State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Northern District

INDIAN CREEK FLOW STUDY

Technical Information Report No. 81-2

Prepared under the Supervision of
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by

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This report was prepared to summarize information collected under W.O. 1600-4068 to evaluate a possible reoperation of Antelope Reservoir, as part of the Department's Instream Water Use Program. Although this report was reviewed by appropriate individuals in the Department and other agencies, it is intended for internal use and should be considered preliminary and subject to revision.

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SUMMARY

A streamflow study was conducted on Indian Creek, Plumas County, in September and October 1976. The purpose of the study was to define the effects of streamflow on trout habitat in Indian Creek as part of an instream flow needs study of the North Fork Feather River drainage.

Two study areas were established on Indian Creek. Study Area 1 was located 12.2 km (7.6 mi) below Antelope Dam. Study Area 2 was located just above Flournoy Bridge and below the confluence of Red Clover Creek. Each section was considered representative of trout habitat types in Indian Creek. Water velocity and depth were measured at five flows ranging from 3.0 m^3/s (106 ft^3/s) to 0.05 m^3/s (1.8 ft^3/s) at Study Area 1 and four flows from 3.1 m^3/s (110 ft^3/s) to 0.56 m^3/s (19.8 ft^3/s) at Study Area 2.

Calculations of usable area for trout production using an unweighted criteria method showed optimum flow to be 0.8 to 1.1 m^3/s (30 to 40 ft^3/s) for Study Area 1 and 2.0 to 2.3 m^3/s (70 to 80 ft^3/s) for Study Area 2.

A weighted criteria method of analyzing the same data gave different optimum flows for each of several trout habitat parameters. Subjective cover and food-producing habitat generally increased with flow up to the highest flows measured. Optimum flows for resting microhabitat were 0.28 to 0.57 m^3/s (10 to 20 ft^3/s) for Study Area 1 and 1.4 to 1.7 m^3/s (50 to 60 ft^3/s) for Study Area 2. Spawning habitat was greatest in Study Area 1 at flows of 2.1 to 2.5 m^3/s (75 to 90 ft^3/s), but continued to increase with flow up to at least 3.1 m^3/s (110 ft^3/s) at Study Area 2.

INTRODUCTION

The objective of this study was to determine the effects of streamflow on trout habitat in Indian Creek. Streamflow augmentation is a way to improve trout habitat. Various parameters of trout life history can be examined with reference to depth, water velocity, and substrate. Four common habitat parameters are spawning area, food-producing area, resting microhabitat, and available cover. Each of these parameters can be evaluated to determine the flow which would maximize trout habitat. If possible, streamflow then can be

changed to maximize the habitat available for trout. Indian Creek was ideal as a study site for possible habitat improvement because Antelope Reservoir provides the opportunity to manipulate flows.

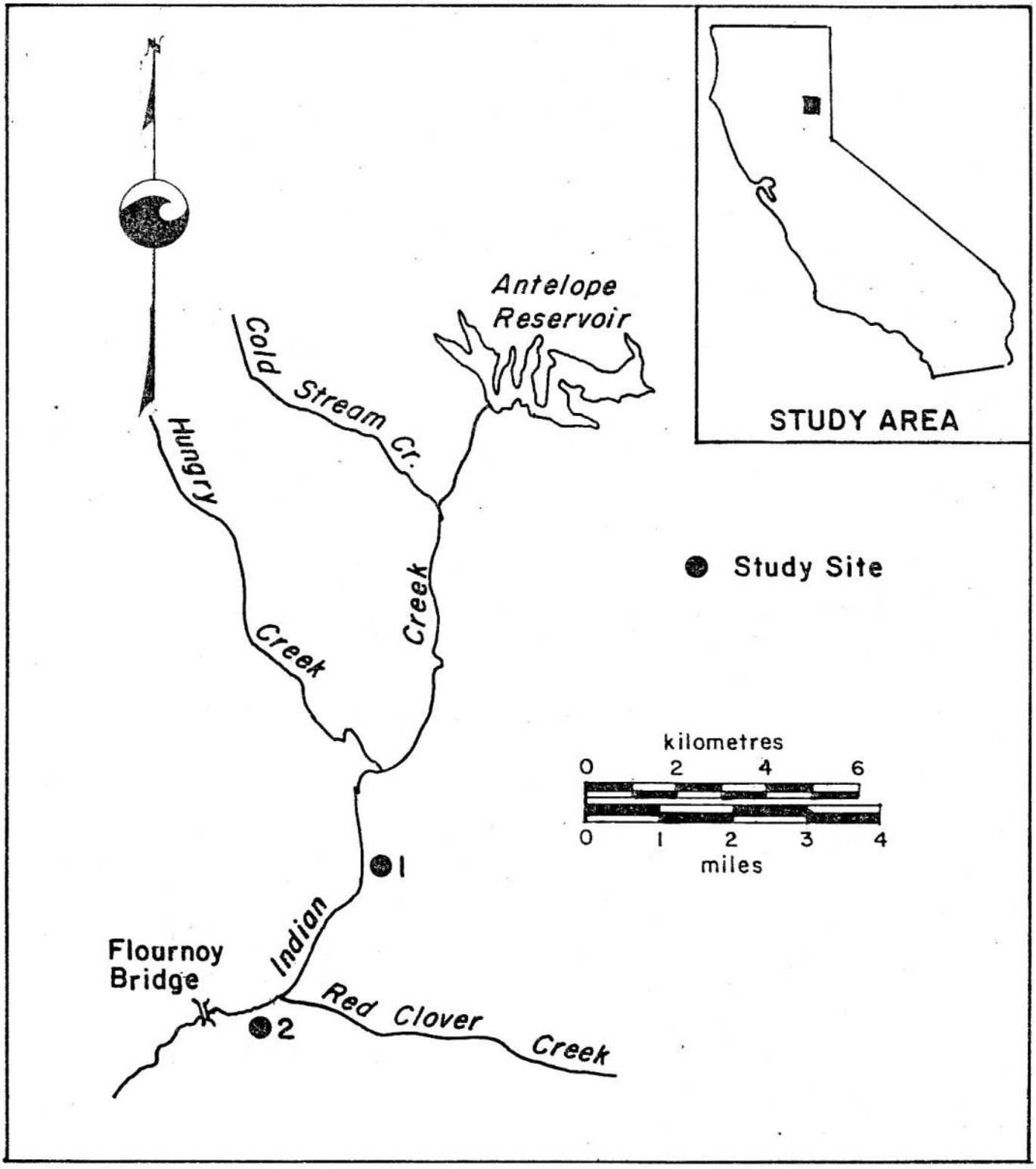
Antelope Dam was constructed in 1963 to provide an additional source of recreation in Plumas County. Present operation is based on the water surface elevation on May 1 of each year. If the reservoir is full (5,002 ft water surface elevation), the release is 0.8 m^3/s (20 ft^3/s) in April, May, and June and 0.28 m^3/s (10 ft^3/s) from July through March. The reservoir usually spills during spring, often considerably more than the scheduled release. Therefore, present operation of the reservoir has little effect on the spring and early summer flows. However, operation of the reservoir does alter the late summer streamflow. Prior to construction of the dam, the average low flow in the creek was 0.08 m^3/s (3 ft^3/s) at the damsite while post-project summer releases are 0.28 m^3/s (10 ft^3/s). During the period from mid-July to mid-October 1976, Antelope Reservoir was drained so the Department of Fish and Game could chemically treat the remaining water to control golden shiners and brown bullhead. The reservoir draining process allowed study of the creek at a wide range of flows in a relatively short period of time.

DESCRIPTION OF STUDY AREA

Indian Creek originates on the western slope of the Sierra Nevada near Susanville. It flows generally south and west through Antelope Reservoir, Genesee Valley, and Indian Valley to its confluence with Spanish Creek, which forms the East Branch of the North Fork Feather River. Indian Creek is a typical high mountain stream with high flows in the spring and early summer months from snowmelt and low flows through the summer and fall.

Two study areas were selected as representative of Indian Creek from Antelope Dam to the Genesee Valley (Figure 1). Study Area 1 was located 12.2 km (7.6 mi) below Antelope Dam and 5.5 km (3.4 mi) above Flournoy Bridge near an unimproved campground. Study Area 2 was located below the confluence of Red Clover Creek and near Flournoy Bridge. Study Area 1 represented 5 640 m (18,500 ft) of stream and Study Area 2 represented 9 750 m (32,000 ft). Five permanent transects were established at each study area. Each transect was perpendicular to streamflow. These transects were at 15-m (50-ft) intervals at Study Area 1 and 30-m (100-ft) intervals at Study Area 2.

