INSTREAM FLOW STUDY REPORT

FOR

ICICLE CREEK

Prepared for the

U.S. Army Corps of Engineers
Seattle District

by

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INTRODUCTION

The Seattle District, U.S. Army Corps of Engineers, is currently studying the feasibility of a hydropower development on Icicle Creek, a tributary to the Wenatchee River in Chelan County, Washington (Figure 1). The City of Leavenworth is the study sponsor, and also holds a preliminary permit from the Federal Energy Regulatory Commission for this site. The Corps of Engineers funded the U.S. Fish and Wildlife Service (FWS) to conduct an instream flow study, using the Instream Flow Incremental Methodology (IFIM), to consider the potential impacts to fish habitat that could occur due to changes in instream flow caused by the potential project. This report presents the findings of the IFIM study conducted by the Fisheries Assistance Office, FWS, Vancouver, Washington.

Icicle Creek flows easterly out of the mountains to intersect the Wenatchee River near Leavenworth. Twenty percent of the annual flow of the Wenatchee is contributed by Icicle Creek. Most of the streamflow is from snowmelt. According to U.S.F.S records, mean annual flow is 628 cubic feet per second (c.f.s.). Extreme flows recorded in the creek range from a minimum of 55 c.f.s. (in 1936) to 11,600 c.f.s. (in 1948), as measured at the USGS gaging station located close to river mile (R.M.) 6. Several diversions occur in the lower 5 miles of the creek. These are for irrigation, for municipal supply for the town of Leavenworth, and for the Leavenworth National Fish Hatchery. Mean monthly flows are graphically provided at appropriate points in this report.

Icicle Creek provides habitat for both anadromous and resident fish. The Leavenworth National Fish Hatchery, located at R.M. 2.8, produces 2.6 million spring chinook salmon (<u>Oncorhynchus tshawytscha</u>) and 100,000 steelhead (<u>Salmo gairdneri</u>) smolts per year. Both steelhead and chinook spawn naturally in the lower creek, but the hatchery dam is a block to upstream salmon migration. Some steelhead may make it past the dam, and they have occasionally been stocked above the dam in the past. Resident fish found in Icicle Creek include rainbow trout (<u>Salmo gardneri</u>), cutthroat trout (<u>Salmo clarki</u>), brook trout (<u>Salvelinus fontinalis</u>), bull char (<u>Salvelinus confluentus</u>) or Dolly Varden (<u>Salvelinus malma</u>)*, and mountain whitefish (<u>Prosopium williamsoni</u>). Rainbow trout are the most numerous, and offer an excellant recreational fishery. The creek is heavily stocked with large rainbows as mitigation for the Rocky Reach Dam, though natural production also occurs in the stream. The stream is managed for a "put and take" fishery.

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* The fish in question are probably bull char rather than Dolly Varden, though this point has been debated. We are recognizing the controversy, but not attempting to resolve it in this report. The curves were developed for Dolly Varden and are considered appropriate for both species.

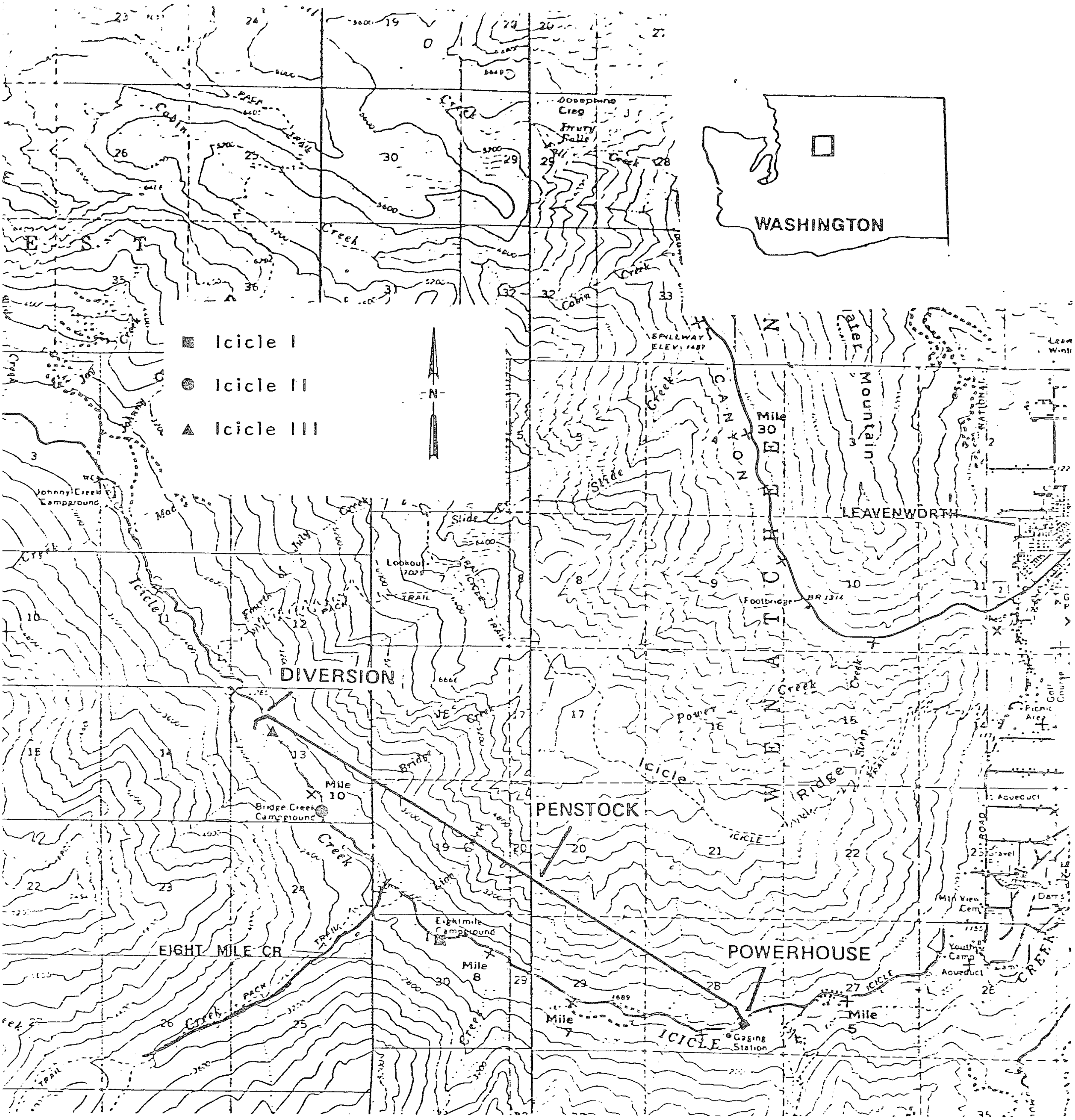


Figure 1. Location map of study area.

Because of the predominance of rainbow trout in the stream, they will be emphasized throughout this report. Flow/habitat relationships will also be considered for cutthroat and brook trout, bull char, and mountain whitefish. With the exception of steelhead and spring chinook adults of each species are yearround residents of the potential project area. Appendix I provides some generalized life history information for each species.

The project plans developed to date involve construction of a small diversion dam near R.M. 11. The dam would create a small, constant pool with a surface area of 1 acre or less. The powerhouse would be located near R.M. 6, at which point the diverted water would be returned to the creek. The Corps of Engineers estimates that the maximum installed capacity of the powerhouse would be between 40 and 80 MW of peak power and between 300,000 and 500,000 MWh of energy annually. The amount of water diverted through the penstock will generally be equivalent to 30% of the total stream discharge.

The IFIM study was developed with the cooperation and assistance of a number of resource agencies, including the Seattle District, Corps of Engineers, National Marine Fisheries Service, Washington Departments of Fisheries and Game, U.S. Forest Service, Yakima Indian Nation, and the City of Leavenworth. Decisions regarding the selection of evaluation species, designation of reach and transect sites, and development of preference curves were coordinated with representatives of these agencies.

Within the section of stream that will be impacted by the potential project, there exists high gradient cascading stretches of highly turbulant waters. In the opinion of the study site selection team, these areas provided poor fish habitat. Consequently, they were not included in this analysis. Aerial photographs taken in May 1983 were utilized to estimate the extent of these cascading stretches. The lower portion of the study area below Eight Mile Creek was approximately 66% cascades, while the area above Eight Mile Creek to the diversion point was about 36% cascades.

Several words of caution must be included here. The first is that an instream flow study such as this only considers how changes in stream flows will affect fish habitat quality. It does not consider the many other factors which may limit populations, such as water temperature and quality, predation, and fishing pressure. Secondly, it measures potential habitat quality, i.e. how well particular combinations of water depth, velocity, and substrate can be expected to meet the needs of fish. It does not predict numbers of fish.

SITE SELECTION

The selection of study sites on Icicle Creek was influenced by two primary factors: the stream area to be effected by the project, and representative fish habitat within that area.

It is necessary to include several definitions prior to continuing with the discussion of site selection. The Corps study area is considered the area of project impact. A representative reach is all or part of a particular stream segment which is selected because it is typical of a fairly large portion of the segment. A study reach is a subset of a representative reach, defined by the locations of transects and the limits of the model. Transects are locations within a study reach where measurements of depth, velocity, and substrate are made.

Prior to the start of field measurements representatives of the U.S. Fish and Wildlife Service, Washington Department of Game, Washington Department of Fisheries, U.S. Forest Service, Corps of Engineers, and City of Leavenworth toured the project area to locate suitable reach and transect sites. Because of significant inflow from Eight Mile Creek and other water sources within the affected area, it was determined that two representative reaches were needed to describe fish rearing habitat and a third reach was selected for an additional evaluation of potential spawning habitat. One reach was established just below the Eight Mile Campground and represents fish rearing habitat from the site of the potential powerhouse upstream to the confluence of Eight Mile Creek. This site is referred to as Icicle I. A speciality spawning reach, hereafter referred to as Icicle II, was located in a potential spawning area just above the Bridge Creek Campground bridge. The third site, Icicle III represents fish rearing habitat from the confluence of Eight Mile Creek upstream to the potential diversion point.

At each study reach, a number of transects was positioned across the stream to describe the various habitat types. Transect placement met the approval of the various agency representatives.

METHODS

Field Data Collection

The collection of field data began on August 1, 1984, and was completed on September 12, 1984. As suggested by the U.S. Fish and Wildlife Service Instream Flow Group (IFG), stream flows were measured in the order of high, medium, and low flows. A three point rating curve approach, which increases the reliability of velocity and water surface elevation predictions, was utilized. This generally allows a useful range of extrapolation of 0.4 times the minimum discharge to 2.5 times the maximum discharge measured.

The actual field measurements were made according to the methods described by Trihey and Wegner (1981).

At each measured flow, the elevation of the headstakes marking the transect ends and the distance between the transects were obtained prior to velocity measurements. Also, the water surface elevation on each bank was determined in relationship to a permanent bench mark and the headstake elevations for each transect. A tagline was stretched across the stream at each transect to measure the distance between each velocity measuring point and the bank headstake. Measurements of depth, velocity, and substrate were taken at predetermined points. The number of velocity measurement points ranged from 25 to 34 depending on the complexity of the substrate and hydraulic conditions along the transect. The velocity at each point was measured using a Marsh-McBirney flow meter. The streambed elevation was determined by substracting the water depth from the surface elevation.

Substrate was examined, characterized, and then quantified utilizing a three digit substrate coding referred to as the Brusven Index. The Brusven coding system is described as follows:

ab.c

where: a equals dominate substrate particle size
b equals subdominate particle size
c equals percent of dominate particle size

Table 1 provides the substrate coding used in this study.

Table 1. Icicle Creek Substrate Coding

Code	Substrate Description	Particle Size
1	Vegetation	
2	Mud/Silt	
3	Sand	
4	Pea Gravel	.1" - .5"
5	Small Gravel	.5" - 1.5"
6	Large Gravel	1.5" - 3.0"
7	Small Cobble	3.0" - 6.0"
8	Large Cobble	6.0" - 12.0"
9	Boulder/Bedrock	

For example: 54.7 would translate into gravel .5"-1.5" being dominate and representing 70% of the substrate, and .1"-.5" gravel being the subdominate substrate.

Data Analysis

The Physical Habitat Simulation System (PHABSIM) developed by IFG was utilized to define habitat flow relationships in Icicle Creek.

The IFG process of evaluating instream flow requirements for any species of fish is composed of two segments: hydraulic simulation, and habitat evaluation. Hydraulic simulation estimates the relationship of one or more sets of measured flow related parameters to stream discharge. The hydraulic simulation model makes it possible to correlate discharge with water surface elevation and mean column velocity utilizing actual field data. Once this step has been accomplished with measured flows, other discharges may be simulated. Fisheries Assistance Office staff simulated a number of discharges for each study reach which included a range of existing and potential project flows.

The calibration of the hydraulic simulation model (IFG4) involves the use of a velocity adjustment factor. This factor is the ratio of the flow the program is requested to predict versus the flow it actually computes. The velocity adjustment factor is used as a guide to the overall accuracy of the simulation. Table 2 is a guideline for evaluating the accuracy of the simulation as provided by Milhous, Wegner, and Waddle (1981).

Table 2. Velocity Adjustment Factor Ratings.

Velocity Adjustment Factor	Classification	Velocity Adjustment Factor
0.90 - 1.00	Good	1.00 - 1.10
0.85 - 0.90	Fair	1.10 - 1.15
0.80 - 0.85	Marginal	1.15 - 1.20
0.70 - 0.80	Poor	1.20 - 1.30
less than 0.70	Very Poor	greater than 1.30

After the completion of the hydraulic simulation, the resultant predictions of hydraulic conditions were interfaced with the Habitat program, which provided estimates of available habitat at various stream discharges through the utilization of probability of use curves for the species of interest. Probability of use curves describe a fish's preference (by species and life history stage) for conditions of depth, velocity, and substrate. Probability of use is equated with frequency that fish are found in these conditions. The point of the greatest frequency of occurrence is assigned a 1.0 probability of use. If frequency of use is zero, then probability of use is zero. Intermediate frequency use values are assigned on a linear scale basis. The Habitat program cross-multiplies the individual probabilities of use for depth, velocity, and substrate to estimate the composite probability of use.

Subsequently, the program expands the habitat values calculated at each point on the transect to the remainder of the stream habitat in the reach. It does this by dividing the reach into cells, with each point of measurement as the centerpoint of a cell; cell boundaries lie midway between measurement points along a transect, and midway between transects along the length of the reach. For the transects forming the upper and lower boundaries of a reach, the length of the cells extends from the transect to a line one-half the distance to the next transect. To compute available habitat, the area of the cell is multiplied by the composite probability of use. This results in an estimate of available habitat expressed as weighted usable area (WUA). One unit of WUA is equivalent to a unit of optimum habitat. The Habitat program standardizes the measure of available habitat by expressing it in square feet of WUA per 1,000 lineal feet of stream. This process is repeated for each discharge of interest.

The probability of use curves utilized for Icicle Creek were developed by the U.S. Fish and Wildlife Service for use in the Yakima River system. In addition, probability of use curves for Dolly Varden (Bull trout) in Icicle Creek were developed by Ecological Services, Olympia

(USFWS). Curves utilized in this report ~~agencies and~~ are presented in tabular form in Appendix II. The appendix also includes a graphic representation of brown trout preference curves for depth, velocity, substrate, and temperature as utilized by Bovee (1978). The graphic representation is meant to illustrate how tabular data can be presented in an alternative format.

Mean monthly natural flow data was obtained fro U.S.G.S. records from a discharge gauge in Icicle Creek, .4 miles upstream of the confluence of Snow Creek. Potential project flows were provided by the Seattle District, Corps of Engineers.

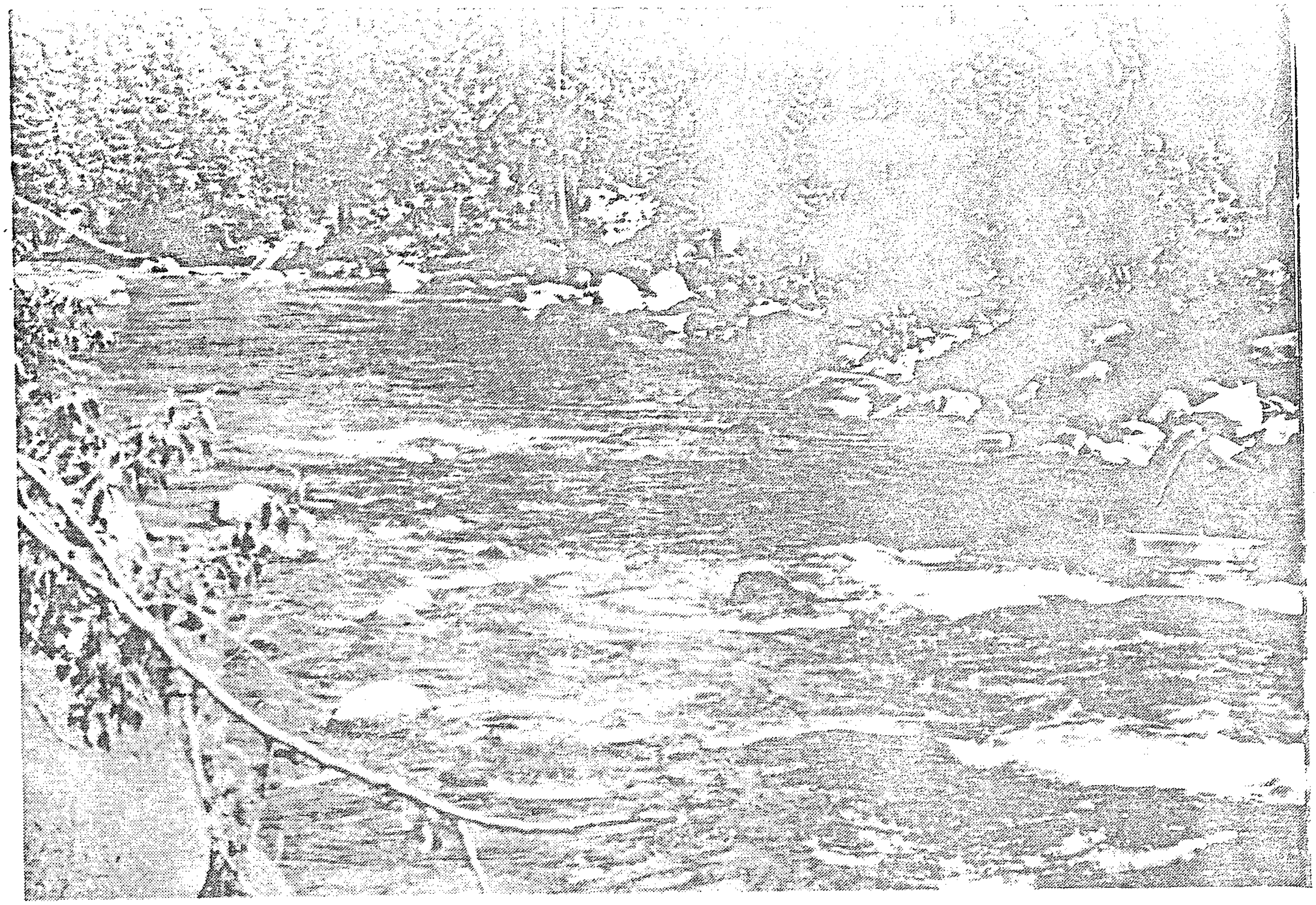
Overview

Icicle Creek demonstrates the discharge fluctuations often seen in mountain streams influenced by snow melt. From April through July the stream receives heavy snow melt and undergoes dramatic discharge increases followed by greatly reduced flows after the spring freshet. The project would take a significant amount of water out of the peak of the natural freshet and, also more importantly, reduce flows nearly in half during other months.

The late summer, fall, and winter low flow periods are considered to be critical to fishes and other aquatic life. Low stream flows during this period severely reduce the available suitable rearing habitat and limit production capacity. It is the survival rate during this period that ultimately determines the population level of the stream. The winter months of November through February probably are not as critical, since the fish are fairly inactive and feeding activity is greatly reduced. Individual territories tend to collapse, and the fish are more tolerant of crowding.

In order to ascertain the potential project's possible impact on fish, we determined how much preferred habitat of a particular species would be available under the specific hydraulic pecularities found in Icicle Creek. This relationship is demonstrated for rainbow trout, cutthroat trout, brook trout, Dolly Varden (bull trout), and mountain whitefish. Additionally, habitat was estimated for summer steelhead and spring chinook salmon at the request of several of the involved resource agencies.

The following results provide insight into existing fish habitat, as well as impacts of potential project operations, based upon the number of fish habitat units per 1,000 lineal feet of stream for those portions of the stream that actually contain fish habitat.



ICICLE I

ICICLE I

The study reach designated Icicle I is 546 feet in length and the transect width averaged 111 feet. Measurements were taken at 405, 215, and 146 cfs. Velocity adjustment factors used in the hydraulic simulations are shown in Table 3.

Table 3. Velocity Adjustment Factors For Icicle I.

Discharge	Transect 0 + 00	2 + 70	0 + 73	2 + 03
50	1.199	.830	.910	.901
75	1.093	.861	.930	.932
100	1.001	.890	.947	.963
125	.936	.914	.959	.995
150	.911	.933	.969	.969
175	.910	.949	.977	.981
200	.917	.962	.983	.991
250	.940	.980	.990	1.005
300	.967	.975	.995	1.016
400	1.023	.982	1.000	1.020
500	1.074	.988	1.002	1.013
600	1.121	.992	1.002	1.013
700	1.162	.996	1.001	1.004
800	1.199	.999	1.000	.992

Figure 2 illustrates the average monthly flows presently occurring in Icicle I as well as the effect of project operations. Figures 3 through 21 demonstrate the discharge vs habitat relationship for the species of interest. This same information is also presented in tabular form in Tables 4 through 10. Maximum habitat is represented by peaks in the curves and is also noted in each table for each lifestage.

Some spawning habitat occurs in Icicle I for all of the species modeled. In the case of rainbow trout, cutthroat trout, brook trout, and Dolly Varden (bull trout), maximum amounts of spawning habitat occur in the area of 400 cfs. Lesser amounts occur below this with a steep decline below 75 cfs. Brook trout spawning habitat disappears below 250 cfs. Considerable mountain whitefish spawning habitat exists and is maximized at 300 cfs. Steelhead spawning habitat is greatest between 300-400 cfs, and declines rapidly at other discharges. Spring chinook spawning habitat is maximized at 600 cfs but is minimal at best.

Adult habitat for rainbow trout, cutthroat trout, and whitefish is maximized at 500, 250, and 500 cfs respectively. Habitat tails off more gradually toward higher discharges than it does for lower discharges for these three species. Steep decreases in habitat occur below about 250-300 cfs. Adult habitat for the chars (brook trout and Dolly Varden) follows a somewhat different pattern. Peak amounts of habitat occur from 100-125 cfs and steeply decline especially at lower discharges. The decline at higher discharges is less dramatic above 250 cfs.

Juvenile habitat for rainbow trout, cutthroat trout, and whitefish all decline rapidly below discharges of 200 cfs. Habitat is maximized for the chars at approximately 100-125 cfs; rapidly dropping once flows get below 100 cfs. In general, juvenile habitat for all species excepting chars, seems to change at a lesser magitude than that for adult habitat over the discharges measured. In the case of brook trout, the change in juvenile and adult habitat was identical, and it was nearly so with Dolly Varden. Peak amounts of juvenile habitat for steelhead and spring chinook occurred at discharges of 200 and 175 cfs, respectively.

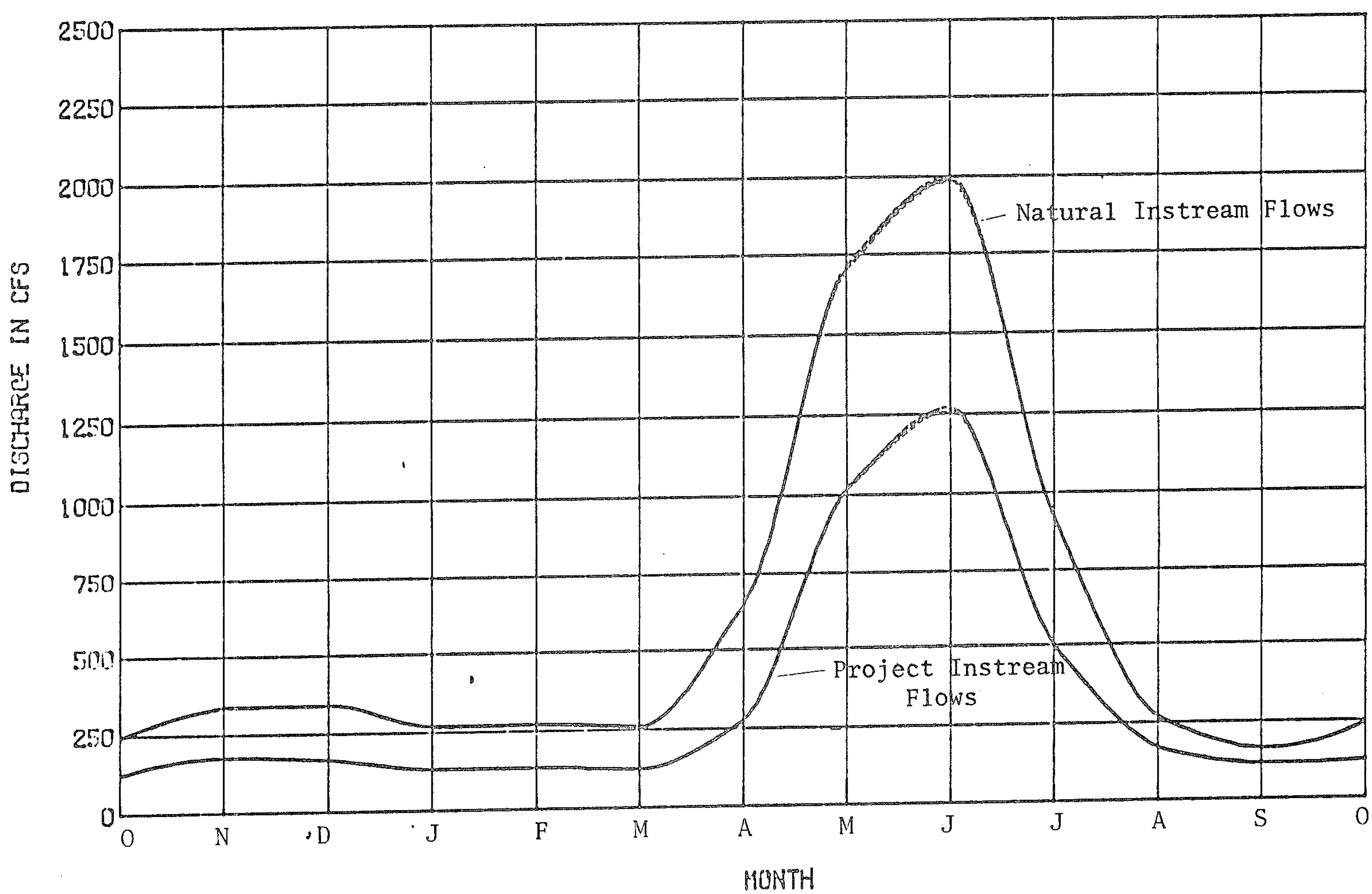


FIGURE 2. MEAN MONTHLY AND POTENTIAL PROJECT FLOWS AT ICICLE I.

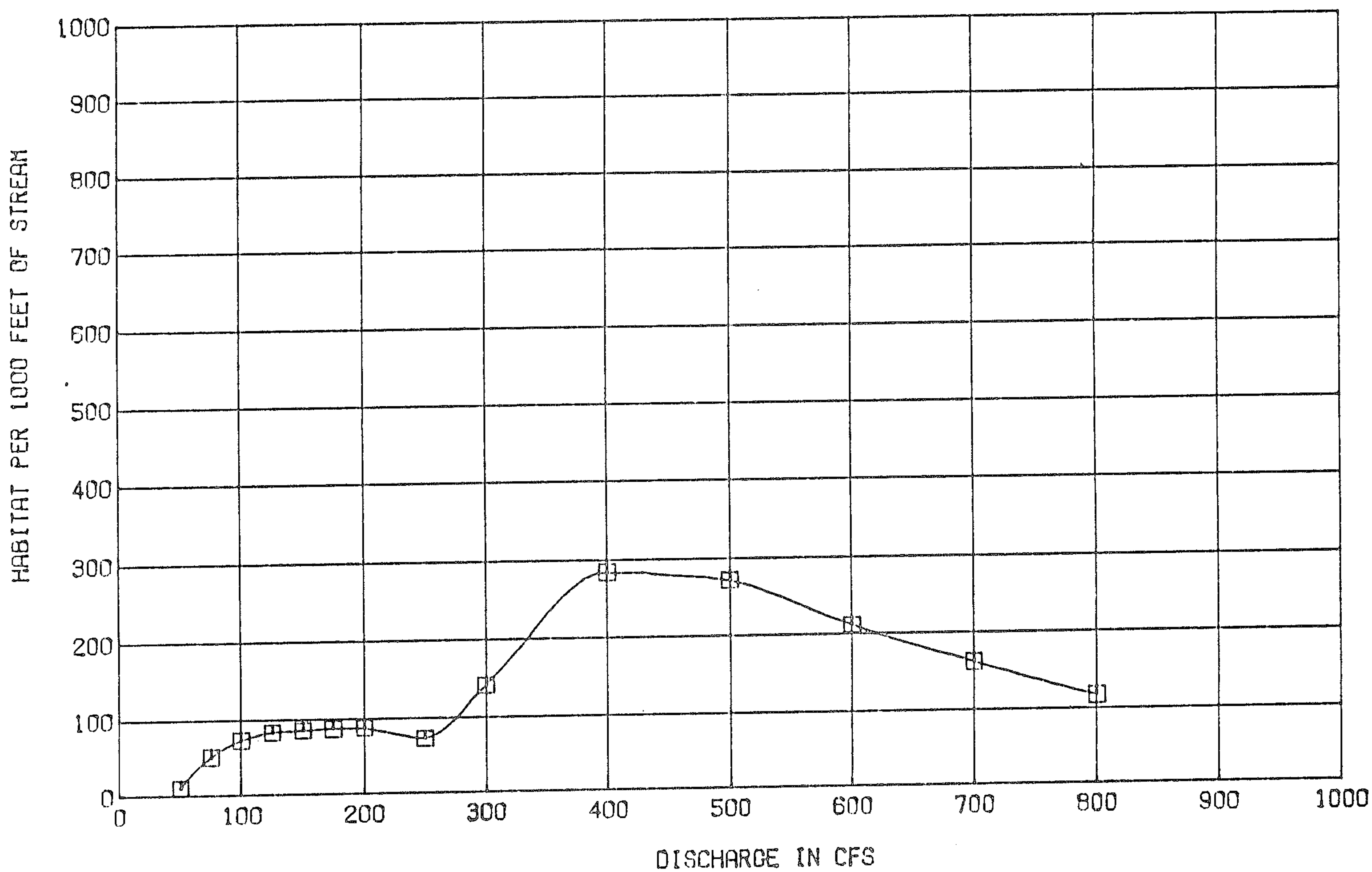


FIGURE 3. RAINBOW TROUT SPAWNING HABITAT AT ICICLE I.

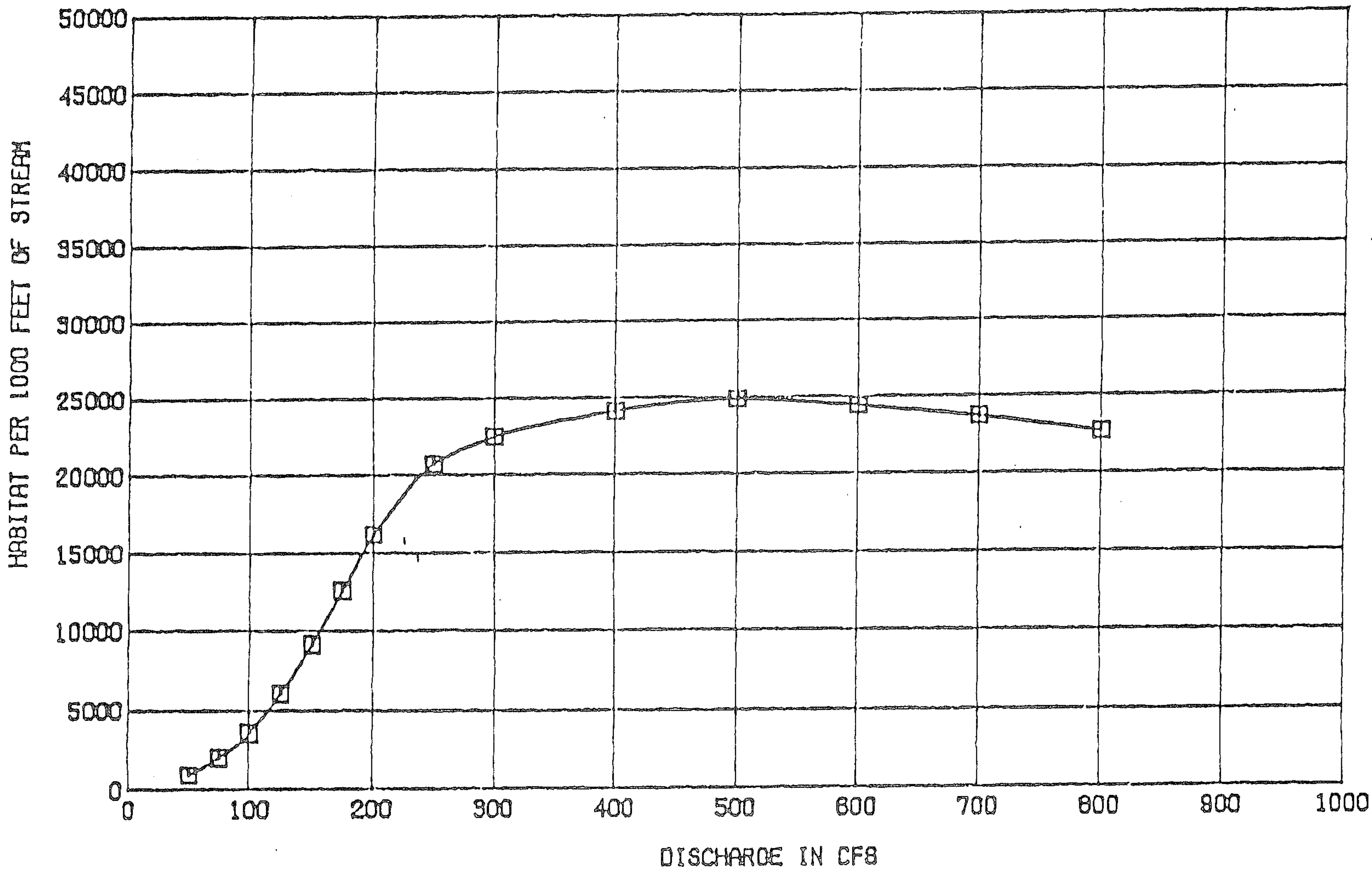


FIGURE 4. ADULT RAINBOW TROUT HABITAT AT ICICLE I.

