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INSTREAM FLOW AND FISHERIES REPORT FOR THE BIRCH AND McGEE CREEK SECTIONS OF THE BISHOP CREEK HYDROELECTRIC PROJECT

Prepared for

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INTRODUCTION

This report includes results from studies on Birch Creek and McGee Creek, parts of Southern California Edison Company's Bishop Creek Hydroelectric Project. The Instream Flow Studies on Birch and McGee creeks consisted of collecting data for, and running, the U.S. Fish and Wildlife Service HABTAT model, modified so that each cell on each transect was analyzed using the appropriate one of four cover-specific suitability index curves provided by the U.S. Fish and Wildlife Service (Aceituno et al. unpublished). These studies differed from many previous Instream Flow Incremental Methodology (IFIM) studies in several particulars:

- Extrapolation of data from individual transects to entire study reaches was based on detailed habitat mapping of the entire stream (Morhardt et al., 1983) so that the transects were weighted in relation to their importance within the study reaches and ultimately their importance in the entire stream. This approach resolved the question of whether a particular set of transects was truly representative of the stream.

- The HABTAT model runs were conducted without any hydraulic simulation, using direct measurements of velocity and depth at six different flows. Hydraulic simulation was not used for two reasons: the two creeks are so narrow that it was infeasible to obtain enough points on many of the transects to allow accurate simulations; and at many of the transect locations the stream bed was too irregular to permit accurate simulations.

- The Suitability Index (SI) curves provided by the U.S. Fish and Wildlife Service specifically for this study (Aceituno et al. unpublished) were not based entirely on the frequency distributions of depth and velocity occurring at the locations at which fish were observed as has usually been the case. They were modified by the agencies in some way to reflect the frequency distributions of random observations of depth and velocity in the streams at places where fish were not observed.

- Different SI curves were provided for locations having no cover, object cover, overhead cover, and both object and overhead cover. Except on lower McGee Creek, each measurement point on each transect was coded for one of these conditions and the appropriate SI curve was used in the analysis. On lower McGee Creek, as determined with the agencies in the field, 25 percent of the measurement locations were treated as if they had overhead cover. The overhead cover characteristic was assigned systematically to every fourth vertical location. If that location already had object cover, then it was assigned to the category with both object and overhead cover.

To put the results of the instream flow studies into perspective, quantitative electrofishing was done on both reaches of McGee Creek in August of 1985. At the same time, lower Birch Creek was sampled qualitatively for its species size distributions and composition, but because of the very low flows, no attempt was made to calculate standing crops. The upper reach of Birch Creek had no flows at the time of electrofishing sampling in August.

METHODS

Mapping:

The sections of Birch and McGee Creeks illustrated in Figure 1 were mapped by EA staff prior to selection of study locations, and the linear distances were measured for 6 habitat types: riffle, run, pool, low-gradient cascade, medium-gradient cascade, and high-gradient cascade. These are all characterized in Figures 2a and b. The purpose of the mapping was to allow transects to be distributed in habitats with approximately the same frequency as the habitats occurred in the stream (Morhardt et al., 1983). Table 1 lists the distances in each reach consisting of the various habitat types in Birch and McGee creeks. Cascades of all gradients were combined into a single cascade variable.

Selection of Study Reaches Four study reaches and transect areas were selected in conjunction with personnel from the U.S. Forest Service and the California Department of Fish and Game on Birch and McGee Creeks on the basis of the habitat mapping. They are described below.

Birch Creek, Upper Reach The upper reach of Birch Creek is 27,800 feet long, beginning at the diversion point at the dirt road crossing near the base of the mountains just below the confluence of the South and Middle Forks. The transect area is half a mile downstream from the road crossing.

Birch Creek, Lower Reach The lower reach, 34,700 feet long, extends from the bottom of the upper reach to well out into the alluvial plain. The transect area was placed in a deep canyon directly opposite Starlight Estates, one mile upstream from the Bishop Creek road crossing.

McGee Creek Upper Reach This reach, 24,400 feet long, extends from the diversion points in a steep canyon above the base of the mountains to the lower end of a deeply incised gorge adjacent to the Buttermilk Road. The transect area was just downstream from the dirt road crossing near the upper end of the reach.

McGee Creek, Lower Reach This reach extends from the bottom end of the upper reach 52,608 feet to a point near the Mill Pond Park area. The transect area was in the meadow, 1.5 miles downstream from the bottom end of the upper reach.

Transect Selection:

Twenty-three transects were selected on Birch Creek, and 22 on McGee Creek in the field by a team including representatives from the U.S. Forest Service and the California Department of Fish and Game. The distribution among habitat types on Birch and McGee Creeks are shown in Table 2.

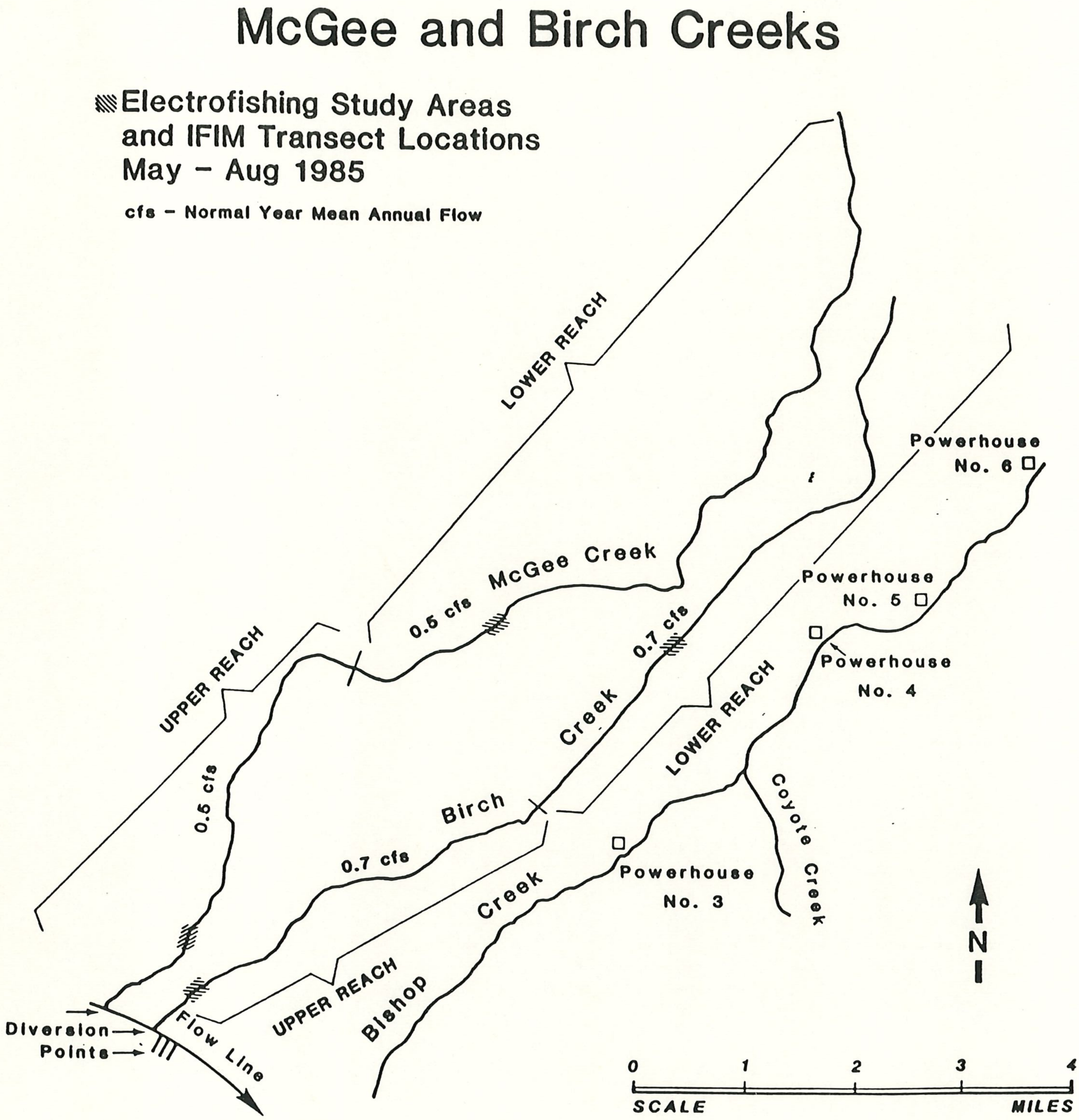
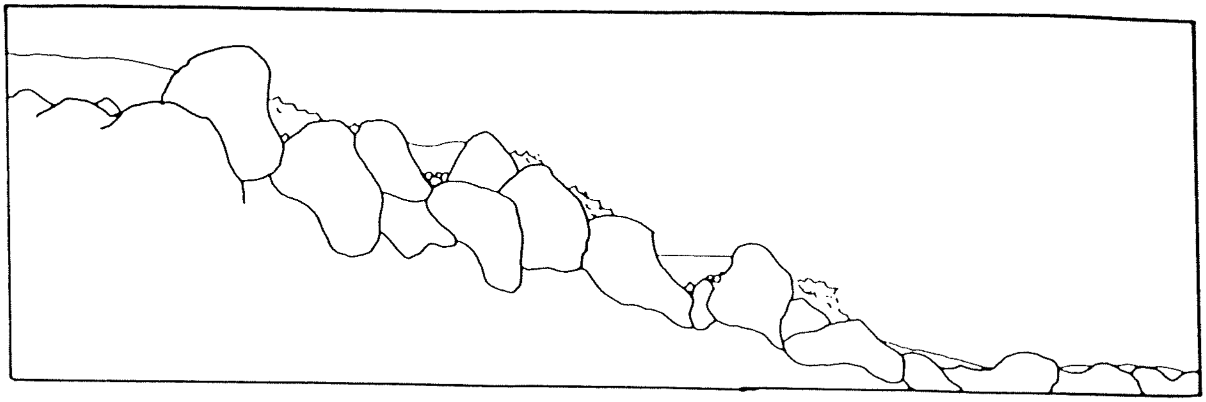
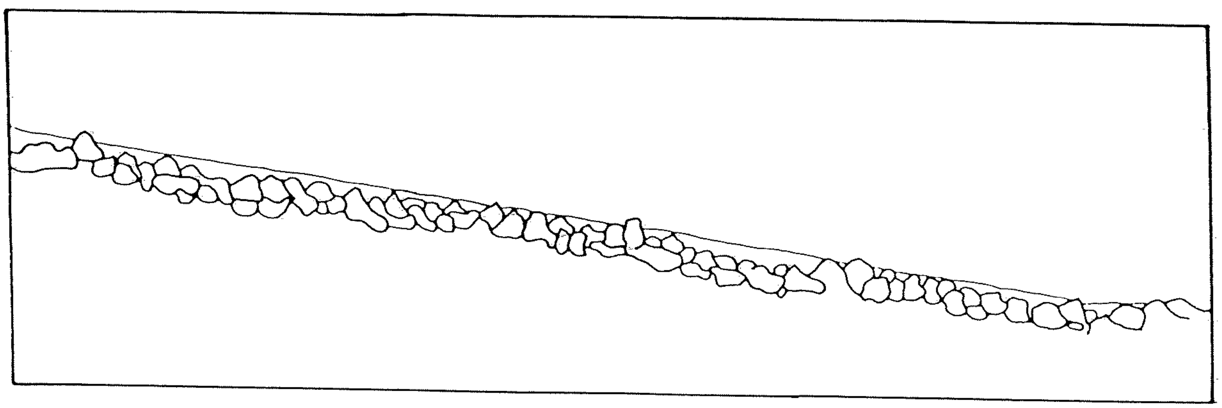


