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BULLETIN No. 150-1

UPPER SACRAMENTO RIVER BASIN INVESTIGATION

An Updating of Bulletin No. 150 and a Reconnaissance Appraisal of Flood Problems and Possible Solutions in the Upper Sacramento River Basin

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FOREWORD

A comprehensive study of local water development opportunities on the Sacramento River and its tributaries between Shasta Dam and Red Bluff was completed in 1964 and reported on in Bulletin No. 150, "Upper Sacramento River Basin Investigation". The objective of the investigation was to form a plan for economic development of the water resources in the basin.

The December 1964 flood pointed out the need for additional flood control in the area and showed that greater emphasis should be placed on determining flood control benefits.

A 2-year extension of the Upper Sacramento River Basin Investigation was authorized by Assembly Concurrent Resolution No. 18, First Extraordinary Session, 1966. This resolution resolved that "... the Department of Water Resources is requested to undertake a finalized economic and financial evaluation of the following potential multipurpose water projects on the tributaries of the upper Sacramento River: Paskenta-Newville Dam and Reservoir (Thomes Creek), Hulen and Dippingvat Dams and Reservoirs (Cottonwood Creek), Deer Creek Meadows Dam and Reservoir, and Millville Dam and Reservoir (Cow Creek) ...." Emphasis was to be placed upon " ... benefits for flood control for the entire upper Sacramento River area ...."

An economic reevaluation of the specific projects mentioned in the resolution, as well as a reconnaissance appraisal of basin-wide flood problems and potential solutions, is presented in this bulletin.

The report recommends: that a comprehensive, staged plan of development be developed for the upper Sacramento River Basin which will consider flood control, local water supplies, export projects, importation and passage of North Coast waters, seepage, and other water-oriented problems; that the counties within the basin give early consideration to adopting floodplain management ordinances; and that the counties establish advisory committees to represent them in planning for water resources development and to evaluate local needs for water developments.

Following a public hearing on this report, a summary of that hearing and the final supplement for Bulletins Nos. 150 and 150-1 will be published as Appendix E of this bulletin.

William R. Gianelli

William R. Gianelli, Director
Department of Water Resources
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State of California

State of California
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ABSTRACT

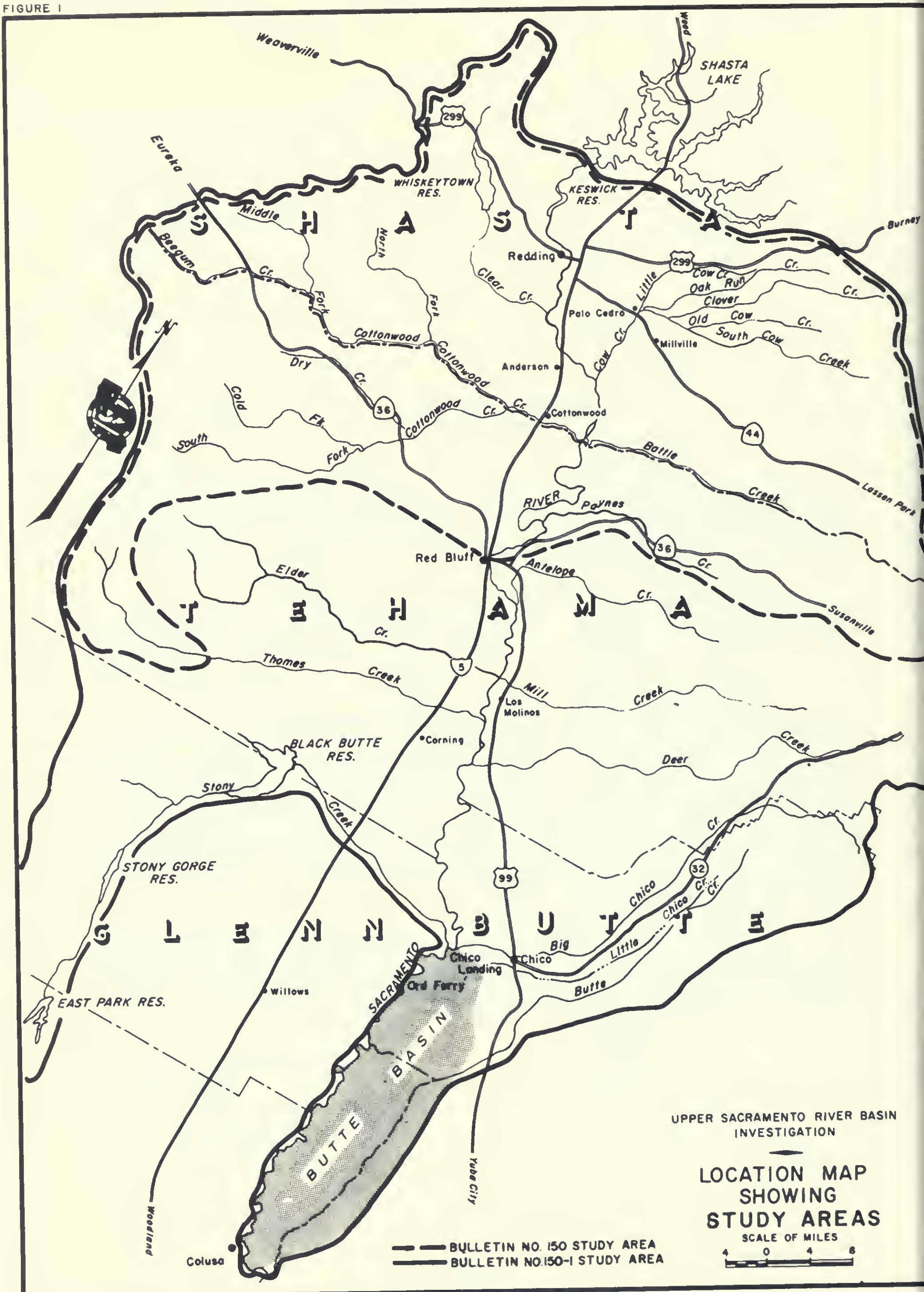
Bulletin No. 150-1 reports on a 2-year extension of the Upper Sacramento River Basin Investigation, which was completed in 1964 and reported on in Bulletin No. 150. The extended study came about primarily as a result of the December 1964 flood which pointed out the need for additional flood control in the area.

The best solution to flood problems in the upper Sacramento River Basin would be a carefully integrated complex of reservoir projects, levee and bypass systems, channel maintenance, and floodplain management.

The upper Sacramento River Basin suffers average annual flood damages of nearly $2,000,000. Reservoir projects on tributary streams can significantly reduce these damages and conserve water for beneficial use. Several tributary projects appear to be suitable for construction either now or in the near future. They are Paskenta-Newville on Thomes Creek; Cottonwood Creek Projects, consisting of either two large reservoirs (Dutch Gulch and Farquhar School) or a series of at least four smaller reservoirs (Hulen, Dippingvat, Rosewood, and Fiddlers); Millville on South Cow Creek; Wing on Inks Creek; Deer Creek Meadows in the upper Deer Creek area; and Jonesville on upper Butte Creek.

The tributary reservoir projects studied during this investigation are not justified for flood control alone. They must be formulated as multiple-purpose projects, and usually demands for additional water supplies will determine the timing of these projects.

FIGURE I



UPPER SACRAMENTO RIVER BASIN INVESTIGATION
LOCATION MAP SHOWING STUDY AREAS
SCALE OF MILES
4 0 4 8
BULLETIN NO. 150 STUDY AREA
BULLETIN NO.150-1 STUDY AREA
SHASTA
TEHAMA
GLENN
BUTTE
SHASTA LAKE
KESWICK RES.
WHISKEYTOWN RES.
BLACK BUTTE RES.
STONY GORGE RES.
EAST PARK RES.
BUTTE BASIN
SACRAMENTO
RIVER
Weaverville
Eureka
Wood
Burney
Redding
Palo Cedro
Millville
Anderson
Cottonwood
Red Bluff
Los Molinos
Corning
Chico
Chico Landing
Ord Ferry
Willows
Colusa
Woodland
Yuba City
Lassen Park
Susanville
299
36
44
5
99
32
Middle
Beegum
Cr.
Fork
North
Fork
Cottonwood
Dry
Cr.
Cold
Fk.
South
Fork
Clear
Cr.
Cow Cr.
Oak Run
Clover
Old Cow
South Cow
Creek
Little
Cow Cr.
Battle
Creek
Paynes
Antelope
Cr.
Elder
Cr.
Thomes
Creek
Mill
Creek
Deer
Creek
Stony
Creek
Big Chico Cr.
Little Chico Cr.
Butte

CHAPTER I. INTRODUCTION

Previous plans for flood control in the Upper Sacramento River Basin included the Iron Canyon Project as a major flood control feature. One of the findings of the Bulletin No. 150 studies completed in 1964 was that the Iron Canyon Project is not economically justified under present economic conditions. This fact, and the floods of December 1964, demonstrated the need for an up-to-date flood control plan for the Upper Sacramento River Basin. The 1964 floods also pointed out that flood control benefits on the tributary streams and in the Butte Basin may be much larger than had been previously estimated. Consequently, flood control storage reservation that was found to be unjustified in some of the tributary projects during the studies for Bulletin No. 150 now shows economic justification.

The 1966 Legislature recognized this fact and passed Assembly Concurrent Resolution No. 18.

Assembly Concurrent Resolution No. 18--Relating to a supplementary study by the Department of Water Resources of certain potential multipurpose water projects on the tributaries of the upper Sacramento River.

WHEREAS, Floods in recent years have caused severe damage and loss of property along the tributaries of the upper Sacramento River; and

WHEREAS, Development of these tributaries could provide unparalleled opportunities for recreation and fish and wildlife enhancement; and

WHEREAS, There is an urgent need to refine and upgrade Bulletin 150 issued by the Department of Water Resources (an earlier study of these tributaries), to take into consideration benefits for flood control for the entire upper Sacramento River area; now, therefore, be it

RESOLVED by the Assembly of the State of California, the Senate thereof concurring, That the Department of Water Resources is requested to undertake a finalized economic and financial evaluation of the following potential multipurpose water projects on the tributaries of the upper Sacramento River: Paskenta-Newville Dam and Reservoir (Thomes Creek); Hulen and Dippingvat Dams and Reservoirs (Cottonwood Creek); Deer Creek Meadows Dam and Reservoir; and Millville Dam and Reservoir (Cow Creek); and report thereon to the Legislature by the second day of the 1968 Regular (Budget) Session; and be it further

RESOLVED, That the Chief Clerk of the Assembly is directed to transmit a copy of this resolution to the Director of the Department of Water Resources.

The study area for Bulletin No. 150 was limited to the Sacramento River Basin between Shasta Dam and Red Bluff and the Thomes Creek drainage basin above Paskenta. Since Assembly Concurrent Resolution No. 18 stated that flood control benefits for the entire upper Sacramento River area should be considered, the study area has been extended to include all of the basin between Shasta Dam and Colusa. These areas are shown in Figure 1.

Scope and Objectives of Investigation

Assembly Concurrent Resolution No. 18 requested the Department to " ... undertake a finalized economic and financial evaluation ... " of the five projects mentioned. A finalized evaluation would include a repayment schedule, an indication of the ability of users of the water supplies to repay the costs, and sources of funding and methods of financing. However, due to the complex nature of the problems involved, such a complete evaluation was not possible within the time and funding available. This report merely updates planning for the specific projects mentioned in ACR 18. Studies for this report have used flood control information collected since the 1964 flood and attempted to incorporate flood control storage in the proposed reservoirs wherever practical.

To adequately evaluate the flood control benefits for the upper Sacramento River area, it is necessary to consider the potential of all of the tributaries for controlling floods. This report presents a reconnaissance evaluation of the flood control potential of various individual developments on the tributaries and presents guidelines for a reduction in flood damages within the basin. These flood control evaluations are based upon preliminary data and future studies may result in different flood control storage requirements and benefits.

Therefore, this report has two main objectives: A reevaluation of the projects listed in ACR 18 and a reconnaissance appraisal of the potential for controlling floods and reducing damages. The remainder of this chapter describes past studies and projects in the basin and related current planning investigations. Chapter II describes the flood problems within the basin and Chapter III discusses the effects of flood control measures on the basin. The specific project reevaluations asked for in ACR 18 are presented in Chapter IV. The conclusions and recommendations are given in Chapter V.

Historical Background

As early as the winter of 1849-50, control of floodflows was recognized as essential to the development of the State of California. However, it wasn't until the appointment of William Ham Hall as State Engineer in 1878 that any constructive engineering data were assembled on flood control. His report to the Legislature in 1880 recognized the place of flood bypasses in a flood control plan for the Sacramento River. Mardsen Manson and C. E. Grunsky, consultants of the Commissioner of Public Works, in 1894 proposed a bypass plan similar to the present Sacramento River Flood Control Project.

In February and March 1904, notable flooding took place in the Sacramento Valley. As a result, the Dabney Commission was appointed by the Commissioner of Public Works. This Commission, composed of private engineers, made its report in December 1904. Their plan proposed a single-channel project with a maximum capacity of about 250,000 cubic feet per second (cfs) at the mouth of the Sacramento River. The leveed main channel was to have a capacity of 163,000 cfs near Colusa. However, before any action could be taken, the storms of March 1907 produced a flood of greater than 250,000 cfs at Chico Landing and demonstrated the inadequacy of the plan.

Also in 1904, a preliminary investigation of the Sacramento River area was begun by the U. S. Reclamation Service (now the United States Bureau of Reclamation) to determine service areas and potential requirements for the conservation of water. Preliminary investigations of the Iron Canyon damsite above Red Bluff were begun.

In 1910, the Debris Commission of the United States War Department (now the U. S. Army Corps of Engineers) produced the Jackson Report, which was adopted by the California Legislature in 1911. This report proposed dredging the Sacramento River below Cache Slough; channel improvements from Cache Slough to Sacramento for a 100,000-cfs flow; and construction of Moulton Weir to allow 185,000 cfs to pass through Butte Basin, the Sutter-Butte Bypass, the Sacramento Weir and Bypass, the Fremont Weir and Yolo Bypass, and the Tisdale Weir and Bypass. It also proposed improving the channel above Moulton Weir and setting back the existing levees. The design flow of the leveed river channel was to be 260,000 cfs from Moulton Weir to Chico Landing.

No work was undertaken in the Butte Basin area under the plan presented in the Jackson report. However, local interests financed considerable work in the other areas. As a result, some valley lands became burdened with debt in excess of their value and it became apparent that greater federal and state participation would be required. This condition led to a modified version of the Jackson Report called the "Grant Report", the name applied to Senate Document 23 of the 69th Congress, First Session.

The Grant Report proposed that the Federal Government, State Government, and local interests each pay one-third of the total cost of the Sacramento River flood control works. In 1925, the State of California approved the Grant Report. At that time, local interests had expended or obligated about $24,000,000 on project work. The Grant Report was incorporated into the federal Flood Control Act of May 15, 1928, and authorized federal participation in the amount of $17,600,000, or one-third of the then estimated total cost of the proposed flood control works. In addition to joint financing, the Grant Report also stipulated that the Butte Basin flood control works be eliminated.

In October 1914, the U. S. Reclamation Service presented its findings on the Iron Canyon Project for various reservoir sizes up to a maximum capacity of 709,000 acre-feet. This study was continued and in 1920 the Service proposed an Iron Canyon Reservoir with 961,000 acre-feet capacity; 640,000 acre-feet would be for conservation storage and the rest for flood control and power. A third report on the Iron Canyon Project, presented in 1925, proposed a still larger reservoir of 1,122,000 acre-feet.

The Department's predecessor agency, the Division of Water Resources of the State Department of Public Works published Bulletins Nos. 13, 25, and 26 in 1928, 1930, and 1931, respectively, which dealt with this area of study. Bulletin No. 13 presented plans for Kennett Reservoir (Shasta) and Iron Canyon Reservoir as part of its preliminary comprehensive plan for flood control in the Sacramento Valley. Bulletins Nos. 25 and 26 expressed serious doubts about the foundation geology of the Iron Canyon Dam site. Also, Bulletin No. 26 proposed that flood control for Butte Basin not be included in the adopted Sacramento River Flood Control Project (levee system) since costs would be greater than benefits.

Development of the Sacramento River Flood Control Project was continued in accordance with the Grant Report plan, and the Butte Basin continued to function as a natural reservoir for the reduction of floodflows at the head of Sutter Bypass. New federal policy was developed in the Omnibus Flood Control Act of 1936. By this legislation, all future construction costs for flood control projects were to be borne by the Federal Government, with the costs of acquisition of rights-of-way and flowage easements and relocation of improvements remaining a local obligation.

In 1938, construction of Shasta Dam as a feature of the authorized Central Valley Project had been undertaken by the U. S. Bureau of Reclamation with flood control storage to be made available in Shasta Lake. This storage would have a very marked effect on the magnitude of floodflows in the upper Sacramento River and particularly in the Butte Basin.

The floods of December 1937, February 1940, and February 1942 appreciably exceeded the project design flood of 260,000 cfs at Chico Landing. The volume of water discharged overbank into Butte Basin in excess of the 100,000 cfs contemplated in the Grant Report caused damage to crops, livestock, and improvements to such a degree that local interests in the upper Butte Basin started construction of a river levee to prevent the overflow. However, the State Reclamation Board was successful in legal proceedings to enjoin such construction.

The Flood Control Act of December 22, 1944, secured congressional authorization for the Iron Canyon Project. The final designs and specifications were never completed, however, and no money was approved for the project.

The Corps of Engineers and the Bureau of Reclamation coordinated their 1945 flood control and water supply plans for the Central Valley. On February 1, 1945, the Corps of Engineers, in a report titled "Comprehensive Flood Control Survey Report on the Sacramento-San Joaquin Basin Streams, California", presented a plan for the upper Sacramento Valley and Butte Basin. The Bureau's studies are published in Senate Document 113, 81st Congress, First Session. The document includes a finding that tributary storage was more costly than Iron Canyon storage.

In 1948 the California State Water Resources Board prepared a report titled "Alternative Plans for Control of Floods in Upper Sacramento Valley". This report recommended the deferral of the Iron Canyon or alternative storage systems to a later date. It also showed that storage on the tributaries solely for flood control was not economical. The Corps of Engineers published an office memorandum in 1951 titled "Sacramento River, California -- Reclamation of Butte Basin". This report described the physical features of an overall plan for the progressive reclamation and flood protection of the Butte Basin.

Bulletin No. 3, "The California Water Plan", published in 1957, included the Iron Canyon Project as well as several tributary reservoirs for ultimate development of the upper Sacramento River Basin.

By Assembly Resolution, the Department of Water Resources was requested to investigate the possible development of specific storage sites in the basin. The study began in 1958 and was concluded in 1964 with the publication of Bulletin No. 150, "Upper Sacramento River Basin Investigation", in March 1965. This report showed that four tributary projects were economically justified and that, under current conditions, the Iron Canyon Project was not. The study now being reported upon is a 2-year extension of this investigation.

Related Investigations

In addition to this study, several related investigations are in progress. These are being conducted by the U. S. Army Corps of Engineers, the U. S. Bureau of Reclamation, and the State Department of Water Resources.

An important step in water resources planning coordination was taken on September 1, 1966, with the signing of an interagency agreement regarding the Sacramento River Basin. This agreement assigned primary responsibility for developing feasibility-level plans for the Paskenta-Newville Project on Thomes and North Fork Stony Creeks to the Bureau of Reclamation, Cottonwood Creek to the Corps of Engineers, and the Rancheria Project on Stony Creek to the Department of Water Resources. The Department was also assigned the responsibility of developing an overall master plan. A copy of this agreement appears as Appendix A to this report. This division of responsibility has been reflected in the studies leading to this report.

The Corps of Engineers, under its Northern California Streams Study, is currently studying the upper Sacramento tributaries. In addition to the final report on this investigation, an interim report has been scheduled for the Cottonwood Creek Basin.

The Bureau of Reclamation is completing a report on the feasibility of the Paskenta-Newville Project. The Bureau also is investigating plans for development of the lower Trinity River which would involve importation of water to the upper Sacramento Valley. In addition, the Bureau is making a study of possible developments on the Sacramento Valley east side streams.

The Department of Water Resources is studying possible conveyance systems for Trinity River water along the west side of the Sacramento

Valley. This study is scheduled for completion in July 1970. Also, an advance planning program is underway on the importation of Middle Fork Eel River water to the Sacramento Valley. Under the Department's Coordinated Statewide Planning Program, there is a continuing preparation and refinement of statewide water demands and plans for meeting those demands. These studies were recently completed for the Sacramento Valley floor.

CHAPTER II. FLOOD PROBLEMS

The Sacramento River Basin has been subjected to many severe floods during this century. Disastrous floods also occurred prior to 1900 but very little is known about them. The first stream gaging station on the Sacramento River was established near Red Bluff in 1895. Early in the 1900's, stations were added on Stony, Mill, and Deer Creeks. In the 1920's, stations were added on Thomes Creek and the Sacramento River near Kennett. By 1940 nearly every major stream had been gaged at strategic locations.

Historic Floods and Damages

Shasta Dam, completed in 1945, has played a major role in the reduction of flood peaks along the Sacramento River. The operating criteria require that Shasta Dam be operated, insofar as possible, to limit Sacramento River flows at Red Bluff to 100,000 cfs and at Ord Ferry to 130,000 cfs. Flow data since 1945 indicates that it is not always possible to achieve this objective, and that additional storage on the tributaries below Shasta will be necessary to meet these criteria.

Table 1 shows the estimated effect that Shasta Dam has had, or would have had, on the most severe floods that have occurred on the Sacramento River since 1900. Examination of this table will show that Shasta had had a varying effect on these floods; the amount of the reduction depends upon the location of the storm center. For instance, though the 1958 and 1964 floods produced approximately the same peak flow at Ord Ferry, Shasta Dam reduced the 1964 flood by approximately 120,000 cfs and the 1958 flood was reduced by only 40,000 cfs.

TABLE 1
ESTIMATED EFFECTS OF SHASTA DAM ON SACRAMENTO RIVER FLOOD PEAKS
(cubic feet per second)

Date	Inflow to Shasta*	Release during peak inflow to Shasta	Reductions in peak flood flows with Shasta Dam	
			At Red Bluff	At Ord Ferry
Dec. 1937	132,000	5,000**	70,000	50,000
Feb. 1940	182,000	10,000**	140,000	115,000
Dec. 1955	201,000	3,000	140,000	120,000
Feb. 1958	116,000	12,000	65,000	40,000
Dec. 1964	187,000	6,000	150,000	120,000

* 1937 and 1940 flows are those recorded at Sacramento River at Kennett.
**Estimated release had Shasta been operating.

The estimated effects of Shasta Dam on the flood peaks shown in Table 1 are different from those found in many state and federal reports. Earlier estimates were based upon a less detailed accounting of the differences in timing of tributary flood peaks or the effects of channel storage on flood routing. The estimates presented in Table 1 reflect these factors as analyzed by the Department of Water Resources. The following paragraphs describe three recent floods in the upper Sacramento River Basin.

The December 1955 storm precipitation was extremely heavy in the basin above Shasta Dam and in the adjacent Feather River Basin. Shasta Dam controlled a record peak inflow to almost negligible outflow during the height of the storm. It is estimated that without Shasta Dam the peak flow at Ord Ferry would have been nearly 300,000 cfs. The key to Shasta's success was the location of the storm center above Shasta. Damages within the upper Sacramento River Basin were limited mainly to agricultural lands along the Sacramento River, lands along the tributaries, and lands within Butte Basin.

The February 1958 flood produced the largest peak flow at Ord Ferry since the construction of Shasta Dam. The storm produced heavy rainfall over the entire area during most of February. Heavy runoff occurred on the valley floor areas. Only a few gaging stations recorded record peak runoffs. It is estimated that without Shasta Dam the peak flow at Ord Ferry would have been in the magnitude of 275,000 cfs. Shasta was much less effective in 1958 than in 1955, the reason being the general widespread nature of the 1958 storm. A significant feature of the 1958 flood was the prolonged high stage. Damages in the upper Sacramento River Basin in the 1958 flood were higher than in 1955. However, as in 1955, the damage was primarily limited to agricultural lands along the Sacramento River, along tributaries, and in Butte Basin. Over 115,000 acres were flooded in Butte Basin alone.

The rains of December 1964 were typical of the patterns which usually occur during major floods in the Sacramento Basin. Being the most recent flood, it will be discussed in more detail. This flood was characterized by extremely heavy precipitation in the mountains above Shasta and on the west side of the valley. Many of the west side tributaries experienced record peaks. Inflow to Shasta Lake was the second highest ever recorded. This storm produced a peak floodflow of 170,000 cfs at Red Bluff. It is estimated that without Shasta Dam the peak flow would have been over 300,000 cfs. Thus, as in 1955, Shasta was very effective in reducing flood stages along the Sacramento River. Table 2 shows the peak flows at various gaging stations within the basin. Also shown are the highest recorded peaks previous to 1964.

The floods of late December were followed on January 5 by an intense local storm which crossed the Sacramento Valley north of Red Bluff. It caused record-breaking runoff on several minor tributaries on both sides of the Sacramento River.

TABLE 2

PEAK FLOWS DURING DECEMBER 1964

Gaging Station	Peak Flow (cfs)	Date	Maximum Previous Peak Flow (cfs)	Peak Date
Clear Creek near Igo	9,940 cfs	12/22 1/	24,500 cfs	12/21/55
Cottonwood Creek near Cottonwood	60,000	12/22	52,300	3/1/41
Red Bank Creek near Red Bluff	3,840	12/22 2/	5,770	1/31/63
Elder Creek at Gerber	11,700	12/22 2/	11,000	2/19/58
Thomes Creek at Paskenta	37,800	12/22	23,500	12/21/55
Stony Creek				
Inflow to Black Butte	47,000	12/23	36,300	2/24/58
near Hamilton City	18,700	12/24 3/	39,900	2/25/58
Cow Creek near Millville	30,300	12/22 2/	45,200	12/27/51
Bear Creek near Millville	2,500	12/22 2/	3,140	12/1/61
Battle Creek near Cottonwood	9,900	12/22	35,000 est.	12/11/37
Paynes Creek near Red Bluff	4,900	12/22 2/	10,600	12/1/61
Antelope Creek near Red Bluff	8,990	12/22	17,500 est.	12/11/37
Mill Creek near Los Molinos	16,000	12/22	23,000 est.	12/11/37
Deer Creek near Vina	18,800	12/22	23,800 est.	12/10/37
Big Chico Creek near Chico	8,700	12/21 2/	8,300	12/10/37
Butte Creek near Chico	21,000	12/22	18,700	12/22/55

1/ Controlled by Whiskeytown Reservoir since 1963.
2/ Higher peaks were recorded on January 5, 1965.
3/ Controlled by Black Butte Reservoir since 1963.

The greatest damages suffered in the study area were along Thomes and Cottonwood Creeks and along the Sacramento River. Table 3 shows the areas flooded during these floods and the damages suffered.1/ The table shows that the residential damages incurred during these floods were comparatively small, $143,000. This indicates that present residential development in the floodplain is limited and that now is the time to develop floodplain management ordinances to limit urban encroachment.

TABLE 3

FLOODED AREA AND FLOOD DAMAGE
DECEMBER 1964 - JANUARY 1965

Stream and reach	Area flooded (Acres)	Primary flood damage ($1,000) Agricultural	Residential	Commercial	Industry & utilities	Public facilities	To[illegible]
Sacramento River Basin below Shasta Dam							
Sacramento River							
Shasta Dam to Red Bluff	-	6	0	2	15	328	
Red Bluff to Chico Landing	38,600	1,097	34	262	12	705	2,
Chico Landing to Colusa	5,000	220	0	8	10	242	
Total, Sacramento River Basin - Shasta Dam to Colusa	43,600	1,323	34	272	37	1,275	2,
Redding Stream Group							
Cottonwood Creek	4,400	323	0	0	15	413	
Battle Creek	700	43	5	0	13	264	
Churn Creek	730	29	53	0	0	139	
Olney Creek	-	0	0	0	0	98	
Oregon Gulch	5	0	13	11	0	22	
Miscellaneous streams	40	4	0	0	4	132	
Total, Redding Stream Group	5,875	399	71	11	32	1,068	1,
Stony Creek Basin							
Stony Creek							
Above Stony Gorge Dam	1,780	78	0	0	0	323	
Stony Gorge Dam to Black Butte Dam	530	10	0	0	0	102	
Below Black Butte Dam	820	6	0	0	6	117	
Total, Stony Creek Basin	3,130	94	0	0	6	542	
Middle Sacramento River Tributaries, East Side							
Big Chico & Mud Creeks and Sandy Gulch	-	0	0	0	11	191	
Deer Creek	700	50	0	0	11	273	
Mill Creek	90	3	0	42	0	202	
Antelope Creek Group	1,040	36	0	0	0	88	
Total, Middle Sacramento River Tributaries, East Side	1,830	89	0	42	22	754	
Middle Sacramento River Tributaries, West Side							
Thomes Creek							
Above Paskenta	-	0	0	0	110	161	
Paskenta to Henleyville	2,470	135	9	0	49	333	
Henleyville to Sacramento River	5,790	671	27	18	285	532	1,
Subtotal, Thomes Creek	8,260	806	36	18	444	1,026	2,
Elder Creek	793	25	0	0	11	101	
Miscellaneous Creeks	712	28	2	0	0	132	
Total, Middle Sacramento River Tributaries, West Side	9,765	859	38	18	455	1,259	2,[illegible]
Butte Basin Area							
Upper Butte Basin	62,000	584	0	0	0	23	
Lower Butte Basin	38,000	224	0	6	0	53	
Butte Creek	400	19	0	0	61	16	
Cherokee Canal	-	0	0	0	0	75	
Total, Butte Basin Area	100,400	827	0	6	61	167	1,[illegible]
Total Upper Sacramento River Basin	164,600	3,591	143	349	613	5,065	9,[illegible]

1/ From "Report on Floods of December 1964 - January 1965" Sacramento-San Joaquin Basins, California and Western Great Basin, California and Nevada, Sacramento District, Corps of Engineers. October 1965.