Figure 1. Areas measured in streamflow study, Indian Creek, Plumas County, October 1976.



METHODS

Field Data Collection

Three criteria were used to identify the area available for trout production at each station: (1) water depth, (2) water velocity, and (3) streambed type. Water depth and velocity were measured for all flows, while substrate type was recorded at the lowest flow for best visibility. Cover (any place an adult trout would hide) was also subjectively noted as no cover, fair cover, or good cover at each measured streamflow.

Steel fence posts or convenient trees were used to mark transects at each station. Total depth and water velocity was measured across each of the five transects at 0.6-m (2-ft) intervals using a Type AA standard current meter and direct-reading wading rod set to measure velocities 0.06 m (0.2 ft) above the substrate. Subjective cover was recorded at the same time.

Water depth, velocity, substrate type, and subjective cover were measured at Study Area 1 from September 29, 1976, to October 29, 1976, at five flows ranging from 3.0 m^3/s (106 ft^3/s) to 0.05 m^3/s (1.8 ft^3/s). These parameters were measured at Study Area 2 from September 28, 1976, to October 8, 1976, at four flows from 3.1 m^3/s (110 ft^3/s) to 0.56 m^3/s (19.8 ft^3/s) (Appendix 1).

Data Analyses

Field data were analyzed by two methods, a simple unweighted method (U. S. Fish and Wildlife Service, 1976) and a more complex weighted criteria method (Waters, 1976). The two methods use different criteria to analyze the same field measurements.

The unweighted method uses one set of criteria to evaluate "usable trout habitat". Wetted area, usable area, and unusable area for trout habitat were computed for all test flows. Usable area had a depth greater than 0.09 m (0.3 ft) and velocity ranging from 0.15 m/s (0.5 f/s) to 1.06 m/s (3.5 f/s) as measured 0.06 m (0.2 ft) above the streambed (U. S. Fish and Wildlife Service, 1976).

Analyzing data using the unweighted method involved calculating wetted area, usable area, and unusable area. This was done for both stations at all test flows. Finally, the percent decline of usable area was determined.

The weighted method assigns weighting factors for depth, water velocity, and substrate at each interval along each transect (Tables 1, 2, 3). The three weighting factors are then multiplied together to obtain a composite relative value for each measuring point. Relative values for each measuring point are then added to obtain a relative value for each habitat type and for each transect. Mean standard deviation and 90 percent confidence intervals are also computed. The relative values for each transect are added to obtain a relative value for each station and for all flows. The mean relative value for each flow is then multiplied by the total area of the station at the highest flow. This value is the area of habitat available at a particular flow. Weighting factors for subjective cover were assigned as follows: 0.0 for no cover, 0.5 for fair cover, and 1.0 for good cover (Waters, 1976).

The weighted method uses a computer program described by Waters (1976). The program calculates velocity while storing depth and substrate. It then computes the composite relative values for each point along each transect for four habitat parameters: (1) subjective cover, (2) food-producing habitat, (3) resting microhabitat, and (4) spawning habitat. Computer printouts for these habitat parameters include: (1) relative units for each transect at each flow, (2) mean relative units for each transect at each flow, (3) standard deviation of mean relative units, and (4) 90 percent confidence interval of mean relative units. This information is then graphed to show relationships between amount of available habitat and flow in the creek.

RESULTS

Unweighted Method

The amount of wetted area at the two study areas did not change greatly throughout the range of test flows (Tables 4 and 5). At the lowest flow measured at each study area, about 80 percent of the streambed was still within the wetted area. However, the area considered usable by trout underwent a marked reduction as the flow was reduced. Usable area in Study Area 1 declined by 98 percent from the highest to the lowest flow. Optimum flows appeared to be from 0.8 to 1.1 m^3/s (30 to 40 ft^3/s) for Study Area 1 and 2.3 to 2.5 m^3/s (80 to 90 ft^3/s) for Study Area 2 (Figures 2 and 3).

TABLE 1

FOOD-PRODUCING CRITERIA AND WEIGHTING FACTORS
FOR TROUT, INDIAN CREEK, 1976*

Velocity (f/s at 0.2' from bottom)		Depth		Substrate	
Range (f/s)	Weighting Factor	Range (ft)	Weighting Factor	Type	Weighting Factor
0.50-0.59	0.1	0.20-0.29	0.5	Rubble (3"-12")	1.0
0.60-0.69	0.2	0.30-0.39	0.7	Gravel (1/8"-3")	0.6
0.70-0.79	0.3	0.40-0.49	0.8	Silt	0.2
0.80-0.89	0.4	0.50-0.59	0.9	Sand	0.1
0.90-0.99	0.5	0.60-2.79	1.0	Others	0.0
1.00-1.19	0.6	2.80-3.39	0.9		
1.20-1.39	0.7	3.40-3.79	0.8		
1.40-1.69	0.8	3.80-4.19	0.7		
1.70-2.09	0.9	4.20-4.59	0.6		
2.10-2.69	1.0	4.60-4.99	0.5		
2.70-3.09	0.9	5.00-	0.4		
3.10-3.39	0.8				
3.40-3.59	0.7				
3.60-3.79	0.6				
3.80-3.89	0.5				
3.90-3.99	0.4				
4.00-4.09	0.3				
4.10-4.19	0.2				
4.20-4.30	0.1				
4.31-	0.0				

*Unpublished data, Pacific Gas and Electric Company.
These data are shown in English units as provided by PGandE.

TABLE 2

RESTING MICROHABITAT CRITERIA AND WEIGHTING FACTORS FOR TROUT, INDIAN CREEK, 1976*

Velocity (at 0.2" from bottom)		Depth		Substrate	
Range (f/s)	Weighting Factor	Range (ft)	Weighting Factor	Type	Weighting Factor
0.00-0.02	0.3	0.00-0.29	0.0	Rubble	1.0
0.03-0.04	0.4	0.30-0.39	0.5	Gravel	1.0
0.05-0.08	0.5	0.40-0.49	0.7	Sand	0.9
0.09-0.12	0.6	0.50-0.59	0.8	Boulder	0.8
0.13-0.18	0.7	0.60-0.69	0.9	Silt	0.7
0.19-0.26	0.8	0.70-	1.0	Clay	0.7
0.27-0.36	0.9			Plant detritis	0.7
0.37-0.54	1.0			Other	0.6
0.55-0.66	0.9				
0.67-0.74	0.8				
0.75-0.80	0.7				
0.81-0.86	0.6				
0.87-0.90	0.5				
0.91-0.93	0.4				
0.94-0.96	0.3				
0.97-0.98	0.2				
0.99-1.00	0.1				
1.01-	0.0				

*Unpublished data, Pacific Gas and Electric Company.
These data are shown in English units as provided by PGandE.

TABLE 3

SPAWNING CRITERIA AND WEIGHTING FACTORS
FOR TROUT, INDIAN CREEK, 1976*

Velocity (f/s at 0.2' from bottom)		Depth		Substrate	
Range (f/s)	Weighting Factor	Range (ft)	Weighting Factor	Type	Weighting Factor
0.00-0.69	0.0	0.00-0.29	0.0	gravel	1.0
0.70-0.79	0.1	0.30-0.39	0.2	others	0.0
0.80-0.89	0.3	0.40-0.49	0.4		
0.90-0.99	0.4	0.50-0.59	0.7		
1.00-1.09	0.5	0.60-0.69	0.8		
1.10-1.19	0.6	0.70-0.79	0.9		
1.20-1.39	0.7	0.80-1.29	1.0		
1.40-1.59	0.8	1.30-1.79	0.9		
1.60-1.89	0.9	1.80-2.09	0.8		
1.90-2.29	1.0	2.10-2.29	0.7		
2.30-2.49	0.9	2.30-2.49	0.6		
2.50-2.59	0.8	2.50-2.69	0.5		
2.60-2.69	0.7	2.70-2.79	0.4		
2.70-2.79	0.6	2.80-2.89	0.3		
2.80-2.89	0.4	2.90-3.00	0.2		
2.90-3.00	0.2	3.01-	0.0		
3.01-	0.0				

*Unpublished data, Pacific Gas and Electric Company.
These data are shown in English units as provided by PGandE.