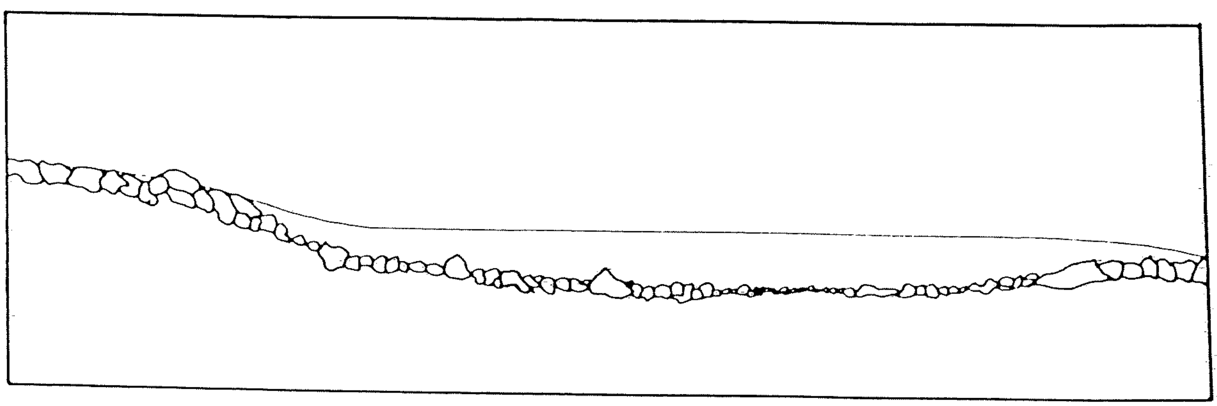
Figure 1. Study areas on McGee and Birch Creeks.



HIGH-GRADIENT CASCADE: Water velocity extremely high, with considerable turbulence; hydraulic controls very closely spaced. Average water surface gradient very high, but may consist of closely spaced pools separated by falls.

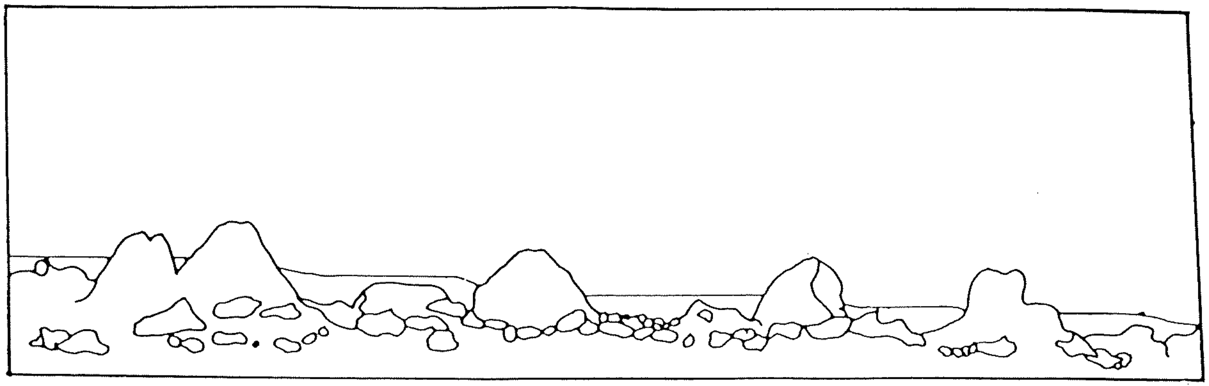


RIFFLE: Water velocity relatively high. Relatively shallow; water surface gradient high, but water level not determined by distinct hydraulic controls. Considerable surface turbulence; zero depth at zero discharge.

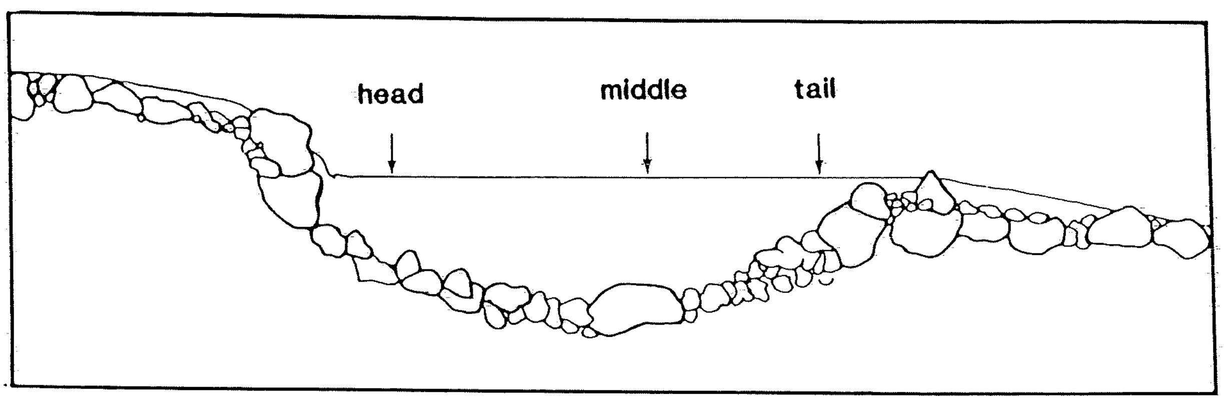


RUN: Relatively fast but nonturbulent flow; deeper than riffle but shallower than pool. Relatively deep, but fairly uniform in depth, without the distinct depression characterizing a pool.

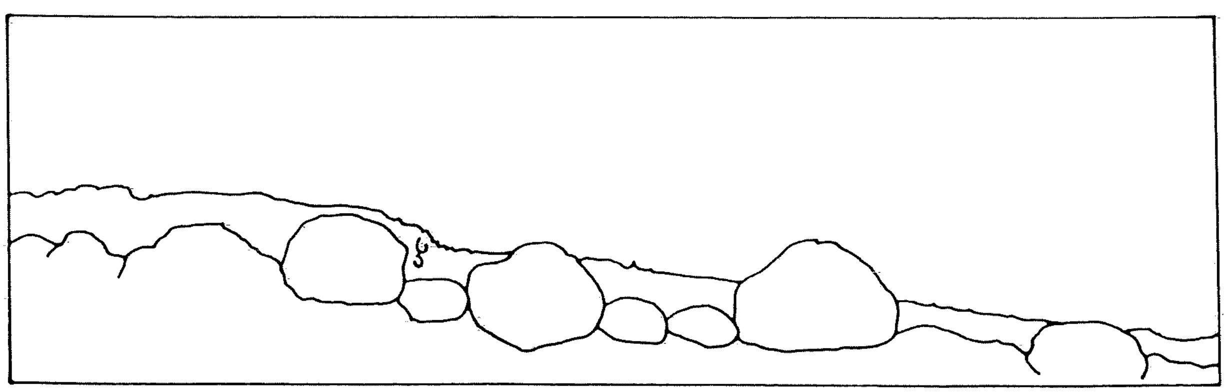
Figure 2. Major habitat categories mapped on Birch and McGee creeks.



LOW-GRADIENT CASCADE: Run or riffle with frequent obstructions (e.g., boulders, logs) which result in diverse flow patterns.



POOL: Water velocity relatively low, nonturbulent. Relatively deep, with distinct longitudinal depression in stream bed. Water surface gradient very low; water level determined by a distinct hydraulic control.



MEDIUM-GRADIENT CASCADE: Water velocity moderately high; moderate turbulence. Hydraulic controls closely spaced. Average water surface gradient medium, but may consist of closely spaced pools interspersed with high-gradient stretches.

Figure 2. (continued)

Table 1 TOTAL FEET OF EACH REACH OF BIRCH AND MCGEE CREEKS, PARTITIONED HABITAT

Habitat Type	Birch Creek Upper	Birch Creek Lower	McGee Creek Upper	McGee Creek Lower	Total
Cascade	5835	2361	7991	7753	23940
Run	7979	1982	13597	41194	64752
Riffle	12153	28488	1271	363	42275
Pool	1431	257	1158	1080	3926
Braided	412	1632	359	2218	4621
Total	27810	34720	24376	52608	139514

Table 2 DISTRIBUTIONS OF HABITAT TYPES AMONG TRANSECTS ON BIRCH AND MCGEE CREEKS. WITHIN A REACH ALL TRANSECTS OF THE SAME TYPE WERE WEIGHTED EQUALLY, AND THE TOTAL WEIGHT OF TRANSECTS OF THE SAME TYPE WAS DETERMINED BY THE PERCENTAGE OF FEET OF THAT HABITAT TYPE AS DETERMINED FROM TABLE 2. BRAIDED CHANNEL WAS TREATED AS THOUGH IT DID NOT CONSTITUTE HABITAT AND HAD NO WEIGHTED USABLE AREA SINCE NO TRANSECTS WERE PLACED THROUGH IT.

Transect	Birch Creek		McGee Creek	
Number	Upper	Lower	Upper	Lower
1	Ri	C	Ru	C
2	Ru	C	Ru	Ru
3	Ri	Ru	Ru	C
4	P	Ri	C	C
5	C	Ri	C	C
6	C	C	Ri	Ru
7	Ri	Ri	P	Ru
8	P	Ru	C	Ri
9	Ru	Ri	C	Ru
10	Ru	Ru	Ru	
11	Ri		Ri	
12	Ru		Ru	
13	C		P	

P=Pool, Ru=Run, Ri=Riffle, C=Cascade

Transect Measurements:

Measurements were made on Birch and McGee creeks during July and August at 6 releases ranging from 0 to 10 cfs.

All transects were sampled with the following methods: Two permanent headstakes were established, one on each bank, to define a cross-sectional transect line perpendicular to the streamflow. Sampling stations along the transect line were established at appropriate intervals to ensure that all major bottom features were incorporated. The elevation of the streambed at each sampling station, relative to a bench mark (one of the headstakes), was measured using standard surveying equipment and techniques.

