in the Los Angeles area. The

centers in the North Coast area and the Bay area should be established immediately.

These centers not only would serve to receive all pertinent data but also, and more important, would be the central points of operation for all agencies, the central points for dissemination of all information, and the central points for coordination of all activities.

A necessary requirement for the flood control center in the North Coast is a reliable radio network to cover and to extend out of the North Coast to other areas in order to provide communication between flood operation centers and between the flood operation center and areas of flood fight emergency and flood fight activity. This radio network, and the other governmental communication facilities available during flood emergencies, should have a flexibility to integrate and coordinate separate smaller systems. A similar network connected to the Flood Control Center in Sacramento also is needed in the Upper Sacramento River Valley. Such networks are recommended. It also is recommended that consideration be given to the use of closed circuit television, both for communication between flood centers, and for dissemination of public information.

Flood Forecast and Flood Warning Systems

The experience of the December, 1964 storm and flood sharply pointed up the need to strengthen and improve the data gathering and flood warning systems. The data and

communication networks and flood warning systems in the Central Valley need improvement and expansion. There are serious deficiencies in the North Coast and the Central Coast.

The topography of these two areas and their proximity to the Pacific Ocean raise special problems in forecasting flood flows. In the flat plain areas of the Central United States flood stages can be forecast from measured daily rainfall amounts or even from measurements of runoff of tributary streams. In California's North Coast and Central Coast areas, however, the time is so short between the first appearance of rain and the following flood crest that special data gathering and forecasting techniques are necessary. To gather data quickly, rainfall stations are installed in remote mountain locations to automatically telemeter rainfall amounts to the forecast center on an hourly or more frequent basis.

In order to provide flood warnings as far in advance as possible the first quantitative rainfall forecasts for a storm are made by analyzing the meteorological characteristics of the storm while it is still well out at sea and often before appreciable rain has fallen on the watersheds that will be affected. As the storm front moves inland and as the situation becomes more clearly defined, particularly by rainfall measurements from the remote telemetering stations, the forecasts are revised and improved. As can be seen, in a situation of this type, any steps that can be taken to obtain more and earlier

data will result in earlier and more accurate flood forecasts and enable the more timely issuance of flood warnings.

The first steps are to take emergency action to repair the system that was destroyed by the storm and on an emergency basis to put in an adequate telemetering stream and rain gage network. This work already is in progress to provide flood protection during the remainder of the present flood season. There also are two other new steps that can be taken. The first is to install additional weather radars, such as that located at Sacramento. There is a particular need for one in the North Coast, probably at Eureka, and possibly one should be located at San Francisco. The second new step is to give strong consideration to the possibility of stationing a permanent weather ship an appropriate distance offshore. Such a weather ship also should be considered as a possible location for a weather radar.

It is recommended that the Department of Water Resources and the Weather Bureau study the problem of making flood forecasts for the North Coast and Central Coast areas and take steps to expand the existing telemetering rain gage network, to install additional weather radar, and to station a permanent weather ship off the California Coast.

Revised Operation Criteria for Folsom and Shasta Reservoirs

As noted elsewhere in this report, the December, 1964 flood nearly filled Folsom Reservoir, a condition that could have

caused excessive releases into the already full downstream channel of the American River and endangered the Sacramento metropolitan area. This points up the need for additional flood control storage on the American River. It also suggests that it would be possible on an interim basis, pending construction of Auburn Dam, to make additional space in Folsom Reservoir available for flood control.

Shasta Reservoir on the Sacramento River also could provide additional flood control reservation for an interim period. The Bureau of Reclamation has recently studied the possibility of raising the normal water surface at Shasta. The additional capacity thus provided, plus some increase in the present flood control reservation, would provide additional flood protection to the Sacramento Valley and Delta area.

It is recommended that the Corps of Engineers and the Bureau of Reclamation immediately review the operation criteria for Folsom and Shasta Reservoirs to see if it is feasible to increase the flood control reservations; in the case of Folsom on an interim basis, pending the completion of the upstream Auburn Reservoir.

Protection of Existing Flood Control Facilities

A survey of the Sacramento Valley levee system immediately following the flood period indicated that the general condition of the system was "fair". In many areas erosion had taken place. Almost without exception the erosion

was in areas where the levees were not protected by rock or cobble riprap. This flood, as have past floods, demonstrated that rock levee protection is best and that vegetation does not provide adequate protection to the levee banks.

It is recommended that the priority of flood requirements be kept in mind in future discussions of and in planning for other uses of the river channels. The existing levee and bypass system was designed primarily as a single-purpose system. In planning recreation and other uses of the system careful consideration must be given to the need to protect the system. Where necessary the project should be rebuilt to serve multiple-purpose uses by doing such things as constructing protected berms where vegetation can be allowed to grow.

Expanded Approach to Flood Control

California has sustained a direct damage of almost $400,000,000 in the eight floods since 1950. This figure does not include the indirect damages to the economy of the State. The total of direct and indirect damages, although it is not known in definite amount, is so great as to raise at least three questions: First, are the flood frequency analyses up-to-date? Second, are we planning our flood control projects on a broad enough base and with a broad enough scope? Third, are the measures of economic justification and financial feasibility that have been applied to flood control projects in the past and are being applied today valid?

Nearly all major Central and Northern California streams have experienced two historic flood flow peaks in the past ten years; once in 1955 and again in 1964. In the past nine years the Yuba River has had three all-time peak floods. Since 1950 there have been eight major floods. The flood frequency curves that are being used in studies of feasibility of flood control projects should be examined to see that they reflect the facts of the past 15 years. It is recommended that state and federal agencies, particularly the Corps of Engineers, review their flood frequency studies.

A much broader approach to flood control should be taken. Future flood control studies should be done on a basin-wide basis and should be comprehensive enough to take into account development of water for other uses such as conservation and power. But with particular reference to flood control, a master flood control plan should be developed for each of the State's basins which would give proper and balanced consideration to all of the possible means of abating flood damage such as reservoirs, levees and stream improvements, bypass channels, flood plain management, watershed management and advance purchase of right-of-way.

There should be a state flood control plan. Such a plan would include the flood control plans for the major basins and would be a master framework within which all agencies could work to provide the State with needed flood protection. Although

studies of flood control problems were made in connection with work leading to The California Water Plan they were not comprehensive enough or complete enough to constitute a comprehensive California Flood Control Plan. In part this probably was due to the fact that the State has done little in this field because historically the Corps of Engineers has had the major responsibility for flood control planning and construction in California, as in all of the United States. In recent years, the U. S. Soil Conservation Service also has been active in small stream flood control under watershed protection legislation. Although federal expenditures for flood control in California since 1949 have ranged from a minimum of $25 million annually to a peak of about $47 million in 1959, it is apparent that these expenditures are inadequate to meet the flood control needs of California's expanding population and economy. The State Government is the only entity vested with a statewide interest and responsibility. It is in the best position to exercise leadership, general direction, and coordination of all interests concerned.