TABLE 4

USABLE AND UNUSABLE AREAS AT VARIOUS FLOWS
AT STUDY AREA 1, INDIAN CREEK, 1976

Test Flow		Wetted Area		Unusable Area		Usable Area		
m^3/s	ft^3/s	m^2	ft^2	m^2	ft^2	m^2	ft^2	% Decline
3.0	106	872	9,385	248	2,670	624	6,715	0
2.3	82	869	9,355	257	2,765	612	6,590	2
1.0	36	813	8,755	247	2,660	566	6,095	9
0.35	12.2	784	8,435	491	5,290	292	3,145	53
0.05	1.8	722	7,775	712	7,665	10	110	98

TABLE 5

USABLE AND UNUSABLE AREAS AT VARIOUS FLOWS
AT STUDY AREA 2, INDIAN CREEK, 1976

Test Flow		Wetted Area		Unusable Area		Usable Area		
m^3/s	ft^3/s	m^2	ft^2	m^2	ft^2	m^2	ft^2	% Decline
3.1	110	2 785	29,980	922	9,930	1 863	20,050	0
2.3	82	2 724	29,320	1 015	10,930	1 708	18,390	8
1.4	48	2 610	28,100	1 453	15,640	1 158	12,460	38
0.56	19.8	2 177	23,440	1 740	18,730	438	4,710	76

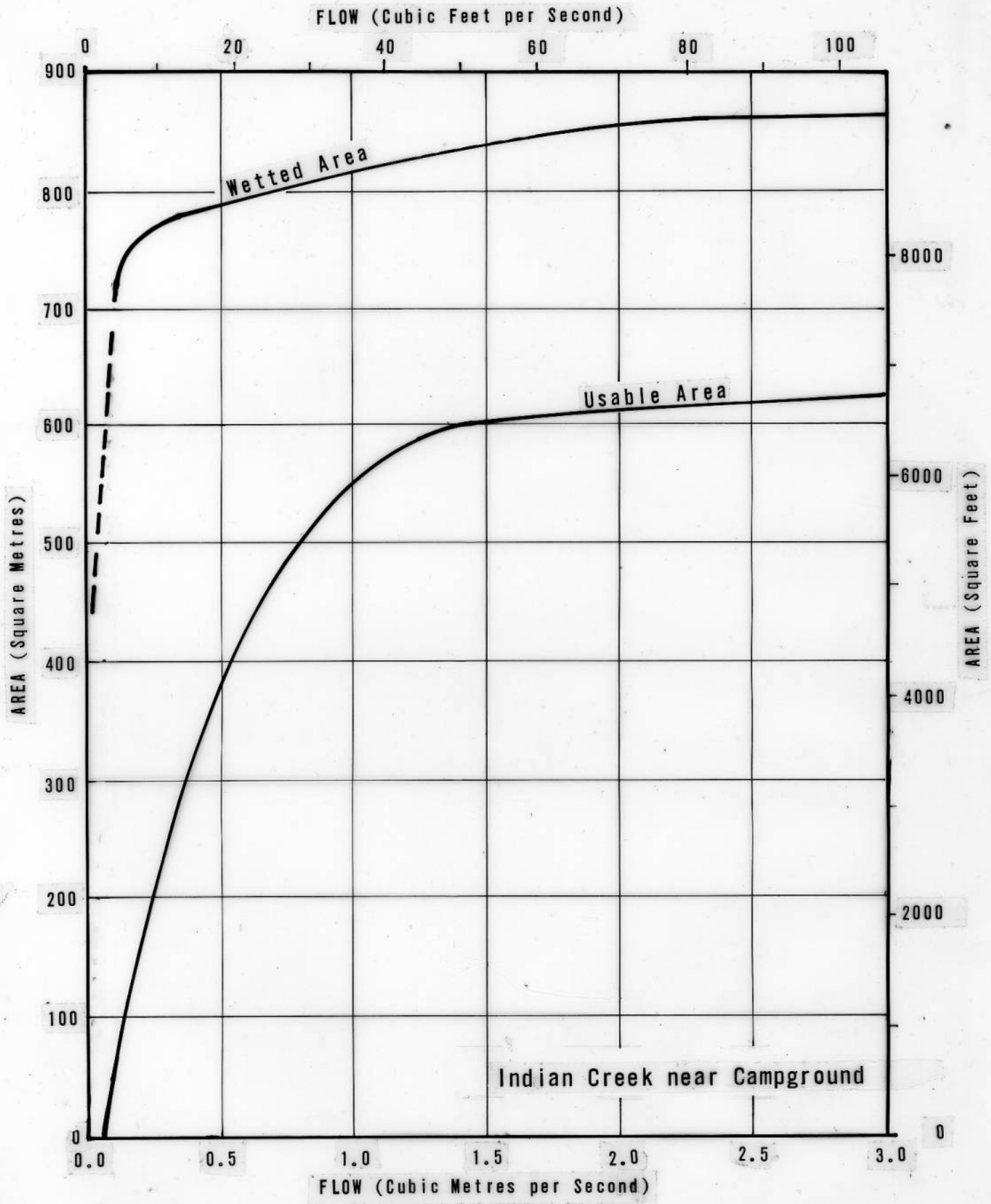


Figure 2. Relationship of wetted area and usable area with flow at Study Area 1, Indian Creek, Plumas County, 1976

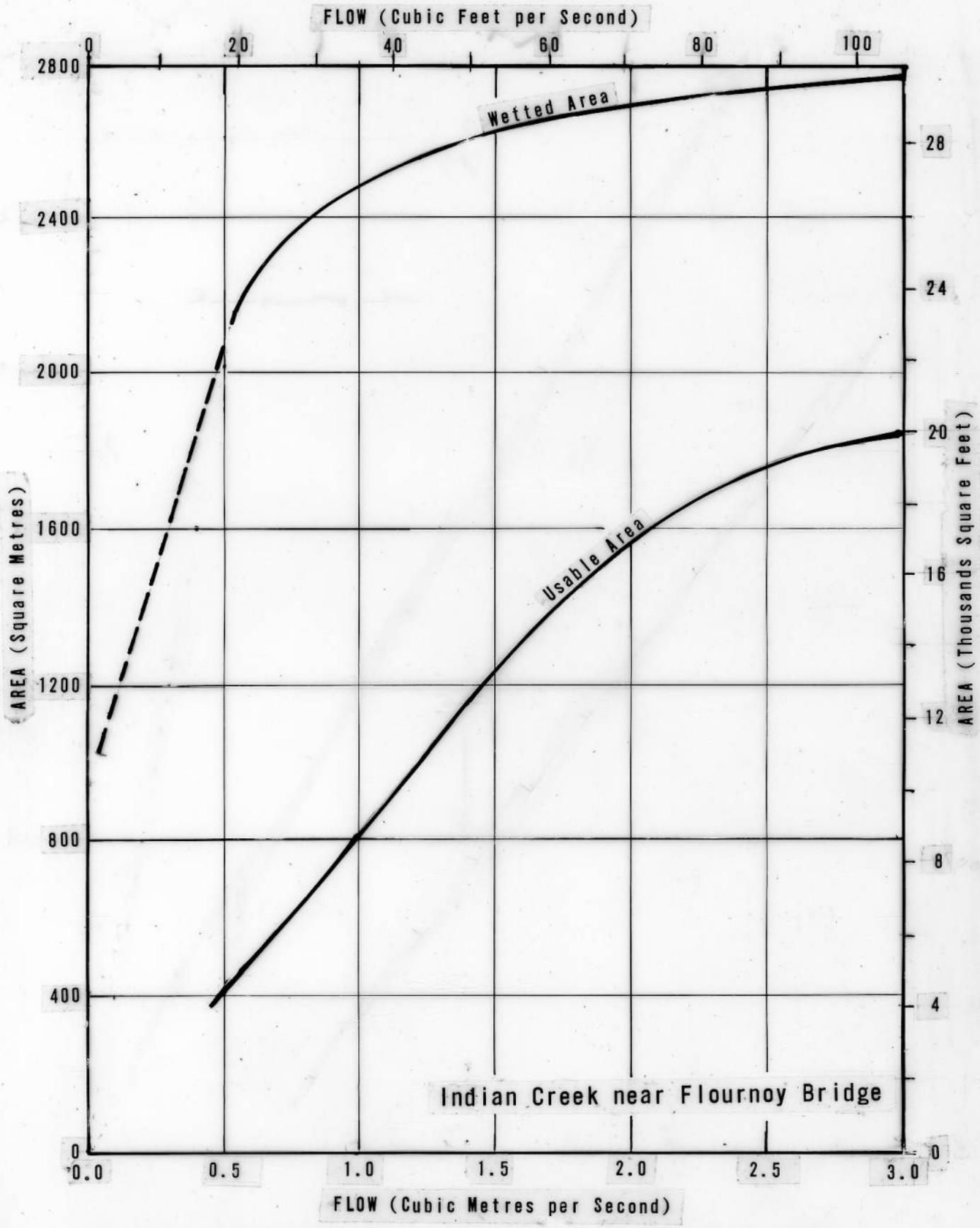


Figure 3. Relationship of wetted area and usable area with flow at Study Area 2, Indian Creek, Plumas County, 1976.