The substrate type for the cell represented by each station was assessed visually and assigned to categories of dominant and subdominant particle size. Cover information was recorded for each cell as the percentages of object cover, overhead cover, and velocity cover within it. Velocity cover was defined as an area of reduced velocity due to the obstruction of normal flow by streambed objects.

Stream depth and velocity were measured at each station for all discharge rates at all study sites. Velocity was measured directly at each station using a Marsh-McBirney hydrostatic flow meter placed 0.6 of the distance down the water column for station depths less than 2.5 feet, and 0.2 and 0.8 of the distance for all other station depths. In the latter case, an average value of the two readings was used to represent the mean column velocity. Depth was determined indirectly for each station by measuring the elevation of the water surface at each discharge and subtracting the known streambed elevation for each station.

The amount of water flowing through the study reaches during periods of sampling (calibration discharge rates) were determined from the measured depths and velocities for a single transect having morphological characteristics that permitted an accurate estimate of discharge (such as a uniform bedrock or cobble substrate). A permanent staff gauge was established for the study reach and monitored as depth and velocity readings were collected for each transect.

In order to produce an index of the amount of habitat available in a stream, the variations in measured depth and velocity with flow must be input, along with indices of habitat preference, into a version of the habitat model (HABTAT) of USFS.

An interagency group has recently finished a preference study for salmonids in East-side Sierra Nevada streams. A preliminary report (Aceituno et al. 1985) was published in January, and a final version was being readied for publication in November 1985 (Aceituno et al. unpublished). EA was furnished a draft copy of the preference curves in the final report (Appendix A) by its authors. Four versions of each of these curves were furnished, corresponding to four conditions of object and overhead cover in a stream: no cover, object cover only, overhead cover only, and a combination of object and overhead cover.

The measured simulated depths and velocities at each flow were evaluated using the HABTAT model modified by EA (called the HABSIM model) to accept habitat suitability functions specific to four different cover types (no cover, overhead cover, object cover, and a combination of object and overhead cover). The data constituting the cover-specific curves were obtained from Appendix A of the final draft of the interagency study on streams of the eastern Sierra Nevada (Aceituno et al. unpublished). The data, with one exception, consisted of the four cover-type curves for each of four life stages (adult, juvenile, fry, and spawning) of brook, brown and rainbow trout, with respect to depth and velocity. These curves are included as Attachment 1. For adult rainbow trout, the report used a single curve for depth and velocity of rainbow trout taken from Bovee (1978).

It appears that, except for the data from Bovee (1978), the researchers made random observations of water depths and velocities in the streams where preference observations were made. These randomly chosen observations were used to adjust the cover-specific suitability functions to take into account the relative availability of various depths and velocities, and the functions are thus "preference curves" rather than utilization curves.

Weighted Usable Area:

The results of the studies are reported as Weighted Usable Area (WUA) expressed as square feet per 1,000 linear feet of stream.

Fish Populations:

Fish populations were sampled quantitatively in both reaches used for instream flow transects in McGee Creek in August 1985.

Block nets were positioned at the upstream and downstream ends of the site to insure no movement in or out of the study area during the sampling period. Sampling was conducted by a crew of 3 biologists with a Smith-Root Mark VII backpack electrofisher. Block or rock salt was placed upstream of the sample site. Three independent passes were made through each sampling site. A constant level of sampling effort was maintained in each pass by monitoring electrofisher on-time and duration of the sampling effort. During each pass all shocked fish were collected by dip net, weighed on a volumetric basis (assuming an equivalence of one gram of wet fish tissue weight to one milliliter of water displaced), measured for fork length, and removed temporarily from the study reach.

The number of fish captured was converted to the number of fish estimated in the reach using the Zippin (1958) technique. This in turn was converted to pounds per acre, pounds per mile, and total numbers per mile.

Condition Factor:

All fish were weighed individually and condition was calculated for all fish captured as (100,000 *g)/(Forklength $(mm))^3$ (Anderson and Gutreuter, 1983)

Stream flows:

None of the study reaches of Birch and McGee creeks is gauged. Consequently, no information other than that gathered during the instream flow studies is available on accretion of flows within the diverted reaches. These data, however, document well the pattern of loss and accretion during the period of study at releases from 0 to 10 cfs.

RESULTS

Accretion of Flow Along McGee Creek:

Figure 3 shows the flows in the lower study reach of McGee Creek as functions of flow in the upper reach during the instream flow studies in spring and summer 1985. There is accretion at all flows, with McGee Creek gaining water as it loses elevation.

Loss of Flow Along Birch Creek:

Figure 4 shows the flows in the lower study reach of Birch Creek as functions of flow in the upper reach during the instream flow studies in spring and summer of 1985. There is an accretion of about 0.2 cfs in the lower reach, observable under conditions of zero release, but at all higher releases there is a loss of flow along Birch Creek as it loses elevation.

Density of Fish in McGee Creek:

Tables 3 and 4 show the estimated total trout populations in the upper and lower reaches of McGee Creek in August 1985.

Size Distribution of Fish in McGee Creek:

Figure 5 shows the size distribution of trout in upper and lower McGee Creek.

Size Distribution of Fish in Birch Creek:

Figure 6 shows the size distribution of brook trout captured in the lower study reach of Birch Creek.

Condition of fish in McGee Creek:

Figure 7a shows the frequency distribution of fork length condition factors for the two reaches of McGee Creek combined. The mean condition factor is 1.07. Figure 7b shows the regression of weight on fork length for McGee Creek. Figure 8a shows a plot of condition factor versus fork length, and Figure 8b shows a comparison of condition in the upper and lower reaches of McGee Creek.

Condition of Fish in Birch Creek:

Condition factors were calculated only for fish in the lower reach of Birch Creek. Figure 9a shows the relationship between fork length and condition factor for these fish, and Figure 9b shows the frequency distribution of condition factors. The mean condition factor for these fish is 1.04.

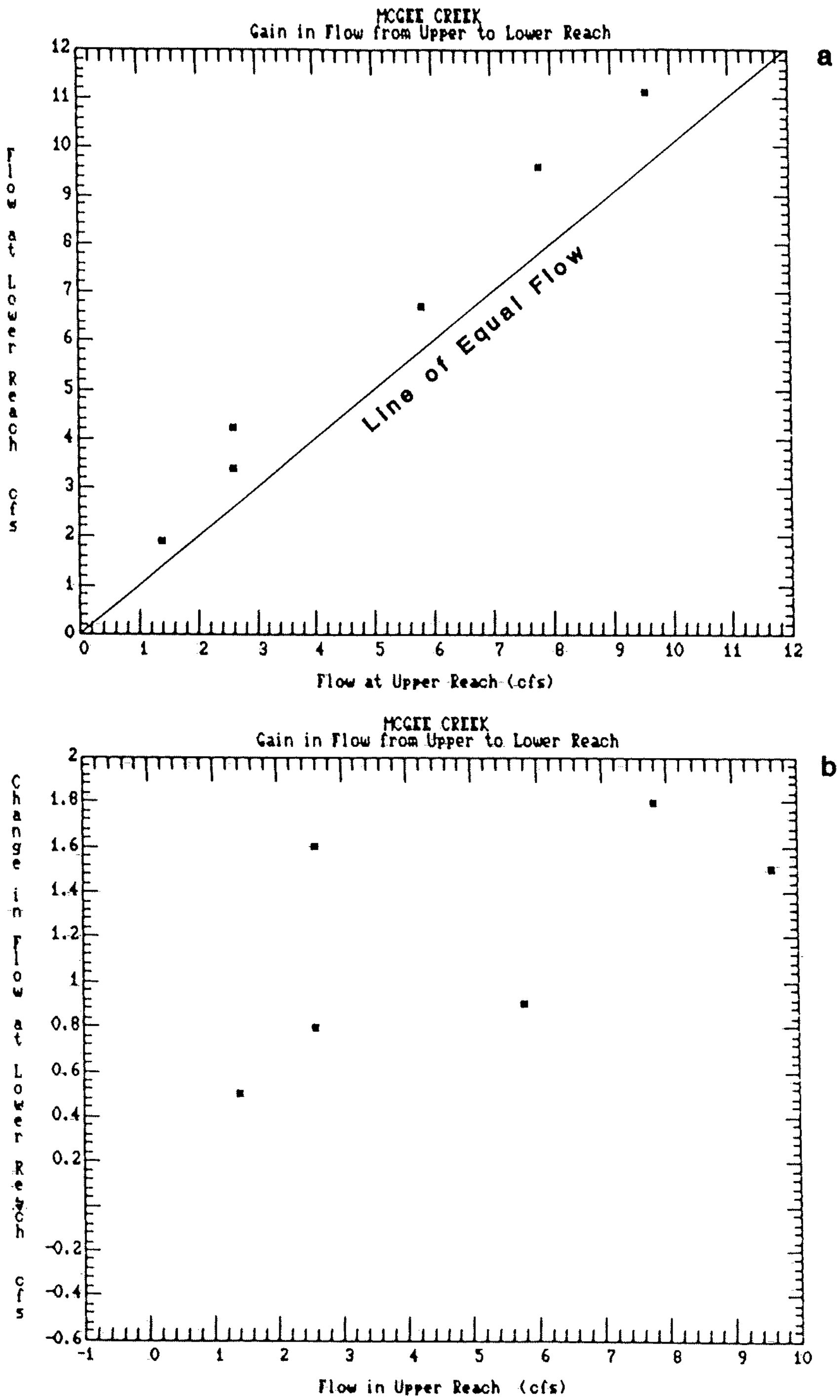
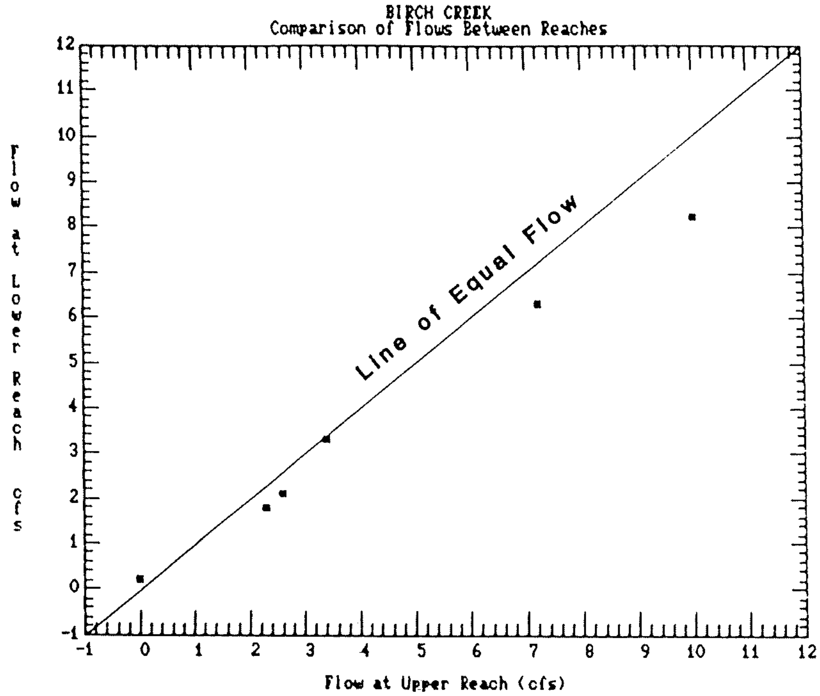


Figure 3. a) Plot of flow in the lower reach of McGee Creek as a function of flow in the upper reach. Accretion occurs at all flows. b) Magnitude of accretion as a function of flow. Scatter probably reflects failure to come to equilibrium.