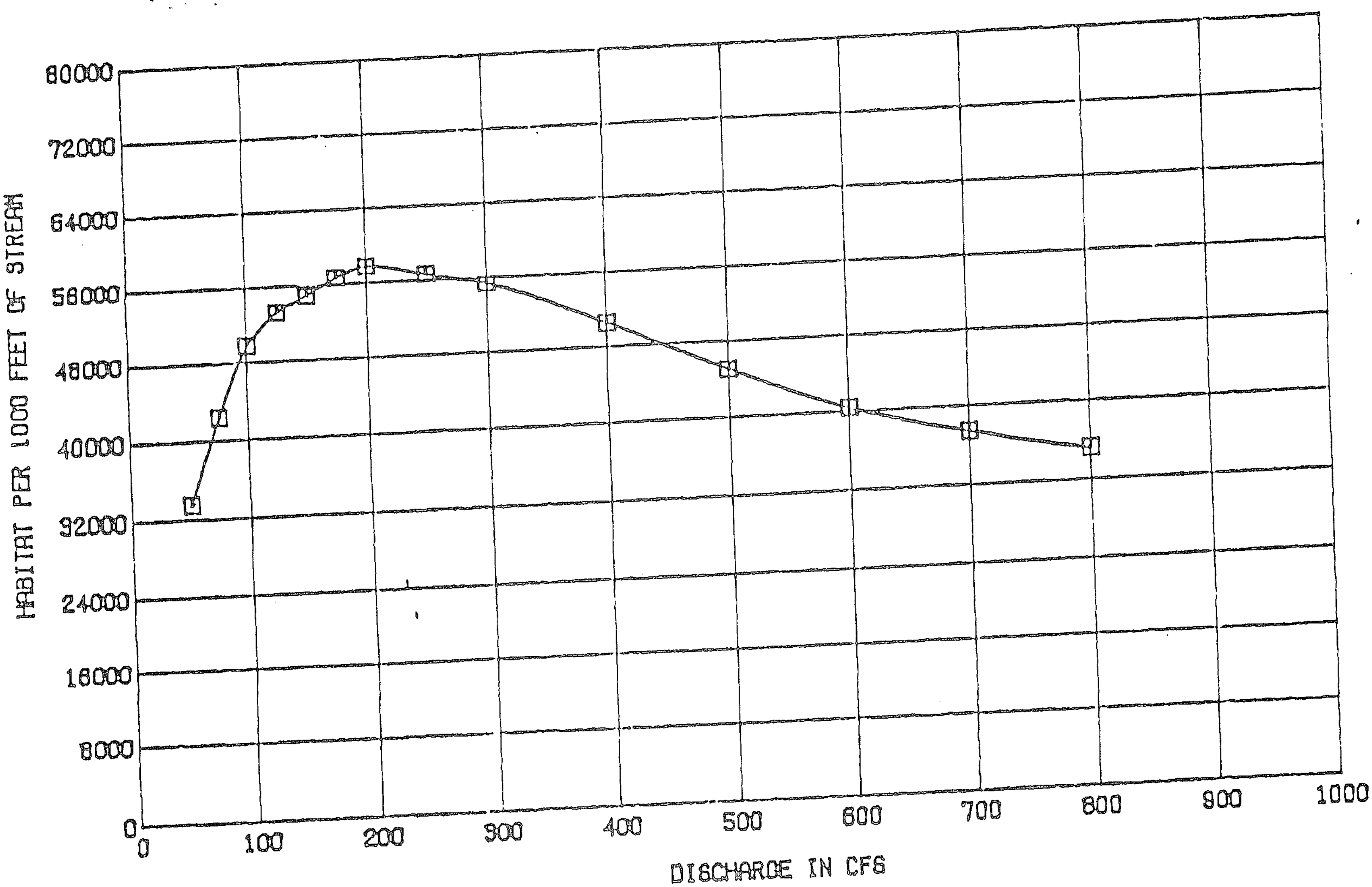


FIGURE 5. JUVENILE RAINBOW TROUT HABITAT AT ICICLE I.

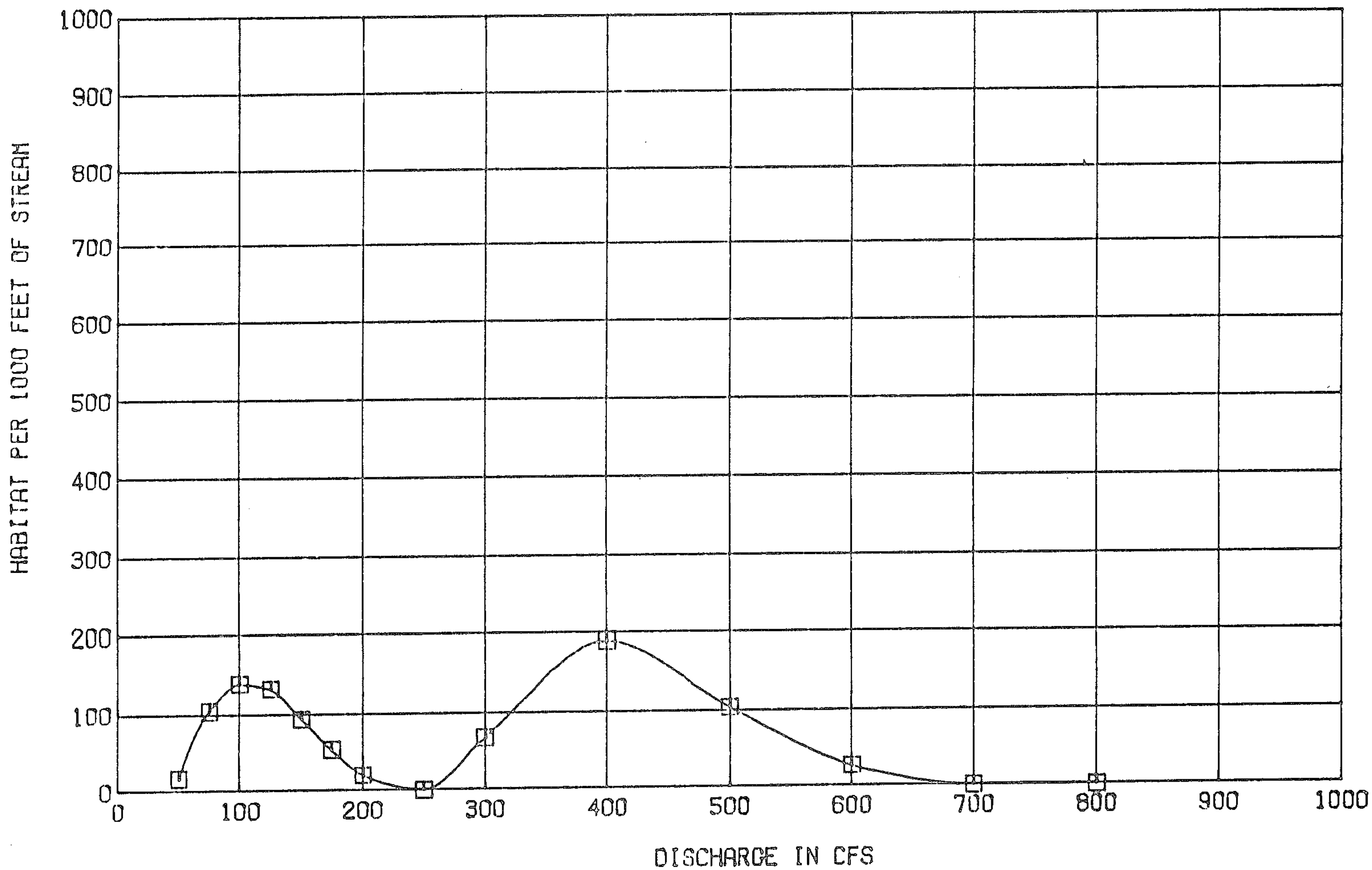


FIGURE 6. CUTTHROAT TROUT SPAWNING HABITAT AT ICICLE I.

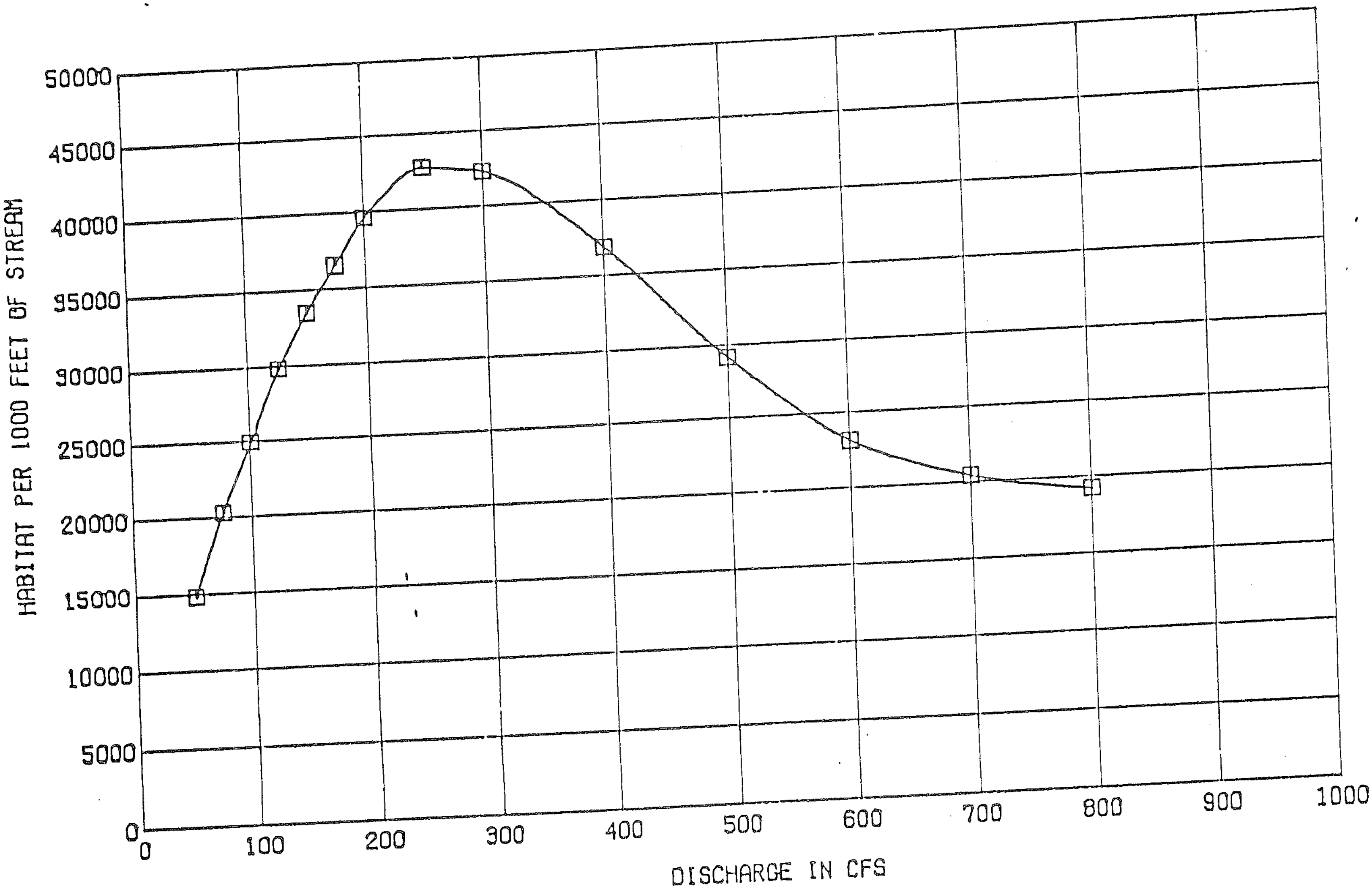


FIGURE 7. ADULT CUTTHROAT TROUT HABITAT AT ICICLE I.

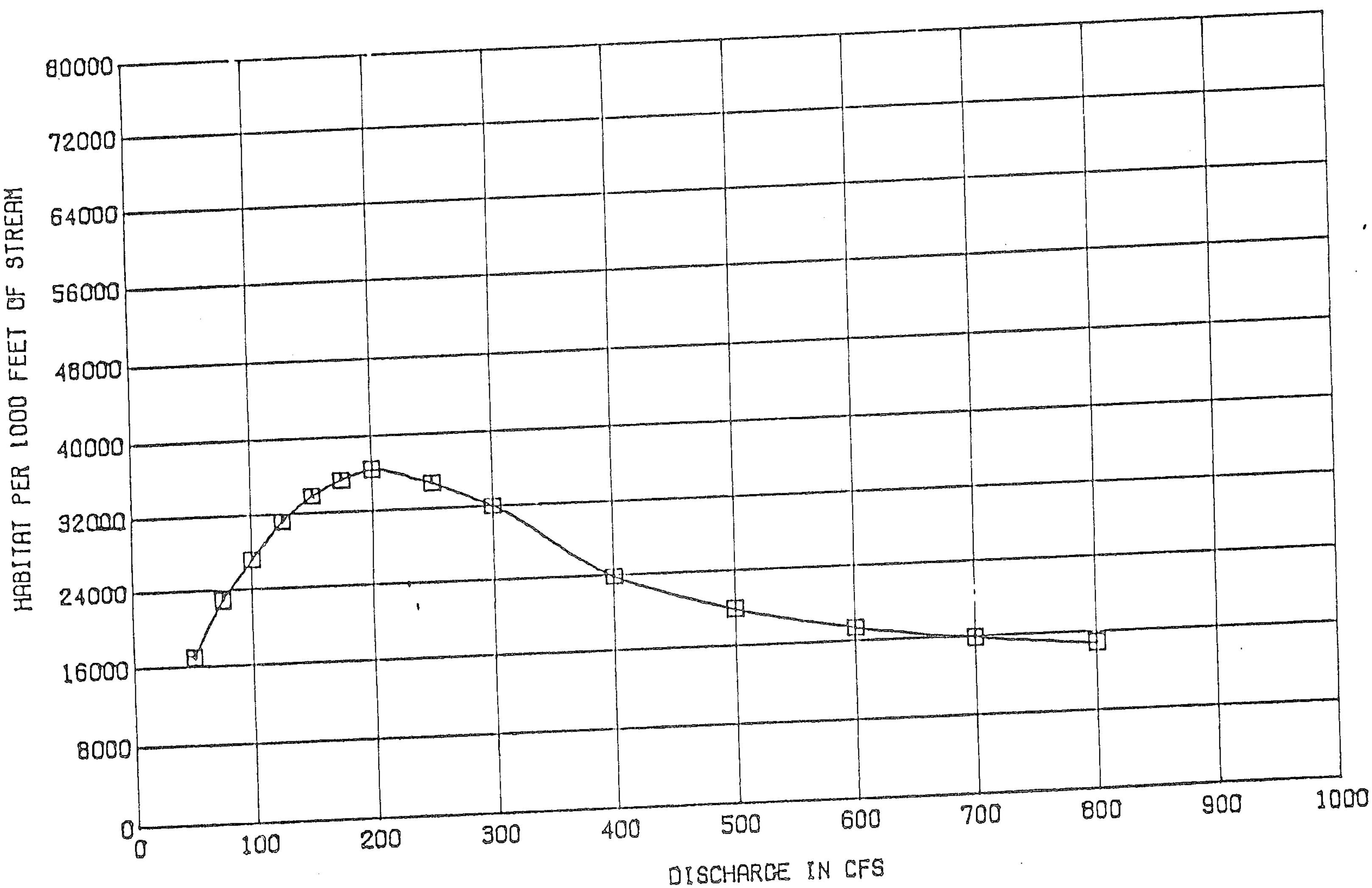


FIGURE 8. JUVENILE CUTTHROAT TROUT HABITAT AT ICICLE I.

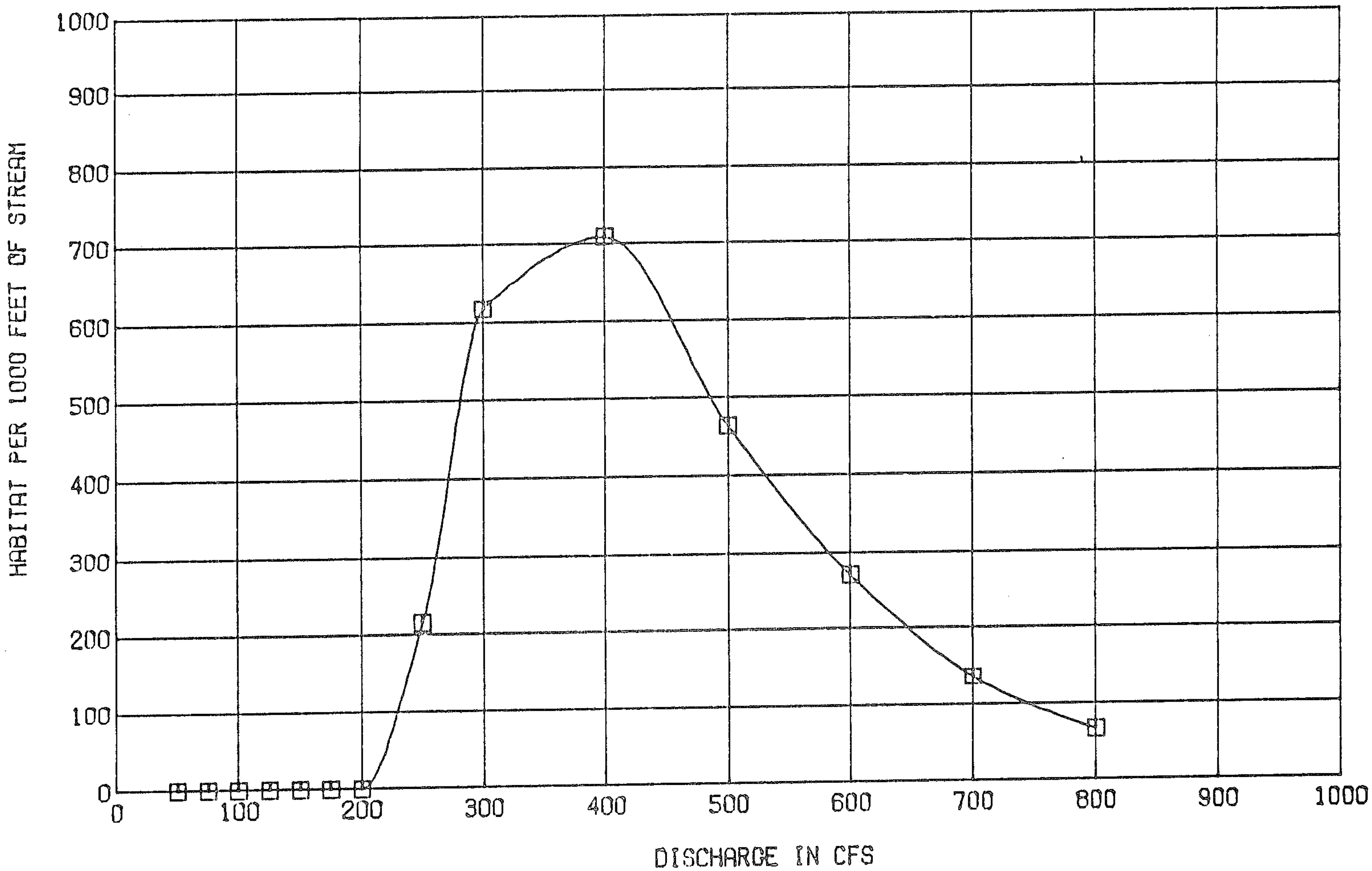


FIGURE 9. BROOK TROUT SPAWNING HABITAT AT ICICLE I.

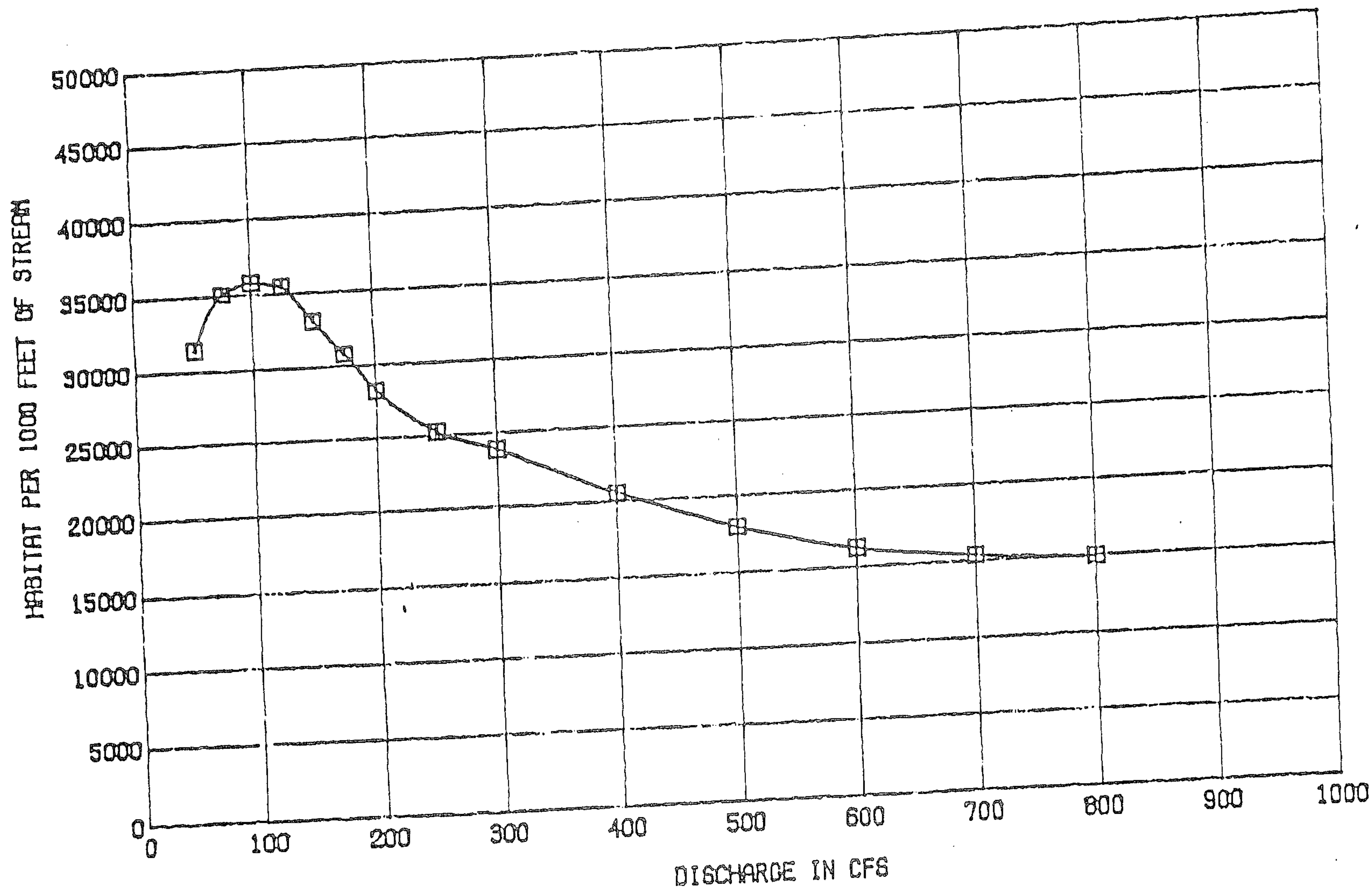


FIGURE 10. ADULT BROOK TROUT HABITAT AT ICICLE I.

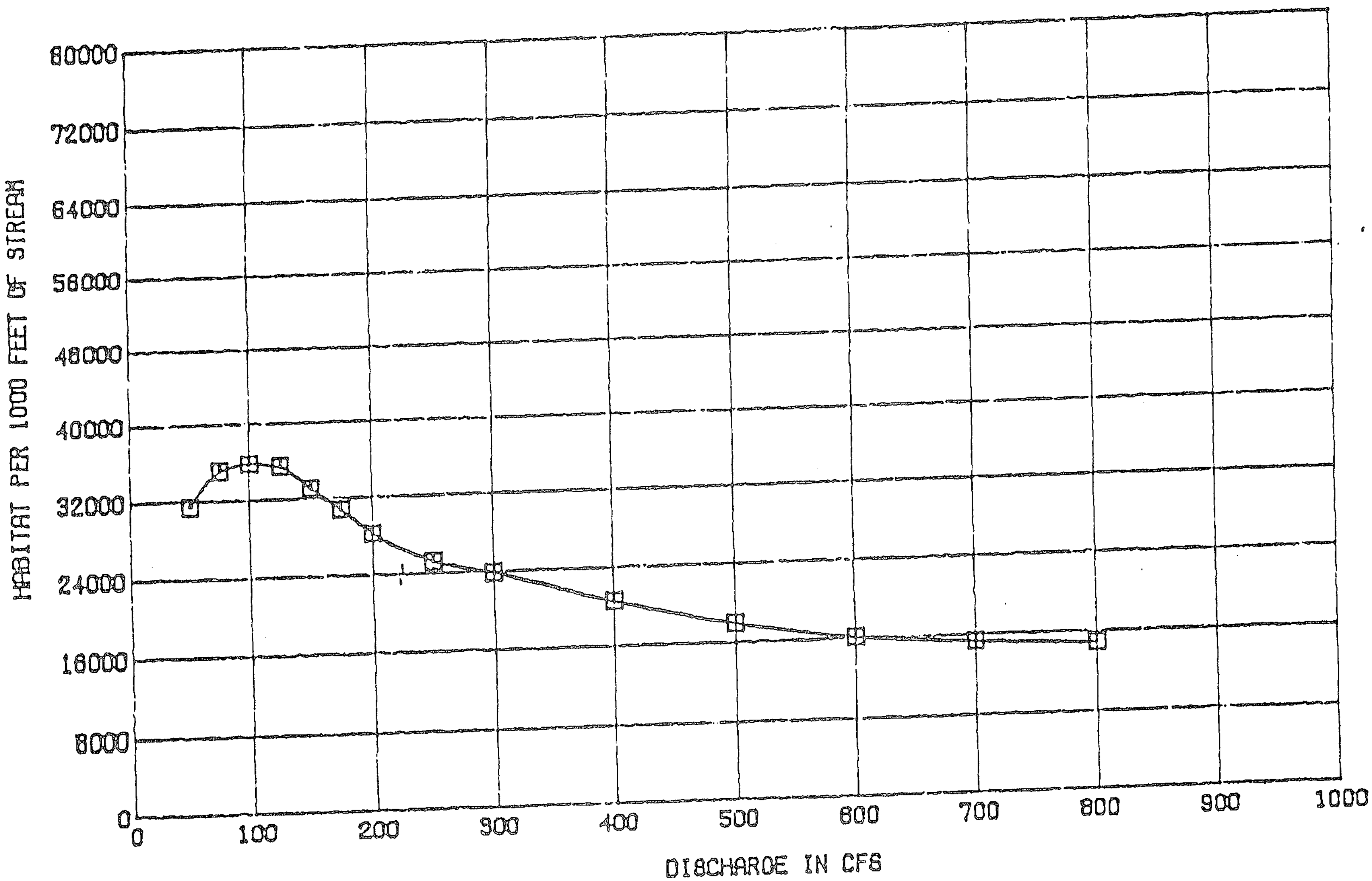


FIGURE 11. JUVENILE BROOK TROUT HABITAT AT ICICLE I.

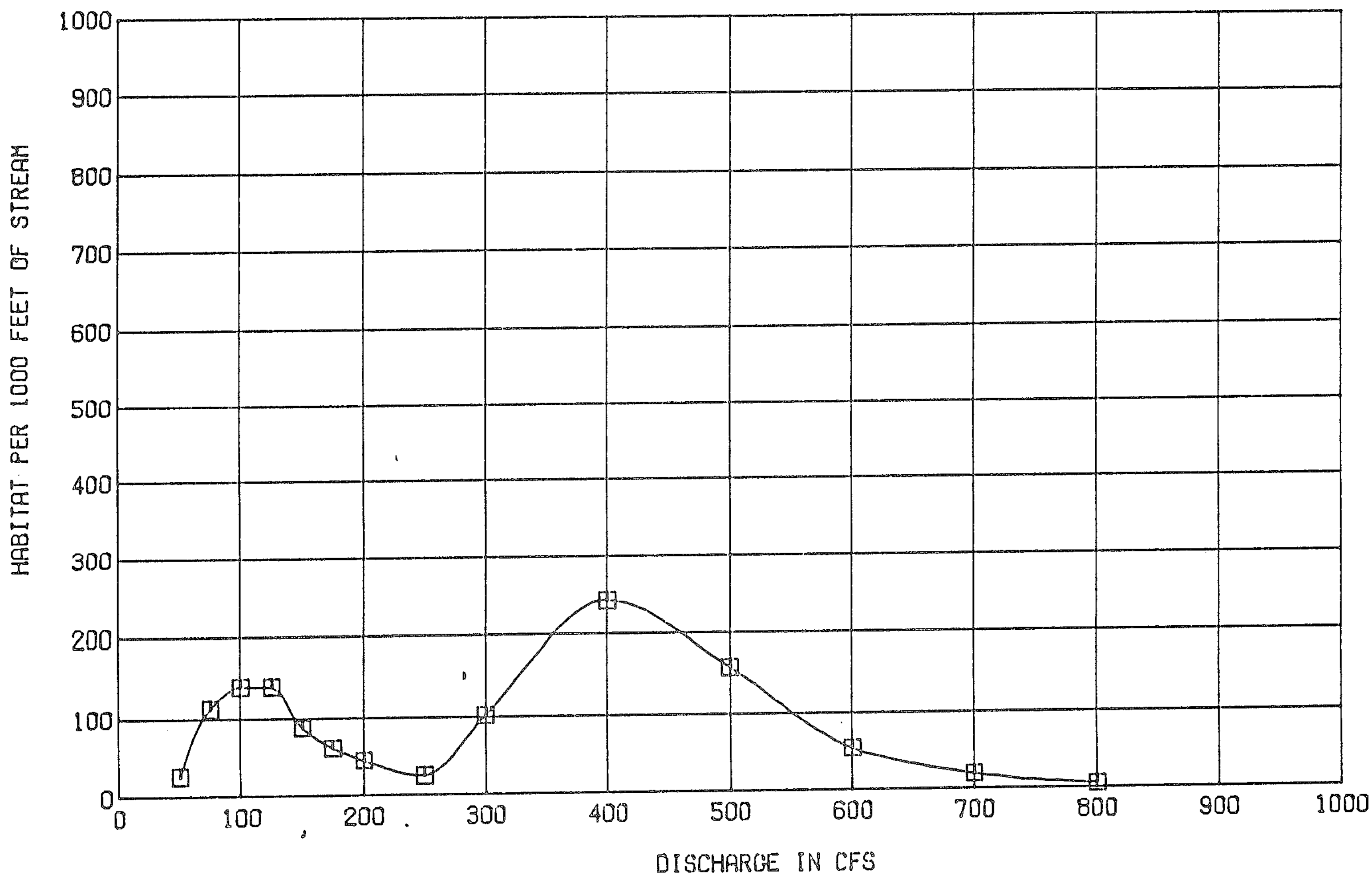


FIGURE 12. DOLLY VARDEN SPAWNING HABITAT AT ICICLE I.