Agricultural damages generally consisted of losses of crops, livestock, feed supplies, trees, and lands through erosion, and the costs of releveling land, repairing fences, roads, and irrigation facilities, and removing silt and debris from farmlands. Residential losses consisted of costs of repairing and cleaning flooded homes, replacing damaged furnishings, and rehabilitating wells and septic tanks. Commercial losses included damages to permanent structures in parks and fishing resorts, losses of stocks, equipment, and business, and costs of cleanup. Industrial and utility damages consisted of the costs of repairing damaged railroad, power, and telephone equipment, and replacing damaged supplies. Public facility damages consisted of the costs of repairing damaged streets, roads, bridges, canals, levees, recreation areas, and diversion dams, and the costs of clearing channels and fighting the flood.

Flood Hydrology

The previous section has shown that Shasta Dam has been extremely effective in controlling some floods while only partially effective in others. Reservoirs on tributary streams will also have varying effects on floods. Because of their location, drainage area, and the location of the storm center, each tributary will vary in its contribution to flood peaks in the Sacramento River. This section will discuss some of the factors that affect the flood hydrology of the upper Sacramento River Basin.

Floodflows within the tributary basins are functions of the rainfall, drainage area, and runoff characteristics. Based upon the data presented in Table 2 (page 9), the creeks producing the largest peak floodflows within their individual basins are ranked in order of magnitude:

(1) Cottonwood Creek
(2) Stony Creek
(3) Cow Creek
(4) Thomes Creek
(5) Battle Creek
(6) Clear Creek
(7) Deer Creek
(8) Mill Creek
(9) Butte Creek
(10) Antelope Creek
(11) Elder Creek
(12) Paynes Creek
(13) Red Bank Creek
(14) Big Chico Creek
(15) Bear Creek

The damages suffered during a major flood are dependent upon the channel capacity, the level of development of the basin, the existing flood protective measures, and other factors.

The flood hydrology of the basin becomes more complicated as the tributaries are combined into the Sacramento River. Prior to the construction of Shasta Dam, the main Sacramento River flood peak was formed above Shasta during most storms. Since the construction of Shasta, this flood peak is usually generated in the tributaries that lie between Redding and Red Bluff. The flood peaks from the tributaries below Red Bluff usually enter the Sacramento River before the upstream peak arrives. Consequently, these tributaries have a lesser effect on the main Sacramento River flood peaks. Table 4 shows the approximate number of hours that the individual tributaries crest before the main Sacramento River peak arrives from upstream during a typical storm.

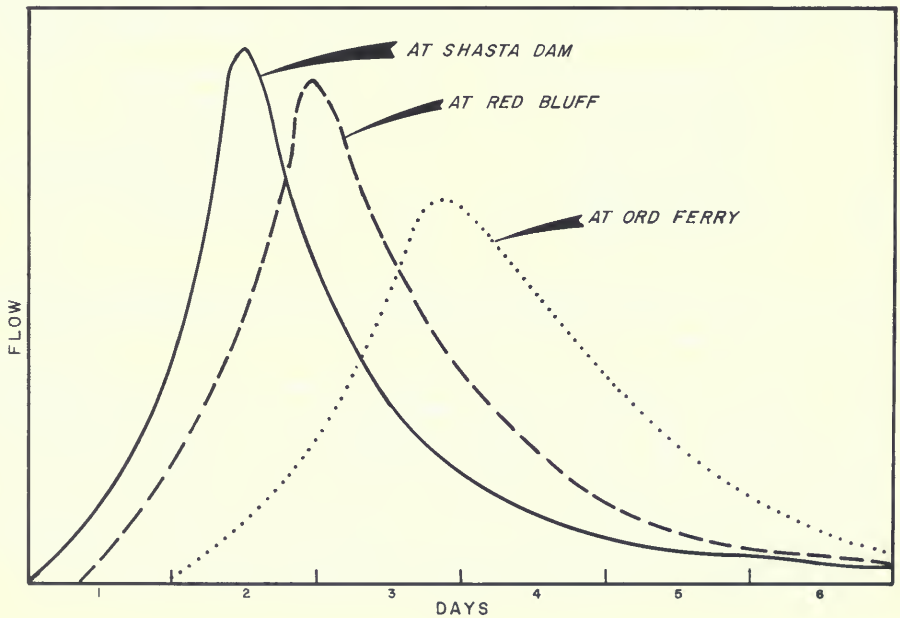
TABLE 4
TIME DISTRIBUTION OF TRIBUTARY FLOOD PEAKS

Tributary	Number of Hours Tributary Peaks Before Sacramento River Peaks
Cottonwood, Cow, Battle, Clear	0
Bear, Paynes	2
Antelope, Red Bank	8
Elder, Thomes, Deer, Mill	14
Stony Creek	12
Big Chico Creek	18

It must be emphasized that these estimates are based on average conditions and that for certain floods they may be quite different.

Another factor which has a significant effect on floodflows is the routing effect. As the flow in a channel increases, the stage also increases and with it the volume of water in temporary storage in the channel. As a result, a flood wave moving down a channel has its time base lengthened and its crest lowered. This effect is shown schematically in Figure 2.

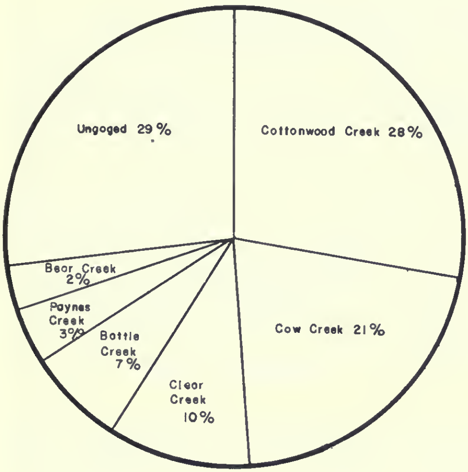
FIGURE 2
EFFECTS OF CHANNEL STORAGE ON A TYPICAL SACRAMENTO RIVER FLOOD



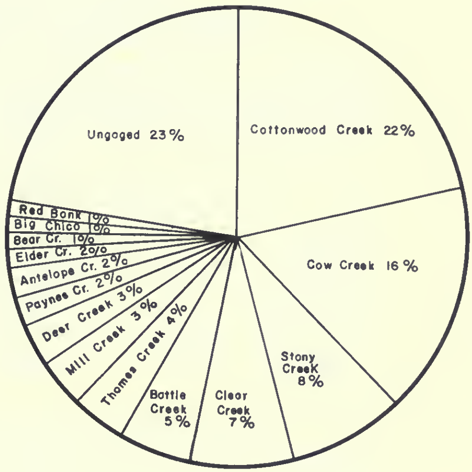
Each of the previously mentioned factors affects floodflows in the Sacramento River Basin. An analysis of historical data and the routing of floodflows through the basin shows the relative effect of the different tributaries on the Sacramento River flows. The effect of each of the major tributaries is shown below in the pie charts. It must again be emphasized that the conditions presented here are average conditions and considerable variations may occur, depending upon the particular storm.

Contributions of Tributary Streams to
Peak Flows At:

Red Bluff



Ord Ferry



It is obvious that Cottonwood Creek and Cow Creek are the largest individual contributors to floodflows in the Sacramento River that originate below Shasta Dam. The ungaged areas also provide a substantial portion of the peak floodflows. It may never be practical to control the runoff from much of these ungaged areas. Each of the remaining tributaries add a small portion of the peak floodflows. Though individually they appear unimportant, together they comprise over 25 percent of the peak runoff during a normal storm. Localized storm patterns can push this percentage much higher.

Flood Frequencies

The maximum recorded floods are often used in the design of flood control works, in the derivation of floodplain management ordinances, and in discussions of flood problems. Of importance, but not commonly understood, is the probability of this event occurring again. Normally one would not expect the damaging floods of 1964 to occur again in the near future. But statistically, a flood of this magnitude is just as likely to occur this year as it was in 1964.

Frequency curves are used to determine the probability that a given flow will be exceeded. These curves are based upon recorded flows, and their accuracy is dependent upon the number of years of record. Most records in the Sacramento Valley are 20 to 50 years in length.

In the discussion of flood frequencies, the term 1-in-50-year flood or 1-in-10-year flood is often mentioned. These terms refer to the probability of a given flow being exceeded. Over a long period of time, a 1-in-50-year flood is a flow which will be equalled or exceeded on the average of once every 50 years. During a 500-year period, for instance, a 1-in-50-year flow will be equalled or exceeded approximately 10 times.

Flood frequency curves are used in determining the amount of flood control reservation needed in a reservoir, in estimating the severity of a particular flood, in determining the need for flood control protective works, in sizing levees and flood bypasses, and in calculating average annual flood damages. Several different techniques are available for developing flood frequency curves. The results of these different methods are largely dependent upon the length of the record of floodflows, the accuracy of the data, and interpretation of the abnormal events within the record.

There are two basic methods in developing flood frequency curves -- graphical and analytical. Each of these basic methods has several variations. The graphical methods generally consist of arranging observed values in the order of magnitude and fitting a curve to the plotted values. The analytical methods involve a derivation of general statistics from the available data on the average magnitude of floods and the variability from that average.

Analytical methods, as outlined by Beard in "Statistical Methods in Hydrology",1/ have been used to develop the frequency curves used during this investigation. At locations where the recorded data was short or nonexistent, methods described by Beard were used to develop the frequency curves.

1/ Beard, Leo R. "Statistical Methods in Hydrology", U. S. Army Engineer District, Corps of Engineers, January 1962.

Annual Flood Damages

In the analysis of flood control projects, it is necessary to determine average annual flood damages. Preliminary flow-damage curves for this investigation have been provided by the Sacramento District, U. S. Army Corps of Engineers. The damage curves, together with frequency curves, are used to determine the average annual flood damages. These damages, as calculated by the Department of Water Resources, are given in Table 5 for the major tributaries and for different reaches of the Sacramento River. Also included in that table are the estimated non-damaging channel capacities where applicable.

TABLE 5

ESTIMATED AVERAGE ANNUAL FLOOD DAMAGES
FOR SACRAMENTO RIVER, BUTTE BASIN, AND MAJOR TRIBUTARIES
(Based upon 1968 conditions)

Reach	Estimated Non-Damaging Channel Capacity (cfs)	Average Annual Flood Damages (Dollars)
Sacramento River		
Keswick to Cottonwood Creek	55,000	8,000
Cottonwood Creek to Tehama	85,000	55,000
Tehama to Chico Landing	70,000	220,000
Chico Landing to Colusa	70,000	175,000
Upper and Middle Butte Basin	---	365,000
Lower Butte Basin	---	200,000±
Cottonwood Creek	15,000	115,000
Elder Creek	17,000	40,000
Thomes Creek	5,000	270,000
Cow Creek	16,000	100,000
Battle Creek	1,500	150,000
Antelope Creek	4,000	55,000
Mill Creek	8,000	40,000
Deer Creek	21,000	50,000
Butte Creek	22,000	30,000
Total		1,873,000

Table 5 shows that the estimated average annual flood damage in the upper Sacramento River Basin amounts to nearly $2,000,000 under 1968 conditions for the Sacramento River, Butte Basin, and the major tributaries. These damages are mostly agricultural, with only a limited amount of urban damages. Many areas along the Sacramento River and its tributaries are subjected to some damages nearly every year because channel capacities are exceeded at relatively low flows.

These annual flood damages will increase as land values increase, more productive crops are grown, and land uses change. Effective and meaningful floodplain management ordinances can reduce urban encroachments upon the floodplain lands and significantly reduce potential future flood damages.

Tributary Flood Storage Requirements

Flood control measures consisting of tributary reservoir storage, levees, channels, and floodplain management can significantly reduce flood damages within the upper Sacramento River Basin. Flood control storage on tributary streams can serve two purposes: (1) control flows to non-damaging levels within the tributary basin, and (2) reduce peak flows in the Sacramento River. Table 6 gives the approximate amount of flood control storage necessary to control 1-in-50-year floodflows within the individual basin to the specified discharges at the mouth of the stream. Protection against a 1-in-50-year flood appears to be an acceptable level of protection for areas having limited urban developments. Most of the upper Sacramento River tributaries fall in this category. Since the table values do not pertain to any particular reservoir, they will have to be modified as specific plans are developed for these tributaries.

TABLE 6

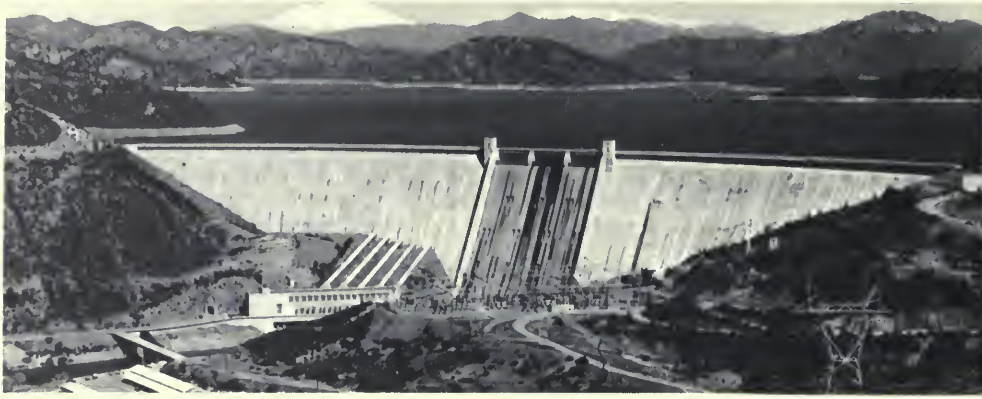
REQUIRED FLOOD CONTROL STORAGE TO
CONTROL 1-IN-50-YEAR LOCAL FLOWS AND REDUCE DOWNSTREAM FLOWS

Stream	Discharge (cfs)	Storage Necessary To Control Local Flows To Discharge Listed (Acre-feet)	Additional Storage To Obtain Reductions In Sacramento River Flows (Acre-feet)1/
Clear Creek	8,000	40,000	25,000
Cow Creek	16,000	40,000	50,000
Cottonwood Creek	15,000	305,000	50,000
Bear Creek	1,000	10,000	3,000
Battle Creek	1,500	70,000	4,000
Paynes Creek	1,000	14,000	3,000
Antelope Creek	4,000	12,000	15,000
Elder Creek	17,000	4,000	70,000
Mill Creek	8,000	9,000	30,000
Deer Creek	21,000	5,000	60,000
Thomes Creek	5,000	80,000	20,000
Butte Creek	22,000	0	---

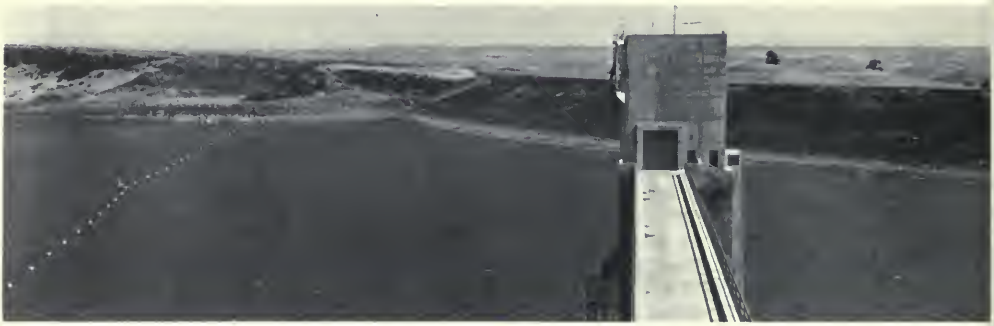
1/ These storage values are based on not allowing any release from the projects during a 1-to-2-day period, during a 1-in-50-year storm.

Reservoirs on these tributaries would affect the flows in the Sacramento River. Operation of these reservoirs would have to be coordinated with the uncontrolled runoff to produce the greatest reduction in peak flow. It would be necessary to hold releases to a minimum for 1 or 2 days to obtain maximum downstream benefits. The values presented in the right-hand column of Table 6 assume tributary reservoirs would be operated in this manner.

The accomplishments of providing flood control storage on each tributary are discussed in Chapter III as will other methods of reducing flood damages, such as floodplain management, levees, and flood bypass channels.



Shasta Dam and Reservoir



Black Butte Dam and Reservoir

Whiskeytown Dam

CHAPTER III. FLOOD CONTROL IN THE UPPER SACRAMENTO RIVER BASIN

As far back as the early 1900's, engineers sought to find adequate sites to construct dams to control floods along the Sacramento River. One of the first projects studied was Iron Canyon Reservoir near Red Bluff. However, geologic conditions eliminated the possibility of constructing a reservoir large enough to develop the full potential of the Sacramento River for irrigation, flood control, and power.

Late in the 1920's, a report by the State recommended that the Kennett site (now called Shasta) be developed initially. This reservoir became the backbone of the Bureau of Reclamation's Central Valley Project. Shortly after Shasta Dam was completed in 1945, the Corps of Engineers obtained authorization for a project at Iron Canyon. However, by this time the reservoir area of this project had become highly developed agriculturally. Because of local opposition, the authorized Iron Canyon Project became dormant. Further studies of Iron Canyon were completed by the Department of Water Resources in 1964, and the results printed in Bulletin No. 150 showed that Iron Canyon was now economically unjustified.

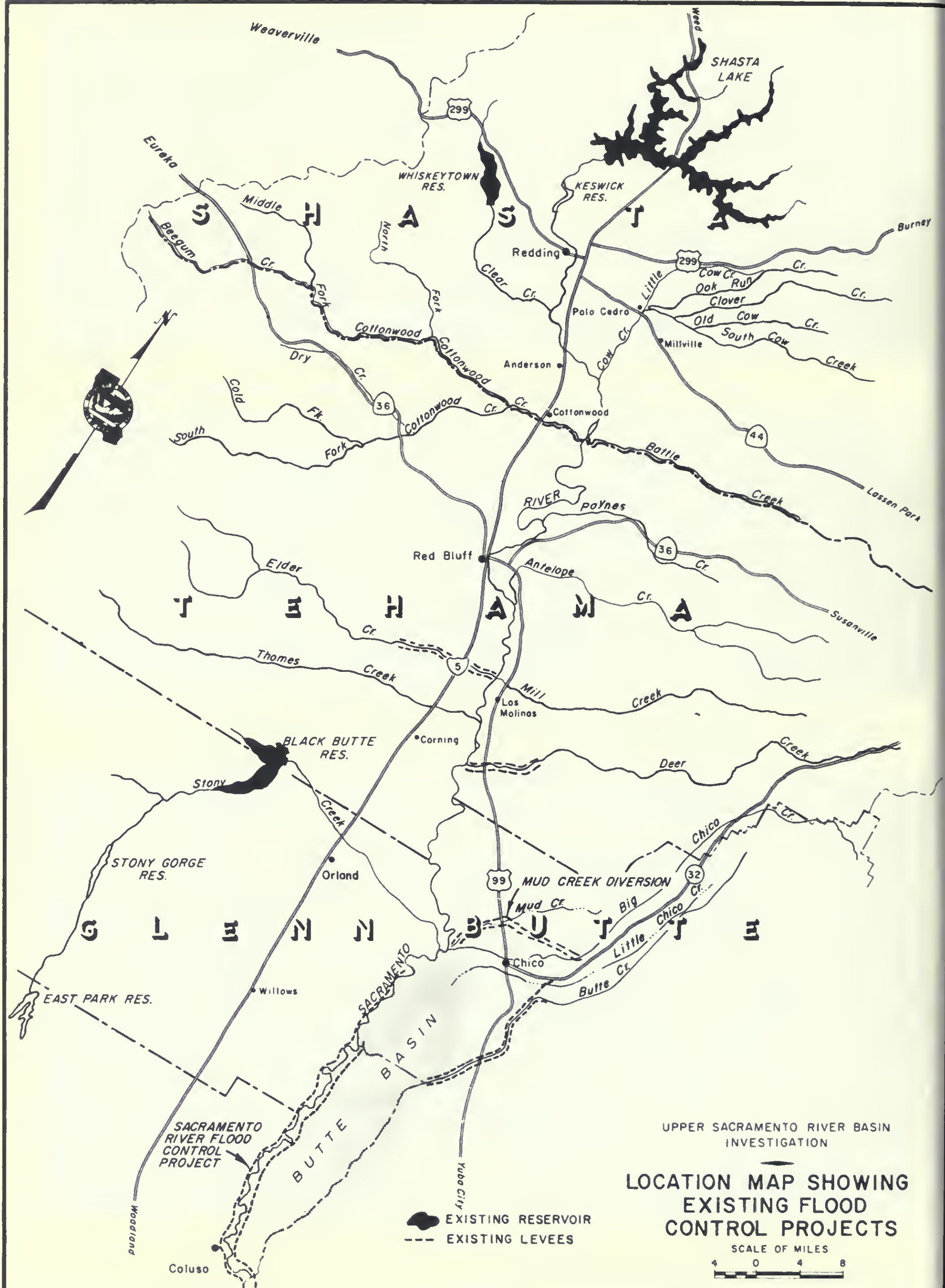
Since Iron Canyon had been the key feature of additional flood control plans for the Sacramento River Basin and changing conditions have brought floodplain management regulations into being, a new flood control plan is now necessary. This chapter presents a reconnaissance appraisal of flood control measures which could be used to reduce flooding and flood damages throughout the basin. Many projects have been studied on the tributary streams. Incorporation of flood control features into these reservoirs is a key to the development of additional flood control in the Sacramento River Basin.

Existing Developments

There are several multiple-purpose and single-purpose projects which presently provide flood protection in the upper Sacramento River Basin (see Figure 3). The largest of these is the 4.5 million acre-foot Shasta Lake, key feature of the Central Valley Project. One million three hundred thousand acre-feet of storage reservation is dedicated to flood control at Shasta. Chapter II demonstrated that this project has been extremely effective in reducing the peak flows at nearly all points downstream. Shasta releases are usually held very low during periods of high runoff. When the peak from the area downstream of Shasta has passed, releases from Shasta are increased to maintain the required flood control reservation.

The Black Butte Project was completed in 1963 by the Corps of Engineers to provide flood protection to Stony Creek and areas along the

FIGURE 3


Weaverville
Weed
SHASTA LAKE
299
Eureka
WHISKEYTOWN RES.
KESWICK RES.
S H A S T A
Middle
Beegum
Cr.
Fork
North
Fork
Redding
Burney
Clear
Cr.
Cow Cr.
Oak Run
Cr.
Little
Clover
Polo Cedro
Old Cow Cr.
South Cow
Millville
Creek
Cottonwood
Cottonwood
Dry
Cr.
Anderson
Cold
Fk.
36
Cottonwood
Cr.
Cr.
Cottonwood
Cow Cr.
44
South
Fork
Battle
Creek
Lassen Park
RIVER
Paynes
36
Cr.
Red Bluff
Antelope
Elder
Cr.
T E H A M A
Susanville
Cr.
Thomes
Creek
5
Mill
Creek
Los Molinos
BLACK BUTTE RES.
Corning
Creek
Deer
Stony
Creek
Chico
Cr.
STONY GORGE RES.
Orland
99
MUD CREEK DIVERSION
32
Mud Cr.
Big
Chico
Cr.
G L E N N
B U T T E
Little
Cr.
SACRAMENTO
Chico
Butte
EAST PARK RES.
Willows
BASIN
BUTTE
SACRAMENTO RIVER FLOOD CONTROL PROJECT
Woodland
Yuba City
Colusa
EXISTING RESERVOIR
EXISTING LEVEES
UPPER SACRAMENTO RIVER BASIN INVESTIGATION
LOCATION MAP SHOWING EXISTING FLOOD CONTROL PROJECTS
SCALE OF MILES
4 0 4 8

Sacramento River. The capacity of this reservoir is 160,000 acre-feet, of which 150,000 acre-feet is dedicated to flood control. Releases from Black Butte are limited to 15,000 cfs unless it becomes necessary to release additional water. The maximum release during the storm of December 1964 was 19,000 cfs. Only in extreme cases will the flows be allowed to reach 40,000 cfs because this would cause inundation of sections of Orland and Hamilton City.

Whiskeytown Reservoir on Clear Creek, completed in 1963, is part of the Bureau of Reclamation's Trinity River Division. It has a maximum capacity of 241,000 acre-feet and is used to reregulate Trinity River water for power generation in Spring Creek Powerhouse. Approximately 30,000 acre-feet of incidental flood control storage space is reserved during the winter.

The major flood control feature of the lower Sacramento River is the Sacramento River Flood Control Project. This project extends from below Chico Landing to Collinsville and is composed of a series of levees, weirs, and flood bypasses. The river channels are not capable of carrying the entire flow of the river so this project is designed to allow overflow into the Butte Basin, the Sutter Bypass, and the Yolo Bypass.

Local flood control projects have been constructed on several tributaries to the Sacramento River. However, none of the projects incorporate flood control storage. The Mud Creek Diversion Project diverts floodflows in Big Chico Creek away from the town of Chico and into the Mud Creek Flood Channel. Elder Creek has been leveed to pass floodflows past the town of Gerber and surrounding agricultural lands. Deer Creek is leveed to protect some agricultural lands. Butte Creek is leveed from the foothills to Butte Basin and Little Chico Creek is diverted into Butte Creek. These levee projects do not reduce the flows but tend to minimize the damages by passing flows away from population centers or containing them within levees.

Pacific Gas and Electric Company reservoirs on Battle Creek, Cow Creek, and Butte Creek are designed for hydroelectric power generation and only provide an incidental amount of flood control.

Proposed New Developments

Tributary reservoirs have been mentioned for years as flood control alternatives to storage on the main stream of the Sacramento River. However, storage is only one possible method of reducing flood damages. Levees, floodplain management, and flood bypasses are also important methods of reducing flood damage potential. Each of these methods is discussed in this chapter. Each major tributary, the Sacramento River, and the Butte Basin is discussed individually in the following sections.

Since the analyses presented in this report are based on preliminary data, it is possible that future studies may result in different total storages and in different storage requirements for the various project purposes. Changes may also occur in total project costs and the allocated costs to various purposes.

Cottonwood Creek

Cottonwood Creek is the largest remaining uncontrolled tributary between Ord Ferry and Shasta Dam. It accounts for approximately 25 percent of the mean annual runoff and 25 to 30 percent of the peak floodflows that originate between Shasta and Red Bluff. The mean annual runoff of Cottonwood Creek is about 550,000 acre-feet. A maximum peak discharge of 60,000 cfs was recorded in December of 1964.

Several possible projects have been considered for the development of Cottonwood Creek. These are shown on Figure 4. Bulletin No. 150 presented four projects, one on each main fork of Cottonwood Creek. Of these, Hulen, on the North Fork, and Dippingvat, on the South Fork, were shown to be economically justified projects. The Rosewood and Fiddlers Projects were not economically justified.

The Corps of Engineers is completing interim studies of Cottonwood Creek and has selected two projects for detailed evaluation. These are Dutch Gulch on the main stem and Farquhar School on the South Fork.

