

CASE STUDY REPORT #67A  
OROVILLE DAM  
FEATHER RIVER

I. Project Description

The Oroville Dam Division is a major component of the California Water Project. The Oroville Dam Complex includes Oroville Dam, Thermalito Diversion Dam, Thermalito Forebay, and Thermalito Afterbay. Oroville Dam, located near Oroville, California, impounds the Lower Feather River (see Figure 1). The Oroville Dam project was planned initially by the U. S. Bureau of Reclamation in the early 1940's, and at that time was called the Feather River Project. In 1952 the project was taken over by the California Division of Water Resources and renamed Oroville Dam Division of the State Water Project. The Oroville Division of the State Water Project was completed by the California Department of Water Resources (DWR) in 1968. Oroville Reservoir impounds 3,500,000 acre-feet of water with uses that include: power generation, flood control, and water conservation which includes most other uses. Four miles downstream from Oroville Dam the Thermalito Diversion Dam diverts water released from Oroville to the Thermalito system (see Figure 1). Thermalito Forebay diverts water through hydroelectric generating facilities at the base of the Forebay Dam into Thermalito Afterbay. Thermalito Afterbay serves as a re-regulating facility and has a maximum storage capacity of 57,500 acre-feet.

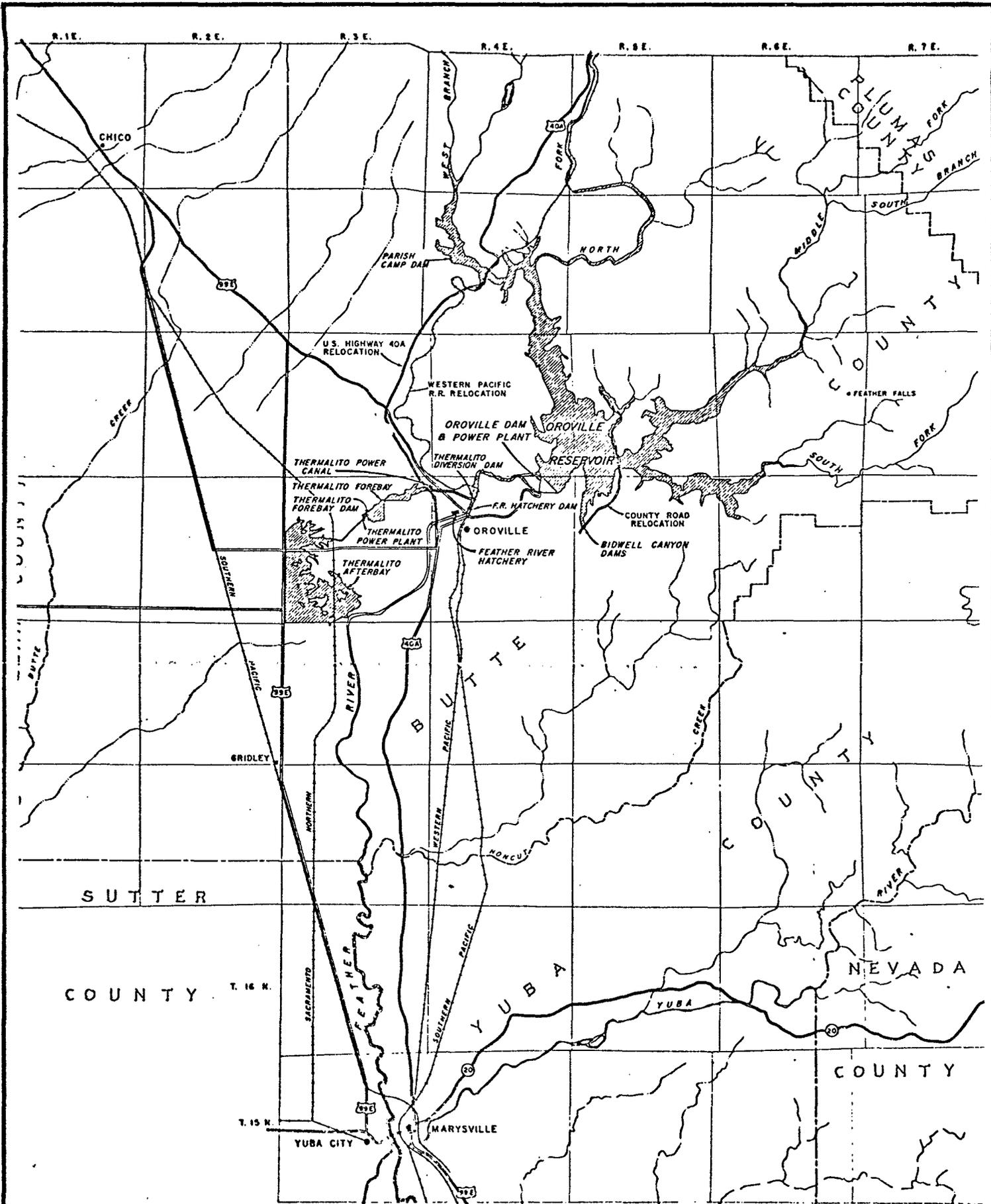


Figure 1  
LOCATION MAP

SOURCE: CALIFORNIA  
DEPARTMENT OF  
WATER RESOURCES,  
1957.

Oroville Dam blocked the spawning migration of salmon, steelhead, and other fish in the Feather River above Oroville. As a condition of the water rights application and the Federal Power Commission license, the State Department of Water Resources was required to construct and maintain a fish hatchery designed to compensate for the loss of upstream spawning and nursery habitat. In support of the hatchery, the Department of Water Resources was required to provide fishery maintenance flows below the project.