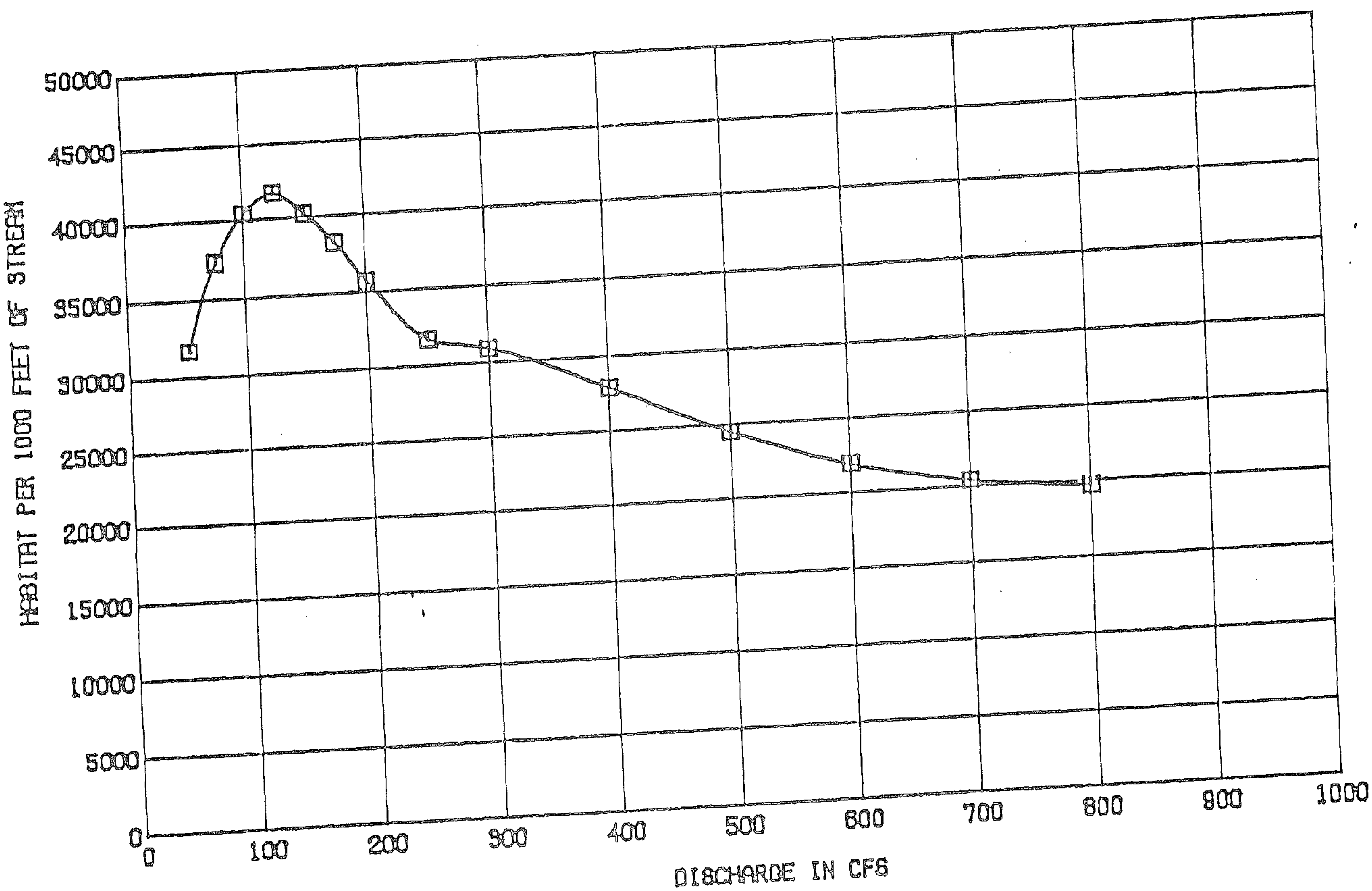


FIGURE 13. ADULT DOLLY VARDEN HABITAT AT ICICLE I.

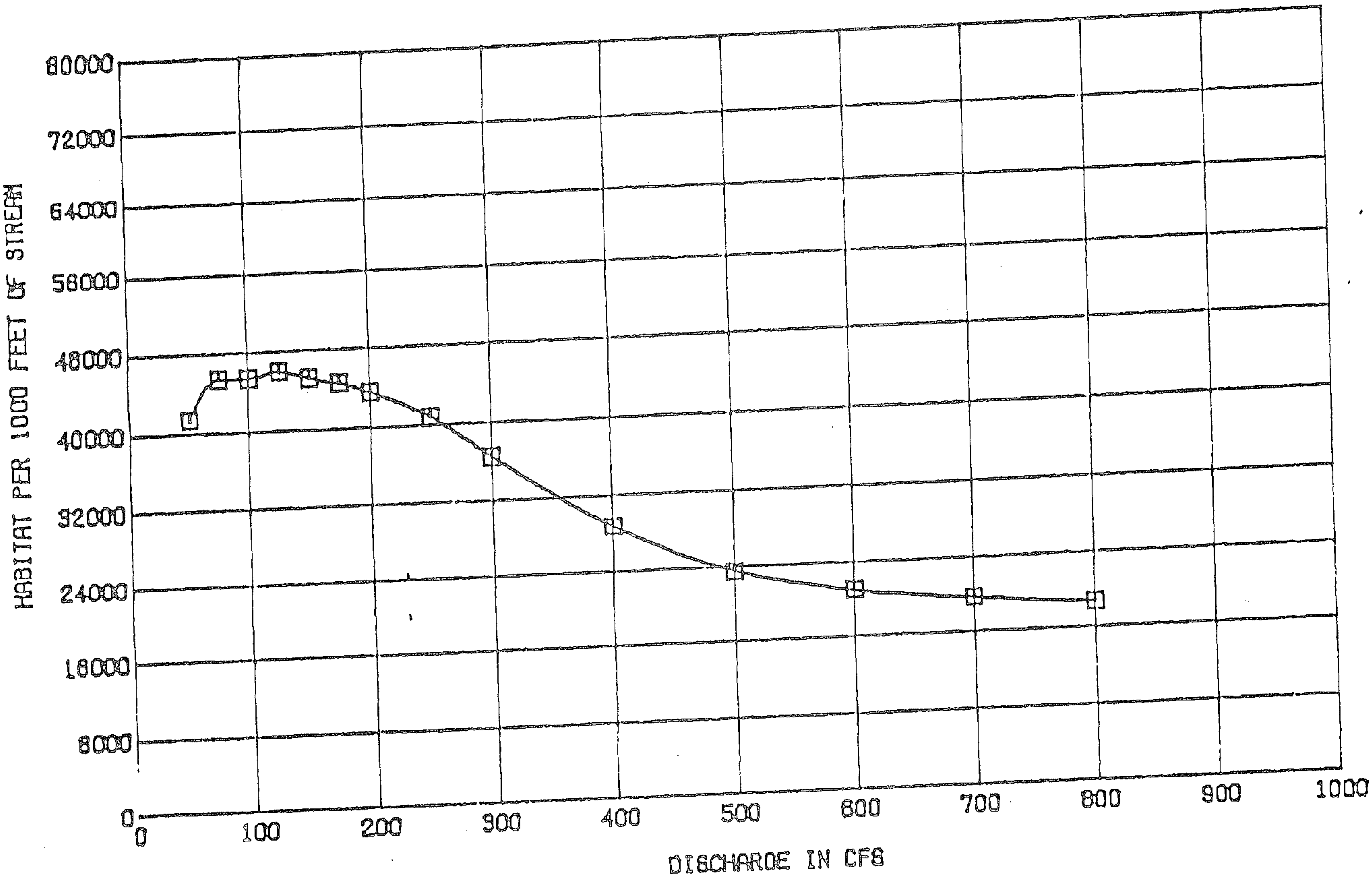


FIGURE 14. JUVENILE DOLLY VARDEN HABITAT AT ICICLE I.

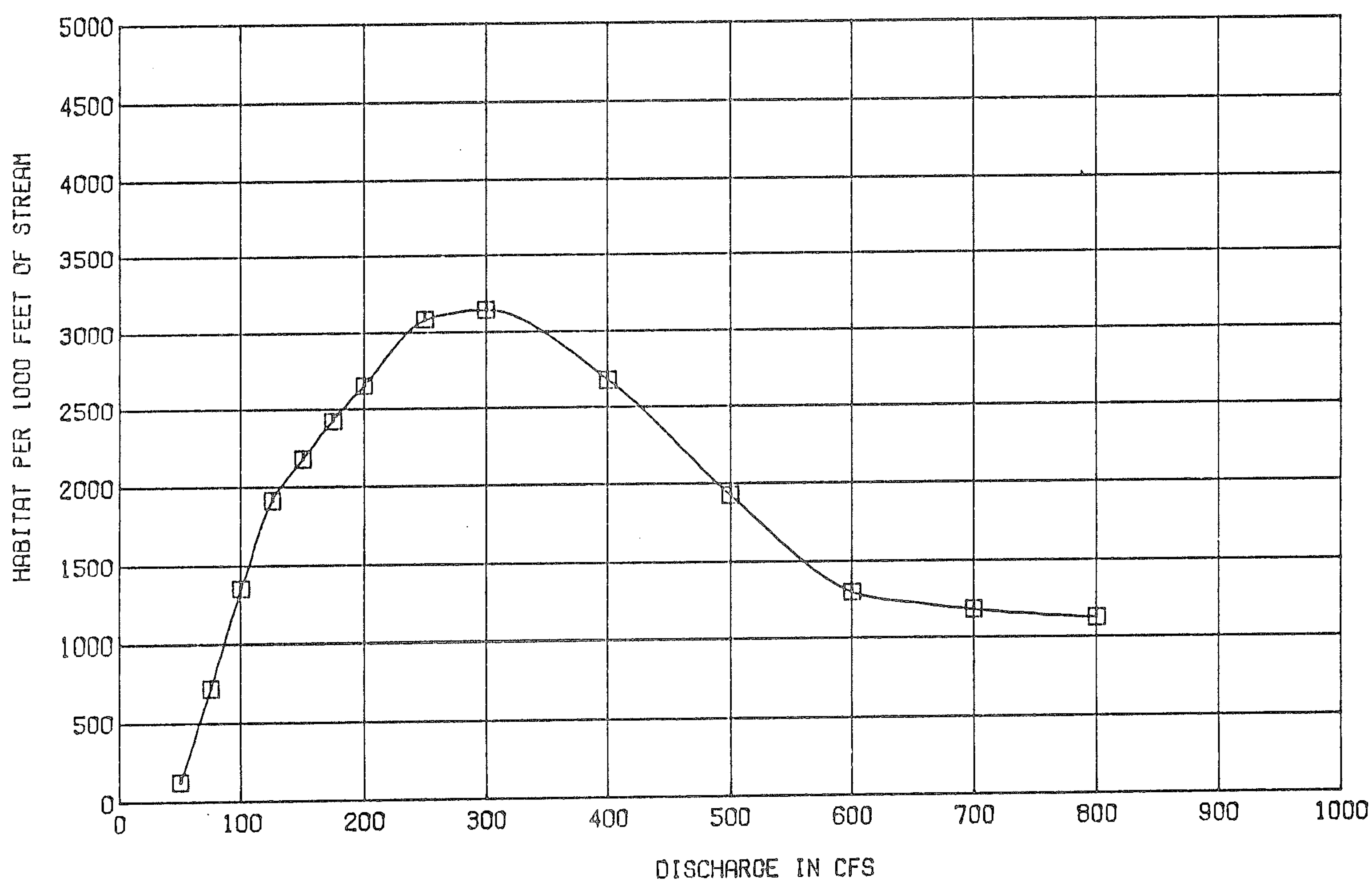


FIGURE 15. MOUNTAIN WHITEFISH SPAWNING HABITAT AT ICICLE I.

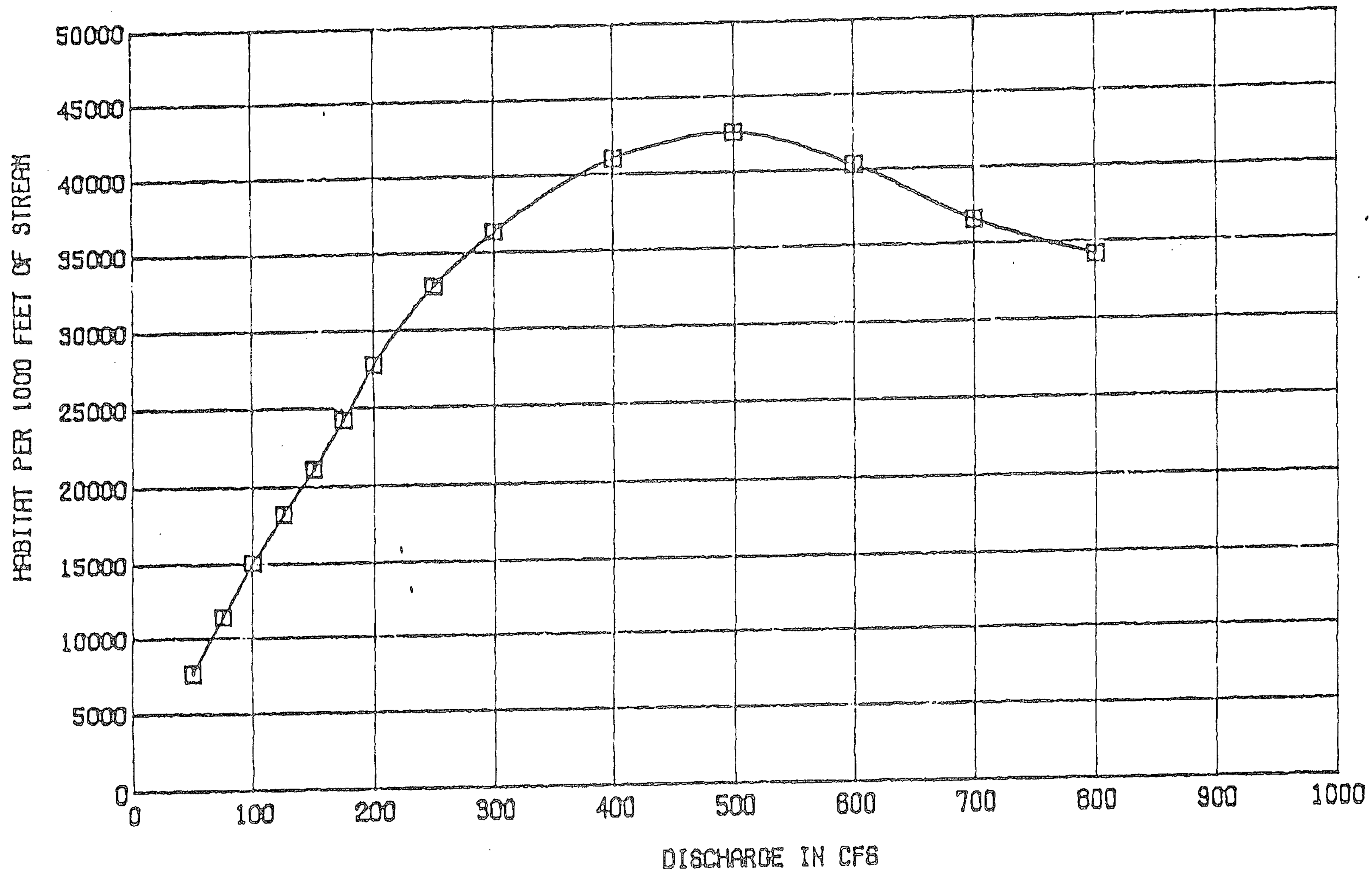


FIGURE 16. ADULT MOUNTAIN WHITEFISH HABTTAT AT ICICLE I.

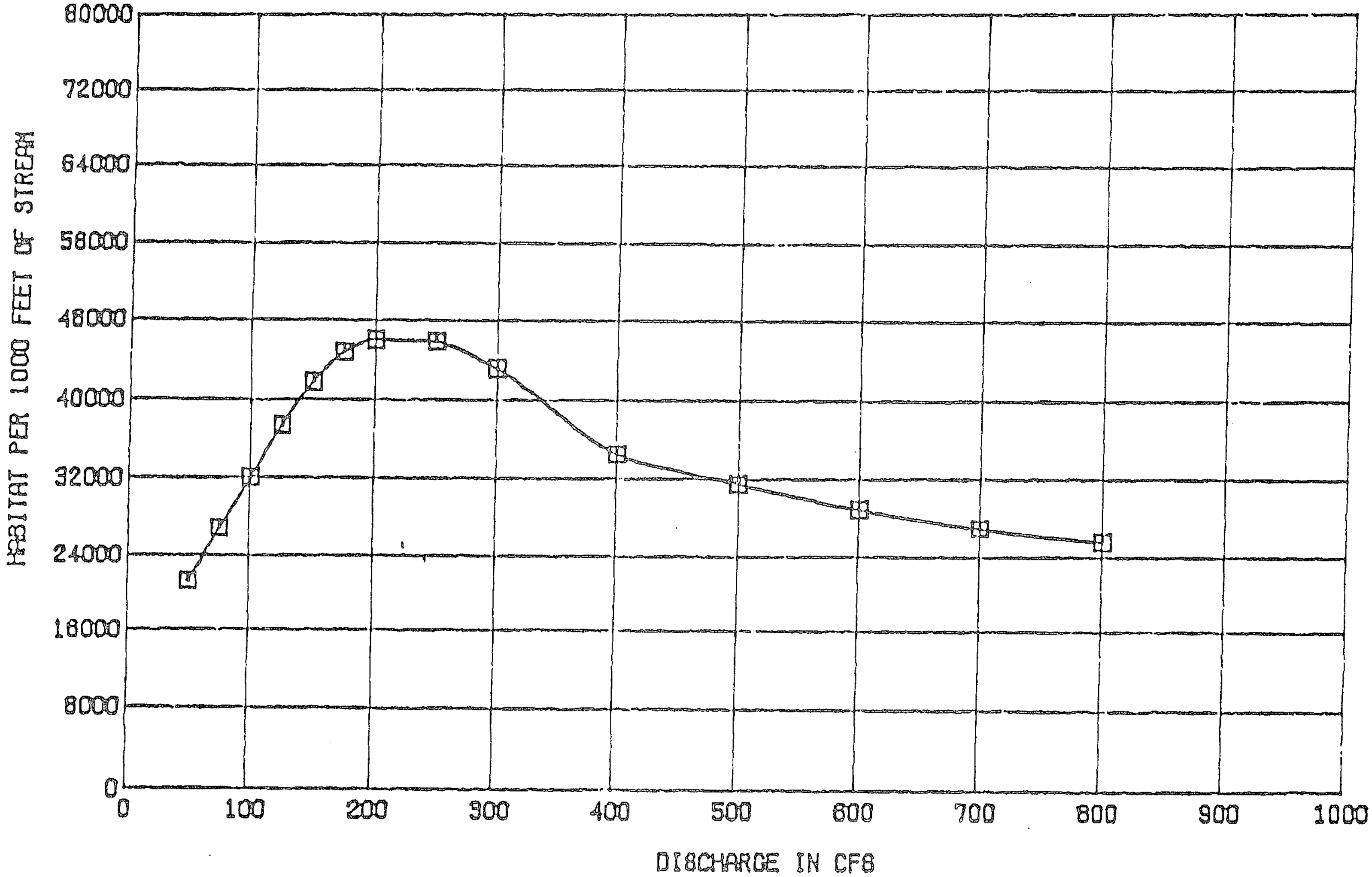


FIGURE 17. JUVENILE MOUNTAIN WHITEFISH HABITAT AT ICICLE I.

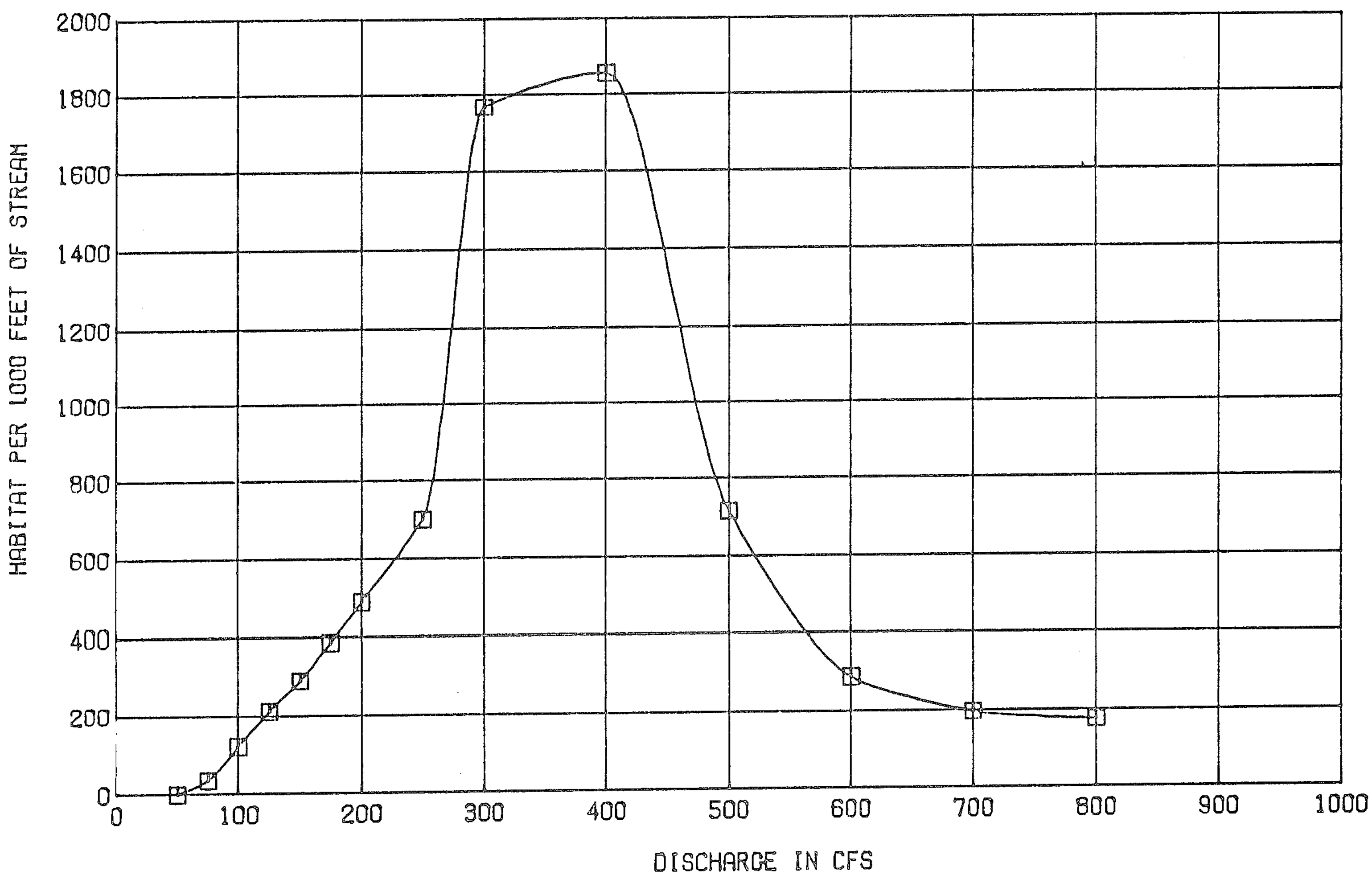


FIGURE 18. STEELHEAD SPAWNING HABITAT AT ICICLE I.

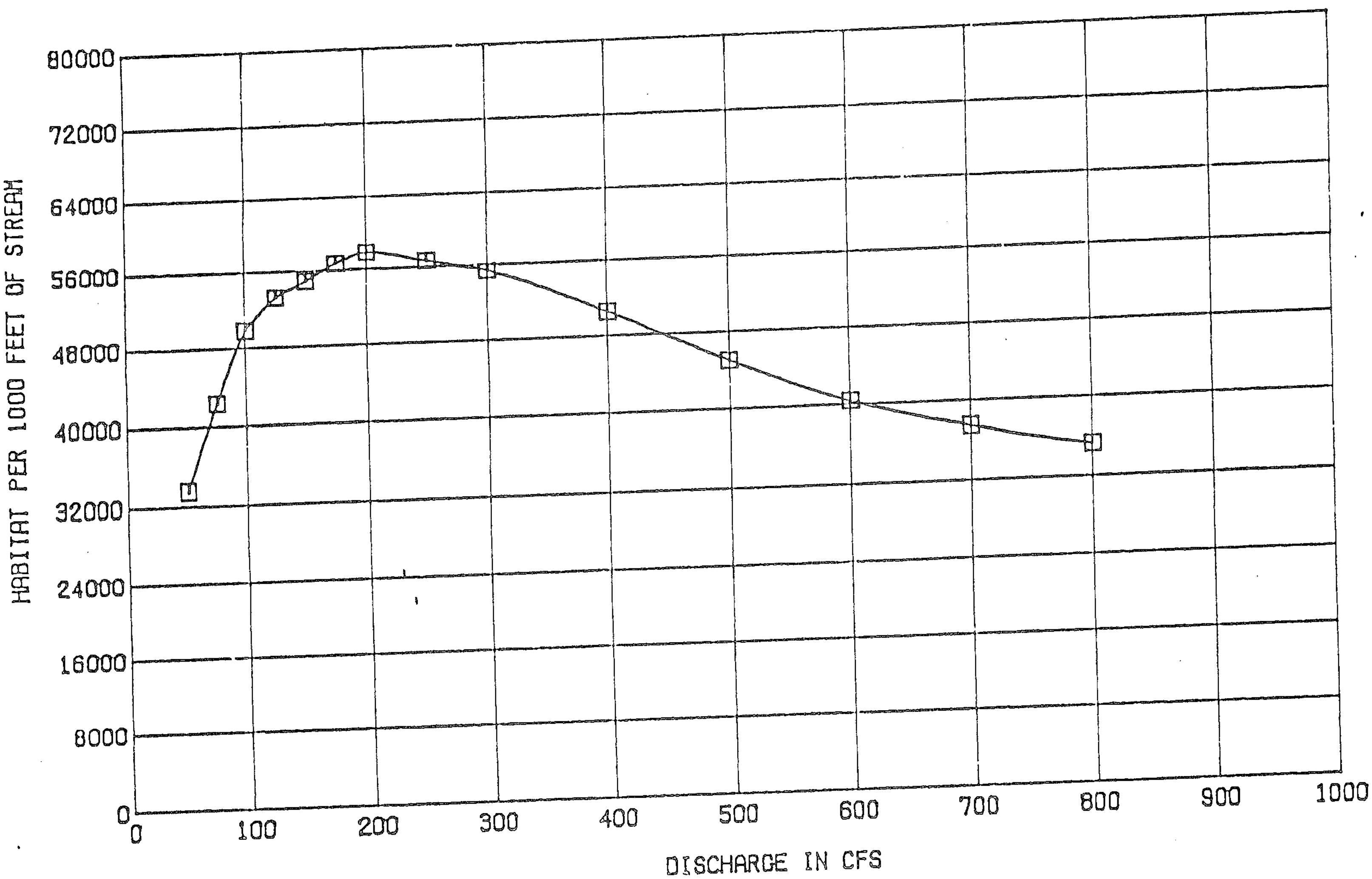


FIGURE 19. JUVENILE STEELHEAD HABITAT AT ICICLE I.

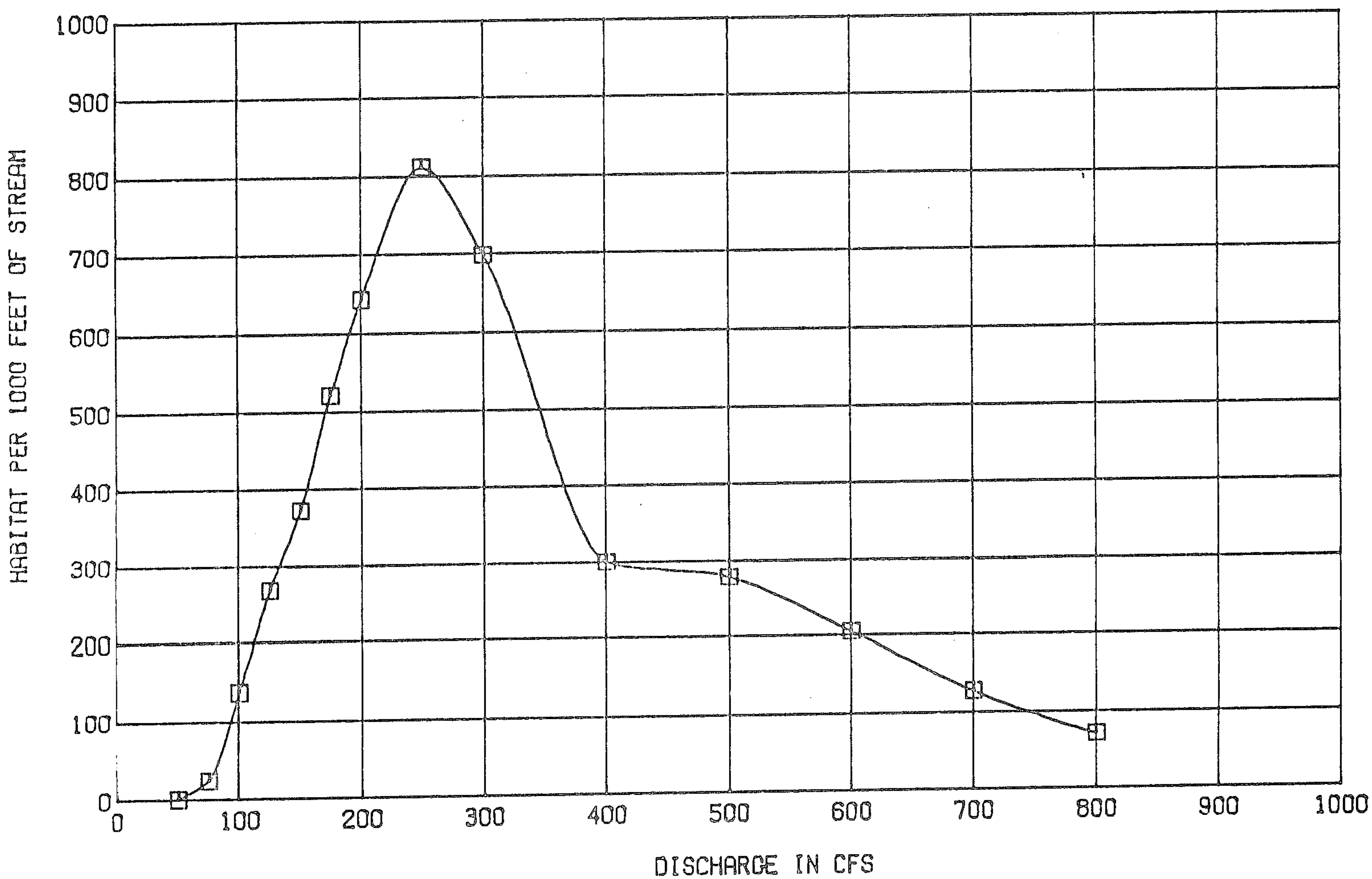


FIGURE 20. SPRING CHINOOK SPAWNING HABITAT AT ICICLE I.

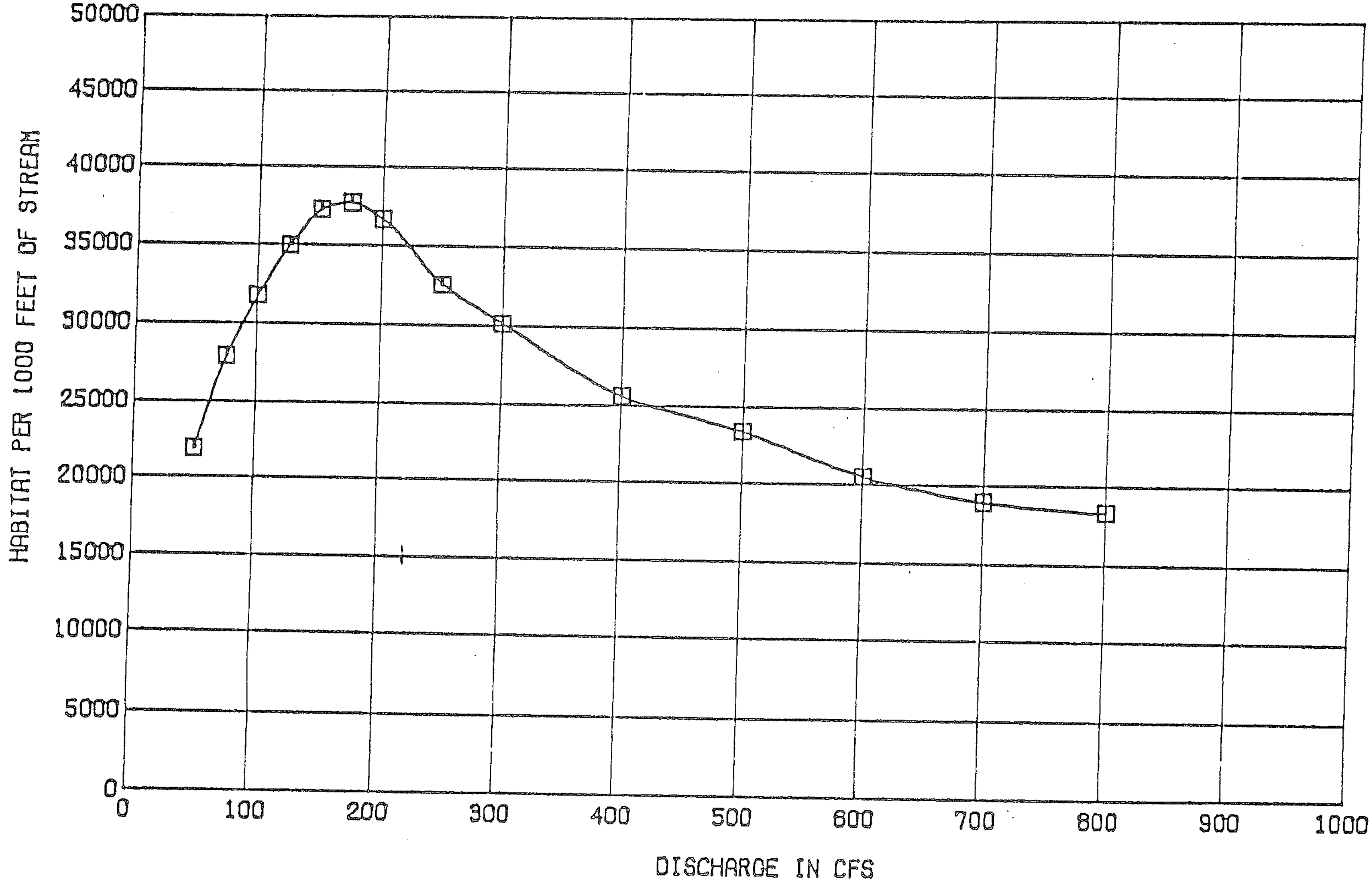


FIGURE 21. JUVENILE SPRING CHINOOK HABITAT AT ICICLE I.

Table 4. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Rainbow Trout at Icicle I.

Discharge	Habitat Spawning	Habitat Adult	Habitat Juvenile
50	11	976	33553
75	51	2073	42288
100	73	3615	49732
125	83	6045	53189
150	85	9116	54838
175	86	12552	56676
200	87	16186	57775 *
250	73	20732	56662
300	141	22487	55341
400	283 *	24071	50520
500	271	24832 *	44974
600	211	24396	40383
700	161	23662	37460
800	116	22678	35256

*Maximum

Table 5. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Cutthroat Trout at Icicle I.