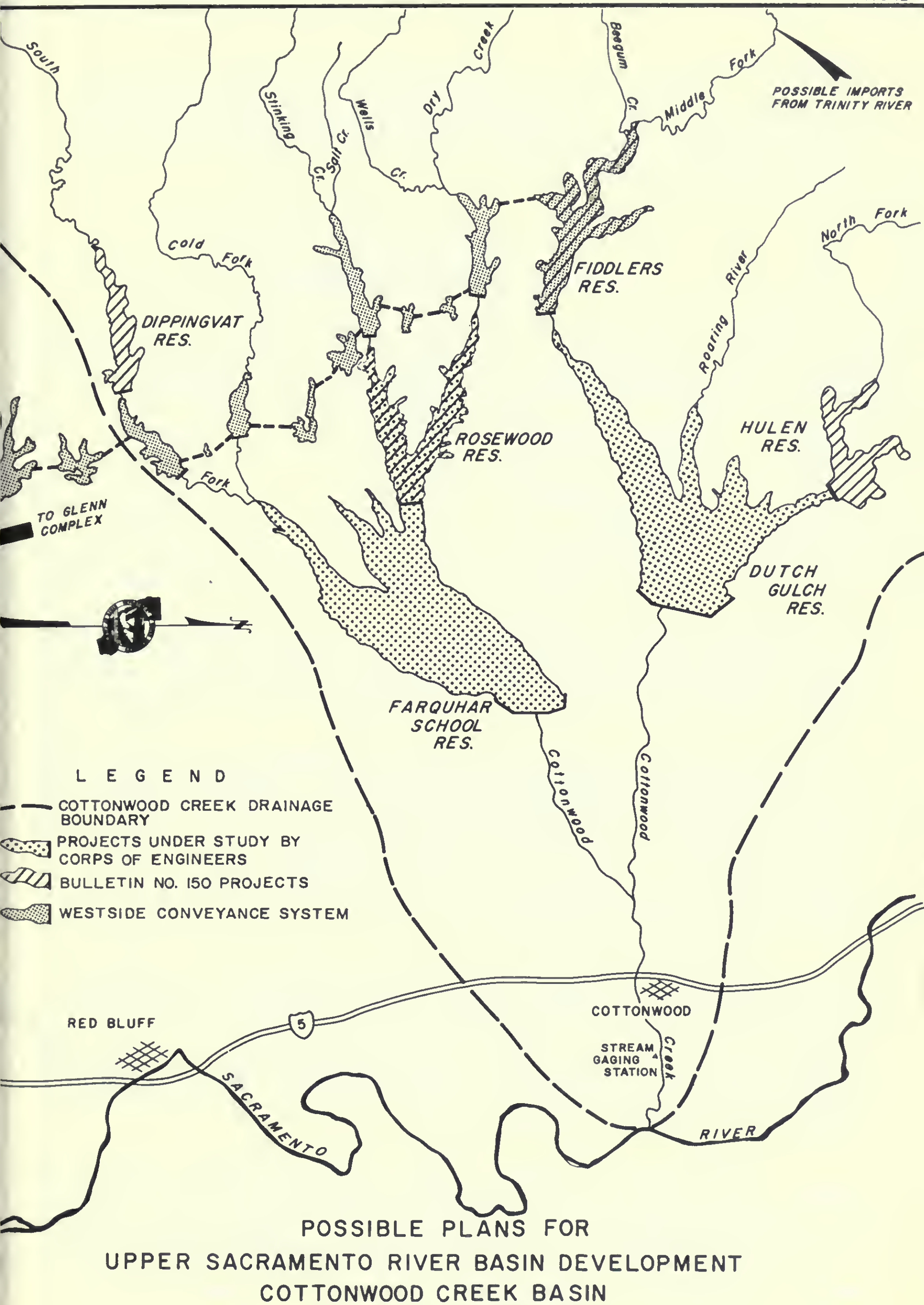
The Department of Water Resources is currently conducting studies of alternate routes for conveyance of Trinity River water to the Sacramento Valley in the vicinity of Cottonwood Creek. The West Side Conveyance System as shown in Bulletin No. 136, "North Coastal Area Investigation", included Fiddlers Reservoir on Middle Fork Cottonwood Creek as the initial reservoir in a series of reservoirs leading to the Glenn Complex (Paskenta-Newville-Rancheria).

The following sections present an analysis of the flood control potential of Hulen, Dippingvat, Fiddlers, and Rosewood Reservoirs and a description of Dutch Gulch and Farquhar School Reservoirs.

Approximately 305,000 acre-feet of flood control storage is necessary in reservoirs on Cottonwood Creek to control Cottonwood Creek to non-damaging flows on a 50-year recurrence interval. Damages begin occurring when the flow at the Cottonwood Creek gage near Cottonwood reaches 15,000 cfs, but the damages remain low and are confined to agricultural lands until the flow reaches 35,000 to 40,000 cfs. Additional flood control storage on Cottonwood Creek would be needed to reduce Sacramento River flows to the maximum degree.

Four small reservoirs (Hulen, Dippingvat, Rosewood, and Fiddlers) could provide flood protection on Cottonwood Creek and its main tributaries. Each reservoir would contain flood control reservations to limit total releases from the four reservoirs to approximately 10,000 cfs during a 1-in-50-year storm. The flow originating below the dams would cause the total flow at the mouth of Cottonwood Creek to exceed 10,000 cfs. The severity of the storm and the location of the storm center would determine the extent of this excess.

The Hulen and Dippingvat Projects are described in Chapter IV. Hulen would control the North Fork to 2,000 cfs and Dippingvat would control the South Fork to 4,000 cfs. A 70,000 acre-foot Fiddlers Reservoir



POSSIBLE PLANS FOR
UPPER SACRAMENTO RIVER BASIN DEVELOPMENT
COTTONWOOD CREEK BASIN

(dedicated entirely to flood control) would control the Middle Fork to 2,000 cfs. A 50,000 acre-foot Rosewood Reservoir would control Dry Fork to 2,000 cfs. In addition, a levee system along the lower reaches of Cottonwood Creek would be necessary to contain floods up to 30,000 cfs to provide 1-in-50-year protection to the basin. Table 7 gives the estimated cost for this plan.

TABLE 7

COSTS FOR THE FOUR RESERVOIRS

	Capacity	Capital Cost	Annual Equivalent Cost
Hulen	136,000 acre-feet	$10,100,000	$526,000
Dippingvat	110,000 acre-feet	12,800,000	593,000
Fiddlers	70,000 acre-feet	15,000,000	630,000
Rosewood	50,000 acre-feet	14,000,000	585,000
Levees1/	30,000 cfs	800,000	42,000

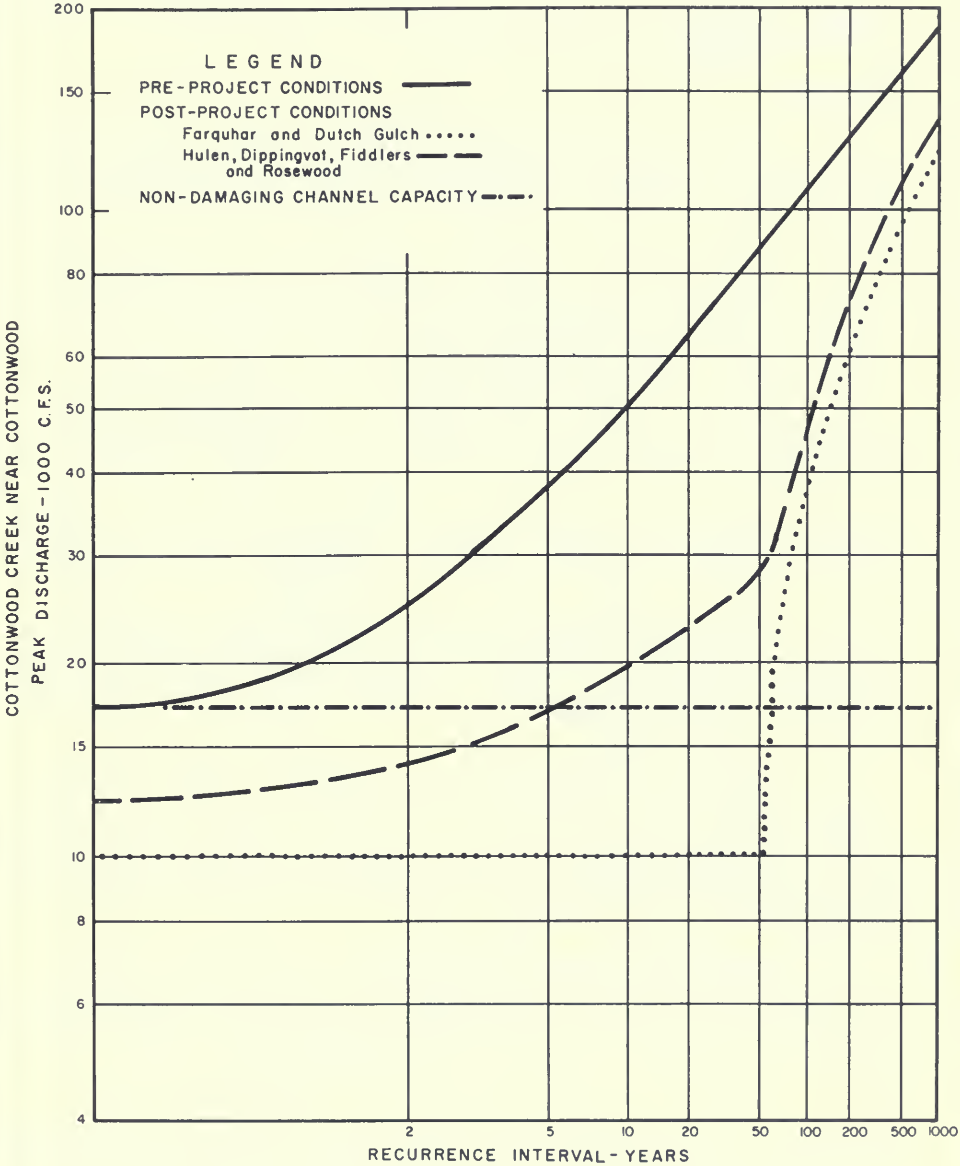
1/ Based upon a preliminary estimate prepared by the Corps of Engineers.

Flood control benefits would accrue along Cottonwood Creek and the Sacramento River and in the Butte Basin. The average annual flood control benefits due to this four-reservoir plan would be $195,000 along Cottonwood Creek and $370,000 along the Sacramento River and in the Butte Basin.

Flood control could alternatively be provided by the construction of the Dutch Gulch and Farquhar School Projects. Preliminary plans indicate that 500,000 acre-feet of flood reservation in these reservoirs would limit the releases to 10,000 cfs. Dutch Gulch is currently envisioned as having a capacity of 1,100,000 acre-feet and Farquhar School 900,000 acre-feet. These projects would provide flood protection, local irrigation (40,600 acre-feet per year), export yield (226,000 acre-feet per year), recreation, and fishery enhancement.

The 500,000 acre-feet reserved for flood control in this plan would be divided about equally between the two reservoirs. The average annual in-basin flood benefits due to restricting maximum flows in Cottonwood Creek to 10,000 cfs for a 1-in-50-year flood would be $250,000. The reservoirs would be operated to make no releases when the flow in the Sacramento River is expected to exceed 130,000 cfs at Ord Ferry. Preliminary data prepared by the Corps of Engineers indicates that downstream flood control benefits will exceed $1,000,000 annually.

The effects of these two plans on flood frequencies on Cottonwood Creek is shown in Figure 5. The main differences between the two plans are the downstream flood control benefits and the export yields. The four-reservoir plan is designed primarily to serve local needs and has limited downstream flood control and export yield benefits (approximately 39 percent) whereas the two-reservoir plan relies heavily on these benefits (approximately 78 percent of the total benefits).



COTTONWOOD CREEK
FLOOD FREQUENCY CURVE

Both plans would substantially reduce flood damages within the Cottonwood Creek Basin but the two-reservoir plan would provide a greater reduction in Sacramento River floodflows.

Cow Creek

Cow Creek accounts for approximately 20 percent of the annual runoff and peak discharges that originate between Shasta Dam and Red Bluff. The mean annual runoff of Cow Creek is approximately 460,000 acre-feet. The maximum peak recorded discharge of 45,200 cfs occurred on December 27, 1951.

Bulletin No. 150 outlined two possible projects for Cow Creek. Millville Dam and Reservoir on South Cow Creek was shown to be an economically justified multiple-purpose project. Bella Vista, on Little Cow Creek, was not economically justified. A project at Millville could include diversion of floodflows from Old Cow and Bear Creeks. The Bella Vista Project could include a diversion of flows from Oak Run and Clover Creeks. These projects are shown on Figure 6. The Millville Project was reevaluated during this investigation and is described in detail in Chapter IV.

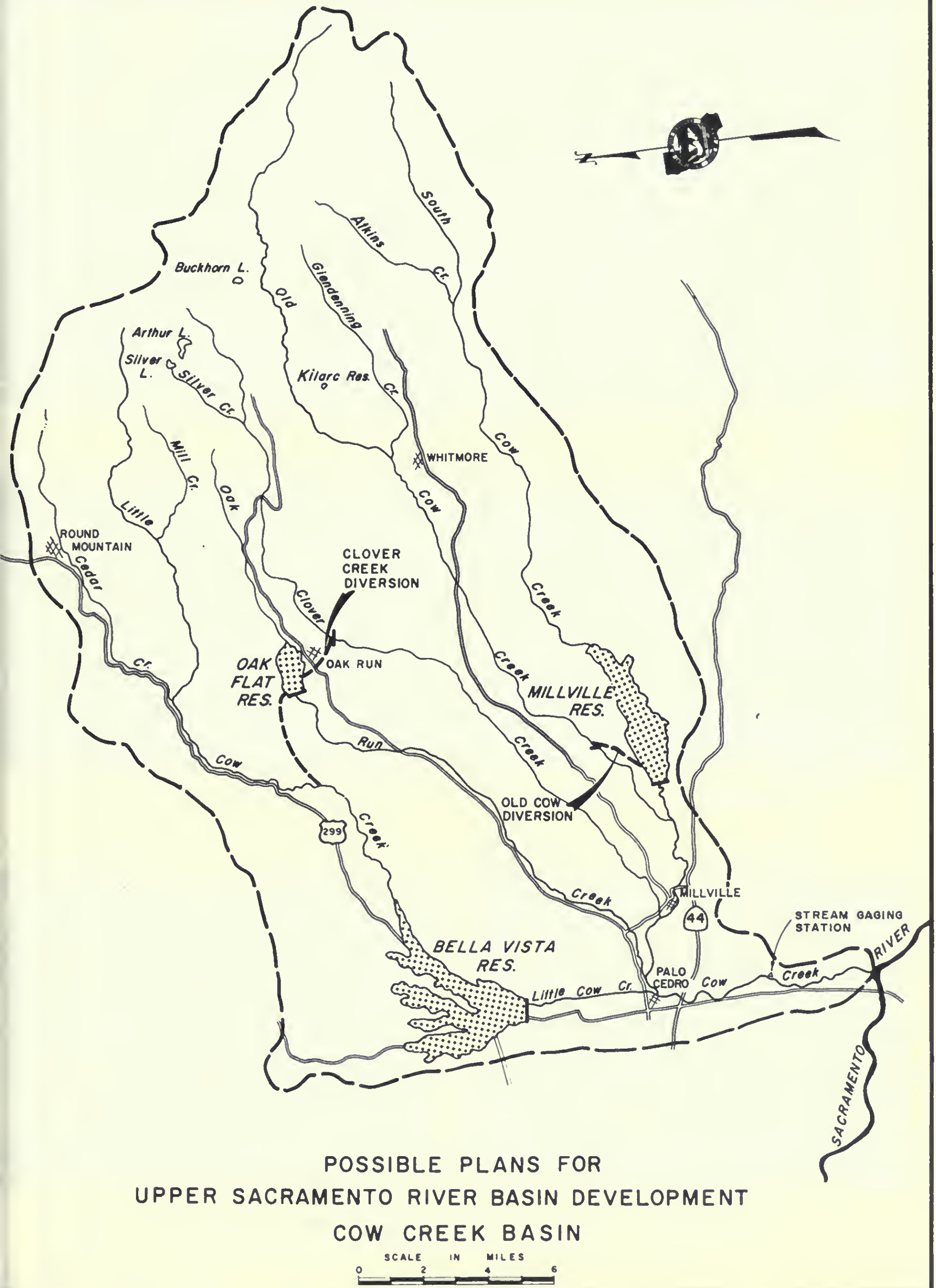
The Corps of Engineers, as part of their Northern California Streams Investigation, has begun studies of Cow Creek and are considering the Bella Vista and Millville sites and alternatives.

Damages in the Cow Creek Basin occur when flows rise above 6,000 cfs in Little Cow Creek, 5,000 cfs in South Cow Creek, and 16,000 cfs in main Cow Creek. These damages are mainly confined to agricultural lands but considerable urban development is occurring along Little Cow Creek, some within the floodplain.

Cow Creek consists of many small tributaries and it would be impractical to construct enough dams to control all floodflows. Projects currently under consideration would control only about two-thirds of the drainage area. The flood frequency curve shown in Figure 7 indicates that even with construction of all projects currently under consideration, flows in excess of the non-damaging channel capacity will occur approximately every 7 years in lower Cow Creek.

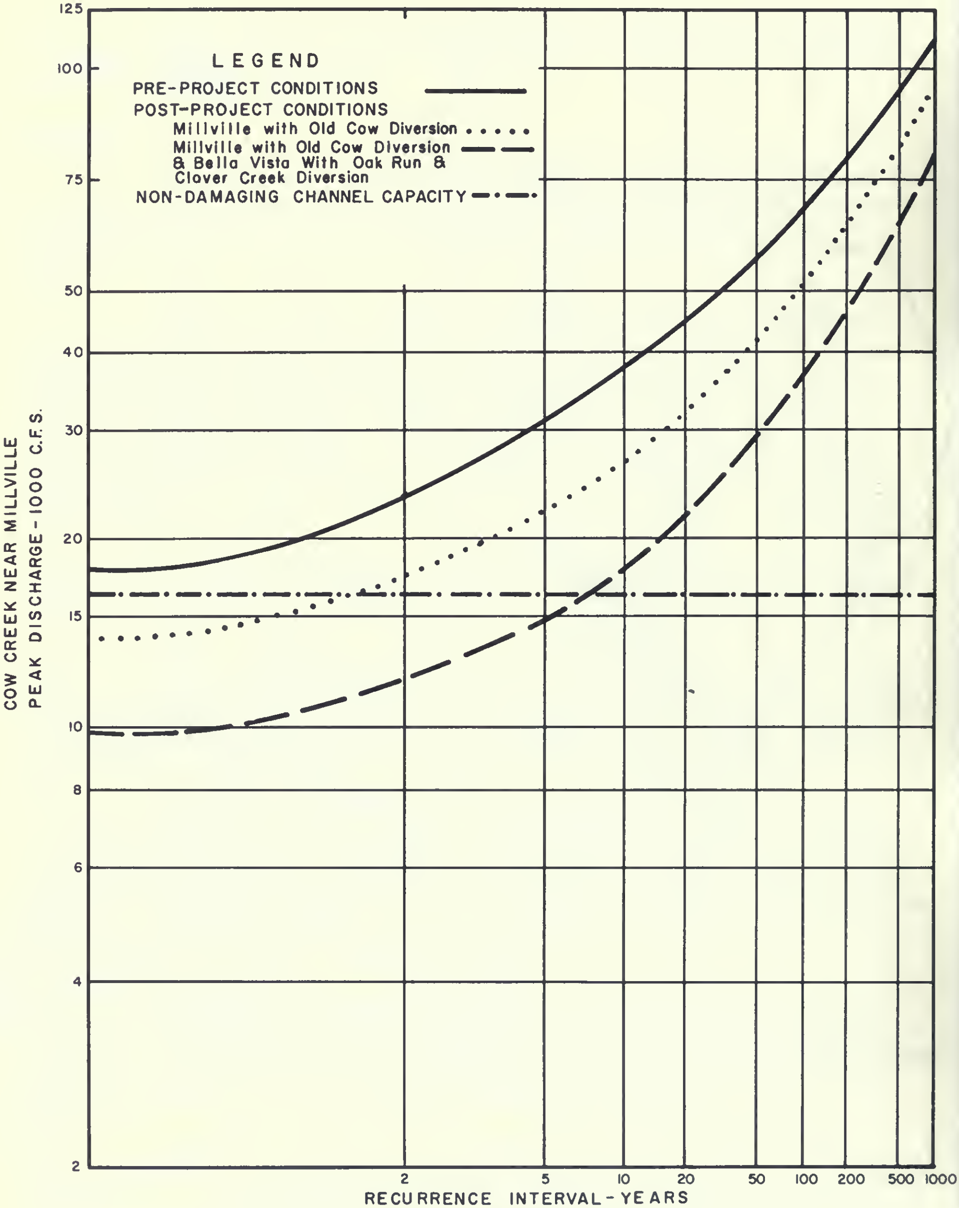
The most practical plan for reducing flood damage in the Cow Creek Basin would include early adoption of floodplain management ordinances and the inclusion of flood control storage reservations in any future projects planned for this basin. The Millville Project is economically justified and should be considered for near-future construction.

Cow Creek is a major contributor to the flood peaks in the Sacramento River, ranking second to Cottonwood Creek among the uncontrolled tributaries. By providing flood control storage in future projects within the basin, a reduction in floodflows in the Sacramento River will occur.



POSSIBLE PLANS FOR
UPPER SACRAMENTO RIVER BASIN DEVELOPMENT
COW CREEK BASIN

FIGURE 7



COW CREEK FLOOD FREQUENCY CURVE

Sacramento River at Red Bluff, 100,000 cfs flow

Sacramento River at Chico Landing, bank erosion along River Road

Sacramento River, overflow through Colusa Weir

Duck hunting club in Butte Basin, elevated for protection from high water

Fishing resort inside Sacramento River Flood Control Project levees -- subject to damages at relatively low flows

Battle Creek

Battle Creek supplies about 17 percent of the mean annual runoff but contributes only about 7 percent to the flood peaks which originate between Shasta Dam and Red Bluff. The mean annual runoff of Battle Creek is approximately 380,000 acre-feet. The maximum recorded discharge since 1940 was 13,000 cfs in 1942. However, a discharge of 35,000 cfs was estimated for the December 1937 flood.

The topography of the Battle Creek drainage is such that there are no good reservoir sites. Several reports have mentioned a possible diversion of Battle Creek into the proposed Wing Reservoir on Inks Creek. This plan is shown on Figure 8.

The average annual flood damages in the Battle Creek Basin are largely to the Coleman Fish Hatchery ($80,000) and to agricultural development downstream ($72,000). Damages to the hatchery begin at about 4,500 cfs and result mostly from the loss of fish. Agricultural damages, comprised mostly of damages to orchards in the vicinity of Bloody Island, begin occurring at about 1,500 cfs.

The diversion of Battle Creek floodflows into Wing Reservoir is a possible solution to flood problems on Battle Creek. Paynes Creek could also be diverted into Wing Reservoir.

Paynes Creek

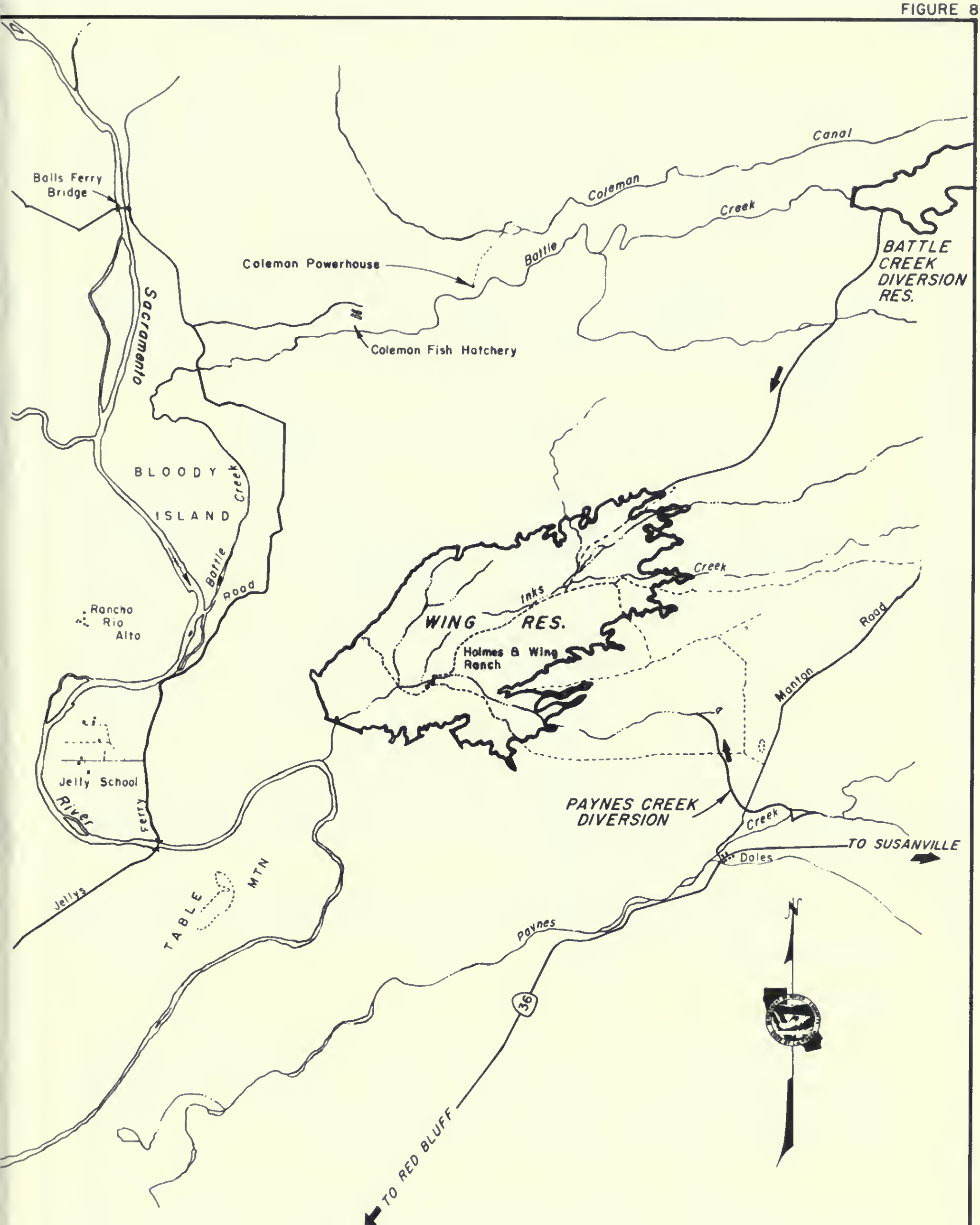
Paynes Creek has a mean annual runoff of 50,000 acre-feet. The maximum recorded flow was 10,600 cfs in December 1961. Bulletin No. 137, "Sacramento Valley East Side Investigation", August 1967, presented a plan for a maximum diversion of 500 cfs from Paynes Creek into Wing Reservoir. This diversion was sized for water conservation only and would be too small for diversion of floodflows.

The maximum non-damaging flow in Paynes Creek is not known. However, very little damage occurred during the 1964 floods when the flow was 7,500 cfs. Paynes Creek has a minor effect on Sacramento River floodflows.

Combined Battle and Paynes Creek Diversion to Wing Reservoir on Inks Creek

The operation of this double diversion project uses the water supplies of two drainage basins and a storage site on the third (see Figure 8) Wing Reservoir would have a maximum storage capacity of 244,000 acre-feet and would be operated with a flood control reservation of 80,000 acre-feet.

One-in-fifty-year protection could be provided in Battle Creek by diverting 22,000 cfs to Wing Reservoir and in Paynes Creek by diverting 10,000 cfs. An average annual flood control benefit of $270,000 could be realized by this operation. In addition to flood control benefits, water



POSSIBLE PLANS FOR
UPPER SACRAMENTO RIVER BASIN DEVELOPMENT
BATTLE, PAYNES AND INKS CREEK BASINS

SCALE IN MILES

0 1 2 3

stored in Wing Reservoir could be used for conservation yield. Approximately 50,000 acre-feet of new annual yield could be conserved. Recreation and fishing at Wing Reservoir would also produce benefits. These benefits were taken directly from Bulletin No. 137. Control of floodflows in Battle Creek could produce anadromous fishery benefits but an evaluation was beyond the scope of this investigation. Table 8 gives the approximate benefits which would be derived from the project.

Cost estimates were prepared for the flood diversions from Battle Creek and Paynes Creek. They are reconnaissance-level estimates based upon limited geologic exploration. The costs of Wing Dam and Reservoir were taken from Bulletin No. 137. This data is shown in Table 8.

