(Wixom, L.H. 1989)

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State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

NORTH FORK FEATHER RIVER FISHERIES MANAGEMENT PLAN

DRAFT

PRELIMINARY DATA SUBJECT TO REVISION

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NORTH FORK FEATHER RIVER MANAGEMENT PLAN

Introduction

This plan for management of fisheries resources of the North Fork Feather River is based upon the results of six years of study from 1981-1986, by the California Department of Fish and Game (DFG) and upon other available resource data. Results of the studies are contained in a data report covering the years 1981-1986 titled, Rock Creek-Cresta Project (FERC 1962), Fisheries Management Study, North Fork Feather River, California, July 1, 1988, Region 2, Environmental Services.

The North Fork Feather River Management Plan includes the area of the North Fork Feather River and East Branch from Poe Dam to its confluence with Spanish and Indian creeks (Figure 1). This plan establishes fishery management goals and provides recommendations for restoring the trout fishery. In addition, a management evaluation and monitoring program is proposed and further study needs are recommended.

The single most important fishery management tool suggested for restoring the trout fishery in the North Fork is: habitat preservation, restoration and improvement. Others follow and are ranked in descending order of importance as follows:

1. Habitat preservation, restoration, improvement.
   a. Water temperature.
   b. Flow.
   c. Spawning habitat improvement.
   d. Barrier removal and tributary recruitment.
   e. Sediment control.
2. Fish production.
   a. Natural production in river reaches.
   b. Suitable domestic catchable-sized or wild native trout in the reservoirs.
3. Recreational access and development.
   a. Reservoir boat launching and angler access.
   b. Camping facilities.
4. Regulation changes more restrictive than two-fish limit.

The Rock Creek-Cresta Project, since completion in 1950, has resulted in major reductions in the trout fishery without creating new resources. As will be discussed, the causes of these losses are attributed to substantially reduced instream flows, loss of spawning habitat, increased water temperatures and sedimentation.

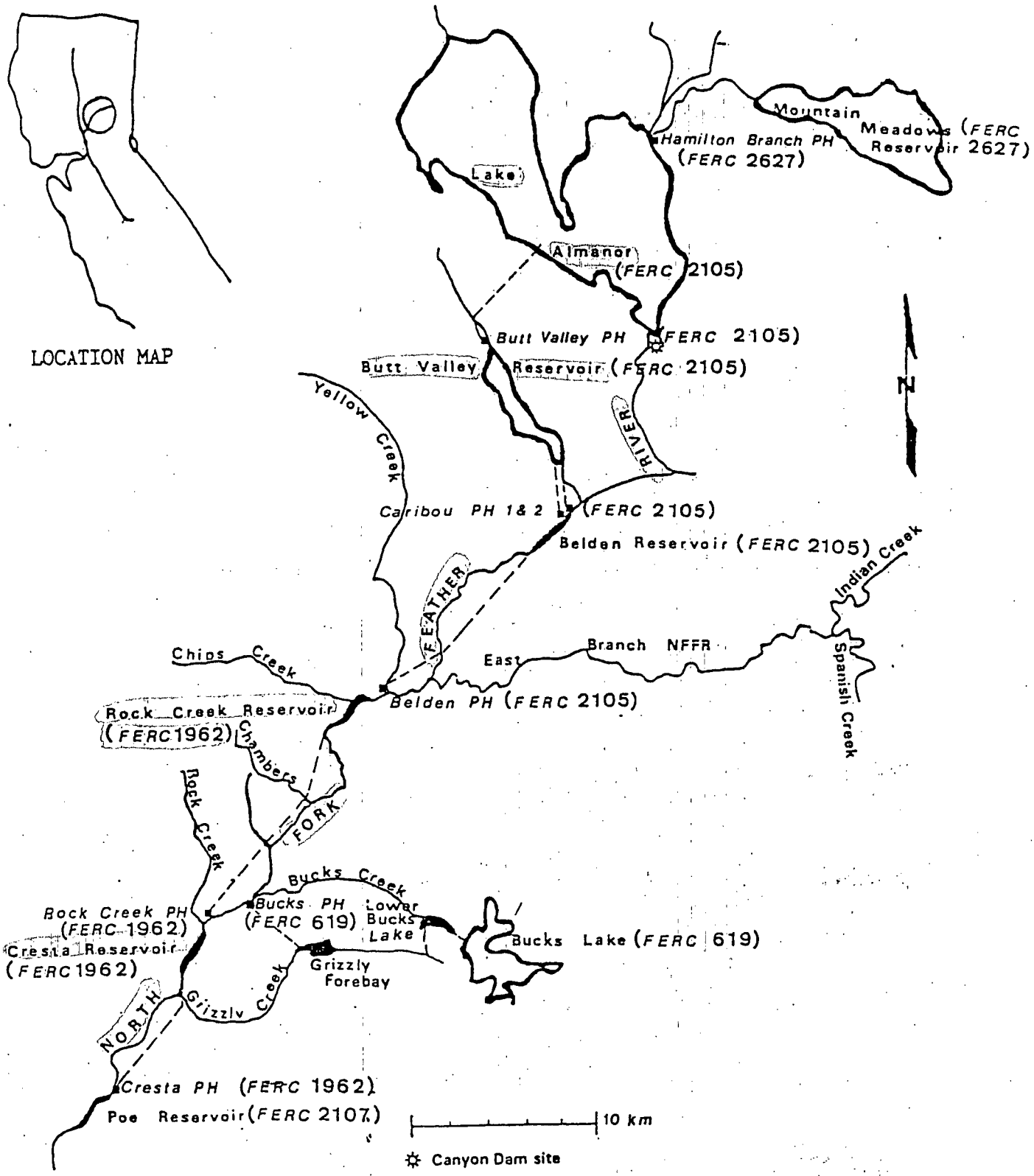

Figure 1. Hydroelectric and water storage developments within the North Fork Feather System. FERC Project 2627 is classified by the Commission as non-jurisdictional and therefore is not federally licensed.

Resource Status

General Setting

The Rock Creek-Cresta Project (FERC Project No. 1962) is located on the North Fork Feather River (NFFR) in Butte and Plumas Counties, California. The NFFR is the main tributary of the Feather River System which is a major tributary to the Sacramento River. The NFFR originates on the southeast slopes of Mt. Lassen and flows south for approximately 101 km before reaching Lake Oroville in Butte County. Included within its flow is the East Branch North Fork Feather River, which extends 29 km eastward, and more than 30 small tributaries that converge along the NFFR, contributing to the large watershed (5776 square km).

The upper watershed consists of a broad plateau-like basin, which is densely timbered except for several large meadows. The largest of these meadows, named Big Meadows in pioneer times, is now inundated by Lake Almanor, a 101-square-km reservoir.

Below Lake Almanor and below the confluence of Spanish and Indian Creeks on the East Branch, the NFFR has cut a deep, rugged canyon downstream to Oroville. This reach of the NFFR is paralleled by State Highway 70 running through most of the famed Feather River Canyon.

The stream has been highly modified for power production by Pacific Gas and Electric (PG&E). Between Lake Almanor, the first major impoundment on the system, and Lake Oroville some 100 km downstream, there are four smaller impoundments on the North Fork and two impoundments on tributaries (Figure 1).

The construction and operation of PG&E's Rock Creek-Cresta Project together with these other hydroelectric water storage developments within the NFFR system have changed the aquatic habitat and fishery resources within the Rock Creek-Cresta section of the river. The impacts from creation of reservoirs and reduction in stream flows has resulted in a habitat that favors nongame fish species rather that trout (USFWS 1962; Moyle et al. 1983).

In the initial application for project construction, the sponsor (PG&E) made no provisions for minimum flows for the protection and maintenance of fish life in the project area, allowing for only tributary inflow and leakage from the dams to satisfy instream flow needs (USFWS 1948).

In 1947 the U.S. Fish and Wildlife Service (USFWS) and the DFG began investigations to determine flow requirments for the maintenance of fish and wildlife resources in the NFFR from Lake Almanor to below Cresta Dam. From these investigations,

recommendations were made for the minimum instream flow release needed to maintain a viable trout fishery and were agreed to by the USFWS, U.S. Forest Service (USFS), DFG, and PG&E. The initial appraisal, including minimum stream flow recommendations, was a joint effort of the USFWS, USFS, and DFG and was released as a memorandum report in early 1948. This memorandum report recommended a minimum flow of not less than 200 cfs be released from Rock Creek Dam and Cresta Dam as measured at the point of release from the dams (USFWS 1948). This report stated further that:

> "flows greater than this would enhance fishery values, and careful study indicates that the fishery resources might be maintained at or near their present levels of abundance with a minimum flow of about 400 second-feet".

These flow recommendations, were revised and the revised numbers included in Article 13 of the Federal Power Commission License No. 1962 as amended February 15, 1950. The revised flows required minimum releases below Rock Creek Dam of 100 cfs from May 1 through October 31 and 50 cfs from November 1 through April 30, and in the Cresta Section below Grizzly Creek (0.8 km below Cresta Dam) 50 cfs year-round. Due to Project operation these minimum streamflows in both river sections are considerably less than unimpaired natural flows (Table 1).

Table 1. Summer flows (cfs), May through October, North Fork Feather River. Mean annual flow in parenthesis.

Gage Station Site	1905-1913*	1914-1948+	1950-1983
Below Pratville at Canyon Dam	1124(1156)	--	--
Pulga	2817(3683)	2161(2678)	--
Below Rock Creek Dam	--	--	100**
Below Grizzly Creek, below Cresta Dam	--	--	50++

* Unimpaired flow prior to construction of Lake Almanor.
\+ "Impaired" flow below Lake Almanor, pre-Rock Creek/ Cresta Project.
** Minimum flow release reduced to 50 cfs November-April.
++ Minimum flow release all year.

Prior to the completion of Lake Almanor in 1914, the unimpaired May through October mean monthly flow for the years 1905 to 1913

was 1124 cfs at the present site of Canyon Dam at Lake Almanor (below Prattville) and 2817 cfs near Pulga, just downstream of the Rock Creek-Cresta Project site (USGS 1905-1913)(Table 1). However, the mean annual unimpaired flow for the 1905-1913 period below Prattville was 1156 cfs and 3683 cfs at Pulga. The minimum mean monthly flow for this nine year period at Pulga was 856 cfs (September 1913).

After completion of Lake Almanor but prior to the completion of the Rock Creek and Cresta dams in 1950, pre-project impaired summer flows for the 34 year period 1914-1948 averaged 2161 cfs at Pulga for May through October (USGS 1914-1948)(Table 1). The minimum mean monthly flow at Pulga for this 34 year period was 479 cfs (October 1933).

River Reaches

The Rock Creek-Cresta Project, completed in 1950, altered 29.5 km of river from Cresta Powerhouse to Belden and transformed 28.4 percent of the river channel into small reservoirs (Rock Creek and Cresta). Each reservoir is approximately 4.2 km long. The Cresta Section was further impacted with the completion of the Poe project in 1958 when Poe Reservoir was built downstream of the Cresta Powerhouse.

The Rock Creek-Cresta Project originates at the head of Rock Creek Reservoir (elevation approximately 670 m) near Belden Town and extends downstream to Cresta Powerhouse (elevation approximately 427 m). Two separate sections of the NFFR exists within the Project area. The Rock Creek Section, 13.5 km in length, extends between the Rock Creek Dam and Powerhouse. The Cresta Section, 7.9 km in length, extends between the Cresta Dam and Powerhouse. Both section have similar stream habitats and contain similar fishery resources.

History of the Fishery

Prior to the completion of State Highway 70 through the Feather River Canyon in 1937, fisherman could ride the Western Pacific Railroad ("Fisherman's Express") to several sites in the canyon for excellent trout fishing.

The North Fork Feather River was once recognized as a prime trout stream. This turbulent stream and the surrounding rugged terrain were of great recreational and scenic value (USFWS 1962). Prior to 1950, the North Fork Feather River downstream from the Rock Creek Dam was a large, fast-flowing stream containing a trophy rainbow trout fishery (Hazel et at. 1976). Wales and Hanson (1952) stated that rainbow and brown trout were in abundance in the section of the NFFR to be altered by the proposed Rock Creek-Cresta Project and without power development it would eventually become one of the most heavily fished trout streams in California.

Indeed, angler effort within the pre-project area in 1946 was estimated at 31,500 angler-days (USFWS 1948) and Wales and Hanson (1952) estimated three trout were caught per angler-day. Assuming three hours per angler-day this approximates a catch rate of 1.0 fish per angler-hour. By 1954 the post-project catch per angler-hour was 0.23 and 0.29 for the Rock Creek and Cresta sections respectively (Rowley 1955). The fishery continued to decline inspite of efforts to restore the fishery through chemical treatments, fish stocking and reduced bag limits. Estimates of angler-use in 1976 were 2,000 angler-days and during the five year period 1981-1985, mean annual values of catch per angler-hour were 0.21 and 0.18 respectively for the Rock Creek and Cresta sections, while total angler-days averaged 5,236 for both sections combined (letter to Lloyd Britton, USFS, 1978; DFG 1988).

A pre-project study conducted in 1946 by the DFG estimated 36,000 angler-days were used to catch 108,000 trout annually on the NFFR from Canyon Dam to Cresta Powerhouse (Wales and Hanson 1952). Based upon this data, annual angler effort within the Rock Creek-Cresta Project area was estimated at 31,500 angler-days (USFWS 1948). A post-project evaluation of the instream flow release agreement was conducted in 1962 by the USFWS. This report stated:

> "...below Belden the fishery resources in North Fork Feather River have been destroyed. Reduced flows and stream fluctuations associated with generation of hydro-electric power have altered habitat once favorable for protection of trout to one suitable for nongame fish. Principal nongame species of fish inhabiting this section are sucker, hardhead, squawfish, and sculpin".

Post-project fishery resources in both stream sections have been dominated by nongame species, particularly Sacramento sucker, Sacramento squawfish, and hardhead (USFWS 1962; PG&E 1979; Moyle et al. 1983; DFG 1988).

Chemical treatments in 1966 and 1977 drastically reduced the standing crops of all fish species in the Rock Creek-Cresta Project area. The standing crop of trout, following the treatments, were increased through restocking efforts. Through this restocking, the fishery was restored for relative short periods of time. Less than two years after each "improvement", the fishery again rapidly deteriorated (Hazel et al. 1976; PG&E 1979; Flint 1980; Moyle et al. 1983). While the only significant stocking occurred immediately following the chemical treatments, infrequent planting of surplus fish occurred during other years. These infrequent plants were primarily in Rock Creek Reservoir and the Rock Creek Section.