Discharge	Habitat Spawning	Habitat Adult	Habitat Juvenile
50	17	14835	17008
75	104	20323	22866
100	138	24949	27227
125	132	29793	31229
150	93	33483	33878
175	53	36554	35452
200	20	39580	36465 *
250	0	42720 *	34754
300	67	42261	32046
400	190 *	36828	23816
500	103	29124	19917
600	27	23156	17439
700	0	20465	15887
800	0	19207	14871

*Maximum

Table 6. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Brook Trout at Icicle I.

Discharge	Habitat		
	Spawning	Adult	Juvenile
50	0	31448	31448
75	0	35083	35083
100	0	35815 *	35815 *
125	0	35478	35478
150	0	33040	33040
175	0	30794	30794
200	0	28196	28196
250	215	25211	25211
300	617	23864	23864
400	709 *	20619	20619
500	464	18009	18009
600	271	16218	16218
700	136	15360	15360
800	66	14925	14925

*Maximum

Table 7. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Dolly Varden (bull trout) at Icicle I.

Discharge	Habitat		
	Spawning	Adult	Juvenile
50	26	31726	41355
75	112	37352	45338
100	138	40399	45328
125	138	41642 *	45958 *
150	87	40220	45783
175	61	38213	44575
200	45	35708	43525
250	25	31685	40779
300	101	30926	33567
400	243 *	27859	28766
500	157	24506	23516
600	54	21941	21015
700	19	20428	19666
800	6	19703	18763

*Maximum

Table 8. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Mountain Whitefish at Icicle I.

Discharge	Habitat: Spawning	Habitat: Adult	Habitat: Juvenile
50	126	7659	21237
75	719	11472	26790
100	1350	15067	32114
125	1914	18182	37488
150	2179	21126	41748
175	2423	24230	44680
200	2649	27756	45937 *
250	3083	32852	45750
300	3145 *	36328	43058
400	2677	41015	34616
500	1925	42583 *	31535
600	1302	40311	29993
700	1182	36551	26980
800	1125	34178	25599

*Maximum

Table 9. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Steelhead Trout at Icicle I.

Discharge	Habitat: Spawning	Habitat: Juvenile
50	0	33553
75	35	42288
100	121	49743
125	210	53189
150	290	54838
175	385	56676
200	487	57775 *
250	699	56662
300	1766	55341
400	1854 *	50520
500	714	44974
600	288	40383
700	196	37460
800	174	35256

*Maximum

Table 10. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Spring Chinook Salmon at Icicle I.

Discharge	Habitat: Spawning	Habitat: Juvenile
50	0	21898
75	1	27860
100	6	31747
125	12	34949
150	17	37239
175	27	37679 *
200	35	36632
250	44	32544
300	39	30107
400	36	25615
500	82	23389
600	99 *	20540
700	86	18953
800	57	18363

*Maximum

I C I C L E   II

ICICLE II

Icicle II was established as a speciality reach to demonstrate potential spawning habitat at various flows. It consists of one transect crossing an area of apparently suitable size substrate for steelhead spawning. The width of the transect is 149 feet and the length of the area it models is approximately 354 feet. Measurements were taken at 347, 188, and 129 cfs. Velocity adjustment factors are shown in Table 11. Natural and potential project flows are shown graphically in Figure 22.

Table 11. Velocity Adjustment Factors For Icicle II.

Discharge	Velocity Adjustment Factor
50	.960
75	.988
100	.994
125	1.002
150	1.005
175	1.008
200	1.010
250	1.008
300	1.001
400	.981
500	.955
600	.924
700	.889
800	.853

Figures 23 through 29 demonstrate the amount of spawning habitat at different flows for the various species. Table 12 shows this same data in tabular form. It is evident that considerable spawning habitat exists for each species except brook trout. Spawning habitat is greatest for steelhead, spring chinook, and whitefish although substantial potential exists for rainbow, cutthroat, and Dolly Varden. Because of the extended spawing period of fish in the spring, the effects of the potential project are hard to pinpoint. Rainbow, cutthroat, and steelhead spawning in March might be negatively impacted by reduced project flows while fish spawning during the freshet months of April, May, and June might benefit from the reduction of the runoff peak.

Fall spawning fish such as Dolly Varden, whitefish, and spring chinook would suffer significant losses of spawning habitat under the potential project flows.

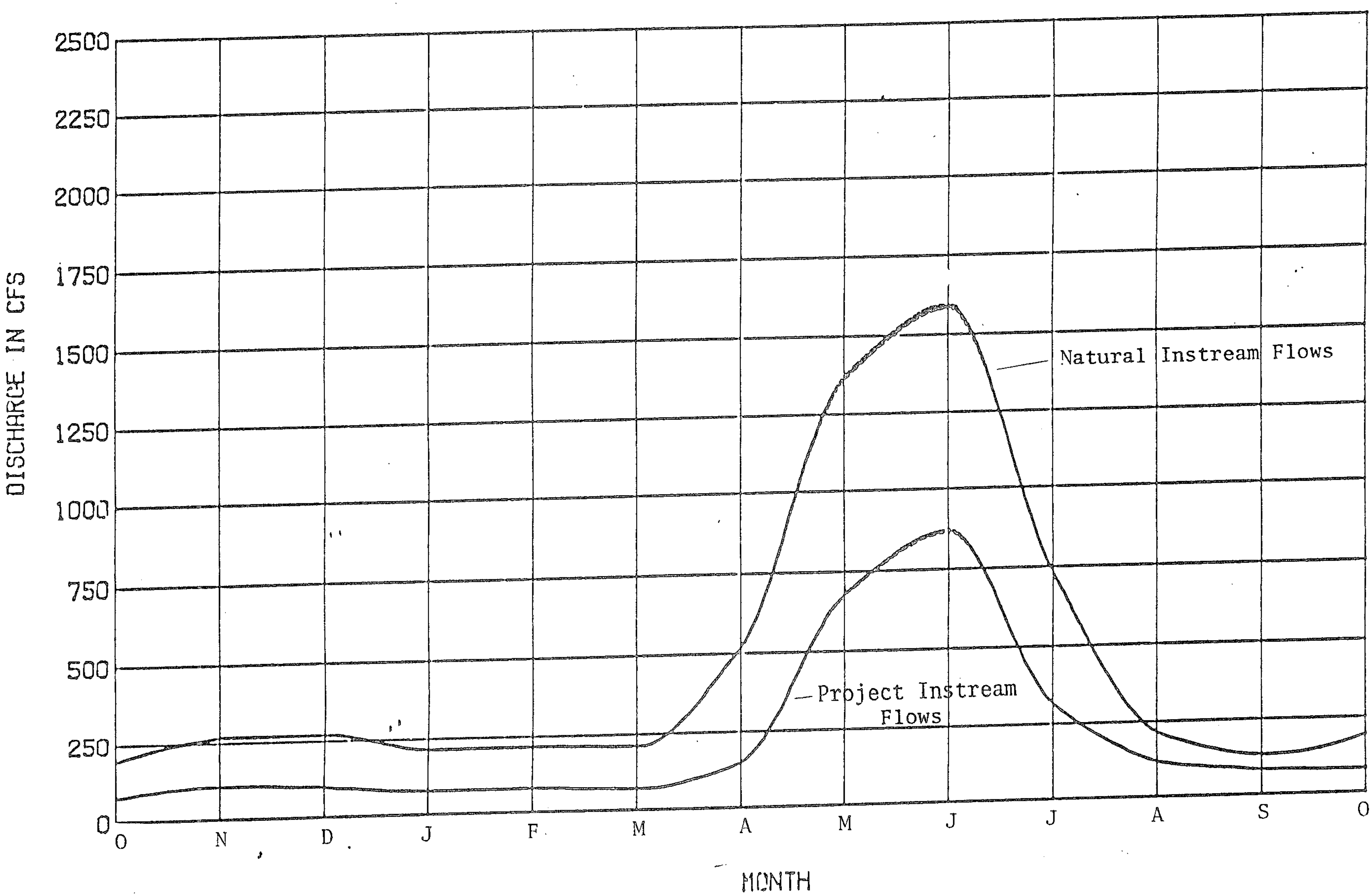


FIGURE 22. MEAN MONTHLY AND POTENTIAL PROJECT FLOWS AT ICICLE II.

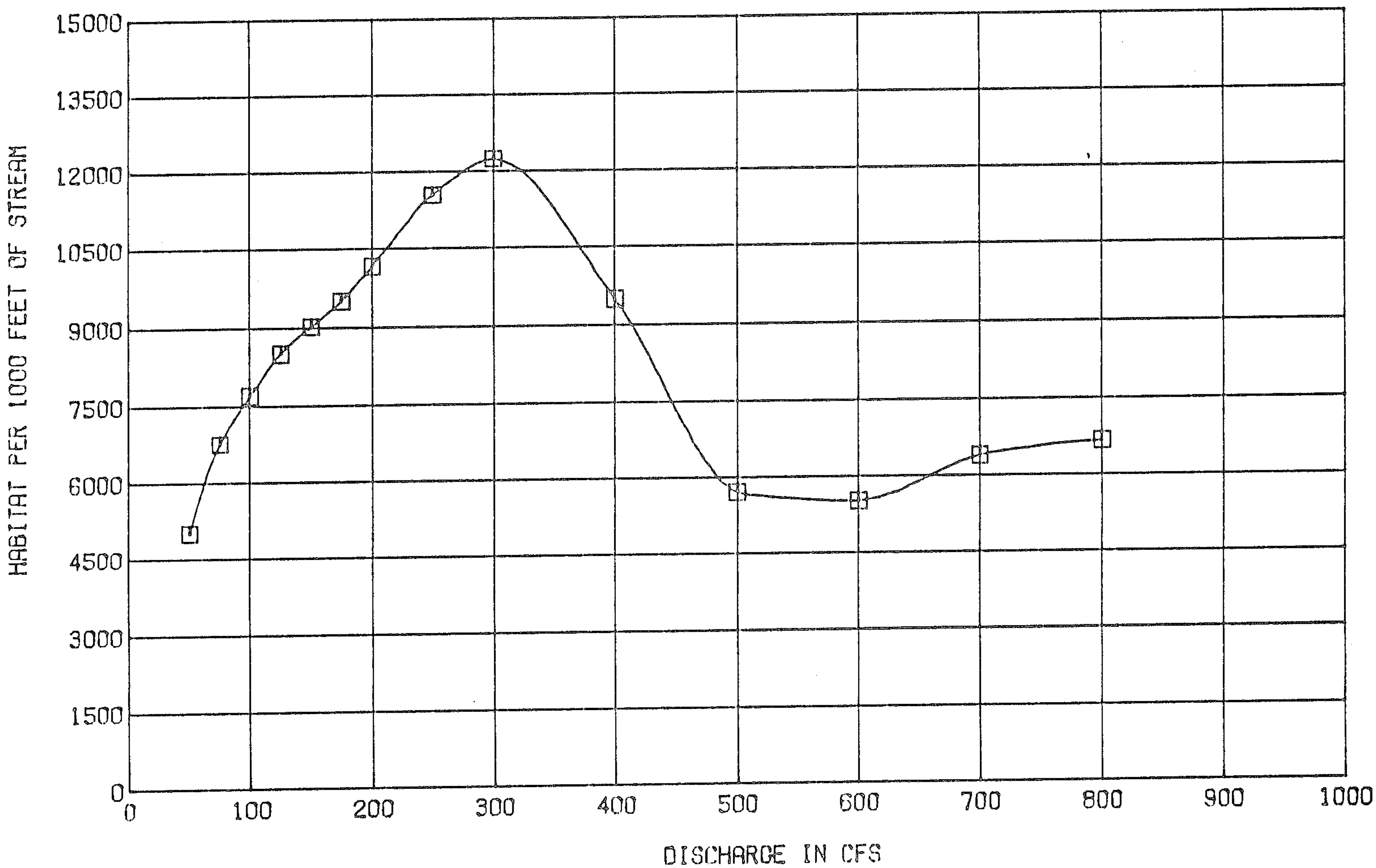


FIGURE 23. RAINBOW TROUT SPAWNING HABITAT AT ICICLE II.

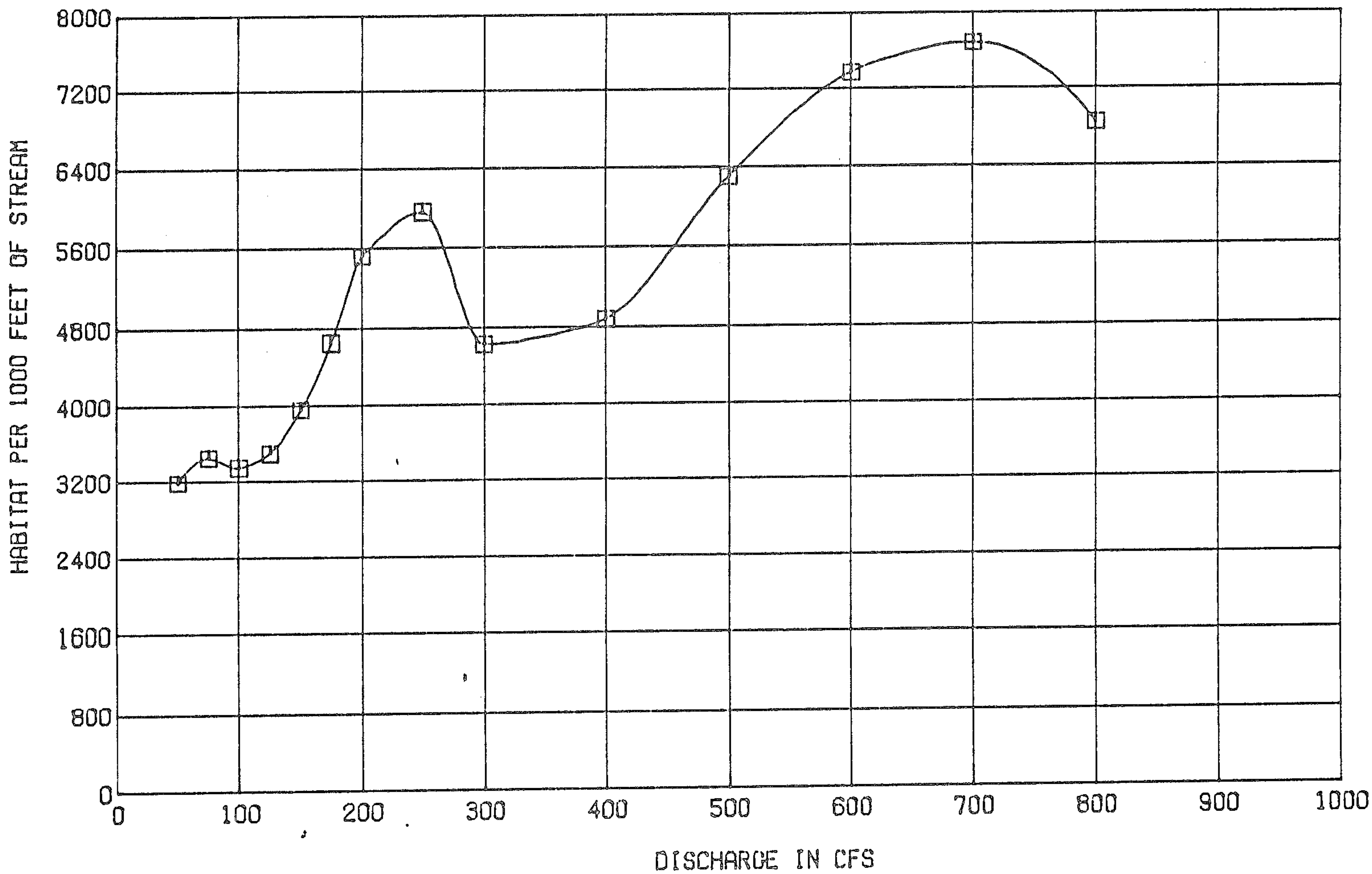


FIGURE 24. CUTTHROAT TROUT SPAWNING HABITAT AT ICICLE II.

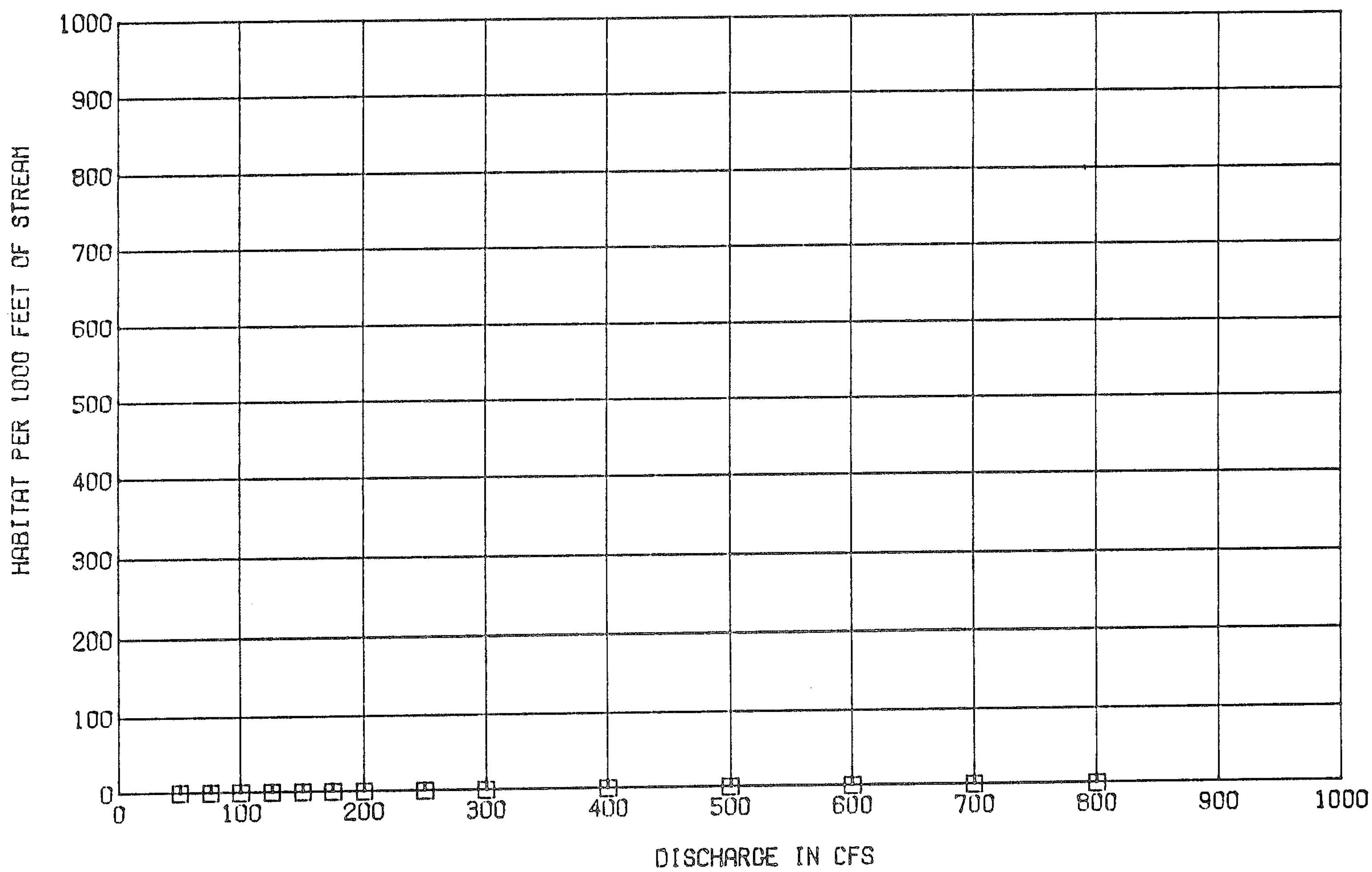


FIGURE 25. BROOK TROUT SPAWNING HABITAT AT ICICLE II.

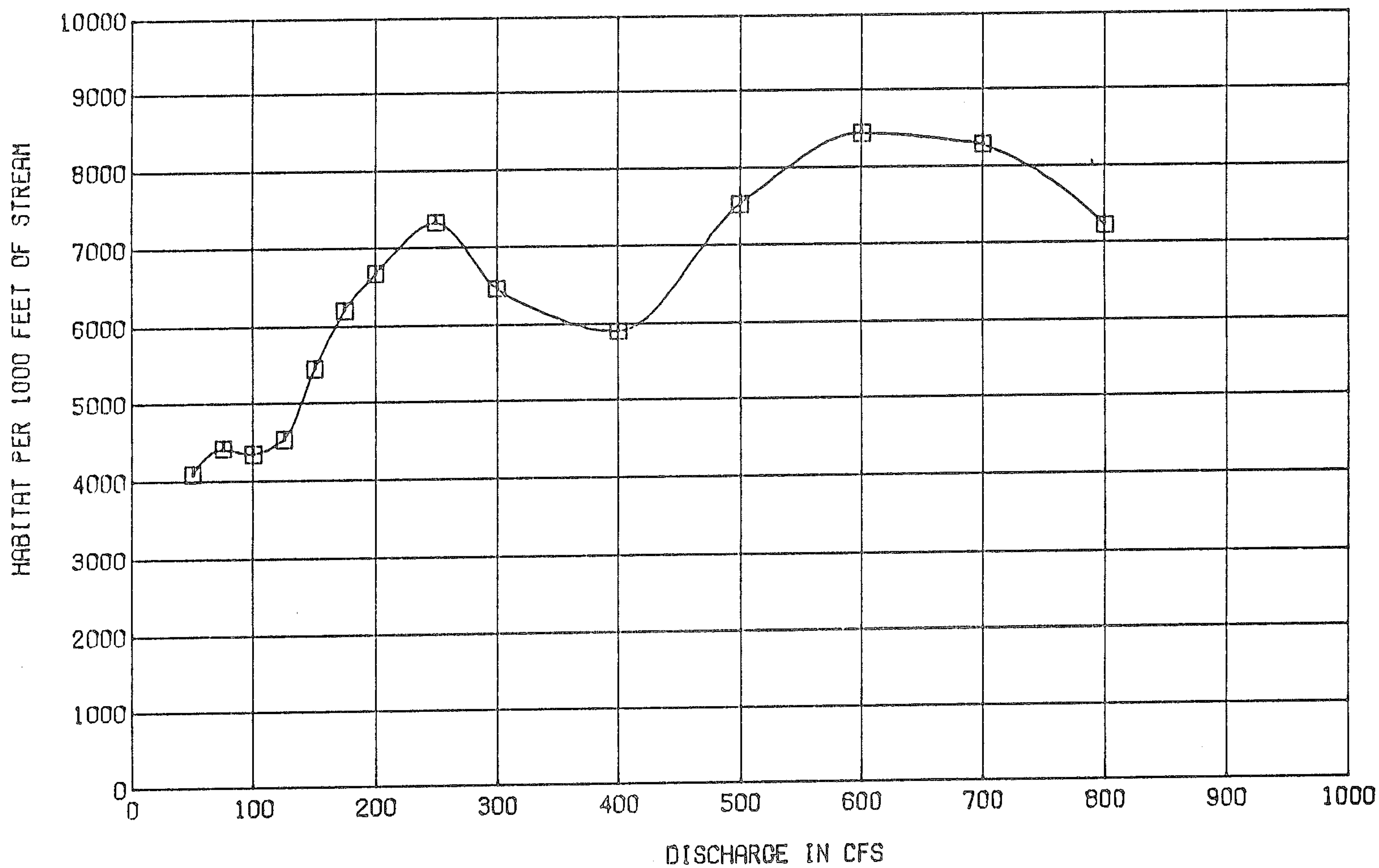


FIGURE 26. DOLLY VARDEN SPAWNING HABITAT AT ICICLE II.

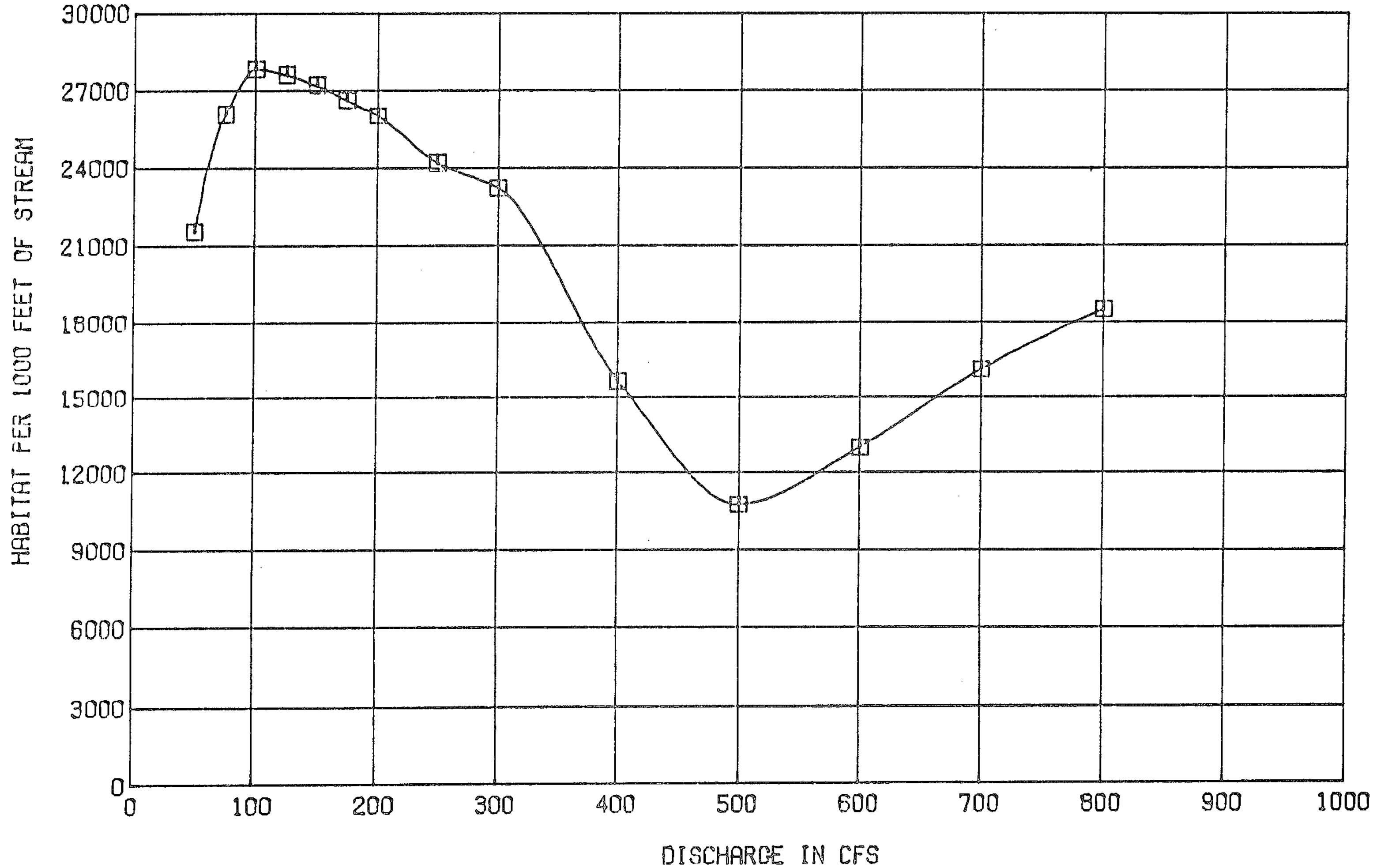


FIGURE 27. MOUNTAIN WHITEFISH SPAWNING HABITAT AT ICICLE II.

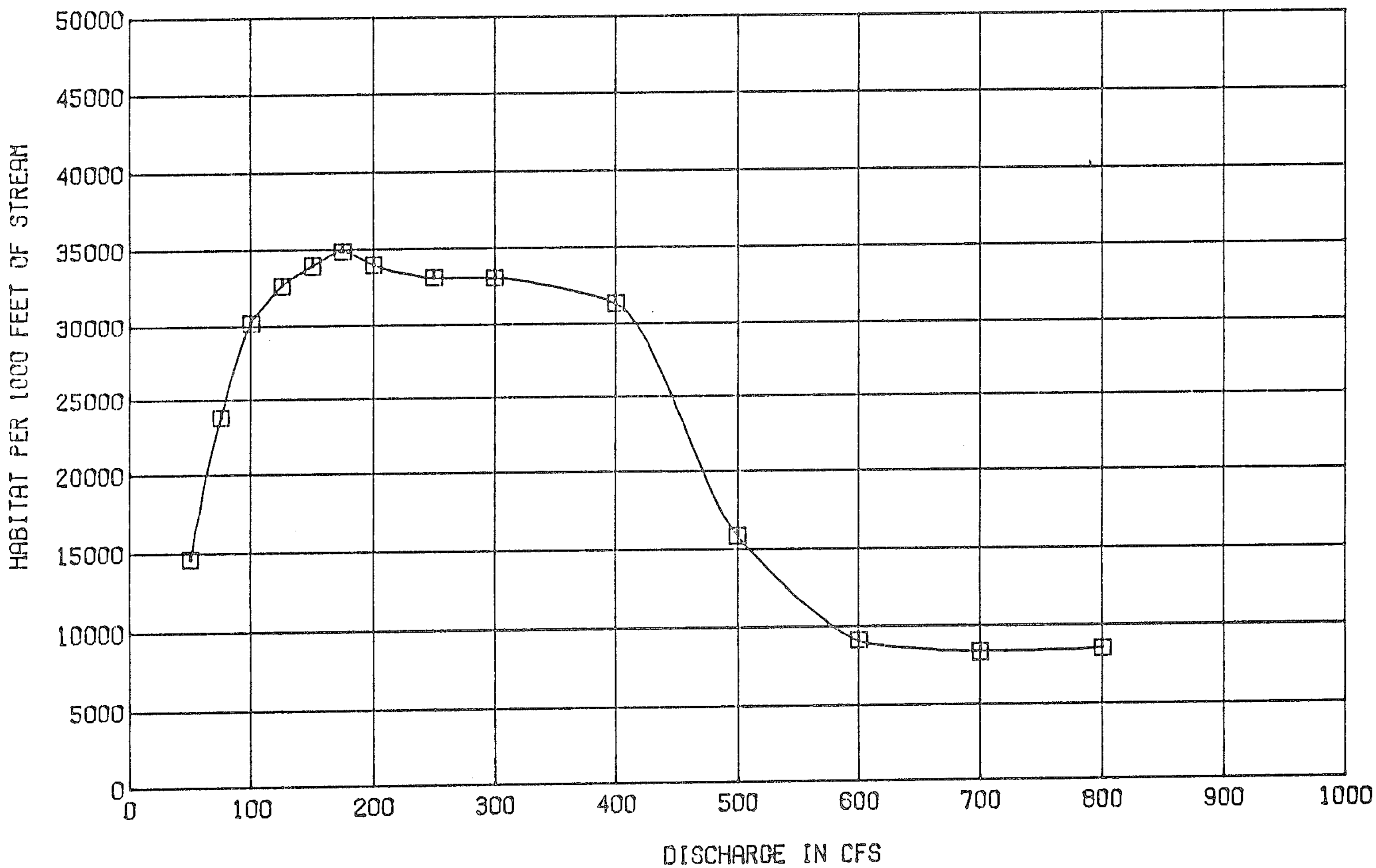


FIGURE 28. STEELHEAD TROUT SPAWNING HABITAT AT ICICLE II.