TABLE 8

PRELIMINARY WING PROJECT COSTS AND BENEFITS

Item	Capitalized Costs	Purpose	Capitalized Benefits
Battle Creek Diversion	$18,200,000	Yield	$16,000,000
Paynes Creek Diversion	1,400,000	Flood Control	8,200,000
Wing Dam and Reservoir	14,200,000	Recreation	7,800,000
		Warmwater Fisheries	1,500,000
Total	$33,800,000	Total	$33,500,000

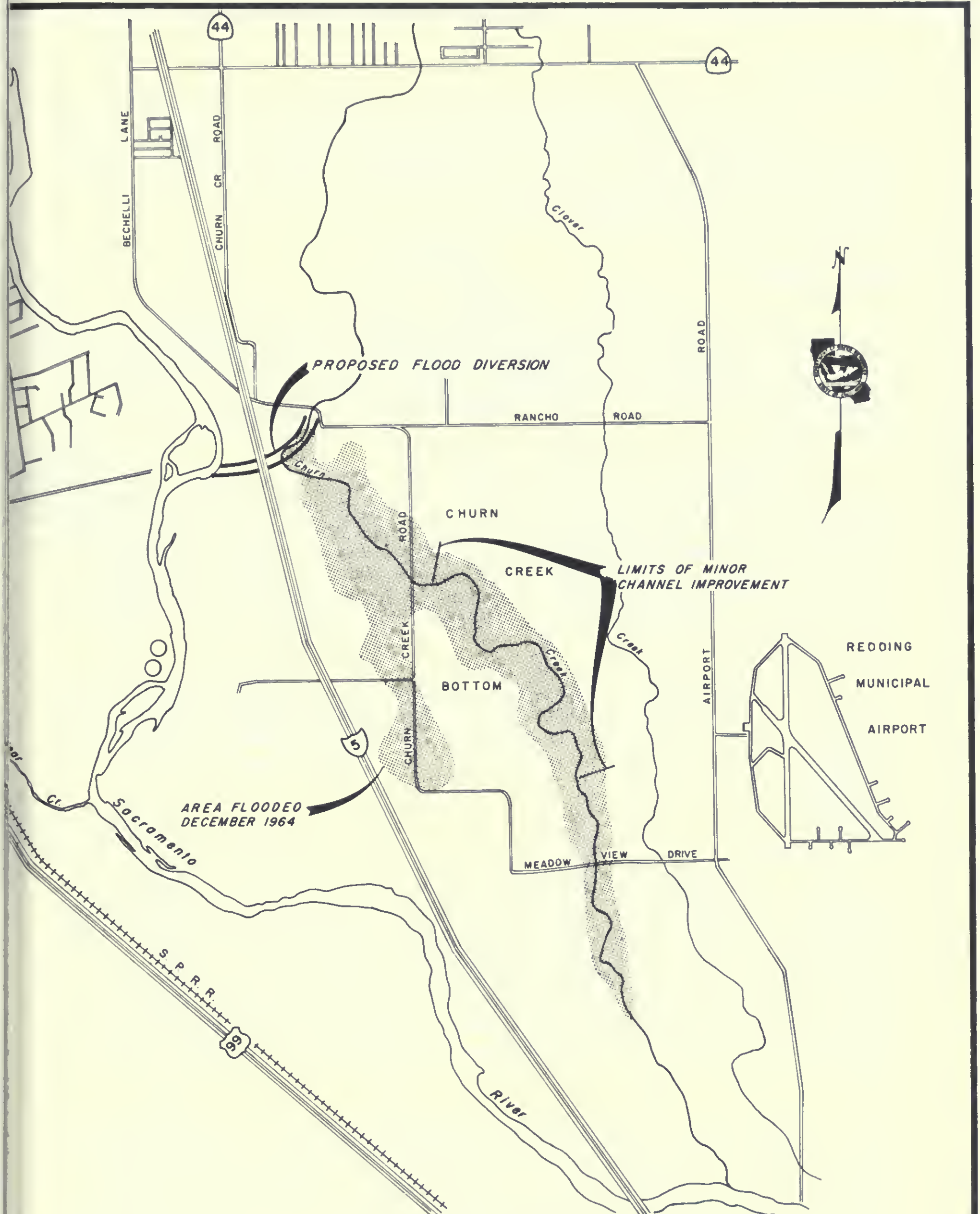
Based upon the costs and benefits presented in Table 8, the Wing Project with diversions from Battle and Paynes Creeks is not economically justified today. However, further studies are warranted to evaluate the merits of this project. It may show justification when demands for additional export are more imminent.

It may be possible to include substantially more storage at the Wing site and incorporate a pump storage scheme utilizing flows from the Sacramento River.

Churn Creek

Churn Creek drains an area of about 36 square miles south of Lake Shasta and east of Redding. This area has become highly urbanized in the past few years. Residential developments have taken place in the Churn Creek Bottom, an area subject to flooding. Recent floods, particularly in December 1964, caused considerable damage.

The Corps of Engineers has proposed a channel improvement bypass scheme (see Figure 9) which would divert floodflows away from these low-lying areas and into the Sacramento River. The capital cost of the project would be about $1,350,000, split equally between federal and local interests. The project appears to be economically justified. The project would have little effect upon reducing floodflows in the Sacramento River since no storage is included in the plan.



POSSIBLE PLANS FOR
UPPER SACRAMENTO RIVER BASIN DEVELOPMENT
CHURN CREEK

Bear Creek

This small tributary to the Sacramento River has a drainage area of approximately 100 square miles. There are no reported flood problems within its drainage basin. It may be possible to divert water from Bear Creek into Millville Reservoir. The benefits and costs of such a plan are discussed in Chapter IV.

Clear Creek

This is the northernmost major tributary in the upper Sacramento River Basin. Whiskeytown Reservoir, part of the Bureau of Reclamation's Trinity River Division, Central Valley Project, is on Clear Creek. Water delivered to Whiskeytown Reservoir from the Trinity River is released either through the Spring Creek Powerplant into Keswick Reservoir or down Clear Creek.

Approximately 30,000 acre-feet of flood control storage is maintained in Whiskeytown during the winter. Though this is an operational convenience, it does provide a measure of flood protection to lower Clear Creek and along the Sacramento River. The peak inflow of December 1964 of 21,000 cfs was reduced to approximately 3,600 cfs outflow. However, the entire flood reservation was used up in accomplishing this reduction. Inflow below the reservoir caused the peak flow in lower Clear Creek to reach 10,000 cfs.

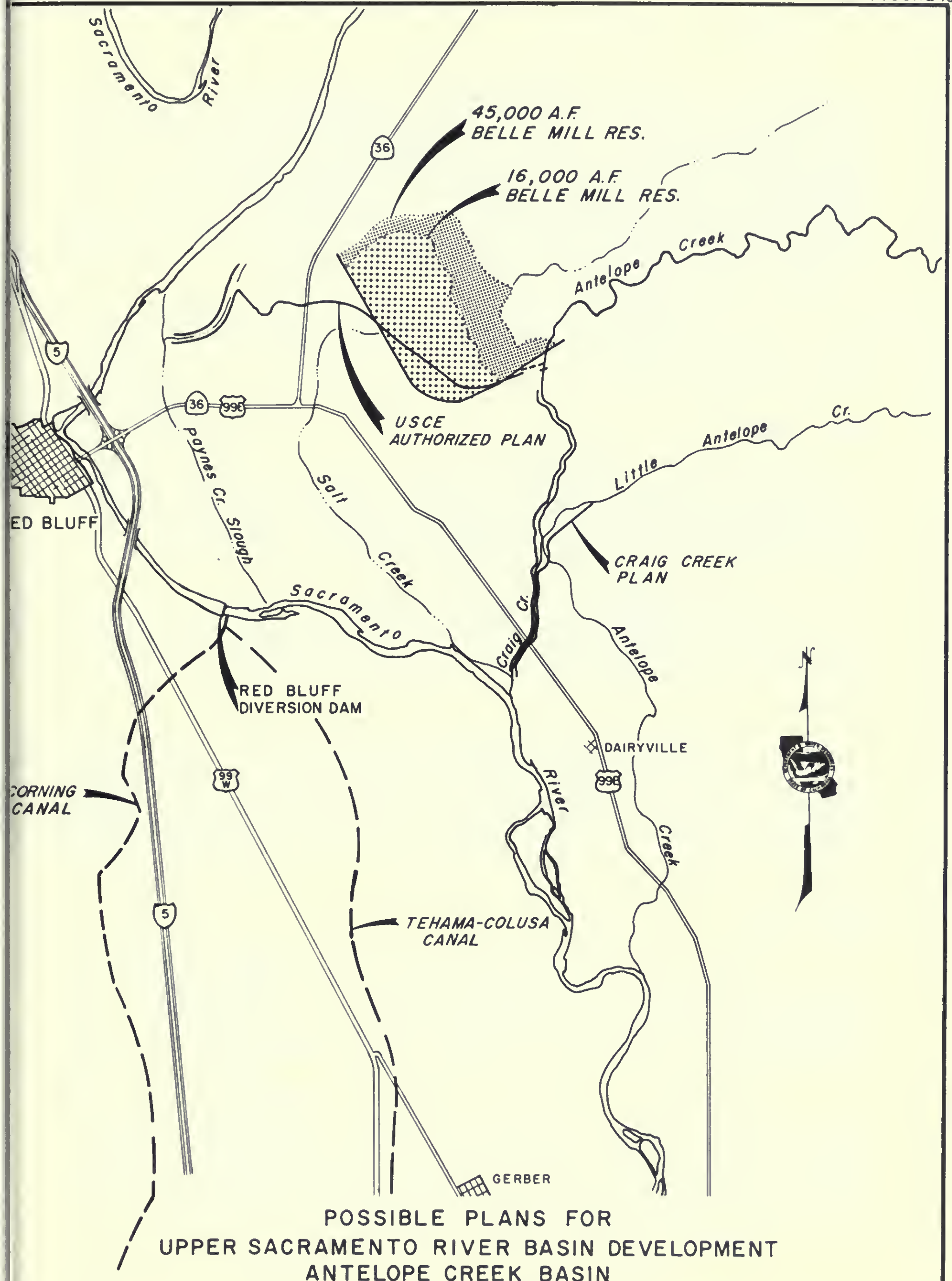
Additional flood control storage in Whiskeytown Reservoir would help reduce peak flows along the Sacramento River. Studies should be made to determine the feasibility of adding this flood control storage and to determine ways to control the relatively large Clear Creek inflow below the reservoir.

Antelope Creek

Antelope Creek was one of the major tributaries included in the Department's Bulletin No. 137, "Sacramento Valley East Side Investigation". The average annual runoff is approximately 100,000 acre-feet and the maximum recorded flow was 11,500 cfs in February 1956. The 1937 flood was estimated to have had a peak of 17,500 cfs. Considerable residential and agricultural development has taken place along lower Antelope Creek. Flooding is quite frequent because the channel capacity is only 4,000 cfs. Agricultural lands and some residences are subjected to flooding nearly every year.

The best plan for reservoir storage development for Antelope Creek appears to be an off-stream reservoir, Belle Mill, with a flood diversion from Antelope Creek (see Figure 10). This plan was presented in Bulletin No. 137. The diversion would be sized to handle the standard project storm of 23,000 cfs by diverting 19,000 cfs to temporary storage in a 16,000 acre-foot Belle Mill Reservoir and passing 4,000 cfs down the natural channel. Releases from Belle Mill Reservoir would be held to 9,000 cfs down an improved Salt-Millrace flood channel. This plan, however, was shown to be not economically justified at the present time.

FIGURE 10



POSSIBLE PLANS FOR
UPPER SACRAMENTO RIVER BASIN DEVELOPMENT
ANTELOPE CREEK BASIN

SCALE IN MILES
0 1 2 3

The Corps of Engineers has an authorized project on Antelope Creek, but due to lack of local support the project has not moved forward. The authorized plan, shown in Figure 10, included a diversion of Antelope Creek flows through a levee system to Paynes Creek Slough and then into the Sacramento River. Another possible scheme studied at the time of the authorized plan was the Craig Creek plan. In this plan, water from Antelope and Little Antelope Creeks would be diverted down a leveed Craig Creek channel, a distributary of Antelope Creek. Current Corps planning is considering a 45,000 acre-foot Belle Mill Reservoir.

Since Antelope Creek has only a slight effect on Sacramento River flows, most flood control benefits from a project on Antelope Creek would be within the basin.

Elder Creek

Levees have been constructed to a capacity of 17,000 cfs along the lower reaches of Elder Creek. The levees protect the town of Gerber and agricultural lands along the creek. The maximum recorded flow on Elder Creek occurred in January 1965, at 14,000 cfs. The average annual runoff of Elder Creek is approximately 70,000 acre-feet.

A good reservoir site exists on Elder Creek (see Figure 11). This site, called Galatin, could be developed up to a capacity of 500,000 acre-feet. It was one of the reservoirs shown in Bulletin No. 136, "North Coastal Area Investigation", as part of the West Side Conveyance System.

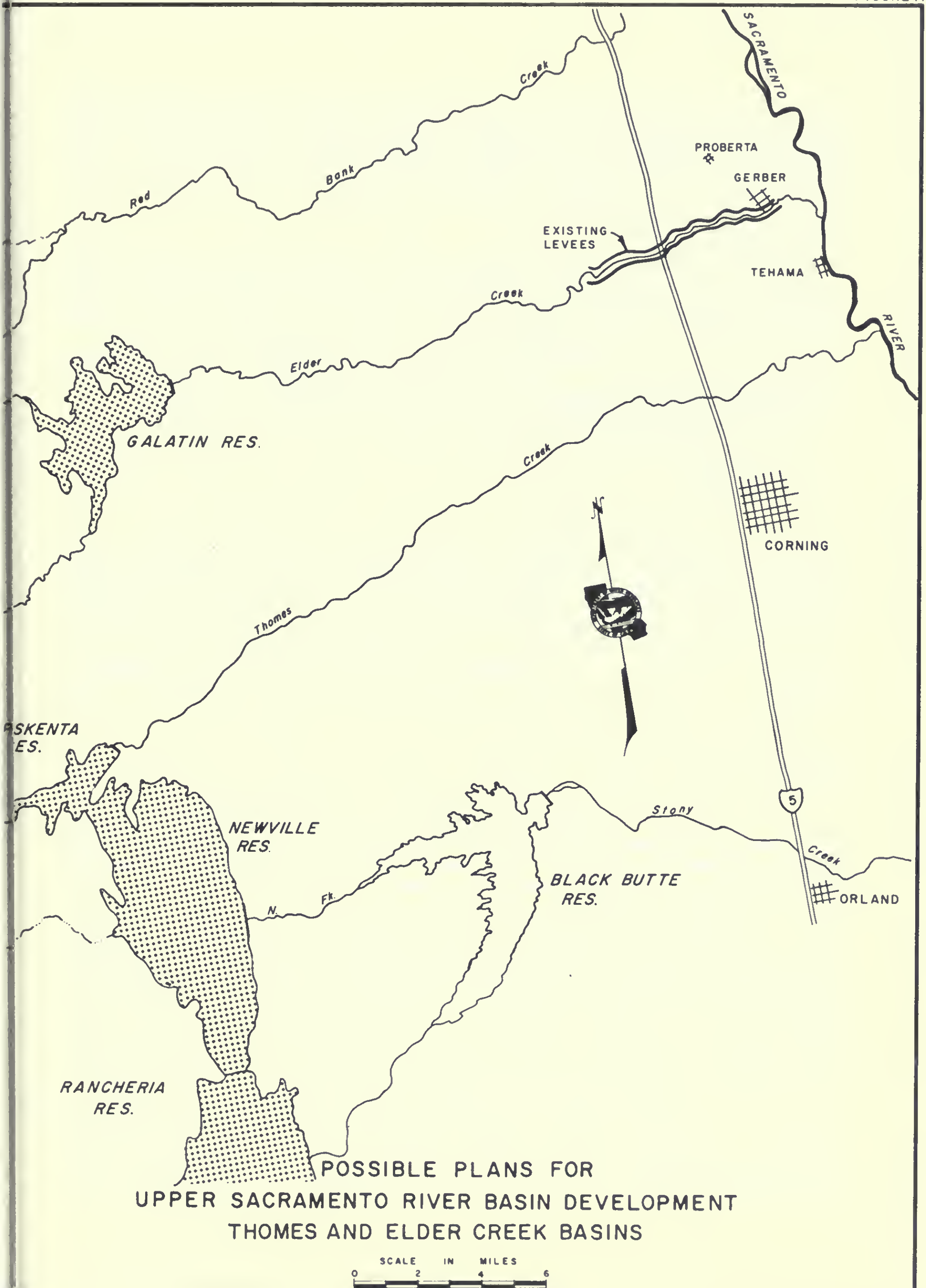
At the present time there does not appear to be a pressing need for additional flood protection on Elder Creek. Flood control storage on Elder Creek could reduce Sacramento River floodflows slightly. Future development of agricultural lands in this area or other areas of the State could present a need for additional water supplies. At that time, Galatin should be considered.

Thomes Creek

Thomes Creek causes the greatest in-basin damages of any remaining uncontrolled tributary in the upper Sacramento River Basin. Annual damages are estimated at nearly $270,000 under today's conditions. The maximum peak discharge during the December 1964 flood was 37,800 cfs. The average annual runoff from Thomes Creek is approximately 200,000 acre-feet.

The Bureau of Reclamation is currently completing studies of the Paskenta-Newville Project on Thomes and North Fork Stony Creeks (see Figure 11). This project would provide flood control, local irrigation supplies, recreation, and yield to the Delta. As currently envisioned, floodflows would be held to 5,000 cfs below Paskenta Dam. A further discussion of this project is given in Chapter IV.

FIGURE 11



POSSIBLE PLANS FOR
UPPER SACRAMENTO RIVER BASIN DEVELOPMENT
THOMES AND ELDER CREEK BASINS

The Paskenta-Newville Project would have a slight effect on peak flows in the Sacramento River. Thomes Creek usually has peaked and flows are declining before the peak Sacramento River flows arrive in that reach of the river. In a typical storm 3 to 5 percent of the peak flows reaching Ord Ferry originate in Thomes Creek.

Mill and Deer Creeks

A full discussion of the flood problems of Mill and Deer Creeks is presented in Chapter IV. At the present time, it appears that no new reservoir flood control projects are warranted for these creeks. Zoning along the lower reaches of Mill Creek would keep damages to a minimum. Even though existing levees on Deer Creek are designed to handle a flow of 21,000 cfs, there have been flood damages during recent major storms and studies should be made to evaluate the possibility of improving or extending these levees.

Big Chico Creek

Big Chico Creek passes through the city of Chico and its suburbs. In 1964, the Corps of Engineers completed the Mud Creek Diversion Project which diverts flows in excess of channel capacities away from Chico Creek into Mud Creek. This project provides standard project flood protection to the urban areas along Big Chico Creek. Additional projects probably will not be needed or warranted for the Big Chico Creek Basin. Since only about 1 percent of the flows at Ord Ferry originate in this basin, projects on Big Chico Creek would have little effect on Sacramento River flows.

Butte Creek

Butte Creek was studied as part of the investigation which led to Bulletin No. 137, "Sacramento Valley East Side Investigation". Several sites studied during this investigation have a potential for controlling floods in lower Butte Creek. Bulletin No. 3 showed a possible diversion of floodflows from Chico Creek into a reservoir on Butte Creek.

Several factors tend to make flood control reservoirs on Butte Creek unjustified. Nearly the entire length of Butte Creek from the foothills to Butte Basin is leveed to a capacity of 22,000 cfs or greater. This provides protection against the maximum flood of record. The Mud Creek Diversion Project on Big Chico Creek gives standard project flood protection to this creek. There would be very little flood control benefit to diverting flows from Big Chico Creek to a reservoir on Butte Creek.

The best plan for Butte Creek appears to be the Jonesville Project as presented in Bulletin No. 137. The primary purpose of this project would be to provide additional water supply to the Paradise, Forest Ranch, and Cohasset Ridges. This project would have very limited flood control potential.

Stony Creek

Erosion problems and damage to agricultural lands have occurred along the valley floor reaches of Stony Creek. Long periods of sustained flow in the creek have encouraged the growth of vegetation in the streambed. Stony Creek generally does not have a defined channel and is braided from one side of the channel to the other. At low flows, the debris cone moves from one bank to the other and causes considerable erosion. A possible solution to this problem could be the construction of a low-water channel within the existing streambed. With this low-water channel in operation, high releases from Black Butte Dam might be contained to a defined channel.

Sacramento River - Keswick Dam to Cottonwood Creek

Damage along this reach of the river occurs when flows reach about 55,000 cfs. Since there is only minor inflow throughout most of this reach, the releases from Keswick make up most of the flow. Only twice since Shasta was completed in 1945 have releases from Keswick exceeded 55,000 cfs (73,000 cfs in 1952 and 78,800 cfs in 1958).

Under 1968 conditions, the average annual damages for this reach are only $8,000. The logical solution to flood problems here appears to be floodplain management. Ordinances restricting developments to an elevation slightly higher than the 1958 flood should protect all lands against floods that would occur on a 100-year recurrence interval.

Sacramento River - Cottonwood Creek to Tehama

Inundation of low agricultural lands in this reach begins when the flow of the Sacramento River at Red Bluff reaches about 85,000 cfs, which occurs nearly every year. Some residential areas near Red Bluff begin flooding when the flow reaches 110,000 cfs. Under present conditions, the average annual damages for this reach are $55,000.

The flow in this reach of the river is derived from Shasta releases, Cottonwood Creek, Cow Creek, and other smaller tributaries. During peak runoff periods, the releases from Shasta are timed so that they usually have only a small effect on the peak flow at Red Bluff. Cottonwood Creek is the main contributor to flood peaks and usually defines the flood crest in the Sacramento River at Red Bluff. Twenty-five to thirty percent of the peak flow at Red Bluff usually originates in Cottonwood Creek and as much as 35 percent has originated there during extreme floods.

Cow Creek usually furnishes about 20 to 25 percent of the peak that passes Red Bluff. A storm centered over Cow Creek can increase this percentage. The smaller tributaries (Clear, Battle, Bear, and Paynes) and the local inflow make up the rest of the flow. These areas could furnish 60 percent or more of the peak runoff during certain storms.

Cottonwood Creek appears to be the major tributary where new flood control projects could substantially reduce floodflows in this reach of the river. If all of the apparently possible projects on Cow Creek were to be constructed, substantial reductions in flow could occur. The contribution of any single one of the remaining tributaries is minor. Even if all the apparently possible upstream reservoir projects now under consideration were built, flooding would still occur on a 1-in-50-year frequency.

The best solution for this reach of the river appears to be construction of projects on Cottonwood Creek and Cow Creek and floodplain management. Tehama County has adopted floodplain management ordinances, and these ordinances should be reviewed, based upon recent hydrologic events, to assure continuing protection to the developing urban areas.

Sacramento River - Tehama to Chico Landing

Most damages in this reach are caused by the occasional flooding of low-lying agricultural lands. Flooding begins at about 70,000 cfs but damages are quite low until the flow reaches about 130,000 cfs. Boat marinas and trailer parks suffer damages at higher flows. The average annual damages are approximately $220,000 under existing conditions.

The Corps of Engineers studied this reach of the river during the 1950's as part of its Chico Landing to Red Bluff investigation. This study showed that levees were economically justified and that bank protection was justified in some locations. However, the local communities did not support the levee scheme. Construction of the bank protective works was made contingent upon Butte, Glenn, and Tehama Counties adopting floodplain management ordinances. Tehama County has adopted these ordinances and the bank protection work has been completed. However, Butte and Glenn Counties have not adopted floodplain management ordinances and the needed bank protective work has not been started.

In 1966 the State Reclamation Board requested the Department to review the Corps' levee project that was studied in the 1950's. The Department concluded that the cost estimates used in the original report could be updated but that a complete new study was needed to determine the benefits.

Upstream storage can reduce the frequency of major floods in this reach of the Sacramento River. However, it may be many years before all the possible upstream reservoirs are constructed and even then some flood damages will still occur. Floodplain management ordinances should be adopted by Butte and Glenn Counties to prevent urban encroachments into the areas subjected to periodic flooding and so that bank protection work can be initiated.

Sacramento River - Chico Landing to Colusa

Damages along this reach of the river are confined to nonresidential facilities and agricultural lands. The lower part of this reach is within the existing Sacramento River Flood Control Project. Boat marinas and fishing resorts built within the project levees suffer damages during high flows. The agricultural lands lying along the river inside of the project levees suffer some damages nearly every year. The average annual damages under today's conditions are $175,000.

Butte Basin

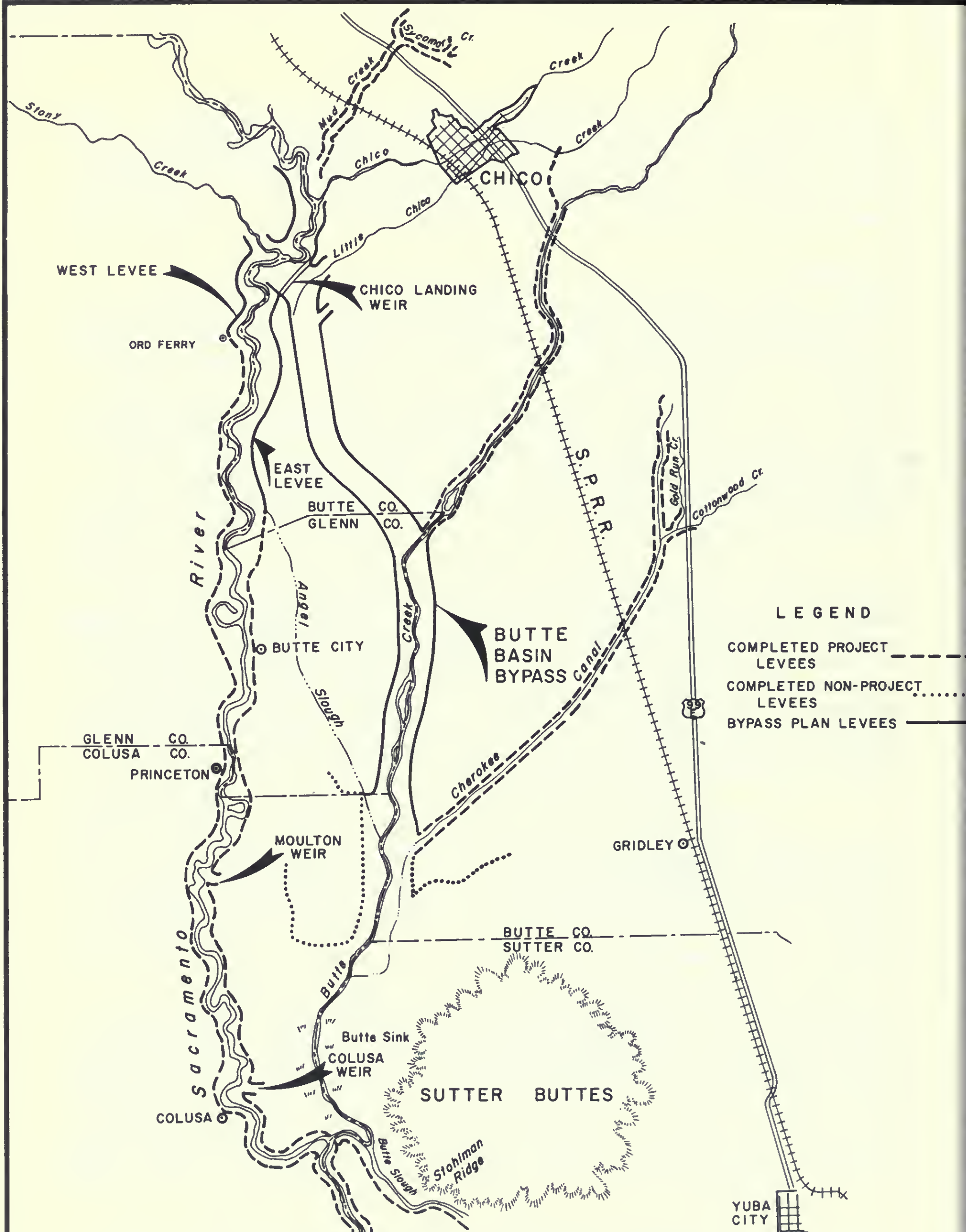
The Butte Basin serves as a natural overflow bypass for the Sacramento River. Historically, water from the Sacramento River has begun to enter the Butte Basin when the flow in the river at Ord Ferry reaches 90,000 cfs. Natural channels in the upper Butte Basin can handle about 10,000 cfs of the initial overflow from the river. When the total flow reaches about 150,000 cfs, general flooding into the Butte Basin occurs. Flood damages in the upper and middle Butte Basin occur largely to the crops and agricultural lands which are inundated by the flows which are bypassed into the basin when the flow in the Sacramento River at Ord Ferry reaches 150,000 cfs.

In past years landowners in the upper Butte Basin have attempted to reclaim and farm their lands. Many of the natural overflow channels have been leveled and levees have been built along the river. These levees prevent low magnitude floodflows from inundating their lands. Flows that would have spilled into the Butte Basin under conditions prevailing in the early 1950's were forced to remain in the river and flow into the Sacramento River Flood Control Project. In 1964, the Reclamation Board had these levees degraded to a level which would insure the integrity of the Sacramento River Flood Control Project and insure that flows greater than 150,000 cfs would not enter the project levees.