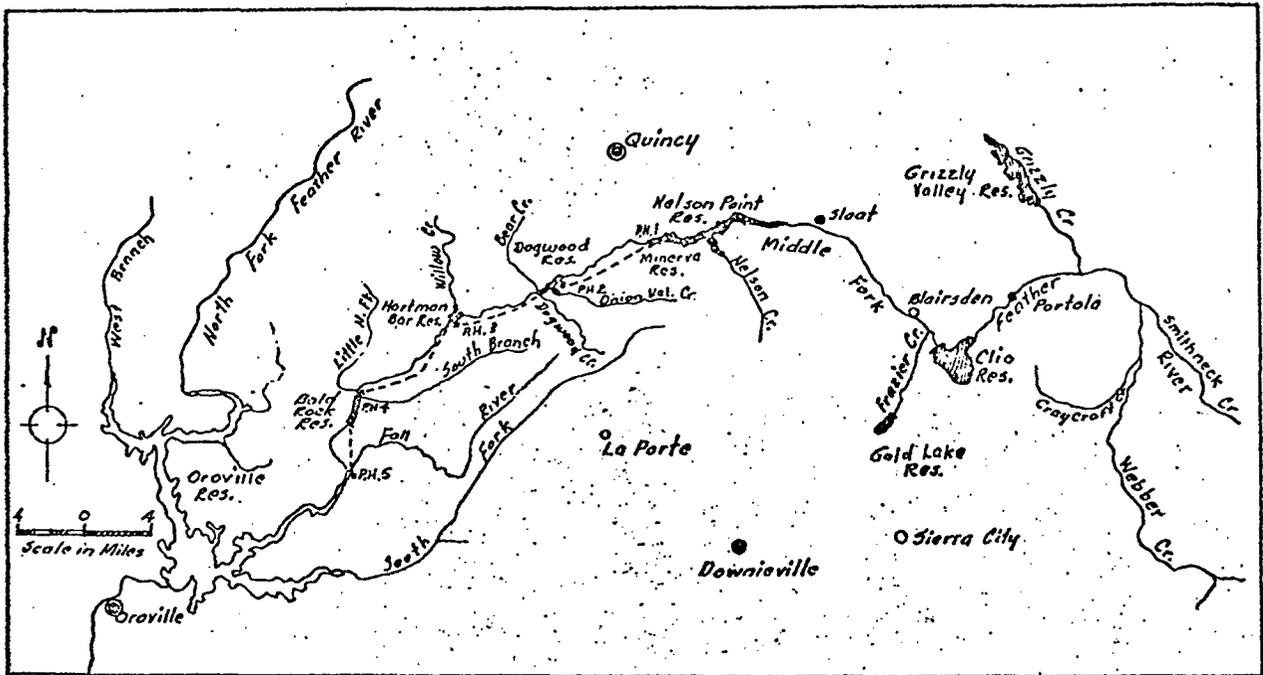
The Feather River hatchery, constructed near the Thermalito Diversion Dam, was completed in 1967.

## II. Pre-Project Condition

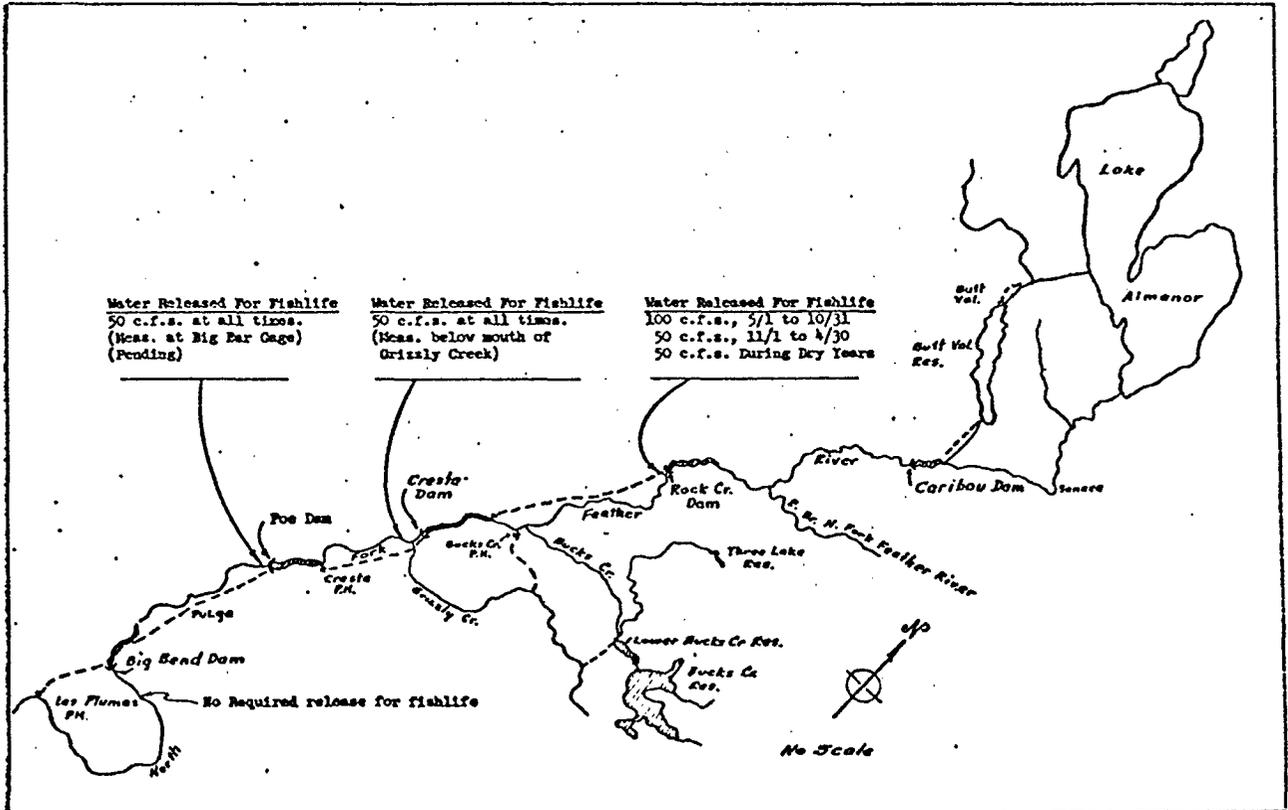
The Upper Feather River basin has been extensively developed for hydroelectric power production. An illustration of the number of hydroelectric facilities on the Feather River is shown in Figure 2. Dams and diversions in the upper basin of the Feather River have been in operation to produce hydroelectric power for more than 50 years. The operation of these facilities to produce electrical power has greatly modified natural stream flows in the watershed by seasonal flow patterns and creating extreme short-term flow fluctuations.