Weighted Method

At both study areas, subjective cover and food-producing area increased with flow throughout the range of flows studied; however, the rate of increase was less above 1.0 m^3/s (35 ft^3/s) at Study Area 1 and above 2.3 m^3/s (81 ft^3/s) at Study Area 2 (Figures 4, 5, 8, 9). Optimum flows for resting microhabitat were near 0.4 m^3/s (15 ft^3/s) at Area 1 and 1.4 m^3/s (50 ft^3/s) at Area 2. Higher and lower streamflows provided considerably less resting microhabitat (Figures 6 and 10). At Study Area 1 spawning habitat increased with flows up to 2.3 m^3/s (81 ft^3/s), then declined, but the rate of increase was reduced above 1.0 m^3/s (35 ft^3/s) (Figure 7). At Study Area 2 spawning area increased with flow throughout the range of flows studied, with a slight decline in the rate of increase above 2.3 m^3/s (81 ft^3/s) (Figure 11) (Appendices 2 and 3).

DISCUSSION

In general, these results suggest that increasing flows in Indian Creek above historic or post-Antelope Reservoir levels would benefit trout habitat. Specifically, at Study Area 1 trout habitat increased rapidly up to 1.0 m^3/s (35 ft^3/s) according to both the unweighted and weighted methods of evaluation. Only resting microhabitat declined at this level of flow. At Study Area 2, by either measure, trout habitat increased with flow throughout the range of flows studied, 0.56 to 3.1 m^3/s (20 to 110 ft^3/s), with a slight reduction in the rate of increase above 2.3 m^3/s (81 ft^3/s). Resting microhabitat declined above 1.4 m^3/s (50 ft^3/s).

Both the weighted and unweighted methods use the same data-collecting techniques (see Methods). Thus, either method of data analysis may be employed. The unweighted method is a much simpler way to analyze data. Usable area is calculated at the different flows to determine optimum releases. However, this method is not as sophisticated as the weighted method because different trout habitat parameters are treated as one.

The weighted method is much more complicated. A computer program is needed to compute relative units for each of the four habitat parameters because hand calculation is difficult and tedious. The results may indicate different flows are optimum for different habitat parameters. Thus, flow releases can be varied by season to meet the requirements of specific habitat types.