It is recommended that comprehensive flood control plans be developed for each of the State's major basins and also that a state flood control plan be developed. Where plans are available they should be reviewed and broadened to be fully reflective of multiple-purpose basin planning. Generally basin flood control plans should be made by the Corps of Engineers although all agencies working on basin-wide water development

plans should broaden their planning to take flood control fully into account. The State flood control plan should be coordinated, developed and maintained by the Department of Water Resources. The Legislature should provide funds for the Department to immediately initiate an appropriate program. That plan also should be revised periodically as part of the core planning effort of the Department. The plan should be an effective guide to the inclusion of flood control in the water resource developments of all federal, state and local agencies.

Criteria for economic justification and financial feasibility for flood control projects need to be reviewed and probably revised. In this regard consideration should be given to developing a rationale whereby the element of protection of human life may be given paramount consideration, along with economics, in determining project feasibility or the timing of project construction. Also, a method should be sought to express in terms of monetary benefit the enhancement of the potential for economic growth of an area when that area has a substantial degree of flood protection. It is recommended that state and federal agencies review their criteria used in making economic justification and financial feasibility studies.

Increased financing and new sources of financing should be made available to construct flood control projects. It is recommended that strong efforts be made to increase federal appropriations for flood control. In this general

regard, the federal Water Supply Act of 1958 may have increased applicability and importance to California. It permits earlier construction of many projects in the interest of flood control, or other urgent need, than could otherwise be financially possible.

State financial resources also should be considered. The State advanced the timing of federal construction of the Black Butte and New Hogan Projects by pledging certain financial assistance that was then lacking. Construction of New Exchequer Dam and Reservoir is being advanced by the State Legislature authorizing a loan of $8 million from the California Water Fund to the Merced Irrigation District to cover the federal flood control contribution until such time as appropriations therefor are made by the Congress. The State decided to construct Oroville Dam ahead of the economic timetable on the basis of affording protection to lives and this decision paid off in December, 1964.

Flood Plain Management

For certain communities and areas, because of their location, protection against floods of the magnitude that experience shows may reasonably be expected to occur may be completely impractical. The fact that certain communities in the State have been completely flooded out twice in nine years is strong evidence that they are poorly located. It is logical that such communities should be relocated at higher elevations,

above the flood plain, and further, that the dangerous flood plains be managed to prevent or to strongly discourage building upon them.

Legislation[1/] was introduced in the 1963 Session of the Legislature, which would have permitted the Department of Water Resources to assist local agencies in establishing and enforcing flood plain regulations in areas subject to frequent flooding. In addition to being supported by the Department, this legislation was supported by the Corps of Engineers, the State Reclamation Board, and the California Water Commission.

It is anticipated that a revised bill will be introduced in the 1965 Session. It would permit the State to guide and assist local agencies to properly manage their flood plains by authorizing the State to review and comment on proposals for regulating flood plain use, or to carry out flood plain studies upon request of local agencies. It also would authorize the State to withhold reimbursement for the cost of lands, easements, and rights-of-way for federal flood control projects where local agencies fail to establish regulations. Such a law would enable the proper management of the State's dangerous flood plains as an essential part of comprehensive flood control plans.

1/ Senate Bill 1435.

It is recommended that this legislation be strongly supported.

Flood Plain Information Studies

In recognition of the foregoing problem of flood plain management, the Congress has given the Corps of Engineers authority to provide technical information to local planning agencies by Section 206 of the 1960 Flood Control Act. That Section reads as follows:

> "SEC. 206. (a) That, in recognition of the increasing use and development of the flood plains of the rivers of the United States and of the need for information on flood hazards to serve as a guide to such development, and as a basis for avoiding future flood hazards by regulation of use by States and municipalities, the Secretary of the Army, through the Chief of Engineers, Department of the Army, is hereby authorized to compile and disseminate information on floods and flood damages, including identification of areas subject to inundation by floods of various magnitudes and frequencies, and general criteria for guidance in the use of flood-plain areas; and to provide engineering advice to local interests for their use in planning to ameliorate the flood hazard: PROVIDED, That the necessary surveys and studies will be made and such information and advice will be provided for specific localities only upon the request of a State or a responsible local governmental agency and upon approval by the Chief of Engineers.
>
> "(b) The Secretary of the Army is hereby authorized to allot, from any appropriations hereafter made for flood control, sums not to exceed $1,000,000 in any one fiscal year for the compilation and dissemination of such information."

This program provides information that is vital to studies of flood plain management and to the development of flood control plans. It is seriously handicapped, however, by the statutory limitation of $1,000,000 each year for the entire nation. A substantial increase of funds for this purpose would permit expanded studies of flood problems. Such increased financing could come about through an increase in federal funds or by appropriation of state funds, either on a cooperative basis or by contracts with the Corps of Engineers. It is recommended that strong support be given to an increase in federal funds for this purpose.

Watershed Management

The management, or lack of management, that is given to a watershed helps to determine whether there are floods or usable water, erosion and sediment or productive land. The use of floodwater retarding structures, sediment control and gully-stabilizing structures, vegetation, contour farming, and improved fire fighting capabilities, have both individual and accumulatively favorable effects on the quality and quantity of stream flow. Benefits from these measures are many and varied and are both on-site and off-site. As more flood plains are developed, the need for watershed protection will increase. It is recommended that the U. S. Soil Conservation Service and State Division of Soil Conservation, who are

principal sponsors of such programs in California, give special attention to implementing such programs on watersheds of streams and portions of river basins which habitually cause the greatest losses in lives and/or property.

CHAPTER VIII. RECOMMENDATIONS

The previous chapter presents "The California Flood Control Program--1965". In that chapter a considerable number of recommendations are made regarding projects that should be expedited, authorized, or planned and actions that should be taken or studies that should be made. Those recommendations constitute the general recommendations of this report and will not be repeated here. Action on those recommendations would implement The California Flood Control Plan.

In the short time available to prepare this report it has not been possible to make studies that would indicate priorities that should be assigned to all of the foregoing recommendations. Such priorities should be determined as soon as possible as a part of a comprehensive flood control plan for the State. In the meantime, from knowledge of existing flood control and flood protection facilities and from the experiences of recent floods, the following immediate actions are recommended.