A trout limit of two fish per day was initiated March of 1978 with the intent to manage the system as a trophy fishery and to encourage predation by trout on nongame fish (Flint 1980).

Existing Fishery

Prior to 1980, long-term, detailed studies documenting project effects had not been conducted. Therefore, as part of the FERC relicensing process, DFG proposed an intensive six-year study of the Rock Creek-Cresta's aquatic and fishery resources. This was mutually agreed to by PG&E and supported by several interest groups.

In July of 1980, PG&E agreed to fund a six-year study of the Project's stream sections, and reservoirs, in an attempt to determine a means to protect the fishery resources and mitigate if necessary the Project's effects.

Trout Habitat

The NFFR runs through a rugged narrow canyon of relative low gradient dominated by large boulders and bedrock as substrate.

The Rock Creek and Cresta sections can each be divided into two distinct subsections. The upper 7.6 km of the Rock Creek Section and the lower 4.7 km of the Cresta Section are characterized by low stream gradient (5.7 and 3.8 m/km, respectively) and long, deep pools connected by relatively short riffles and runs. In contrast, the lower 6.0 km of the Rock Creek Section and the upper 3.2 km of the Cresta Section are characterized by steeper stream gradient (14.2 and 10.4 m/km, respectively) and swifter waters in a boulder-strewn canyon (PG&E 1979).

Thick riparian vegetation greater than 1.5 m tall covers less than 40 percent of the bank area in each river section. Aquatic weed beds are non-existent (DFG 1988).

Estimates of spawning habitat indicate that virtually no suitable gravel is available in the main river (DFG 1982). Total available spawning gravel in the Cresta and Rock Creek sections was estimated at 125 and 392 square meters, respectively. These estimates represent 0.07 and 0.13 percent of the total area available in the two respective river sections. These spawning gravels are generally limited to patches of gravel behind large boulders. It is believed the majority of spawning now occurs in

selected tributaries to the main river. However, sixty percent of these tributaries have man-made barriers near the mouths preventing adult trout spawning migrations and thereby reducing total habitat available.

Temp.

Daily minimum water temperatures exceed 20.0°C during much of the midsummer period in the Project area and may occasionally exceed 22.5°C; daily maximum temperatures reach as high as 23.5°C. Temperatures under extreme low flow conditions are a few degrees warmer (PG&E 1979).

At the present, the river moves considerable sediment from upstream sources transported downstream through the East Branch to the Project area. As a result, PG&E is evaluating plans to dredge Rock Creek and Cresta reservoirs to remove a portion of the accumulated sediments.

Fish Populations

There are eight species of fish established in the NFFR area of the Rock Creek-Cresta Project. The principal trout species present are the rainbow trout followed by a much smaller population of brown trout. Nongame fish populations are dominated by Sacramento sucker followed by Sacramento squawfish and hardhead. Smallmouth bass are found primarily in the Cresta Section but are occasionally found in the Rock Creek Section. This species contributes little to the sport fishery. Sculpin are very numerous throughout both sections, while brown bullhead are present but are rarely seen in the angler's catch or standing crops.

Fish populations were monitored each fall from 1982 through 1985 by electrofishing. Over the four year period, rainbow trout averaged 17.08 and 22.89 percent of the number sampled in the Cresta and Rock Creek sections respectively, while Sacramento sucker averaged 65.20 and 49.29 percent, respectively (Table 2). These populations averaged over the years 1982-85 can be compared to samplings associated with each chemical treatment in the Rock Creek Section during 1966 and 1977.

The differences observed between the estimates in test sections associated with chemical treatments (1966 and 1977) and the 1982-1985 sampling, using electrofishing gear, are most likely due to sampling method and sample site.

Table 2. Percent of total number sampled from electrofishing and chemical treatments.

	Percent of Total Number Sampled			
	Rock Creek Section			Cresta Section
	1966*	1977*	1982-85	1982-85
Brown Trout	0	0	0.60	1.93
Brown Trout(hat)**	--	--	1.29	1.24
Rainbow Trout	2.13	4.46	22.89	17.08
Rainbow Trout(hat)	--	--	1.54	1.54
Sub-Total:	2.13	4.46	26.32	21.79
S. Sucker	72.02	46.40	49.29	65.20
S. Squawfish	4.83	12.97	8.00	6.22
Hardhead	10.16	14.29	13.25	1.50
Smallmouth Bass	0	5.88	0.09	2.22
Misc.	10.85	16.01	3.05	3.07
Sub-Total:	97.86	95.55	73.68	78.21
Grand Total:				
no./ha	1594	987	1380	910
kg/ha	578.9	252.7	226.5	86.4

* data from chemical treatments
** (hat) indicates fish of hatchery origin.

Management Goals

The goals for trout restoration and management on the North Fork Feather River are:

1. The natural reproduction and rearing of trout shall be encouraged to the greatest extent possible by protecting and improving the habitat of the NFFR and its tributaries and by affording protection from disease, predators and competing fish species. The habitat characteristics considered critical are:

   a. adequate and stable flows for protection of trout habitat.
   b. suitable water temperatures for adequate trout growth.
   c. adequate clean spawning gravels.
   d. high water clarity with low values of suspended sediments and settleable solids.
   e. access by adult trout spawners to spawning areas in tributaries as well as the main river.

2. Maintain optimum trout populations of a size structure capable of producing outstanding trout angling opportunities including the opportunity to creel and/or catch and release fish over 12 inches. This shall be done by maintaining a catch per angler-hour (based upon fish sized 10 inches or greater) at the rate of at least 0.50 for creeled trout or at least 1.00 including catch and release fish for each of the reservoirs and river reaches in the Project area.

3. The management of the trout resource in the river reaches of the NFFR and the East Branch from Poe Dam to the confluence with Indian and Spanish creeks, should be concerned with optimizing the adult rainbow and brown trout habitat by optimizing conditions for growth and survival, but at the same time provide sufficient conditions for spawning and rearing of fry and juvenile trout to sustain full use of adult habitat.

4. Mitigation for angler-use lost through project development should be obtained from the Rock Creek-Cresta Project sponsor. Estimates of angler-use indicate that up to 76,000 angler-days may have been expended on the North Fork of the Feather River had the project area existed today in its natural state. Should full mitigation in the project area prove to be impractical, compensation will be sought in the non-project areas from Belden Powerhouse to Gansner Bar and the East Branch of the NFFR, or other areas of the North Fork drainage such as Yellow Creek and Humbug Valley.

5. Supplement natural production and enhance angler-use in the project reservoirs through the use of hatchery produced trout of suitable domestic strain or wild fish.

6. Evaluate and monitor changes in the habitat and fishery to direct future management.

Management Programs and Recommendations

Specific programs to achieve the management goals are:

I. HABITAT PRESERVATION, RESTORATION AND IMPROVEMENT

Water Temperature

Post project (Rock Creek-Cresta hydroelectric facilities) water temperatures in the NFFR have long been suspect as a cause for the decline of the pre-project trophy fishery (USFWS 1962). In 1962 a USFWS post-project evaluation report recommended that DFG study water temperatures as a means to provide suitable habitat for trout (USFWS 1962). PG&E (1979) has also identified water

temperatures as one of the two factors that may be limiting trout production on the NFFR.

Raleigh et al. (1984) stated that stream rainbow trout select temperatures between 12 and 19°C. Hooper (1973) has stated that "flourishing trout populations are not found in streams exhibiting temperatures in excess of 70°F (21.1°C) for any length of time". Hooper states further that "a good trout stream should have summer temperatures in the range of 50-60°F (10-15.6°C), with an upper limit of 68°F (20°C)". According to Hokanson et al. (1977), zero growth rates for rainbow trout occurred at 23°C in the lab. Wurtsbaugh and Davis (1977) suggested "any substantial increase of stream temperature with out a concomitant increase of food abundance would result in decreased trout production". Wurtsbaugh and Davis go on to say that "temperature related effects on the stream community may result in changes in the quantities of benthic organisms upon which the fish subsist". Smith and Li (1983) found that juvenile rainbow trout sought higher focal point velocities as food demand increased at higher temperatures. Water temperatures which affects standard metabolic rate and thus food demand is one of several energetic factors to which trout respond when selecting velocities (Smith and Li 1983). Brungs and Jones (1977) determined 19°C as the maximum weekly average temperature for growth for both juvenile and adult rainbow trout.

The number of days the daily maximum water temperatures were within specified temperature (°C) intervals for July, August and September at Storrie (Station R9) near the downstream end of the Rock Creek Section and near Cresta Powerhouse (Station C1) near the downstream end of the Cresta Section are summarized in Table 3.

Trout living in water having temperatures above their optimum range are placed at a competive and selective disadvantage (Brown and Moyle 1981). Considering the optimum range of 12-19°C recommended by Raleigh (1984), daily maximum water temperatures have exceeded 19°C during much of the midsummer period in the project area, and have reached as high as 24°C.

Table 3. Summary of the number of days the daily maximum water temperatures were within selected temperature (^{o}C) intervals.

Year	Rock Creek Section Station R9 ≤19	>19≤21	>21	N	Cresta Section Station C1 ≤19	>19≤21	>21	N
July:								
1981	na	na	na	na	na	na	na	na
1982	11	14	0	25	4	19	2	25
1983	29	2	0	31	22	9	0	31
1984	0	7	12	19	0	15	16	31
1985	0	8	23	31	0	4	27	31
August:								
1981	0	2	25	27	0	0	27	27
1982	10	21	0	31	4	23	4	31
1983	8	22	1	31	1	17	12	30
1984	1	29	1	31	1	20	0	21
1985	2	21	8	31	2	10	19	31
September:								
1981	9	10	11	30	9	8	13	30
1982	26	4	0	30	22	8	0	30
1983	22	1	0	23	4	13	0	17
1984	10	20	0	30	11	19	0	30
1985	30	0	0	30	29	1	0	30

To improve the water temperatures for trout, colder water needs to be obtained from Lake Almanor for release downstream. Generally, the temperature of the water transferred through the power tunnels does not change. Thus, the temperature of the water entering the Prattville tunnel from Lake Almanor greatly influences water temperatures downstream. During the Rock Creek-Cresta project DFG and PG&E documented that cold water was present in Lake Almanor and was not completely drawn upon by the Prattville intake for release downstream (DFG 1988; WCC 1986).

RECOMMENDATIONS:

1. For adequate trout growth, daily maximum water temperatures in the NFFR Rock Creek-Cresta project area shall not exceed the upper limit of the range recommended by Raleigh (1984), 12-19^{o}C.

2. Continuous recording thermographs designed to measure daily water temperatures be installed near the downstream end of the Rock Creek and Cresta sections. These sites should be maintained during the May through October period for the lifer of the project.

3. Water temperature control facilities be installed at Lake Almanor and Butt Valley Reservoir.

Instream Flows

Rainbow trout sustain the most important fish resource within the Rock Creek-Cresta Project area based upon its economic and recreational attributes. This significance must be reflected in setting minimum flow requirements within the project area.

There is a definite relationship between the annual flow regime and the quality of trout habitat. The most critical period is typically during base flow (lowest flows of late summer to winter). A base flow greater than or equal to 50 percent of the average annual daily flow is considered excellent for maintaining quality trout habitat, a base flow of 25 to 50 percent is considered fair, and a base flow of less than 25 percent is considered poor (Raleigh et al. 1984 adapted from Binns and Eiserman 1979 and Wesche 1980).

However, in some steams the major factor limiting salmonid densities may be the amount of adequate overwintering habitat (Bustard and Narver 1975).

Burt and Mundie (1986) studied the effects of 81 case histories of regulated stream flows and found that 76 percent of the cases studied yielding known outcomes showed decreased salmonid populations. From these cases showing reduced salmonid populations, 60 percent were associated with flow reductions, and the greatest loss of fish was directly related to the removal of greater than 30 percent of the pre-project flow. Similarly, Baldrige et al. (1987) found reductions in trout populations and biomass with a slight increase in nongame fish populations associated with partially regulated streams. While in fully regulated streams, trout populations disappeared and nongame fish dominated.

However, Burt and Mundie (1986) found additional factors associated with flow regulation that contributed to a reduction in number of salmonids. They were: blockage of habitat (occurring in 35 percent of cases with reduced salmonids), sedimentation of habitat (in 29 percent of cases), fluctuating flows (19 percent), changes in water temperature (17 percent), pollution (6 percent), difficulty of passage for downstream migrants (6 percent), absence of gravel recruitment (4 percent), inundation of habitat (4 percent), and gas supersaturation (2 percent).

It is the policy of the Fish and Game Commission as well as the California Fish and Wildlife Plan that natural production and

rearing of trout will be encouraged to the greatest extent possible by protecting and improving habitat and by affording protection from disease, predators and competing fish species. Since the fishery in the Rock Creek-Crest area is dependent upon adult fish in the catch and adult spawners are required for natural production, stream management in the Rock Creek-Cresta Project area should be to optimize adult rainbow and brown trout habitat and to provide sufficient spawning, fry and juvenile habitat to sustain full use of the adult habitat.

From studies using the Instream Flow Incremental Methodology (IFIM) in the Rock Creek and Cresta river section during 1986, the flow regime that provides optimum adult rainbow trout habitat has been identified (Hardin-Davis 1986).

The flow that would provide optimum adult rainbow trout habitat in the Rock Creek Section is 260 cfs while 325 cfs is required in the Cresta Section (Figures 2, 3). Although these flows do not provide for the greatest spawning, fry, and juvenile habitat there is little loss in habitat for these life stages particularly in the Rock Creek Section.

These flows of 260 cfs in the Rock Creek Section and 325 cfs in the Cresta Section constitute only 7.1 and 8.8 percent respectively of the unimpaired 1905-1913 mean annual flow of 3,683 cfs as measured at Pulga.

Brown trout are an important trout species in the Rock Creek-Cresta area fishery. However, wild brown trout contributed less than seven percent to the angler's creel over the years 1981-1985 as determined from angler surveys in the Rock Creek and Cresta sections. The recommended minimum flows for adult rainbow trout will not significantly reduce brown trout habitat in the respective river sections (Figures 4, 5).

Appendix I contains weighted useable area (WUA) of fish habitat vs flow relationships for Sacramento sucker, Sacramento squawfish, and hardhead.