The lower reaches of the Feather River below the City of Oroville were strongly influenced by the higher elevation hydroelectric power operations. The large number of

Figure 2



Middle Fork Feather River and Tributaries showing sites of power and irrigation development proposed by the Richvale Irrigation District.



Existing Hydroelectric Development on the North Fork Feather River.

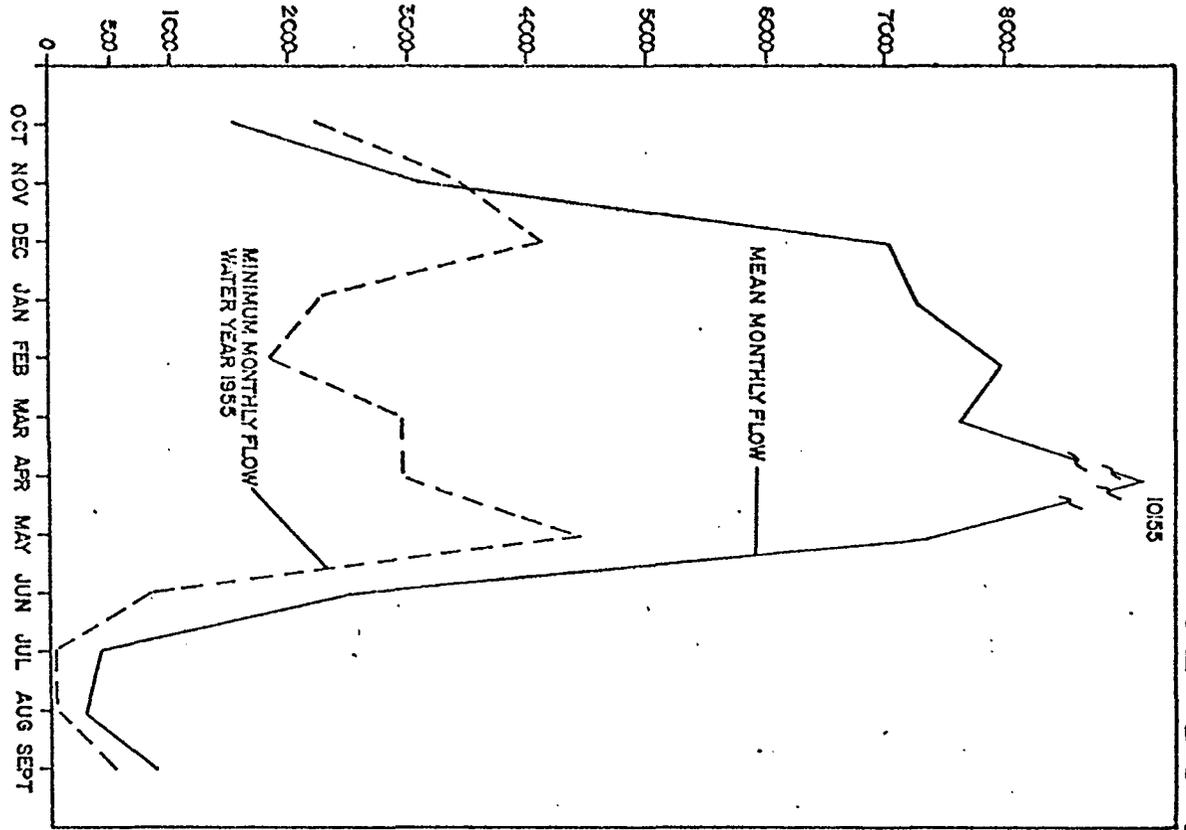
SOURCE: CALIFORNIA DEPARTMENT OF FISH & GAME, 1961.

tributaries that enter the main Feather River near Oroville tended to lessen the severity of the effects of upstream power development. The mean monthly instream flow near Oroville prior to the construction of Oroville Dam is shown in Figure 3. This hydrograph does not show hourly or daily instream flow fluctuations which were often great; however, it does indicate the monthly flow conditions. The lowest flows typically occurred in July and August and were occasionally less than 100 cfs as compared to 2,000 to 8,000 for other months. These low summer flows were the result of heavy irrigation diversions below Oroville.

The main Feather River in the vicinity of the City of Oroville formerly supported a fair to good fishery for largemouth and smallmouth black bass, salmon, steelhead, shad, striped bass, bluegill, sunfish and brown bullheads. An array of game and nongame species common to the Sacramento River drainage was present. From Oroville to the confluence of the Middle and South Forks of the Feather River angler use was generally light except during the salmon and steelhead season when angling pressure became heavy.

Salmon and steelhead trout supported an important sport fishery in the main Feather River above Oroville. Estimates by Department of Fish and Game during the 1954-55 spawning season indicated that at least 10,500 king salmon and steelhead spawned above the Sutter-Butte Dam. However, the bulk of the