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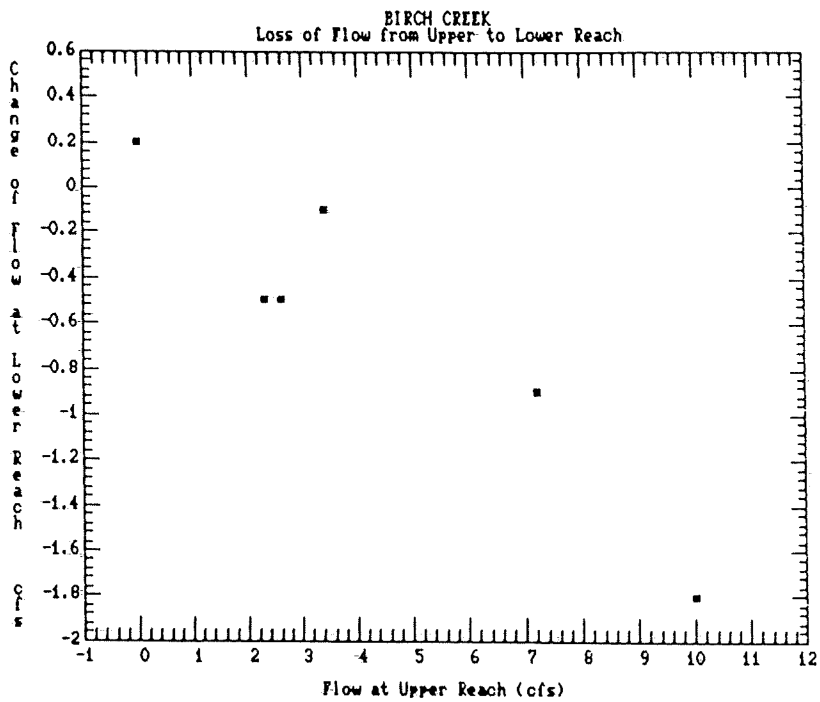


b

Figure 4. a) Plot of flow in the lower reach of Birch Creek as a function of flow in the upper reach. Loses occur except at zero flow in the upper reach. b) Magnitude of losses as a function of flow.

TABLE 3 TROUT POPULATION DATA FOR THE UPPER McGEE CREEK STUDY AREA. ONE-FOURTH OF THE FISH WERE BROOK TROUT. THE REMAINDER WERE BROWN TROUT.

EA ENGINEERING SCIENCE AND TECHNOLOGY INC.
FISH POPULATION ESTIMATING PROGRAM

STREAM: MCGEE CREEK
REACH: UPPER
FISH: TROUT
DATA DATE: 1985

STATION LENGTH = 220 FEET   STATION WIDTH = 6 FEET

PASS:	1	2	3
NUMBER REMOVED:	59	18	16

	MAXIMUM LIKELIHOOD	ZIPPIN	REGRESSION TECHNIQUE
SAMPLING AREA POPULATION ESTIMATE	100	104	96
TOTAL CATCH	93	93	93
LOWER 95 % CONFIDENCE LIMIT	89.66	91.47	20.38
UPPER 95 % CONFIDENCE LIMIT	110.34	117.02	171.44
CAPTURE PROBABILTIY	0.567	0.524	0.613
CHI SQUARE STATISTIC	4.569	3.874	6.866

LENGTH/WEIGHT REGRESSION COEFFICIENTS:

INTERCEPT - -10.563
SLOPE - 2.808

POPULATION ESTIMATES USING THE ZIPPIN TECHNIQUE

	LOWER 95% LIMIT	ESTIMATE	UPPER 95% LIMIT
NUMBER PER MILE	2195	2502	2808
NUMBER PER KILOMETER	1363	1554	1744
NUMBER PER ACRE	3018	3440	3861
NUMBER PER HECTARE	3634	4142	4650
POUNDS PER MILE	167	191	214
POUNDS PER KILOMETER	104	119	133
POUNDS PER ACRE	230	262	295
KILOGRAMS PER MILE	76	87	97
KILOGRAMS PER KILOMETER	47	54	60
KILOGRAMS PER HECTARE	126	143	161

TABLE 4 TROUT POPULATION DATA FOR THE LOWER McGEE CREEK STUDY AREA. ALL FISH CAPTURED WERE BROWN TROUT.

EA ENGINEERING SCIENCE AND TECHNOLOGY INC.
FISH POPULATION ESTIMATING PROGRAM

STREAM: MCGEE CREEK
REACH: LOWER
FISH: BROWN TROUT
DATA DATE: 1985

STATION LENGTH = 60 FEET STATION WIDTH = 4 FEET

PASS:	1	2	3
NUMBER REMOVED:	23	12	2

	MAXIMUM LIKELIHOOD	ZIPPIN	REGRESSION TECHNIQUE
SAMPLING AREA POPULATION ESTIMATE	38	39	40
TOTAL CATCH	37	37	37
LOWER 95 % CONFIDENCE LIMIT	33.80	34.80	12.97
UPPER 95 % CONFIDENCE LIMIT	42.20	43.15	66.98
CAPTURE PROBABILTIY	0.661	0.630	0.597
CHI SQUARE STATISTIC	1.880	1.585	1.528

LENGTH/WEIGHT REGRESSION COEFFICIENTS:

INTERCEPT - -8.916
SLOPE - 2.501

POPULATION ESTIMATES USING THE ZIPPIN TECHNIQUE

	LOWER 95% LIMIT	ESTIMATE	UPPER 95% LIMIT
NUMBER PER MILE	3062	3430	3797
NUMBER PER KILOMETER	1901	2130	2358
NUMBER PER ACRE	6314	7073	7831
NUMBER PER HECTARE	7604	8517	9431
POUNDS PER MILE	172	192	213
POUNDS PER KILOMETER	107	119	132
POUNDS PER ACRE	354	396	439
KILOGRAMS PER MILE	78	87	96
KILOGRAMS PER KILOMETER	48	54	60
KILOGRAMS PER HECTARE	193	216	240

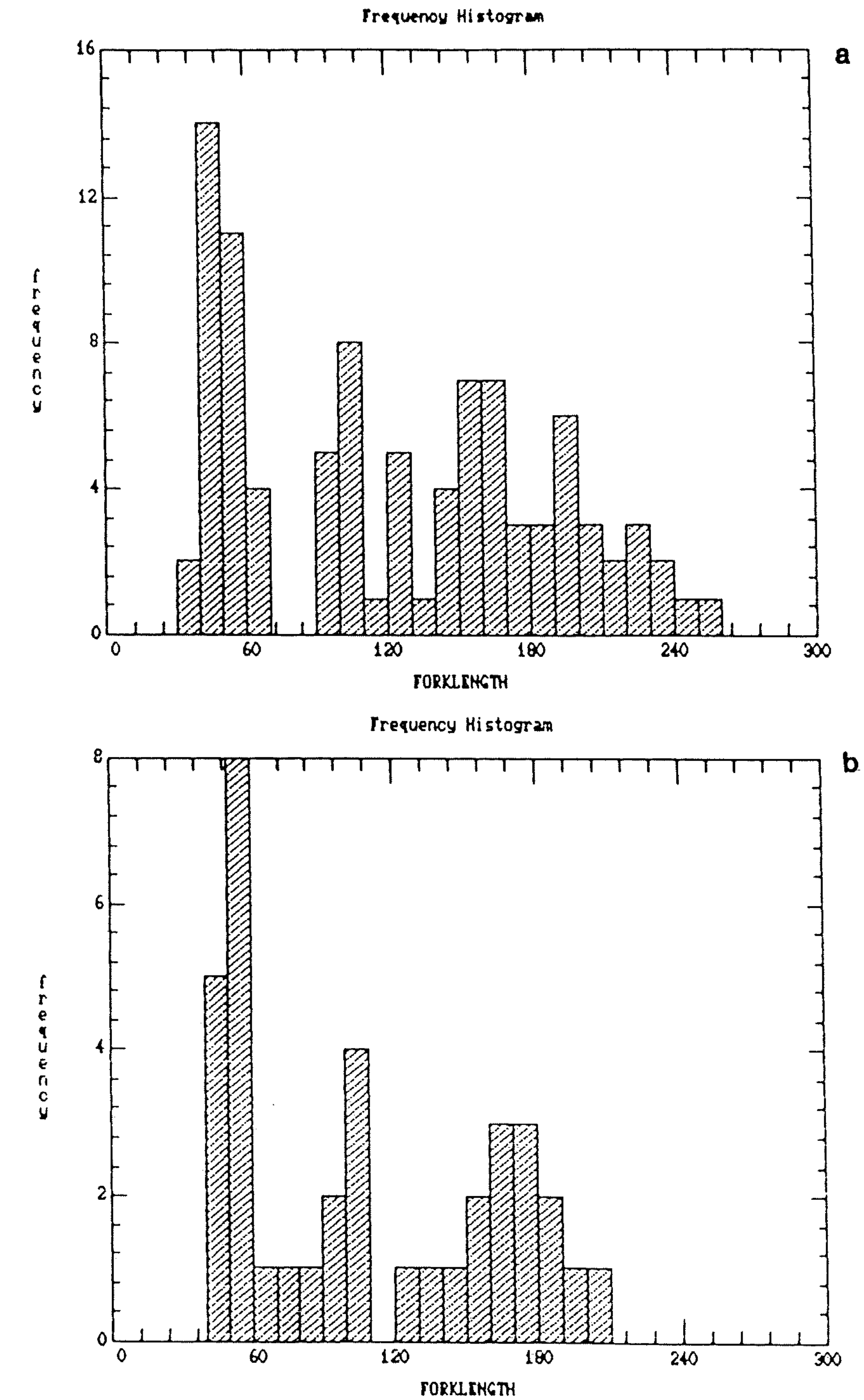


Figure 5. a) Size distribution of brown and brook trout in the upper McGee Creek study reach. b) Size distribution of brown trout captured in the lower McGee Creek study reach.