RECOMMENDATIONS:

1. The minimum fish flow release schedules from Rock Creek and Cresta dams for optimum adult rainbow trout habitat shall be:

Rock Creek Dam - 260 cfs, all year
Cresta Dam - 325 cfs, all year

2. The flows are to be measured at the point of release from Rock Creek Dam and Cresta Dam.

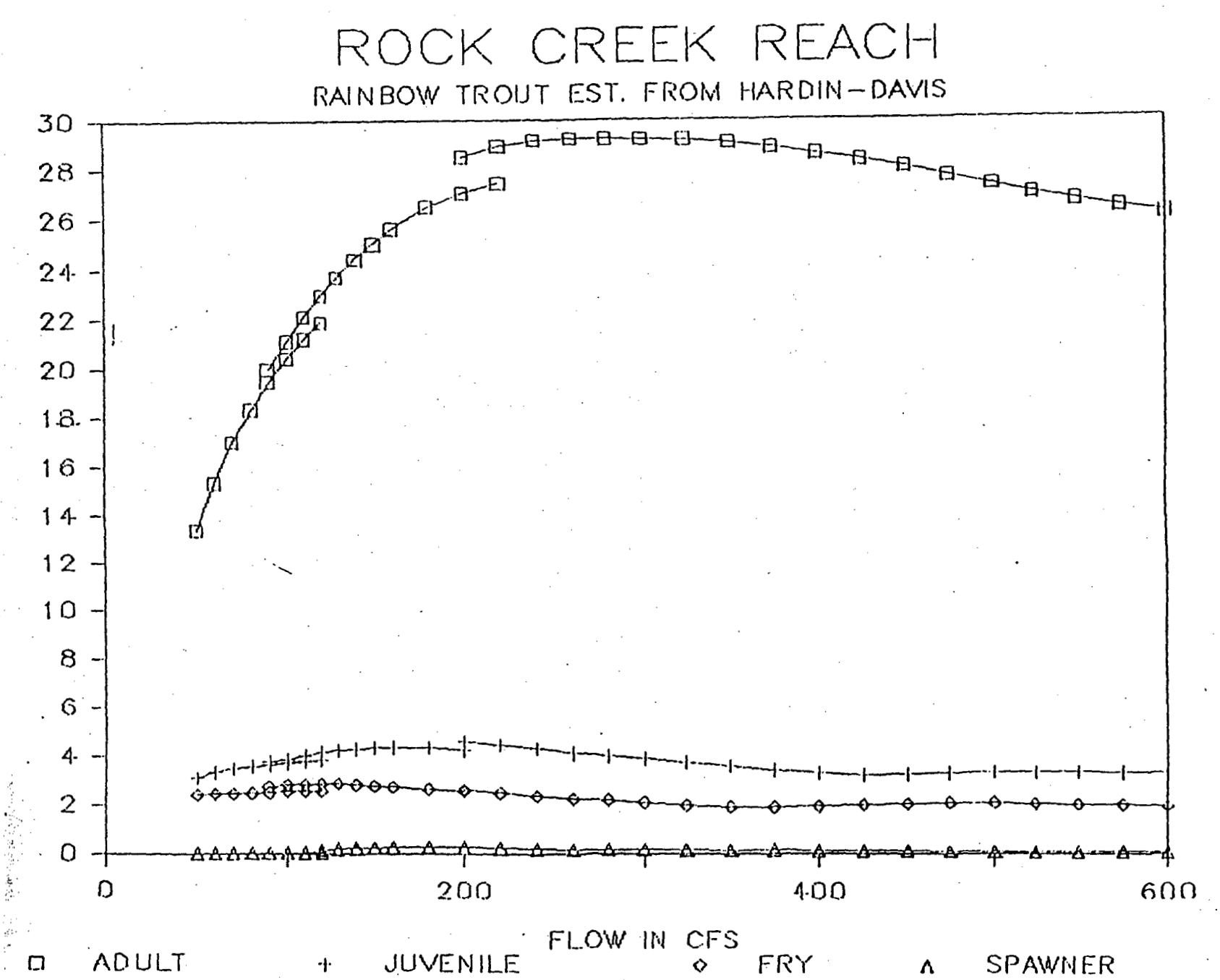

Figure 2. Rainbow trout habitat vs flow relationship, Rock Creek Section, North Fork Feather River.

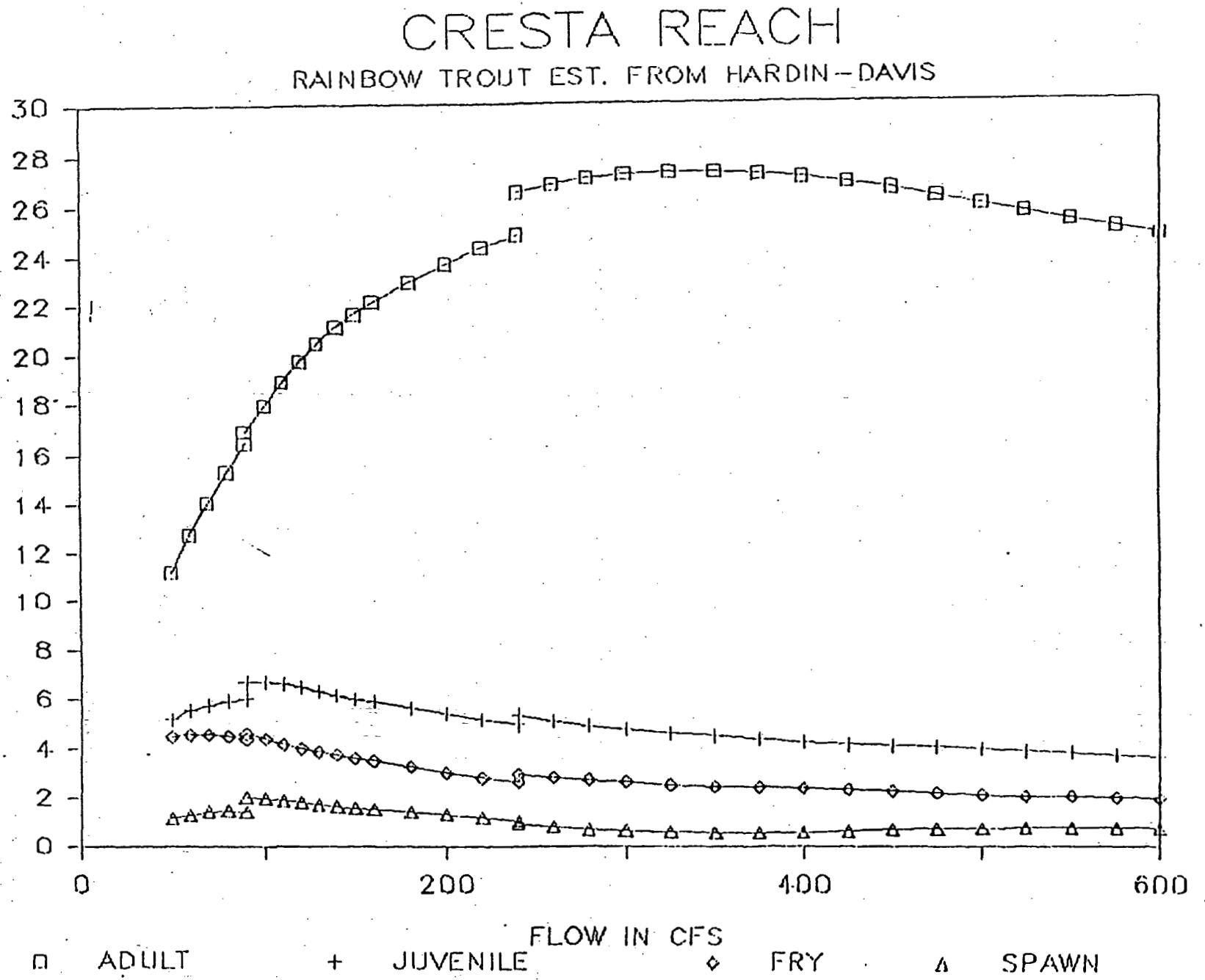

Figure 3. Rainbow trout habitat vs flow relationship, Cresta Section, North Fork Feather River.

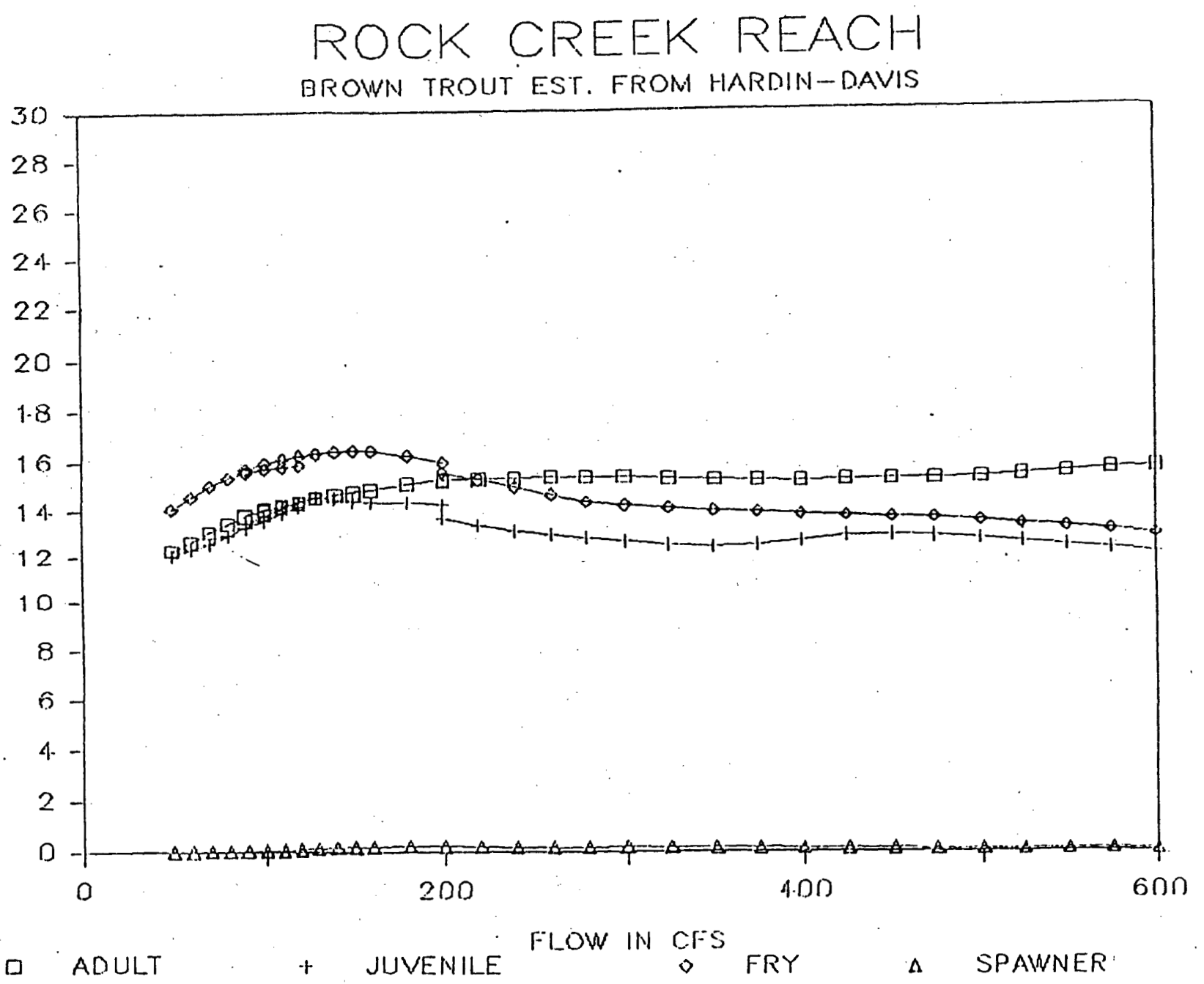

Figure 4. Brown trout habitat vs flow relationship, Rock Creek Section, North Fork Feather River.

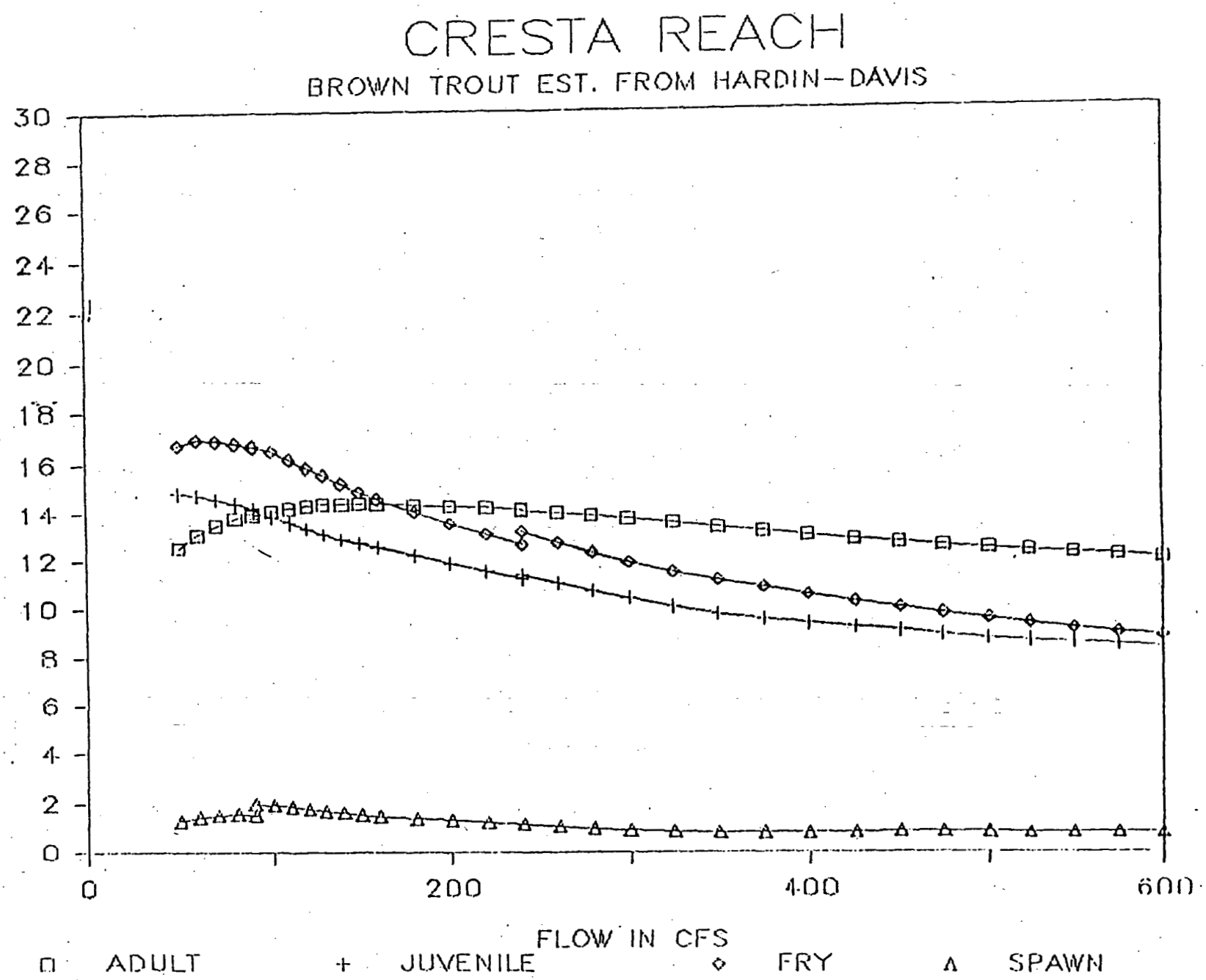

Figure 5. Brown trout habitat vs flow relationship, Cresta Section, North Fork Feather River.