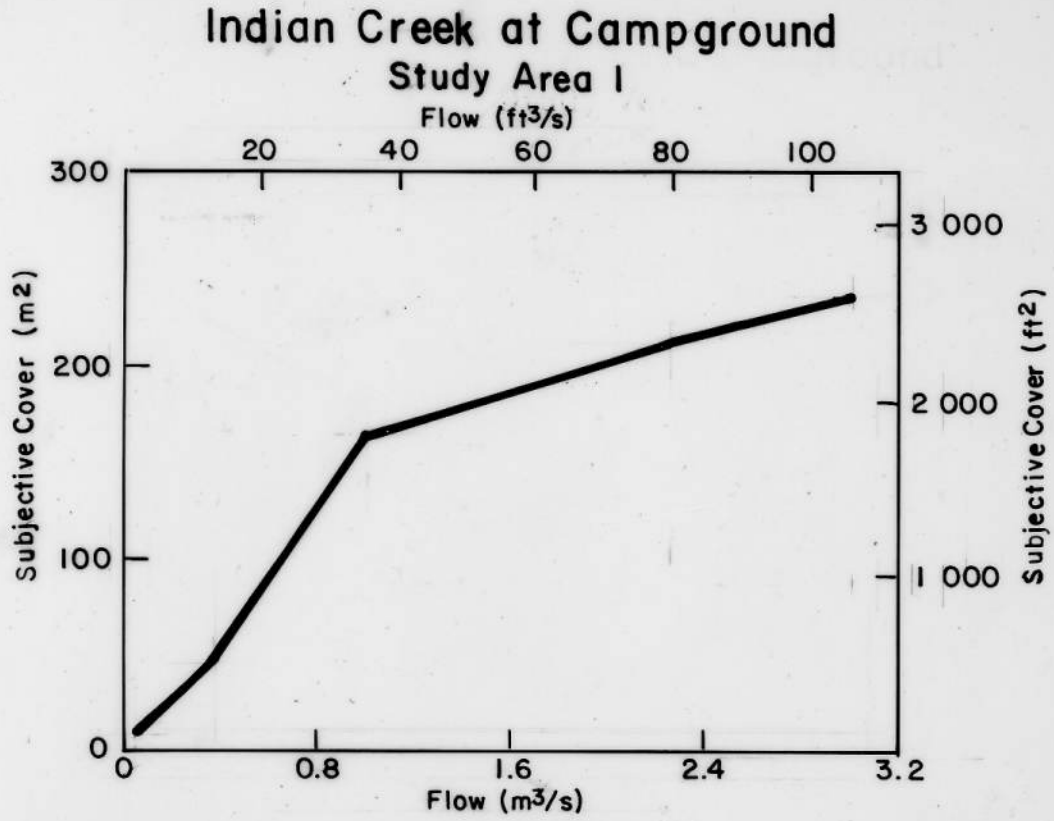


Figure 4 Relationship of Subjective Cover with Flow

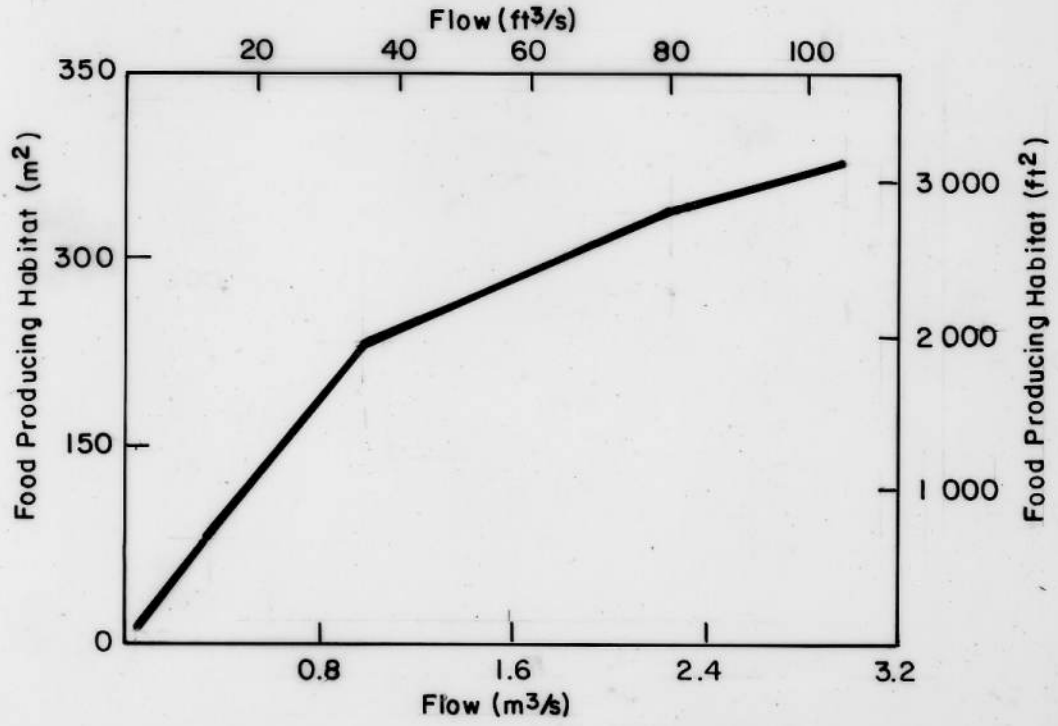


Figure 5 Relationship of Food-Producing Habitat with Flow

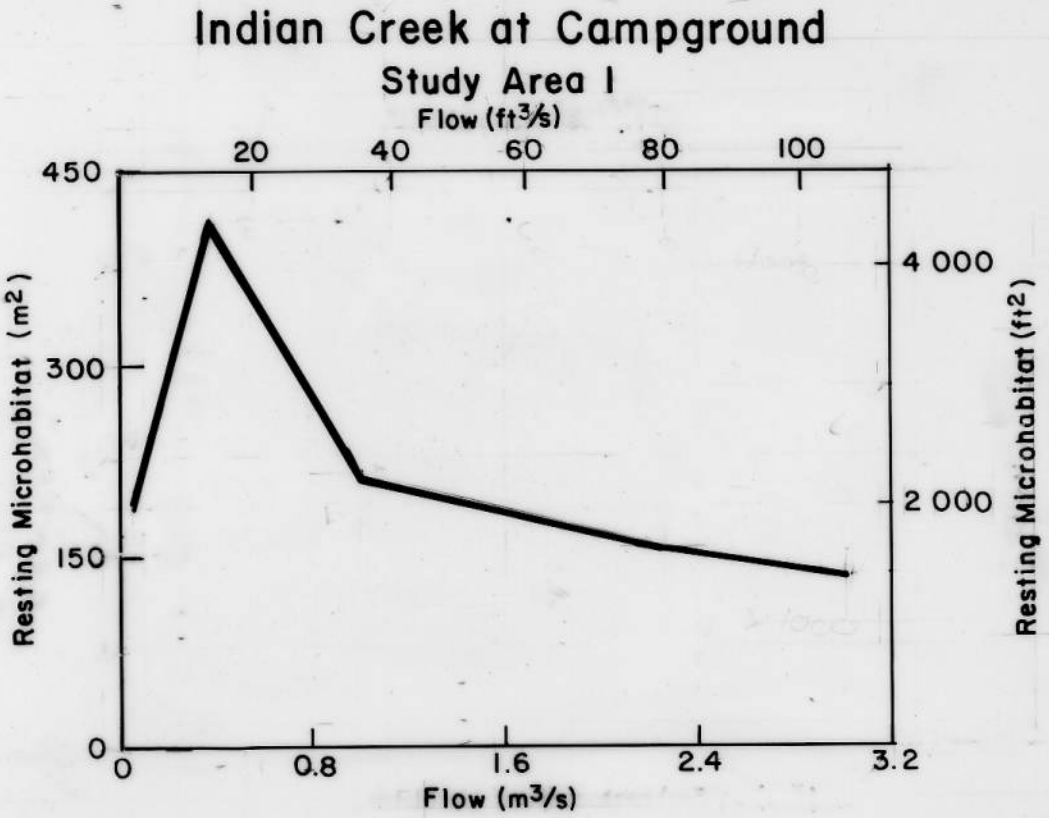


Figure 6 Relationship of Resting Microhabitat with Flow

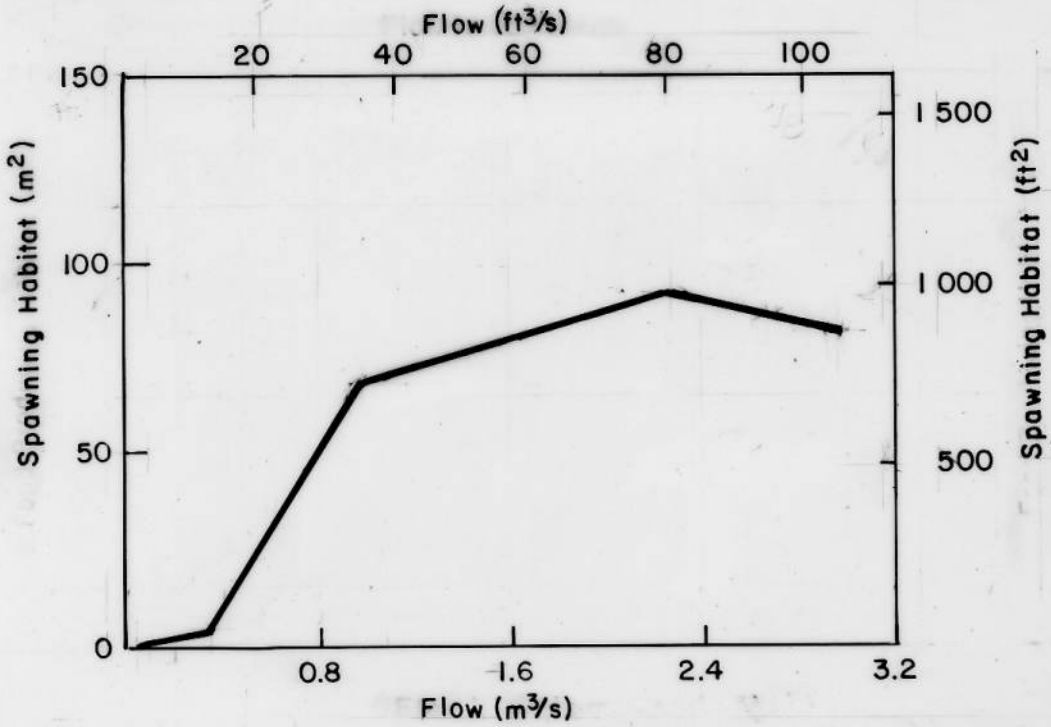


Figure 7 Relationship of Spawning Habitat with Flow

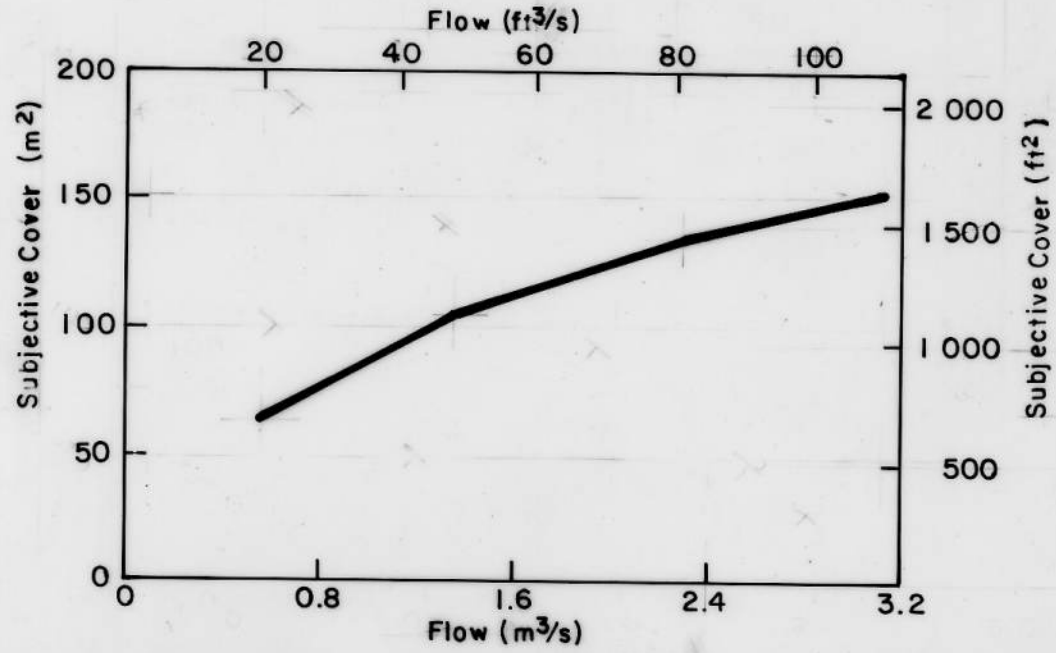


Figure 8 Relationship of Subjective Cover with Flow

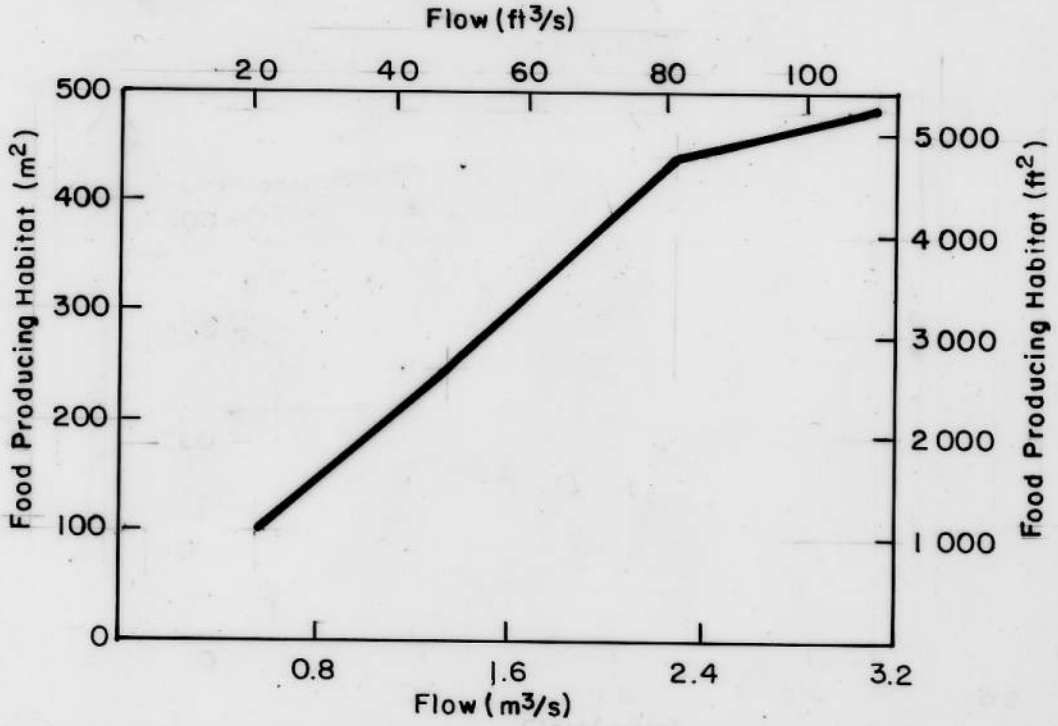


Figure 9 Relationship of Food-Producing Habitat with Flow

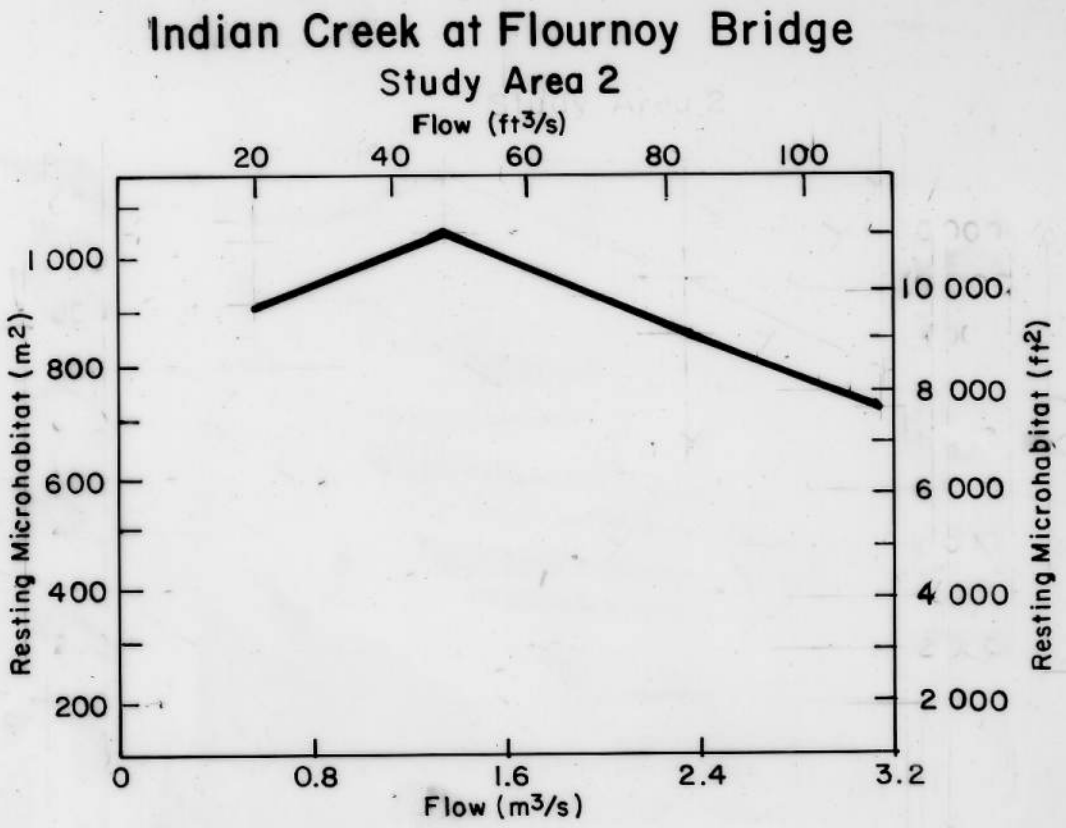


Figure 10 Relationship of Resting Microhabitat with Flow

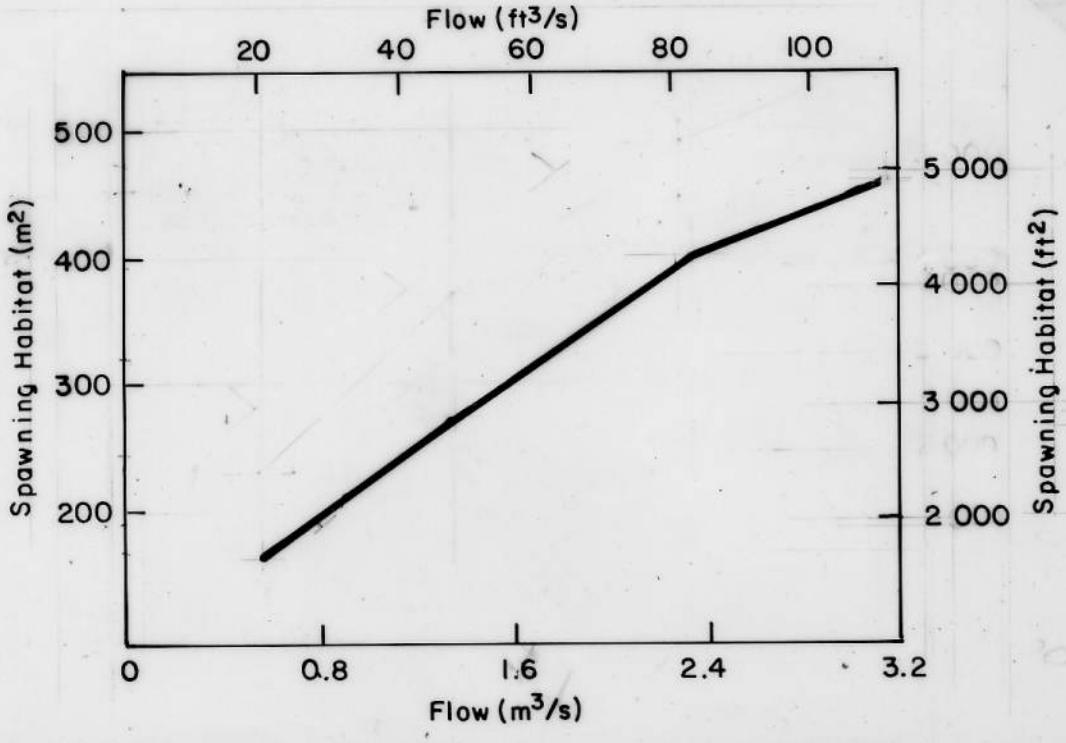


Figure 11 Relationship of Spawning Habitat with Flow

In 1977, following completion of the Indian Creek flow study, the Federal Cooperative Instream Flow Service Group (IFG) introduced another weighted method of instream flow evaluation. The advantage of the IFG method lies in its usage of different criteria for each fish species. Although this method has become the most widely used, the Indian Creek data were not reanalyzed using these criteria because of a difference in the method of data collection. At Indian Creek, water velocity was measured 0.06 m (0.2 ft) from the bottom. The IFG method uses mean velocity which is measured four-tenths of the total depth from the bottom. The IFG method should be used in future studied to facilitate comparison with studies on other streams.

CONCLUSIONS