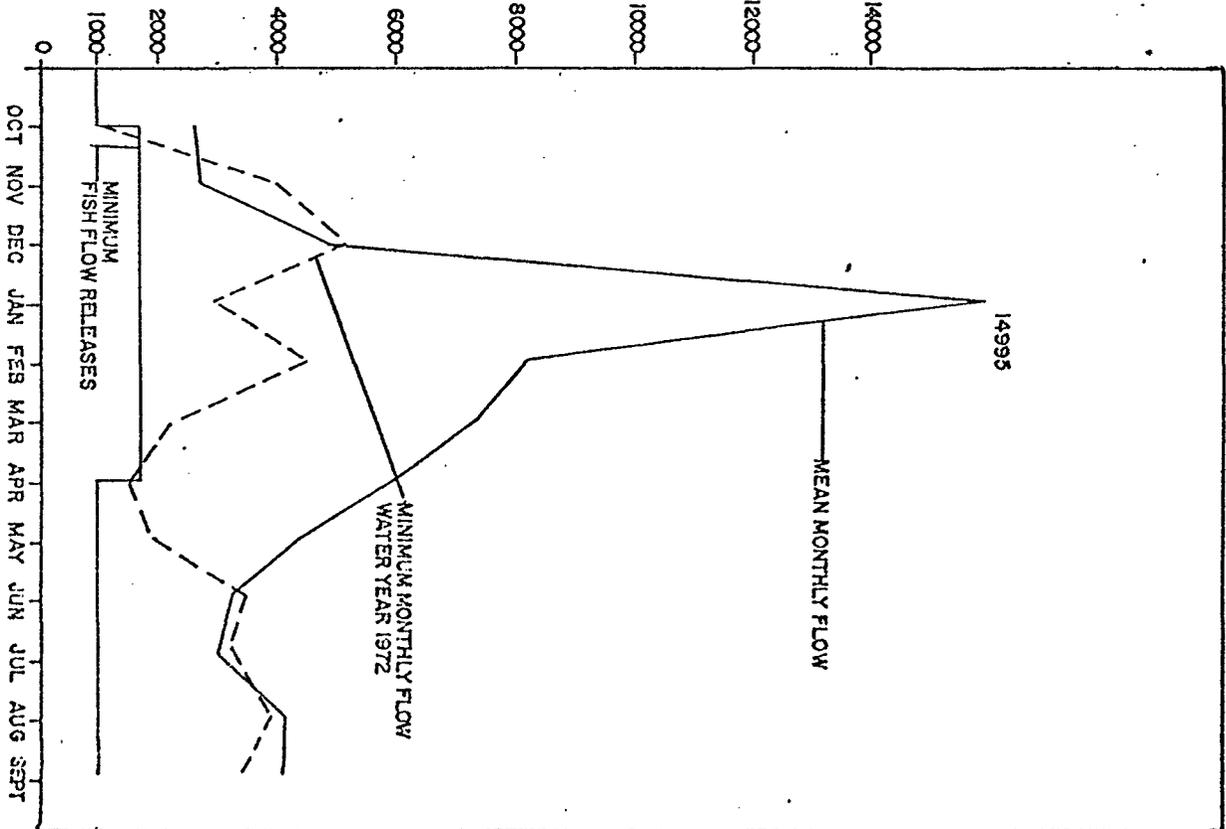
STREAMFLOW (CFS)



PRE-PROJECT: OCTOBER 1944 - SEPTEMBER 1957  
 GAUGE STATION NO.  
 SOURCE: DWR WATER SUPERVISION REPORTS

FIGURE 3  
 STREAMFLOW CONDITIONS, FEATHER RIVER  
 ORVILLE DAM

STREAMFLOW (CFS)



POST-PROJECT: OCTOBER 1968 - SEPTEMBER 1975  
 GAUGE STATION NO. 114071  
 SOURCE: 8985ACE WATER RECORDS VOL. 2

salmon spawned downstream from Oroville as very little suitable spawning habitat existed above Oroville Dam.

California Department of Fish and Game estimated that 950 black-tailed deer utilized the area now occupied by Oroville Lake. Of these 950 deer, 390 were migratory animals and the remaining 560 were residents. Numerous species of birds utilized the area. The important game birds included quail, ducks, geese, bandtailed pigeons, doves and pheasants.

### III. Project Development

In the early 1940's the U. S. Bureau of Reclamation (USBR) proposed the construction of the Feather River Project Oroville Dam. In 1945 the U. S. Fish and Wildlife Service (FWS) compiled a report which recommended that "400 cfs be released to the Feather River below the lower most diversion at all times to maintain fish life." This recommendation was accepted by the USBR as part of their proposed operational schedule.

In 1952 the Department of Fish and Game was informed by the Federal Power Commission that the State of California had filed a Notice of Application for a Federal Power Commission license No. 2100. The Federal Power Commission subsequently requested recommendations from the Department of Fish and Game to prevent or mitigate possible losses or possible damage to fish and wildlife resources that may result from the construction of the project. The Department of Fish and Game's

reply was limited due to the short term available to carry out any extensive investigations of the project. The initial recommendation was:

"The exact effects of this project on the fisheries resources cannot be predicted until plans and proposed operating schedules have been formulated by the applicant. The Department of Fish and Game recommends that any license issued at the present time make provisions for fish protection devices and flow releases as may be recommended by the Department of Fish and Game after additional studies have been completed. It is anticipated that the following measures will have to be taken:

"1. A definite provision for flows to be maintained at all times in the main Feather River downstream from the existing Sutter-Butte Diversion Dam.

"2. Provisions that adequate screening be provided on all irrigation canals or conduits planned for the diversion of water directly from the Feather River if found necessary by the Department of Fish and Game.

"3. All diversion dams planned for the main Feather River below the present Sutter-Butte Diversion Dam be designed to facilitate the passage of fish.

"4. Surveys be made of the lower portion of the River to determine the feasibility of improving conditions for salmon spawning.

"It is further recommended that the recreational potential of the Oroville Reservoir be developed as fully as possible and provision be made during the planning stages for the necessary recreational and sanitary facilities.

"These recommendations are submitted under the terms of Public Law 732 and various sections of the Fish and Game Code."

As the Feather River project began to develop the Department of Fish and Game initiated several environmental investigations on the Lower Feather River to examine both physical and biological parameters. These investigations were to provide information from which instream flow requirements for fish could be estimated.

The physical parameters initially examined in 1954 were historic stream flow patterns and temperature fluctuations. Historic stream flow conditions are shown in Figure 3. Annual stream temperature variations indicated an average maximum of 80°F and average minimum of 47°F (Figure 4).

Two biological investigations involving the examination of fishery conditions in the lower Feather River were initiated by California Department of Fish and Game in 1954 and completed in 1956: a) "Size of the 1955 Salmon Runs in the Feather, Yuba, Cosumnes and Mokelumne Rivers" and b) "Studies on the Downstream Migration of Young Salmon in the Feather River 1955". The following excerpts represent the Department of Fish and Game conclusions from each report:

a) "The 1955 fall salmon run in the Feather River was the largest ever observed in this stream by the salmon survey crew. The bulk of the run spawned on the riffles from the mouth of Honcut Creek upstream to Sutter-Butte Dam. Between Oroville and Sutter-Butte Dam salmon were not so numerous, although most riffles were adequately populated.