- Authorize and construct Marysville Reservoir on the Yuba River (page 130).
- Authorize and construct Auburn Reservoir on the American River (page 130)
- Expedite studies of Dos Rios, Spencer, and English Ridge Reservoirs on the upper Eel River to determine the feasibility of construction for flood control in advance of need for water supply (pages 130 and 131).

- Expedite studies of the Butler Valley Project on the Mad River for flood control (page 131).

- Expedite studies and authorize and construct Knights Valley Reservoir in the Russian River Basin (page 131).

- Expedite studies of the Paskenta-Newville Project looking toward early construction (page 131).

- Expedite studies on the upper Sacramento River tributary of Cottonwood, Deer, Mill, and Cow Creeks looking toward early construction (page 132).

- Accelerate construction of Sacramento River Bank Protection Project (page 134).

- Authorize and construct Nashville Reservoir on the Cosumnes River (page 139).

- Authorize and construct Lakeport Reservoir on Scott Creek (page 139).

- Authorize and construct Wilson Valley Reservoir on Cache Creek (page 139).

- Authorize and construct the Eel River Delta Levee Project (page 139).

- Authorize and construct the Sonoma Creek Project (page 140).

- Authorize and construct the Napa River Project (page 140).

- Authorize and/or construct the following projects in Southern California (page 140):

    1. Lytle and Warm Creeks
    2. Beardsley Watershed
    3. Revolon Watershed
    4. San Gabriel River Watershed
    5. San Diego River Mission Valley
    6. Tijuana River Basin

- Make comprehsive basin-wide studies with flood control as a major purpose in the following areas (pages 142-144):

1. Sacramento Valley and Sacramento-San Joaquin Delta (page 142)
2. San Joaquin Valley (page 143)
3. Eel River Basin (page 143)
4. Klamath River Basin (page 143)
5. Trinity River Basin (page 143)
6. Mad River Basin (page 144)
7. Smith River Basin (page 144)
8. Russian River Basin (page 144)
9. Minor Northern California Basin Projects including Lost River-Tule Lake, Butte Valley, Shasta Valley, Scott Valley, South Fork Pit River, Susan River, and North Fork of the Feather River above Lake Almanor (page 144)

- Establish area flood control centers in or near Eureka and in San Francisco Bay area (page 145).

- Construct a reliable radio network to provide communications to the North Coast (page 146).

- Expand the existing hydrologic telemetering network in the North Coast (page 148).

- Install additional weather radar in Northern California (page 148).

- Investigate the possibility of stationing a permanent weather ship off the Northern California Coast (page 148).

- Increase flood control reservation in Folsom Reservoir pending completion of Auburn Reservoir (page 149).

- In planning recreation and other uses of the existing levee system give consideration to the priority of flood requirements and if necessary rebuild the system to serve multiple-purpose uses (page 150).

- Review flood frequency studies (page 151).

- Initiate studies to provide and maintain on a current basis a statewide flood control plan (page 152).

- Initiate studies to develop master flood control plans for the major drainage basins of the State (page 152).

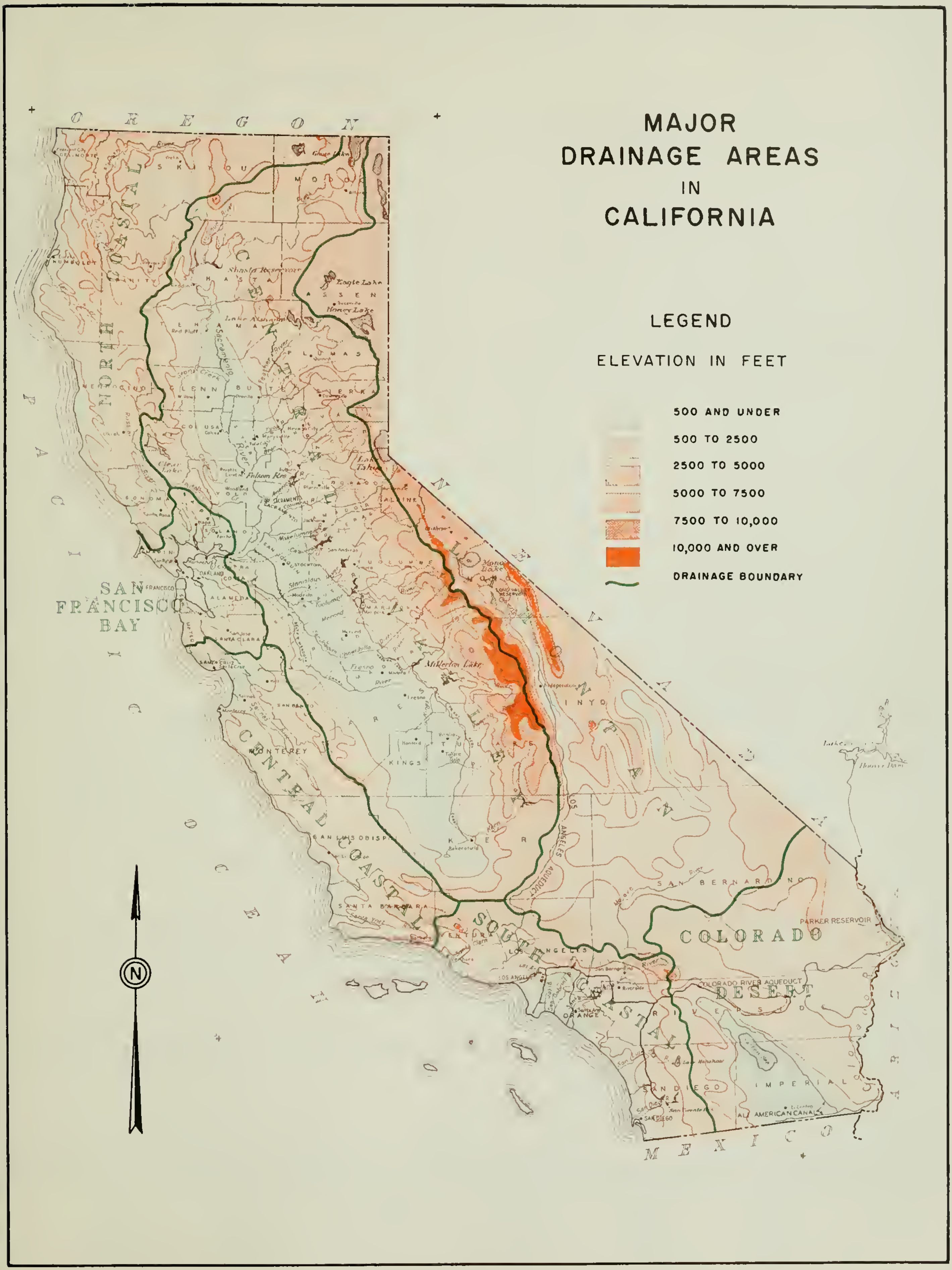
- Review and revise criteria for economic justification and financial feasibility of flood control projects giving consideration to the element of protection of human life (page 153).