In August 1964, the Reclamation Board adopted a master plan for the Butte Basin. This plan was not presented for construction but merely as a guide for landowners who wished to build levees to reclaim their land and protect themselves from flooding. This plan (see Figure 12) is intended to pass 150,000 cfs down the Sacramento River and 60,000 cfs through the bypass during a project design flow of 210,000 cfs. The key feature of this plan would be an overflow weir near Chico Landing.

This plan appears to be a suitable solution to handling large floodflows. If the complete bypass is ever constructed, consideration should be given to making provisions for flows in excess of 210,000 cfs. Upstream storage on the tributaries should be able to maintain most floods below 210,000 cfs at Ord Ferry. But, it will be many years before all of the upstream reservoirs are built, and high magnitude floods will occasionally produce flows in excess of 210,000 cfs. The bypass system should be designed so that only 150,000 cfs is allowed to enter the project levees along the Sacramento River.

FIGURE 12



POSSIBLE PLANS FOR
UPPER SACRAMENTO RIVER BASIN DEVELOPMENT
ADOPTED BUTTE BASIN BYPASS PLAN

The lower Butte Basin receives overflow waters from the Sacramento River via natural overflow and controlled spills over Moulton and Colusa Weirs. Water is temporarily stored in the "sink" due to the topography which forms a natural constraint to drainage. The Butte Slough gradually drains these floodwaters into the Sutter Bypass. The Butte Basin is vastly important to the operation of the Sacramento Flood Control Project. Due to the retarding effect of natural storage in the Butte Basin "sink", a flow of approximately 200,000 cfs at the latitude of Ord Ferry is normally reduced to a total outflow of about 150,000 cfs through Butte Slough and the Sacramento River.

Future construction of upstream storage projects would reduce the magnitude of flood peaks entering the "sink". But since overflow into the Butte Basin over Colusa Weir occurs when the flow reaches 28,000 cfs, the lower basin would continue to receive floodwaters nearly every year regardless of the amount of upstream storage constructed. Typical future storage developments on the tributaries would store peak floodflows and release them over a 5-to-10-day period. This operation would have an effect on the lower Butte Basin in that the peak stage in the "sink" would be lower, but the "sink" would remain inundated for longer periods of time. A possible solution to this problem would be the dredging of Butte Slough and the construction of a control structure at Stohlman Ridge in Butte Slough. Further studies of the Butte Basin should consider this possibility.

The Butte Basin provides wintering grounds for millions of waterfowl using the Pacific Flyway. It is the location of many of the finest duck clubs in the Central Valley. Construction of the bypass plan as adopted by the Reclamation Board would have very little effect on the lower Butte Basin. Water would reach the lower basin in essentially the same quantity and quality as it does today. Waterfowl in the lower basin should be unaffected by the bypass plan. However, many changes would occur in the upper and middle basins. Land outside of the levees would be reclaimed and put to more productive use. At the present time, many acres of marshland and riparian habitat support large quantities of waterfowl and upland game. If these marshlands are reclaimed, the Department of Fish and Game feels that it may be necessary to replace them with other suitable habitat. The most likely place would be within the project levees. The Department of Fish and Game has proposed that some lands within the bypass could be purchased and dedicated to wildlife as has been done in the Sutter Bypass at the Sutter National Wildlife Refuge.

The major flood damage area in the upper Sacramento River Basin centers around the Butte Basin. A large percentage of the downstream flood control benefits claimed by upstream storage projects result from a reduction of overflows into the upper Butte Basin. These storage projects will reduce the damages in the upper Butte Basin; but even with full development of potential upstream storage projects, overflows from the Sacramento River will continue to enter the upper Butte Basin during major storms. Provisions are needed to control the location of these overflows and to allow them to pass safely through the upper basin and into the lower Butte Basin.

Flood Control Accomplishments

Projects on tributaries of the upper Sacramento River would provide flood control in the individual stream basins and along the Sacramento River. Table 9 lists possible projects and shows the effect they would have on tributary floodflows.

TABLE 9

ESTIMATED PEAK TRIBUTARY FLOODFLOW REDUCTIONS DUE TO PROJECTS

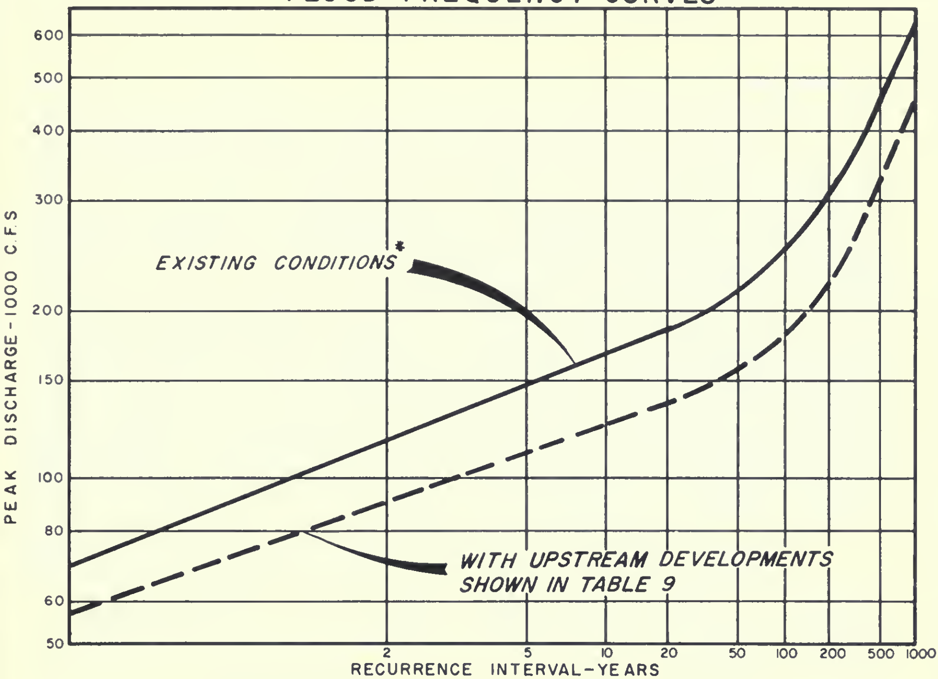
Stream	Project	1-in-50 Year Flood Flow Reductions 2/ (cfs)
Cottonwood Creek	Farquhar School and Dutch Gulch 1/	80,000
	Hulen, Dippingvat, Fiddlers 1/ and Rosewood	52,000
Cow Creek	Millville, Bella Vista and Diversions	32,000
Thomes Creek	Paskenta-Newville	37,000
Battle Creek	Battle Creek Diversion to Wing	21,000
Paynes Creek	Paynes Creek Diversion to Wing	10,000
Antelope Creek	Belle Mill	16,000
Elder Creek	Galatin	21,000
Bear Creek	Bear Creek Diversion to Millville	5,000

1/ Alternatives.
2/ As measured at the major gaging station of each tributary.

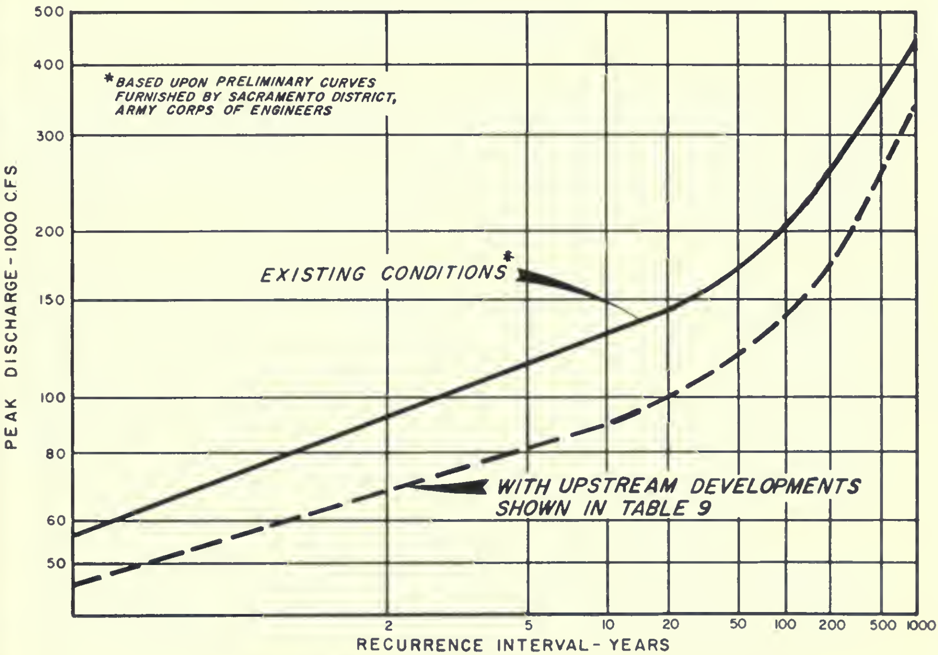
The projects listed in Table 9 are those which, at the present time, appear to show promise for construction in the foreseeable future. The data shown in the table is the result of a hydraulic analysis of the various projects. An economic analysis has not been made for every project to determine if it is feasible to provide the storage required to obtain the flood peak reductions shown.

Construction of reservoirs on the tributaries will have a marked effect on flows in the Sacramento River. The effects of the projects listed in Table 9 on the Sacramento River flows at Red Bluff and Ord Ferry (Chico Landing) are shown in Figure 13. The curves shown in the figures indicate the resultant conditions if each reservoir was operated to control flooding within its individual basin and not to maximize the peak reductions in the Sacramento River at Ord Ferry.

FLOOD FREQUENCY CURVES



SACRAMENTO RIVER AT ORD FERRY



SACRAMENTO RIVER AT RED BLUFF

Figure 13 shows that even with all of these projects in and operating, approximately once in every 30 years the flows at Red Bluff would exceed 110,000 cfs, the flow at which some flooding of residential areas occurs. On the average of once in every 300 years, a flow as high as that which occurred in 1964 (170,000 cfs) would be reached. Flows at Ord Ferry would exceed 100,000 cfs approximately once every 3 years and 210,000 cfs about once every 150 years.

Additional reductions in Sacramento River flows are possible if additional flood control storage is provided in each reservoir. This additional storage would be used to hold reservoir releases to essentially zero outflow while the Sacramento River is in a flood condition. The releases from all reservoirs would have to be fully coordinated to insure that the maximum reductions could be obtained. Operation of the system in this manner will require substantially more monitoring of flows and rainfall than we have at the present time.

Only a few of the tributary projects described in this chapter have been shown to be economically justified and it will be many years before some of them will be built. These projects would reduce the frequency of major flooding within the basin, but could not prevent damaging floods. In the meantime, floodplain management ordinances appear to be the most promising way of reducing future flood damages.

Additional Studies

The solution to the flood problems in the upper Sacramento River Basin will require implementation of the measures mentioned in this chapter. The inclusion of flood control features in all future reservoir developments will bring about a gradual decrease in flood damages within the basin. Continuing studies and action by local, state, and federal governments are needed to help solve the remaining flood problems.

In nearly all cases, reservoir projects cannot be justified for flood control alone. Previous investigations of the Sacramento River Basin by the Department have dealt with individual projects. Bulletin No. 137, "Sacramento Valley East Side Investigation", and Bulletin No. 150, "Upper Sacramento River Basin Investigation", presented individual projects on the tributaries of the Sacramento River. This investigation has updated previous studies of projects within the basin and provided a reconnaissance appraisal of the flood problems within the basin. Studies by the federal water development agencies, the Bureau of Reclamation and the U. S. Army Corps of Engineers, have also been oriented toward specific projects.

A comprehensive plan is needed to coordinate and guide the planning and staging of projects within the basin. A program is needed to integrate the flood control aspects and other purposes, such as in-basin water service, export water service, recreation, and fisheries -- thereby developing a multiple-purpose staged plan of development for the

Sacramento River Basin. An interagency agreement signed in September 1966 assigned the Department the responsibility of preparing a master plan of development for the entire basin. An investigation is needed to enable the Department to fulfill this responsibility.

The rapid development of urban areas along the State's waterways is creating flood problems which did not exist 15 years ago. Storage projects on the tributaries will take years to complete and will never completely solve flood problems in the Sacramento River Basin. Floodplain management studies are needed now to define the areas subjected to flooding so that zoning ordinances can be established. The Corps of Engineers has initiated floodplain studies on a few streams but more studies have been requested by local agencies than can be done in the near future with the funds available. This type of program should be expanded so that these studies can be completed as soon as possible. The Cobey-Alquist Flood Plain Management Act, adopted by the 1965 State Legislature, declares that local levels of government have the responsibility for establishing and enforcing floodplain regulations. Studies leading to the adoption of these regulations can be performed by the Department if the local agency pays the costs of the studies.

FIGURE 14


Weaverville
Wood
SHASTA LAKE
299
WHISKEYTOWN RES.
KESWICK RES.
S H A S T A
Middle
Beegum
Eureka
Cr.
North
HULEN RES.
Fork
Redding
Burney
Clear Cr.
Cow Cr.
Oak Run
Clover
Old Cow
South Cow Creek
Little Cow Cr.
Polo Cedro
Millville
MILLVILLE RES.
Cottonwood
Dry Cr.
Anderson
Bear Cr.
Cold
36
Fk
DIPPINGVAT RES.
South Fork
Cottonwood Cr.
Cottonwood
44
Battle Creek
Lassen Park
RIVER
Paynes
Red Bluff
Antelope
Elder
Cr.
T E H A M A
Susanville
PASKENTA RES.
Thomes Creek
5
Mill Creek
Los Molinos
NEWVILLE RES.
DEER CREEK MEADOWS RES.
BLACK BUTTE RES.
Corning
Deer Creek
CROWN RES
Stony
Creek
Chico Cr.
STONY GORGE RES
99
32
Big
G L E N N
B U T T E
Chico
Butte Cr.
SACRAMENTO
EAST PARK RES.
Willows
BUTTE BASIN
Woodland
Yuba City
UPPER SACRAMENTO RIVER BASIN INVESTIGATION
LOCATION MAP SHOWING PROJECTS STUDIED
SCALE OF MILES
4 0 4 8
PROJECTS STUDIED

CHAPTER IV. TRIBUTARY RESERVOIR PROJECTS

The legislation, Assembly Concurrent Resolution No. 18, which initiated this investigation requested that five specific projects be reevaluated: Hulen and Dippingvat on Cottonwood Creek, Millville on Cow Creek, Paskenta-Newville on Thomes and Stony Creeks, and Deer Creek Meadows on Deer Creek. Hulen, Dippingvat, and Millville were projects investigated in the studies which led to Bulletin No. 150. The Paskenta-Newville Project has been studied by state and federal agencies in recent years. A 1966 interagency agreement assigned to the Bureau of Reclamation the task of completing feasibility-level studies of Paskenta-Newville; these studies are nearing completion. The fifth project, Deer Creek Meadows Reservoir was discussed in Bulletin No. 137 as part of the Mill-Deer Project. This chapter presents our findings on the five specific projects mentioned in the resolution. These projects are shown on Figure 14.

Related Planning Considerations

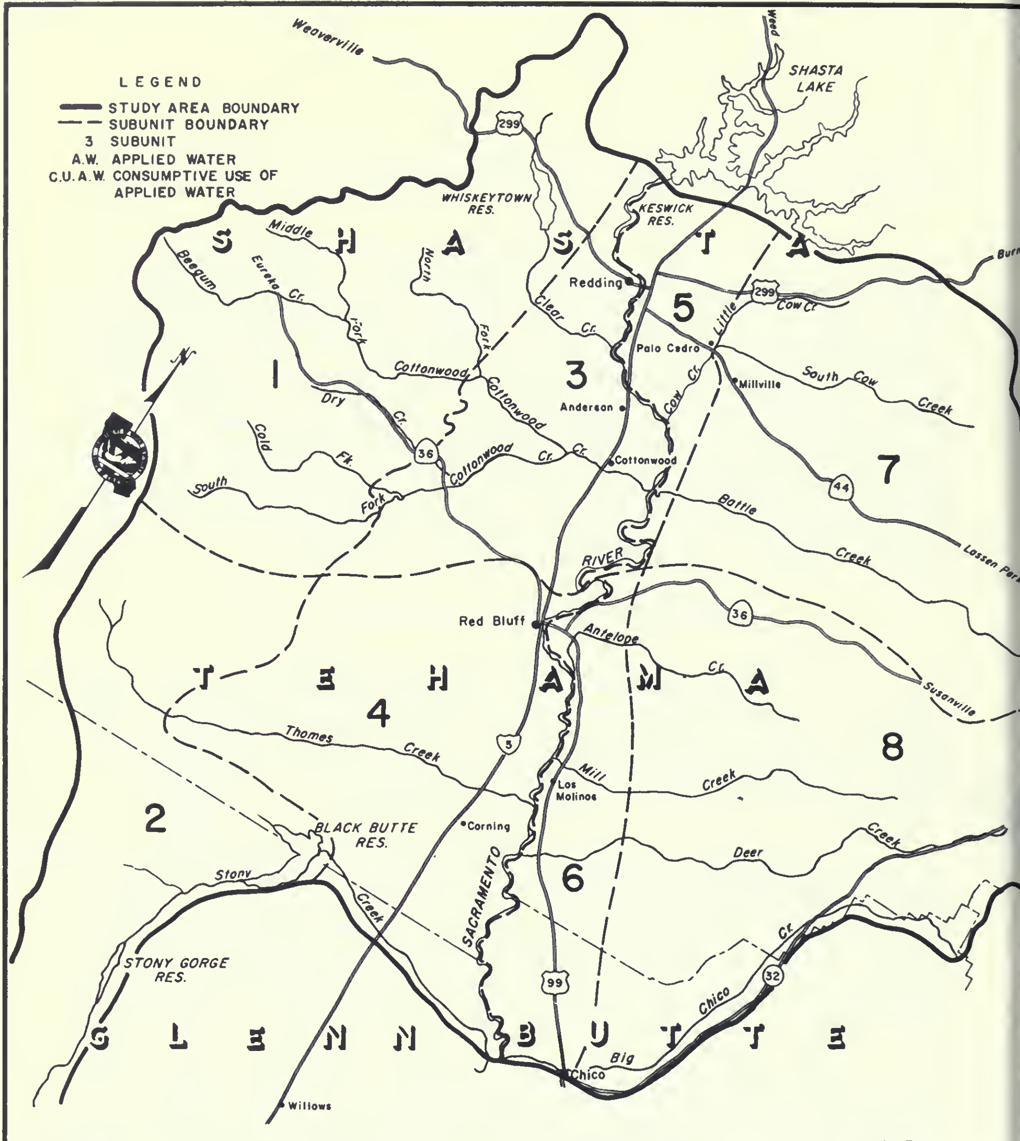
The reservoir projects considered for development on the tributaries of the Sacramento River would be multiple-purpose projects. The purposes considered include water service to the local area, flood protection, recreation, fisheries enhancement, hydroelectric power, and the export of water to other areas of need. A discussion of the planning considerations for each of these purposes follows.

As part of the Department's Coordinated Statewide Planning Program, estimates have been made of the future water demands for various study areas throughout the entire State. Most of the upper Sacramento River Basin is included in Study Area I, which is divided into eight subunits. The study area and estimates of the applied and consumptive use of water by subunit are given in Figure 15 for 1960, 1990, and 2020 levels of development. Water to meet these demands will come from a combination of ground water, in-basin surface water, and imported water developments.

The effects the tributary reservoirs would have on flood control in the Sacramento River Basin were presented in the previous chapter. The flood control benefits for the tributary storage projects analyzed in this chapter are derived from damage reduction within the tributary basin and downstream along the Sacramento River. Primary flood control storage is provided in all tributary projects where economically justified.

The increasing demand for recreation opportunities is of special importance to the development of California's water resources. The California Public Outdoor Recreation Plan of 1960 indicated that about 60 percent of all recreation in California is water oriented. The plan further stated that public access to thousands of acres of potential recreation lands and waters was sorely needed. This need will be magnified many times in the future.

FIGURE 15



Subunit 1

Year	A.W.	C.U.A.W.
1960	3,500	2,000
1990	5,500	3,100
2020	7,900	4,400

Subunit 2

Year	A.W.	C.U.A.W.
1960	4,900	2,700
1990	13,100	7,700
2020	14,000	8,200

Subunit 3

Year	A.W.	C.U.A.W.
1960	101,000	55,000
1990	213,000	95,000
2020	219,000	97,000

Subunit 4

Year	A.W.	C.U.A.W.
1960	297,000	130,000
1990	488,000	247,000
2020	568,000	346,000

Subunit 5

Year	A.W.	C.U.A.W.
1960	43,000	25,000
1990	93,000	55,000
2020	103,000	59,000

Subunit 6

Year	A.W.	C.U.A.W.
1960	159,000	99,000
1990	237,000	148,000
2020	285,000	179,000

Subunit 7

Year	A.W.	C.U.A.W
1960	48,000	29,000
1990	61,000	36,000
2020	75,000	45,000

Subunit 8

Year	A.W.	C.U.A.W.
1960	4,400	2,600
1990	4,400	5,600
2020	14,300	8,300

WATER REQUIREMENTS
COORDINATED STATEWIDE PLANNING

STUDY AREA I

SCALE OF MILES

4 0 4 8

The magnitude of the demand for all kinds of outdoor recreation is shown by the following Department of Water Resources' estimates of annual statewide recreation use:

Year	Statewide Outdoor Recreation Use (recreation-days)
1960	220,000,000
1990	2,500,000,000
2020	5,000,000,000

The portions of these uses that will be water oriented will cause increased pressure on water resource developments in all areas of the State.

Water developments must maintain existing fish and wildlife resources to the maximum practical extent. The upper Sacramento River is one of the most important salmon and steelhead streams in the State. The upper reaches of most tributaries are important trout habitats. Many of the west side tributaries contain potentially good salmon and steelhead spawning areas but support few fish because of low early fall and late spring flows. Some of the projects considered for development may be able to furnish adequate water supplies to enhance this valuable resource.

Bulletin No. 160-66, "Implementation of the California Water Plan", demonstrated the large future water needs of the State. The upper Sacramento River Basin produces nearly 4 million acre-feet of uncontrolled runoff. Proper development of this resource will result in water to meet in-basin requirements as well as statewide demands.

Preliminary studies using current hydroelectric power values showed that the development of hydroelectric power from the sites considered would cost more than the expected revenue. Consequently, power developments were not included in any of the plans presented in this report.

Development of Benefits and Cost

This section describes the principles and methods used in determining the economic justification, benefits, and costs for the Hulen, Dippingvat, and Millville Projects. The methods used for Deer Creek Meadows can be found in Bulletin No. 137. The Bureau's Paskenta-Newville report will contain a description of the methods and criteria used in their evaluation.

A project is economically justified if the primary project benefits exceed the total project cost when referenced to a similar time basis. Before authorization and construction of a project can proceed, determination of both economic justification and financial feasibility must be made. The determination of financial feasibility was beyond the scope of this investigation. A project is financially feasible if (1) Customers are ready, willing, and able to pay reimbursable costs for project products and services; (2) Sufficient capital is authorized and available to finance construction to completion; (3) Estimated revenue to be derived during the prescribed repayment period is sufficient to cover reimbursable project costs; and (4) There is no less expensive way of accomplishing the same purpose.

Salmon fishing on the Sacramento River at Balls Ferry

Typical spawning gravels below Millville Reservoir

Millville Reservoir area

Hulen Reservoir area

Dippingvat Reservoir area

Period of Analysis

The projects presented in this chapter, with the exception of the Paskenta-Newville Project, have been analyzed on the basis of construction in 1975, a 100-year economic life, and an interest rate of 4 percent. The Paskenta-Newville analysis is from the Bureau's study and is based upon the current federal interest rate of 3-1/8 percent. Each project has been analyzed independently of other possible projects within the basin.

Designs and Cost Estimates

Preliminary designs and cost estimates were prepared for the projects presented in this chapter. Details of these estimates are on file in the Department's Northern District office in Red Bluff.

Local Irrigation

Benefits to lands derived from project water are the differences between the return to the land with and without the project. In each project evaluated, ground water or other surface water supplies are possible sources of additional water. Irrigation distribution costs have been subtracted from the farm headgate benefit to derive the net benefit of water at the dam outlet.

Flood Control

Benefits from providing flood control storage in tributary reservoirs can accrue from within the tributary basin and along the Sacramento River. Benefits are computed as the differences between flood damages with and without the project. Each project has been analyzed as if it were to be the next project built. If a construction sequence different than this were assumed, different benefits would result.

Recreation

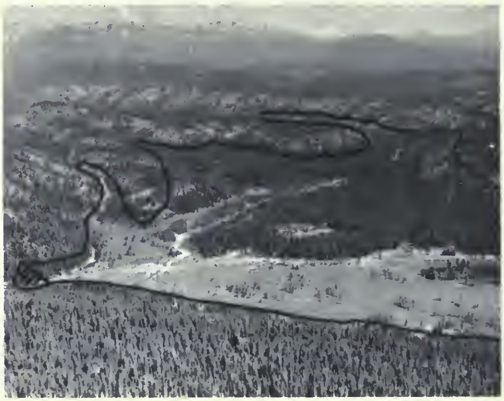
Recreation benefits due to construction of a specific project are the differences between recreation use with and without the project. The recreation-day values were supplied by the Department of Parks and Recreation, using current methods of analysis. Facilities were assumed to be built to minimum state park standards and were staged to meet the ultimate demands. A memorandum report covering these studies has been prepared by the Department of Parks and Recreation and is on file in the Department's Northern District office in Red Bluff.

Fishery Enhancement

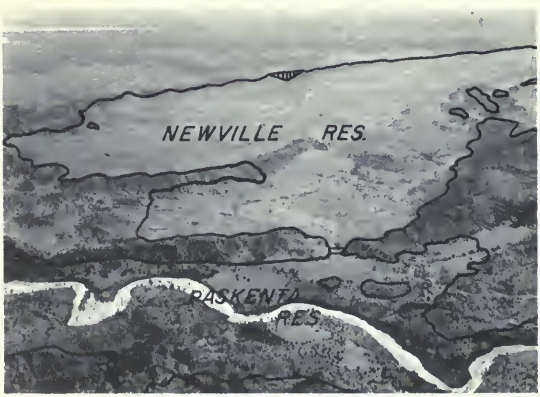
Providing stabilized spawning flows in the tributaries will increase the number of king salmon spawners. It is estimated that for every salmon which returns to spawn, three will be caught in the ocean or in the river. A fish caught commercially is calculated to have a value of $4.08. Ocean sport and river sport fishing benefits are based upon the value of a day's fishing and the amount of time required to catch a fish. Ocean sport benefits are $6.00 per fish and river sport benefits are

Hulen Dam and Reservoir

Dippingvat Dam and Reservoir



Deer Creek Meadows Dam and Reservoir



Paskenta-Newville Project,
Thomes Creek in foreground

Millville Dam and Reservoir,
Old Cow Creek left foreground

$28.00 per fish. Costs associated with attaining this increased production are given for each project. A Department of Fish and Game office report containing data presented in this report is on file in the Northern District office.

Yield to Sacramento-San Joaquin Delta

The major portion of the water to serve State Water Project needs in the southern portion of the State is pumped out of the Sacramento-San Joaquin Delta. This water is derived from two main sources, unregulated runoff and releases from upstream reservoirs such as Oroville.

Reservoirs such as Hulen, Dippingvat, and Millville would store waters which would have reached the Delta during periods of surplus flow. These waters would be conserved and released to meet water and fishery needs. The flows which would reach the Delta during dry periods would be usable as export yields. The determination of the yield, months of surplus, and months of deficiency are based upon the "Coordinated State Water Project - Central Valley Project Operation Study" used in the Oroville water rights hearing. This operation study is based upon the year 2015 level of development, considered to be average during the period of analysis.

Additional export water to the system following the Middle Fork Eel River Development is assumed to be needed in 1990. The benefit for providing this export yield is estimated to be $30 per acre-foot.

Hulen Project

The Hulen Project would be located in Shasta County on the North Fork of Cottonwood Creek (see Figure 14). The project would consist of a dam and reservoir, recreation facilities, and improvement of the stream channel of Cottonwood Creek below its confluence with the North Fork for increased salmon spawning potential.

The drainage area tributary to Hulen damsite is 86 square miles. The estimated average annual runoff for the period 1921-22 through 1940-41 is 121,000 acre-feet when corrected for estimated maximum future upstream water use.

Hulen Reservoir would be operated to provide downstream releases for irrigation in the Gas Point Road service area, to provide flood protection to the Cottonwood Creek area and downstream along the Sacramento River, and to enhance the salmon spawning runs in Cottonwood Creek. In addition, the project would provide suitable areas for recreational development and would augment flows available for export from the Sacramento-San Joaquin Delta.