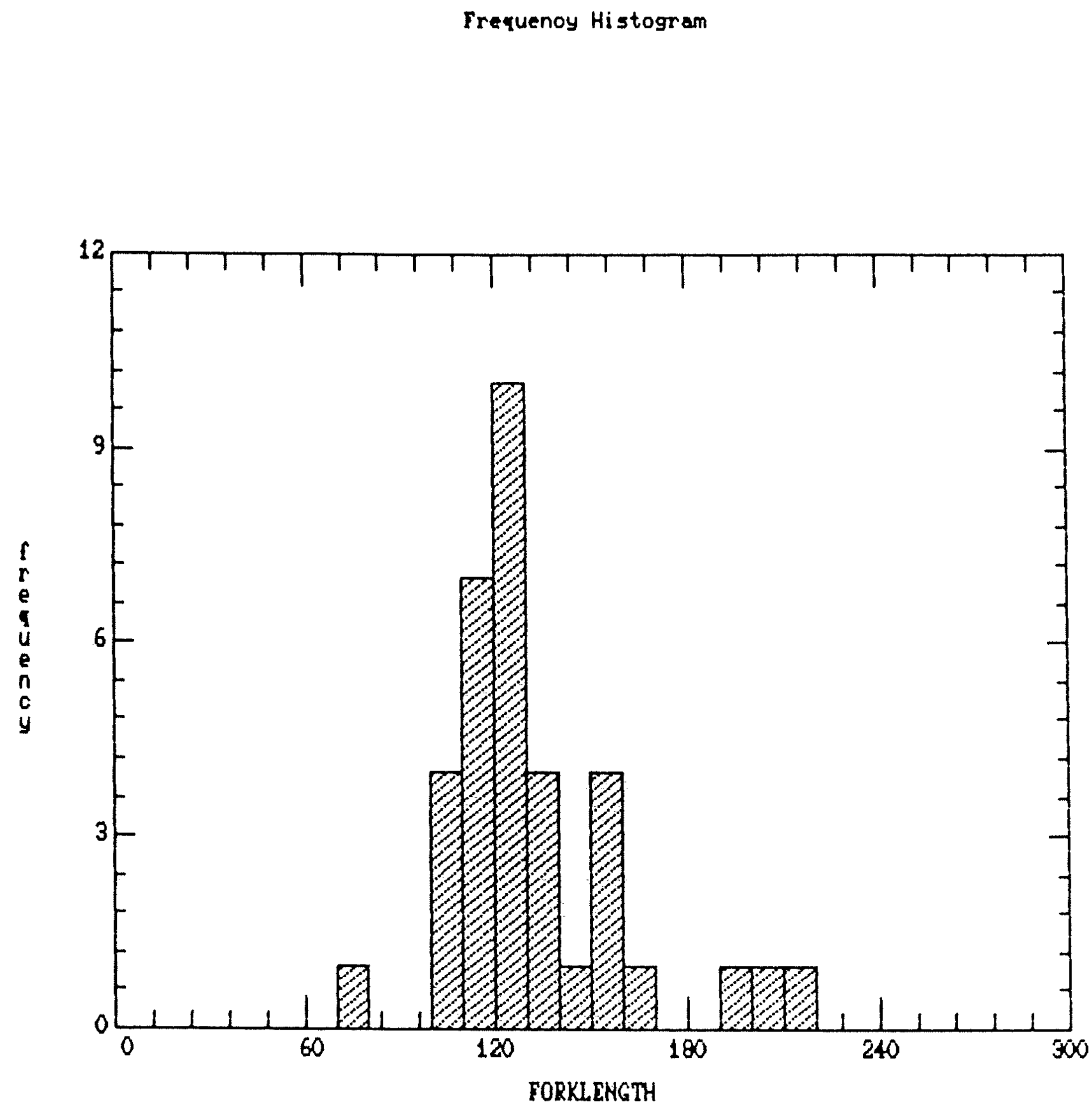


Figure 6. Size distribution of brook trout captured in the lower study reach of Birch Creek in August 1985.

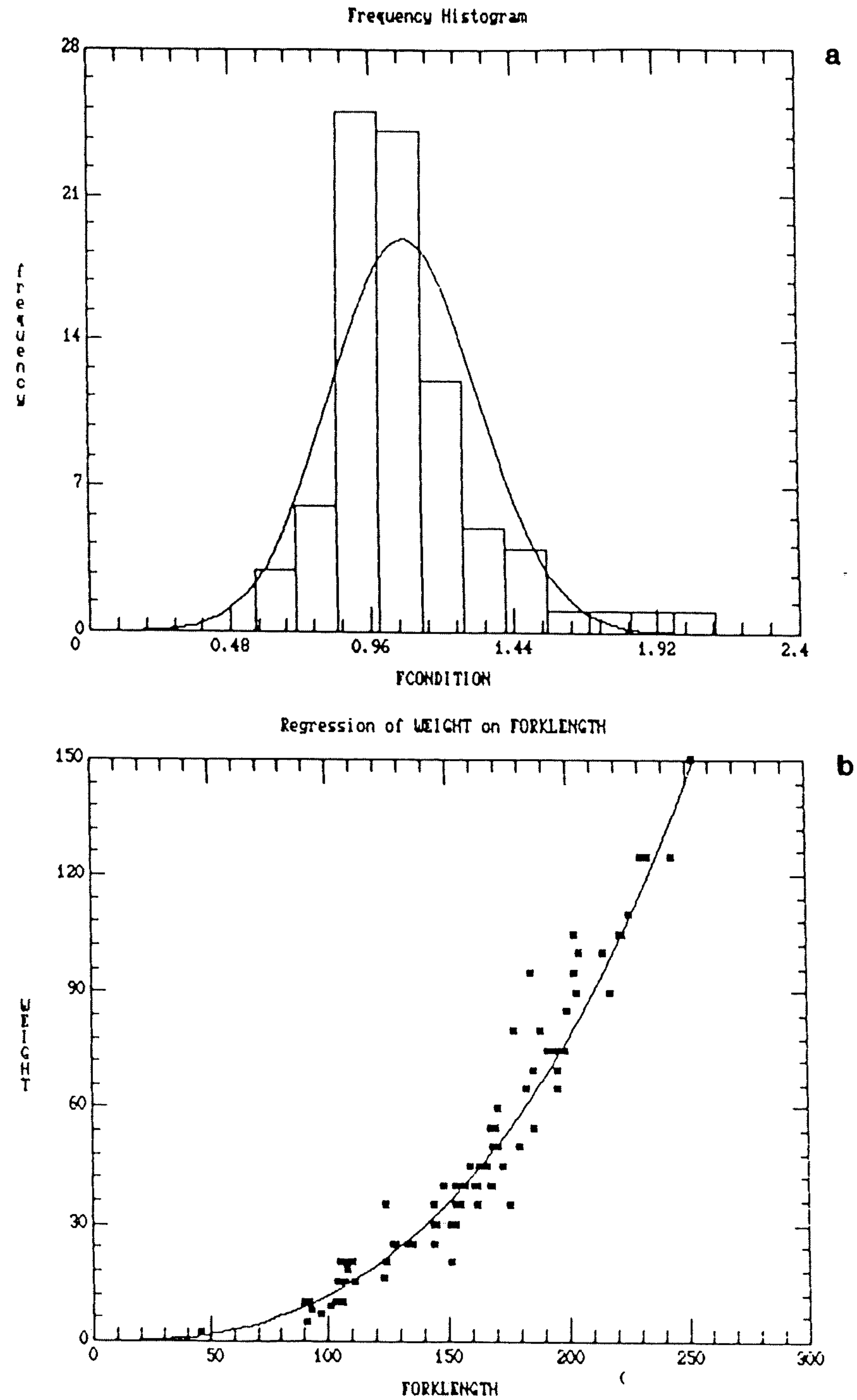


Figure 7. a) Fork length condition factors for all fish captured in both upper and lower reaches of McGee Creek. Mean value is 1.0742. b) Regression of weight (g) on fork length (mm) for both reaches of McGee Creek.

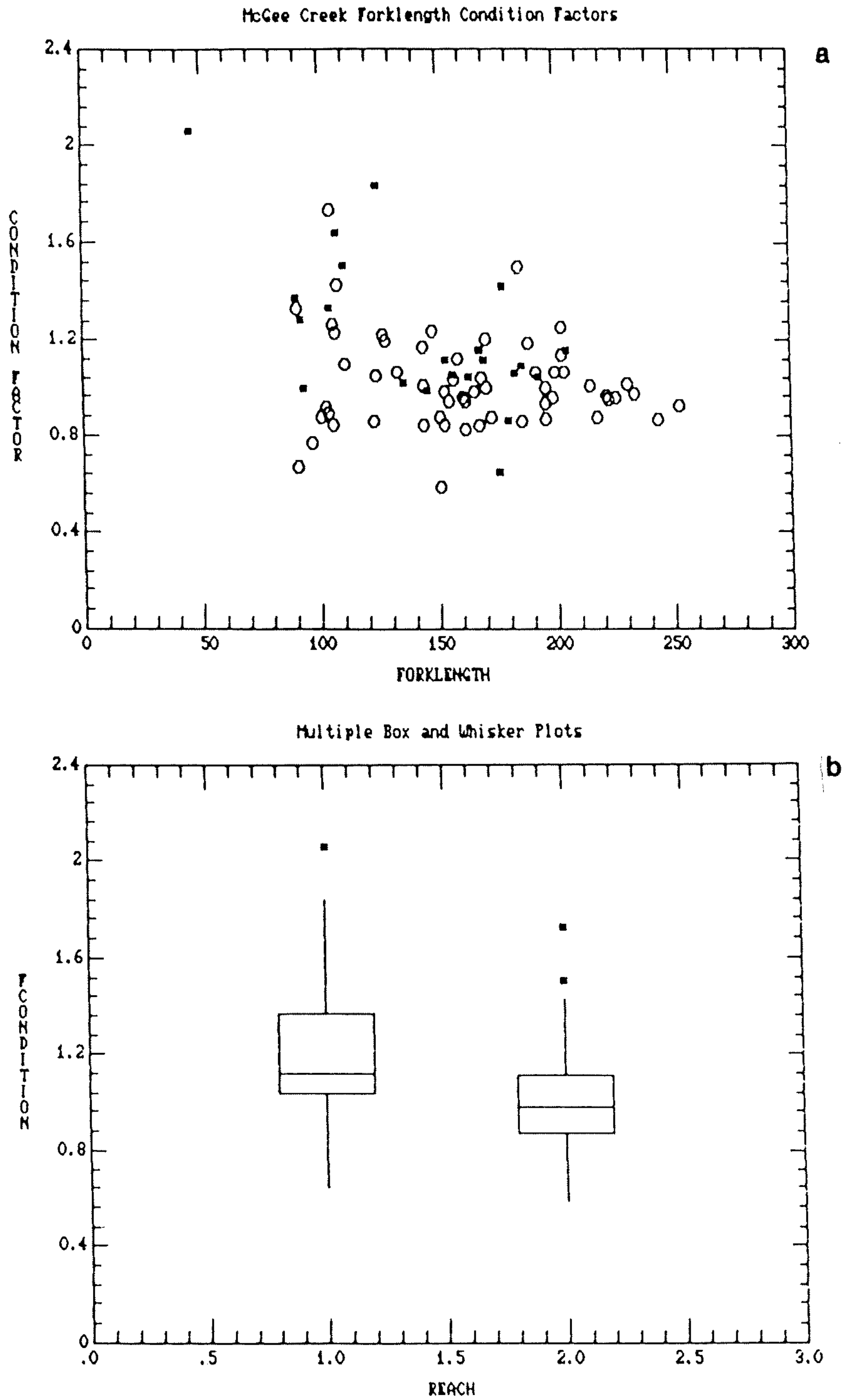


Figure 8. a) Condition factors as a function of fork length for upper (○) and lower (■) McGee Creek. b) Comparison of fork length condition factors for the upper and lower reaches of McGee Creek. The median condition factor is higher in the lower reach.