Spawning Habitat Improvement

Spawning habitat is sorely lacking within the Rock Creek and Cresta sections due to the lack of suitable gravels created by the lack of gravel recruitment below dams and the presence of barriers to migration. Historically, migrating runs of trout spawners from these reaches had access to large spawning areas now blocked by Rock Creek and Cresta dams, such as: Chips Creek, Yellow Creek, N.F. Feather to Seneca and tributaries of the East Branch (Figure 6). Spawner collections at barriers during the study period 1981-1985 showed the presence of large numbers of adult spawners that were prevented further upstream migration.

Results of a habitat survey in 1981 indicate the estimated total available spawning gravel at 125 square meters in the Cresta Section and 392 square meters in the Rock Creek Section. These estimates represent 0.07 and 0.13 percent of the total area in the respective river sections. These spawning gravels are generally limited to patches of gravel deposited behind large boulders.

Estimates of spawning habitat were again made in 1986 during instream flow studies. These spawning simulations were inconclusive since the substrate code used was unable to depict the small amounts of gravel in the channel, and when gravel was present, it was often found in edge cells where the hydraulic simulation was less accurate.

It is believed the majority of spawning activity now occurs in selected tributaries to the main river. However, sixty percent of these tributaries have man-made barriers near the mouths preventing passage of adult trout spawners and reducing total habitat available. A tributary improvement feasibility study for selected streams of the North Fork of the Feather River was prepared by Reiser and Ramey (1987). The Study identified problem areas in the tributary streams and developed concepts for habitat enhancement in each using gravel placement and artificial spawning channels.

Experience in habitat restoration through gravel placement to restore or rejuvenate gravel or the creation of artificial trout spawning channels is limited. A current project in Wyoming on tributaries of the Snake River involving renovation of spawning gravels has resulted in significant increases in returning spawning cutthroat trout (Kiefling 1985). In California, PG&E has restored gravel on Helms Creek but no post-project evaluation has been completed. Reiser and Ramey (1987) list 16 additional projects using gravel placement for habitat enhancement throughout the United States and Canada. Fourteen of the projects were evaluated with 12 of the projects designated as successful and meeting project objectives.

The existence of artificial spawning channels for trout are rare. Only one exists in California, the Pleasant Valley Spawning

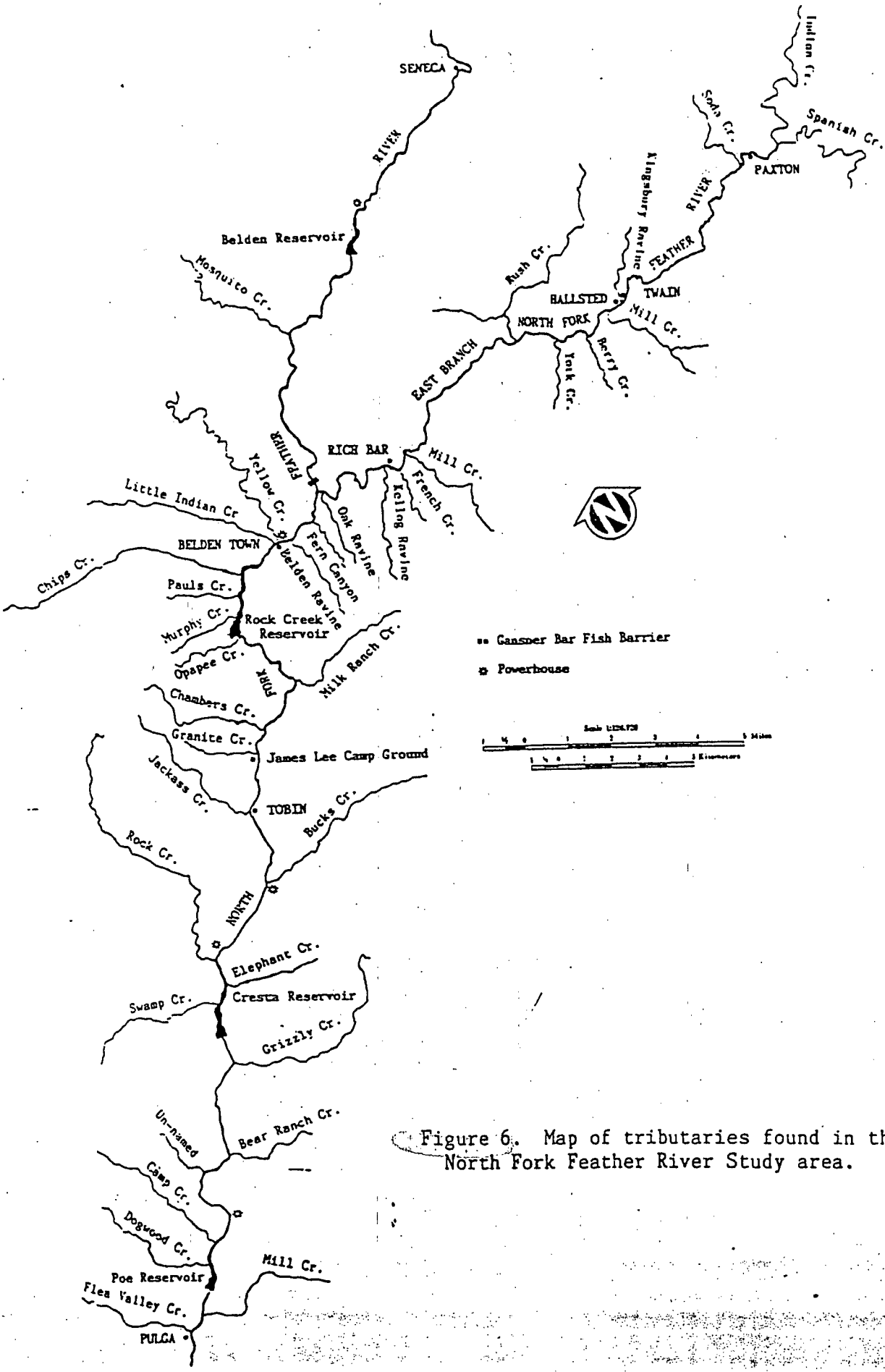

Figure 6. Map of tributaries found in the North Fork Feather River Study area.

Channel in Inyo County (Johnson et al. 1966). Built in 1962 by the Los Angeles Department of Water and Power, it has realized an increase in brown trout spawning pairs of 118 in 1962-1964 to 500 in 1971-1972 (Deinstadt 1987). Several channels have been built for salmon spawning on the Pacific Coast and success has ranged from poor to excellent. Reiser and Ramey (1987) list 9 additional habitat enhancement projects using spawning channel. Eight of the projects have been evaluated with 7 projects listed as successful.

RECOMMENDATIONS:

1. Improve and maintain the spawning habitat for trout in selected tributaries. Following the phased approach developed by Reiser and Ramey (1987), implement the measures proposed for Opapee and Chambers creeks as follows:

   a. Opapee Creek - develop a 750 foot long off-stream spawning channel.

   b. Chambers Creek - place clean gravels in the streambed at selected locations within the lower 900 feet of the creek.

2. Implementing the above mentioned projects initially will allow for the combined testing of spawning channels and spawning gravel placement as tributary enhancement measures. Should these prove effective, then the remaining measures proposed by Reiser and Ramey (1987) should be implemented on Milk Ranch Creek and Granite Creek as follows:

   a. Milk Ranch Creek - develop a 600 foot long off-stream spawning channel.

   b. Granite Creek - place clean gravel in the streambed in the lower portion of the creek, realign the lower 150 feet of channel to reduce stream gradient and improve upstream passage for trout spawners.

3. Improve and maintain the spawning habitat for trout spawning in various river reaches and additional tributaries should the recommendations in 1 above prove to be effective as follows:

   a. Cresta Section:

      Main River - rejuvenate selected riffles with gravel placement for trout spawning.
      Grizzly Creek - increase existing trout spawning areas with suitable gravel placement.

b. Rock Creek Section:

Main River - rejuvenate selected riffles with gravel placement for trout spawning.

Rock Creek - increase existing trout spawning areas with gravel placement if response from improved passage over the barrier warrants the project feasible.

c. Belden Town to Paxton:

Soda Creek, Rush Creek, and Mill Creek (at Hallsted) - rejuvenate riffles in these tributaries if response from barrier removal warrants a project feasible.

4. Increased hydroelectric development or enlargement of existing facilities within the N.F. Feather River watershed that reduce the effects of flushing flows that are required to maintain quality substrate, prevent sediment deposition and maintain or enhance the fishery habitat, shall be prevented.

Barrier Removal/ Tributary Recruitment

The placement of the two dams has prevented adult trout spawners access to upstream spawning areas in the main-stem river and tributaries. In addition, with the construction of the dams, gravel recruitment from upstream sources was severely reduced, and access to local tributaries, located between dams, inadequate due to barriers created by highway and railroad culverts, and nature. Spawner collections at these barriers during the study period 1981-1985, showed the presence of large numbers of adult spawners that were prevented upstream migration.

Presently, Cresta Dam, Rock Creek Dam and the Gansner Bar Fish Barrier Dam are main-stem barriers to fish migration. Prior to the Rock Creek and Cresta dams, no barriers on the main-stem river existed in the Project area/ No barriers of any kind are found on 28.2 km of the East Branch of the NFFR from its confluence with the NFFR to Highway 89.

Within the area from Poe Dam to Highway 89, 26 tributaries were examined for barriers (Figure 6). Sixteen of these tributaries contained man made barriers within 1000 km of the mouth: dams, and/or highway or railroad culverts. Natural barriers were found on nine tributaries, one tributary was found to be barrier free (Table 4). One additional man-made barrier was identified as the Gansner Bar Fish Barrier near Belden Town.

The removal of or providing passage over the first identified barrier on thirteen selected tributaries in the Project area and the NFFR above Belden Town will result in 1100 m of additional

Table 4. Summary of stream bed distances (in meters) to first and second barriers.

	Mouth to First Barrier	First Barrier Type*	Additional Beyond First Barrier	Second Barrier Type	Improvement Priority
Cresta Reach:					
Dogwood Cr.	0	RC	50(est)	F	low
Camp Cr.	20	RC	50	F	low
Un-named (Cedar)	30	RC	50	F	none
Bear Ranch Cr.	70	F**	No Further		none
Grizzly	1000	HG++	1000	F	high
Sub-Total	1120		1150		
Rock Creek Reach:					
Swamp Cr.	10	RC	20	F	none
Elephant	10	F**	No Further		none
Rock Cr.	70	D	30	F	medium
Bucks Cr.	250	F	100	F	high
Jackass Cr.	100	RC**	No Further		none
Granite Cr.	70	HC	100	F	low
Chambers Cr.	300	F**	No Further		none
Milk Ranch Cr.	150	RC	500	F	high
Opapee Cr.	120	HC**	No Further		none
Sub-Total	1080		750		
Belden Reach:					
Murphy Cr.	50	F	No Further		none
Pauls Cr.	40	F	No Further		none
Chips Cr.	>4000	--	Unknown		
Little Indian	0	HC	1000	D	low
Yellow Cr.	>1000	F**	No Further		none
Fern Cr.	200	HG**	10	RC	none
N.F. Feather	400	D+	11265	D	high
Sub-Total	5690		12275		
East Branch to Paxton:					
Oak Ravine	100	RC**	No Further		none
Kellog Ravine	80	F**	No Further		none
Mill Cr.(Rich Bar)	80	RC	1300	F	medium
Rush Cr.	50	HC	2000	F	high
Mill Cr.(Hallsted)	300	RC	2000	--	high
Soda	20	HC	1500	F	high
Sub-Total	630		6800		

* HC=highway culvert, RC=railroad culvert, F=falls, D=dam (man-made), HG=high gradient

** Barrier removal not recommended or reasonable

\+ Gansner Bar Fish Barrier

++ Judged to be a partial barrier

stream bed in the Cresta Reach, 730 m in the Rock Creek Reach, 12,265 m in the Belden Reach to Belden Reservoir, and 6800 m in the East Branch. These improvements will effectively double the existing area presently available to adult trout spawners. Second barrier removal is not recommended on most tributaries.

The main stem river is heavily dependent upon the recruitment of wild trout from tributary spawning and nursery areas. Following the 1966 chemical treatment program to control nongame fish species in the Rock Creek section, wild rainbow trout were recorded in the creel of 1968 and 1969. It was stated that these fish had drifted down from the untreated tributaries (Hazel et al. 1976, PG&E 1979).

In addition, during the Rock Creek-Cresta fishery study, the proportion of wild trout in the total trout standing crop estimates for 1982-1985 period averaged 87.0 percent rainbow and 2.3 percent brown trout in the Rock Creek section. Whereas, in the Cresta section, wild trout composition was 78.4 percent rainbow and 8.9 percent brown trout of the total trout population (DFG 1988).

Construction of hydroelectric facilities cause concern because they reduce streamflows, increase water temperatures and reduce gravel recruitment. Therefore, tributaries of the NFFR are valuable for the local trout fishery, because water temperatures, spawning flows and spawning habitats are still suitable for trout production.

Data from the DFG fishery study on the NFFR suggest that only 0.13 percent of the area in the Rock Creek section and 0.07 percent in the Cresta section had gravel suitable for spawning (DFG 1988). Tributary monitoring of downstream migrations of juvenile rainbow trout indicated that these tributaries act as nursery grounds for the recruitment of the young to the main river channel.