A reservoir with a 136,000 acre-foot storage capacity would provide all of these project purposes and would maximize the net benefits available to this development. The project would provide increased salmon spawning runs by 6,250 fish, provide 20,000 acre-feet per year of additional flow for local irrigation, provide 40,000 acre-feet of flood control reservation, increase the potential yield at the Sacramento-San Joaquin Delta by 17,000 acre-feet annually, and provide facilities for an ultimate demand of 780,000 recreation-days of annual use.

Project Features and Costs

The project presented here is basically the same as that presented in DWR Bulletin No. 150 with some modifications to the operating criteria. The dam would be an earthfill structure, 222 feet high, with a crest elevation at 882 feet (see Figure 16). The details of the design may be found in the preliminary edition of Bulletin No. 150. The cost estimate for Bulletin No. 150 has been updated to 1968 price levels and is presented in Table 10.

TABLE 10

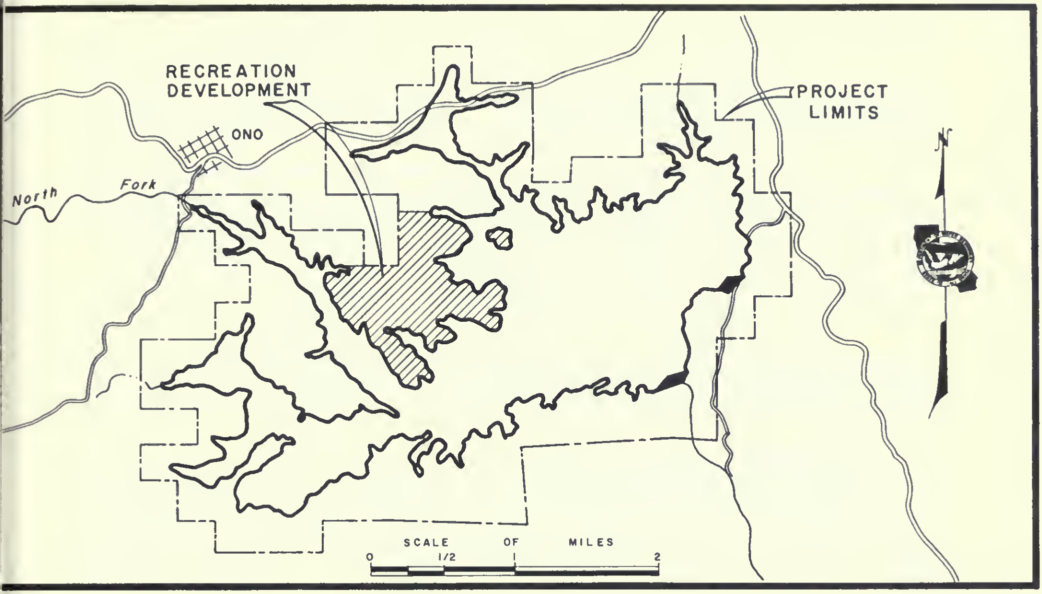
SUMMARY OF COSTS OF HULEN DAM, RESERVOIR, AND APPURTENANCES

Item	Construction Cost	Engineering, Administration, Contingencies, and Interest During Construction	Total Capital Cost
Dam and Appurtenances			
Embankment	$3,760,000		
Spillway	850,000		
Outlet Works	470,000		
Saddle Dam	200,000		
Subtotal	5,280,000	$2,100,000	$7,380,000
Reservoir			
Land Acquisition and Clearing	1,000,000		
Relocation of Roads and Utilities	270,000		
Subtotal	1,270,000	350,000	1,620,000
TOTAL	$6,550,000	$2,450,000	$9,000,000

The cost of irrigation distribution facilities was not included as a project cost. To be compatible with this approach, the irrigation benefit was based upon the benefit at the farm headgate minus distribution costs.

The costs of the recreational facilities to meet the expected usage were based on minimum state park criteria with a local agency building and operating the facilities. These facilities included water supply, sanitation, interior roads, boat launching ramps, and swimming beaches. The reservoir would be stocked with warmwater fish, and non-game fish would be removed from the reservoir area. These items would have a total capitalized cost of $2,750,000.

FIGURE 16



General Project Features
(All elevations are USGS datum)

Dam

Location	Section 16, T30N, R6W, MDB&M
Type	Zoned earthfill
Height above streambed, in feet	222
Crest elevation, in feet	882
Volume of fill, in cubic yards	2,470,000

Reservoir

Drainage area, in square miles	86
Water surface elevation at normal pool, in feet	869
Storage capacity, in acre-feet	136,000
Water surface area, in acres	2,740

Spillway

Type	Gated weir with three 20'×20' gates
Weir crest elevation, in feet	849
Design capacity, in cfs	30,000

Outlet Works

Type	36-inch steel pipe with multiple-level intake

The entire length of the main stem of Cottonwood Creek from the confluence of the Middle and North Forks to the Sacramento River would be improved for salmon spawning with water released from the Hulen Project.

In order to assure fish enhancement benefits provided by streamflow releases, the integrity of the spawning grounds below the project must be preserved and maintained. A stream habitat easement program proposed to protect 19 miles of main Cottonwood Creek would cost approximately $200,000. A streambed maintenance program would cost $10,000 annually. The total capitalized value of these costs is $450,000.

The development of the Hulen Project would cause loss of wildlife habitat, principally for deer and quail. Compensation for these losses could be accomplished by management of project lands on the south side of the reservoir.

Summary of Project Costs. A summary of project costs during the 100-year period of analysis is presented in Table 11. The capital cost of the project is estimated to be $10,100,000. The total capitalized cost of all initial and future expenditures is estimated to be $12,900,000. This is equivalent to an annual cost of $526,000 over the 100-year analysis period.

TABLE 11

SUMMARY OF HULEN PROJECT COSTS

Project Feature	Capitalized Costs			Average Annual Equivalent Cost
	Capital Cost	Operation, Maintenance, Replacement, and General Expenditures	Total	
Dam, Reservoir, and Appurtenances	$ 9,000,000	$ 700,000	$ 9,700,000	$396,000
Access Rights and Stream Improvement for Salmon Spawning	200,000	250,000	450,000	18,000
Recreation Facilities	900,000 1/	1,850,000	2,750,000	112,000
TOTAL	$10,100,000	$2,800,000	$12,900,000	$526,000

1/ Includes present worth of future expenditures.

Project Accomplishments and Benefits

The benefits and accomplishments of a 136,000 acre-foot capacity reservoir at the Hulen site are discussed in this section.

Local Irrigation. The Hulen service area contains 5,500 irrigable acres along Gas Point Road north of Cottonwood Creek and 1,000 acres south of Cottonwood Creek in the Baker Ranch area. Of this area 5,000 acres, having a maximum annual water requirement of 20,000 acre-feet, could be served by this project. The remaining 500 acres would support urban developments or be dry farmed. The Hulen Project would provide 24,000 acre-feet at the reservoir on an irrigation schedule. This would meet projected maximum future demands for irrigation water and allow for 4,000 acre-feet of transportation losses.

Portions of the service area show signs of urbanization. Many small residential farms exist at the present time. It is not expected that any major agricultural developments will occur in this area.

Approximately 3,000 acre-feet of water is presently applied to the service area from ground water pumping. The studies leading to Bulletin No. 150 showed that sufficient quantities of ground water might be available to supply the ultimate demands of this area. Estimates prepared during this investigation indicate that the cost of this water would average less than $6.00 per acre-foot. However, since the availability of ground water is subject to considerable discussion, the Hulen Project has been analyzed assuming that ground water is not available in sufficient quantities. If any further studies are made of this project, or other projects on Cottonwood Creek, detailed studies should be made to more closely determine the cost and availability of the ground water supplies.

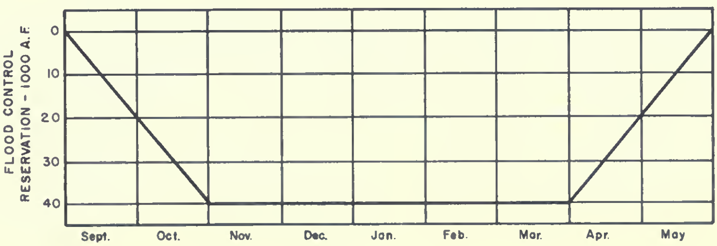
The crops projected for this area have a relatively low payment capacity and high water use. A weighted benefit of $10.60 per acre-foot was calculated for the crops projected for this area. Primary distribution costs are estimated to average $2.00 per acre-foot. This results in a net benefit of $8.60 per acre-foot at the reservoir. It is assumed that 25 percent of the ultimate demand will be met initially and full demand for project water will occur by the year 2000.

Based upon the above assumptions, the present worth of all future benefits for local irrigation is $3,300,000 or an average annual benefit of $135,000.

Flood Control. Forty thousand acre-feet of flood control storage would be provided on a November 1 to April 1 schedule (see Figure 17). This storage would allow for control of the 1-in-50-year flow on North Fork Cottonwood Creek to a maximum release of 2000 cfs.

FIGURE 17

FLOOD CONTROL OPERATION SCHEDULE FOR HULEN RESERVOIR



Flow-damage curves prepared by the Corps of Engineers were used in determining the flood control benefits. The benefits for providing this flood control are given in Table 12.

TABLE 12

HULEN PROJECT FLOOD CONTROL BENEFITS

Reach	Average Annual Values		Benefits
	Pre-Project Damages	Post-Project Damages	
Cottonwood Creek	$ 207,000	$ 152,000	$ 55,000
Sacramento River from Cottonwood Creek to Colusa, including Butte Basin	1,590,000	1,465,000	125,000
TOTAL			$180,000

Recreation. Water-associated recreation opportunities for boating, picnicking, reservoir fishing, and swimming would be provided at Hulen Reservoir. Facilities would be provided for some overnight use. The estimated annual recreation use will increase from 47,000 visitor-days initially to 780,000 visitor-days at the end of the period of analysis.

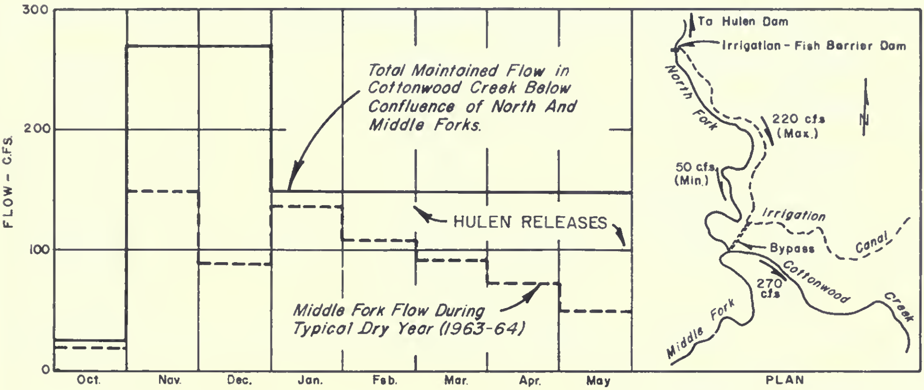
A value of $1.50 per recreation-day was used to calculate recreation benefits at Hulen. The estimated capitalized value of recreation benefits is $5,700,000. This is an average annual equivalent benefit of $232,000.

Fishery Enhancement. The Hulen Project would provide 38,000 acre-feet of water annually for fishery enhancement. Water released from Hulen Reservoir would augment the natural flow in the Middle Fork to maintain a minimum flow of 270 cfs below the confluence during November and December and 150 cfs from January through May. This release schedule is shown in Figure 18 for a moderately dry year (1963-1964).

Fluctuating flow releases in the North Fork below Hulen Dam could cause eggs deposited by spawning king salmon to be left exposed if preventive measures are not taken. Figure 18 shows a system whereby 50 cfs would be maintained in the North Fork at all times and additional releases bypass the lower reach of the North Fork. The combination irrigation diversion -- fish barrier dam would be designed to pass 50 cfs down the North Fork and divert all other fish releases (up to 220 cfs) into the first reach of the irrigation canal. The fish release water for lower Cottonwood Creek would be diverted back into the creek at the confluence of the North and Middle Forks.

FIGURE 18

HULEN PROJECT FISHERY ENHANCEMENT RELEASE SCHEDULE



Studies by the Department of Fish and Game indicate that adequate water temperatures for salmon spawning will be available in all but a few critically dry years.

Benefits for increased salmon runs will accrue due to the operation of Hulen Reservoir. Assured spawning releases of 270 cfs during November and December will increase the number of spawners in the Cottonwood Creek system by 6,250 fish. This will result in an estimated increase of 14,750 fish in the ocean commercial catch, 1,250 fish in the river sport catch, and 2,750 fish in the ocean sport catch. A 10-year buildup period would be necessary to attain this increased production.

The average annual benefit would be $82,000. The capitalized value of these benefits would be $2,000,000.

Yield to the Sacramento-San Joaquin Delta. The operation of Hulen Reservoir would create new yields to the Delta. Waters which previously reached the Delta during periods of excess would be conserved and released during periods of need.

The Hulen Project would yield 17,000 acre-feet of water to the Delta annually. A value of $30 per acre-foot was used in calculating the benefit, with the demand starting in 1990. The capitalized value of this benefit is $6,800,000. This is an average annual equivalent benefit of $278,000.

Summary of Project Benefits. A summary of the estimated project benefits during the 100-year period of analysis is presented in Table 13. The present worth of the total benefits is $22,200,000. This is an average annual equivalent benefit of $907,000.

TABLE 13

SUMMARY OF HULEN PROJECT BENEFITS

Feature	Present Worth of Total Benefits	Average Annual Equivalent Benefit
Local Irrigation	$ 3,300,000	$135,000
Flood Control	4,400,000	180,000
Recreation	5,700,000	232,000
Fishery Enhancement	2,000,000	82,000
Yield to Delta	6,800,000	278,000
TOTAL	$22,200,000	$907,000

Economic Justification

For a project to be economically justified, the primary tangible benefits from the project must exceed the total project cost when referenced to a similar time basis.

The present worth value of the project benefit was estimated to be $22,200,000. The total capitalized cost of the project, based on 1968 price levels and including present worth values of future expenditures for additions and for operation and maintenance, was estimated to be $12,900,000. The resulting comparison of benefits and costs indicate that the project is economically justified by the ratio of 1.72 to 1.0.

Allocation of Project Costs

A preliminary cost allocation was made to determine the proportion of the cost of the multiple-purpose project that should be charged to each of the various project purposes. The separable costs-remaining benefits method of analysis was used. For each of the purposes, the benefits set forth above would be limited by the least costly alternative method of providing the service. Table 14 is a summary of the preliminary cost allocation.

This allocation shows that the cost of producing new water supplies for the Delta would be $11.60 per acre-foot. Since it was assumed that the demand for additional Delta water will not occur until 1990, water would be delivered only during the last 85 years of the period of analysis.

TABLE 14

PRELIMINARY COST ALLOCATION FOR THE HULEN PROJECT
(Based upon average annual equivalent values)

	Irrigation	Flood Control	Recreation	Fishery Enhancement	Delta Yield	Total
Benefits	$135,000	$180,000	$232,000	$82,000	$278,000	$907,000
Alternative Costs	271,000	236,000	1/	260,000	186,000	
Total Justifiable Costs	135,000	180,000	232,000	82,000	186,000	815,000
Initially Separable Costs	75,000	43,000	110,000	17,000	-0-	
Remaining Benefits Before Dual-Costs				65,000	186,000	
Allocated Dual-Costs				17,000	49,000	
Total Separable Costs	75,000	43,000	110,000	34,000	49,000	311,000
Remaining Benefits	60,000	137,000	122,000	48,000	137,000	504,000
Percentage Distribution of Remaining Benefits	11.9%	27.2%	24.2%	9.5%	27.2%	100.0%
Total Project Cost						526,000
Total Separable Costs						-311,000
Total Remaining Joint Costs						215,000
Allocated Remaining Joint Costs	25,000	59,000	52,000	20,000	59,000	215,000
Separable Costs	75,000	43,000	110,000	34,000	49,000	311,000
Total Allocated Costs	$100,000	$102,000	$162,000	$54,000	$108,000	$526,000

1/ Alternative costs greater than benefits.

The Hulen Project analyzed during this investigation assumes that irrigation water would be served to the local area. The cost allocation assumes a single-purpose water supply reservoir as an alternative to a multiple-purpose project at Hulen. Using these assumptions, the allocated cost of 20,000 acre-feet of local irrigation water is $6.40 per acre-foot at the damsite. Further detailed studies of the ground water potential are necessary to determine the yields and costs of pumping. It may be more economical to serve the local area from ground water than from the Hulen Project. A Hulen Project without local irrigation would still have a benefit-cost ratio greater than unity.

Dippingvat Project

The Dippingvat Project is located in northwestern Tehama County on the South Fork of Cottonwood Creek (see Figure 14). The project would consist of a dam, reservoir, recreation facilities, and stream habitat improvement for salmon spawning.

The drainage area tributary to Dippingvat damsite is about 127 square miles. The estimated average annual runoff from the period 1921-22 through 1940-41 is 102,000 acre-feet when corrected for estimated maximum future upstream water use.

The Dippingvat Project was initially studied for the Bulletin No. 150 investigation and found to be economically justified. Costs and benefits for this project were updated and revised during this investigation to reflect current criteria and conditions. The general features of the Dippingvat Project are shown on Figure 19. A Dippingvat Reservoir with a storage capacity of 110,000 acre-feet would be operated to provide flood protection along South Fork Cottonwood Creek, along lower Cottonwood Creek, and along the Sacramento River, and to provide facilities for an ultimate demand of 91,000 recreation-days of annual use. In addition it would increase the annual king salmon spawning run in Cottonwood Creek by 18,000 fish and provide 11,000 acre-feet of new yield to the Sacramento-San Joaquin Delta.

The Dippingvat Project was analyzed with local irrigation as a project purpose. It was found that 9,000 acre-feet of water could be served to a service area along lower South Fork for $9.50 per acre-foot, exclusive of distribution costs. This cost makes it uneconomical to serve the crops projected for this area from Dippingvat Reservoir. Hence, local irrigation was not included as a project purpose in the final analysis.

Project Features and Costs

The dam section used in the present cost estimate is the same one presented in Bulletin No. 150. The only change made to the design was the addition of a radial gate system in the spillway to allow for release of stored floodwaters. Embankment costs and costs of the appurtenances were updated using current price indexes. Costs of lands and roads were revised to reflect current values and conditions.

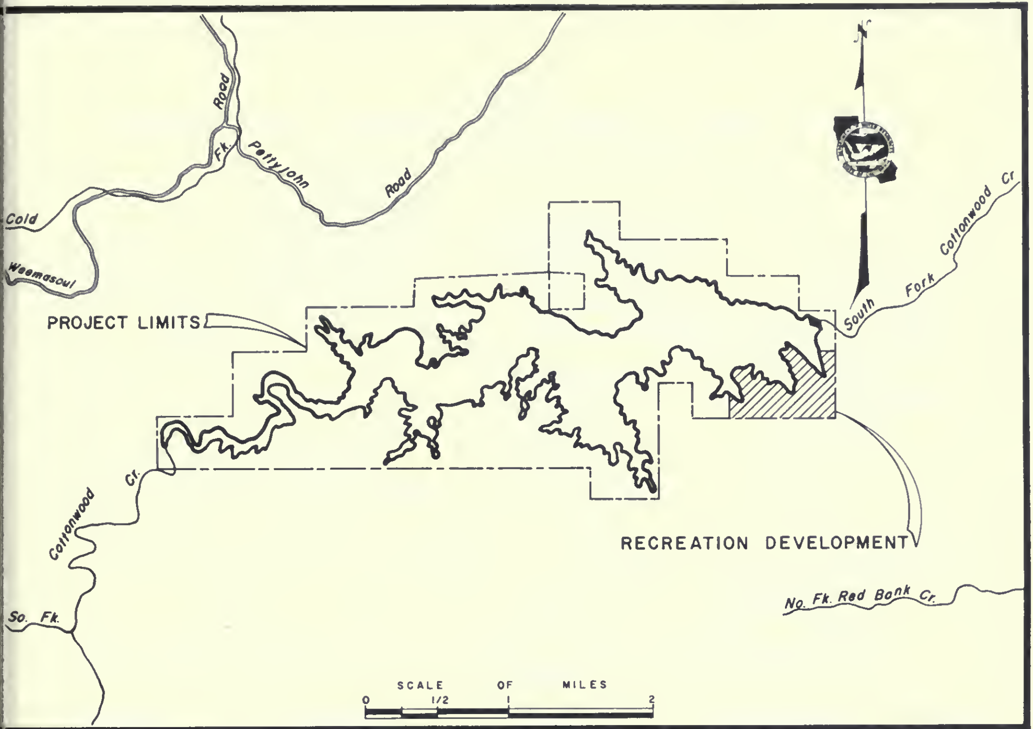
A summary of the costs for the Dippingvat Dam, Reservoir, and appurtenances is given in Table 15.

Facilities would be provided to handle the ultimate recreation use. Lands within the project limits could be developed to meet the maximum demands. The reservoir would be stocked with warmwater fish and nongame fish would be removed from the reservoir area. These items would have a capitalized cost of $640,000.

The Dippingvat Project would be operated to enhance the present salmon runs in South Fork and lower Cottonwood Creek. A 10-year fingerling planting program would be necessary at a cost of approximately $40,000 per year. To insure that the stream channel along South Fork Cottonwood is properly managed, it would be necessary to acquire stream channel easements along 32 miles of the South Fork and lower Cottonwood Creeks. These easements would have a capital cost of approximately $270,000. An average cost of $15,000 per year would be required to provide for a stream gravel rehabilitation program. The total capitalized cost of these expenditures would be $960,000.

DIPPINGVAT PROJECT

FIGURE 19



<u>General Project Features</u>
(All elevations are USGS datum)

<u>Dam</u>

Location.	Section 36, T27N, R7W, MDB&M
Type.	Earth and rock fill
Height above streambed, in feet	230
Crest elevation, in feet	1,216
Volume of fill, cubic yards	2,800,000

<u>Reservoir</u>

Drainage area, in square miles	127
Water surface elevation at normal pool, in feet	1,203
Storage capacity, in acre-feet	110,000
Water surface area, in acres	1,230

<u>Spillway</u>

Type	Gated chute with two radial gates 40'x 30'
Weir crest elevation, in feet	1,173
Design capacity, in cfs	62,000

<u>Outlet Works</u>

Type	30-inch steel pipe with multiple-level intake

TABLE 15

SUMMARY OF COSTS OF DIPPINGVAT DAM, RESERVOIR, AND APPURTENANCES

Item	Construction Cost	Engineering, Administration Contingencies, and Interest During Construction	Total Capital Cost
Dam and Appurtenances			
Embankment	$5,640,000		
Spillway	1,910,000		
Outlet Works	850,000		
Subtotal	8,400,000	$2,800,000	$11,200,000
Reservoir			
Land Acquisition and Clearing	510,000		
Relocation of Roads and Utilities	330,000		
Subtotal	840,000	260,000	1,100,000
TOTAL	$9,240,000	$3,060,000	$12,300,000

Some deer and quail habitat would be lost due to the construction of the Dippingvat Project. This habitat could be replaced by management and improvement of 600 acres within the project limits on the south side of the reservoir.

Summary of Project Costs. A summary of the project costs during the 100-year period of analysis is given in Table 16. The present worth of all expenditures during the 100-year period is $14,500,000, and the average annual equivalent cost would be $593,000.

Project Accomplishments and Benefits

The construction of the Dippingvat Project with a reservoir storage capacity of 110,000 acre-feet would provide flood control, recreation, fishery enhancement, and yield to the Sacramento-San Joaquin Delta. The benefits due to each of these purposes are discussed in the following sections.

Flood Control. Fifty-six thousand acre-feet of flood control storage would be provided at Dippingvat Reservoir. This reservation is greater than 50 percent of the gross reservoir capacity. In order to operate the reservoir efficiently, a flood control operation schedule

TABLE 16

SUMMARY OF DIPPINGVAT PROJECT COSTS

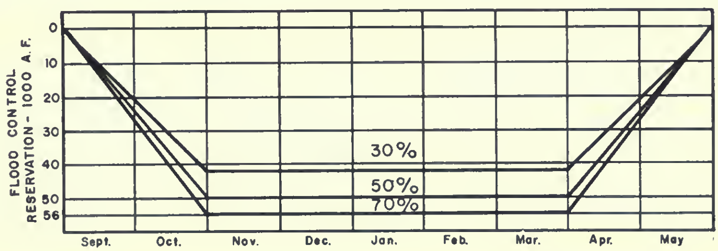
Project Feature	Capitalized Costs: Capital Cost	Capitalized Costs: Operations, Maintenance, Replacement, and General Expense	Capitalized Costs: Total	Average Annual Equivalent Cost
Dam, Reservoir and Appurtenances	$12,300,000	$ 600,000	$12,900,000	$528,000
Access Rights, Plantings, and Stream Improvement for Salmon Spawning	300,000	660,000	960,000	39,000
Recreation Facilities	200,000 1/	440,000	640,000	26,000
TOTAL	$12,800,000	$1,700,000	$14,500,000	$593,000

1/ Includes present worth of future expenditures.

like that shown in Figure 20 would be used. The parameter used on the diagram is the preceding 60 days precipitation as a percentage of the mean annual precipitation. The resulting flood control reservation will enable the maximum releases to be held to 4,000 cfs during a 1-in-50-year flood.

FIGURE 20

FLOOD CONTROL OPERATION SCHEDULE FOR DIPPINGVAT RESERVOIR



The operation of Dippingvat Reservoir would reduce flood damage along the South Fork and lower Cottonwood Creek and along the Sacramento River. The average annual benefits are $166,000 (see Table 17) and the present worth of all flood control benefits is $4,050,000.

TABLE 17

DIPPINGVAT PROJECT FLOOD CONTROL BENEFITS
Average Annual Values

Reach	Pre-Project Damages	Post-Project Damages	Benefits
Cottonwood Creek	$ 129,000	$ 96,000	$ 33,000
Along Sacramento River Cottonwood Creek to Colusa, including the Butte Basin	1,590,000	1,457,000	133,000
TOTAL			$166,000

This project by itself would not provide a significant degree of flood protection to the Cottonwood Creek Basin other than along the South Fork. A flood control plan utilizing Dippingvat and Hulen Reservoirs was presented in Chapter III.

Recreation. Recreation use at Dippingvat Reservoir was updated during this investigation to reflect current population growth projections. The use estimates include activities directly connected with the reservoir and its shoreline. No overnight camping facilities have been included at Dippingvat Reservoir because of the limited amount of developable lands.

The estimated annual recreation use will increase from 12,000 visitor-days initially to 91,000 visitor-days at the end of the period of analysis.

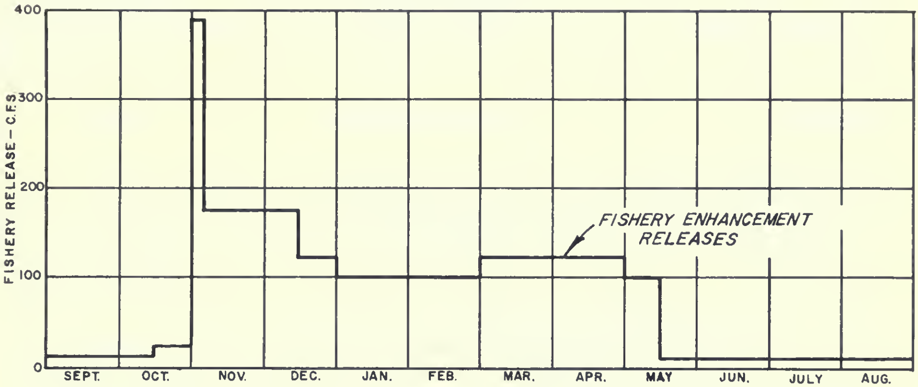
Benefits for recreation use at Dippingvat were calculated using a value of $1.45 per recreation day. The average annual benefit over the period of analysis is $58,000. The total capitalized value of recreation benefits is $1,410,000.

Fishery Enhancement. South Fork Cottonwood Creek contains gravels which could be utilized much more extensively if adequate flows at suitable temperatures were provided. Controlled releases from Dippingvat would enable the average spawning run of king salmon in South Fork and lower Cottonwood Creek to increase by 18,000 fish. The schedule of releases from Dippingvat for fishery enhancement is shown in Figure 21. These releases will total 56,000 acre-feet per year.

The potential average spawning run would be reached within approximately 10 years if an extensive 10-year planting program were conducted. At that time, the Dippingvat Project should produce 42,500 salmon annually for the ocean commercial catch, 7,900 annually for the ocean sport catch, and 3,600 annually for the river sport catch.

FIGURE 21

DIPPINGVAT PROJECT FISHERY ENHANCEMENT RELEASE SCHEDULE



The average annual benefit due to this increased production would be $238,000. The present worth of all fishery enhancement benefits would be $5,820,000.