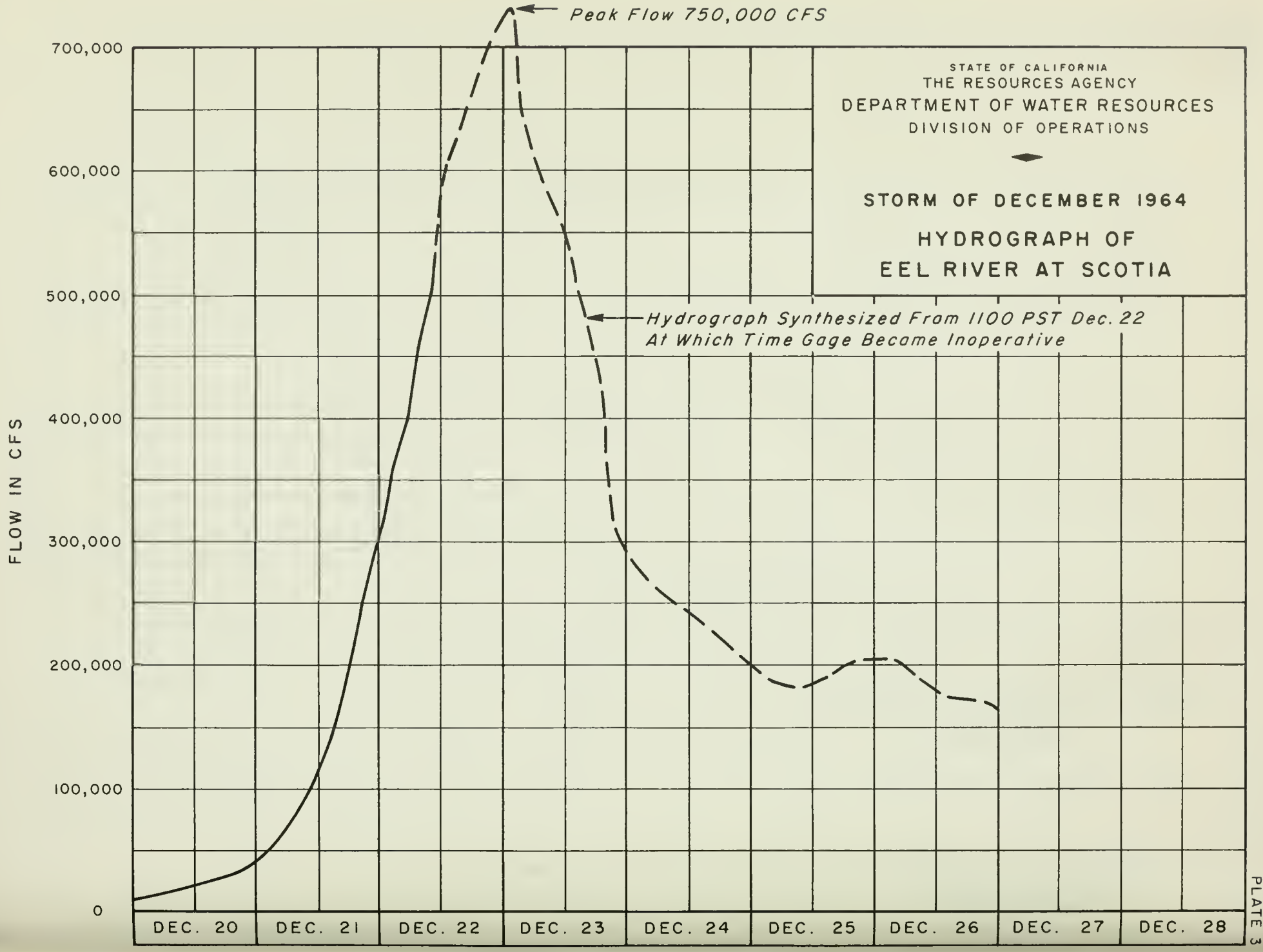
- Increase federal appropriations for flood control (page 153).

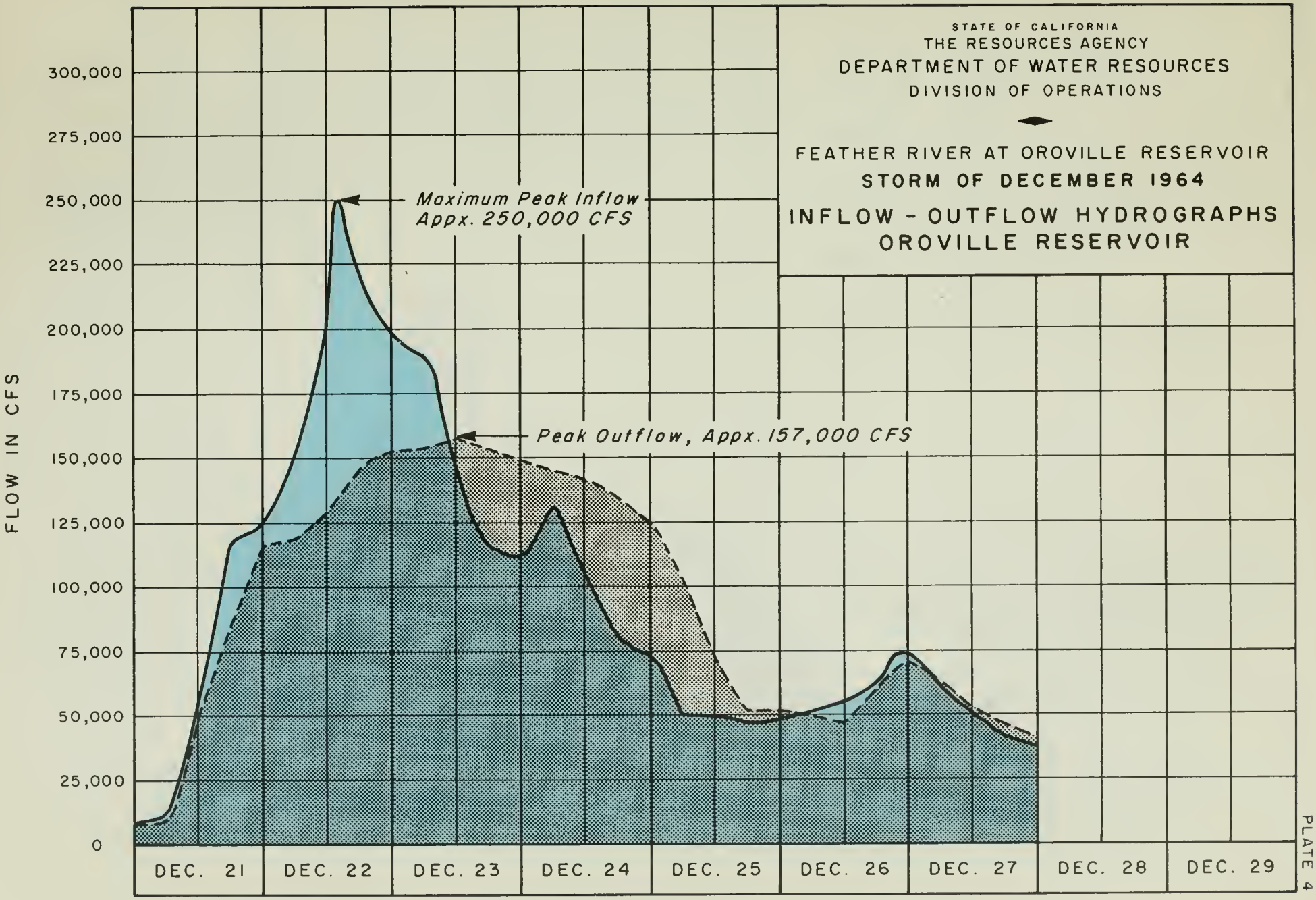
- Enact at state level strong flood plain management legislation (page 156).