"From mid-October to mid-December a total of 8,167 dead salmon were recovered in the Feather River between Oroville and Live Oak. It is estimated that the survey crew recovered 10 percent of the salmon which spawned and died in the stretch of river between Oroville and Sutter-Butte Dam, 10 percent between Sutter-Butte Dam and Gridley and 7 percent in the section between Gridley and Live Oak. From this data it is calculated that 86,000 salmon spawned in the Feather River below Oroville. The following table shows the distribution of the salmon population by river section.

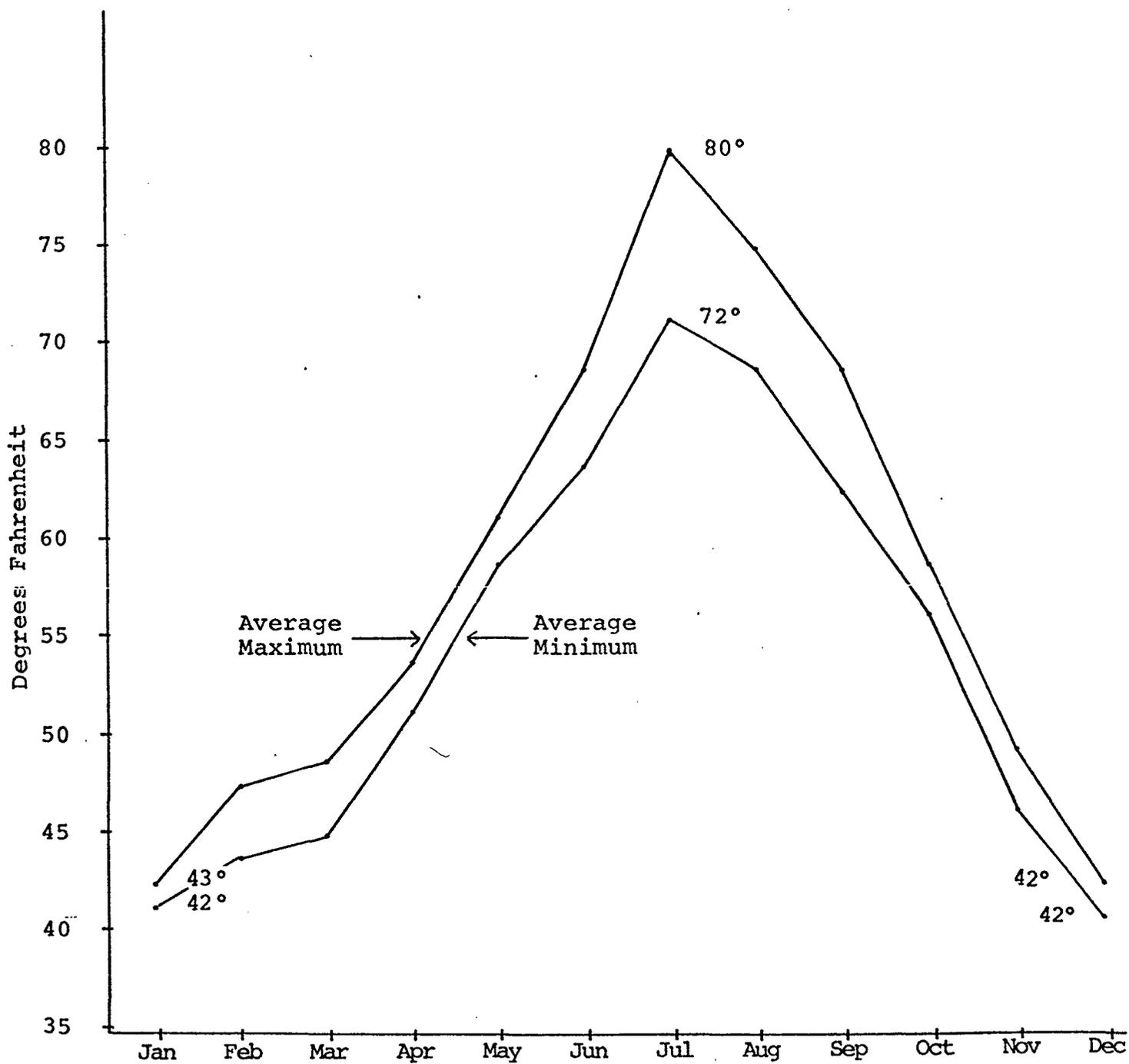


Figure 4  
 1954  
 FEATHER RIVER AT GRIDLEY BRIDGE

River Section	No. Dead Salmon	Estimated Recovery Rate	Estimated Population
Oroville to Sutter-Butte Dam	595	10%	6,000
Sutter-Butte Dam to Gridley	6,369	10%	63,000
Gridley to Live Oak	1,203	7%	17,000
		Total	86,000"

b) "1. A fyke net study was conducted in the Feather River from January 13 to May 28, 1955 by the Marine Fisheries Branch of the California Department of Fish and Game. This program was planned to compare the production of young salmon above Oroville with that of the remainder of the river and to determine the duration and intensity of the downstream migration.

"2. Standard riffle fyke nets, each with a 3 by 5 foot opening, were used in the study. One net was fished near Oroville to sample the migration of young salmon out of the area which will be inundated by the proposed Feather River project. A second net was operated near Gridley to sample the migration from the entire spawning area in the river. The two nets were operated in similar sites where water velocities were 5+ft./sec. A third net was used in the Sutter-Butte canal during April and May to determine the extent of fish loss in this water diversion.

"3. The catch per hour for each net for the period from January 13 to April 9, 1955 was used as a basis for comparing the data obtained at the Oroville and Gridley stations. The catch data for this period shows that 14% of the migrants originated in the spawning riffles upstream from Oroville and 86% were produced in the remainder of the river. After April 9 the losses of salmon in two major water diversions influenced the fyke net catches to such an extent that the information acquired could not be used quantitatively.

"4. The peak of the downstream salmon migration at Oroville occurred in the week of April 17 to 23. At the Gridley station the bulk of the migrants moved downstream from mid-March to mid-April. The fact that the peak of migration at the upstream net took place later in the year than the peak at the downstream net reflects the long

journey made by the salmon from the upper reaches of the river to the Oroville net site. Since most of the salmon netted at Gridley come from riffles only a short distance upstream, an early peak in the migration could be expected at this location.