Fishery enhancement benefits presented here are approximately 50 percent of the values shown in Bulletin No. 150. In that report, benefits were based upon the maximum spawning run. The benefits presented here are based upon the average potential spawning run, which is estimated to be 50 percent of the maximum run.

Yield to the Sacramento-San Joaquin Delta. Operation of the Dippingvat Project would create new yield to the Delta for export to other areas of need. Waters which previously reached the Delta during periods of excess would be conserved and released during periods of need.

The Dippingvat Project would yield 11,000 acre-feet of water to the Delta annually. It has been assumed that this water will be needed beginning in 1990 and that it will have a value of $30 per acre-foot. The average annual benefit due to this yield is $180,000 and the present worth of all export benefits is $4,420,000.

Summary of Project Benefits. Table 18 gives a summary of the benefits of the Dippingvat Project. The average annual benefit is $642,000 and the present worth of all benefits is $15,700,000.

Economic Justification

The present worth of project benefits for the 100-year period of analysis (1975-2075) is estimated to be $15,700,000. The total capitalized cost of the project, based upon 1968 price levels and including future expenditures for operation, maintenance, and replacement, is $14,500,000. A comparison of costs and benefits indicates that the Dippingvat Project would have a benefit-cost ratio of 1.08 to 1.

TABLE 18

SUMMARY OF DIPPINGVAT PROJECT BENEFITS

Project Purpose	Present Worth of Total Benefits	Average Annual Equivalent Benefit
Flood Control	$ 4,050,000	$166,000
Recreation	1,410,000	58,000
Fishery Enhancement	5,820,000	238,000
Delta Yield	4,420,000	180,000
TOTAL	$15,700,000	$642,000

A preliminary cost allocation among the various project purposes is given in Table 19. Though the project has a favorable benefit-cost ratio, the separate project purposes are not justified when subjected to a cost allocation. If the project costs and benefits are adjusted to a 1980 construction date (instead of 1975), each of the project purposes are justified. The project would therefore be economically justified if constructed in 1980.

TABLE 19

PRELIMINARY COST ALLOCATION FOR THE DIPPINGVAT PROJECT
(Based upon average annual equivalent values)

	Flood Control	Recreation	Fishery Enhancement	Delta Yield	Total
Benefits	$166,000	$58,000	$238,000	$180,000	$642,000
Alternative Costs	386,000	1/	463,000	120,000	
Total Justifiable Costs	166,000	58,000	238,000	120,000	582,000
Initially Separable Costs	104,000	26,000	39,000	-0-	
Remaining Benefits Before Dual-Costs			199,000	120,000	
Allocated Dual-Costs			65,000	39,000	
Total Separable Costs	104,000	26,000	104,000	39,000	273,000
Remaining Benefits	62,000	32,000	134,000	81,000	309,000
Percentage Distribution of Remaining Benefits	20.1%	10.4%	43.3%	26.2%	100.0%
Total Project Cost					593,000
Total Separable Costs					-273,000
Total Remaining Joint Costs					320,000
Allocated Remaining Joint Costs	64,000	33,000	139,000	84,000	320,000
Separable Costs	104,000	26,000	104,000	39,000	273,000
Total Allocated Costs	$168,000	$59,000	$243,000	$123,000	$593,000

1/ Alternative costs greater than benefits.

Bulletin No. 150 indicated that the Dippingvat Project was economically justified with a benefit-cost ratio of 2.1 to 1. The primary difference lies in the fishery enhancement benefits. The benefits shown in this report are less than 50 percent of those shown in Bulletin No. 150. The reasons for the difference were discussed in the fishery enhancement section.

Millville Project

The Millville Project is located in eastern Shasta County on South Cow Creek (see Figure 14). The project would consist of a dam, reservoir, recreational facilities, and stream habitat improvements for salmon spawning.

The Millville Project was studied during the Bulletin No. 150 investigation. During the present investigation, costs and benefits were updated to reflect current conditions and new information.

Benefits and costs were compared for several different reservoir sizes. Net benefits would be maximum for a reservoir with a capacity of 140,000 acre-feet and a normal pool elevation of 768 feet. Project purposes include local irrigation, flood control, recreation, fishery enhancement, and yield to the Sacramento-San Joaquin Delta.

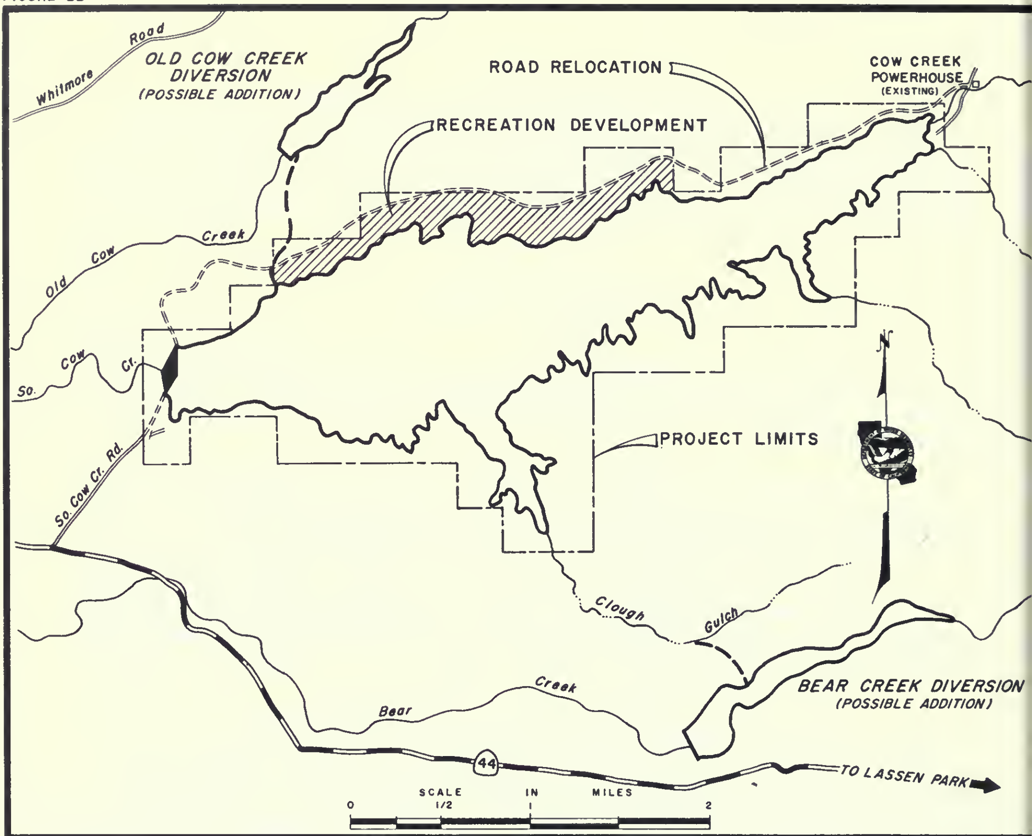
The general project features for the Millville Project are shown on Figure 22. Millville Reservoir would supply 8,000 acre-feet of irrigation water for use within the Cow Creek Basin; provide a measure of flood control along South Cow Creek, lower Cow Creek, and the Sacramento River; provide facilities for an ultimate annual use of 380,000 recreation-days; increase the annual spawning runs of king salmon by 6,900 fish; and provide 20,400 acre-feet of new yield to the Sacramento-San Joaquin Delta.

Project Features and Costs

The dam would be an earth-rock structure, 185 feet high, with a crest elevation of 785 feet. A gated spillway with the crest 5 feet below the conservation pool appears to be the most economical design due to the relatively small flood conservation storage. Costs of land acquisition and road relocations were updated to reflect current land values and road costs. Table 20 gives a summary of the costs for the Millville Project. Additional information concerning geology, materials, and mapping can be found in Bulletin No. 150.

Costs of a distribution system for the irrigation yields were subtracted from the benefit at the farm headgate to compute the benefit at the dam. Hence, no specific costs were included for an irrigation distribution system.

FIGURE 22



General Project Features
(All elevations are USGS datum)

Dam	
Location	$NE\frac{1}{4}$, Sec 17, T31N, R2W, MDB&M
Type	Earth-rock
Height above streambed, in feet	185
Crest elevation, in feet	785
Volume of fill, in cubic yards	2,750,000
Reservoir	
Drainage area, in square miles	79
Water surface elevation at normal pool, in feet	768
Storage capacity, in acre-feet	140,000
Water surface area, in acres	1,900
Spillway	
Type	Gated weir with two 17' x 28' gates
Weir crest elevation, in feet	753
Design capacity in cfs	20,000
Outlet Works	
Type	60-inch steel pipe with multiple-level intake

TABLE 20

SUMMARY OF COSTS OF MILLVILLE

DAM, RESERVOIR, AND APPURTENANCES

Item	Construction Cost	Engineering, Administration, Contingencies, and Interest During Construction	Total Capital Cost
Dam and Appurtenances			
Embankment	$4,150,000		
Spillway	560,000		
Outlet Works	660,000		
Subtotal	5,370,000	$2,130,000	$ 7,500,000
Reservoir			
Land Acquisition and Clearing	1,100,000		
Relocation of Roads and Utilities	1,030,000		
Subtotal	2,130,000	870,000	3,000,000
TOTAL	$7,500,000	$3,000,000	$10,500,000

Facilities would have to be provided to handle the ultimate recreation use. No additional lands would have to be purchased for recreational developments as lands within the project right-of-way would be sufficient. These facilities would include water supply, sanitation, interior roads, boat launching ramps, and swimming beaches. The reservoir would be stocked with warmwater fish and the non-game fish removed from the reservoir area. The capitalized cost of these items would be $1,350,000.

The Millville Project would be operated to enhance the present salmon runs in South Cow and lower Cow Creeks. To insure that the stream channel along South Cow Creek is properly managed, it would be necessary to acquire easements to 14 miles of streambed. Capital cost of this easement would be approximately $50,000. Annual stream gravel maintenance would be required at a cost of $12,000 annually. The total capitalized value of these expenditures would be $350,000.

Very little deer habitat exists in the Millville Reservoir area. The main loss of wildlife would occur through inundation of 5 miles of riparian habitat bordering South Cow Creek. Presently, this habitat supports large populations of valley quail and resident and migratory birds as well as limited numbers of small mammals. Replacement of such streamside habitat cannot be accomplished on lands immediately bordering the reservoir. Compensation could be accomplished by acquiring easements and managing similar streamside habitat downstream from the project.

Summary of Project Costs. A summary of the project costs during the 100-year period of analysis is shown in Table 21. The capitalized value of all expenditure during the 100-year period of analysis is $12,800,000 and the average annual equivalent cost would be $522,000.

TABLE 21

SUMMARY OF MILLVILLE PROJECT COSTS

Project Feature	Capitalized Costs: Capital Cost	Capitalized Costs: Operations, Maintenance, Replacement, and General Expense	Capitalized Costs: Total	Average Annual Equivalent Cost
Dam, Reservoir, and Appurtenances	$10,500,000	$ 600,000	$11,100,000	$454,000
Access Rights and Stream Improvement for Salmon Spawning	50,000	300,000	350,000	14,000
Recreation Facilities	450,000 1/	900,000	1,350,000	54,000
TOTAL	$11,000,000	$1,800,000	$12,800,000	$522,000

1/ Includes present worth value of future expenditures.

Project Accomplishments and Benefits

Construction of the Millville Project with a reservoir storage capacity of 140,000 acre-feet would provide local irrigation water, flood control, recreation, fishery enhancement, and yield to the Sacramento-San Joaquin Delta. The benefits for each of these purposes are discussed in the following sections.

Local Irrigation. The Millville service area contains 6,600 irrigable acres along South Cow and lower Cow Creek. Approximately

3,000 acres of the area are presently irrigated by ground water pumping. The ultimate demand for irrigation water is expected to reach 21,500 acre-feet by the year 2020 but urban encroachment is expected to reduce this demand to 17,000 acre-feet by the year 2070.

The Millville Project formulated in Bulletin No. 150 omitted local irrigation as a project purpose. Studies leading to that report showed that ground water could be supplied to meet the area's ultimate demands for less than $6.00 per acre-foot. A Millville Project to help meet the ultimate local irrigation demands is presented in this report in case ground water is unavailable or available at a higher cost than has been estimated. If further studies of this project are made, detailed studies should be made to determine the cost and availability of ground water.

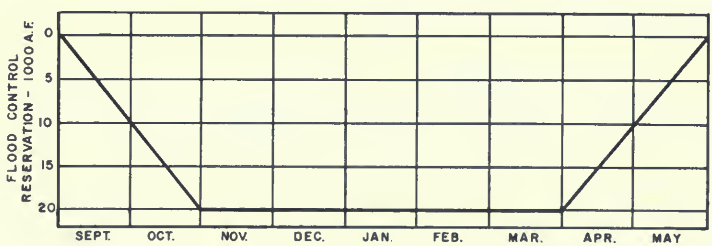
The Millville Project analyzed here would provide 10,000 acre-feet of water on an irrigation schedule. This would allow 8,000 acre-feet of new yield and 2,000 acre-feet for distribution losses. It has been assumed that 25 percent of the yield would be delivered initially and that full demands would be met within 15 years. The land use projected for this area includes some orchards and field crops but mostly irrigated pasture. The benefit for water supplied to this area was calculated to be $10.40 at the farm headgate. Primary distribution costs were estimated to be $2.00 per acre-foot. This results in a net benefit of $8.40 per acre-foot at the dam outlet.

Based upon the above analysis, the present worth of all future benefits for local irrigation is $1,340,000 and the average annual benefit is $55,000.

Flood Control. Twenty thousand acre-feet of flood control storage would be provided in Millville Reservoir to reduce flows in South Cow Creek and Cow Creek and along the Sacramento River. Primary flood control storage would be provided from November 1 to April 1. Figure 23 shows the flood control operation schedule for this project.

FIGURE 23

FLOOD CONTROL OPERATION SCHEDULE FOR MILLVILLE RESERVOIR



The operation of this reservoir would produce flood control benefits as shown in Table 22. The annual flood control benefit is $104,000 and the capitalized value of future benefits is $2,550,000. This project by itself would not develop a significant degree of protection to the Cow Creek Basin. The flood problems in this basin were described in Chapter III.

TABLE 22

MILLVILLE PROJECT FLOOD CONTROL BENEFITS
Average Annual Values

Reach	Pre-project Damages	Post-project Damages	Benefits
South Cow Creek	$ 52,000	$ 25,000	$ 27,000
Lower Cow Creek	40,000	21,000	19,000
Along Sacramento River and Upper Butte Basin	1,590,000	1,532,000	58,000
TOTAL			$104,000

Recreation. Revised estimates of the potential for recreation use at Millville Reservoir were made during this investigation. These estimates reflect recent population growth projections. Estimates include activities directly associated with the reservoir and its immediate shoreline. Other similar Sacramento Valley reservoirs have experienced approximately 10 percent overnight use. The estimates include this overnight use as well as facilities to accommodate the users.

The estimated annual recreation use would increase from 22,000 visitor-days initially to 380,000 visitor-days at the end of the period of analysis.

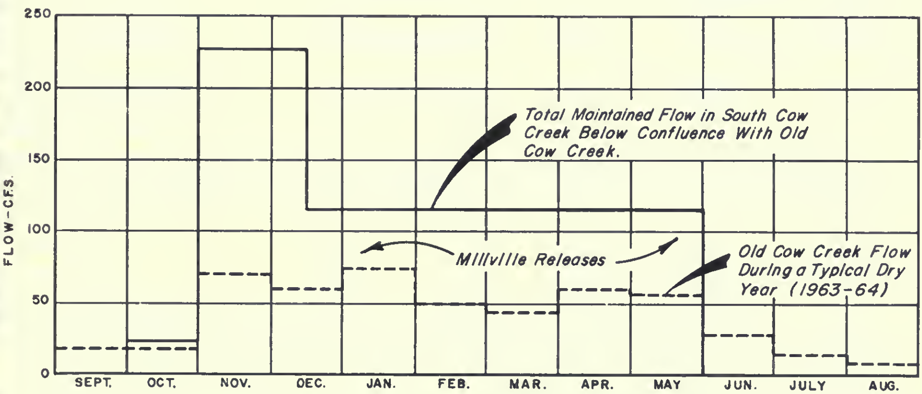
Benefits for recreation use at Millville Reservoir have been estimated to be $1.70 per visitor-day. The average annual benefit over the period of analysis is $125,000. The total capitalized value of all recreation benefits is $3,070,000.

Fishery Enhancement. The Millville Project would be operated to enhance present salmon runs in South Cow and lower Cow Creeks. Project releases would be augmented by natural flow from Old Cow Creek. The schedule of releases from Millville Reservoir for fishery enhancement is shown in Figure 24. These releases total 39,000 acre-feet per year. By providing assured spawning flows from the project, the salmon run could be increased by 6,900 spawners. This would be accomplished by maintaining a flow below the confluence with Old Cow Creek of 230 cfs from November 1 to December 15, and 115 cfs from December 16 through May 31. A minimum of 50 cfs would be maintained in South Cow Creek above the confluence with Old Cow Creek at all times from November through May. This potential average spawning run would be reached after 8 years of project operation.

The increased spawning run would produce an estimated annual increase in ocean commercial and ocean sport catches of 16,280 and 3,040 salmon, respectively, and 1,380 fish in the river sport catch.

FIGURE 24

MILLVILLE PROJECT FISHERY ENHANCEMENT RELEASE SCHEDULE



The average annual benefit due to this increased production will be $94,000. The capitalized value of these benefits would be $2,310,000.

Yield to Sacramento-San Joaquin Delta. The operation of Millville Reservoir would create new yield at the Sacramento-San Joaquin Delta for export to other areas of need. This operation would conserve water during periods of Delta surplus and release it during periods of deficiency.

The Millville Project would produce 20,400 acre-feet of new yield to the Delta. This yield will be needed starting in 1990. The average annual benefit due to this yield is $328,000. The present worth of all benefit is $8,030,000.

Summary of Project Benefits. Table 23 gives a summary of the benefits of the Millville Project. The average annual benefit is $706,000 and the present worth of all benefits is $17,300,000.

Economic Justification

The present worth of project benefits for the 100-year period of analysis (1975-2075) is estimated to be $17,300,000. The total

TABLE 23

SUMMARY OF MILLVILLE PROJECT BENEFITS

Project Purpose	Present Worth of Total Benefits	Average Annual Equivalent Benefits
Local Irrigation	$ 1,340,000	$ 55,000
Flood Control	2,550,000	104,000
Recreation	3,070,000	125,000
Fishery Enhancement	2,310,000	94,000
Delta Yield	8,030,000	328,000
TOTAL	$17,300,000	$706,000

capitalized cost of the project, based upon 1968 price levels and including future expenditures for operation, maintenance, and replacement, is $12,800,000. The benefit-to-cost ratio is 1.35 to 1.

Allocation of Project Costs

A preliminary cost allocation for the Millville Project is shown in Table 24. The Millville Project analyzed during this investigation assumes that irrigation water would be served to the local area. The cost allocation assumes a single-purpose water supply reservoir as an alternative to a multiple-purpose project at Millville. Using these assumptions, the allocated cost of 8,000 acre-feet of local irrigation water is $7.30 per acre-foot at the damsite. Further detailed studies of the ground water potential are necessary to determine the yields and costs of pumping. It may be more economical to serve the local area from ground water than from the Millville Project. A Millville Project without local irrigation would still have a benefit-to-cost ratio greater than unity.

The 20,400 acre-feet of new Delta yield could be supplied at a cost of $17.70 per acre-foot from 1990 to 2075.

Possible Additions to the Millville Project

Diversion of Bear Creek and Old Cow Creek are possible additions to the Millville Project. Bear Creek would be diverted by a 140-foot-high dam and an open cut into Clough Gulch. The estimated cost of this diversion is about $2,900,000. The water diverted to Millville Reservoir could increase the salmon fishery releases, provide flood protection to lower Bear Creek and along the Sacramento River, and increase the yield to the Delta. The present worth of these benefits is approximately $3,500,000. This addition appears to be favorable and should be considered in any future studies of the Millville Project.

TABLE 24

PRELIMINARY COST ALLOCATION FOR THE MILLVILLE PROJECT
(Based upon average annual equivalent values)

	Irrigation	Flood Control	Recreation	Fishery Enhancement	Delta Yield	Total
Benefits	$55,000	$104,000	$125,000	$94,000	$328,000	$706,000
Alternative Costs	254,000	231,000	271,000	313,000	219,000	
Total Justifiable Costs	55,000	104,000	125,000	94,000	219,000	597,000
Initially Separable Costs	30,000	25,000	54,000	14,000	-0-	
Remaining Benefits Before Dual-Costs				80,000	219,000	
Allocated Dual-Costs				48,000	132,000	
Total Separable Costs	30,000	25,000	54,000	62,000	132,000	303,000
Remaining Benefits	25,000	79,000	71,000	32,000	87,000	294,000
Percentage Distribution of Remaining Benefits	8.5%	26.9%	24.1%	10.9%	29.6%	100.0%
Total Project Cost						522,000
Total Separable Cost						303,000
Total Remaining Cost						219,000
Allocated Remaining Joint Cost	18,000	59,000	53,000	24,000	65,000	219,000
Separable Costs	30,000	25,000	54,000	62,000	132,000	303,000
Total Allocated Costs	$48,000	$84,000	$107,000	$86,000	$197,000	$522,000

The diversion of Old Cow Creek requires a dam on Old Cow Creek with a canal leading to Millville Reservoir. The estimated capital cost is $6,700,000. Benefits from diverting water from Old Cow Creek to Millville would be derived from increased flood protection in Cow Creek Basin and downstream, increased salmon spawning potential, and increased yield to the Delta. The present worth of these benefits is $5,100,000. Under present conditions, this diversion does not appear to be favorable.

Deer Creek Meadows Reservoir

A study of this dam and reservoir is reported on in Bulletin No. 137, "Sacramento Valley East Side Investigation, August 1967". In that report, the dam and reservoir are the key features of the Mill-Deer Project.

The project (see Figure 14) is located in eastern Tehama County. Surplus waters from Mill Creek would be diverted to Deer Creek Meadows Reservoir on upper Deer Creek by means of the Morgan Springs Diversion Dam via Childs Meadow Conduit. Water would be rediverted to terminal storage in Crown Reservoir on Brush Creek via the Ishi Diversion Dam and Yahi Canal. The project would include facilities for water-associated recreation and fishery enhancement. This project would be operated for recreation, flood control, fishery enhancement, local irrigation, and yield to the Sacramento-San Joaquin Delta.

Studies leading to Bulletin No. 137 indicated that specific reservations for flood control were not justified. Benefits for incidental flood control were assumed to be 50¢ per acre-foot of active storage. Studies for this report have included a more detailed estimate of the flood control potential of this project and the benefits which could be attained.

Since the Bulletin No. 137 data is recent, no attempt has been made to refine the costs or benefits (except flood control). The present study has: (1) evaluated the potential of the Mill-Deer Project as presented in Bulletin No. 137 to control flooding, (2) searched for alternative reservoir sites which might economically control flooding, and (3) estimated the benefits which could be derived from various flood control plans.

Flood Control Potential of the Mill-Deer Project

As presented in Bulletin No. 137, the Mill-Deer Project included two storage features -- a 153,000 acre-foot reservoir at Deer Creek Meadows and a 11,000 acre-foot offstream Crown Reservoir. No specific reservations were included in either reservoir for flood control.

Deer Creek Meadows Reservoir would control the runoff of 52 square miles of upper Deer Creek. This represents only about one-fourth of the total drainage area above the valley floor. Most of the runoff comprising the peak flow along lower Deer Creek originates below the damsite. Hence, storage at Deer Creek Meadows would have very little effect on the flood peaks along lower Deer Creek. It would reduce flows in the upper reaches, particularly in the areas along Highway 32 where many campgrounds are located.

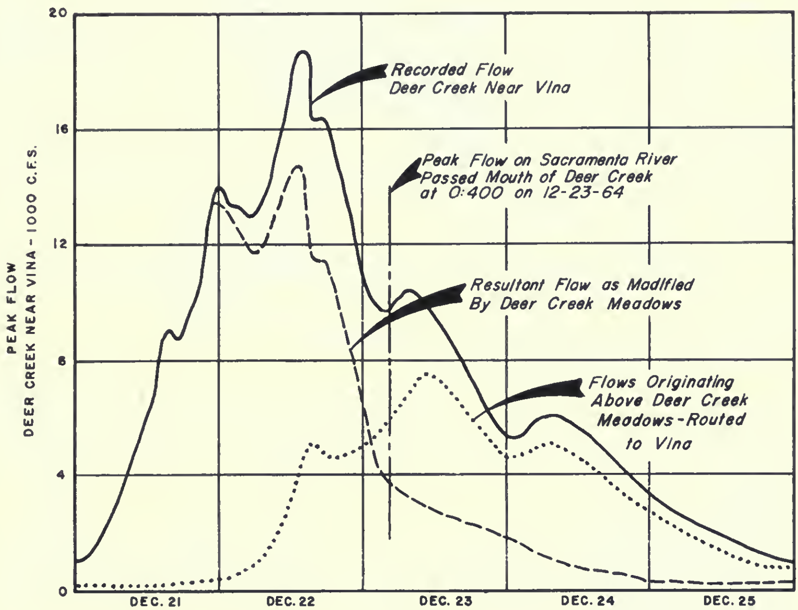
Deer Creek Meadows Reservoir might have some influence upon peak flows in the Sacramento River. Under most flood circumstances, the peak runoff from Deer Creek flows into the Sacramento River approximately 14 hours before the main Sacramento River peak arrives. This indicates that flows arriving in lower Deer Creek after the peak in Deer Creek would have a measurable effect on Sacramento River flows.

Figure 25 shows the Deer Creek flows during the December 1964 flood and the possible effect a dam at Deer Creek Meadows could have had. The solid line indicates the actual flow that was recorded at the Vina gage on Deer Creek. The dotted line indicates the flows which would have passed through Deer Creek Meadows Reservoir and traveled to the Vina gage. These flows were lagged 20 hours to allow for travel time. The dashed lines indicate the flows which would have occurred at the Vina gage had Deer Creek Meadows Reservoir been constructed and held the releases to zero.

Deer Creek Meadows Reservoir would have reduced the peak flow in lower Deer Creek from 18,800 cfs to 14,500 cfs. However, it would have reduced the Deer Creek flow contributing to the Sacramento River peak from

FIGURE 25

THE EFFECTS OF A DAM AT DEER CREEK MEADOWS IN THE DECEMBER 1964 FLOOD



9,600 cfs to 3,400 cfs. An analysis of the standard project flood on Deer Creek[1] shows that a reservoir at Deer Creek Meadows could reduce the peak flow on lower Deer Creek from 27,400 cfs to 22,000 cfs if no releases were made during the early part of the storm. The inflow to the peak Sacramento River flows would be reduced from 14,000 cfs to 5,000 cfs if no releases were made during the peak of the flood.

Protection against a 1-in-50-year flood at Deer Creek Meadows Reservoir could be provided by reserving 20,000 acre-feet of storage for floods during the winter. Full flood control reservations would be maintained from November 1 to April 1 each year with reduced amounts during

1/ Taken from "Office Report, Standard Project Floods-Sacramento River and Tributaries above Ord Ferry", U. S. Army Engineer District, Corps of Engineers, Sacramento, California, March, 1963.

September, October, April, and May. Maximum releases would be limited to 2,500 cfs. This operation would reduce the 1-in-50-year peak flow on lower Deer Creek by about 3,000 cfs and the inflow to the Sacramento River peak by 5,000 cfs.

Crown Reservoir would contain only 11,000 acre-feet of storage at normal pool. As envisioned in Bulletin No. 137, the diversion channels were designed to carry only 225 cfs and to act as an artificial spawning channel as well as diversion canal. A new canal to carry 5,000 cfs would cost in excess of $1,000,000 to construct. Since existing levee protection on lower Deer Creek has a design capacity of 21,000 cfs, the only flood control benefits from the new canal would be those along the Sacramento River. The capitalized benefit of diverting 5,000 cfs out of Deer Creek during times of high flow in the Sacramento River would be about $650,000. It therefore would not be economical to construct a flood diversion from Deer Creek to Crown Reservoir.

The possibility of constructing a larger Crown Reservoir will be discussed in the next section.

Alternative Flood Control Sites

The Deer Creek Basin contains many good damsites in the steep canyons above the valley floor. However, there are very few good reservoir sites. With the exception of Deer Creek Meadows, storage is very costly at every site which the Department has investigated.