Reoperation of Antelope Reservoir provides a way to increase trout habitat in the upper reaches of Indian Creek. Present operation of the reservoir calls for a release of 0.28 m^3/s (10 ft^3/s) from July through March and 0.57 m^3/s (20 ft^3/s) in April, May, and June when the reservoir is full. Increasing the release to provide higher late summer flows would improve trout habitat according to this study. The reservoir would undergo a larger drawdown. This could be detrimental to the aesthetics of the lake recreation. Therefore, decisions to increase flows released from the reservoir should be balanced between potential improvement of the creek fishery and recreation and maintenance of the lake fishery and recreation.

ACKNOWLEDGMENTS

Field measurements of depths, velocities, and flows for this study were made by John Nolan, Water Resources Technician II, who also analyzed the data for the unweighted method. Data analysis for the weighted method was graciously done by Brian Waters and Paul Kubicek, biologists with the Pacific Gas and Electric Company. The methodology and computer program used for the weighted method were also developed by PGandE.

LITERATURE CITED

U. S. Fish and Wildlife Service. 1976. Tuolumne River Flow Study, Canyon Power Project, California. 40 pp and Appendices.

Waters, Brian F. 1976. A methodology for evaluating the effects of different streamflows on salmonid habitat. In: Proceedings of the Symposium and Specialty Conference on Instream Flow Needs, American Fisheries Society, May 3-6, 1976. pp. 254-266.