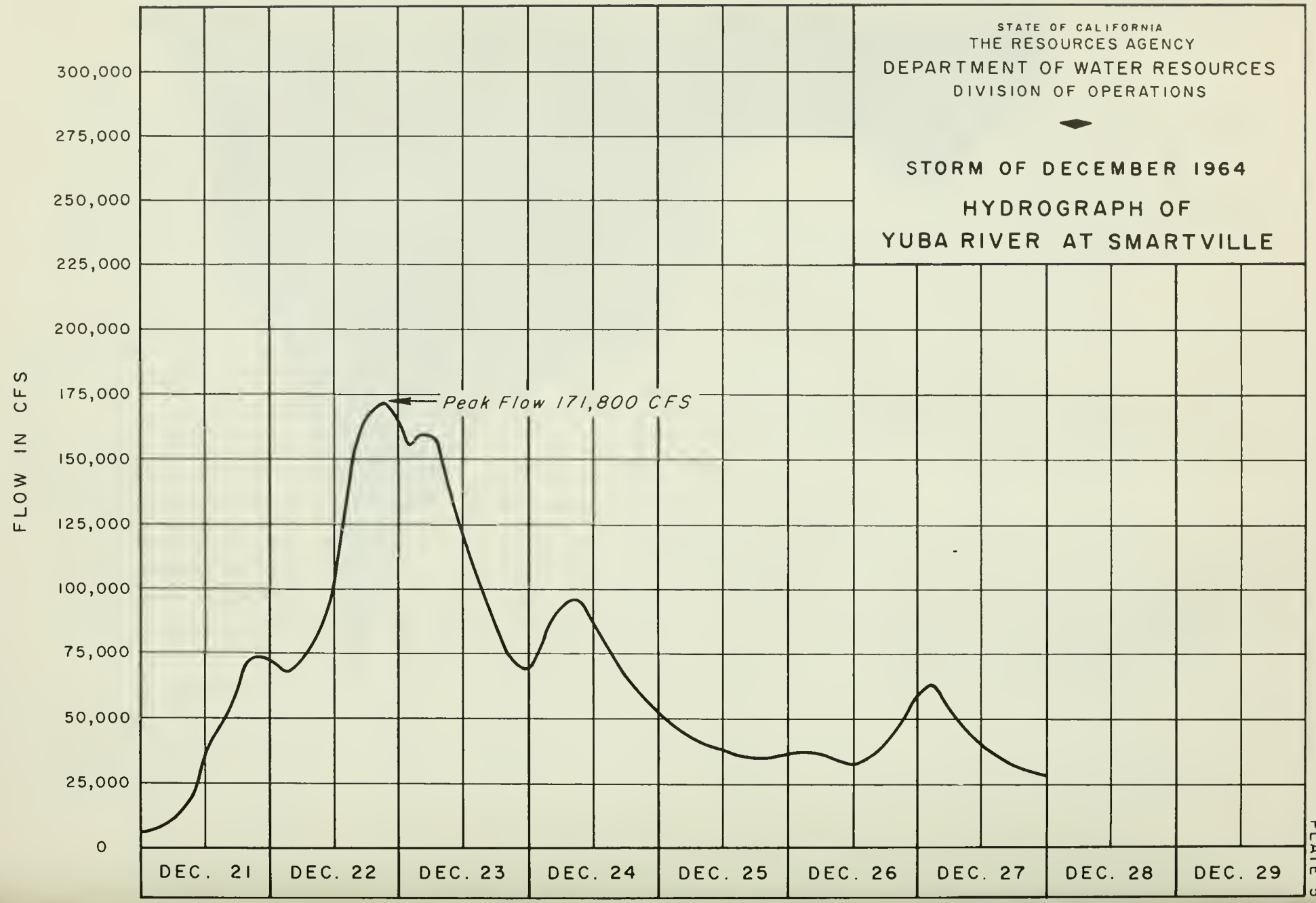
- Increase funds available for flood plain information studies (page 157).