"5. The average length of the salmon captured in the fyke nets increased very little as the season progressed indicating the migrants move out of the spawning area of the Feather River quite rapidly.

"6. The duration of the downstream migration of young salmon in the Feather River in 1955 was essentially from January 1 to June 1."

After evaluating project recommendations from the U.S. FWS and the California Department of Fish and Game, the Federal Power Commission on February 11, 1957 issued license No. 2100 which covered the Feather River Project. This license was further amended June 6, 1958. The water release agreement at this time was that the Department of Water Resources shall release from the Thermalito Diversion Dam a flow of not less than 400 cfs at all times.

In March of 1962 the Department of Water Resources formally applied to the Federal Power Commission to amend Federal Power Commission license 2100 to change the name of the project from Feather River Project to "Oroville Division, State Water Facilities".

In July of 1961 the Department of Fish and Game initiated what was supposed to be a final pre-project evaluation of the effects of the Oroville Division facilities on fish and wildlife. The objective of this evaluation was to provide the Department of Water Resources with final recommendations for

the preservation and enhancement of those resources. This evaluation examined the previous pre-project studies and where deficiencies were found the Department of Fish and Game initiated additional research. Collection of field data for the new study was initiated in August 1962 and the analysis of the data was completed in 1964 (The Streamflow Requirements of Salmon in the Lower Feather River, Butte County, California). This study relied on measurements and considerations of habitat area as determined from water depth, velocity and stream bed composition.

The Department of Fish and Game conclusion:

"..indicates that the greatest amount of usable salmon spawning area is available when Feather River flows are approximately 1,700 cubic feet per second. Reductions in flow from 1,700 cfs rapidly diminish the spawning area, while increases from 1,700 to 3,400 cfs have virtually no effect on the availability of suitable gravels."

A final amendment to the Federal Power Commission license No. 2100 was approved on July 19, 1967. The terms of the final amended license stipulated the following release agreement:

"Interagency Agreement No. 456705, Agreement and Stipulation

"1. Water Resources shall release from the Thermalito Diversion Dam for fishery purposes a flow of not less than 400 cfs at all times, such flow is to be released into the Feather River and the Feather River Fish Hatchery pipeline. Any modification to this flow for purposes of study and experimentation is to be mutually agreeable to the parties hereto. Based upon the April through July unimpaired runoff of the Feather River near Oroville of the preceding water year (October 1 through September 30) additional water shall be released from the Thermalito Afterbay River outlet to maintain flows in the Feather River immediately below said outlet and to the mouth of

the Feather River at Verona in accordance with the following schedule, provided that such additional releases would not cause Oroville Reservoir to be drawn below elevation 733 feet (approximately 1,500,000 acre-feet):

The Preceding April through July Unimpaired Runoff* of the Feather River near Oroville, Percent of Normal**	Minimum Flow Schedule in Feather River Below Thermalito Afterbay		
	<u>October through February</u>	<u>March</u>	<u>April through September</u>
76% or greater [wet]	1,700 cfs	1,700 cfs	1,000 cfs
55-76% [normal]	1,700 cfs	1,700 cfs	1,000 cfs
Less than 55% [dry]	1,200 cfs	1,000 cfs	1,000 cfs

\* As computed for inclusion in Water Resources' Bulletin, No. 120-xx "Water Conditions in California - Fall Report".

\*\* Normal is defined as the April through July 1911-1960 mean unimpaired runoff near Oroville, 1,942,000 acre-feet.

"If the April 1 runoff forecast in a given water year indicates that, under normal operation of the project, the reservoir level will be drawn to elevation 733 feet (approximately 1,500,000 acre-feet), releases for fish life in the above schedule may suffer monthly deficiencies in the same proportion as the respective monthly deficiencies imposed upon deliveries of water for agricultural use from this project. However, in no case shall the fish water releases in the above schedule be reduced by more than 25 percent.

"During the 8-year period following closure of Diversion Tunnel No. 1 Water Resources and Fish and Game will, by study and experimentation, assess the appropriateness of project operation in maintaining the pre-project fish populations pursuant to Articles 29, 30, 43, and 45 of License 2100. However, in the event of the occurrence of year or years of less than 55 percent of April-July runoff, the study period will be extended an equal number of years. Funding of required studies and experimentation shall be the responsibility of Water Resources; provided, however, that the total amount of moneys expended for this purpose shall not exceed \$390,000. If at any time during the 8-year study there is a demonstrated net reduction in pre-project fish populations

attributable to project operations, mutually acceptable plans shall be developed by Fish and Game, Water Resources and the United States Fish and Wildlife Service to compensate for such reductions and to prevent further reductions. Said plans shall be submitted to the Federal Power Commission for its approval. The plans will not include a change in the water flow maintenance schedule except in water years where the preceding April-July unimpaired runoff of the Feather River near Oroville is 76 percent or greater of normal. In the 76 percent or greater years increased releases may be made from the Thermalito Afterbay river outlet, if necessary, to increase the minimum flows up to 2,500 cfs during October 1 through March 31 period, provided the total increase for fishery purposes during this period does not exceed 100,000 acre-feet.

"The scope of the 8-year study shall be as contained in Appendix 1 to this Agreement and Stipulation. In the event there is a net increase in pre-project fish populations as a result of operation of the project then such gains shall be recognized.

"In the event the parties herein fail to reach an agreement as contemplated herein, any party may request the Commission to hold a hearing and make the determinations required under License 2100. Such request shall not, however, propose any change in the water schedule except within the limits agreed upon in this Paragraph 8."