APPENDIX 1

STREAMFLOW RECORDS FOR INDIAN CREEK
OCTOBER 1975 - SEPTEMBER 1977

11401125 INDIAN CREEK NEAR BOULDER CREEK GUARD STATION, NEAR TAYLORSVILLE, CA

LOCATION (REVISED).--Lat 40°10'47", long 120°36'27", in SE¼SE¼ sec.22, T.27 N., R.12 E., Plumas County, on left bank 150 ft (46 m) downstream from Antelope Dam, 1.8 mi (2.9 km) upstream from Cold Stream, 1.3 mi (2.1 km) south of Boulder Creek Guard Station, 12.3 mi (19.8 km) northeast of Genesee, and 14.3 mi (23.0 km) northeast of Taylorsville.

DRAINAGE AREA.--68.6 mi^2 (177.7 km^2).

PERIOD OF RECORD.--October 1965 to current year. June 1961 to September 1965 in reports of California Department of Water Resources.

GAGE.--Water-stage recorder and steel-lipped concrete control. Supplementary water-stage recorder on dam and concrete spillway. Altitude of gage is 4,930 ft (1,502 m), from topographic map. October 1965 to September 1968, at site 0.9 mi (1.4 km) downstream at different datum.

REMARKS.--Flow regulated since Nov. 25, 1963 by Antelope Lake, capacity, 22,500 acre-ft (27.7 hm^3). See schematic diagram of North Fork Feather River basin. Records since October 1968 are combined flow of release from Antelope Dam and flow over spillway.

COOPERATION.--Records furnished by California Department of Water Resources and reviewed by the Geological Survey.

AVERAGE DISCHARGE.--11 years, 65.8 ft^3/s (1.863 m^3/s), 47,670 acre-ft/yr (58.8 hm^3/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 828 ft^3/s (23.4 m^3/s) May 24, 1967, gage height, 6.31 ft (1.923 m) previous site and datum, and Jan. 24, 1970 (includes flow over spillway); no flow for several months in 1971-72 (caused by draining of Antelope Lake).

EXTREMES FOR CURRENT YEAR.--Maximum daily discharge, 141 ft^3/s (3.99 m^3/s) July 16-27; minimum daily, 10 ft^3/s (0.28 m^3/s) many days.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	18	10	10	10	10	10	10	45	20	20	140	95
2	18	10	10	10	10	10	10	47	20	20	140	95
3	14	10	10	10	10	10	10	47	20	20	140	94
4	10	10	10	10	10	10	10	46	20	20	139	94
5	10	10	10	10	10	10	10	44	20	20	138	94
6	10	10	10	10	10	10	10	40	20	20	117	93
7	10	10	10	10	10	10	10	37	20	20	102	93
8	10	10	10	10	10	10	10	35	20	20	102	92
9	10	10	10	10	10	10	10	34	19	20	101	91
10	10	10	10	10	10	10	10	36	21	20	101	91
11	10	10	10	10	10	10	10	38	21	20	101	90
12	10	10	10	10	10	10	10	34	21	20	100	90
13	10	10	10	10	10	10	10	30	21	20	100	102
14	10	10	10	10	10	10	11	26	21	36	100	119
15	10	10	10	10	10	10	14	24	21	96	99	118
16	10	10	10	10	10	10	16	22	21	141	99	118
17	10	10	10	10	10	10	17	21	20	141	99	118
18	10	10	10	10	10	10	21	20	20	141	99	117
19	10	10	10	10	10	10	24	20	20	141	99	116
20	10	10	10	10	10	10	29	20	20	141	99	115
21	10	10	10	10	10	10	34	20	21	141	99	114
22	10	10	10	10	10	10	39	20	21	141	99	113
23	10	10	10	10	10	10	44	20	20	141	99	113
24	10	10	10	10	10	10	48	20	20	141	98	112
25	10	10	10	10	10	10	53	20	20	141	98	111
26	10	10	10	10	10	10	52	20	20	141	98	110
27	10	10	10	10	10	10	48	20	20	141	98	108
28	10	10	10	10	10	10	45	20	20	140	98	107
29	10	10	10	10	10	10	43	20	19	140	97	92
30	10	10	10	10	---	10	43	20	20	140	97	56
31	10	---	10	10	---	10	---	20	---	140	96	---
TOTAL	330	300	310	310	290	310	711	886	607	2644	3292	3071
MEAN	10.6	10.0	10.0	10.0	10.0	10.0	23.7	28.6	20.2	85.3	106	102
MAX	18	10	10	10	10	10	53	47	21	141	140	119
MIN	10	10	10	10	10	10	10	20	19	20	96	56
AC-FT	655	595	615	615	575	615	1410	1760	1200	5240	6530	6090

CAL YR 1975 TOTAL 20202 MEAN 55.3 MAX 437 MIN 10 AC-FT 40070
WTR YR 1976 TOTAL 13061 MEAN 35.7 MAX 141 MIN 10 AC-FT 25910

SACRAMENTO RIVER BASIN

11401125 INDIAN CREEK NEAR BOULDER CREEK GUARD STATION, NEAR TAYLORSVILLE, CA

LOCATION.--Lat 40°10'47", long 120°36'27", in SE¼SE¼ sec.22, T.27 N., R.12 E., Plumas County, on left bank 150 ft (46 m) downstream from Antelope Dam, 1.8 mi (2.9 km) upstream from Cold Stream, 1.3 mi (2.1 km) south of Boulder Creek Guard Station, 12.3 mi (19.8 km) northeast of Genesee, and 14.3 mi (23.0 km) northeast of Taylorsville.

DRAINAGE AREA.--68.6 mi^2 (177.7 km^2).

PERIOD OF RECORD.--October 1965 to current year. June 1961 to September 1965 in reports of California Department of Water Resources.

GAGE.--Water-stage recorder and steel-lipped concrete control. Supplementary water-stage recorder on dam and concrete spillway. Altitude of gage is 4,930 ft (1,502 m), from topographic map. October 1965 to September 1968, at site 0.9 mi (1.4 km) downstream at different datum.

REMARKS.--Flow regulated since Nov. 25, 1963 by Antelope Lake, capacity, 22,500 acre-ft (27.7 hm^3). See schematic diagram of North Fork Feather River basin. Records since October 1968 are combined flow of release from Antelope Dam and flow over spillway.

COOPERATION.--Records furnished by California Department of Water Resources and reviewed by the Geological Survey.

AVERAGE DISCHARGE.--12 years, 60.6 ft^3/s (1.716 m^3/s), 43,900 acre-ft/yr (54.1 hm^3/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 828 ft^3/s (23.4 m^3/s) May 24, 1967, gage height, 6.31 ft (1.923 m) previous site and datum, and Jan. 24, 1970 (includes flow over spillway); no flow for several months in 1971-72, 1977 (caused by draining of Antelope Lake).

EXTREMES FOR CURRENT YEAR.--Maximum daily discharge, 100 ft^3/s (2.83 m^3/s) Oct. 2; no flow for several months.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	73						0	10	7.0	2.6	1.0	1.0
2	100						0	10	5.0	2.6	1.0	1.0
3	98						0	10	5.0	2.6	1.0	1.0
4	97						0	10	5.0	2.6	1.0	1.0
5	81						0	10	5.0	2.0	1.0	1.0
6	26						0	10	5.0	1.3	1.0	1.0
7	13						0	10	4.0	1.3	1.0	1.0
8	10						0	10	3.3	1.3	1.0	1.0
9	7.5						0	10	3.3	1.3	1.0	1.0
10	6.2						0	10	3.3	1.3	1.0	1.0
11	5.6						0	10	3.3	1.3	1.0	1.0
12	5.0						0	10	3.3	1.2	1.0	1.0
13	2.3						0	10	3.3	1.0	1.0	1.0
14	0						0	10	3.3	1.0	1.0	1.0
15	0						0	10	3.3	1.0	1.0	1.0
16	0						0	10	3.3	1.0	1.0	1.0
17	0						0	10	3.3	1.0	1.0	1.0
18	0						0	10	3.3	1.0	1.0	1.0
19	0						0	10	3.3	1.0	1.0	1.0
20	0						0	10	6.0	1.0	1.0	1.0
21	0						0	10	10	1.0	1.0	1.0
22	0						0	10	10	1.0	1.0	1.0
23	0						0	10	10	1.0	1.0	1.0
24	0						0	10	10	1.0	1.0	1.0
25	0						0	10	10	1.0	1.0	1.0
26	0						0	10	10	1.0	1.0	1.0
27	0						3.5	10	5.7	1.0	1.0	1.0
28	0						10	10	2.6	1.0	1.0	1.0
29	0				---		10	10	2.6	1.0	1.0	1.0
30	0				---		10	10	2.6	1.0	1.0	1.0
31	0	---			---		---	10	---	1.0	1.0	---
TOTAL	524.6	0	0	0	0	0	33.5	310	155.1	40.4	31.0	30.0
MEAN	16.9	0	0	0	0	0	1.12	10.0	5.17	1.30	1.00	1.00
MAX	100	0	0	0	0	0	10	10	10	2.6	1.0	1.0
MIN	0	0	0	0	0	0	0	10	2.6	1.0	1.0	1.0
AC-FT	1040	0	0	0	0	0	66	615	308	80	61	60