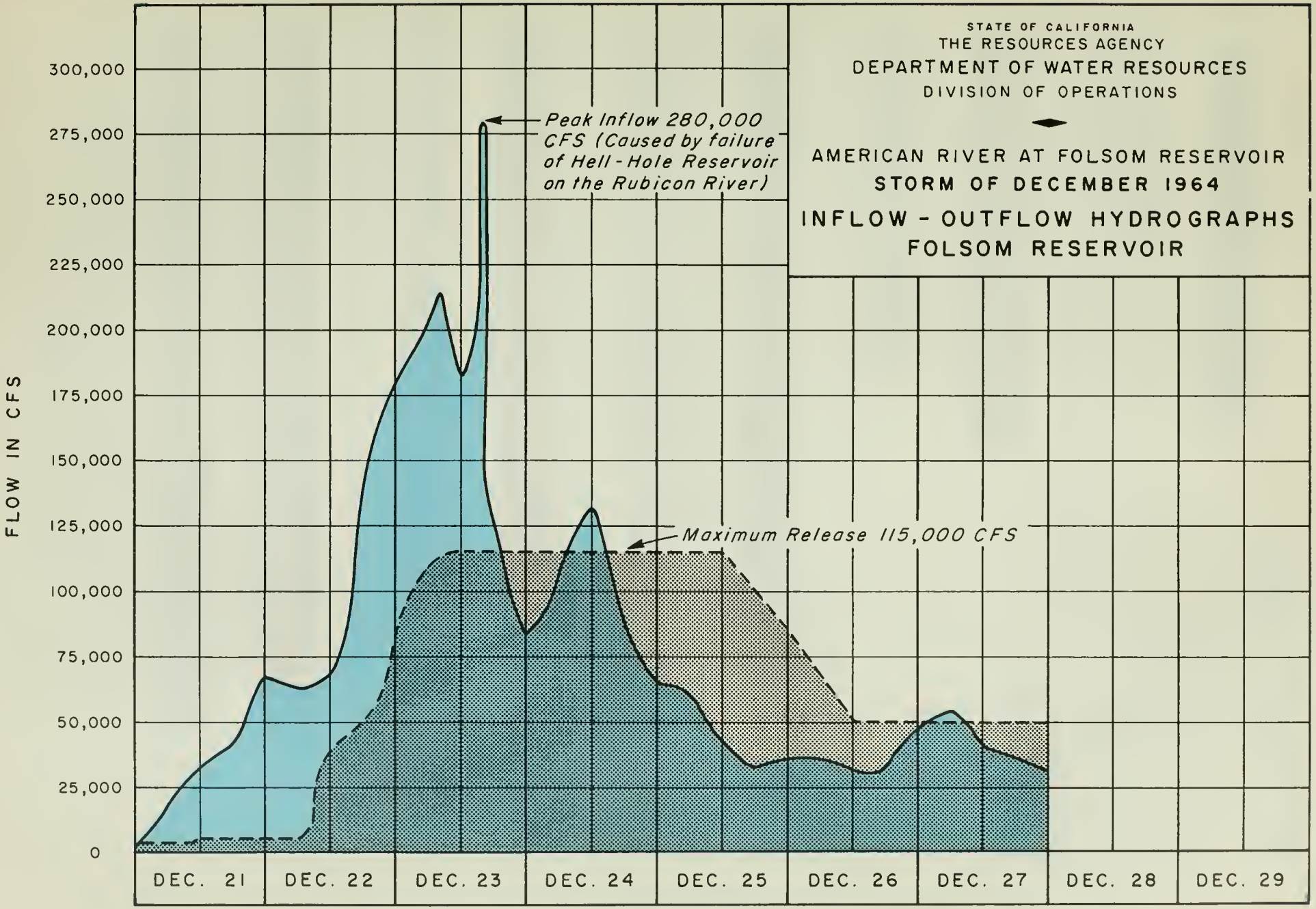
- Give special attention to watershed management programs on streams where greatest flood damages are suffered (page 157).