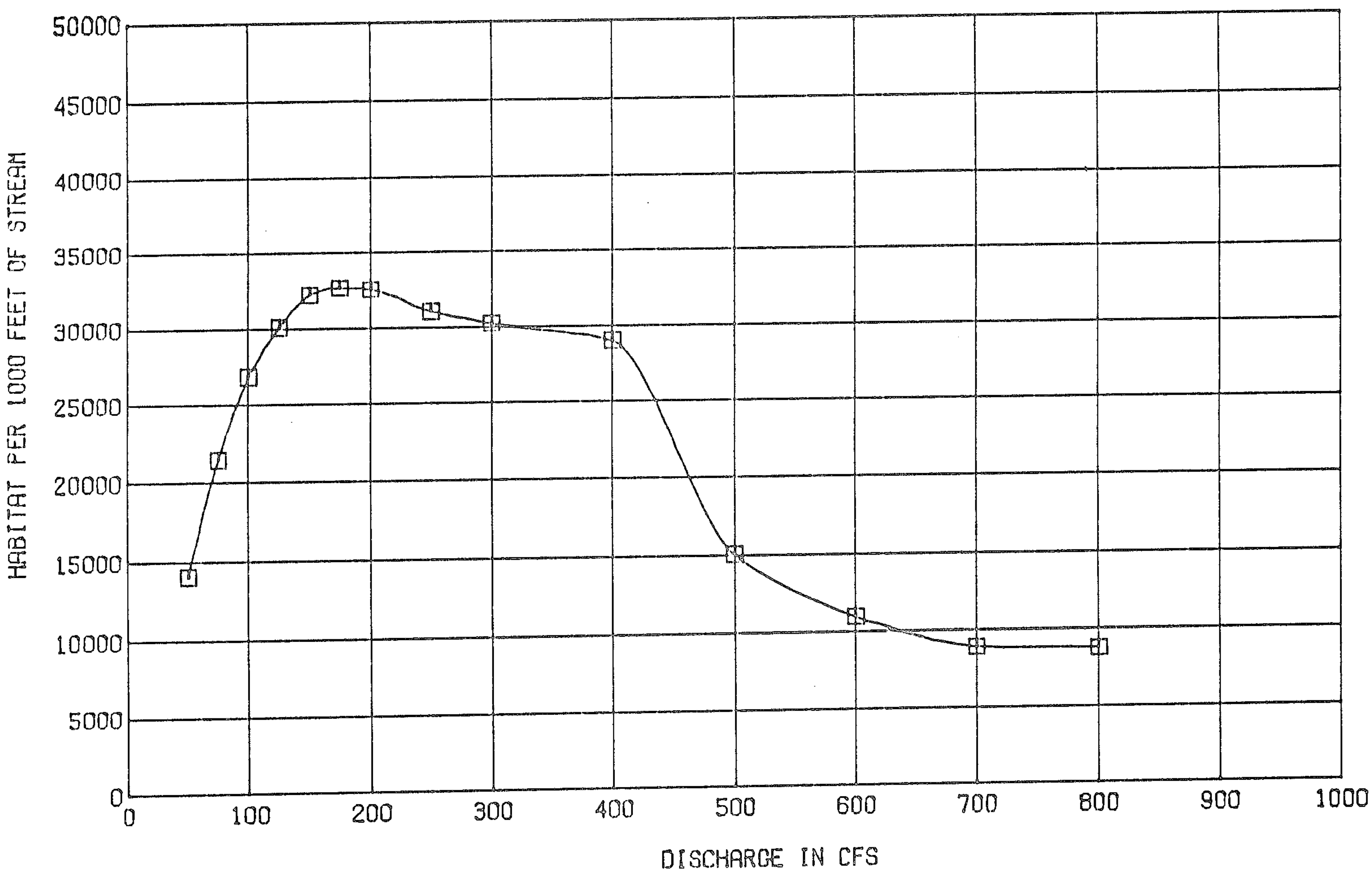
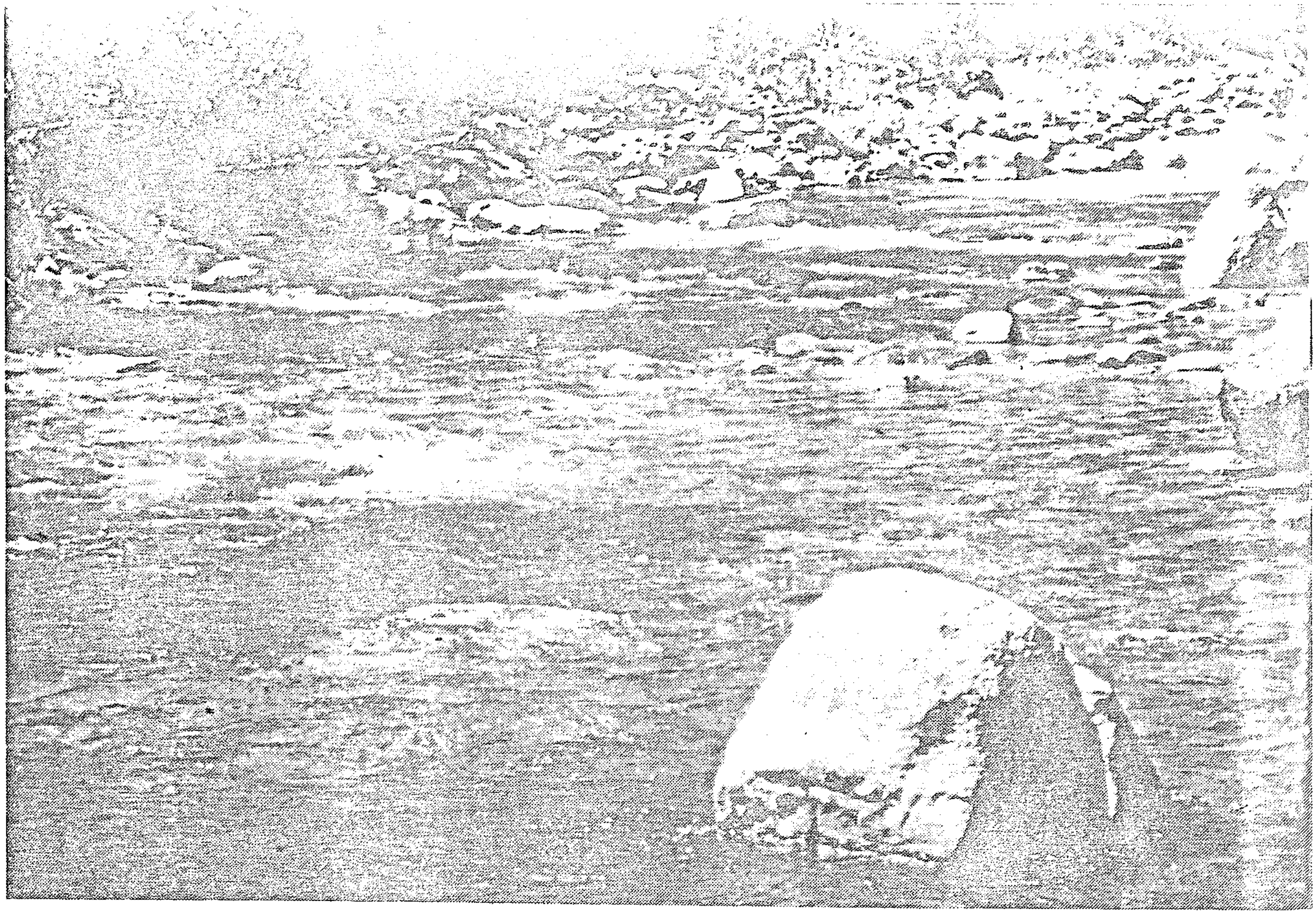


FIGURE 29, SPRING CHINOOK SPAWNING HABITAT AT ICICLE II.

Table 12. Discharge vs Square Feet of Available Spawning Habitat Per 1,000 Feet of Stream For Selected Species at Icicle II.

	Habitat						
Discharge	Rainbow	Cutthroat	Brook T.	Dolly V.	Whitefish	Steelhead	Chinook
50	5009	3185	0	4090	21561	14587	14041
75	6763	3449	0	4414	26077	23813	21450
100	7702	3344	0	4342	27843 *	30179	26810
125	8495	3492	0	4527	27609	32638	30057
150	9011	3953	0	5442	27187	33931	32210
175	9484	4645	0	6195	26604	34848 *	32688 *
200	10161	5515	0	6667	25996	33978	32568
250	11540	5961	0	7318	24187	33125	31060
300	12234 *	4619	0	6462	23201	33085	30224
400	19478	4870	0	5891	15637	31332	28953
500	5711	6301	0	7521	10730	15841	15037
600	5524	7373	0	8428 *	12980	9140	10929
700	6392	7683 *	0	8270	16092	8356	8930
800	6665	6837	0	7225	18497	8504	8847

*Maximum



ICICLE III

ICICLE III

Fish habitat in the uppermost section of the study area is represented by the study reach designated, Icicle III. This reach is 477 feet in length and transect width averages 117 feet. Flow measurements were obtained at 395, 170, and 102 cfs. Table 13 denotes the velocity adjustment factors. Figure 30 illustrates natural and potential project flows for this reach. Natural flow patterns in this area are consistent with those noted in Icicle I. Actual discharges in Icicle III generally represent about 80% of the flow that would be seen at the same time in Icicle I.

Table 13. Velocity Adjustment Factors For Icicle III.

	Transect				
Discharge	0 + 00	1 + 77	1 + 43	1 + 65	0 + 92
50	1.028	.943	.881	.827	.899
75	.974	.947	.933	.880	.951
100	.979	.973	.968	.914	.976
125	.977	.974	.991	.936	.969
150	.979	.988	1.005	.952	.979
175	.979	.998	1.005	.964	.974
200	.978	1.005	1.008	.973	.977
250	.976	1.010	1.008	.983	.981
300	.972	1.009	1.002	.987	.981
400	.959	.994	.981	.983	.972
500	.946	.966	.956	.971	.963
600	.933	.932	.929	.957	.953
700	.920	.893	.902	.941	.942
800	.908	.853	.876	.924	.931

Figures 31 through 49 depict the discharge vs habitat relationships for each of the species in question. The same data in tabular form is shown in Tables 14 through 20.

Spawning habitat is virtually non existant at Icicle III except for mountain whitefish which peaks at 250 cfs and the steelhead and spring chinook which peak at 300 cfs.

Adult habitat for rainbow trout is fairly constant at discharges of 250 cfs and above. Significant habitat losses occur below 200 cfs. Adult cutthroat trout habitat peaks at 250 cfs, rapidly declines at flows below 200 cfs, and gradually declines at discharges exceeding 250 cfs. The chars again differ from the others by reaching peak habitat levels between 50 and 100 cfs. Habitat is lost quickly then gradually tails off at the highest flows. Mountain whitefish habitat peaks at 400 cfs and only slightly drops at flows up to 800 cfs. Discharges below 300 cfs rapidly provide habitat losses.

Juvenile habitat for rainbow trout, cutthroat trout, and mountain whitefish peaks at 150, 175, and 200 cfs respectively. At flows below these, habitat declines rapidly. At discharges above 200 cfs habitat gradually declines. Char habitat peaks between 50 and 100 cfs and appears to decline at lower discharges. Discharges above 100 cfs cause steady declines in habitat. Steelhead habitat peaks at 150 cfs, declines quickly at lower flows, and slowly declines at discharges above 200 cfs. Spring chinook habitat peaks at 125 cfs and declines rather quickly at other discharges.

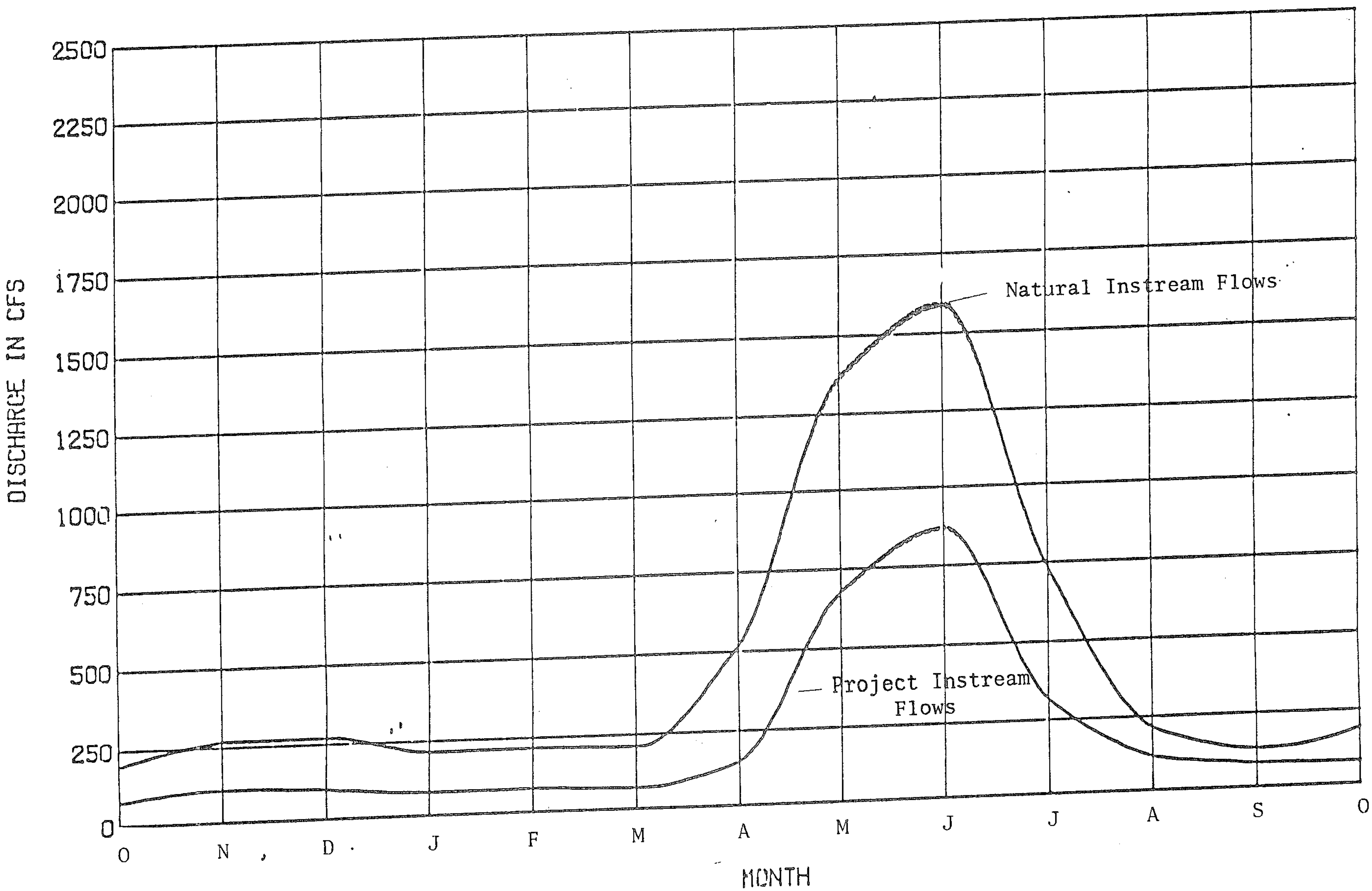


FIGURE 30. MEAN MONTHLY AND POTENTIAL PROJECT FLOWS AT ICICLE III.

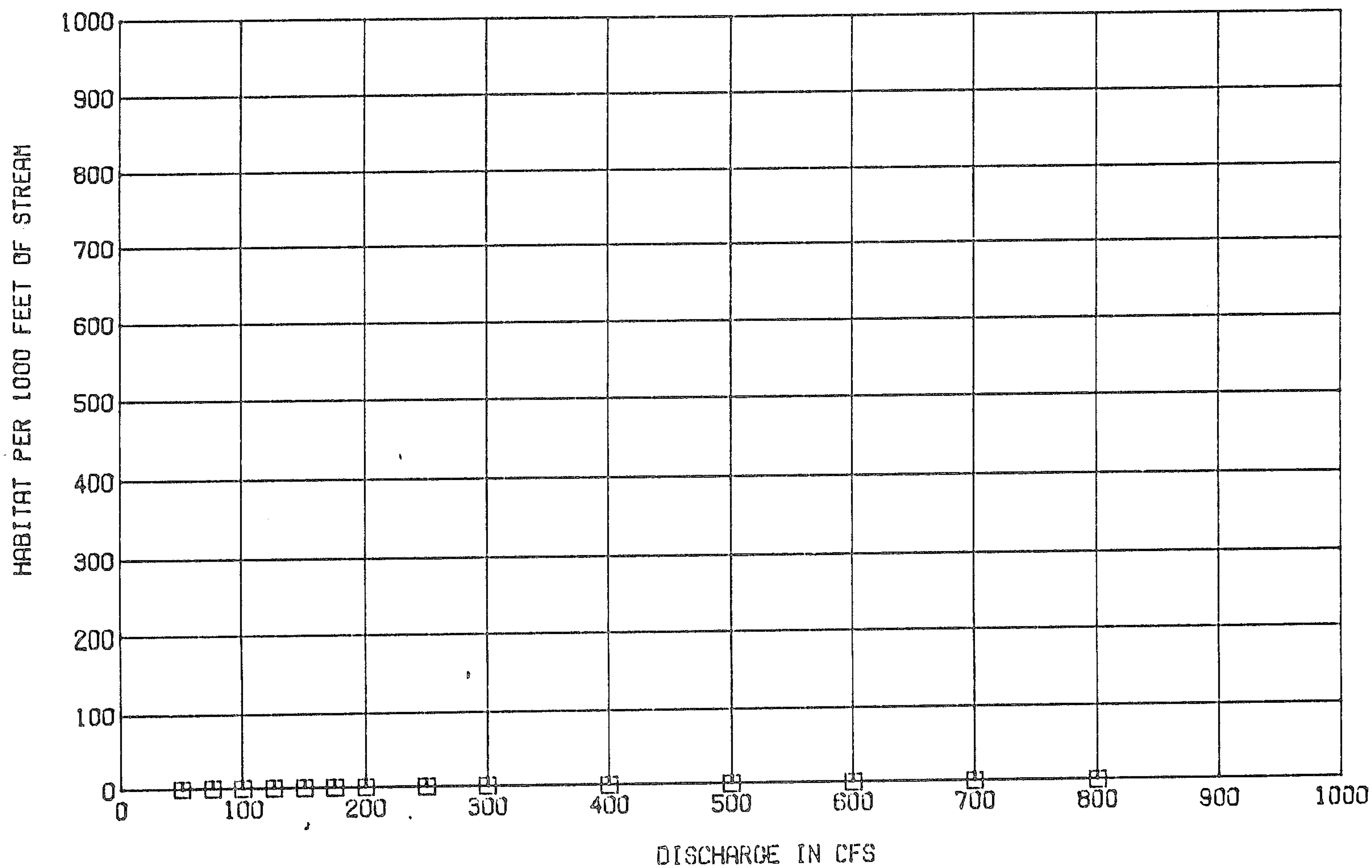


FIGURE 31. RAINBOW TROUT SPAWNING HABITAT AT ICICLE III.

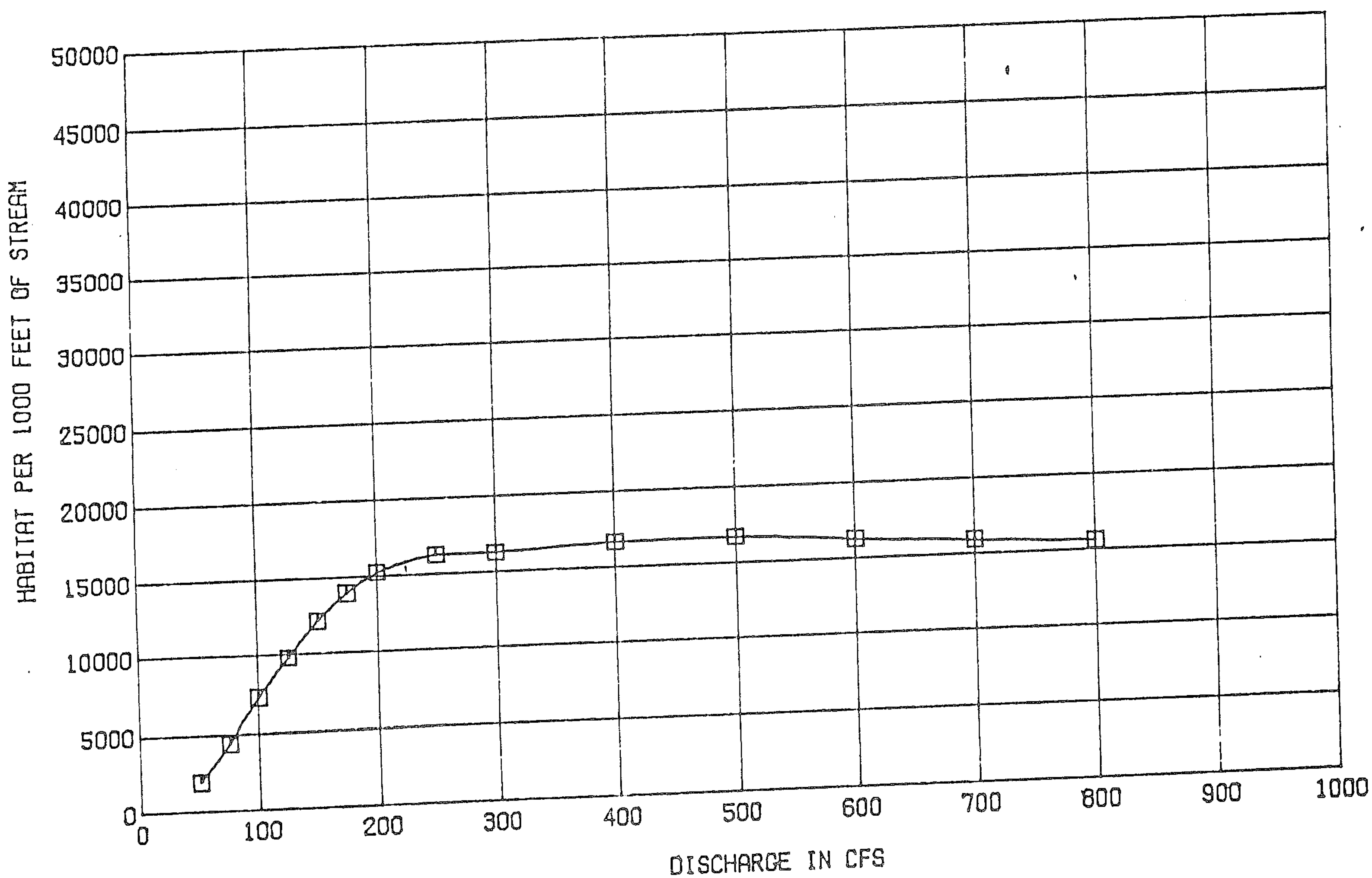


FIGURE 32. ADULT RAINBOW TROUT HABITAT AT ICICLE III.

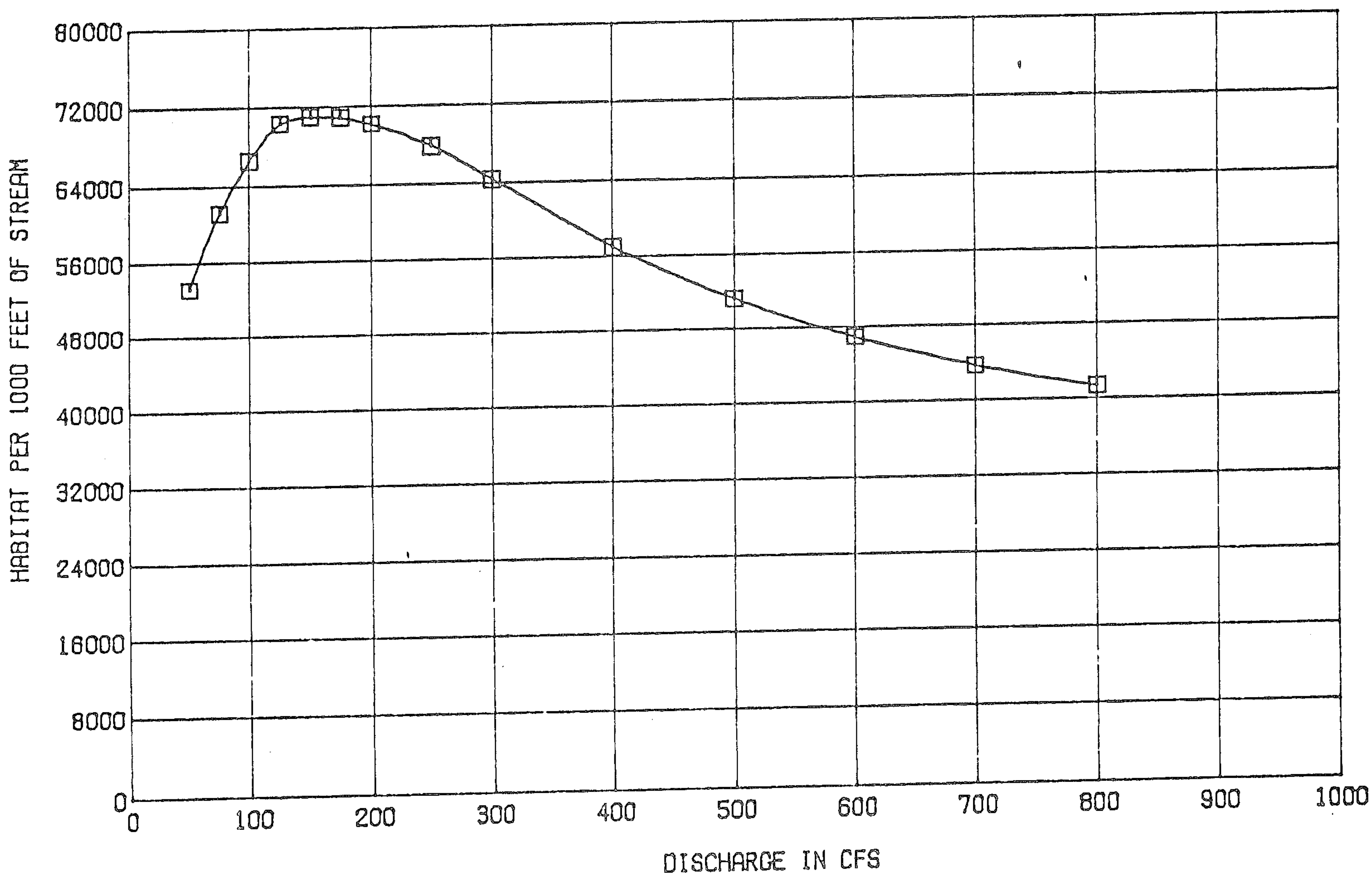


FIGURE 33. JUVENILE RAINBOW TROUT HABITAT AT ICICLE III.

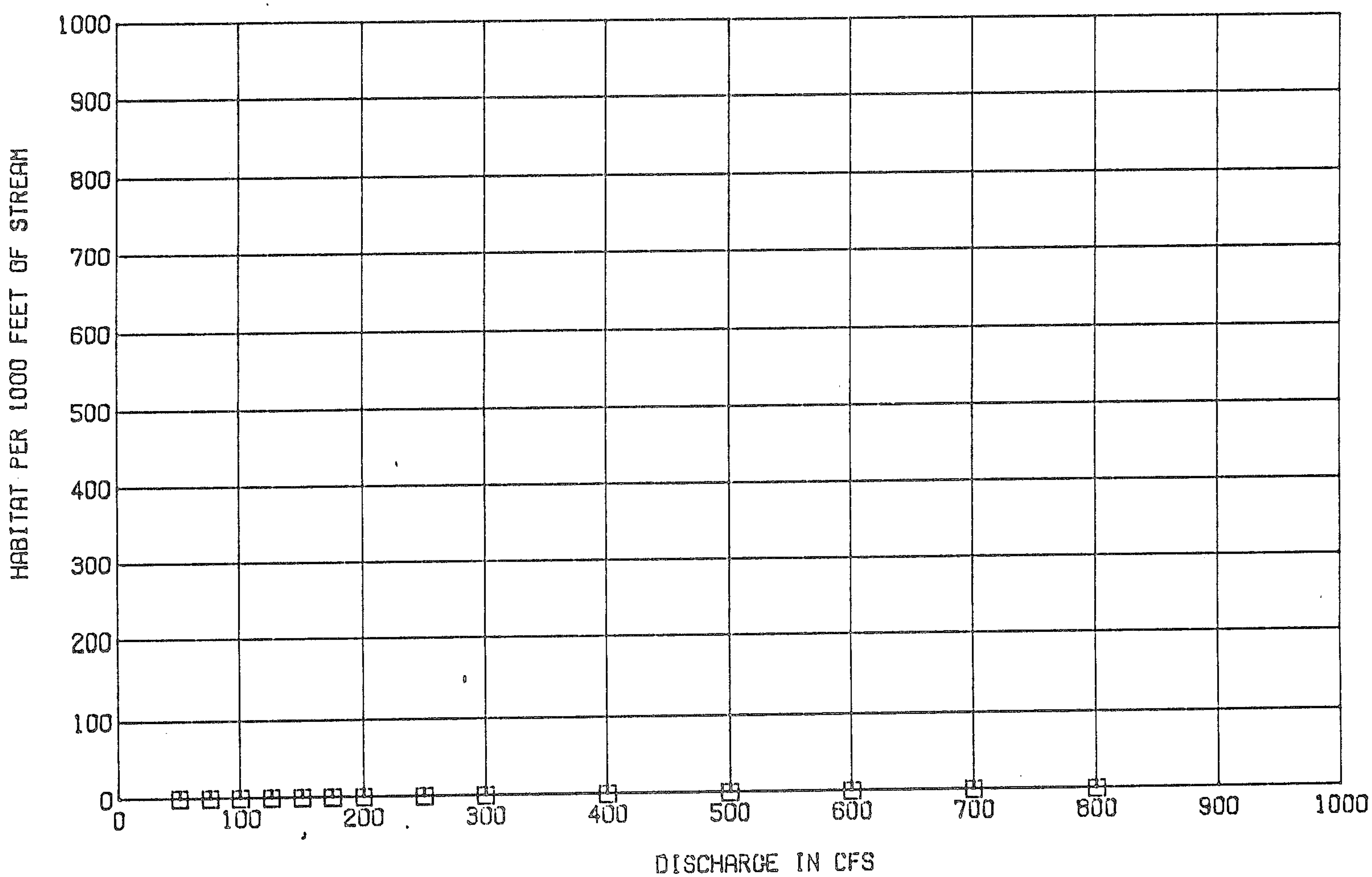


FIGURE 34. CUTTHROAT TROUT SPAWNING HABITAT AT ICICLE III.

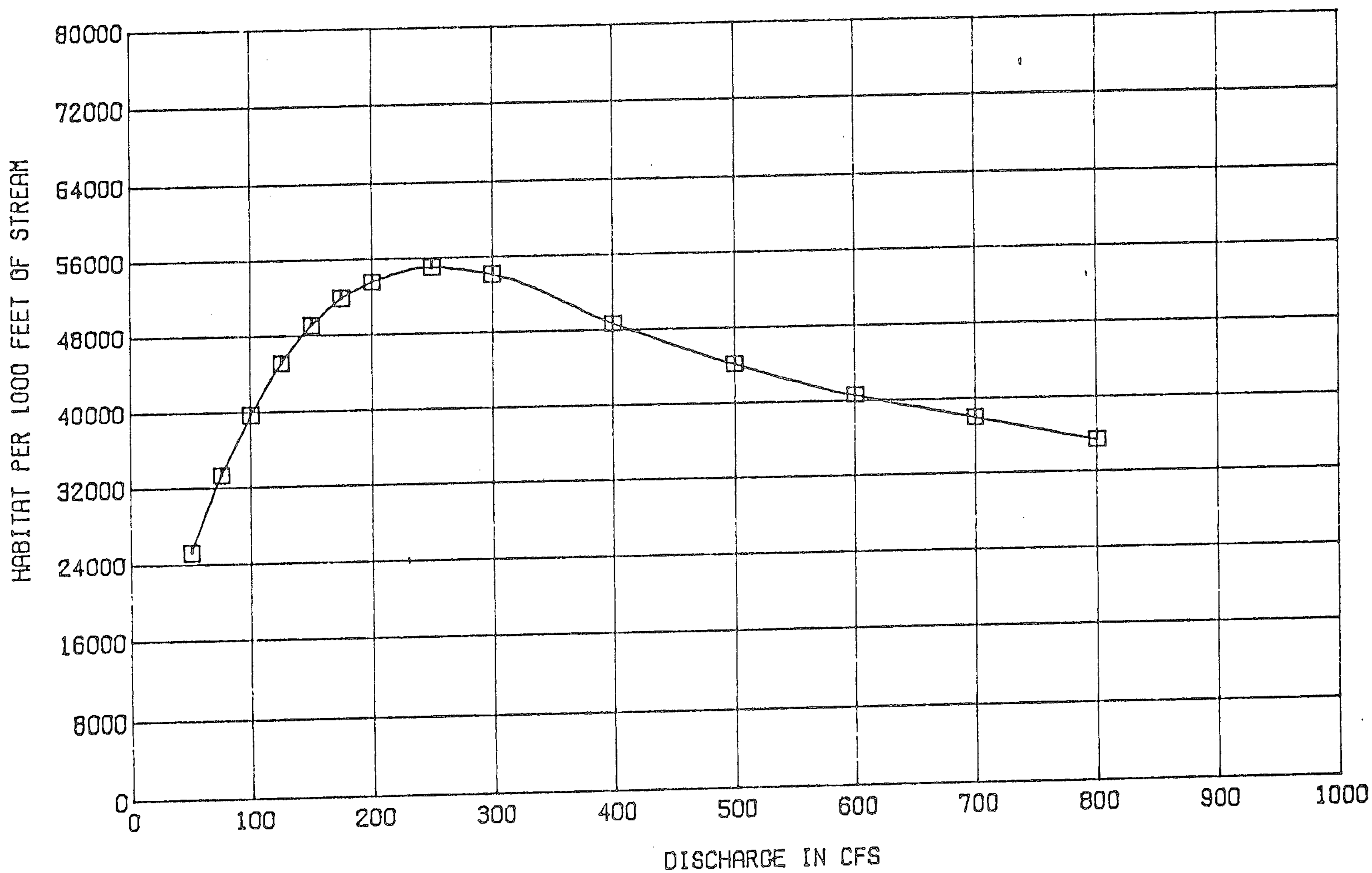


FIGURE 35. ADULT CUTTHROAT TROUT HABITAT AT ICICLE III.