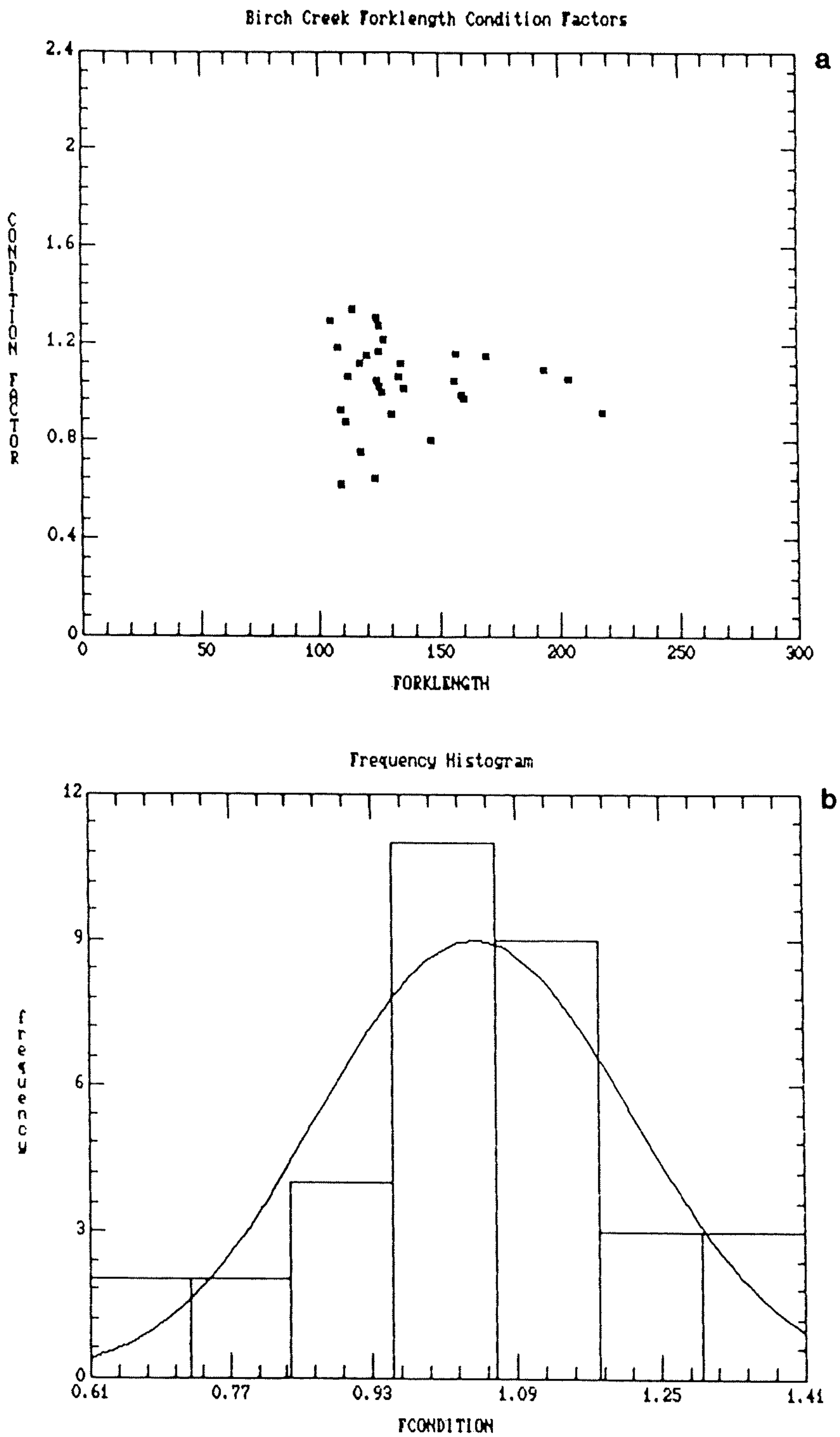


Figure 9. a) Fork length condition factors as a function of fork length (mm) for brook trout in the lower study reach of Birch Creek. b) Frequency distribution of fork length condition factors for these fish.

Weighted Usable Area:

Figures 10-13 show Weighted Usable Area as a function of flow for brown and brook trout in the Birch Creek and upper McGee Creek study areas, and for brown trout only in the lower McGee Creek study reach. The upper curves are for each life stage of each species. The lower curve is derived by combining the data in the upper curves to achieve mean normalized mean WUA using the following averaging technique:

1. Each of the curves in the upper figure was normalized by dividing each value on the curve by the highest value on the curve.

2. The average of all normalized curves was then taken.

3. The resulting average curve was normalized by dividing each value comprising it by its highest value.

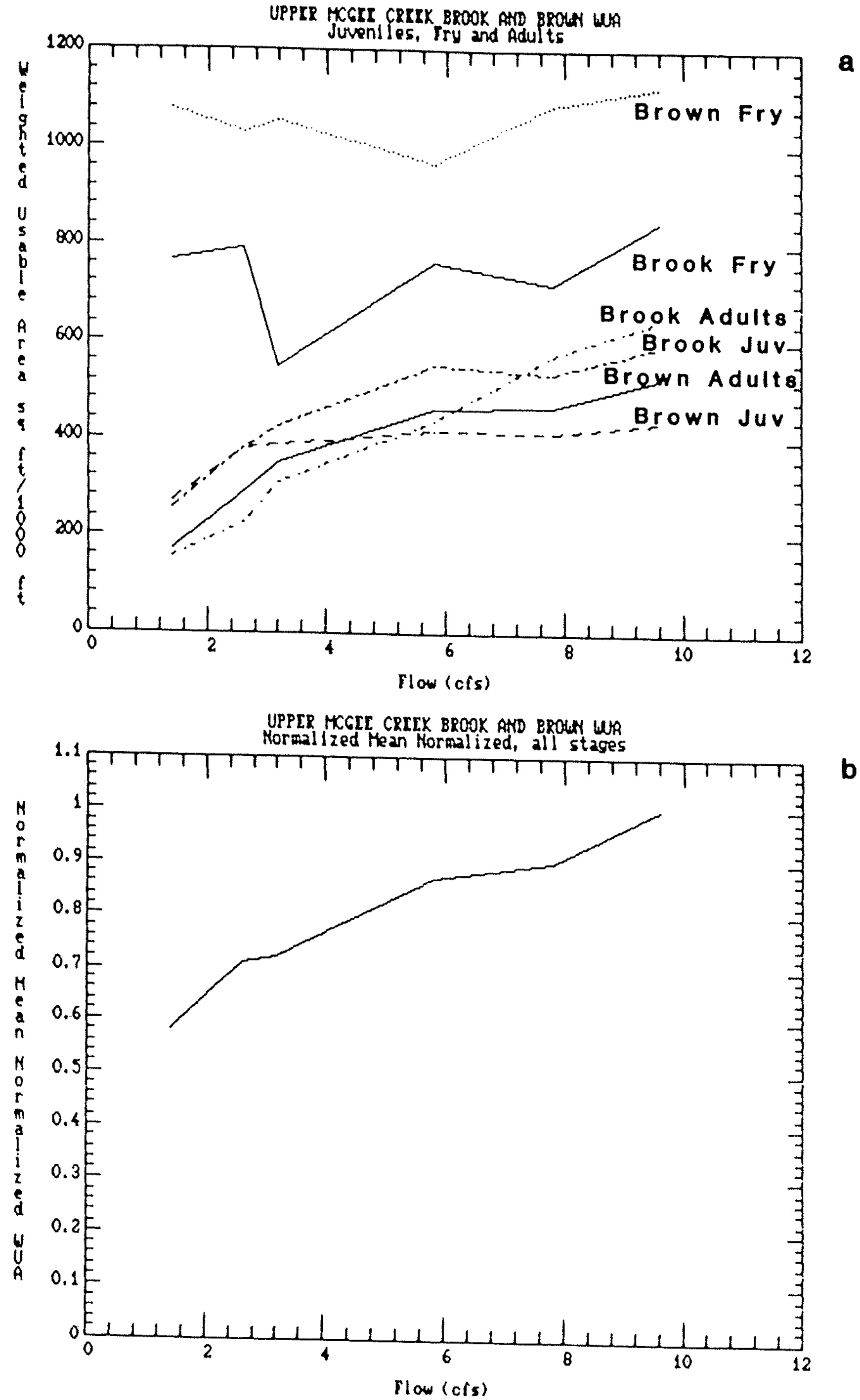


Figure 10. a) Weighted Usable Area (WUA) for brook and brown trout juveniles, fry, and adults for the upper study reach on McGee Creek. b) Mean normalized mean WUA calculated from the data in a.