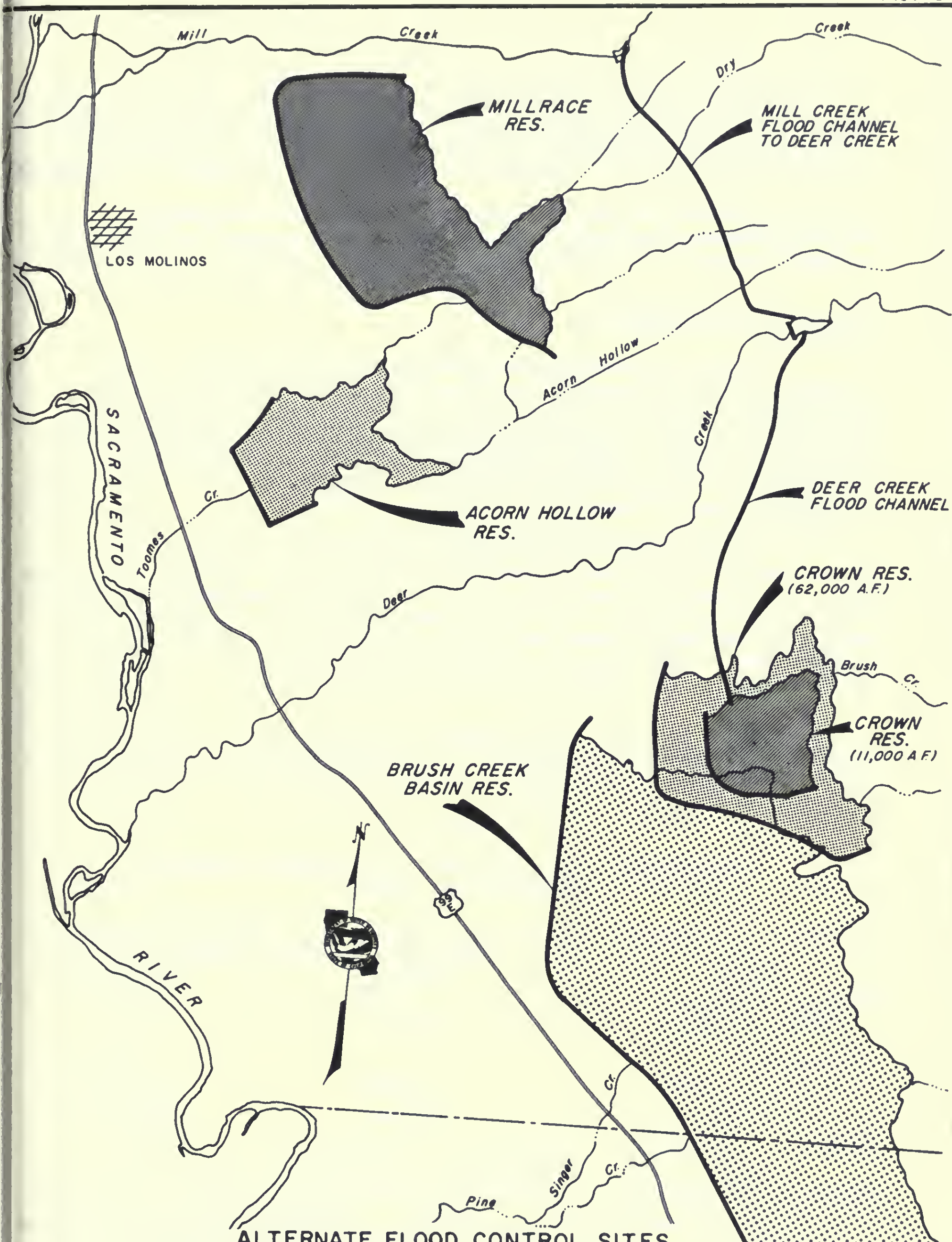
The topography of Mill Creek is very similar to that of Deer Creek. There are many good damsites, but storage capacity is limited. Hence, the cost of storage is quite high. Schemes have also been studied to divert both Deer and Mill Creeks into common valley floor reservoirs (see Figure 26).

An enlarged Crown Reservoir could be constructed with a capacity of 62,000 acre-feet. Floodwaters from Mill and Deer Creeks could be diverted into Crown Reservoir by the flood channels shown in Figure 26. This capacity would be sufficient to limit flows in each creek to approximately 4,000 cfs for a 1-in-50-year flow. This project would cost approximately $35,000,000.

Brush Creek Basin Reservoir (see Figure 26) with a storage capacity of 400,000 acre-feet could be designed to receive all floodflows from Deer and Mill Creeks and to provide conservation storage. However, the cost of a dam and conveyance channels is estimated to be in excess of $80,000,000. Poor foundation conditions such as those which were encountered at Crown Reservoir could push this estimate much higher.

The Millrace site on Toomes Creek is ideally located to receive floodwaters from Deer and Mill Creeks. The reservoir would have a capacity of approximately 95,000 acre-feet and could provide conservation as well as flood control storage. The cost of this project is estimated to be in excess of $35,000,000.

FIGURE 26



ALTERNATE FLOOD CONTROL SITES
UPPER SACRAMENTO RIVER BASIN DEVELOPMENT
DEER AND MILL CREEKS

The Acorn Hollow site is also located on Toomes Creek. However, only 40,000 acre-feet of storage is available at this site with maximum development. A reservoir at this site could only partially control flood-flows in Mill and Deer Creeks, and the cost would be in excess of $25,000,000.

As part of their Northern California Streams Investigation, the Corps of Engineers is studying several sites in the middle reaches of Deer and Mill Creeks.

Best Plan of Development

All of the flood control reservoirs on Mill and Deer Creeks studied during this investigation would have a high construction cost. Benefits for flood control from these reservoirs would come from a reduction in flow along lower Deer and Mill Creeks, along the Sacramento River, and in Butte Basin. Levees along lower Deer Creek are designed to pass 21,000 cfs, so annual damages are quite low. Mill Creek has a high channel capacity so annual damages are very low here also.

The main benefits from flood control on Deer and Mill Creeks would come from reduction in damage along the Sacramento River and in Butte Basin. Even here the benefits are quite low because Deer and Mill Creeks are not heavy contributors to the Sacramento River peak flows. As mentioned before, these creeks peak, on the average, about 14 hours before the Sacramento River peaks. Consequently, these streams do not contribute substantially to the peak flows in the Sacramento River.

Table 25 shows the potential downstream benefits which could be derived by reducing the flows in Deer or Mill Creeks to the given amounts. The benefit values are approximately equal for each stream.

TABLE 25

DEER AND MILL CREEKS, POTENTIAL FLOOD CONTROL BENEFITS
Average Annual Values

	Maximum Flow in Deer or Mill Creek	
Reach	4,000 cfs	1,000 cfs
Sacramento River - Tehama to Colusa	$15,000	$35,000
Butte Basin - Upper and Middle	12,000	27,000
Total for each creek	$27,000	$62,000

Based on 4 percent interest and a 100-year repayment period, only $1,500,000 in expenditures could be justified for each creek for flood control projects to limit flows to 1,000 cfs. Only $660,000 would be justified if releases were held to 4,000 cfs. None of the alternative flood control projects mentioned in the previous section could be constructed for these costs.

It is therefore concluded that, under today's conditions, it is not economical to include flood control as part of any downstream reservoir in this area. The Mill-Deer Project as presented in Bulletin No. 137 appears to be the best plan for development of the water resources of this basin. The Crown Reservoir as presented in Bulletin No. 137 is the best initial development to provide offstream storage on Deer Creek.

Deer Creek Meadows Reservoir could be modified to provide 20,000 acre-feet of flood control storage. The only additional cost involved would be $375,000 to enlarge the outlet to discharge 2,500 cfs. The costs of the Mill-Deer Project are shown in Table 26.

TABLE 26

SUMMARY OF MILL-DEER PROJECT COSTS

Project Feature	Capitalized Costs			Average Annual Equivalent Cost
	Capital Cost	Operation, Maintenance, Replacement, and General Expense	Total	
Morgan Springs Diversion, Childs Meadows Conduit, and Appurtenances	$ 3,880,000	$ 20,000	$ 3,900,000	$ 159,000
Deer Creek Meadows Dam, Reservoir and Appurtenances	14,950,000	650,000	15,600,000	636,000
Recreation Facilities	4,400,000	11,900,000*	16,300,000	665,000
Ishi Diversion Yahi Canal**	950,000	550,000	1,500,000	61,000
Crown Dam, Reservoir and Appurtenances	5,410,000	90,000	5,500,000	225,000
Recreation Facilities	100,000	600,000*	700,000	29,000
Vina Canal, Primary Irrigation Distribution System, and Appurtenances	1,210,000	390,000	1,600,000	65,000
TOTAL	$30,900,000	$14,200,000	$45,100,000	$1,840,000

* Includes present worth value of future additions.
** Including artificial spawning facilities.

The incidental flood control benefits shown in Bulletin No. 137 were based upon a value of 50¢ per acre-foot of active storage. A more detailed analysis shows the actual benefits to be $40,000 annually, or a capitalized benefit of $1,000,000. This is based upon reducing the 1-in-50-year flood at Deer Creek Meadows to 2,500 cfs by providing 20,000 acre-feet of flood control storage. The revised benefits for this project are given in Table 27.

TABLE 27

SUMMARY OF MILL-DEER PROJECT BENEFITS

Project Purposes	Capitalized Benefits	Average Annual Equivalent Benefits
Recreation	$23,800,000	$ 975,000
Fishery Enhancement	18,400,000	750,000
Local Irrigation Yield	5,500,000	225,000
Export Yield	5,900,000	240,000
Flood Control	1,000,000	40,000
TOTAL	$54,600,000	$2,230,000

The total capitalized cost of the Mill-Deer Project would be $45,100,000. The present worth of all benefits would be $54,600,000. The resultant benefit-cost ratio would be 1.21 to 1, and the project would be economically justified if constructed in 1970.

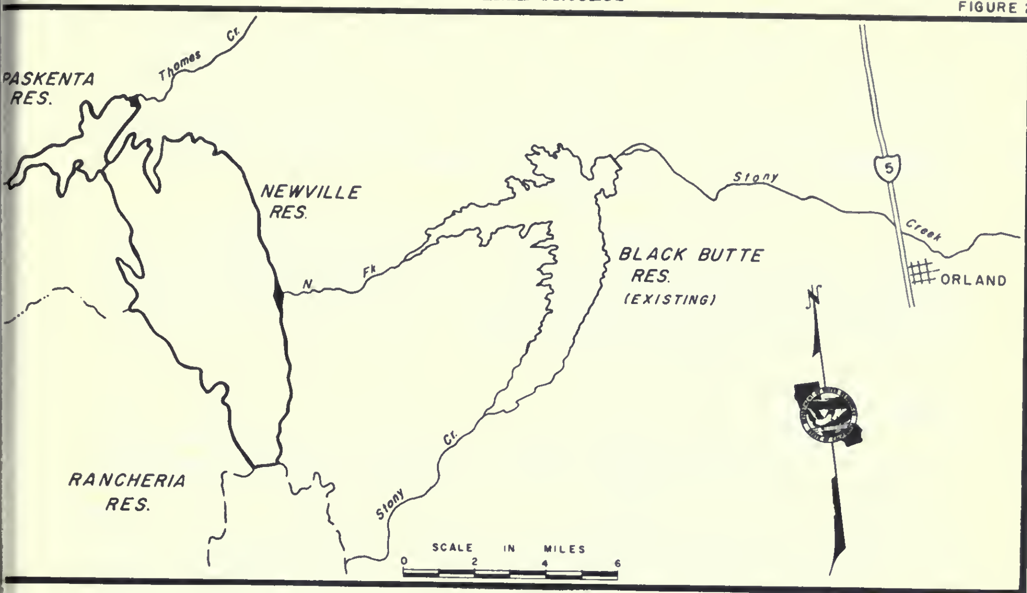
Paskenta-Newville Project

The Bureau of Reclamation has studied this project in detail and is nearing completion of a feasibility report. The following information has been taken from preliminary data received from the Bureau. Figure 27 shows the location of this project on Thomes and North Fork Stony Creeks and gives the pertinent data.

Project Analysis and Costs

Since North Fork Stony Creek has a mean annual runoff of only 26,000 acre-feet, most of the water for this project would be derived from Thomes Creek (196,000 acre-feet per year). Water from Paskenta Reservoir would be diverted to Newville Reservoir over an uncontrolled weir located in a saddle between the reservoirs.

FIGURE 27



General Project Features
(All elevations are USGS datum)

Dam	Paskenta	Newville
Location	Sec. 6, T23N R6W, MDB&M	Sec. 3, T22N R6W, MDB&M
Type	Rolled earth and rockfill	Rolled earth, sand and gravel fill
Height above streambed, in feet	233	390
Crest elevation, in feet	1,023	989
Reservoir		
Drainage area, in square miles	191	55
Water surface elevation at normal pool, in feet	1,006	975
Storage capacity, in acre-feet	129,600	2,986,700
Water surface area, in acres	1,943	16,560
Spillway		
Type	Uncontrolled crest	Gated weir
Weir crest elevation, in feet	1,006	960
Outlet Works		
Capacity, in cfs	1,400	4,500

The Paskenta-Newville Project would store water to irrigate 10,700 acres in the local service area. The project would provide 80,000 acre-feet of flood control storage to limit 1-in-50-year floodflows on Thomes Creek to 5,000 cfs. The project would provide 300,000 acre-feet annually for export to other service areas of the Central Valley Project. In addition, the reservoir would provide opportunities for warmwater fishing and other types of recreation use.

The estimated capital cost of the dam, reservoir, land, facilities, and distribution system is $137,000,000. The estimated annual operation, maintenance, and replacement costs are $543,000. These costs include costs for the local conveyance and distribution and the capital cost includes interest during construction.

Project Benefits

The Paskenta-Newville Project would provide 43,000 acre-feet annually for irrigation in the local service area. Through integrated operation with the joint CVP-SWP system, this project would make 300,000 acre-feet of new yield available at the Delta for export. It would require approximately 25 years to fill this reservoir and thereby attain this export yield. Floodwaters from Thomes Creek would be diverted to Newville Reservoir which will reduce floodflows on lower Thomes Creek to non-damaging levels. Some flood control benefits will be accrued downstream along the Sacramento River. Benefits would also be accrued for fish and wildlife and recreation use. These benefits are summarized in Table 28.

TABLE 28

SUMMARY OF PASKENTA-NEWVILLE PROJECT BENEFITS

Project Purpose	Annual Equivalent Benefits
Municipal and Industrial	$5,136,000
Irrigation	2,010,000
Fish and Wildlife	69,000
Flood Control	610,000
Recreation	322,000
TOTAL	$8,147,000

Economic Justification

The estimated annual equivalent cost of the Paskenta-Newville Project (computed at 3 1/8 percent for 100 years) is $4,720,000. The estimated annual equivalent benefits are $8,147,000. The resultant benefit-cost ratio, 1.7 to 1, shows that the project is economically justified.

CHAPTER V. CONCLUSIONS AND RECOMMENDATIONS

Numerous plans have been investigated to control the runoff of the upper Sacramento River Basin and to prevent damaging floods. Shasta Dam, the result of one of these plans, was constructed in the 1940's as the first step in controlling the Sacramento River. Early plans called for another reservoir (Iron Canyon) on the main stem of the river near Red Bluff, but urbanization of areas which would have fallen within the reservoir area and other problems have forced abandonment of the Iron Canyon proposal. In recent years, the search for new conservation and flood control projects has been switched from the main stem to the tributaries. Nearly every major tributary from Shasta Dam to Colusa has been studied during previous state or federal investigations.

This report presents a reevaluation of five upper Sacramento River tributary reservoirs and identifies others which show a good potential for controlling floodflows and developing new water supplies. The report also presents a reconnaissance appraisal of basin-wide flood problems and potential solutions.

Conclusions

It is concluded that:

1. The streams which make the largest contribution to peak floodflows in the Sacramento River are (in order of magnitude) Cottonwood Creek, Cow Creek, Stony Creek, Clear Creek, Battle Creek, Thomes Creek, Deer Creek, Mill Creek, Antelope Creek, Paynes Creek, Elder Creek, Red Bank Creek, Bear Creek, and Big Chico Creek. Of these, the flood contribution from Cottonwood and Cow Creeks is by far the largest.

2. Runoff from the Sacramento Valley floor area contributes substantially to peak floodflows in the Sacramento River during some storms. It will not be practical to develop storage projects to control this valley runoff in the foreseeable future.

3. The streams which produce the highest peak flows within their individual basins are (in order of magnitude) Cottonwood, Stony, Cow, Thomes, Battle, Clear, Deer, Mill, Elder, Antelope, Big Chico, Paynes, Red Bank, and Bear Creeks.

4. The tributary basins which now suffer the greatest annual flood damages are the Thomes Creek, Battle Creek, Cottonwood Creek, and Cow Creek Basins. The other tributary basins each receive less than $100,000 flood damages annually.

5. Several tributary projects appear to be suitable for construction in the near future. These projects can provide needed flood protection to the tributary basins and some reduction of flood peaks on the Sacramento River. In addition to providing flood protection, they can supply water to meet local needs, provide suitable habitat for increased salmon spawning, provide water for areas of deficiency within the State, and provide new recreational environment. The individual projects which appear to be the most favorable for construction in the near future are:

Paskenta-Newville. This project on Thomes Creek and North Fork Stony Creek would provide complete flood protection to the Thomes Creek Basin and a small reduction in flood peaks on the Sacramento River. It would provide 43,000 acre-feet per year of local irrigation water and 300,000 acre-feet per year for export if integrated with the joint CVP-SWP system. It would require approximately 25 years to fill this reservoir and thereby attain this export yield. The Bureau of Reclamation is responsible for the feasibility studies of this project.

Cottonwood Creek Projects. Either two large reservoirs (Dutch Gulch and Farquhar School) or a series of at least four smaller reservoirs (Hulen, Dippingvat, Rosewood, and Fiddlers) appear to be suitable means of providing flood protection to the Cottonwood Creek Basin as well as serving local needs. The large reservoirs would provide a greater reduction in Sacramento River floodflows and more water for export to other areas of need. By interagency agreement, the Corps of Engineers is responsible for studies to select the best plan of development for this basin.

Millville. This project on South Cow Creek could provide some flood protection for the Cow Creek Basin and along the Sacramento River. Additions to this project and construction of other projects within the Cow Creek Basin would be necessary to obtain a high degree of flood protection.

Wing. This project could deliver excess flows from Battle and Paynes Creeks to a reservoir on Inks Creek. Water conserved in Wing Reservoir could yield 50,000 acre-feet of new yield to other areas of the State as well as provide flood protection.

Deer Creek Meadows. This project has limited flood control potential but has high recreation and fishery enhancement potential. It is capable of yielding 20,000 acre-feet of new water for local irrigation and 18,000 acre-feet of new water to the Delta.

Jonesville. This project on upper Butte Creek would provide very little additional flood protection. Levees on lower Butte Creek already provide a high degree of protection to the agricultural lands within the basin. This project would provide 25,000 acre-feet of additional water supplies to the Paradise, Cohasset, and Forest Ranch areas and provide good recreational potential.

6. In addition to these reservoirs, there are other projects which should be considered in future years. Among these are Bella Vista Reservoir on Little Cow Creek, the Bear and Old Cow Creek diversions to Millville Reservoir, the Belle Mill Project on Antelope Creek, Galatin Reservoir on Elder Creek, and additional storage to control floodflows on Clear Creek.

7. It will be many years before all of the tributary projects are constructed. Even though some have been shown to be economically justified, their financial feasibility must be demonstrated before authorization, design, and construction can proceed.

8. Under conditions of full development of the tributary reservoir projects, flood damages will still occur within the upper Sacramento River Basin.

9. The best solution to flood problems in the upper Sacramento River Basin is a carefully integrated complex of reservoir projects, levee and bypass systems, channel maintenance, and floodplain management. This "solution" will take many years to implement.

10. The tributary reservoir projects studied during this investigation are not justified at this time for flood control alone. They must be formulated as multiple-purpose projects, and usually demands for additional water supplies will determine the timing of these projects.

11. A comprehensive plan of staged development is needed now to guide future developments in the upper Sacramento River Basin. Chapter III of this report has presented the framework for including flood control in such a plan.

12. The most immediate steps needed to reduce future flood damages are the adoption of floodplain management ordinances. The following paragraphs identify some of the more important areas where early consideration should be given to adopting floodplain management ordinances.

Along Cow Creek. This area has developed rapidly in the past few years. Subdivisions are common on lands where 10 years ago there were only farms. The lack of a large flood in the past 10 years has led residents of this area to underestimate the flood threat.

The Antelope Area East of Red Bluff. Many houses in this area suffered water damages during the 1964 floods. Since Tehama County has a floodplain management ordinance, consideration should be given to reviewing this ordinance in light of these recent hydrologic events.

Along the Sacramento River Near Hamilton City. This area east of the river is subjected to chronic flooding because all flows in excess of 150,000 cfs are forced out of the channel. At the present time, very little residential damage occurs. Floodplain management ordinances are needed to insure that residences are kept out of this area. Bank erosion work, as part of the Chico Landing to Red Bluff Project, could be completed with the adoption of proper ordinances. Studies are also necessary to determine if levees are still economically justified along this reach of the river.

Below All New Flood Control Reservoirs. If history is any indication, it will not take long after completion of new reservoirs before urban and suburban development encroaches on stream channel lands. Land developers tend to underestimate the flood potential after a project is completed. Floodplain management ordinances should be an integral part of any new flood control project.

13. With full development of potential upstream storage projects, overflows from the Sacramento River will continue to enter the upper Butte Basin during major storms. Provisions are needed to control the location of these overflows and to allow them to pass safely through the upper basin and into the lower Butte Basin.

Recommendations

It is recommended that:

1. A comprehensive plan of staged development for the upper Sacramento River Basin be developed. This plan should consider flood control, local water supplies, export projects, importation and passage of North Coast waters through the upper Sacramento River Basin, seepage problems, and other water-oriented problems within the basin.

2. The Corps of Engineers and Bureau of Reclamation continue studies of the upper Sacramento River Basin and seek authorization for projects found feasible.

3. The State Reclamation Board continue its efforts to solve the flood problems in the Butte Basin, recognizing that with full development of potential upstream storage projects, overflows from the Sacramento River will continue to enter the upper Butte Basin during major storms and that provisions are needed to control the location of these overflows and to allow them to pass safely through the upper basin and into the lower Butte Basin.

4. The counties of Shasta, Butte, and Glenn give early consideration to adopting floodplain management ordinances.

5. All counties in the upper Sacramento River Basin establish citizens advisory committees to represent them in planning for flood control and general water resources developments and to evaluate local needs for water developments.

APPENDIXES

APPENDIX A

First Extension of Joint Planning Agreement for
Development of Water Resources of the Eel and Mad River Basins

AGREEMENT ON FEASIBILITY LEVEL PLANNING
OF THE PASKENTA-NEWVILLE, RANCHERIA
AND COTTONWOOD CREEK PROJECTS

California State-Federal Interagency Group
September 1966

The basic agreement establishing a joint program for development of the water resources of the Eel and Mad River basins, entered into on June 14, 1966, was extended by the four agencies comprising the California State-Federal Interagency Group on September 1 to include division of responsibility for feasibility level planning of the Paskenta-Newville, Rancheria and Cottonwood Creek projects on the west side of the Sacramento Valley.

This extension of the basic agreement is based on the understanding that all four agencies will participate in the final formulation of each project included in the extension with the objective of optimizing development of local resources and assuring that the projects formulated are in consonance with plans for diversion and storage of waters originating in the North Coastal area of California and provide the best sequence of construction to meet statewide needs. Further, it is understood that the State does not waive its rights to proceed with authorization and construction of the Paskenta-Newville or Cottonwood Creek projects in the event that federal authorizations are delayed or terms relating to the sharing of yield and storage capacity are not satisfactory to the State.

The Bureau of Reclamation is assigned primary responsibility for the completion of feasibility level planning and the seeking of federal authorization for the Paskenta-Newville Project on Thomes and North Fork Stony Creeks, such project to be planned as a joint state-federal project with yield and storage capacity to be shared between the State Water Project and the Federal Central Valley Project.

The Corps of Engineers is assigned primary responsibility for developing feasibility level plans and seeking federal authorization for the Dutch Gulch and Farquhar projects and for determining the flood control potential of other possible projects in the Cottonwood Creek Basin. The Department of Water Resources and the Bureau of Reclamation will assist in defining the potential market for water conserved and power developed by future projects in the basin and in evaluating the conservation benefits. The State Water Project and the Central Valley Project will be considered as potential contractors for the water conserved.

The Department of Water Resources will reevaluate plans for development of the Upper Sacramento tributaries called for by Assembly Concurrent Resolution 18 and formulate a basin-wide master plan, making full use of information developed by the Corps for the Cottonwood Creek Basin. The Department of Water Resources is assigned primary responsibility for feasibility level planning of the Rancheria compartment of the Glenn Reservoir Complex, such development to be planned as a joint state-federal project in the same manner as described for the Paskenta-Newville compartment.

The Soil Conservation Service is assigned primary responsibility for watershed management planning in connection with the Paskenta-Newville, Rancheria and Cottonwood Creek projects. It is understood that the preparation of a watershed management plan is contingent upon authorization and funding of a USDA study of an intensity compatible with the needs of the lands tributary to the structures.

Signed September 1, 1966 at Vacaville

(s) William E. Warne
William E. Warne, Chairman
Director
Department of Water Resources
State of California

(s) R. J. Pafford, Jr.
Robert J. Pafford, Jr.
Regional Director
Region 2
Bureau of Reclamation
U. S. Department of the Interior

(s) E. E. Wilhoyt, Jr.
Brig. Gen. Ellis E. Wilhoyt, Jr.
Division Engineer
Corps of Engineers
U. S. Department of the Army

(s) T. P. Helseth
Thomas P. Helseth
State Conservationist
Soil Conservation Service
U. S. Department of Agriculture

e of California | The Resources Agency of California

emorandum

: Mr. Gordon W. Dukleth, District Engineer
Northern District
Department of Water Resources
P. O. Box 607
Red Bluff, California 96080

Date : JUN 17 1968

Subject: Upper Sacramento River Basin Investigation, Recreation Analysis of Hulen, Millville, and Dippingvat Reservoir Site

: Department of Parks and Recreation

I am pleased to transmit a memorandum report, "Recreation Potential of Hulen, Millville, and Dippingvat Reservoir Sites", which was prepared in fulfillment of the recreation contract services required for the Upper Sacramento River Basin Investigation under Interagency Agreement No. 256218.

This report reevaluates potential recreation use, facility requirements, costs, and benefits for the subject reservoirs in light of recent recreation data and changes in reservoir sizing and operations.

The proposed reservoirs would provide a satisfactory environment for various water-associated recreation activities, despite revised reservoir operations characterized by moderate annual fluctuation and infrequent severe long-term drawdown. Recreation development costs are considerably higher than previously estimated due to recent increases in construction costs. Recreation benefits are somewhat lower than previously estimated due primarily to reservoir operations less favorable to recreation and to changes in evaluation criteria. Although these estimates are adequate for a reconnaissance evaluation, the recreation aspects of these projects should be studied more intensively for a feasibility level analysis.

Henry A. Hjersman

HENRY A. HJERSMAN
Supervisor, Contract Services Section

APPENDIX C

emorandum

: Honorable William R. Gianelli, Director
Department of Water Resources
1416 Ninth Street
Sacramento, California 95814

Date: July 19, 1968

: Department of Fish and Game

ect: WP - State of California, Department of Water Resources - Upper Sacramento River Basin Investigation - Fish and Wildlife Evaluation of Tributary Developments and Butte Basin Flood Control

We are pleased to transmit herewith an office report entitled "Fish and Wildlife Evaluation of Tributary Developments and Butte Basin Flood Control", which was prepared as part of your Upper Sacramento River Basin Investigation. Funds used to prepare the report were provided by the Department of Water Resources during 1966-67 and 1967-68 under Interagency Agreement Nos. 255282 and 256339.

The report describes the fish and wildlife resources that would be affected by Hulen, Dippingvat, and Millville projects and recommends measures necessary to preserve and enhance these resources. Wildlife losses that would result from construction of the projects could be mitigated by habitat development on 1,240 acres and by preservation of downstream riparian habitat through fee acquisition or streamside habitat easements. Substantial enhancement of the State's king salmon resource could be achieved by suitable streamflow releases and protection of important spawning gravels in Cottonwood and Cow creeks. Development of warmwater fisheries in project reservoirs would also provide appreciable fishery benefits.

The report also evaluates the effects of flood control in Butte Basin on waterfowl, under ultimate conditions of upper Sacramento River tributary development and a Butte Basin Bypass. Recommendations are presented for actions by the State and private waterfowl interests that should be taken immediately to assure perpetuation of existing waterfowl habitat.

We greatly appreciate the opportunity provided by the Department of Water Resources to prepare this report, and we urge that its contents be incorporated into Bulletin No. 150-1.

Director

Attachment

APPENDIX D

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