To summarize findings by DFG (1988), four factors indicate that tributaries to the NFFR are important for the recruitment of rainbow trout to the NFFR fishery, they are: 1) a high percent composition (>75%) of wild rainbow trout in the standing crop from 1982-1985, 2) small amount of available spawning gravel in the Rock Creek and Cresta sections, 3) the documented migration of juvenile rainbow trout out of the tributaries, and 4) spawning trout were found accumulated at the mouths of tributaries during the spring. Thus, the following recommendations are made.

RECOMMENDATIONS:

1. Barriers to adult trout spawners should be improved and/or removed to improve fish passage and increase spawning habitat in the following tributaries :

a. Cresta Section:

Grizzly Creek (first barrier is a natural high gradient cascade)
Camp Creek (railroad culvert)
Dogwood Creek (railroad culvert)

b. Rock Creek Section:

Rock Creek (man-made dam at mouth)
Granite Creek (highway culvert)
Milk Ranch Creek (railroad culvert)
Bucks Creek (natural barriers)

c. Belden Town Area:

Little Indian Creek (highway culvert and man-made dam)
Gansner Bar Fish Barrier (provide passage to trout spawners over man-made fish barrier if future needs warrant additional natural spawning)

d. East Branch NFFR:

Mill Creek at Rich Bar (railroad culvert and natural falls)
Rush Creek (highway culvert, scheduled for completion 1989)
Mill Creek at Hallsted (railroad culvert)
Soda Creek (highway culvert, completed 1988)

2. All tributaries within the Rock Creek-Cresta project area (and including East Branch tributaries) should be maintained with natural stream flows free of hydroelectric development, and pollution from mining and housing development.

Specific protection and habitat improvement should be afforded, but not limited to, the tributaries of the NFFR and East Branch that juveniles and adult spawners were collected from during the Rock Creek-Cresta Fisheries Manangement Study (Figure 6). They are as follows:

Soda Creek	Murphy Creek
Kingsbury Ravine	Yellow Creek
Mill Creek (Hallsted)	Chips Creek
Berry Creek	Opapee Creek
York Creek	Milk Ranch Creek
Rush Creek	Chambers Creek

(continued next page)

Mill Creek (Rich Bar)	Granite Creek
French Creek	Jackass Creek
Kellog Ravine	Bucks Creek
Oak Ravine	Rock Creek
Mosquito Creek	Elephant Creek
Fern Canyon	Grizzly Creek
Belden Ravine	Mill Creek (Pulga)
Little Indian Creek	Flea Valley Creek
Pauls Creek	

3. Flows releases into the following tributaries should be augmented to offset the effects of altered streamflow associated with the existing hydroelectric facilities that have reduced trout spawning, nursery, rearing habitat, and spawner access:

	Existing	Proposed*	
	Flow(cfs)	Flow(cfs)	Time period
Milk Ranch Cr.	0	3	all year
Bucks Creek	3	6	" "
Grizzly Creek	4	8	" "

* These flow recommendations subject to change pending results of Instream Flow studies proposed by FERC.

Reservoir Sediment Sluicing and Source Control

Interest in sluicing (operation of low level outlet gates) originated in 1965 when PG&E was cited by Fish and Game for "destruction of fishlife" following a sluice gate opening at PG&E's Chili Bar Dam. An agreement with PG&E and the DFG developed after the above event. This agreement stated that sluicing would occur during periods of natural spill over diversion dams to allow for maximum transport of silt and debris downstream; "to insure that normal sluicing procedures were (are) not detrimental to fish and wildlife".

In 1981, PG&E began to experience operational problems with the Rock Creek Dam's low level outlets (sluice tubes) and drum gates, due to a build up of sediment and debris at the face of the dam. To ensure the operability of the dam, periodic local dredging and more frequent sluicing was initiated. The DFG and Central Valley Regional Water Quality Control Board (CVRWQCB) have expressed concerns that the release of sediments from PG&E's operations at the reservoirs may be impacting water quality and fishery resources downstream. In 1984, PG&E agreed with the DFG, the CVRWQCB and the U.S. Corps of Engineers (COE) to develop a plan for the long term management of the sediments accumulating in Rock Creek Reservoir from upstream erosion.

PG&E's Sediment Management Plan, dated July 15, 1985, deals with interim and long term sediment management plans and implementation. The long term Sediment Management Plan outlined four programs to address sediment accretion in Rock Creek Reservoir:

1. Dredging of "sediments from the reservoir and transport to suitable disposal areas".

2. Upstream erosion control, implementation of a "Memorandum of Agreement with agencies and landholders to address studies of upstream erosion problems and to implement erosion control projects to reduce downstream sedimentation".

3. Continued studies; "including a sampling and monitoring program in the watershed".

4. Operational procedures; "after dredging, PG&E will continue a regular program of sluicing to ensure low level outlets (sluice tubes) and other openings at the face of the dam remain operable and clear of sediments".

Since the flood of February 1986, PG&E has become concerned with the amount of sediment now accumulated in Cresta Reservoir.

The DFG commends PG&E on its efforts to reduce erosion and for long term sediment management goals in the NFFR. The DFG recommends continued support from all agencies and landholders for the implementation of upstream erosion control, and continued studies.

The level of sediment recorded during sluice events on the NFFR during the Rock Creek-Cresta project have in some cases exceeded the National Academy of Sciences (NAS) standards (80 mg/l suspended solids) for support of a good fishery (NAS 1973). The highest concentrations of sediment (80,000 mg/l suspended solids) was recorded during tunnel adit and drum gate cleaning at Cresta Dam. Concurrently the background levels of sediment recorded during high flow events have also exceeded the NAS levels.

To preclude any impacts from the sluice discharges, the concentrations of sediment released in the sluice should be less than the concentration the river carries naturally at that flow (Orsborn 1987). It has been well documented in the literature that sluicing and high concentrations of sediment can be harmful or disruptive to aquatic resources. Currently there is inadequate data available from the NFFR to describe the sediment-flow relationship; ie. predict what concentration of sediment the river can carry at what flow. Thus, because of this lack of knowledge, and the documented high concentrations of sediment during reservoir, tunnel and drum gate sluicing, the following recommendation is made.

RECOMMENDATION:

It is the recommendation of DFG to prohibit any further sluice or low level outlet release operations and any operational maintenance at the dams and associated facilities (tunnels, adits, powerhouses, drum gates) that release sediment into the NFFR and tributaries. Sediment produced from maintenance cleaning of tunnel adits, drum gates, or related operations shall be removed from the facilities; not diluted and discharged into the river.

Nongame Fish Control

Chemical treatments in 1966 and 1977 drastically reduced the standing crops of all fish species in the Rock Creek-Cresta Project area. The standing crop of trout, following each treatment, was increased through restocking efforts. Through this restocking, the fishery was restored for relative short periods of time. Less than two years after each "improvement", the fishery again rapidly deteriorated (Hazel et al. 1976; PG&E 1979; Flint 1980; Moyle et al. 1983).

Future chemical treatment operations to control nongame fish species in the project area are not recommended unless the worth of such operations can be justified to improve and protect the wild trout fishery. Past operations have yielded limited, short-term success. Data indicates that project waters would need chemical treatment every several years to keep nongame fish numbers in check. The worth of such periodic treatments in this instance are questionable from both biological and economic standpoints. However, should new evidence show the need for chemical treatments, the value of such a treatment should be justified on the basis of biologic and economic factors at the time the treatment is proposed.

Wild trout populations will benefit much more from efforts to improve habitat, water temperature and flow regimes, than from poisoning operations (Moyle et al. 1983).

II. FISH PRODUCTION

Fish Stocking

Regular stocking of trout by the Department did not occur in the Rock Creek-Cresta Project area after completion of the Rock Creek-Cresta Project in 1950 due to unsuitable habitat attributed to reduced flows and associated proliferation of nongame fish. The only significant stocking occurred immediately following chemical treatments with infrequent planting of surplus fish

during other years. These infrequent plants were primarily in Rock Creek Reservoir and the Rock Creek Section (DFG file records). The regular annual stocking of the East Branch terminated in 1976 due to a lack of available hatchery fish (Flint 1987).

No significant evaluation was made as to the impact the various stocked trout species and strains had upon the fishery until 1980 when all trout stocked were marked for evaluations that occurred between 1981-1986.

Between 1981 and 1986 a series of subcatchable and catchable sized trout strains (domestic brown and rainbow, wild rainbow, and rainbow hybrids) were evaluated to determine the best species and strain of trout suitable for the Rock Creek and Cresta sections.

Selected stocks of planted fish were found to significantly impact the angler's annual harvest. Collectively, planted trout annually composed as high as 80.6 percent of the East Branch catch, 58.8 percent of the Rock Creek-Cresta combined section catch, and 41.2 percent of the Rock Creek-Cresta combined reservoir catch (Tables 5, 6, 7). Of the groups examined, Eagle Lake trout x Pit rainbow hybrid (ELT x RTP), Pit rainbow (RTP), Eagle Lake trout domestics (ELT-D) and Shasta brown trout (BNS) catchable strains consistantly gave the highest returns. Brown trout were best in reservoirs.

Catchable sized plants gave the highest returns while subcatchable sized groups the smallest. Yearling progeny of NFFR wild rainbow spawners (RTFR) gave much lower returns than other strains of the same age during the course of the study. This may be attributed to their small and varied size at time of stocking. However, yearling RTFR fish consistantly gave multi-year returns as did all Ceratomyxa resistant catchables.

The planting schedule was drastically altered in late 1981 when the disease Ceratomyxa shasta, a myxosporidan, was discovered in the study area. This along with disease problems at key DFG production hatcheries limited the availability of trout strains known to have a significant resistance to ceratomyxosis. Within the Feather River system infections of ceratomyxosis were first detected with the completion of the Oroville Project in the late 1960's. The presence of this organism caused high mortality to most trout strains stocked in Lake Oroville and steelhead raised at the newly completed Feather River Hatchery. Although extensive tests were not made, it was felt C. shasta was confined to Lake Oroville and downstream (Manzer 1987).

In California, C. shasta has been documented in the Pit River and Trinity River systems (Schafer 1968). In Oregon and Washington it is found in the Deschutes, Willamette, Columbia and Siletz

Table 3. Estimated returns to the creel of trout stocked in the Rock Creek-Cresta sections, NFFR.

Strain	Year Stocked	Wgt(g) Stocked	Number Stocked	Estimated Angler Harvest 1981	1982	1983	1984	1985		Total	Percent Return Total	Percent Return First-Year
ELTxRTP(c)-82+	83	93	2691			980	57	14		1051	39.1	36.4
RTP(c)-84	85	130	4760					1110		1110	23.3	23.3
BNS(c)-80	82	120	5771		887	221	19	28		1155	20.0	15.4
BNS(c)-82	84	142	3952				533	106		639	16.2	13.5
ELT-D(c)-82	83	206	3947			380	0	0		380	9.6	9.6
RTSxRTKJ(c)-80	81	134	5395	505	0	0	0	0		505	9.4	9.4
RTFR(y)-82	83	102	7911			579	165	14		758	9.6	7.3
RTFR(y)-81	82	60	8737		489	* 73	108	28		698	8.0	5.6
RTH(c)-80	81	145	2071	72	0	0	0	0		72	3.5	3.5
RB(y)-84	85	38	2520					1	***	1	2.0	2.0
RTSxRTKJ(s)-81	81	42	13643		193	0	0	0		193	1.4	1.4
RTFR(y)-83	84	45	7288				83	139		222	3.0	1.1
BNS(s)-79	80	38	53340	423	188	0	0	14		625	1.2	0.8
ELT-D(s)-84	84	38	11700					92		92	0.8	0.8
BNS(s)-81	82	25	9737			0	0	66	**	66	0.7	0.7
RTFR(y)-84	85	23	13000					78		78	0.6	0.6
BNW(s)-83	84	24	7500					14		14	0.2	0.2
BNS(f)-80	81	10	19380		0	0	0	0		0	0.0	0.0
RTS(s)-81	81	42	13643		0	0	0	0		0	0.0	0.0
Total Stocked Fish Harvest:				1000	1757	2233	965	1704				
Total Estimated Harvest(All Fish):				2700	3800	3795	2481	3124				
Percent Planted Fish of Total Harvest:				37.0	46.2	58.8	38.9	54.5				

* 18 from Cresta Reservoir, although none stocked there
** 16 from Cresta Reservoir, although none stocked there
*** 1 tag returned by angler, total tagged=50

Table 4. Estimated returns to the creel of trout stocked in the Rock Creek-Cresta reservoirs, NFFR.

Strain	Year Stocked	Wgt(g) Stocked	Number Stocked	Estimated Angler Harvest 1981	1982	1983	1984	1985	Total	Percent Return Total	First-Year
BNS(c)-82	84	142	981 *				159	17	176	17.9	16.2
BNS(c)-80	82	120	1910		206	54	0	0	260	13.6	10.8
RTSxRTKJ(c)-80	81	134	1931	171	0	0	0	0	171	8.9	8.9
RTP(c)-84	85	130	240 *					16	16	6.7	6.7
RTSxRTKJ(s)-81	81	42	4279		49	0	0	0	49	1.1	1.1
RTFR(y)-83	84	45	2045 *				0	16	16	0.8	0.0
RTS(s)-81	81	42	4279					0	0	0.0	0.0
ELT-D(s)-84	84	38	3300					0	0	0.0	0.0
RTH(c)-80	81	145	253	0	0	0	0	0	0	0.0	0.0
BNS(f)-80	81	10	6680					0	0	0.0	0.0
RB(y)-84	85	38	480					0	0	0.0	0.0
Total Stocked Fish Harvest:				171	255	54	159	49			
Total Estimated Harvest(All Fish):				842	840	355	386	297			
Percent Planted Fish of Total Harvest:				20.3	30.4	15.2	41.2	16.5			

* Cresta Reservoir stocked only

Table 5. Estimated returns to the creel of trout stocked in the East Branch, NFFR.

Strain	Year Stocked	Wgt(g) Stocked	Number Stocked	Estimated Angler Harvest 1981	1982	1983	1984	1985	Total	Percent Return Total	First-Year
ELT-D(c)-82	83	206	1078			409	0	0	409	37.9	37.9
ELTxRTP(c)-82	83	93	1847			459	52	0	511	27.6	24.9
RTFR(y)-82	83	102	1860			409	52	0	461	24.8	22.0
RTSxRTKJ(c)-80	81	134	1581	211	0	0	0	0	211	13.3	13.3
BNS(c)-80	82	120	1800		144	0	0	0	144	8.0	8.0
RTSxRTKJ(s)-81	81	42	5617		58	0	0	0	58	1.0	1.0
RTFR(y)-83	84	45	40				0	0	0	0.0	0.0
BNS(c)-82	84	142	100				0	0	0	0.0	0.0
RTFR(y)-84	85	23	2900					0	0	0.0	0.0
RTS(s)-81	81	42	5617	0	0	0	0	0	0	0.0	0.0
Total Stocked Fish Harvest:				211	202	1277	104	0			
Total Estimated Harvest(All Fish):				1010	664	1584	1099	715			

systems (Buchanan et al. 1982). Schafer (1968) found that all waters infective with ceratomyxosis contained "wild" rainbow trout presumed resistant to the disease and that domestic strains of brown and brook trout were also highly resistant. Other studies indicate long term disease problems may result from introductions of less adapted susceptible host fish leading to increased numbers of C. shasta, resulting in serious C. shasta induced losses in native salmonid populations (Ratliff 1983; Wade 1986).