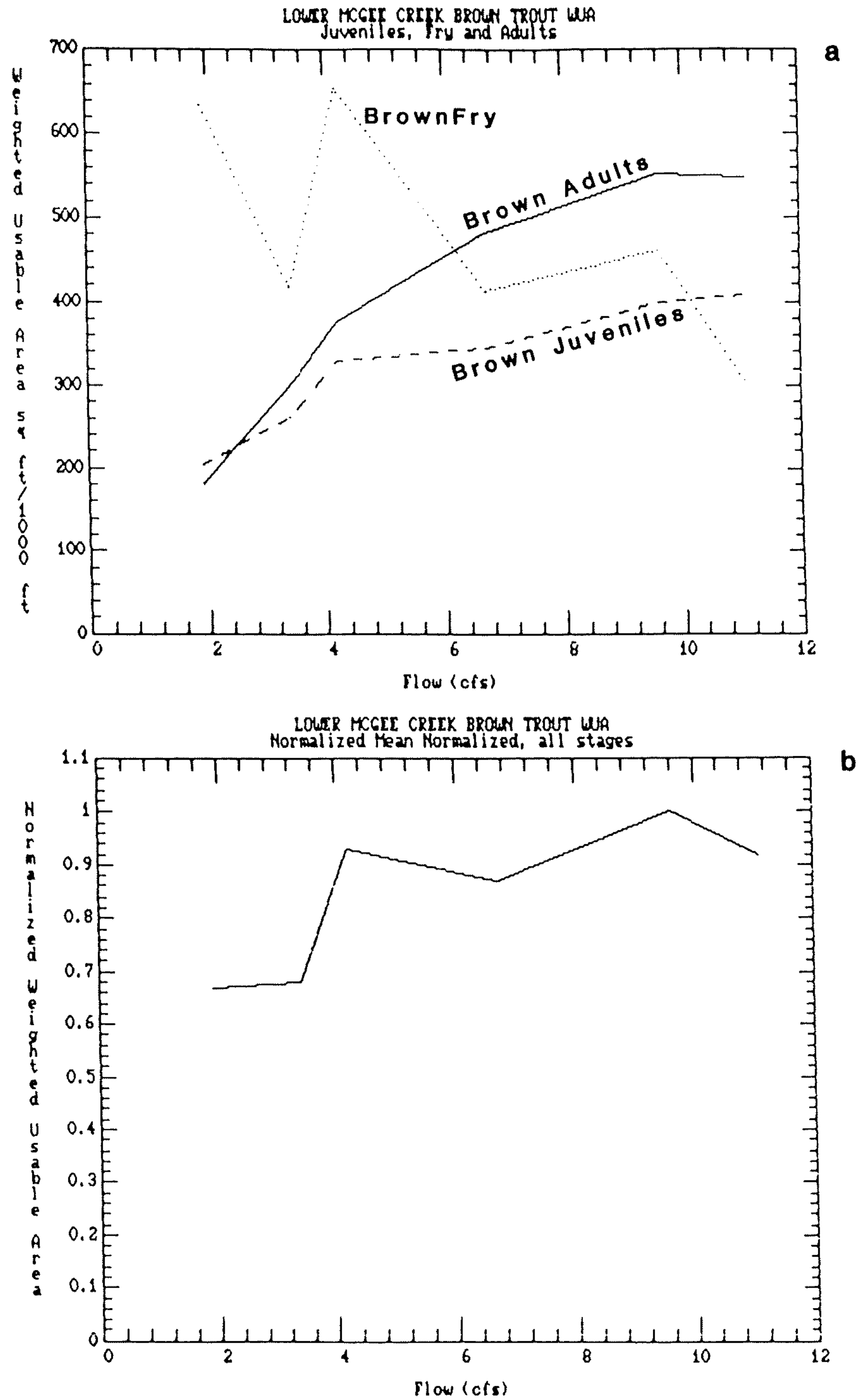


Figure 11. a) Weighted Usable Area (WUA) for brown trout in the lower study area of McGee Creek. b) Mean normalized mean WUA from the data in a.

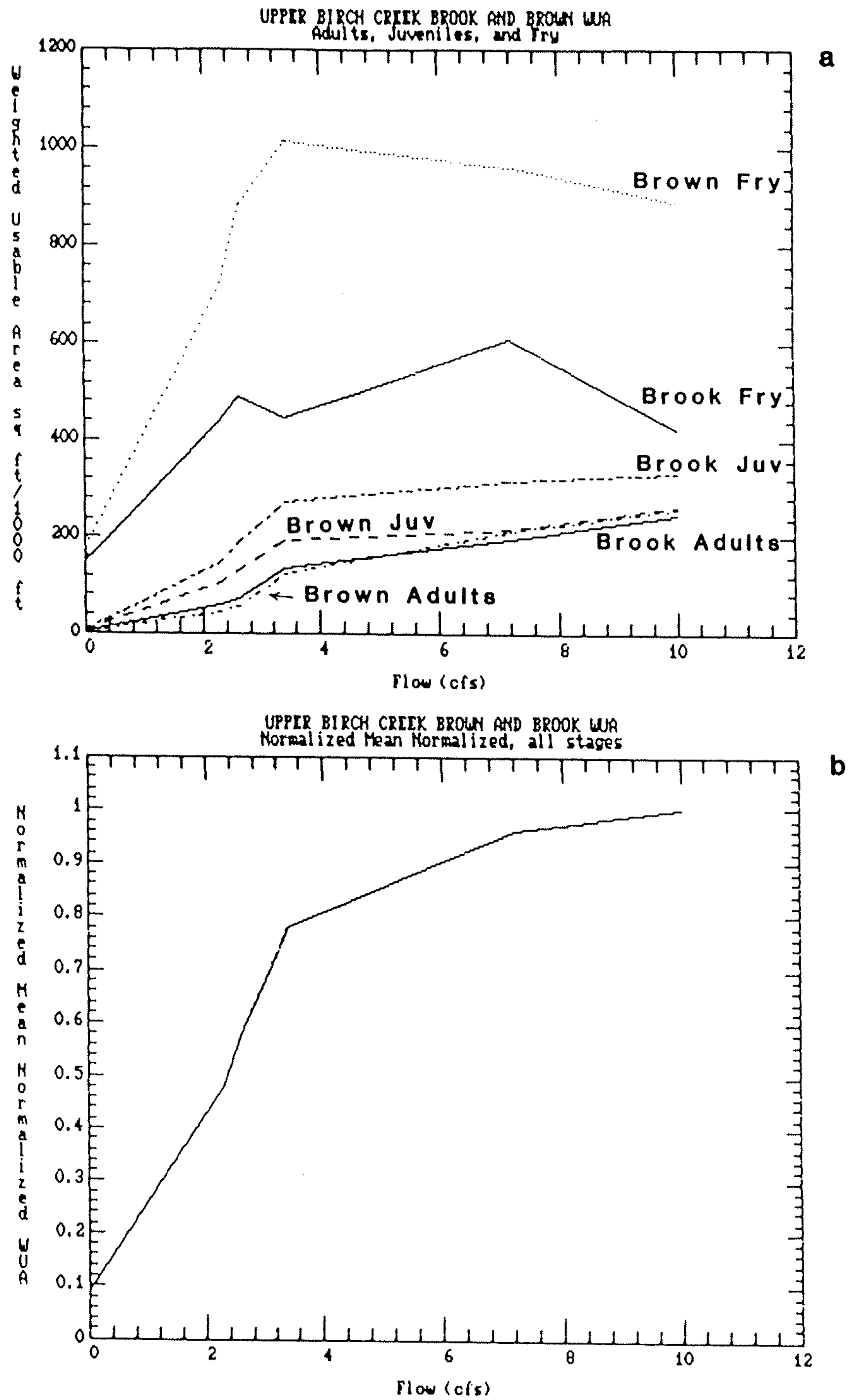


Figure 12. a) Weighted Usable Area (WUA) for brook and brown trout in the upper study area of Brich Creek. b) Mean normalized mean WUA from the data in a.

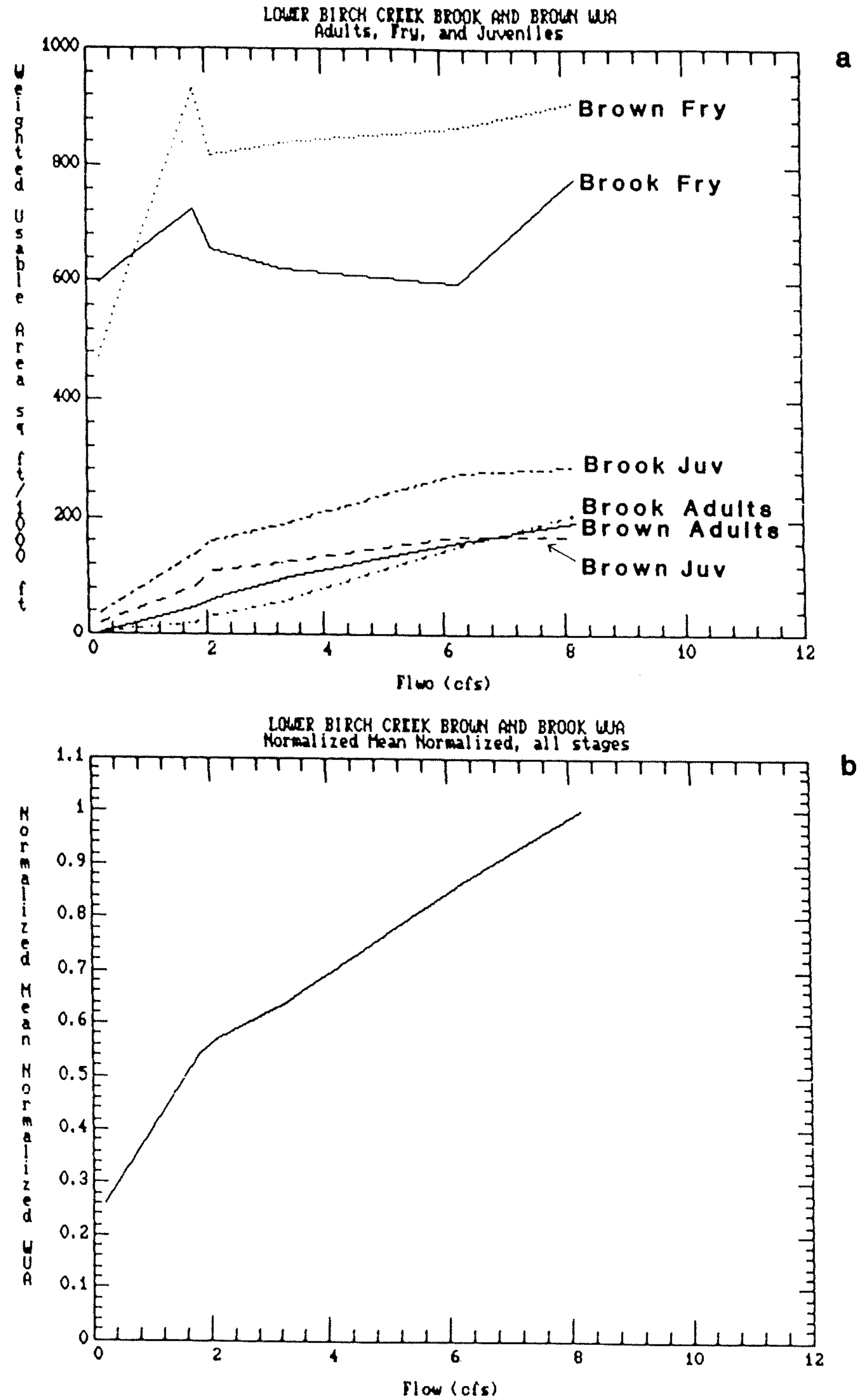


Figure 13. a) Weighted Usable Area (WUA) for brook and brown trout for the lower study area of Birch Creek. b) Mean normalized mean WUA for brook and brown trout from the data in a.