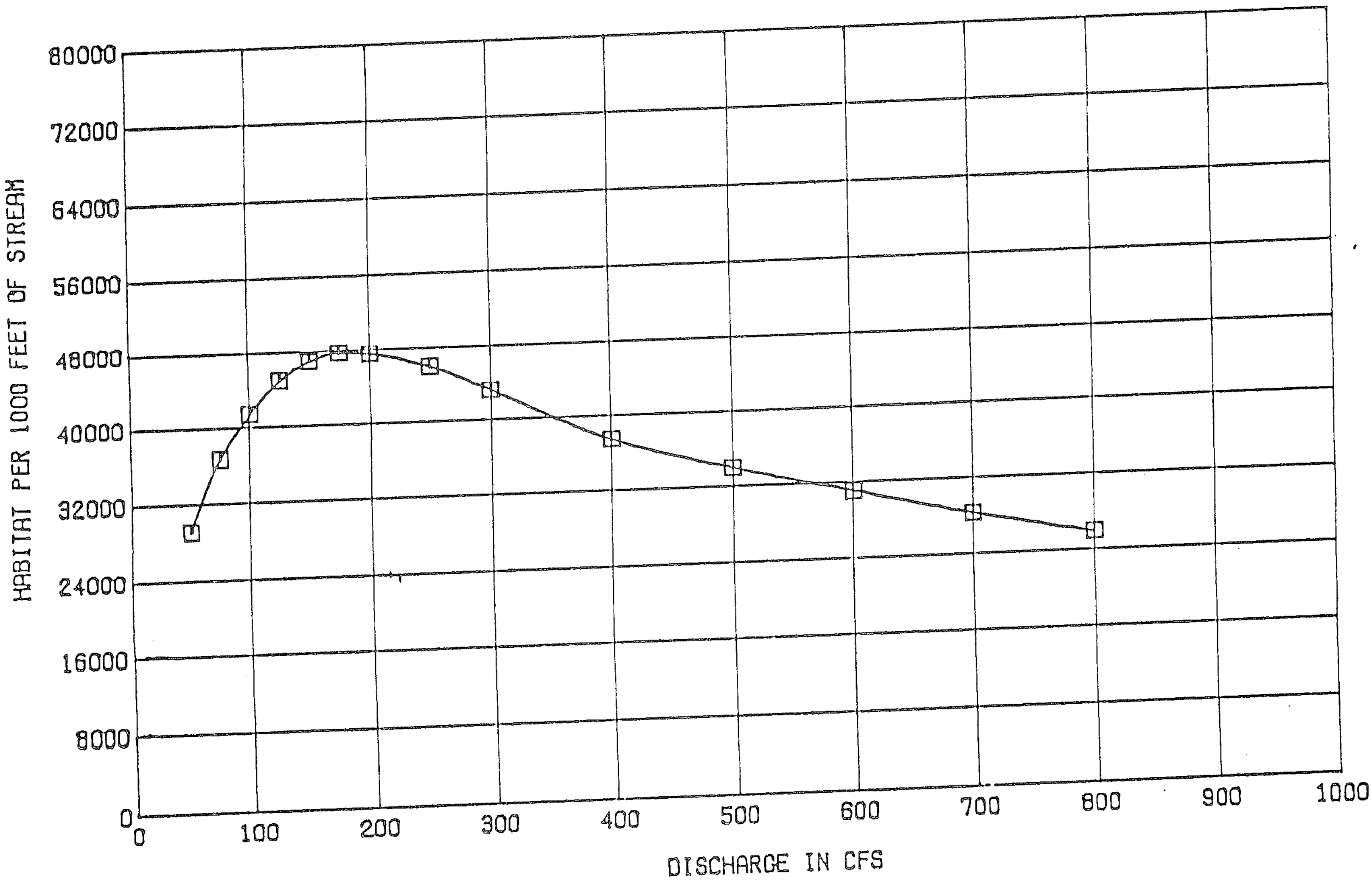


FIGURE 36. JUVENILE CUTTHROAT TROUT HABITAT AT ICICLE III.

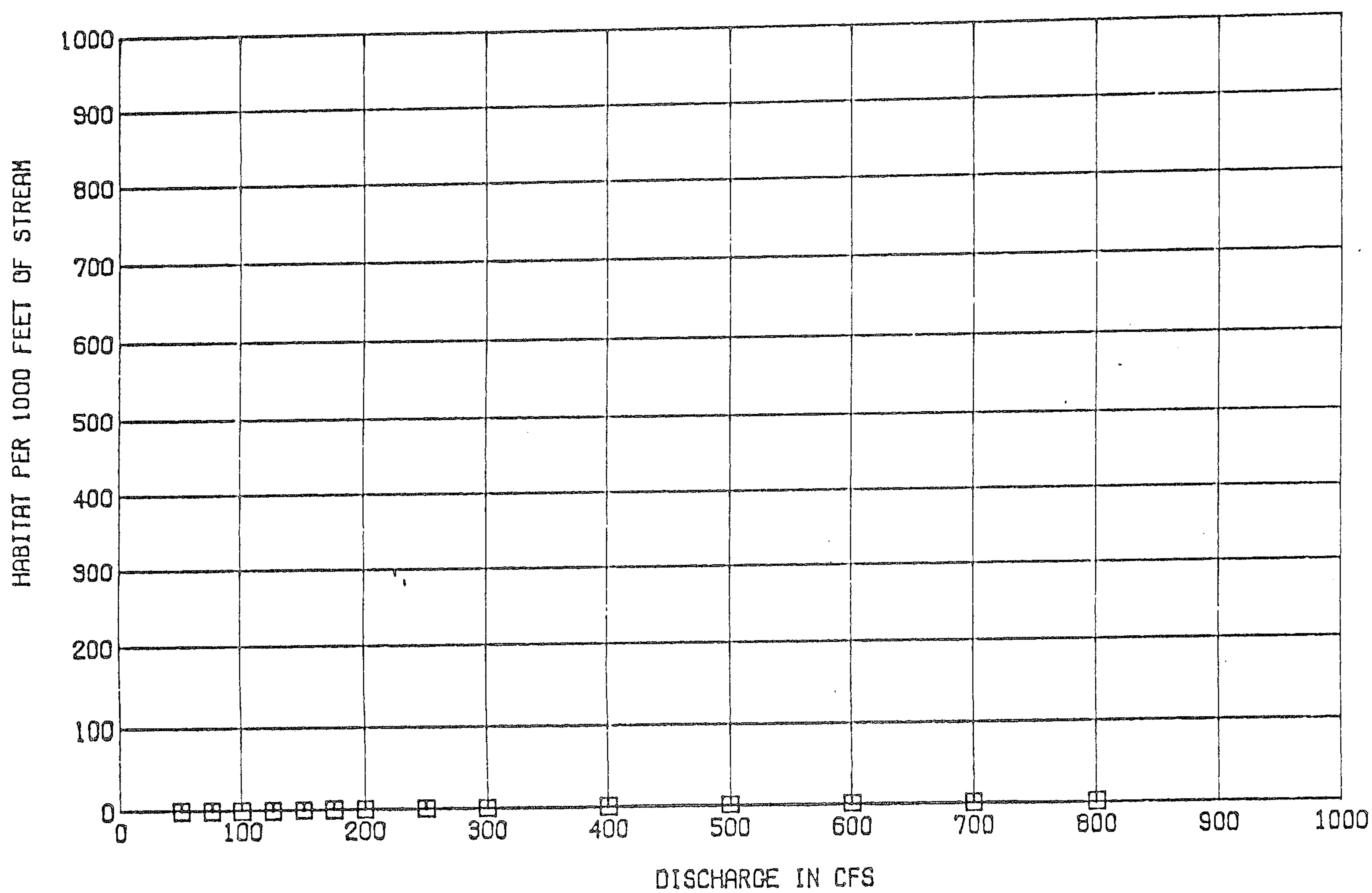


FIGURE 37. BROOK TROUT SPAWNING HABITAT AT ICICLE III.

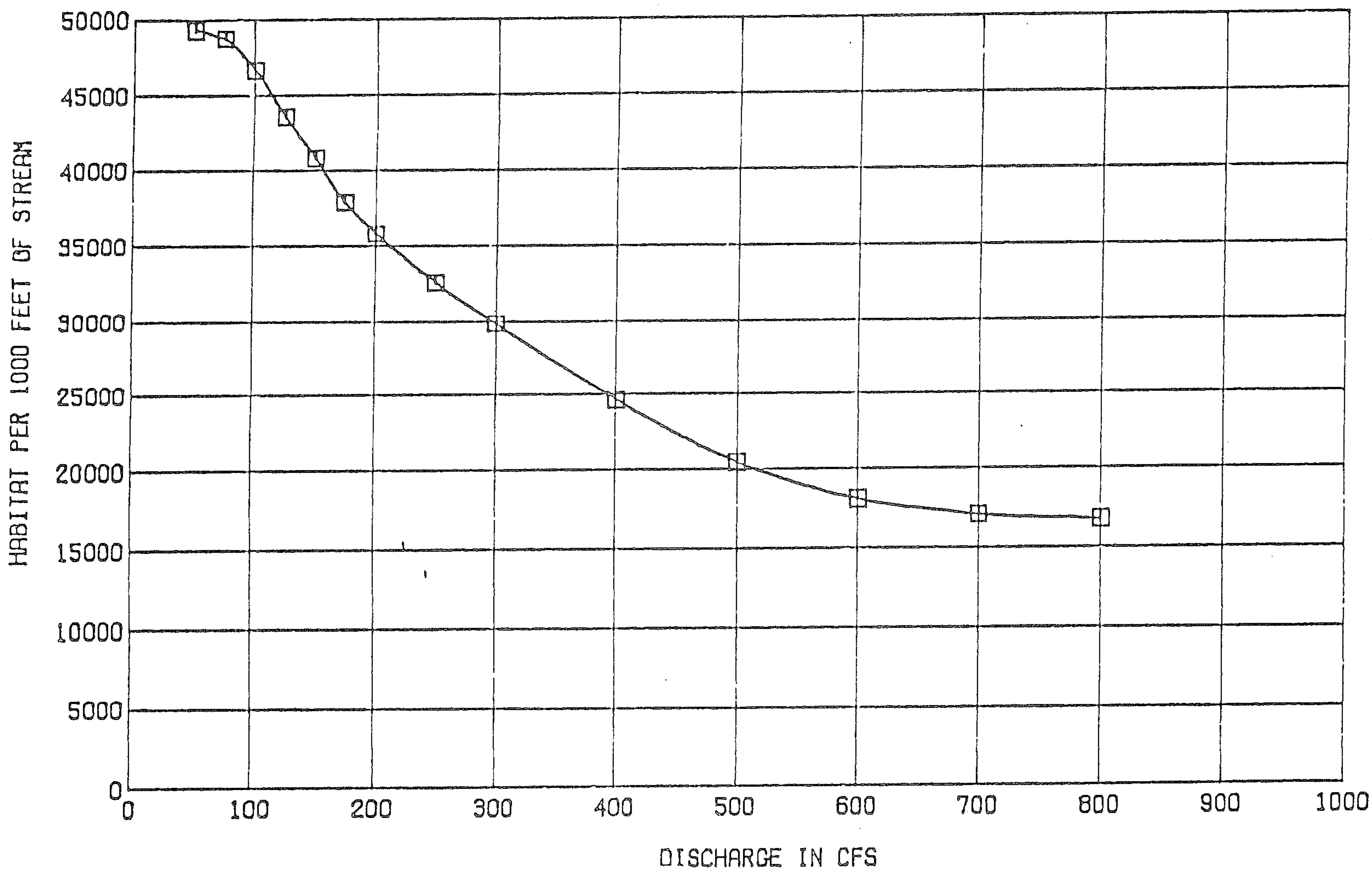


FIGURE 38. ADULT BROOK TROUT HABITAT AT ICICLE III.

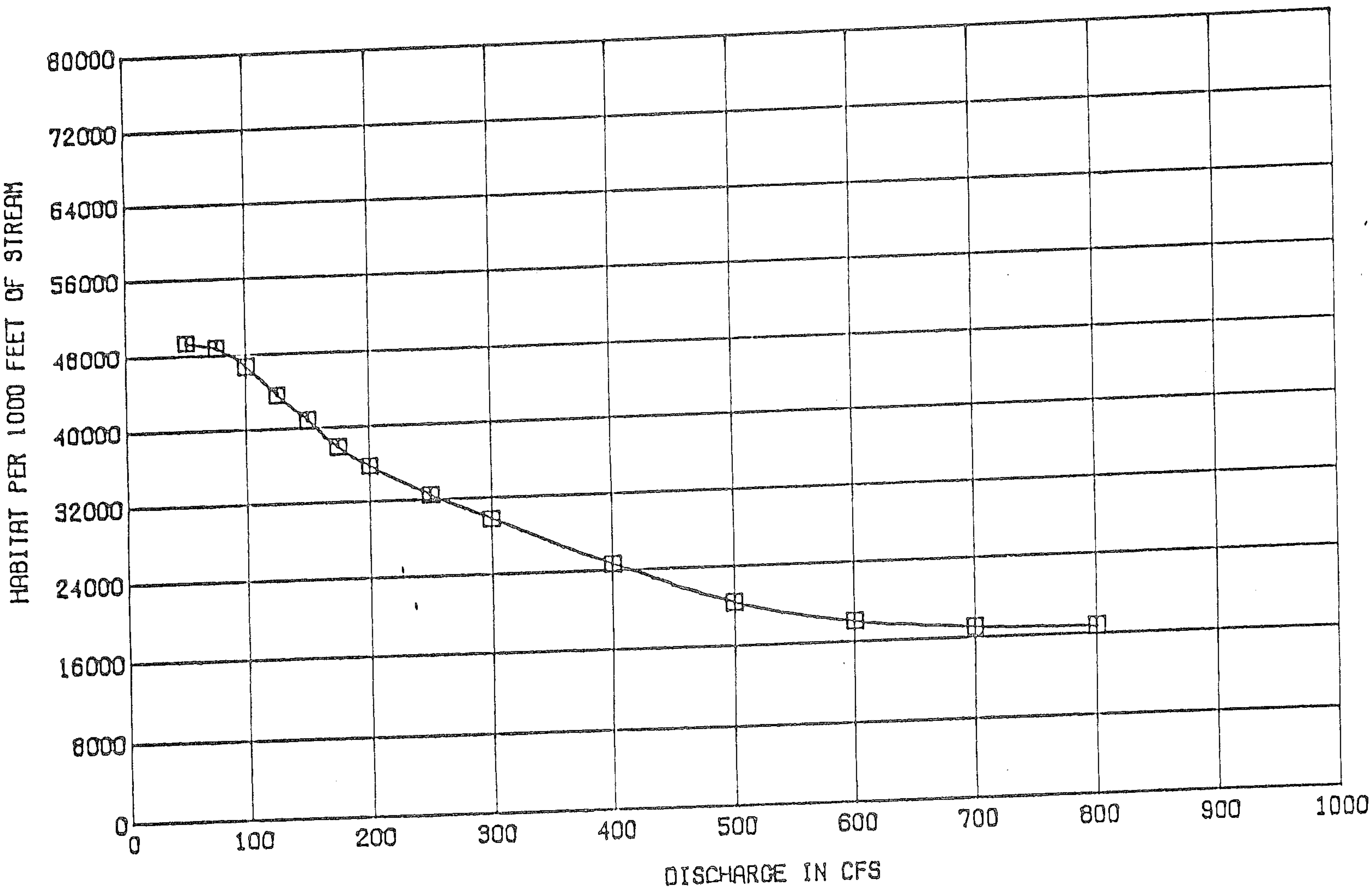


FIGURE 39. JUVENILE BROOK TROUT HABITAT AT ICICLE III.

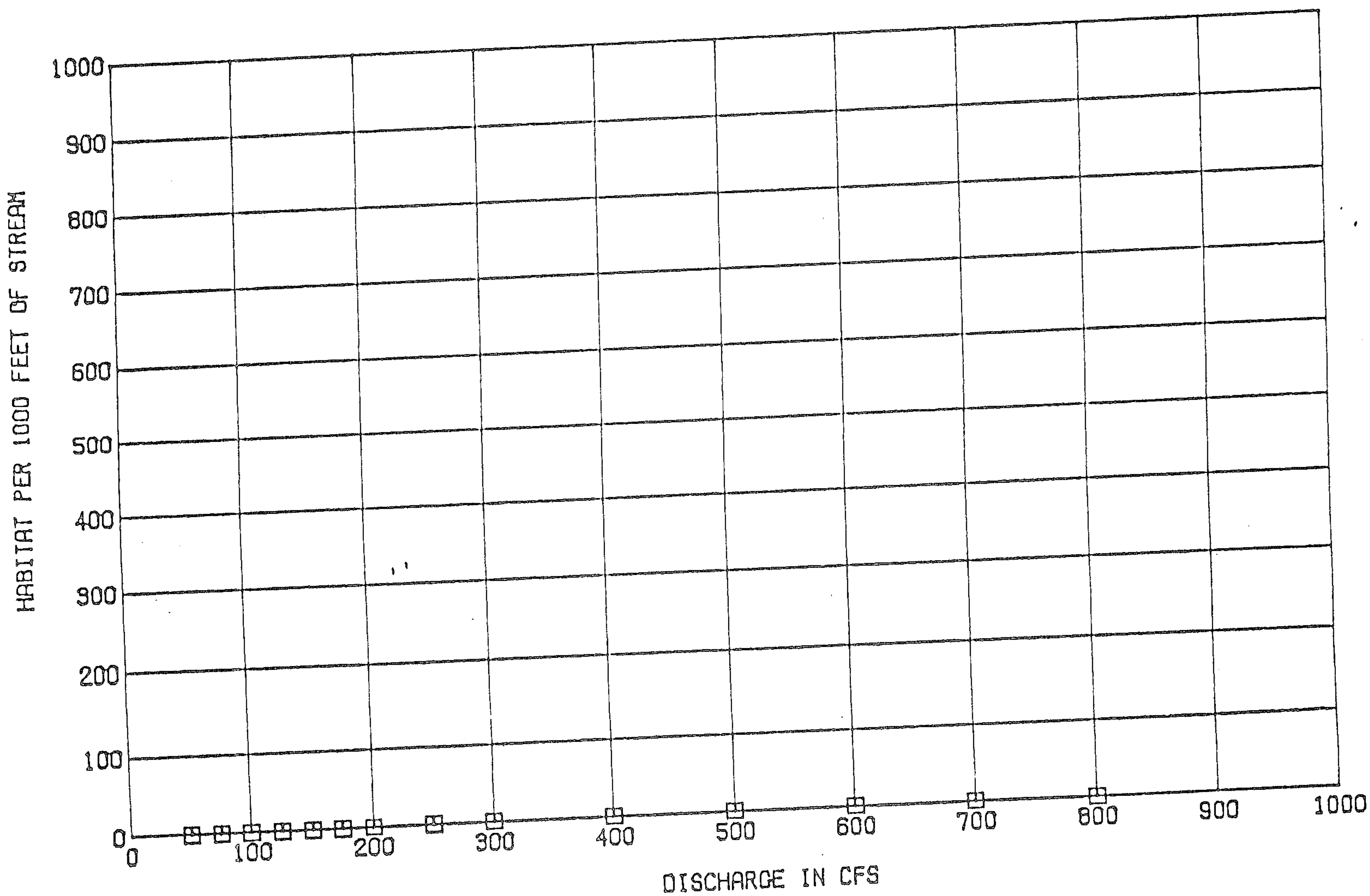


FIGURE 40. DOLLY VARDEN SPAWNING HABITAT AT ICICLE III.

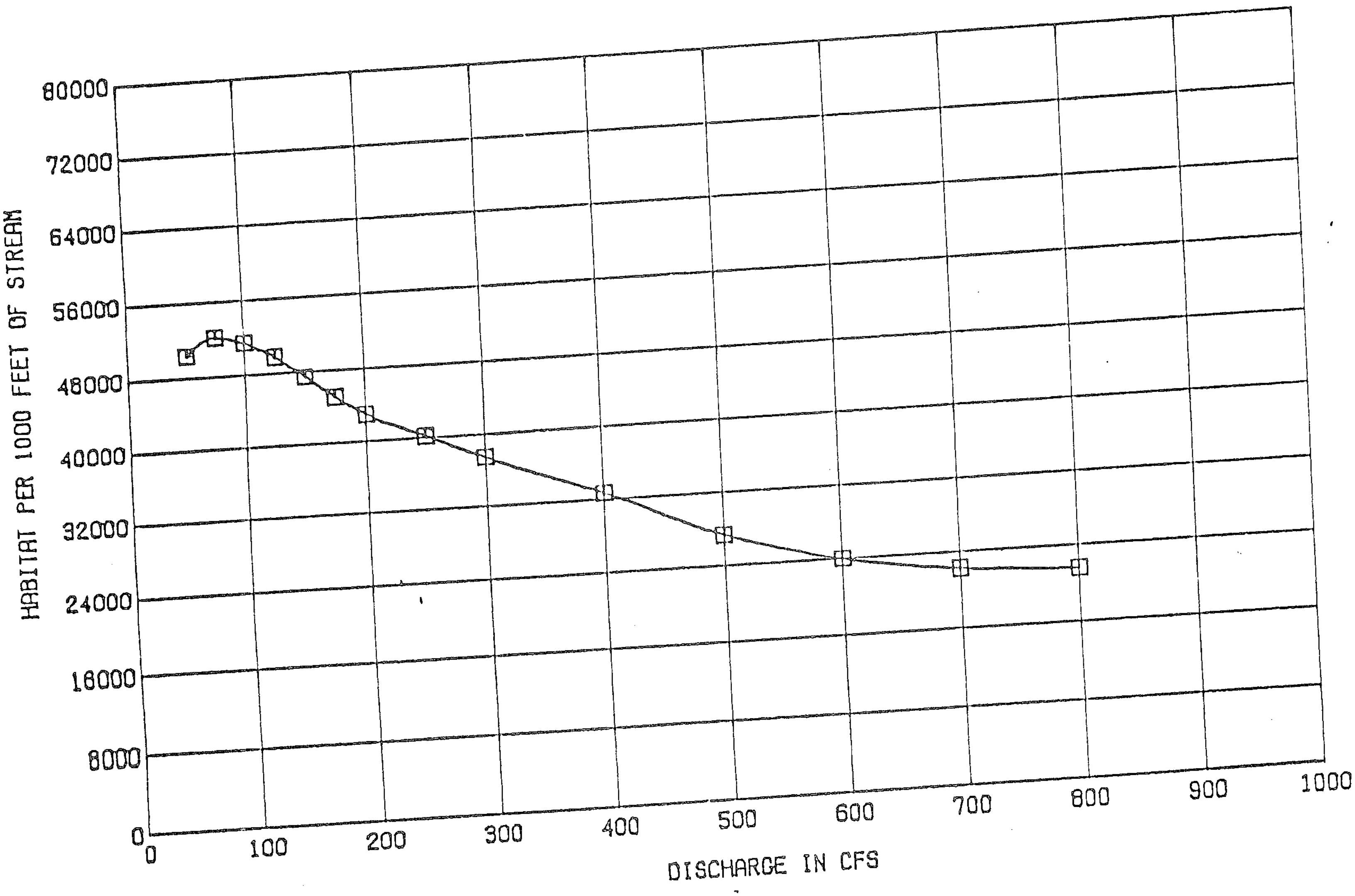


FIGURE 41. ADULT DOLLY VARDEN HABITAT AT ICICLE III.

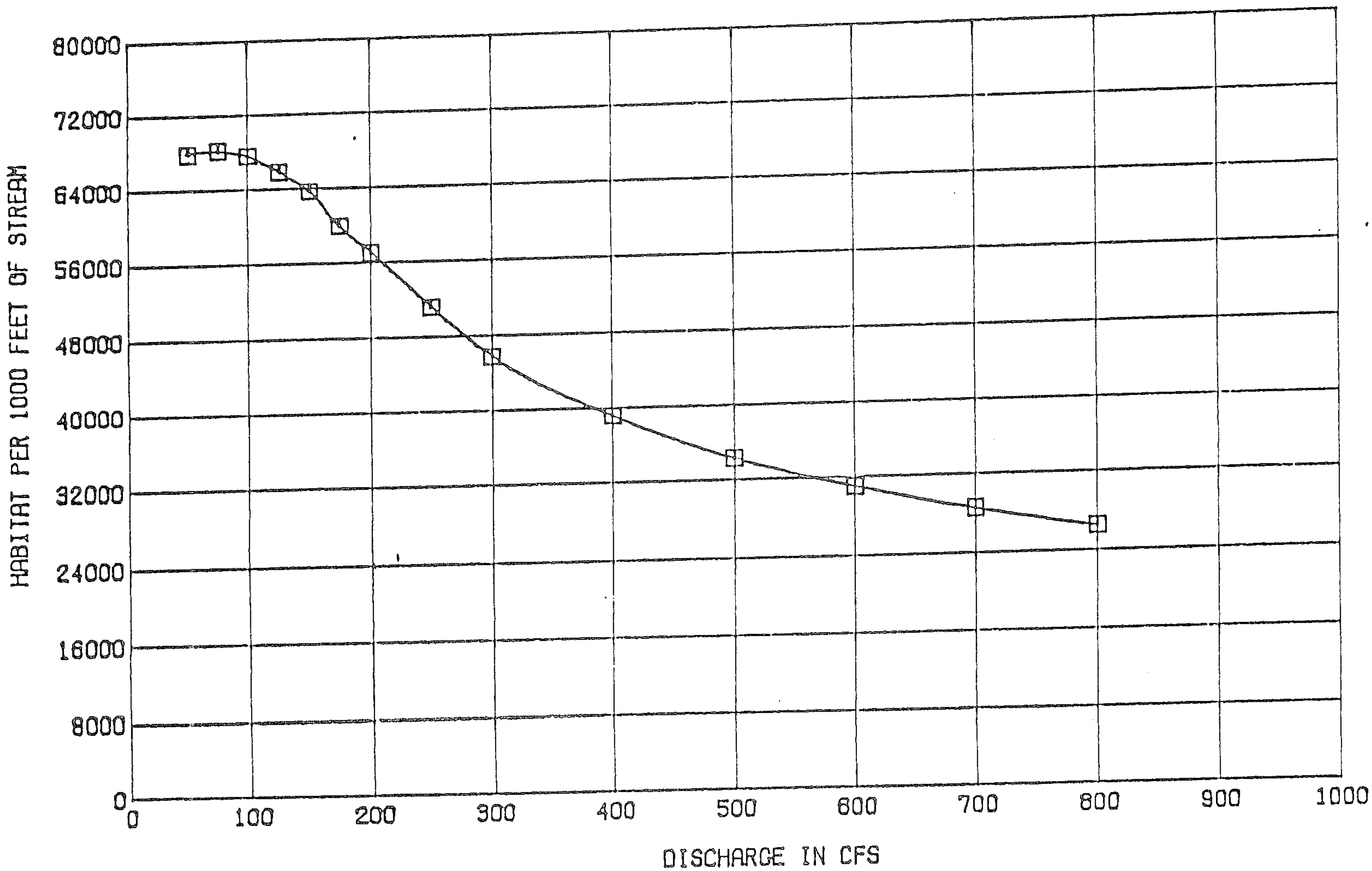


FIGURE 42. JUVENILE DOLLY VARDEN HABITAT AT ICICLE III.

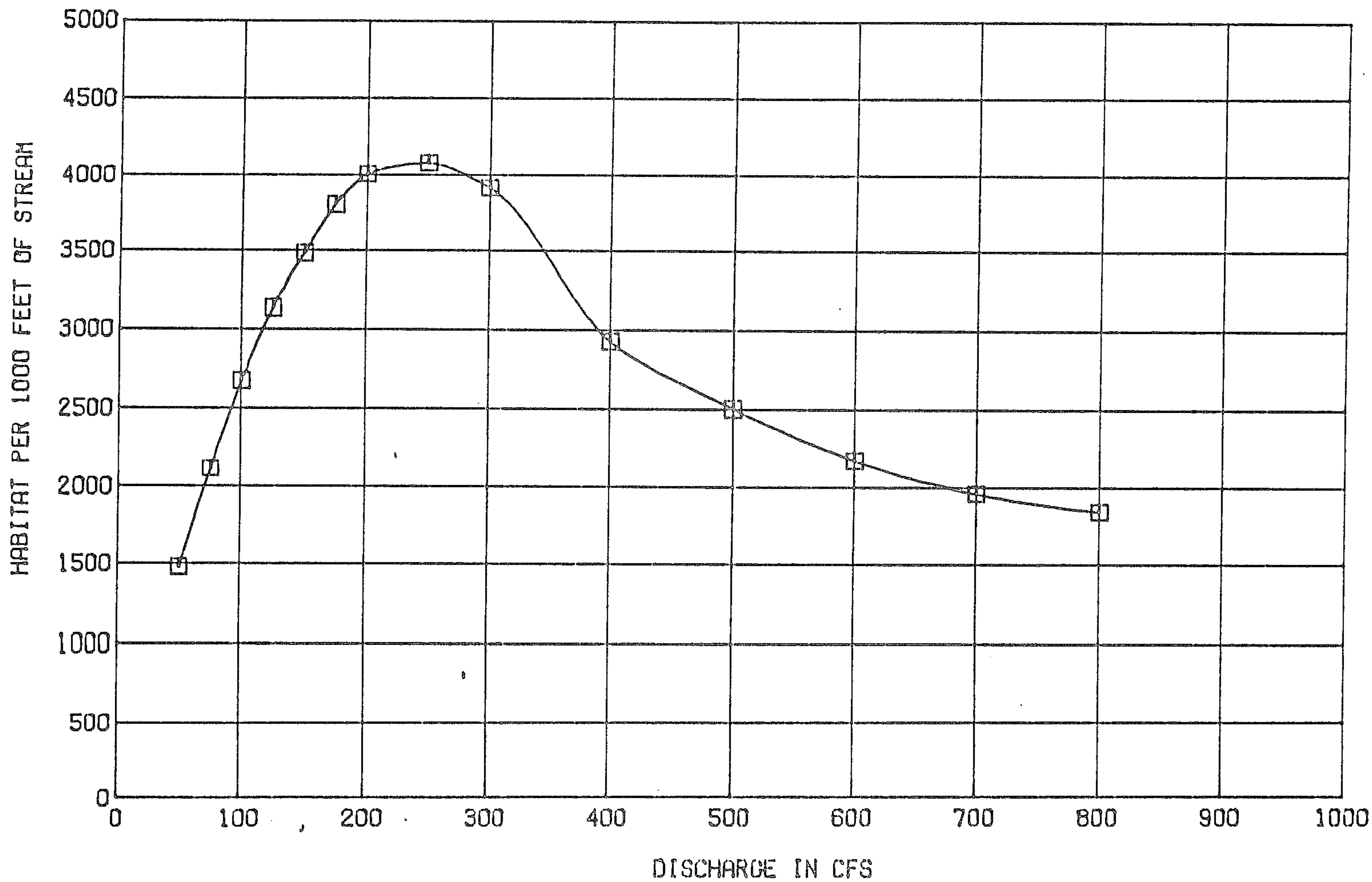


FIGURE 43. MOUNTAIN WHITEFISH SPAWNING HABITAT AT ICICLE III.

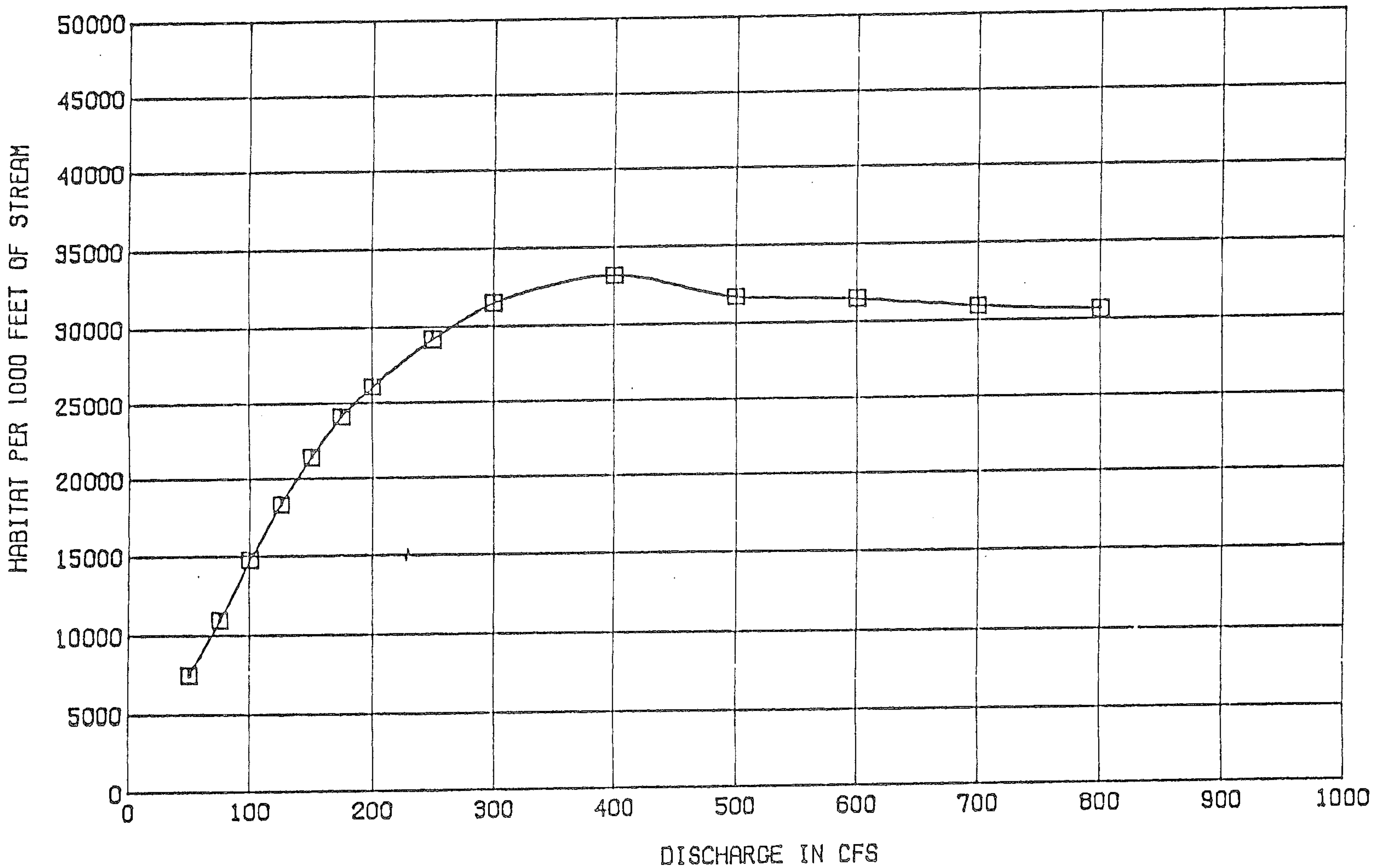


FIGURE 44. ADULT MOUNTAIN WHITEFISH HABITAT AT ICICLE III.