Water temperatures above 10°C are necessary for initial infection and the disease progresses more rapidly with increased water temperatures (Bell 1986). Buchanan et al. (1982) found that survival decreased as water temperature increased from 12°C to 21°C in studies of four stocks of summer steelhead subjected to infections of ceratomyxosis in the Willamette River, Oregon.

During 1981 within the Rock Creek-Cresta area, several dead trout were found to contain spores of C. shasta. From 1982 through 1985 disease tests were conducted to determine the presence of this organism throughout the NFFR watershed (DFG 1988).

C. shasta was found in test fish every year studied in Rock Creek Reservoir, Cresta Reservoir and Belden Forebay except in 1985 when test fish from Cresta Reservoir were terminated at the laboratory accidently without examination. Evidence of this organism in test fish was not found at other sites during any year that included Butt Valley Reservoir, Lake Almanor, Antelope Reservoir and the East Branch of the NFFR.

Studies during 1981-85 indicate the best returns to the angler's creel resulted from the stocking of catchable-sized domestic trout strains. A wild trout fishery sustained from natural or wild stocked fingerlings is the DFG's priority and is consistant with the policy of the Fish and Game Commission, that artificial propagation and rearing of trout will be utilized only when necessary to augment the natural supply. Further, fingerling and subcatchable sized trout shall take prioity over catchables if the hatchery stocking program with the smaller fish will maintain satisfactory fishing. Satisfactory is defined by the Fish and Game Commission as an average of two fish per angler-day or one-half fish per angler-hour.

Thus, it is with this mandate and the results of the 1981-85 studies on the NFFR that the following recommendations are made.

RECOMMENDATIONS: —

1. The management of the river reaches and reservoirs of the Rock Creek-Cresta Project area and the East Branch of the N.F. Feather River will be to achieve the angler catch goal of

producing and maintaining a fishery that yields a catch per angler-hour (based upon fish sized 10 inches or greater) of at least 0.50 for creeled trout or at least 1.00 including catch and release fish.

2. Provide suitable conditions for the natural production in the Rock Creek and Cresta river reaches.

3. The East Branch from Twain to Virgilia should be stocked with 5,000 hatchery produced catchable trout sized 2.0 fish per pound annually. These hatchery produced trout should be resistant to ceratomyxosis such as brown trout, Pit rainbow, Eagle Lake trout and/or Eagle Lake x Pit hybrid stock.

4. Should it become feasible to augment the natural production of the river reaches with the hatchery production of wild rainbow trout, develop and maintain a permanent stock from wild trout obtained from the Rock Creek-Cresta area of the N.F. Feather River capable of producing adequate numbers of fingerling and/or sub-catchables so as to maintain a catch per angler-hour (based upon fish sized 10 inches or greater) of at least 0.50 for creeled trout or at least 1.00 including catch and release fish for each river reach. A suitable on-site hatchery location should be chosen in the Feather River Canyon or at an existing off-site DFG hatchery, such as the Department's Crystal Lake Hatchery, or private facility. This gene pool will be constantly renewed as appropriate to maintain a suitable wild stock resistant to ceratomyxosis.

These fish shall be stocked in the area from Poe Dam to Gansner Bar on the NFFR and selected tributaries if future studies indicate a viable program possible through tributary stocking.

5. Intensively manage each reservoir under a put-and-take fishery by stocking each reservoir with 25,000 trout sized 2.0 fish per pound annually. The amount and size at time of stocking would be subject to evaluation. The strains of trout would need to be resistant to C. shasta. Suggested strains to be stocked are brown trout, Pit rainbow, Eagle Lake trout, and/or Eagle Lake x Pit hybrid stock.

6. The effectiveness of all stocking shall be evaluated as part of the proposed Fish Population and Angler Creel Survey Evaluation and Monitoring Program. Changes in stocking rates, size at stocking, area stocked, and strain of trout stocked shall be a part of the monitoring program.

7. Terminate all trout stocking of strains susceptible to C. shasta in the East Branch, Rock Creek-Cresta area from Poe Dam to Belden Powerhouse, and the NFFR between Belden Town and Belden Dam including Belden Reservoir. Future studies and knowledge of this disease may dictate that this area be expanded to prevent

the promotion of this disease. At the present, stock only Pit rainbow, Eagle Lake trout x Pit rainbow hybrid, Eagle Lake trout wild or domestics, brown trout and Feather River rainbow wild strains known to have the greatest resistance to C. shasta.

III. RECREATIONAL ACCESS AND DEVELOPMENT/ REGULATION CHANGE

Recreational Access and Development

Additional recreational services should be developed along with the fishery resources. It is the Department's belief that PG&E has precluded recreational (including angler-use) growth in the Project area by not developing access at Cresta Reservoir, preventing access through prohibitive sign placement at Rock Creek Reservoir, and creating a depressed fishery through substantially reduced flows and increased water temperatures.

It is the Department's view that PG&E's Rock Creek-Cresta Project is responsible for the mitigation of 76,000 angler-days in the Project area. This use estimate would have existed today without power development.

RECOMMENDATIONS:

1. Provide angler access/parking sites for an additional 15 vehicles along Highway 70 over the length of Cresta Reservoir.

2. Provide boat access/launching facilities in a Rock Creek Reservoir Angler Access at Chips Creek Inlet or Indian Bar, and a Cresta Reservoir Angler Access at Rock Creek Inlet.

The boat access/launching facilities at each reservoir shall include a surfaced parking area for 20 vehicles, one sealed-vault type sanitary facility, refuse containers, and a boat ramp suitable to launch trailered and cartop boats. All in-water recreational activity shall be prohibited, including boating and swimming, within 1/4 mile of the dams. A line of buoys will be placed across each reservoir 1/4 mile upstream of each dam demarking the limit of the prohibited area. Boats using the reservoirs shall be restricted to a 5 miles per hour maximum speed limit.

Although Poe Reservoir is not a part of the Rock Creek-Cresta Project, improved angler access should be eventually provided at Poe Reservoir as for Rock Creek and Cresta reservoirs.

3. Provide camping facilities within the immediate Rock Creek-Cresta Project area to encourage a wide base of recreational use in the area by revitalizing the James Lee Campground site to offset the closing of the James Lee and Belden campgrounds by the U.S. Forest Service.

Regulation Change

In an effort to access the existing sport fishery and make management recommendations to improve the fishery as part of the relicensing process, angler surveys, as well as other studies, were conducted annually from 1981 through 1985 within the Rock Creek-Cresta Project area and the lower 16.1 km of the East Branch.

The NFFR from Cresta Powerhouse to Hallsted is a road-side fishery. As such, the Rock Creek, Cresta and East Branch river reaches supports only a modest wild trout fishery with an estimated angler use of 797, 653 and 262 angler hours respectively per river km annually (Table 8). Under existing conditions as studied, the Cresta, Rock Creek and East Branch river reaches will not support an enlarged wild trout fishery over that documented during the 1981-85 period and certainly not a trophy wild trout fishery without changes in physical habitat, flow, temperature and angling regulations. At the present, natural spawning is considered limited.

Table 8. Estimated annual values, 1981-1985.

	Cresta	Cresta Res.	Rock Creek	Rock Cr. Res.	Belden	East Branch	Total Study Area
Length(km)	7.7	4.3	13.4	4.0	3.2	16.1	48.7
Angler Hours	5030	2014	10678	3594	2241	4211	27768
Angler Hours/km	653	468	797	898	700	262	570
Creeled Trout	897	343	2283	201	375	1014	5113
Released Trout	2503	123	2913	78	262	976	6855
Catch/A-H Creel	0.178	0.170	0.214	0.056	0.167	0.241	0.184
Catch/A-H Total	0.676	0.231	0.487	0.078	0.284	0.473	0.431

Existing conditions of the trout fishery can be characterized from the information presented in the report by DFG (1988) for the years 1981-85 as follows:

1. Estimates of annual catch per angler hour values of less than 0.25 for creeled fish were found for all areas studied. This is considered poor and is consistent with data collected during 1954 by Rowley (1955). However, the catch rate increases considerably if "catch and release" fish are included increasing the catch rate to 0.676, 0.487 and 0.473 for the Cresta, Rock Creek and East Branch reaches, respectively.

2. Rock Creek and Cresta reservoirs combined, averaged 1,869 angler-days per year with a catch rate of 0.10 fish per angler-hour.

3. Wild rainbow trout constituted about 50 percent of the angler's creel, indicating the presence of natural reproduction within the various study areas either from river or tributary spawning or both.

4. Age II fish constitute the majority of the angler's creel of wild rainbow trout for all areas while age IV are rare (Table 9). These age II fish averaged approximately 250 millimeters (10 inches) fork length for all areas sampled with approximately 40 percent of the angler's catch less than 250 mm. Fish greater than or equal to 300 mm (11.8 inches) comprised 20.2 percent of the 1981-85 catch in the Cresta and Rock Creek sections while in 1954, Rowley (1955) reported 42.0 percent in this size group.

5. Mean annual survival rates of wild rainbow trout from age I to III averaged a low 0.20 annually for the Rock Creek and Cresta sections. This is compared to an average 26.9 percent November to May survival of 23 groups of hatchery reared rainbow trout in Convict Creek, California (Reimers 1963) and an annual survival from age II to VI of 37.8 percent for brook trout in Maine (Rupp 1955 cited in McAfee 1966).

6. Trout growth improved as flow increased over the years 1979-83 and 1984-85. However, when compared to other California streams of similar habitat, the Rock Creek Section's growth was less at annulus I regardless of flow and year, and similar at annulus II and III during years of high flow (Table 10). Growth in the Cresta Section was less than that found in the Rock Creek Section and for the most part less than that found in comparable streams.

7. Angler surveys conducted during 1983 and 1984 indicated that of the 60.4 percent returning the 265 questionaires distributed, 55.6 percent expressed satisfaction with the existing two fish limit while 43.1 percent wanted to keep fish greater than 356 mm.

Table 9. Age composition of observed wild rainbow trout in the angler's creel, 1982-1985.

		Age I	II	III	IV	Total	n
Rock Creek Section	%	24.2	59.8	13.9	2.1	100.0	244
	Mean FL*	224	258	304	351		
	std	28.8	30.1	34.0	146.7		
Cresta Section	%	9.5	63.5	27.0	0	100.0	63
	Mean FL	203	250	310			
	std	27.9	36.3	40.8			
East Branch	%	20.3	56.5	18.8	4.4	100.0	69
	Mean FL	224	252	295	342		
	std	23.7	34.8	28.9	30.6		

* Fork length in millimeters

Table 10. Fork length at annulus formation for rainbow trout found in similar stream habitat type systems.

	Stream Habitat Type	Average Length at Annulus I	II	III
West Slope Sierra*	B	98	165	211
Upper Sacramento R.*	B	98	211	299
M.F. Feather River*	B	107	183	234
N.F. Feather River:				
Rock Creek(1984-85)		95	206	257
Cresta(1984-85)		84	184	259
Rock Creek(1979-83)		91	191	254
Cresta(1979-83)		86	157	208

* from Snider and Linden (1981)

Three factors are particularly important to improving the on-site quality of a fishing experience: the number of fish caught, the rate of catching these fish, and the size of fish caught. A basic premise leading to more restrictive angling regulations such as, "catch and release" angling is that all three of these quality factors will be enhanced for most participating anglers (Hunt 1981).

Increased numbers of wild trout available to the angler can be achieved through several methods. Survival can be improved with changes in physical habitat, such as: increased instream flows, and reduced levels of sediment from upstream man-made sources and sediment accumulation in the river reaches from improper reservoir sluicing, and decreased summer water temperatures.

Increased trout production can occur with improved spawning habitat in the main river, tributaries and improved spawner access through tributary barrier removal. Kiefling (1984) found that renovation of spawning gravels and enhancement of habitat for young of the year cutthroat trout has resulted in a significant increase in spawning cutthroat trout returning to Three Channel Spring Creek, Wyoming.

Survival can also increase with the use of more restrictive angling regulations. Hunt (1981) found that abundance, biomass and survival rate characteristics all changed favorably when restrictive angling regulations were imposed upon a Wisconsin stocked brown trout fishery. The catch rate of trophy-sized trout (longer than 38 cm) was 28 times greater in an catch-and-release area than in an area of the South Platte River, Colorado, with standard regulations (Anderson and Nehring 1984). Angling mortality was reduced with gear restrictions that usually prohibit the use of bait since bait caught fish that are released have a relative high mortality rate (Snider and McKee 1982).

RECOMMENDATIONS:

1. Maintain the two-fish limit in the Rock Creek and Cresta river reaches. Recommendations for changes in this management tool should be subject to the results of the proposed Fish Population and Angler Creel Survey Evaluation and Monitoring Program.

2. Initiate a five-fish limit in Poe, Cresta, and Rock Creek reservoirs, and the river reach extending upstream from Rock Creek Reservoir to the confluence of the East Branch.

3. Maintain the existing two-fish limit in the East Branch from its confluence with the NFFR upstream to the confluence of Indian and Spanish creeks.

4. To improve spawning potential in the tributaries, impose a five-fish limit on all tributaries entering the NFFR from Poe Dam to confluence with East Branch (including those tributaries entering Poe, Cresta and Rock Creek Reservoirs), tributaries to the East Branch NFFR from confluence with NFFR upstream to confluence with Spanish and Indian Creeks, and all tributaries to the NFFR from confluence with East Branch NFFR to Belden Dam.

IV. OFF-SITE MITIGATION

East Branch N.F. Feather River

The East Branch was evaluated in part during the 1981-86 studies as a potential area for off-site mitigation of the adverse impacts of the Rock Creek-Cresta Project.

Beyond the recommendations proposed to enhance wild trout spawning through improvements to the tributaries and the stocking of catchable sized trout in the upper reach, little can be done at the present time to improve temperature and flow conditions in the East Branch during critical times of the year.