#### IV. Post-Project

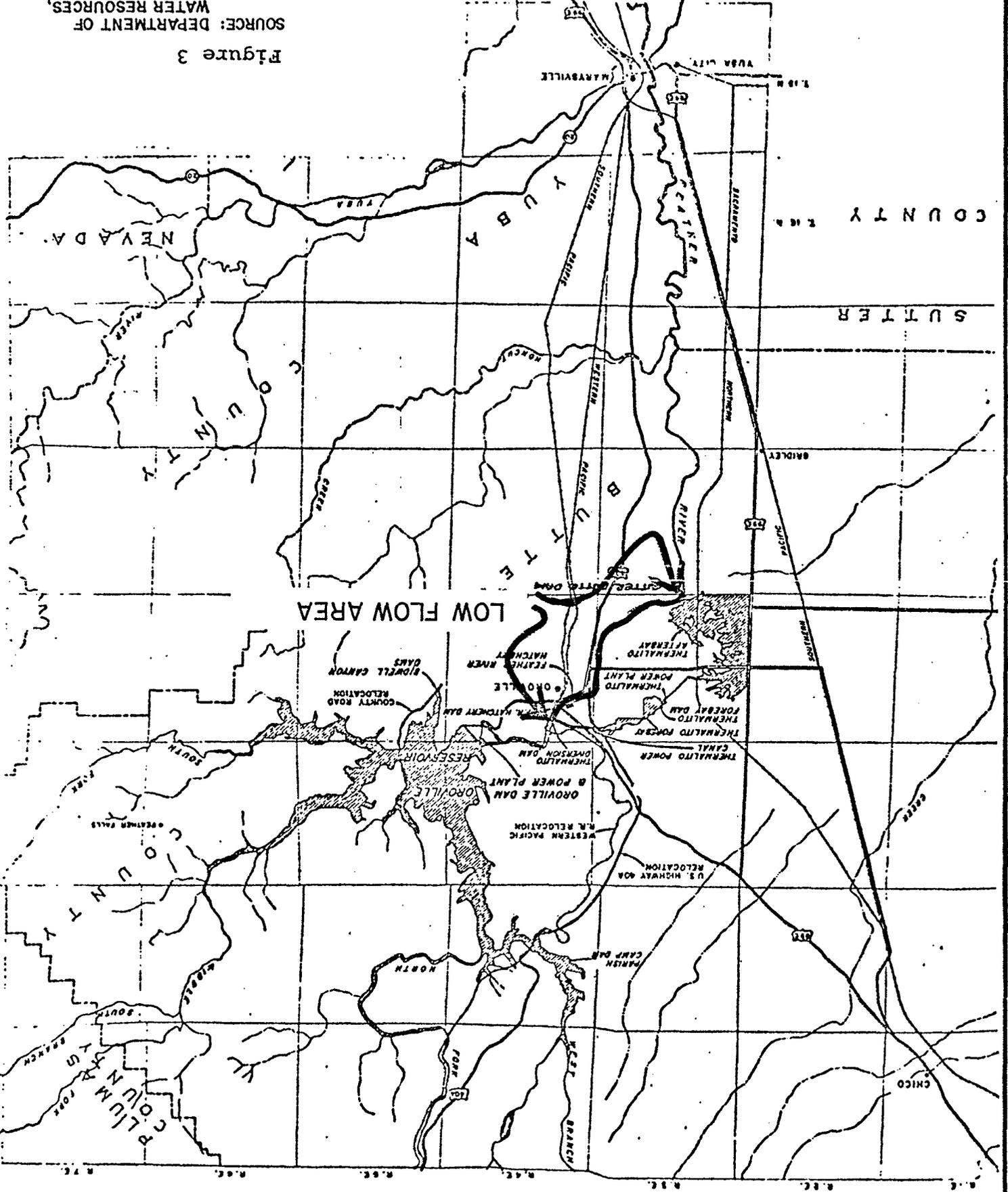
Instream flow conditions in the lower Feather River have changed considerably since the construction of the Oroville Complex. Mean monthly pre-project stream flows peaked at 10,155 cfs whereas post-project flows peak at about 14,995 cfs (see Figure 3).

A stipulation of the Interagency Agreement No. 456705 established an 8-year period of investigation of the Feather River below Oroville. This investigation was designed to determine the effects of the Oroville project on the downstream

233

SOURCE: DEPARTMENT OF WATER RESOURCES, 1957.

Figure 3



fishery as well as possible operational practices to mitigate any adverse effects and was to be completed in 1975.

Several studies were undertaken as part of the post-project investigation. These studies include: 1) predation of yearling king salmon upon wild king salmon fry, 2) salmon spawning population estimates using creamer counts and 3) salmon spawning population estimates from hatchery fish totals.

The predation study on king salmon fry was initiated in response to a large reduction in salmon fry which occurred in the lower Feather River. Apparently the release of yearling king salmon from the Feather River hatchery during the out-migration of salmon fry resulted in heavy losses to cannibalism. The conclusions derived by these studies are as follows:

"1. Predation of yearling king salmon upon young-of-the-year salmon fry can be severe.

"2. Flushing flows of short duration, as applied here, have no noticeable effect upon the distribution and availability of yearlings to predation.

"3. If yearlings must be planted during the natural downstream migration period of wild salmon, then the yearlings should be released downstream of the spawning area into waters that are not conducive to 'holding-up' these fish (shifting sand river bottoms, wide flat shallow areas, murky water, etc.)."

Spawning king salmon population estimates, including both creamer survey estimates and fish taken at the hatchery, have been used to analyze the status of salmon spawning runs in the Feather River. From the total of creamer counts and hatchery fish, the fall run king salmon populations were estimated at 18,144 in 1968; 60,588 in 1969; 61,525 in 1970 and 40,041 in 1971.

In 1973 the California Department of Fish and Game released a report on the Status of King Salmon Runs in the Feather River. The report indicated that with proper management the salmon run would range from 40 to 60 thousand adult king salmon each year. During a normal water year about 4 to 15 percent of the fall run salmon enter the Feather River hatchery, 30 percent of the salmon spawn in the area between Thermalito Diversion Dam and the discharge from Thermalito Afterbay, 40 to 50 percent to spawn in the Middle River and less than 10 percent use in the lower reaches of the river. This report also noted the presence of a spring run of salmon, which was expected to maintain itself at about 2,000 fish annually.

During low stream flow periods the Department of Fish and Game Feather River fishery investigation team noted a problem of king salmon fingerlings stranded in isolated pools because of relatively rapid changes in stream elevation flows. These changes in flow are related to the operation of Oroville Dam in response to storms and snowmelt runoff. The Department of Fish and Game anticipated that the Oroville fishery investigation team would generate an instream flow recommendation which would minimize this problem.