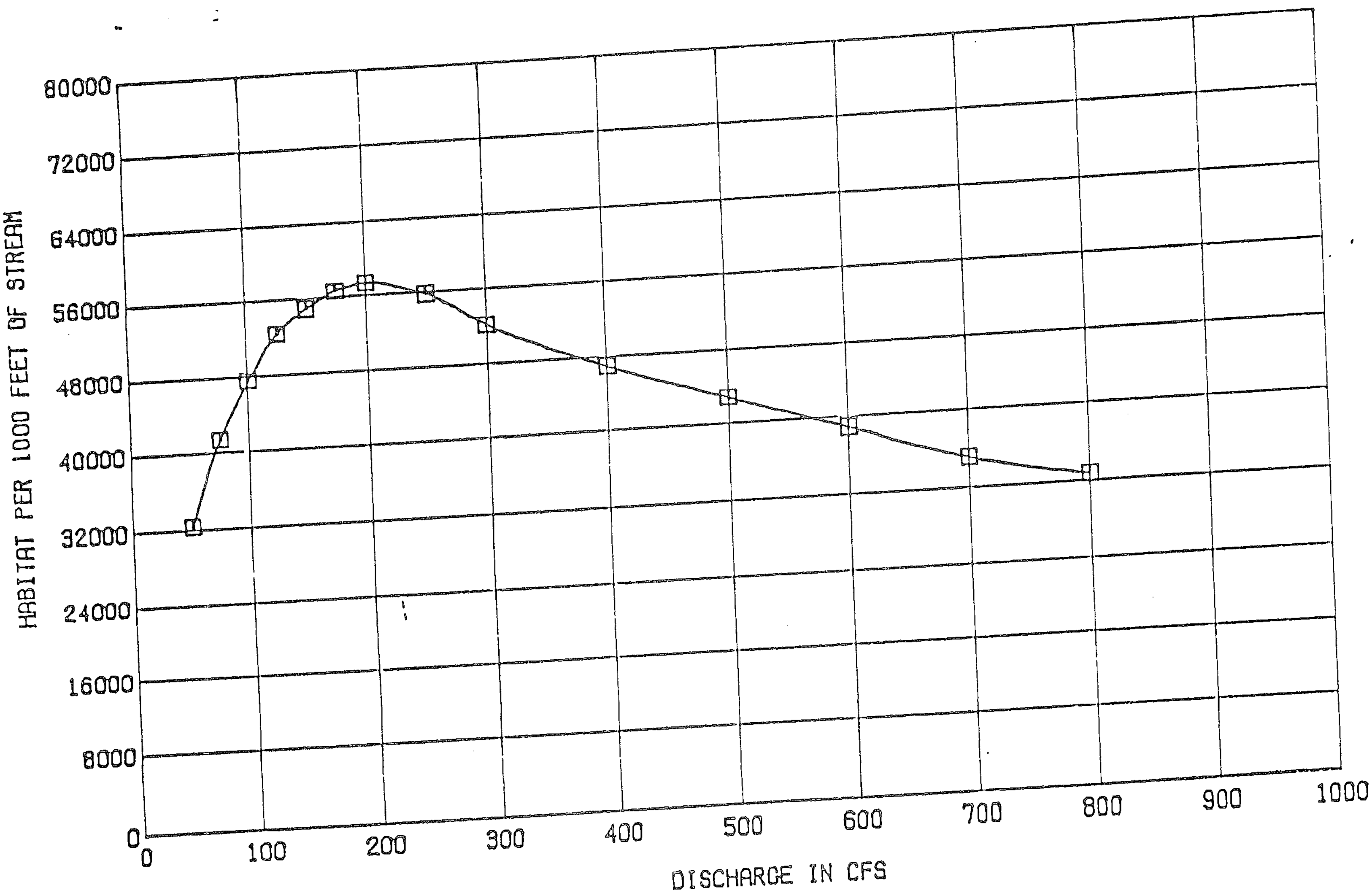


FIGURE 45. JUVENILE MOUNTAIN WHITEFISH HABITAT AT ICICLE III.

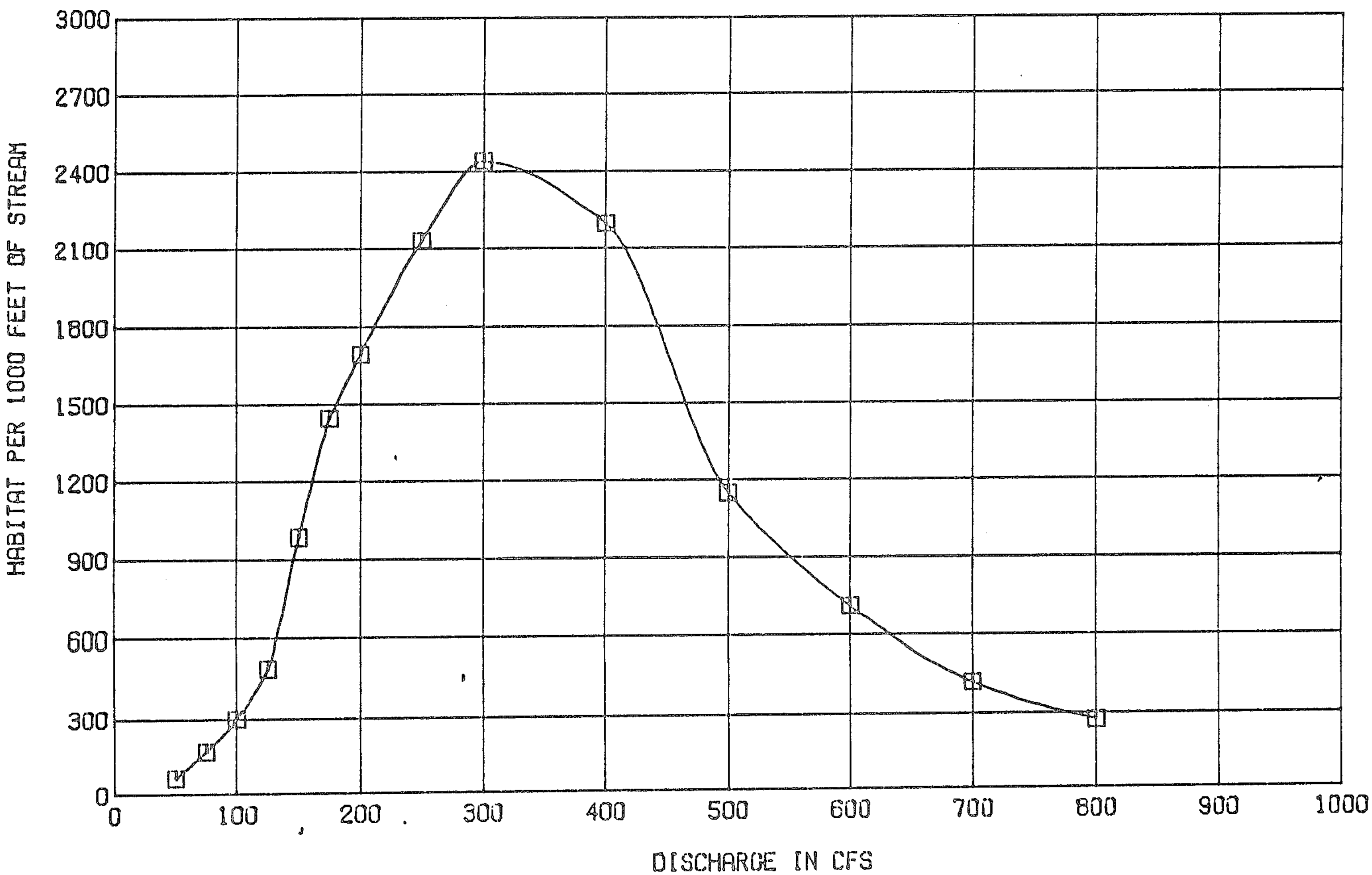


FIGURE 46. STEELHEAD SPAWNING HABITAT AT ICICLE III.

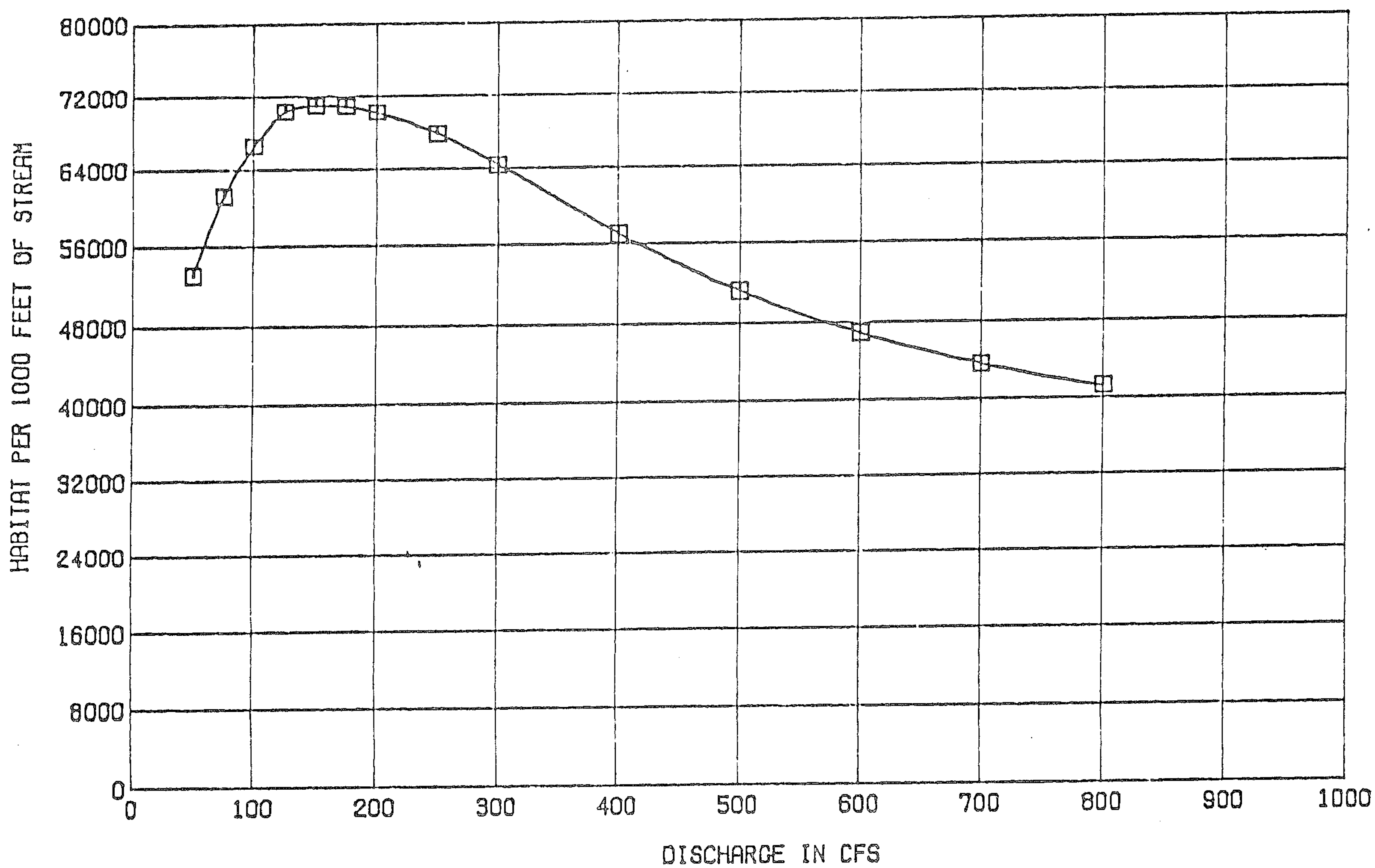


FIGURE 47. JUVENILE STEELHEAD HABITAT AT ICICLE III.

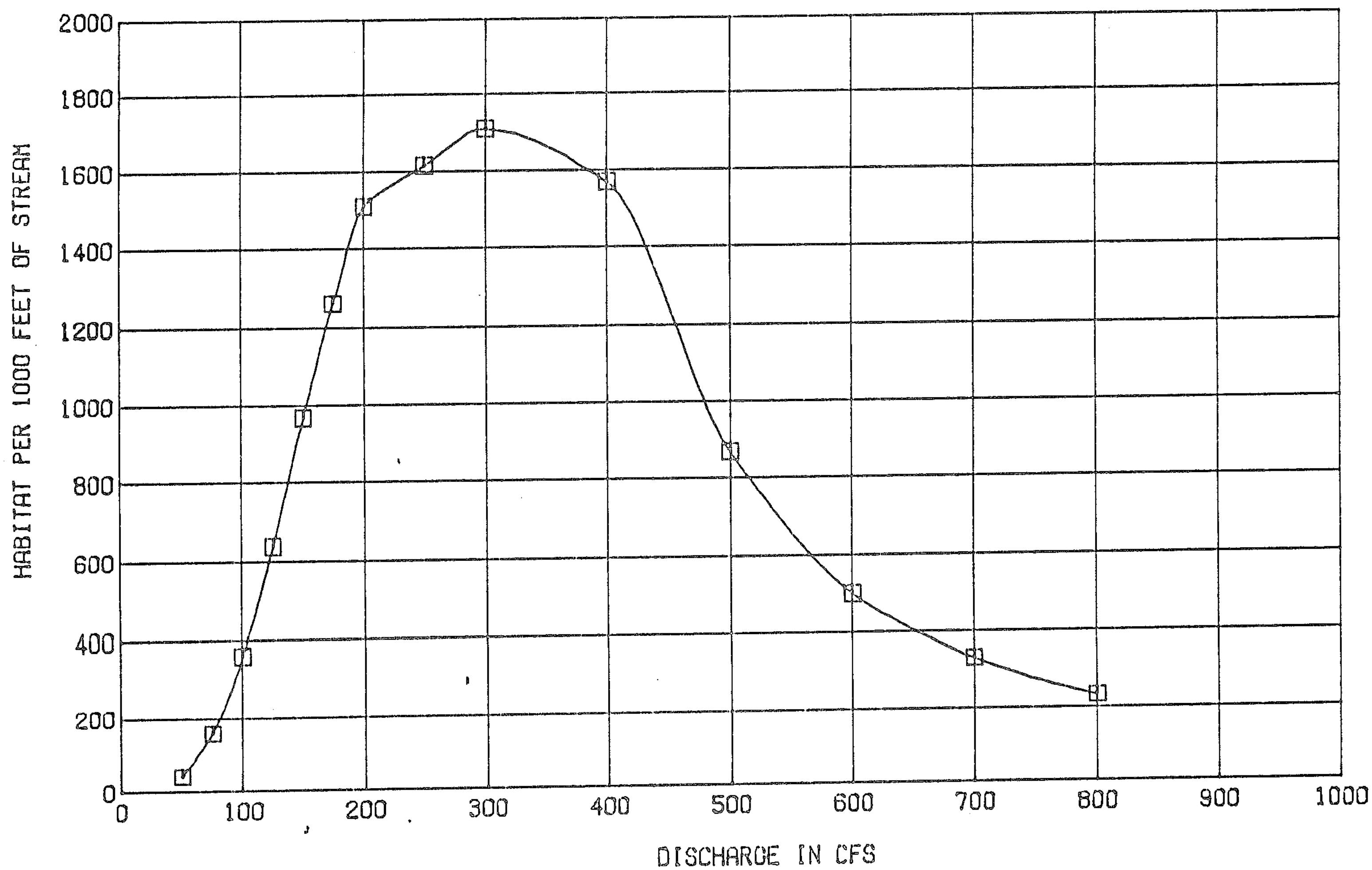


FIGURE 48. SPRING CHINOOK SPAWNING HABITAT AT ICICLE III.

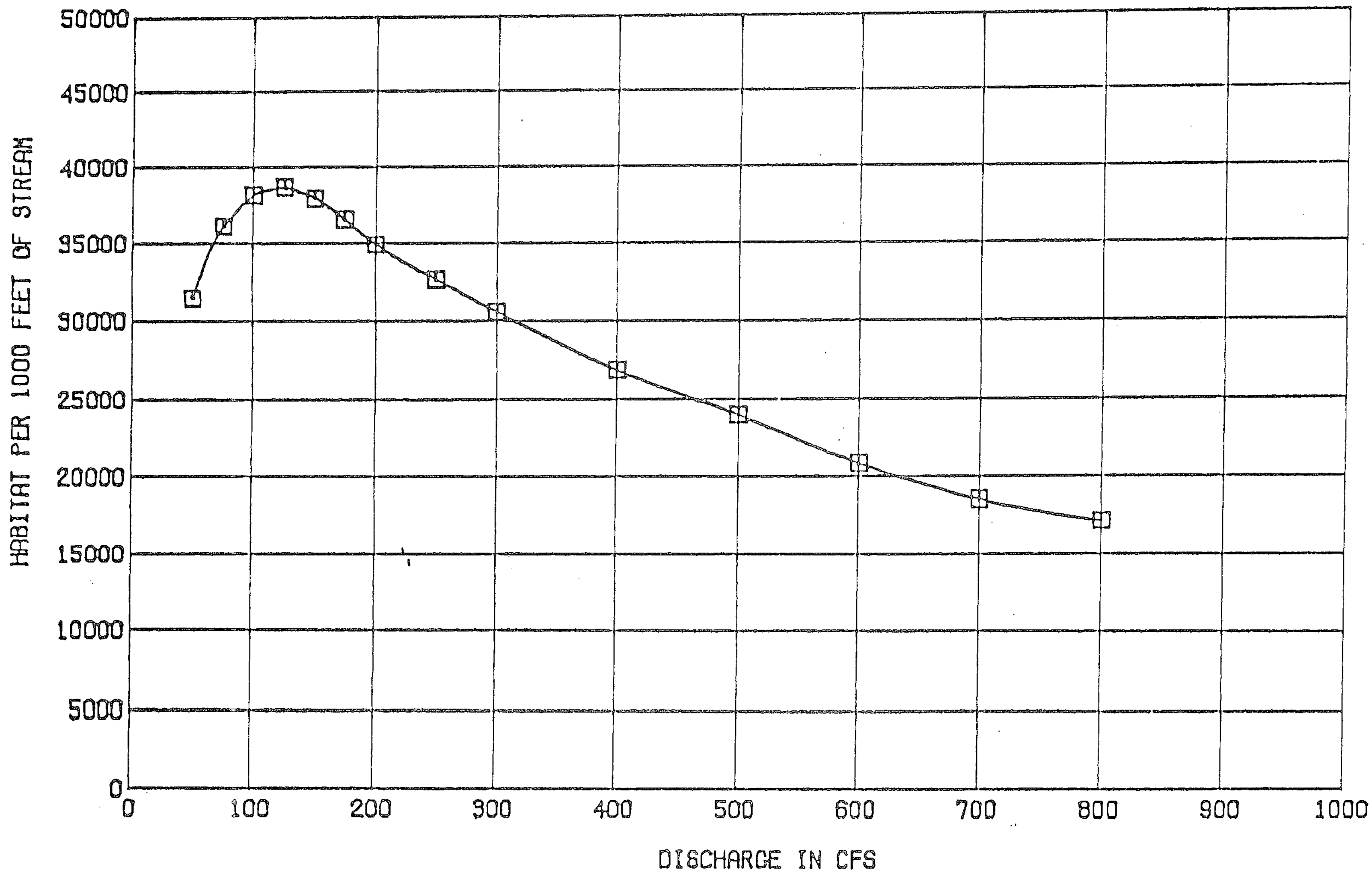


FIGURE 49. JUVENILE SPRING CHINOOK HABITAT AT ICICLE III.

Table 14. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Rainbow Trout at Icicle III.

	Habitat		
Discharge	Spawning	Adult	Juvenile
50	1	1944	53088
75	1	4397	61125
100	1	7254	66507
125	1	9808	70279
150	1	12172	70955 *
175	1	13954	70833
200	1	15218	70151
250	1	16264	67805
300	1	16276	64335
400	0	16646	57018
500	0	16722 *	51218
600	0	16292	46884
700	0	15928	43614
800	0	15607	41272

*Maximum

Table 15. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Cutthroat Trout at Icicle III.

	Habitat		
Discharge	Spawning	Adult	Juvenile
50	0	25270	29099
75	0	33282	36677
100	0	39679	41399
125	0	45071	44881
150	0	49083	46822
175	0	51824	47671 *
200	0	53550	47523
250	0	55004 *	45909
300	0	54133	43120
400	0	48620	37409
500	0	44078	33982
600	0	40608	31134
700	0	37997	28335
800	0	35407	25929

*Maximum

Table 16. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Brook Trout at Icicle III.

Discharge	Habitat Spawning	Habitat Adult	Habitat Juvenile
50	0	49300 *	49300 *
75	0	48727	48727
100	0	46654	46654
125	0	43491	43491
150	1	40754	40754
175	1	37856	37856
200	1	35805	35805
250	2	32539	32539
300	2	29792	29792
400	2	24654	24654
500	2	20472	20472
600	2	18125	18125
700	2	17129	17129
800	2	16807	16807

*Maximum

Table 17. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Dolly Varden (Bull Trout) at Icicle III.

Discharge	Habitat Spawning	Habitat Adult	Habitat Juvenile
50	2	50337	67798
75	2	52175 *	68116 *
100	2	51439	67531
125	2	49716	65788
150	2	47429	63646
175	2	45004	59845
200	2	42899	57005
250	3	40148	51077
300	4	37430	45703
400	4	32745	39105
500	4	27371	34297
600	3	23989	31068
700	2	22235	28518
800	2	21552	26464

*Maximum

Table 18. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Mountain Whitefish at Icicle III.

Discharge	Habitat		
	Spawning	Adult	Juvenile
50	1477	7501	32423
75	2115	10964	41315
100	2671	14762	47533
125	3135	18329	52384
150	3483	21438	54911
175	3800	24062	56623
200	4005	26102	57314 *
250	4077 *	29159	55771
300	3913	31485	52102
400	2923	33184 *	46911
500	2505	31700	42737
600	2176	31486	38918
700	1960	30917	35132
800	1845	30647	32774

*Maximum

Table 19. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Steelhead Trout at Icicle III.

Discharge	Habitat	
	Spawning	Juvenile
50	64	53088
75	171	61125
100	298	66507
125	490	70279
150	984	70955 *
175	1444	70833
200	1693	70151
250	2131	67805
300	2440 *	64334
400	2197	57018
500	1150	51218
600	710	46884
700	419	43614
800	275	41272

*Maximum

Table 20. Discharge vs Square Feet of Available Habitat Per 1,000 Feet of Stream For Spring Chinook Salmon at Icicle III.

Discharge	Habitat: Spawning	Habitat: Juvenile
50	42	31417
75	160	36098
100	360	38116
125	637	38619 *
150	967	37899
175	1262	36533
200	1509	34885
250	1614	32615
300	1707 *	30544
400	1569	26882
500	869	23966
600	501	20867
700	332	18563
800	234	17169

*Maximum

PROJECT IMPACTS

The fish habitat versus discharge relationships for the species of interest show the same pattern for each of the two reaches (Icicle I and III). The primary difference is that Icicle I requires somewhat higher discharges to reach peak habitat values. Luckily, natural inflow between the two areas provides the necessary additional flow to reach a balance. In general, discharges necessary to meet goals at Icicle I will be met automatically if goals are met at Icicle III. For example, adult rainbow trout habitat is maximized at Icicle III by a discharge of 250 cfs. Icicle I is very nearly maximized at 300 cfs. Allowing a flow of 250 cfs at Icicle III will result in a discharge of 313 cfs at Icicle I. This is based on data received from the COE (Paul Cook, ERS, personal communication) indicating that the flow at Icicle III will represent about 80% of the total flow at Icicle I.

Resident fish spend their entire lives in fresh water; as a result, both adults and juvenile are always present. In the analysis of the potential project impact on fish populations, the adult habitat requirements were utilized to represent the historical habitat levels. This lifestage is considered to be the most critical based on the following factors: the overwinter survival of adults determines the next year's spawning population; and adult habitat are is generally less than juvenile habitat at low flows, especially for rainbow trout.

Adult Habitat.

As can be seen in figures 2 and 30, project operations will significantly reduce the discharges in the study area. Figure 50 clearly identifies both losses and gains in adult rainbow trout habitat under project conditions at Icicle I. In the spring, a positive project benefit to adult rainbow trout habitat occurs due to the project's reduction of the annual spring freshet. However, as previously stated, it is the late summer and fall flows which are most critical to fish survival, and which appear to be limiting the populations in Icicle Creek. Unfortunately, it is during this time that highly significant adult habitat reductions would occur under project operations. Beginning in September, flows would be reduced to levels about 50 percent of natural flows. This results in adult rainbow trout habitat losses sometimes exceeding 70 percent in Icicle I. Figure 51 demonstrates this same effect for adult rainbow habitat at Icicle III.

It should be noted that while figures 50 an 51 show a continued wide disparity between habitat availability during natural and project flows during the months of November, December, January, and February, this does not represent as severe an impact as it would during the late summer and fall months. As previously stated, fish are generally inactive during the winter, and their habitat needs are reduced.

Significant adult habitat losses during the critical late summer-winter periods were also noted for cutthroat and whitefish at both study reaches (Tables 21 and 22). The reasons for such declines are easily seen in the adult habitat/discharge relationship for each of these three species. The natural flows during most of these months provide nearly

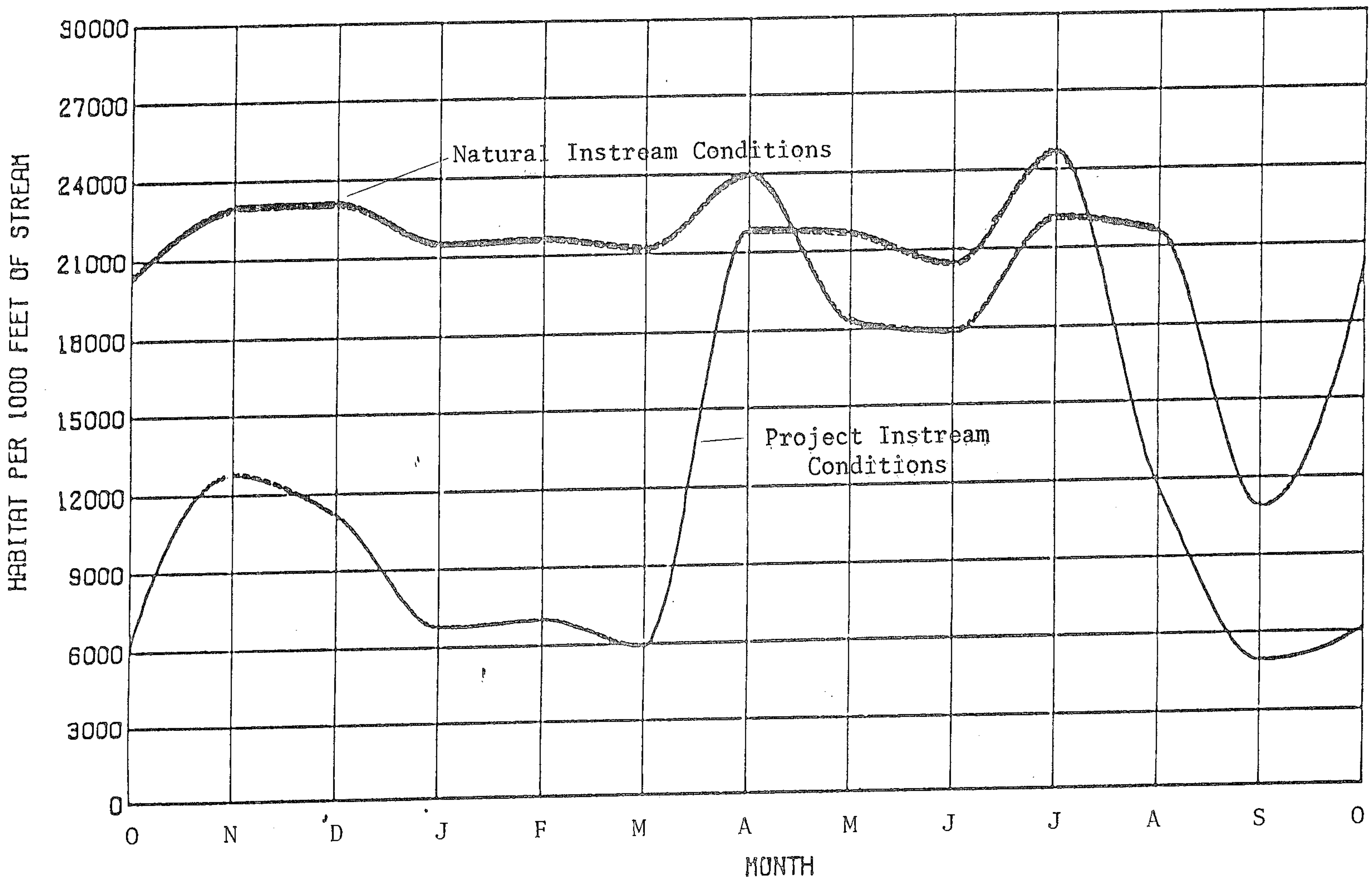


FIGURE 50. ADULT RAINBOW TROUT HABITAT AVAILABLE AT MEAN MONTHLY NATURAL AND POTENTIAL PROJECT FLOWS FOR ICICLE III.

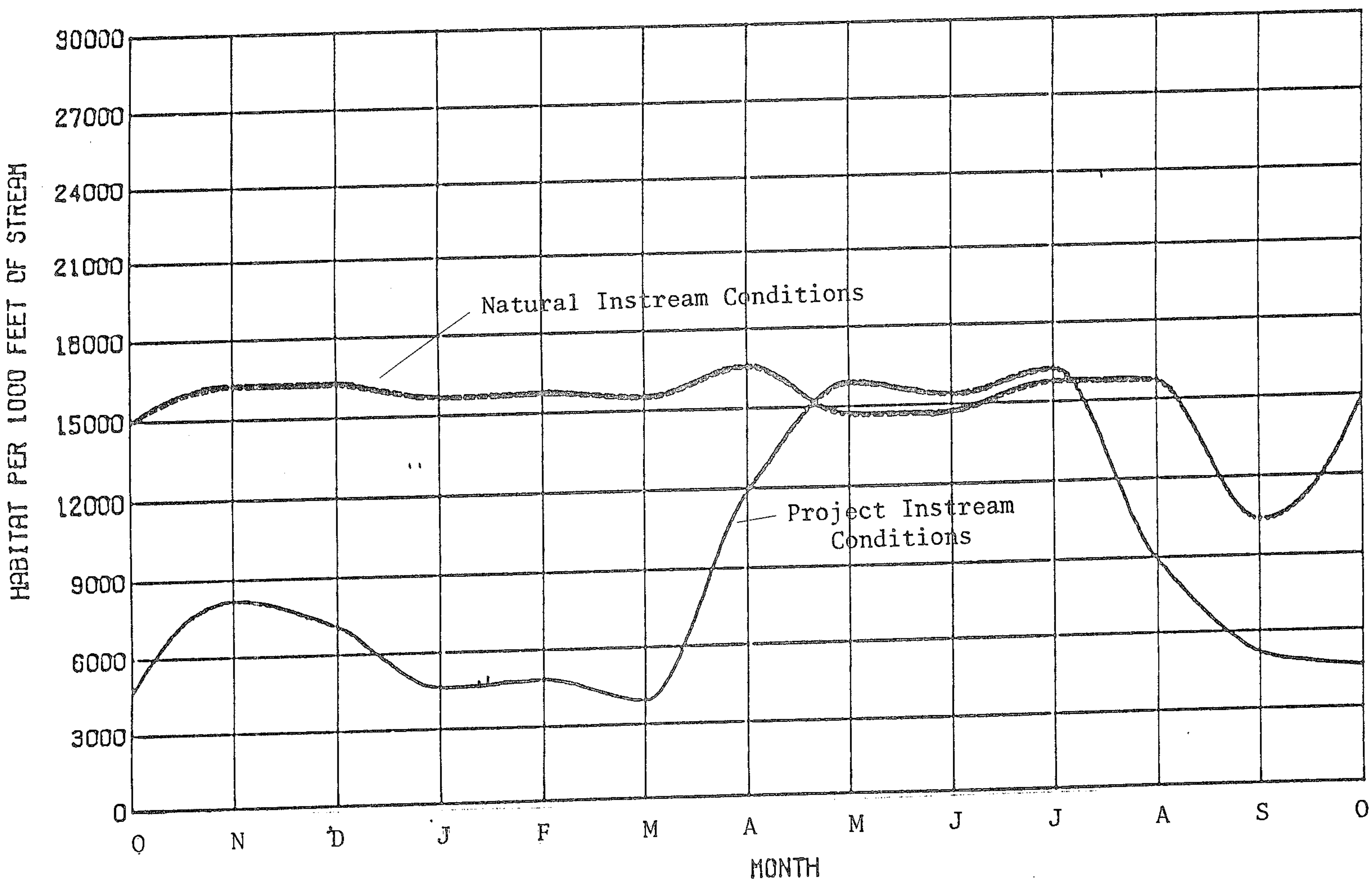


FIGURE 51. ADULT RAINBOW TROUT HABITAT AVAILABLE AT MEAN MONTHLY NATURAL AND PROPOSED PROJECT FLOWS FOR ICICLE III.

maximum adult habitat, while project discharges would reduce the amount of habitat available to the fish.

Table 21. Changes in Predicted Adult Habitat Under Project Versus Natural Flow Conditions at Icicle I.

Month	Discharge		Habitat Change Under Project Conditions				
	Natural	Project	Rainbow	Cutthroat	Brook T.	Dolly V.	Whitefish
October	244	126	-70%	-30%	+40%	+30%	-43%
November	339	177	-44%	-10%	+34%	+26%	-37%
December	341	166	-52%	-13%	+40%	+30%	-41%
January	268	131	-69%	-28%	+43%	+32%	-45%
February	271	133	-68%	-27%	+43%	+32%	-44%
March	261	124	-72%	-31%	+41%	+34%	-46%
April	650	277	-9%	+97%	+55%	+48%	-35%
May	1715 *	1024 *	+19%	+32%	+5%	+10%	+3%
June	1999 *	1272 *	+14%	+44%	+9%	+12%	+3%
July	923 *	505	+11%	+61%	+22%	+27%	+28%
August	270	170	-47%	-16%	+28%	+24%	-31%
September	164	115	-55%	-20%	+13%	+6%	-25%

* Projections beyond 800 cfs subject to increasing unreliable velocity adjustment factors.

Table 22. Changes in Predicted Adult Habitat Under Project Versus Natural Flow Conditions at Icicle III.