Humbug Valley

The Department has had a long term interest and commitment in improving habitat conditions in Yellow Creek and Humbug Valley. Presently, Yellow Creek has Wild Trout status from Big Springs downstream to Highway 70. A small segment of Yellow Creek has restrictive angling regulations to promote a trophy trout fishery. Various portions of Yellow Creek have been fenced to exclude cattle to improve trout habitat by promoting the return of riparian vegetation, reducing channelization and stream bank erosion. In addition, the DFG and PG&E have expressed interest in improving wildlife values within Humbug Valley through improved land management practices. California Trout, Inc. has expressed an interest in additional enhancement of Yellow Creek through a habitat improvement program for brown trout (Franklin and Baldrige 1987).

RECOMMENDATIONS:

Develop and implement a management plan for Humbug Valley for the purpose of improving wildlife and fisheries values that could be considered as partial mitigation for the adverse effects of the Rock Creek-Cresta Project. To facilitate the implementation of the plan, management of the land should occur under either a cooperative agreement between PG&E and the Department, a conservation easement deeded to the Department, or through a transfer of ownership to the DFG. The area of management would consist of all the lands owned by PG&E in Humbug Valley. The minimum amount of land needed for effective management, however, would be the area beginning on a line extending north and south 150 feet east of Yellow Creek and extending west to the border of private and federal lands. Conservation easements should be obtained for areas outside existing PG&E lands deemed important to the management of Humbug Valley and Yellow Creek.

V. FERC LICENSE DURATION

The proper management of the N.F. Feather River requires that the system be managed as one unit as opposed to the piecemeal management that exists presently with three FERC licenses in operation: FERC 2105 (Upper North Fork Project), FERC 1962 (Rock Creek-Cresta Project), and FERC 2107 (Poe Project). Therefore, it is recommended that the period of license for the relicensing of FERC 1962 be set to coincide with the termination of the FERC 2105 (Upper North Fork) license period. FERC 2105 is set to expire in the year 2004.

Evaluation and Monitoring Program

Evaluating and monitoring the effectiveness of the North Fork Feather River Management Plan is of the utmost importance and will involve many activities. In order to comply with Public Resources Code Sections 21081.6, a detailed monitoring program must be developed for all required mitigation conditions. The monitoring program should include the following:

a. Specific criteria to measure effectiveness of mitigation.

b. Annual monitoring for a minimum of five years. Annual written reports submitted to the lead agency and the DFG.

c. Annual monitoring reports, each of which include corrective recommendations that shall be implemented in order to ensure that mitigation efforts are successful.

1. Fish Population Monitoring

The status of the fish population shall be monitored each year in the Rock Creek and Cresta sections similar to that done during 1982-1985. The sites sampled shall be chosen so that changes in the fish populations can be monitored as they respond to changes in habitat and management practices. Emphasis should be on species composition, abundance, length frequency and age distribution.

2. Angler Creel Survey

A creel survey similar to that conducted during 1981-1985 shall be conducted each year to evaluate the sport fishery.

3. Temperature Studies

Continuous recording thermographs (USGS approved) designed to measure daily temperature shall be installed near the downstream end of the Rock Creek Section and the Cresta Section. Site selection would be subject to approval of the DFG. Provide mean daily and daily maximum and minimum temperatures by December 30 of each year. These shall be operated during the May 1 through October 30 period of each year for the life of the Project.

Additional Studies

Suggested areas of further study are the result of either: studies to date that did not adequately address a problem or were incomplete, new concerns brought to the forefront by past studies, or areas of study simply not addressed by past work but now appear important to the future management of the North Fork.

1. Tributary Stocking

Tributary stocking of subcatchable or fingerling-sized wild trout should be evaluated as to its impact upon the main-stem fishery.

Tributary stocking studies in the NFFR area during 1984 and 1985 were prompted in part by studies of headwater stocking of large steelhead fry in British Columbia (Hume 1984) and the DFG's tributary stocking of fingerlings and fry in the NFFR watershed during the early 1900's.

A rainbow trout stocking program was tested at Mill Creek near Twain in 1984, to estimate the effect of stocking on downstream movement in an isolated stream not saturated by spawners from the river. During June of that year a 1000 m reach of Mill Creek, above the barrier, was stocked with 11,500 wild strain rainbow trout fry having an average size of 200 per ounce.

Comparison of the rate of trap catch per effort in Mill Creek during peak outmigration months (June-August) in 1983 with that of 1984 showed a substantial increase after fry were stocked. Likewise, population estimates made in June 1983, and June 1984 after stocking showed a 100 percent increase in the estimate. Standing crop estimates made in October 1984 also showed an increase over both the 1983 and 1984 June estimates.

This was followed by tributary stocking of larger marked fish during the fall of 1985 to determine the impact this procedure had upon the angler harvest and standing crops in the Rock Creek river reach. Four tributaries to the Rock Creek Section were stocked with a total of 9331 subcatchable-sized Eagle Lake trout

domestics (ELT-D(s)-85). The tributaries were Milk Ranch, Chambers, Granite and Opapee creeks. However, evaluation of this stocking was terminated with the storm of February 1986 when historic flood waters occurred in the study area.

2. Dissolved Gas Supersaturation (Gas Bubble Disease)

Investigate the levels of dissolved-gas supersaturation of the N.F. Feather River with particular attention to the impact the present and future hydro-development of the system has upon these levels. If levels exceed the Environmental Protection Agency criterion of 110 percent TGP, make recommendations that will reduce the effects of these hydro-developments through changes in operation and/or spillway design.

Gas bubble disease is a condition affecting aquatic animals in water supersaturated with atmospheric gases (Hauck 1986). It is caused by supersaturation of gases in water: bubbles form within the tissues of aquatic organisms, resulting in death when emboli block vital circulatory pathways (Chamberlain et al. 1980). The mechanisms that can create gas supersaturation are: rapid heating of water causing reduced solubility of gases at high water temperatures, air entrainment during high runoff (Colt 1984), and gas entrainment below dam spillways (Weitkamp and Katz 1980; Marking 1987).

Recent studies by Colt (1984) of the seasonal changes in dissolved-gas supersaturation in the Sacramento River system showed the highest levels were on the N.F. Feather River at Pulga on May 5, 1982 when the mean daily flow was 5570 cfs (USGS 1982) with levels of 101 mm Hg. These levels exceeded the United States Environmental Protection Agency's criterion of 110 percent of saturation or 76 mm Hg (Colt 1984) by 25 mm Hg.

Weitkamp and Katz (1980) reported excessive mortality occurred in bio-assay tests of rainbow trout fry at 115 percent super saturation of nitrogen. Losses of young salmonids attributed to this disease have been reported regularly at the DFG's hatcheries near Sacramento on the American River. No losses have been reported at the Feather River Hatchery on the Feather River below Oroville Dam (Thompson 1988).

Colt (1984) was unable to partial out the mechanisms of gas supersaturation and their relative contribution to high gas supersaturation levels. The author stated further that, although entrainment of air at dams did not appear to be a major source of gas supersaturation in the Sacramento River, either mechanism of air entrainment or rapid heating of water could account for the observed high levels above Oroville Dam (at Pulga). Other workers, however, found that hydroelectric facilities and steam electricity-generating stations are the largest and most researched artificial sources of supersaturation and with

increased industrial water use, this disease has now become a severe problem in several important waterways with these facilities producing supersaturation by gas entrainment below dam spillways (Weitkamp and Katz 1980; Chamberlain et al. 1980).

3. Columnaris Disease

Investigate further the impact of Columnaris disease upon the N.F. Feather River trout fishery and its relationship to populations of Sacramento sucker.

Outbreaks of the disease caused by Flexibacter columnaris among populations of trout at large were not documented within the study area but only observed in live car held test fish. This live car experience in itself would cause enough environmental stress to upset the balance between the potential pathogen and the host and cause an outbreak of the disease. The N.F. Feather River has been changed in its ecology into a chain of impoundments, lowered flows in the river reaches, increased summer water temperatures, and a proliferation of nongame species, principally the Sacramento sucker (Catostomus occidentalis). These factors can cause environmental stress and in turn contribute to outbreaks of Columnaris disease. Snieszko (1983) states that suckers are resistent to Columnaris disease but serve as carriers and with increased sucker populations there is an increased reservoir of infection, and the susceptibility of trout is greatly increased with higher water temperatures during the summer.

4. Aquatic Invertebrate Investigations

Documentation in the literature has shown aquatic invertebrates to be indicators of water quality. Lack of adequate water quality data on the NFFR has limited our ability to describe the range of productivity of the river and its relationship to trout populations found there.

Ward and Stanford (1979) state that temperature and flow (and their ramifications) remain perhaps the two most important controlling factors for aquatic invertebrates of unpolluted streams. Changes in the invertebrate composition below hydroelectric facilities have been largely attributed to regulated flows and temperature alterations (Gersich and Brusven 1981). Wurtsbaugh (1977) suggested, "any temperature related effects on the stream community may result in changes in the quantities of benthic organisms upon which fish subsist". Because of the invertebrate position in the food chain of trout, rivers subjected to regulated flows cause concern for the integrity of these benthos communities. Therefore, it is proposed that determination of the quality and abundance of aquatic invertebrates and their response to project improvements in temperature would enhance our knowledge of the aquatic resources of the NFFR.

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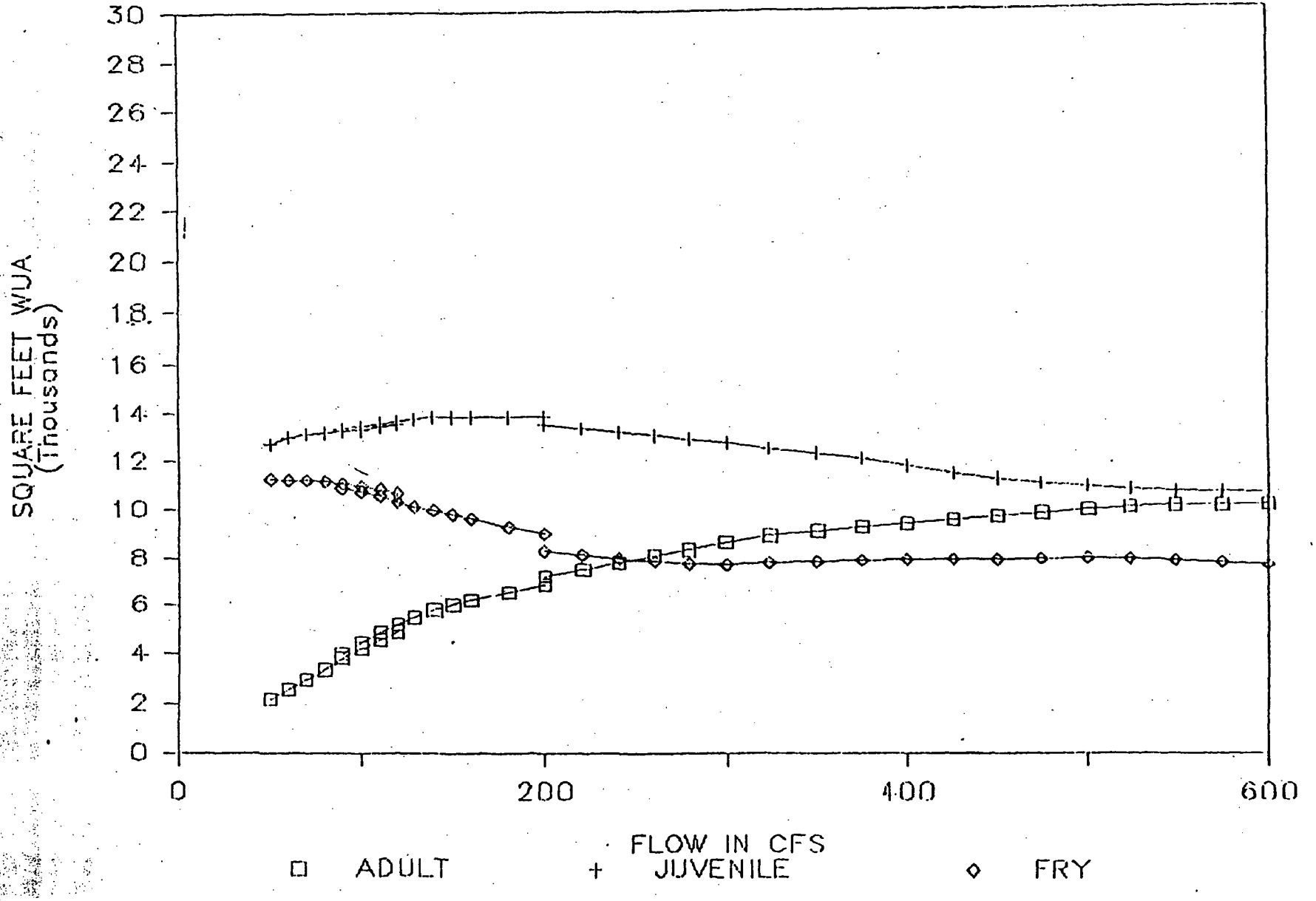
APPENDIX I