CAL YR 1976 TOTAL 12645.6 MEAN 34.6 MAX 141 MIN 0 AC-FT 25080
WTR YR 1977 TOTAL 1124.6 MEAN 3.08 MAX 100 MIN 0 AC-FT 2230

APPENDIX 2

RELATIVE UNITS FOR STUDY AREA 1,
INDIAN CREEK, PLUMAS COUNTY, 1976

INDIAN CREEK NEAR CAMPGROUND

RELATIVE UNITS OF SUBJECTIVE COVER

TRANSECT	1.8 CFS	12.2 CFS	36.4 CFS	81.6 CFS	105.8 CFS
1	0.5000	1.0000	5.5000	5.5000	6.0000
2	0.0000	0.0000	2.0000	5.0000	6.5000
3	0.0000	1.0000	1.0000	1.5000	2.5000
4	0.0000	1.5000	3.5000	4.0000	4.0000
5	0.0000	1.5000	5.5000	6.5000	6.5000
TOTAL	0.5000	5.0000	17.5000	22.5000	25.5000

MEAN

RELATIVE UNITS OF SUBJECTIVE COVER

1	0.0278	0.0556	0.3056	0.3056	0.3333
2	0.0000	0.0000	0.1053	0.2632	0.3421
3	0.0000	0.0455	0.0455	0.0682	0.1136
4	0.0000	0.0833	0.1944	0.2222	0.2222
5	0.0000	0.0833	0.3056	0.3611	0.3611
MEAN	0.0053	0.0526	0.1842	0.2368	0.2684

INDIAN CREEK NEAR CAMPGROUND

RELATIVE UNITS OF FOOD PRODUCING HABITAT

TRANSECT	1.8 CFS	12.2 CFS	36.4 CFS	81.6 CFS	105.8 CFS
1	0.0000	0.4999	5.1799	6.9999	8.6899
2	0.0000	1.7799	6.5629	8.7899	9.4999
3	0.1399	3.8739	10.2699	14.0199	14.6499
4	0.0000	0.5999	2.1599	2.9399	3.1799
5	0.0000	0.0000	1.2999	3.0399	3.1419
TOTAL	0.1399	6.7539	25.4729	35.7899	39.1619

MEAN

RELATIVE UNITS OF FOOD PRODUCING HABITAT

1	0.0000	0.0278	0.2878	0.3889	0.4828
2	0.0000	0.0937	0.3454	0.4626	0.5000
3	0.0064	0.1761	0.4668	0.6373	0.6659
4	0.0000	0.0333	0.1200	0.1633	0.1767
5	0.0000	0.0000	0.0722	0.1689	0.1746
MEAN	0.0015	0.0711	0.2681	0.3767	0.4122

INDIAN CREEK NEAR CAMPGROUND

RELATIVE UNITS OF RESTING MICROHABITAT

TRANSECT	1.8 CFS	12.2 CFS	36.4 CFS	81.6 CFS	105.8 CFS
1	5.3649	12.5699	7.4719	6.0189	4.1699
2	3.8299	9.4659	0.9679	0.6579	0.2589
3	1.3899	2.6259	2.1299	0.2699	0.9599
4	4.1729	8.1729	3.9489	3.6899	2.0789
5	4.8759	10.5099	8.0199	5.5269	6.5679
TOTAL	19.6339	43.3449	22.5389	16.1639	14.0359

MEAN
RELATIVE UNITS OF RESTING MICROHABITAT

1	0.2981	0.6983	0.4151	0.3344	0.2317
2	0.2016	0.4982	0.0509	0.0346	0.0136
3	0.0632	0.1194	0.0968	0.0123	0.0436
4	0.2318	0.4541	0.2194	0.2050	0.1155
5	0.2709	0.5839	0.4456	0.3071	0.3649
MEAN	0.2067	0.4563	0.2373	0.1701	0.1477

INDIAN CREEK NEAR CAMPGROUND

RELATIVE UNITS OF SPAWNING HABITAT

TRANSECT	1.8 CFS	12.2 CFS	36.4 CFS	81.6 CFS	105.8 CFS
1	0.0000	0.0000	0.8999	1.0499	1.7999
2	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.2799	2.3999	2.6199	2.3299
4	0.0000	0.0899	2.9099	3.5299	2.7199
5	0.0000	0.0000	0.9799	2.4499	1.8399
TOTAL	0.0000	0.3699	7.1899	9.6499	8.6899

MEAN

RELATIVE UNITS OF SPAWNING HABITAT

1	0.0000	0.0000	0.0500	0.0583	0.1000
2	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0127	0.1091	0.1191	0.1059
4	0.0000	0.0050	0.1617	0.1961	0.1511
5	0.0000	0.0000	0.0544	0.1361	0.1022
MEAN	0.0000	0.0039	0.0757	0.1016	0.0915

APPENDIX 3

RELATIVE UNITS FOR STUDY AREA 2
INDIAN CREEK, PLUMAS COUNTY, 1976

INDIAN CREEK NEAR FLOURNOY BRIDGE

RELATIVE UNITS OF SUBJECTIVE COVER

TRANSECT	19.8 CFS	48.5 CFS	82.2 CFS	110.5 CFS
1	1.5000	2.0000	3.0000	4.0000
2	2.0000	3.5000	4.5000	4.5000
3	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000
TOTAL	3.5000	5.5000	7.5000	8.5000

MEAN

RELATIVE UNITS OF SUBJECTIVE COVER

1	0.0517	0.0690	0.1034	0.1379
2	0.0606	0.1061	0.1364	0.1364
3	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000
MEAN	0.0232	0.0364	0.0497	0.0563

INDIAN CREEK NEAR FLOURNOY BRIDGE

RELATIVE UNITS OF FOOD PRODUCING HABITAT

TRANSECT	19.8 CFS	48.5 CFS	82.2 CFS	110.5 CFS
1	0.0000	0.1599	0.5499	0.7619
2	0.0099	0.3399	0.6999	1.0829
3	0.3799	1.3499	4.0299	5.0699
4	2.1299	4.2339	6.5499	6.7299
5	3.4499	7.2239	12.0119	13.4279
TOTAL	5.9699	13.3079	23.8419	27.0729

MEAN
RELATIVE UNITS OF FOOD PRODUCING HABITAT

1	0.0000	0.0055	0.0190	0.0263
2	0.0003	0.0103	0.0212	0.0328
3	0.0141	0.0500	0.1493	0.1878
4	0.0819	0.1628	0.2519	0.2588
5	0.0958	0.2007	0.3337	0.3730
MEAN	0.0395	0.0881	0.1579	0.1793

INDIAN CREEK NEAR FLOURNOY BRIDGE

RELATIVE UNITS OF RESTING MICROHABITAT

TRANSECT	19.8 CFS	48.5 CFS	82.2 CFS	110.5 CFS
1	15.5879	18.1049	14.5049	11.4929
2	15.4109	17.4649	16.6199	14.8649
3	10.1799	10.1999	8.9799	7.6999
4	5.8139	7.8849	3.8099	4.9899
5	2.7499	2.9599	2.5299	1.7299
TOTAL	49.7429	56.6148	46.4448	40.7779

MEAN
RELATIVE UNITS OF RESTING MICROHABITAT

1	0.5375	0.6243	0.5002	0.3963
2	0.4670	0.5292	0.5036	0.4505
3	0.3770	0.3778	0.3326	0.2852
4	0.2236	0.3033	0.1465	0.1919
5	0.0764	0.0822	0.0703	0.0481
MEAN	0.3294	0.3749	0.3076	0.2701

INDIAN CREEK NEAR FLOURNOY BRIDGE

RELATIVE UNITS OF SPAWNING HABITAT

TRANSECT	19.8 CFS	48.5 CFS	82.2 CFS	110.5 CFS
1	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0799
3	0.0899	0.8799	4.1899	5.6499
4	3.2999	5.4599	8.2899	8.7999
5	3.8799	8.3999	8.9799	10.0999
TOTAL	7.2699	14.7399	21.4599	24.6299

MEAN

RELATIVE UNITS OF SPAWNING HABITAT

1	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0024
3	0.0033	0.0326	0.1552	0.2093
4	0.1269	0.2100	0.3188	0.3385
5	0.1078	0.2333	0.2494	0.2806
MEAN	0.0481	0.0976	0.1421	0.1631