Month	Discharge		Habitat Change Under Project Conditions				
	Natural	Project	Rainbow	Cutthroat	Brook T.	Dolly V.	Whitefish
October	195	77	-69%	-36%	+34%	+21%	-56%
November	271	109	-50%	-24%	+45%	+31%	-47%
December	273	98	-57%	-29%	+49%	+33%	-52%
January	214	77	-71%	-37%	+39%	+24%	-58%
February	217	79	-69%	-36%	+40%	+24%	-58%
March	209	71	-75%	-40%	+39%	+23%	-61%
April	520	147	-28%	+12%	+108%	+81%	-33%
May	1372 *	681	+8%	+43%	+5%	+10%	+5%
June	1599 *	872 *	+4%	+35%	+M%	+3%	+1%
July	738	320	+3%	+44%	+69%	+66%	+4%
August	216	116	-44%	-20%	+28%	+20%	-37%
September	131	82	-50%	-24%	+13%	+6%	-37%

Minimal (M) - Less than 1 percent
* - Projections beyond 800 cfs subject to increasing unreliable velocity adjustment factors.

The brook trout and Dolly Varden show positive adult habitat benefits from projected flow reductions every month. It appears that this advantage may start to evaporate at discharges below 100 cfs at Icicle I and below 50 cfs at Icicle III.

Spawning Habitat.

Within the potential project area, both fall and spring spawning fish occur. Table 23 presents the approximate spawning periods of fish in Icicle Creek.

Table 23. Approximate Spawning Periods of Fish in Icicle Creek.

Species	J	F	M	A	M	J	J	A	S	O	N	D
Rainbow trout				X	X	X						
Cutthroat trout				X	X	X						
Brook trout									X	X		
Dolly Varden									X	X		
Mountain Whitefish										X	X	
Summer Steelhead *			X	X								
Spring Chinook *								X	X			

* Not presently inhabiting project area.

Most of the potential spawning area for all species occurs in Icicle I and especially Icicle II. Fall spawning fish will suffer substantial reductions of spawning habitat under the potential project. Dolly Varden habitat may be significantly reduced and the minimal brook trout habitat eliminated. Spring spawning fish may incur either positive or negative habitat benefits depending on when they spawn during the spring months.

The analysis contained in this report is based upon mean monthly flows for the years 1937 through 1971. Mean monthly flows tend to mask high or low flows of short duration. Use of daily instantaneous low flow records would have undoubtedly presented less favorable habitat than did the mean monthly records, for both the natural and project flows during short duration periods of low flow, and could be expected to predict impacts more pronounced than those discussed in this report. Such things as redd dewatering, juvenile and adult stranding, and temperature changes can have profound impacts on fish populations during natural short term flow reductions, and may be exaggerated by with-project conditions.

The primary period of concern for fish in Icicle Creek is the late summer and fall season. Alterations of project water withdrawls allowing for more instream flows during this period could reduce the negative impact. However, almost any diversion at this time of year will reduce critical habitat from that available with the present situation.

Literature Cited

Bell, C. B. 1984. Fisheries handbook of engineering requirements and biological criteria, Fish Passage Development and Evaluation Program, Corps of Engineers, North Pacific Division, Portland, OR. 290 pp.

Bovee, K. D. 1978. Probability of Use Criteria For the Family Salmonidae. IFIP No. 4. Cooperative Instream Flow Service Group, Fort Collins, Colorado. 88 pp.

Milhous, R. T., D. L. Wegner, and T. Waddle. 1981. User's guide to the physical habitat simulation system. Instream Flow Information Paper II. USDI, Fish and Wildlife Service, Washington, D.C. FWS/OBS-81/43 254 pp.

Trihey, E., and D. L. Wegner. 1981. Field data collection procedures for use with the physical habitat simulation system of the Instream Flow Group. Cooperative Instream Flow Service Group, Ft. Collins, Colorado. 151 pp.

APPENDIX I

Generalized Life History of Selected Species in Western United States (Bell, 1984)

Species	Age at Maturity (in Yrs)	Weight (in Lbs)	Average No. Eggs	Fresh Water Rearing	Time in Ocean	Preferred Temperature	Spawning Time	Egg Incubation	Remarks
Rainbow Trout	3-4	1/4-42	1,500	Life	-----	50-58° F.	Spring	April-June depending on temperature.	Nest Builder
Cutthroat Trout	3-4	1/4-17	800-1,200	Life	-----	50° F.	Feb-May	Feb-May	Nest Builder
Brook Trout (Char)	3-4	1/8-5	500-2,500	Life	-----	50-55° F.	Fall	Sept-Dec depending on water temp.	Nest Builder
Dolly Varden (Char) Bull Trout	4-6	1/4-20	1,500-3,500	Life	-----	50-55° F.	Sept-Nov	Sept-March depending on water temp.; Most in March	Nest Builder
Rocky Mtn. Whitefish	3-4	1/8-4	2,500	Life	-----	45-50° F.	Fall (Oct-Nov) spawn from 42° down to 32° F. on falling temp.	Oct thru Mar. (hatch mainly in March at 40°-42° F.	No Nest
Summer Steelhead	3-4	4-12	2,500	1-2 yrs	1-3 yrs	50-55° F.	Feb-March	Feb-April	Nest Builder
Spring Chinook	4-6	10-20	5,000	1 yr or longer	2-5 yrs	50-55° F.	Aug-late Sept	Oct-mid January	Nest Builder

[illegible]

NO 5 RAINBOW TROUT SPAWNING CURVE NO. [illegible]

VELOCITY DATA

VELOCITY	0.00	.50	.80	1.30	1.50	1.90	2.10	3.10	99.90
INDEX	0.00	0.00	.45	.95	1.00	1.00	.95	0.00	0.00

DEPTH DATA

DEPTH	0.00	.10	.60	.90	2.00	3.00	99.00
INDEX	0.00	[illegible]	1.00	1.00	.15	0.00	0.00

SUBSTRATE DATA

SUBSTRATE	0.00	44.[illegible]	44.50	45.50	[illegible]	[illegible]	[illegible]	47.[illegible]	48.00	[illegible]
INDEX	0.00	0.00	.10	.50	.10	[illegible]	.10	.10	0.00	[illegible]
SUBSTRATE	50.00	50.60	50.90	51.00	51.[illegible]	51.80	52.00	52.60	52.[illegible]	[illegible]
INDEX	0.00	0.00	.40	0.00	0.00	.40	0.00	0.00	.60	0.00
SUBSTRATE	53.60	53.[illegible]	54.50	54.[illegible]	55.30	56.50	56.90	57.50	57.[illegible]	58.50
INDEX	0.00	[illegible]	.50	.50	.50	.75	.50	[illegible]	.50	.20
SUBSTRATE	[illegible]	[illegible]	59.90	60.00	60.[illegible]	[illegible]	[illegible]	61.[illegible]	61.60	61.70
INDEX	.40	.20	.40	0.00	0.00	.70	.90	0.00	0.00	.70
SUBSTRATE	61.90	62.00	62.60	62.7[illegible]	62.[illegible]	63.00	63.60	63.70	63.90	64.50
INDEX	[illegible]	0.00	0.00	.70	.50	0.00	0.00	.70	.50	.50
SUBSTRATE	65.90	66.50	67.50	67.90	68.[illegible]	68.90	69.50	69.90	70.00	70.70
INDEX	1.00	1.00	.50	1.00	.50	.90	.50	.50	0.00	0.00
SUBSTRATE	70.90	71.00	71.70	71.[illegible]	72.00	72.70	72.90	73.[illegible]	73.[illegible]	73.90
INDEX	.10	0.00	0.00	.10	0.00	0.00	.10	0.00	0.00	.10
SUBSTRATE	74.50	74.90	75.50	75.90	75.50	76.90	77.50	78.[illegible]	78.90	79.50
INDEX	.10	.10	.30	.10	.50	.10	.10	0.00	.10	0.00
SUBSTRATE	79.90	80.00	99.90							
INDEX	.10	0.00	0.00							

[illegible]

NO. 8 RAINBOW TROUT ADULT CURVE NO. 10402

VELOCITY DATA

VELOCITY	0.00	.70	1.00	1.20	1.50	1.90	4.00	99.90
WEIGHT	0.00	.10	.30	1.00	1.00	.60	0.00	0.00

DEPTH DATA

DEPTH	0.00	[illegible]	1.95	2.70	99.90
WEIGHT	0.00	.10	.20	1.00	1.00

SUBSTRATE DATA

SUBSTRATE	0.00	99.90
SIZE	1.00	1.00

[illegible]

[illegible] RAINBOW TROUT JUVENILE CURVE NO. 10403

VELOCITY DATA

VELOCITY	0.00	.20	.30	.80	1.50	3.00	4.10	99.90
INDEX	0.00	.90	1.00	1.00	.70	.15	0.00	0.00

DEPTH DATA

DEPTH	0.00	.30	.60	.70	99.90
INDEX	0.00	.00	.90	1.00	1.00

SUBSTRATE DATA

SUBSTRATE	0.00	99.90
INDEX	1.00	1.00

NO. 11 CUTTHROAT TROUT SPAWNING CURVE NO. 10501

VELOCITY DATA

VELOCITY	0.00	.30	.60	.65	.80	1.10	1.50	1.70	2.20	3.40
INDEX	0.00	0.00	.90	.95	1.00	1.00	.40	.20	.05	0.00
VELOCITY	99.90									
INDEX	0.00									

DEPTH DATA

DEPTH	0.00	.20	.40	.70	.80	.90	1.40	99.90
INDEX	0.00	0.00	[illegible]	1.00	1.00	.95	0.00	0.00

SUBSTRATE DATA

SUBSTRATE	0.00	44.40	44.50	45.50	45.90	46.50	46.90	47.50	48.00	49.90
INDEX	0.00	0.00	.10	.30	.10	.50	[illegible]	.10	0.00	0.00
SUBSTRATE	50.00	50.60	50.90	51.00	51.40	51.50	52.00	52.50	52.90	53.00
INDEX	0.00	0.00	.40	0.00	0.00	.20	0.00	[illegible]	[illegible]	0.00
SUBSTRATE	53.60	53.90	54.50	54.90	55.50	56.50	56.90	57.50	57.90	58.50
INDEX	0.00	.40	.30	.50	.50	.75	.50	[illegible]	.50	.20
SUBSTRATE	58.90	59.50	59.90	60.00	60.60	60.70	60.90	61.00	61.60	61.70
INDEX	.40	.20	.40	0.00	0.00	.70	.50	0.00	0.00	.70
SUBSTRATE	61.90	62.00	62.60	62.70	62.90	63.00	63.50	63.70	63.90	64.50
INDEX	.90	0.00	0.00	.70	.90	0.00	0.00	.70	[illegible]	.50
SUBSTRATE	65.90	66.50	67.50	67.90	68.50	68.90	69.50	69.90	70.00	70.70
INDEX	1.00	1.00	.50	1.00	.50	.90	.50	.90	0.00	0.00
SUBSTRATE	70.90	71.00	71.70	71.90	72.00	72.70	72.90	73.00	73.70	73.90
INDEX	.10	0.00	0.00	.10	0.00	0.00	.10	0.00	0.00	.10
SUBSTRATE	74.30	74.90	75.50	75.90	76.50	76.90	77.50	78.50	78.90	79.50
INDEX	.10	.10	.30	.10	.50	.10	.10	0.00	.10	0.00
SUBSTRATE	79.90	80.00	99.90							
INDEX	.10	0.00	0.00							

NO. 12 CUTTHROAT TROUT   ADULT   CURVE NO. 10502

VELOCITY DATA

VELOCITY	0.00	.10	.40	.60	1.00	1.20	1.70	1.90	2.40	3.00
INDEX	0.00	0.00	.50	.80	.95	1.00	1.00	.95	.60	0.00
VELOCITY	99.90									
INDEX	0.00									

DEPTH DATA

DEPTH	0.00	.50	1.20	1.80	2.40	3.20	4.50	5.50	5.50	99.90
INDEX	0.00	0.00	1.00	1.00	.60	.40	.20	.10	0.00	0.00

SUBSTRATE DATA

SUBSTRATE	0.00	99.90
INDEX	1.00	1.00

[illegible] [illegible] 13.0[illegible]

NO. 13 CUTTHROAT TROUT JUVENILE CURVE NO. 10503

VELOCITY DATA

VELOCITY	0.00	.10	.20	.50	.60	1.10	1.70	2.00	2.40	3.00
INDEX	0.00	0.00	.20	.95	1.00	1.00	.80	.40	.15	0.00
VELOCITY	99.90									
INDEX	0.00									

DEPTH DATA

DEPTH	0.00	.50	1.20	1.30	1.60	2.50	4.10	99.90
INDEX	0.00	0.00	.95	1.00	1.00	.60	0.00	0.00

SUBSTRATE DATA

SUBSTRATE	0.00	99.90	100.00	999.00
INDEX	1.00	1.00	0.00	0.00

NO. 17 EASTERN BROOK TROUT SPAWNING CURVE NO. 10701

VELOCITY DATA

VELOCITY	0.00	.20	.50	.60	1.10	1.20	1.80	2.10	99.90
INDEX	0.00	.60	.95	1.00	1.00	.95	.10	0.00	0.00

DEPTH DATA

DEPTH	0.00	.40	.50	.70	.80	2.00	4.00	99.90
INDEX	0.00	.75	1.00	1.00	.90	.10	0.00	0.00

SUBSTRATE DATA

SUBSTRATE	0.00	40.60	40.70	40.90	41.00	41.60	41.70	41.90	42.00	42.60
INDEX	0.00	0.00	.50	.70	0.00	0.00	.50	.70	0.00	0.00
SUBSTRATE	42.70	42.90	43.00	43.60	43.70	43.90	44.50	45.50	45.90	46.50
INDEX	.60	.80	0.00	0.00	.70	.90	1.00	.90	1.00	.50
SUBSTRATE	46.90	47.50	47.90	48.50	48.90	49.50	49.90	50.00	50.60	50.70
INDEX	.90	.40	.60	.30	.70	.20	.60	0.00	0.00	.30
SUBSTRATE	50.90	51.00	51.40	51.70	51.90	52.00	52.60	52.70	52.90	53.00
INDEX	.50	0.00	0.00	.30	.50	0.00	0.00	.40	.60	0.00
SUBSTRATE	53.60	53.70	53.90	54.50	54.90	55.50	56.50	56.90	57.50	57.90
INDEX	0.00	.50	.70	.90	.80	.80	.40	.70	.40	.70
SUBSTRATE	58.50	58.90	59.50	59.90	60.00	64.40	64.50	64.90	65.50	65.90
INDEX	.30	.60	.20	.50	0.00	0.00	.40	0.00	.30	0.00
SUBSTRATE	74.40	74.50	74.90	75.50	75.90	99.90				
INDEX	0.00	.30	0.00	.20	0.00	0.00				

[illegible] 83/02/30. 11.58.42.

NO. 18 EASTERN BROOK TROUT ADULT CURVE NO. 10702

VELOCITY DATA

VELOCITY	0.00	.30	.50	.80	1.00	1.30	3.90	99.90
INDEX	1.00	1.00	.95	.80	.50	.10	0.00	0.00

DEPTH DATA

DEPTH	0.00	.10	.35	.55	.85	99.90
INDEX	0.00	0.00	.60	.80	1.00	1.00

SUBSTRATE DATA

SUBSTRATE	0.00	99.90
INDEX	1.00	1.00

[illegible]

NO. 19 EASTERN BROOK TROUT — JUVENILE — CURVE NO. 10703

VELOCITY DATA

VELOCITY	0.00	.30	.50	.80	1.00	1.30	3.90	99.90
INDEX	1.00	1.00	.95	.80	.50	.10	0.00	0.00

DEPTH DATA

DEPTH	0.00	.10	.25	.55	.95	99.90
INDEX	0.00	0.00	.60	.80	1.00	1.00

SUBSTRATE DATA

SUBSTRATE	0.00	99.90	100.00	999.00
INDEX	1.00	1.00	0.00	0.00

NO. 21   DOLLY VARDEN (BULL TROUT)   SPAWNING   CURVE NO.   10901

VELOCITY DATA

VELOCITY	0.00	.80	1.20	2.00	99.90
INDEX	0.00	1.00	1.00	0.00	0.00

DEPTH DATA

DEPTH	0.00	.30	.60	.90	1.10	1.50	2.00	5.00	99.90
INDEX	0.00	.10	1.00	1.00	.50	.20	.10	0.00	0.00

SUBSTRATE DATA

SUBSTRATE	0.00	44.40	44.50	45.50	45.90	46.50	46.90	47.90	48.00	49.90
INDEX	0.00	0.00	.10	.30	.10	.50	.10	.10	0.00	0.00
SUBSTRATE	50.00	50.60	50.90	51.00	51.60	51.90	52.00	52.60	52.90	53.00
INDEX	0.00	0.00	.40	0.00	0.00	.40	0.00	0.00	.40	0.00
SUBSTRATE	53.60	53.90	54.50	54.90	55.50	56.[illegible]	56.90	57.50	57.90	58.50
INDEX	0.00	.40	.30	.50	.50	.70	.50	.30	.50	.20
SUBSTRATE	58.90	59.50	59.90	60.00	60.60	60.70	60.90	61.00	61.60	61.70
INDEX	.40	.20	.40	0.00	0.00	.70	.90	0.00	0.00	.70
SUBSTRATE	61.90	62.00	62.60	62.70	62.90	63.00	63.60	63.70	63.90	64.50
INDEX	.90	0.00	0.00	.70	.90	0.00	0.00	.70	.90	.50
SUBSTRATE	65.50	66.50	67.50	67.90	68.50	68.90	69.50	69.[illegible]	70.00	70.70
INDEX	1.00	1.00	.50	1.00	.50	.90	.50	.90	0.00	0.00
SUBSTRATE	70.90	71.00	71.70	71.90	72.00	72.70	72.90	73.[illegible]	73.70	73.90
INDEX	.10	0.00	0.00	.10	0.00	0.00	.10	0.00	0.00	.10
SUBSTRATE	74.50	74.90	75.50	75.90	76.50	76.90	77.50	77.50	78.90	79.50
INDEX	.10	.10	.30	.10	.50	.10	.10	0.00	.10	0.00
SUBSTRATE	79.90	80.00	99.90							
INDEX	.10	0.00	0.00							

[illegible] [illegible]

NO. 22 DOLLY VARDEN (BULL TROUT) ADULT CURVE NO. 10902

VELOCITY DATA

VELOCITY	0.00	.50	1.00	1.30	4.00	99.90
INDEX	1.00	1.00	.90	.20	0.00	0.00

DEPTH DATA

DEPTH	0.00	.10	.50	.80	99.90
INDEX	0.00	0.00	.40	1.00	1.00

SUBSTRATE DATA

SUBSTRATE	0.00	99.90
INDEX	1.00	1.00

NO. 23 DOLLY VARDEN (BULL TROUT) JUVENILE CURVE NO. 10903

VELOCITY DATA

VELOCITY	0.00	.50	.60	2.50	3.00	99.90
INDEX	1.00	1.00	.80	.05	0.00	0.00

DEPTH DATA

DEPTH	0.00	.20	2.20	6.00	99.90
INDEX	0.00	1.00	1.00	0.00	0.00

SUBSTRATE DATA

SUBSTRATE	0.00	99.90
INDEX	1.00	1.00

NO. [illegible] ROCKY MOUNTAIN WHITEFISH   SPAWNING   CURVE NO. 10601

VELOCITY DATA

VELOCITY	0.00	1.50	1.80	2.80	3.30	99.90
INDEX	0.00	1.00	1.00	.10	0.00	0.00

DEPTH DATA

DEPTH	0.00	.30	.90	99.90
INDEX	0.00	0.00	1.00	1.00

SUBSTRATE DATA

SUBSTRATE	0.00	44.50	45.50	45.90	46.50	46.90	47.50	47.90	48.50	48.90
INDEX	0.00	.10	.30	.10	.50	.10	.50	.10	.50	.10
SUBSTRATE	49.50	49.90	50.50	50.90	51.90	52.50	52.90	53.50	53.90	54.50
INDEX	0.00	0.00	0.00	.40	.40	0.00	.40	0.00	.40	.20
SUBSTRATE	54.90	55.50	56.50	56.90	57.50	57.90	58.50	59.50	59.90	60.50
INDEX	.50	.50	.70	.50	.70	.50	.30	.20	.40	0.00
SUBSTRATE	60.70	60.90	61.50	61.70	61.90	62.00	62.60	62.70	62.90	63.00
INDEX	.70	.90	0.00	.70	.90	0.00	0.00	.70	.90	0.00
SUBSTRATE	63.60	63.70	63.90	64.50	64.90	65.50	65.90	67.90	68.50	68.90
INDEX	0.00	.70	.90	.50	1.00	.70	1.00	1.00	.70	1.00
SUBSTRATE	69.50	69.90	70.00	70.60	70.70	70.90	71.00	71.60	71.70	71.90
INDEX	.50	.90	0.00	0.00	.70	.90	0.00	0.00	.70	.90
SUBSTRATE	72.00	72.60	72.70	72.90	73.00	73.60	73.70	73.90	74.50	74.90
INDEX	0.00	0.00	.70	.90	0.00	0.00	.70	.90	.50	1.00
SUBSTRATE	75.50	75.90	77.50	78.50	78.90	79.50	79.90	80.50	80.90	81.50
INDEX	.70	1.00	1.00	.70	1.00	.30	.90	0.00	.40	0.00
SUBSTRATE	81.90	82.50	82.90	83.50	83.90	84.50	84.90	85.50	86.50	86.90
INDEX	.40	0.00	.40	0.00	.40	.20	.50	.50	.70	.50
SUBSTRATE	87.50	87.90	88.50	89.50	89.90	90.00	99.90	0.00		
INDEX	.70	.50	.50	.20	.40	0.00	0.00	0.00		

[illegible] - CURVE STATION NO. [illegible]

NO. 15 ROCKY MOUNTAIN WHITEFISH ADULT CURVE NO. 10602

VELOCITY DATA

VELOCITY	0.00	1.00	1.30	2.20	2.80	3.30	3.50	4.20	99.90
INDEX	.60	.80	1.00	1.00	.65	.20	.07	0.00	0.00

DEPTH DATA

DEPTH	0.00	.50	1.00	2.00	2.50	99.90
INDEX	0.00	0.00	.10	.40	1.00	1.00

SUBSTRATE DATA

SUBSTRATE	0.00	99.90
INDEX	1.00	1.00

NO. 16 ROCKY MOUNTAIN WHITEFISH JUVENILE CURVE NO. 10605

VELOCITY DATA

VELOCITY	0.00	1.10	1.30	1.50	2.00	3.70	99.90
INDEX	.55	.95	1.00	1.00	.35	0.00	0.00

DEPTH DATA

DEPTH	0.00	.50	1.00	1.10	2.80	2.90	3.20	5.00	[illegible].90
INDEX	0.00	0.00	.90	1.00	1.00	.90	.50	.40	.40

SUBSTRATE DATA

SUBSTRATE	0.00	99.90
INDEX	1.00	1.00

NO. 6 STEELHEAD TROUT SPAWNING CURVE NO. 10301

VELOCITY DATA

VELOCITY	0.00	.80	1.50	1.80	2.00	2.50	2.70	3.00	4.20	99.90
INDEX	0.00	0.00	.30	.95	1.00	1.00	.95	.25	0.00	0.00

DEPTH DATA

DEPTH	0.00	.30	.80	.90	1.20	1.50	2.30	4.20	99.90
INDEX	0.00	0.00	.95	1.00	1.00	.75	.50	0.00	0.00

SUBSTRATE DATA

SUBSTRATE	0.00	46.40	46.50	46.90	47.50	47.90	48.90	49.00	53.60	53.90
INDEX	0.00	0.00	.50	0.00	.50	0.00	.10	0.00	0.00	.10
SUBSTRATE	54.50	54.70	56.50	56.90	57.50	57.90	58.50	58.90	59.00	60.60
INDEX	.10	.10	.50	.10	.50	.10	.10	.10	0.00	0.00
SUBSTRATE	60.70	60.90	61.00	61.60	61.70	61.90	62.00	62.60	62.70	62.90
INDEX	.50	.90	0.00	0.00	.50	.90	0.00	0.00	.50	.20
SUBSTRATE	63.00	63.60	63.70	63.90	64.50	64.90	65.50	65.90	66.50	68.50
INDEX	0.00	0.00	.50	.90	.50	1.00	.50	1.00	1.00	.50
SUBSTRATE	68.90	69.50	69.90	70.00	70.60	70.70	70.90	71.00	71.60	71.70
INDEX	1.00	.50	.90	0.00	0.00	.50	.90	0.00	0.00	.50
SUBSTRATE	71.90	72.00	72.60	72.70	72.90	73.00	73.60	73.70	73.90	77.50
INDEX	.90	0.00	0.00	.50	.90	0.00	0.00	.50	.90	.50
SUBSTRATE	74.90	75.50	75.90	77.50	78.50	78.90	79.50	79.90	80.40	84.40
INDEX	1.00	.50	1.00	1.00	.50	1.00	.50	.90	0.00	0.00
SUBSTRATE	84.50	85.90	86.50	86.90	87.50	87.90	88.50	89.00	99.90	
INDEX	.10	.10	.50	.10	.50	.90	.10	0.00	0.00	

[illegible] CURVE [illegible]

[illegible] 13.51.41.

NO. 7 STEELHEAD TROUT JUVENILE CURVE NO. 10302

VELOCITY DATA

VELOCITY	0.00	.20	.30	.80	1.50	3.00	4.10	99.90
IDATE.	0.00	.90	1.00	1.00	.70	.15	0.00	0.00

DEPTH DATA

DEPTH	0.00	.20	.60	.70	99.90
IDATE.	0.44	.0?	.90	1.00	1.00

SUBSTRATE DATA

SUBSTRATE	0.0?	99.90
INDEX	1.00	1.00

TITLE OF SUITABILITY-OF-USE CRITERIA CURVES   FILE IS-

SS CODE: 4=.1-.5" 5=.5-1.5" 6=1.5-3" 7=3-6" 8=6-12" 9=12+"

NO. 1 SPRING CHINOOK   SPAWNING   CURVE NO. 10101

VELOCITY DATA

VELOCITY	0.00	.50	1.00	1.30	1.90	2.60	2.75	2.95	3.25	3.80
INDEX	0.00	0.00	.10	.30	1.00	1.00	.65	.64	.46	0.00
VELOCITY	99.90									
INDEX	0.00									

DEPTH DATA

DEPTH	0.00	.20	.50	.90	[illegible]	[illegible]	1.55	[illegible]	3.20	99.90
INDEX	0.00	0.00	.10	1.00	[illegible]	.87	.56	.15	0.00	0.00

SUBSTRATE DATA

SUBSTRATE	0.00	46.40	46.50	46.90	47.50	47.90	48.90	49.00	53.40	53.90
INDEX	0.00	0.00	.50	0.00	.50	0.00	.10	0.00	0.00	.10
SUBSTRATE	54.50	56.40	56.50	56.90	57.50	57.90	58.50	58.90	59.30	60.60
INDEX	.10	.10	.50	.10	.50	.10	.10	.10	0.00	0.00
SUBSTRATE	60.70	60.90	61.00	61.60	61.70	61.90	62.00	62.40	62.70	62.90
INDEX	.50	.90	0.00	0.00	.50	.90	0.00	0.00	.50	.90
SUBSTRATE	68.00	68.60	68.70	68.90	64.50	64.90	65.50	65.90	66.50	68.50
INDEX	0.00	0.00	.50	.90	.50	1.00	.50	1.00	1.00	.50
SUBSTRATE	68.90	69.50	69.90	70.00	70.60	70.70	70.90	71.00	71.60	71.70
INDEX	1.00	.50	.90	0.00	0.00	.50	.90	0.00	0.00	.50
SUBSTRATE	71.90	72.00	72.60	72.70	72.90	73.00	73.60	73.70	73.90	74.50
INDEX	.90	0.00	0.00	.50	.90	0.00	0.00	.50	.90	.50
SUBSTRATE	74.90	75.50	75.90	77.50	75.50	75.90	79.50	77.90	80.00	87.40
INDEX	1.00	.50	1.00	1.00	.50	.90	.50	.50	0.00	0.00
SUBSTRATE	87.50	85.90	86.50	86.90	87.50	87.80	88.50	89.00	99.90	
INDEX	.10	.10	.50	.10	.50	.90	.10	0.00	0.00	

[illegible]

NO. 2 SPRING CHINOOK JUVENILE CURVE NO. 10102

VELOCITY DATA

VELOCITY	0.00	.25	.50	.70	1.10	1.40	2.00	3.00	99.90
INDEX	0.00	.80	1.00	1.00	.80	.40	.10	0.00	0.00

DEPTH DATA

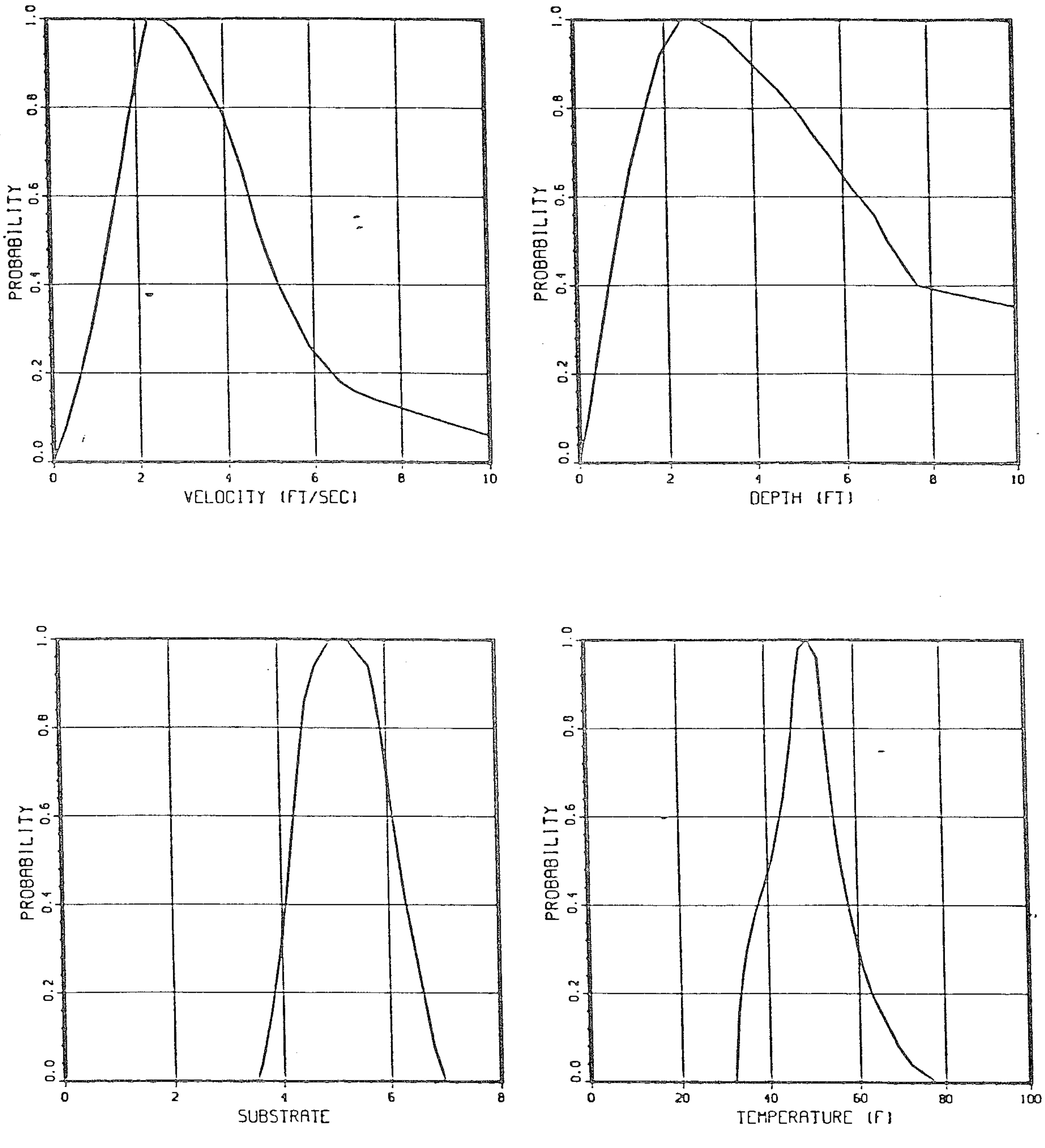
DEPTH	0.00	.70	1.00	1.20	99.90
INDEX	0.00	.20	.70	1.00	1.00

SUBSTRATE DATA

SUBSTRATE	0.00	99.90	100.00	999.00
INDEX	1.00	1.00	0.00	0.00

BROWN TROUT (TURBID WATER, S=.001)

11322 INCUBATION 78/01/24.



FY-85 Budget File Copy

Icicle Creek IFIM Study
Budget Estimate

FY 1984:

Personnel	
GS-13 2 man days	$350
GS-12 5 man days	700
GS-11 40 man days	4,400
GS-09 40 man days	3,700
GS-05 36 man days	2,050
Total 123 man days	$11,200
Per Diem	
60 man days x $50.00/day	$3,000
Equipment	
Boat (14')	$1,500
Wet Suits (3)	600
Calibrate flow meter (2)	300
Vehicle rental and mileage	1,200
Tag line	100
Misc.	200
Total	$ 3,900
FAO VANCOUVER SUB-TOTAL	$18,100
Overhead	$6,875
TOTAL FY 1984	$25,000

FY 1985:

Personnel			
Computer work	GS-11	20 man days	$2,200
Report writing	GS-11	20 man days	2,200
Review	GS-13	5 man days	900
Analysis	GS-09	20 man days	1,850
Secretarial	GS-05	5 man days	500
Total 70 man days			$5,800
Computer expenses			750
FAO VANCOUVER SUB-TOTAL FY 85			$6,525
Overhead			$2,475
TOTAL FY 1985			$9,000
TOTAL			$34,000