IFIM RESULTS OF WUA VS FLOW FOR NONGAME SPECIES

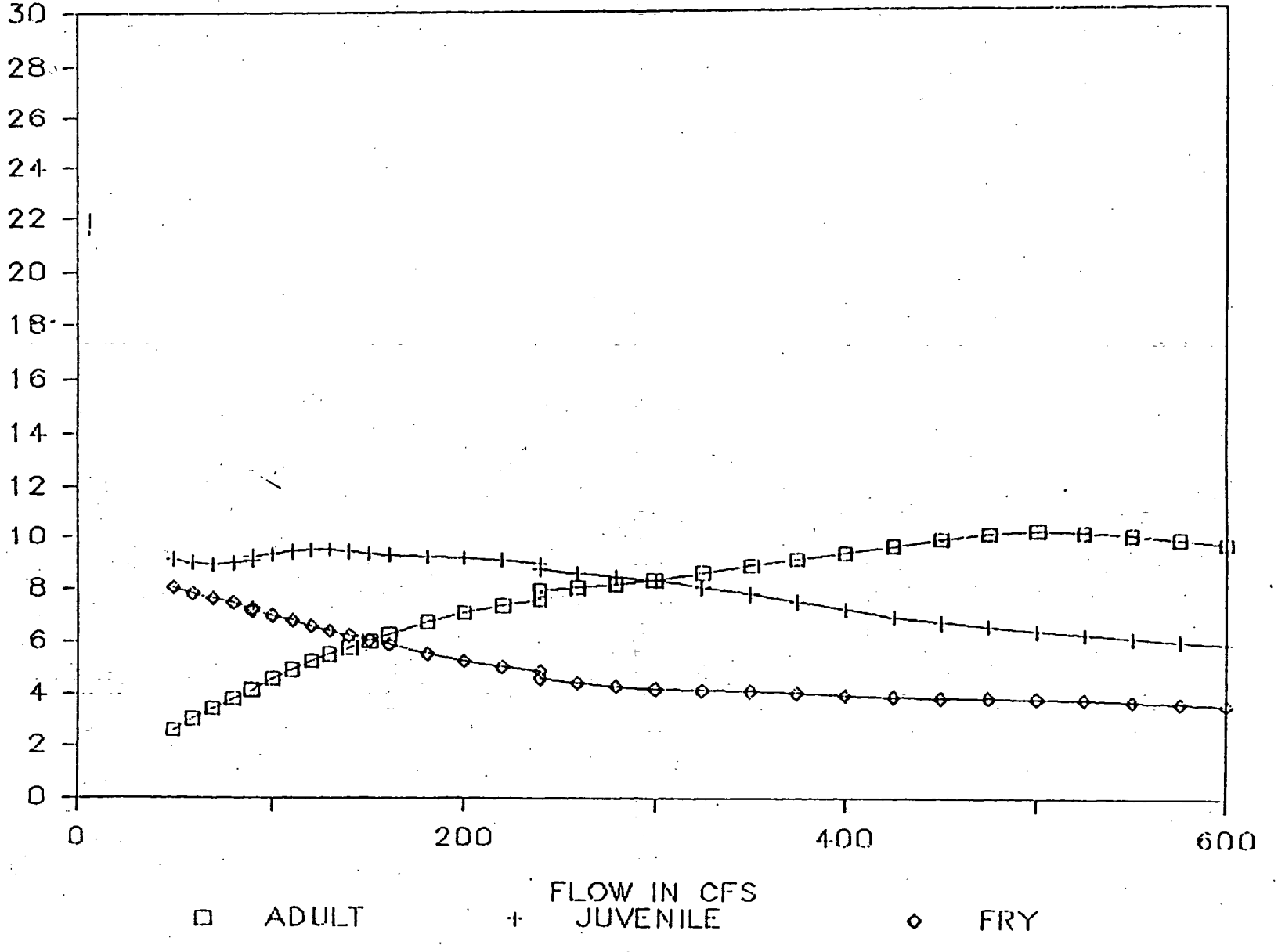
ROCK CREEK REACH

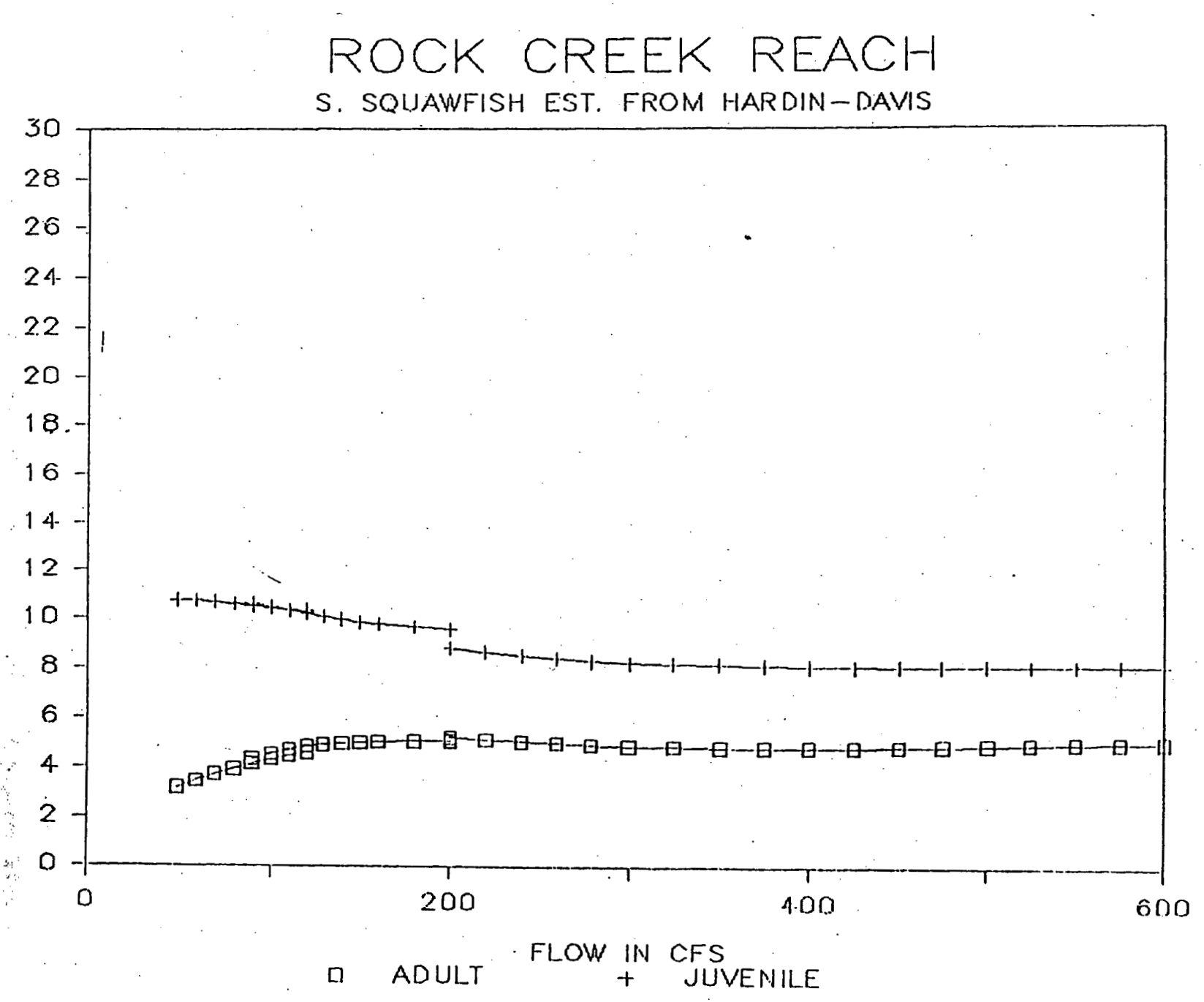
S. SUCKER EST. FROM HARDIN-DAVIS



CRESTA REACH

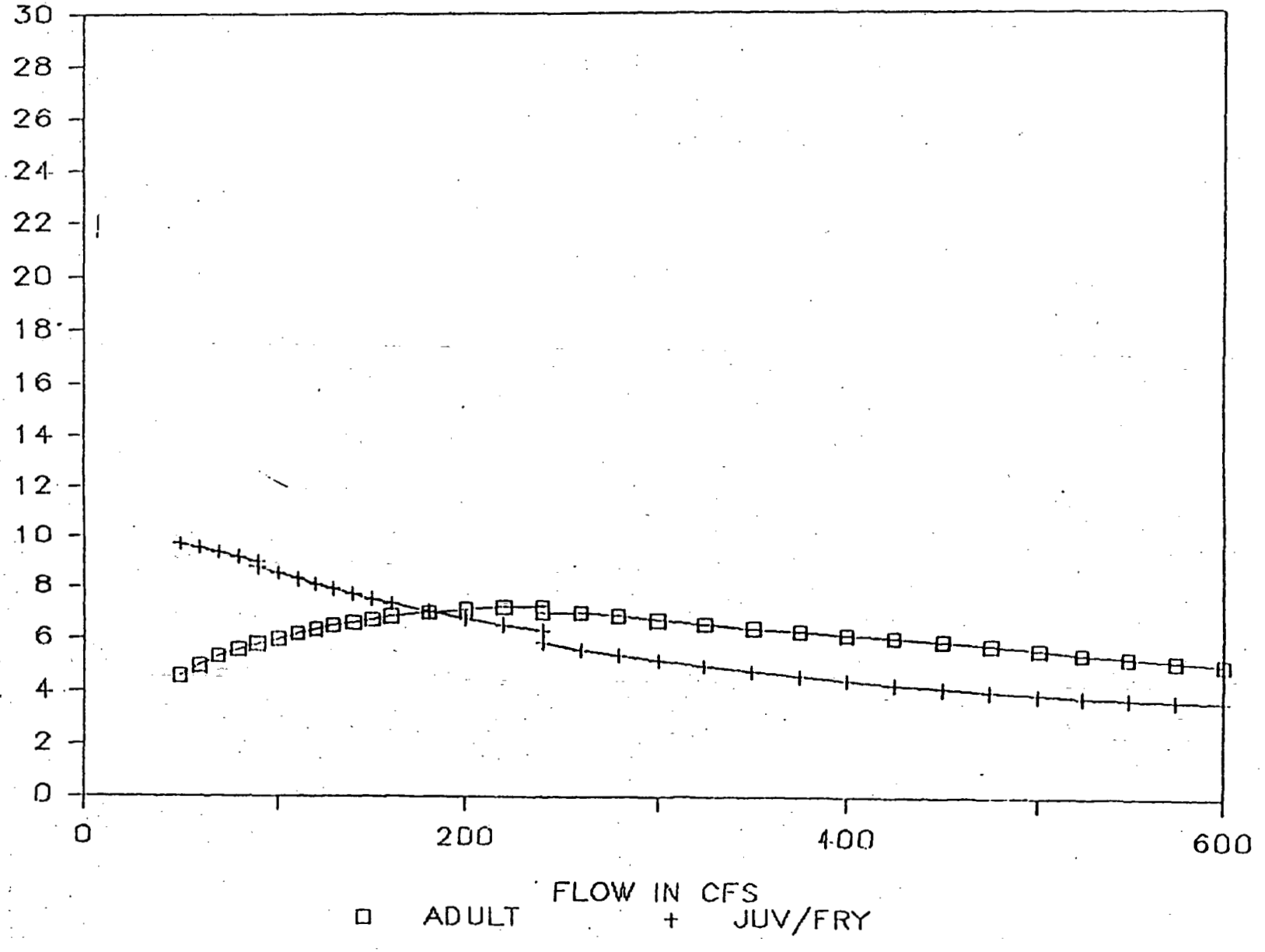
S. SUCKER EST. FROM HARDIN-DAVIS




ROCK CREEK REACH
S. SQUAWFISH EST. FROM HARDIN-DAVIS
SQUARE FEET WUA (Thousands)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
200
400
600
FLOW IN CFS
ADULT
JUVENILE

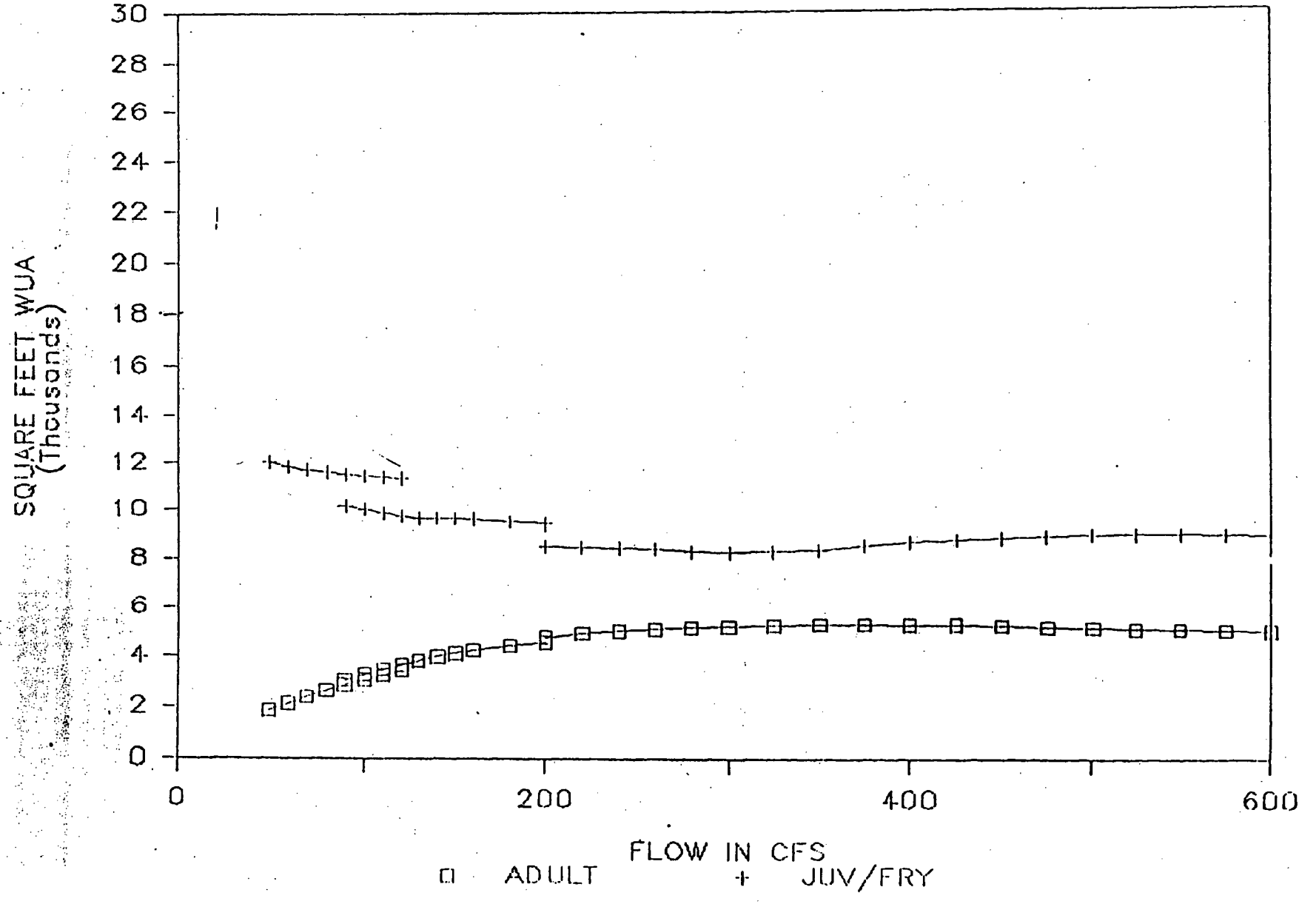
CRESTA REACH

S. SQUAWFISH EST. FROM HARDIN–DAVIS



ROCK CREEK REACH

HARDHEAD EST. FROM HARDIN-DAVIS



CRESTA REACH

HARDHEAD EST. FROM HARDIN-DAVIS