In June 1974 the Department of Fish and Game proposed a physical modification of the Feather River channel to increase the amount of spawning gravel available to salmon. The proposed modification included the construction of a 40-foot by

1,200-foot spawning channel to be located on the gravel bar adjacent to the hatchery. This spawning channel was completed in time to be used during the fall 1974 spawning run.

The Department requested an experimental water release to coincide with the use of the new spawning channel. This request of July 1974 stated that an additional release of water will significantly increase egg survival. To test this hypothesis the Department of Fish and Game requested an additional 400 cfs at the hatchery for a total of 800 cfs to be released from October 16, 1974 to January 31, 1975. Results of this experiment indicated an overwhelming improvement of eggs survival from 40 to over 65 percent, a 25 percent improvement. The Department of Fish and Game was unable to obtain the annual release of the higher flows after demonstrating the improved spawning conditions. A minimum of 1,100 salmon used the new spawning channel in its first year of operation (Painter, pers. comm.).

The culmination of the eight-year fishery investigation was on an instream flow release recommendation of 1,000 cfs combined release to the low flow section of the Feather River which now receives a minimum flow of 400 cfs. This recommendation was made by the California Department of Fish and Game in June of 1975; as of February 1, 1976, no action has been taken by the State of California on this recommendation (Painter, pers. comm.).

## V. Conclusion

Instream flows in the Feather River below the Oroville Dam-Thermalito Afterbay complex have been reduced from the historic condition (see Figure 3). Releases from Oroville and Thermalito have been greater than minimum instream flow reservations since the dam's completion in 1968. During dry years, instream flows have remained well above the minimum reservation.

In response to the Department of Water Resources proposal to construct the Oroville Dam project, the Department of Fish and Game initiated several environmental investigations on the lower Feather River to examine both physical and biological parameters.

Initially examined were historic stream flow patterns and stream temperature fluctuations. Biological investigations included estimations of the size of the adult salmon population on studies of the downstream migration of juvenile salmon.

The Federal Power Commission evaluated the preliminary recommendations of the U. S. Fish and Wildlife Service and the Department of Fish and Game and issued FPC license No. 2100 in 1957. This license reserved a minimum instream flow of at least 400 cfs at all times.

In 1962, the State of California applied for an amendment to FPC No. 2100. Upon notice of the Department of Water Resources application for amendment, the Department of Fish and

Game initiated follow-up investigations. The objective of these investigations was to provide the Department of Water Resources with final recommendations for the preservation and enhancement of fish and wildlife resources below Oroville Dam. These studies relied on a quantified description of habitat area as determined from water depth, velocity and streambed composition. From the information generated by these studies, the minimum flow schedule in the project development section was formulated. An additional stipulation of the streamflow release agreement was a requirement for an 8-year post-project study and experimentation to assess the project operations to determine its ability to maintain the pre-project fish populations.

Several studies were undertaken as part of the post-project investigation. These studies include: 1) predation of yearling king salmon upon wild king salmon fry, 2) salmon spawning population estimates using creamer counts, and 3) salmon spawning population estimates from hatchery fish totals.

The diversion of water at the Thermalito Diversion Dam through Thermalito Forebay and Afterbay and discharged back into the Feather River at the Sutter Butte Dam has created an area of reduced flow (Figure 1). This area known as the low flow area supports a concentration of spawning salmon and steelhead trout. In 1974 the California Department of Fish and Game recommended the modification of the Feather River streambed near the hatchery to increase the amount of spawning

area available to salmon. This modification was completed by the California Department of Water Resources in time for use during the fall 1974 salmon run. The Department of Fish and Game requested an experimental flow of 800 cfs for the low flow area during the operation of this spawning channel. This request has now been raised to 1,000 cfs as a result of investigations supervised by Dick Painter, California Department of Fish and Game.

The Feather River supports an excellent salmon and steelhead trout fishery. The fall run of king salmon, prior to the construction of Oroville Dam was estimated to be 10,000+ fish annually above the Oroville Dam site. The construction of the Oroville Dam blocked the spawning migration and inundated spawning and nursery habitat. The California Department of Water Resources constructed the Feather River salmon and steelhead hatchery below Oroville Dam to compensate for the blockage of spawning migration routes and inundation of spawning habitat during October through March.

A combination of increased instream flows and spawning habitat improvement resulted in overwhelming improvement in spawning success. However, the increased flows were obtained for only one year (Painter, pers. comm.).

The estimated population of king salmon spawning in the lower Feather River since the completion of Oroville Dam has stabilized at approximately 60,000 fish. The California Department of Fish and Game stated in their recommendation

that a minimum flow of 1,000 cfs would maintain and improve the population of king salmon spawning each fall in the low flow section of the lower Feather River. However, the State of California has not taken any action on the 1,000 cfs recommendation. Subsequently the Oroville instream flow release continues at levels originally agreed upon at the time of project completion.

#### BIBLIOGRAPHY

##### Personal Communications

Painter, Richard. February, 1976. Associate Fishery Biologist, California Department of Fish and Game.

##### References

- California. Department of Fish and Game. 1955. Fish, wild-life and recreational resources in relation to the proposed Oroville Reservoir, Butte County, California. 70 pp.
- . 1955. Size of the 1955 salmon runs in the Feather, Yuba, Cosumnes and Mokelumne Rivers. Unpublished report. 3 pp.
- . 1955. Studies on the downstream migration of young salmon in the Feather River. 15 pp.
- California. Department of Water Resources. 1957. Investigation of Upper Feather River Basin development. Interim report on engineering, economic and financial feasibility of initial units. Bulletin no. 59. 135 pp.
- . 1962. Application to Federal Power Commission for amendment of license for project no. 2100 - state water facilities - Oroville division. 247 pp.
- . 1965. State water project, Oroville Dam pamphlet. 3 pp.
- . 1966. Oroville Reservoir Thermalito Forebay Thermalito Afterbay water resources recreation report. Bulletin no. 117-6. 48 pp.
- U. S. Federal Power Commission. 1974. Federal Power Commission reports, opinions, decisions, and orders volume 38. July 1, 1967 - December 31, 1967. 1366 pp.