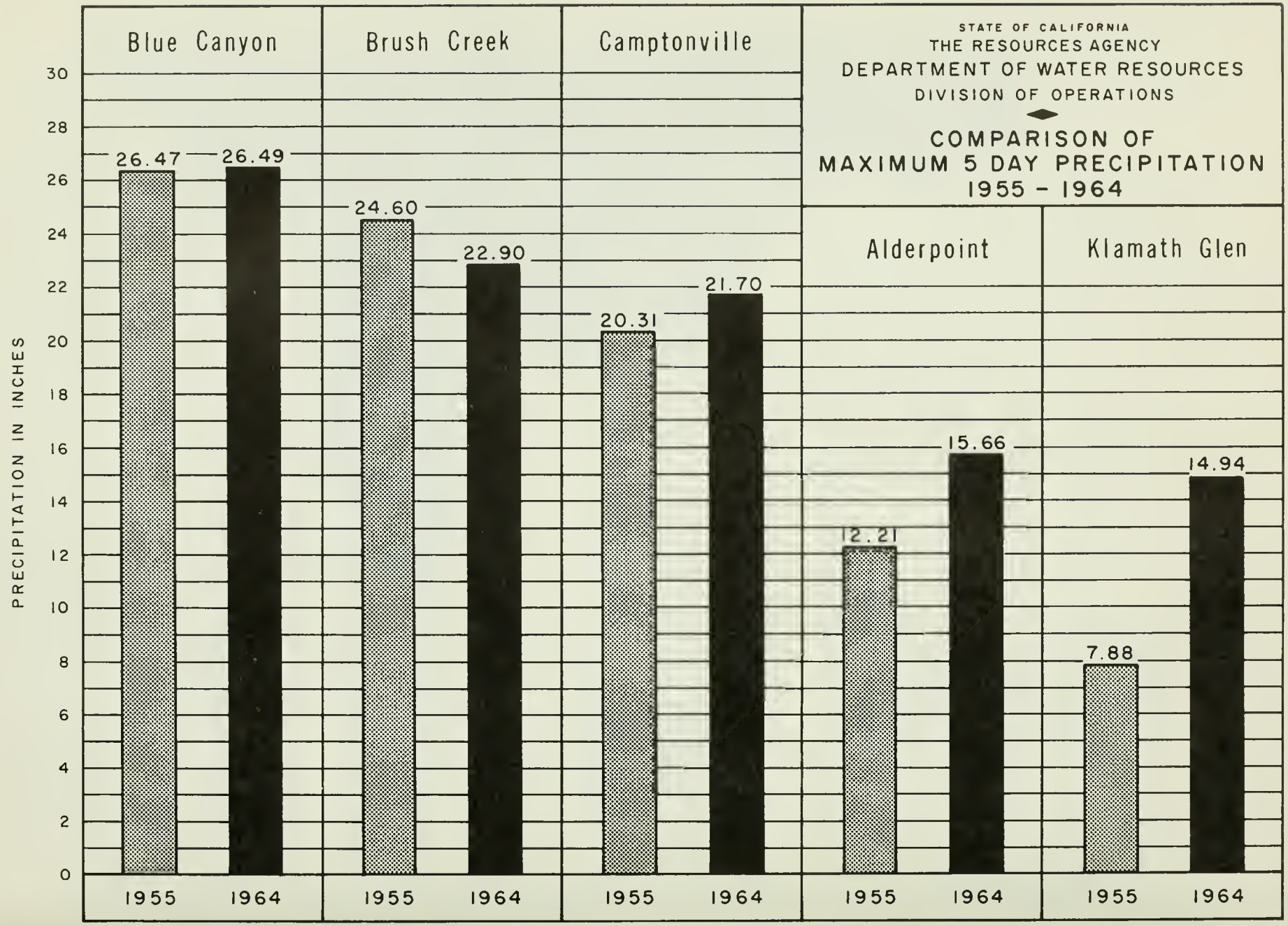

MAJOR DRAINAGE AREAS IN CALIFORNIA
LEGEND
ELEVATION IN FEET
500 AND UNDER
500 TO 2500
2500 TO 5000
5000 TO 7500
7500 TO 10,000
10,000 AND OVER
DRAINAGE BOUNDARY
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
NORTH COASTAL
CENTRAL VALLEY
LAHONTAN
CENTRAL COASTAL
SOUTH COASTAL
COLORADO DESERT
SAN FRANCISCO BAY
Shasta Reservoir
Eagle Lake
Honey Lake
Lake Almanor
Clear Lake
Folsom Res.
Lake Tahoe
Mono Lake
Millerton Lake
PARKER RESERVOIR
COLORADO RIVER AQUEDUCT
LOS ANGELES AQUEDUCT
ALL AMERICAN CANAL

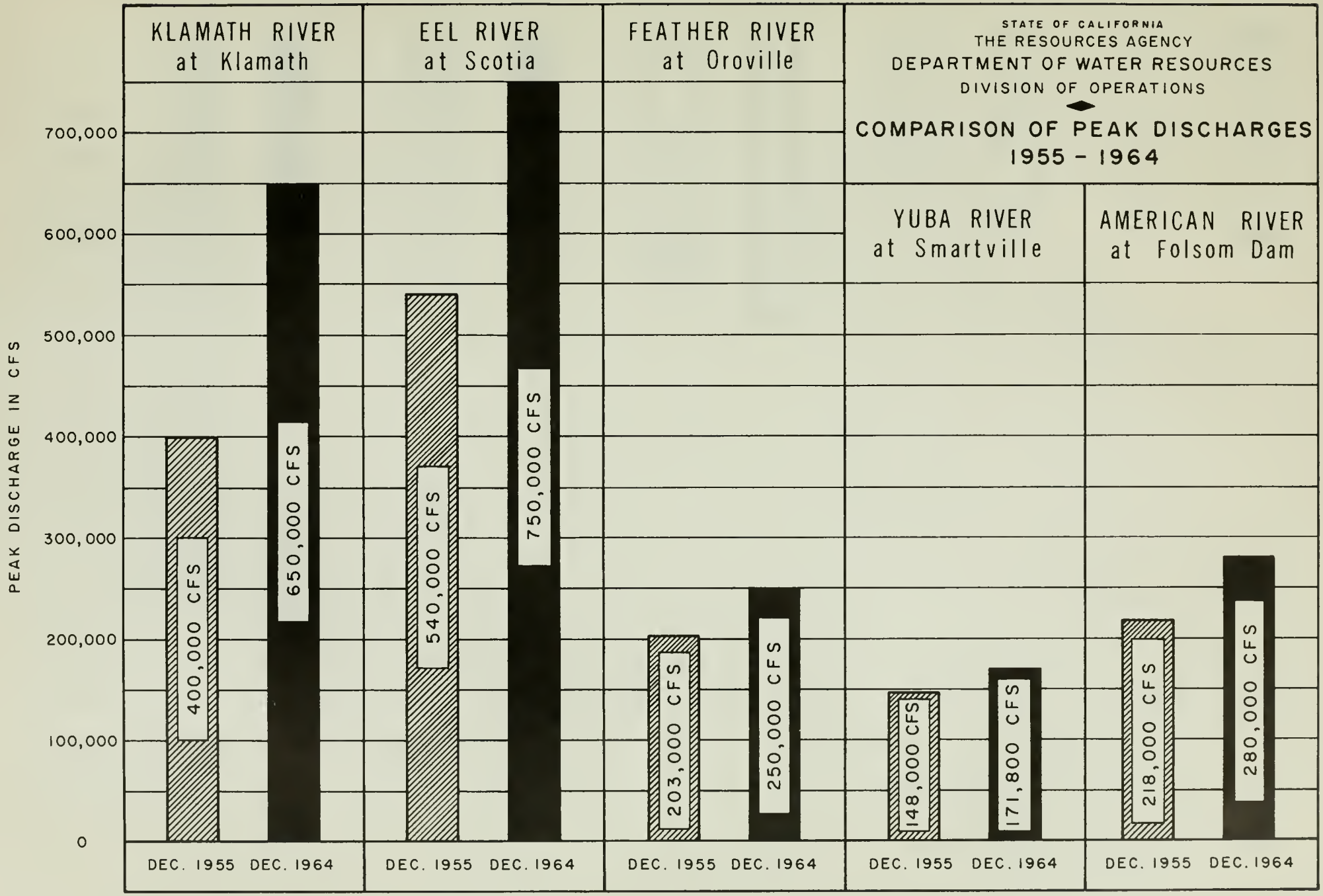

Peak Flow 750,000 CFS
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
FLOW IN CFS
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF OPERATIONS
STORM OF DECEMBER 1964
HYDROGRAPH OF
EEL RIVER AT SCOTIA
Hydrograph Synthesized From 1100 PST Dec. 22
At Which Time Gage Became Inoperative
DEC. 20
DEC. 21
DEC. 22
DEC. 23
DEC. 24
DEC. 25
DEC. 26
DEC. 27
DEC. 28
PLATE 3


STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF OPERATIONS
FEATHER RIVER AT OROVILLE RESERVOIR
STORM OF DECEMBER 1964
INFLOW - OUTFLOW HYDROGRAPHS
OROVILLE RESERVOIR
Maximum Peak Inflow
Appx. 250,000 CFS
Peak Outflow, Appx. 157,000 CFS
FLOW IN CFS
300,000
275,000
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
0
DEC. 21
DEC. 22
DEC. 23
DEC. 24
DEC. 25
DEC. 26
DEC. 27
DEC. 28
DEC. 29
PLATE 4


STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF OPERATIONS
STORM OF DECEMBER 1964
HYDROGRAPH OF
YUBA RIVER AT SMARTVILLE
FLOW IN CFS
300,000
275,000
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
0
Peak Flow 171,800 CFS
DEC. 21
DEC. 22
DEC. 23
DEC. 24
DEC. 25
DEC. 26
DEC. 27
DEC. 28
DEC. 29
PLATE 5


STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF OPERATIONS
AMERICAN RIVER AT FOLSOM RESERVOIR
STORM OF DECEMBER 1964
INFLOW - OUTFLOW HYDROGRAPHS
FOLSOM RESERVOIR
Peak Inflow 280,000 CFS (Caused by failure of Hell-Hole Reservoir on the Rubicon River)
Maximum Release 115,000 CFS
FLOW IN CFS
300,000
275,000
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
0
DEC. 21
DEC. 22
DEC. 23
DEC. 24
DEC. 25
DEC. 26
DEC. 27
DEC. 28
DEC. 29
PLATE 6


STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF OPERATIONS
COMPARISON OF
MAXIMUM 5 DAY PRECIPITATION
1955 - 1964
PRECIPITATION IN INCHES
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Blue Canyon
26.47
26.49
Brush Creek
24.60
22.90
Camptonville
20.31
21.70
Alderpoint
12.21
15.66
Klamath Glen
7.88
14.94
1955
1964
PLATE 7


KLAMATH RIVER at Klamath
EEL RIVER at Scotia
FEATHER RIVER at Oroville
YUBA RIVER at Smartville
AMERICAN RIVER at Folsom Dam
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF OPERATIONS
COMPARISON OF PEAK DISCHARGES
1955 - 1964
PEAK DISCHARGE IN CFS
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
400,000 CFS
650,000 CFS
540,000 CFS
750,000 CFS
203,000 CFS
250,000 CFS
148,000 CFS
171,800 CFS
218,000 CFS
280,000 CFS
DEC. 1955 DEC. 1964
DEC. 1955 DEC. 1964
DEC. 1955 DEC. 1964
DEC. 1955 DEC. 1964
DEC. 1955 DEC. 1964
PLATE 8

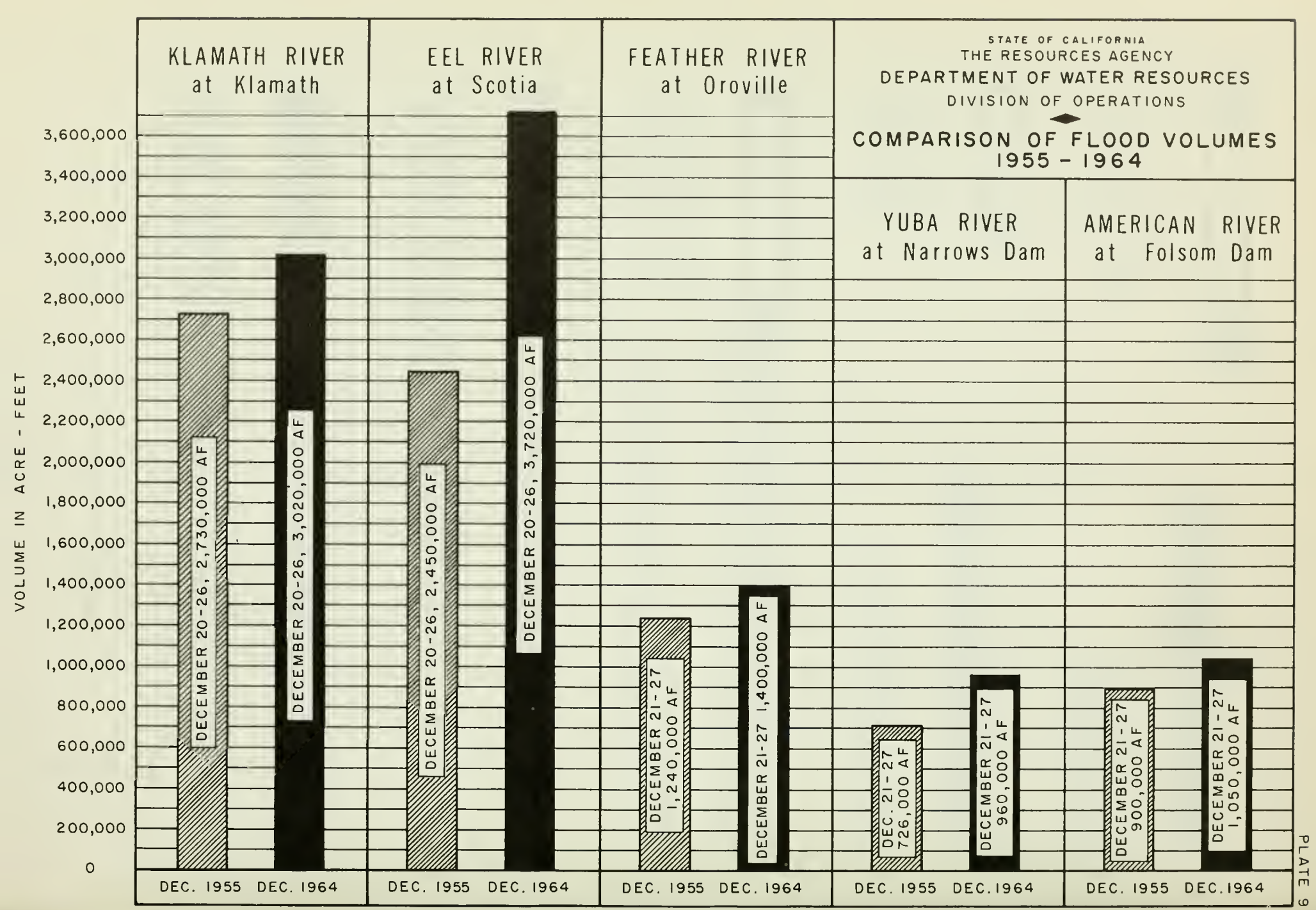

KLAMATH RIVER at Klamath
EEL RIVER at Scotia
FEATHER RIVER at Oroville
YUBA RIVER at Narrows Dam
AMERICAN RIVER at Folsom Dam
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF OPERATIONS
COMPARISON OF FLOOD VOLUMES
1955 - 1964
VOLUME IN ACRE - FEET
3,600,000
3,400,000
3,200,000
3,000,000
2,800,000
2,600,000
2,400,000
2,200,000
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
DECEMBER 20-26, 2,730,000 AF
DECEMBER 20-26, 3,020,000 AF
DECEMBER 20-26, 2,450,000 AF
DECEMBER 20-26, 3,720,000 AF
DECEMBER 21-27 1,240,000 AF
DECEMBER 21-27 1,400,000 AF
DEC. 21-27 726,000 AF
DECEMBER 21-27 960,000 AF
DECEMBER 21-27 900,000 AF
DECEMBER 21-27 1,050,000 AF
DEC. 1955 DEC. 1964
DEC. 1955 DEC. 1964
DEC. 1955 DEC. 1964
DEC. 1955 DEC. 1964
DEC. 1955 DEC. 1964

PLATE 9