DISCUSSION

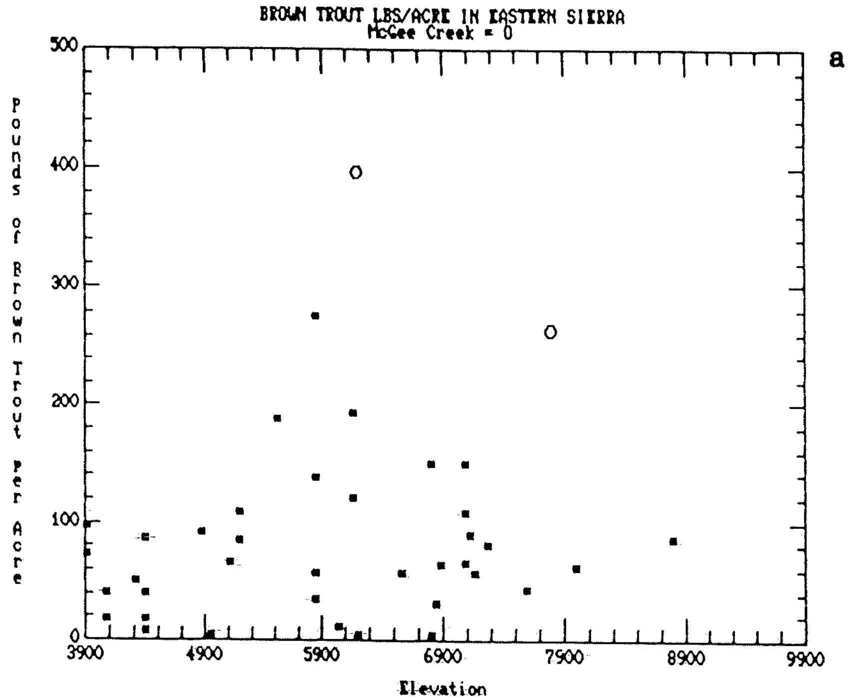
Condition Factors: The condition of fish in both Birch and McGee creeks appears to be good based on Fulton-type condition factors (calculated using the technique of Anderson and Gutreuter, 1983). The mean values of fork length condition factors are as good or better than the condition factors of 0.99-1.08 observed in adult brown trout fed maximum rations for 35-42 days at temperatures of 3.8C to 9.5C (Elliott 1975) or those of 0.95-1.08 observed by Mesick (1984) in adult brown trout fed maximum rations for 60 days at temperatures of 14.5C. They are also as good as those observed by Ellis and Gowing (1957) in a study comparing natural sections of a Michigan stream with another section enriched with food (0.88-1.06). We converted the data of Needham et al. (1945) on brown trout in Convict Creek to forklength condition factor and found that they had observed conditions with a mean value of 0.819, much less good than the fish in Birch and McGee creeks.

Comparison of McGee Creek Brown Trout Populations With Those of Other Eastern Sierra Streams:

The California Department of Fish and Game has recently completed a comprehensive survey of fish populations in streams of the Owens River basin (Deinstadt et al. 1985) and this study provides the most suitable available benchmark for comparison with fish populations in McGee Creek. Figures 14-16 compare the populations in McGee Creek with a subset of the streams sampled by Deinstadt. Excluded are Bishop Creek, the Bishop Creek Canal, the Owens River, Hot Creek, and the adjacent reach of Mammoth Creek. None of these stream sections bear much resemblance to McGee Creek. Bishop Creek is a much larger canyon stream, the Owens River below Pleasant Valley Dam is an order of magnitude larger than any of the other streams, and below Crowley Lake is heavily regulated with large quantities of aquatic plants. Bishop Creek Canal is a man-made low gradient ditch, much of it with emergent aquatic vegetation and Hot Creek is infused with a large supply of nutrients flowing out of the Hot Creek fish hatchery. The lowest station on Mammoth Creek is near the Hot Creek confluence and its populations are probably influenced by the proximity to Hot Creek as well.

When compared to the remaining streams, McGee Creek has more pounds per acre than any of the others, more pounds per mile than all except one undiverted reach each of Rock Creek, Convict Creek, and two reaches of Mammoth Creek, all much larger streams, and larger numbers of trout per mile than all except one reach of Convict Creek and Lone Pine Creek.

Suitability Index Curves: The analysis presented in this report is based on unpublished Suitability Index curves provided to EA by the U.S. Fish and Wildlife Service as the final work product of a joint agency data collection and analysis program (Aceituno et al. unpublished). The California Department of Fish and Game, however, is continuing to analyze the data that resulted in these



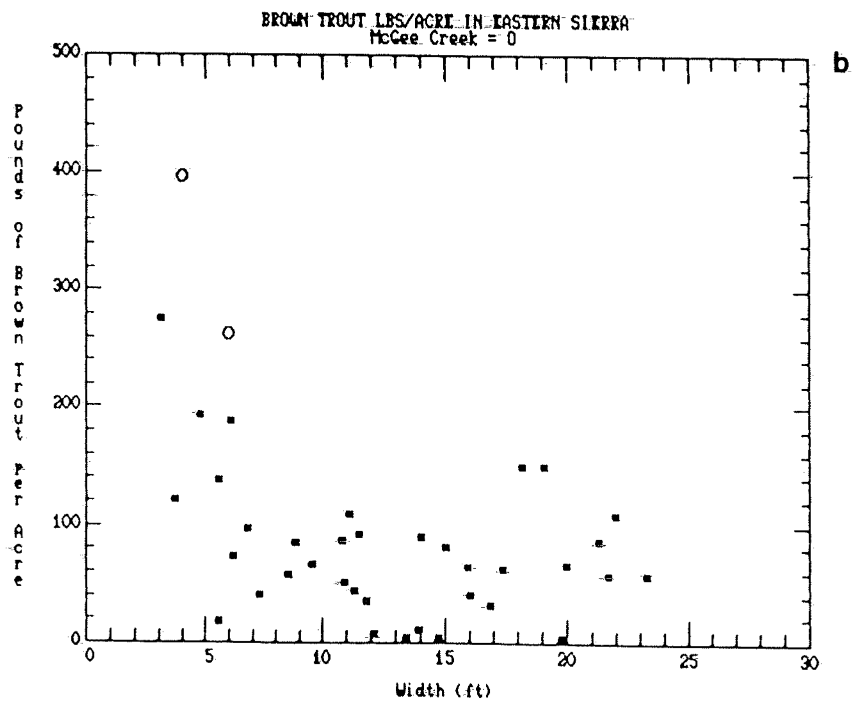


Figure 14. Pounds per acre of brown and brook trout combined as functions of elevation (a) and width (b) in McGee Creek compared to brown trout densities in other eastern Sierra streams.

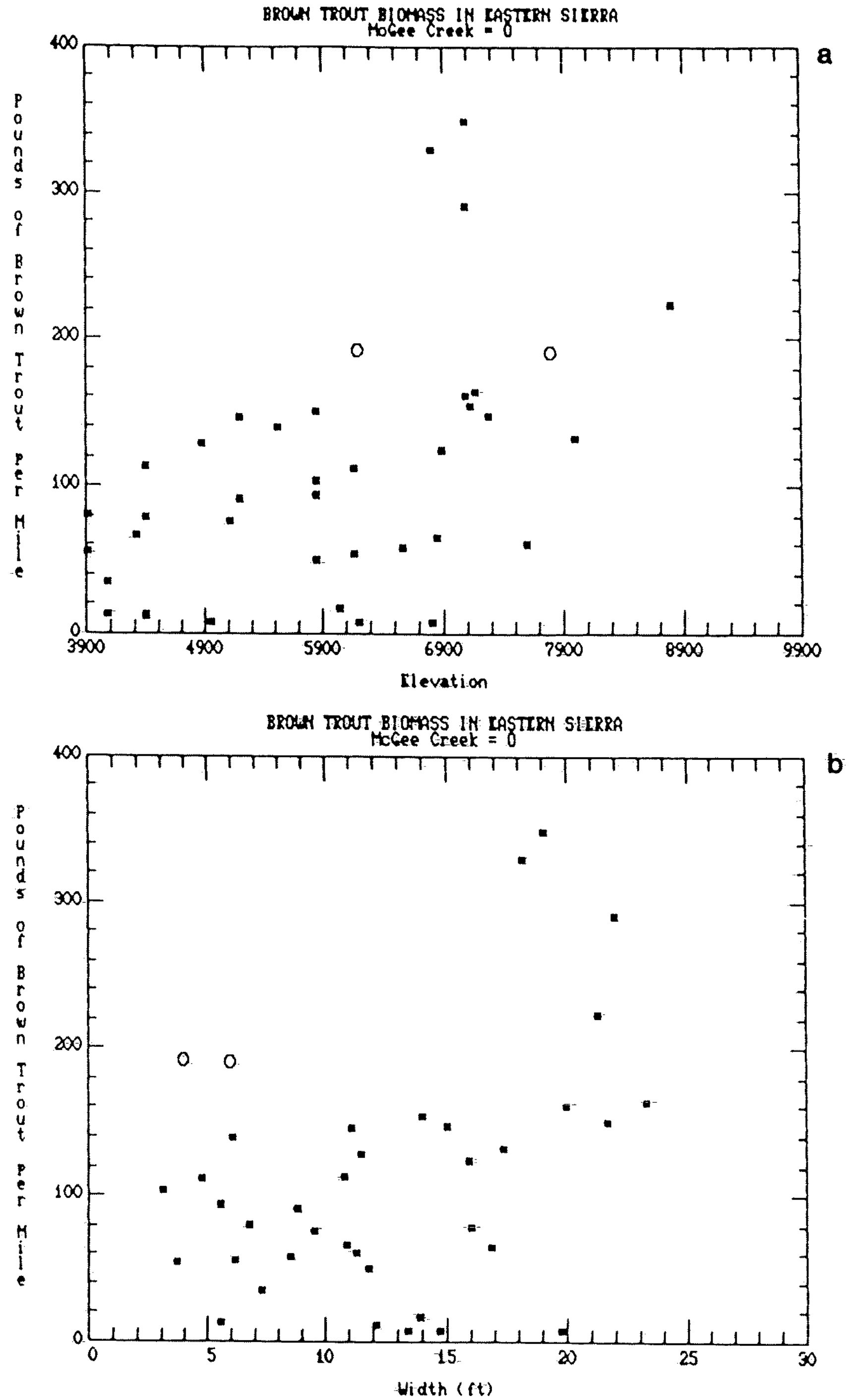
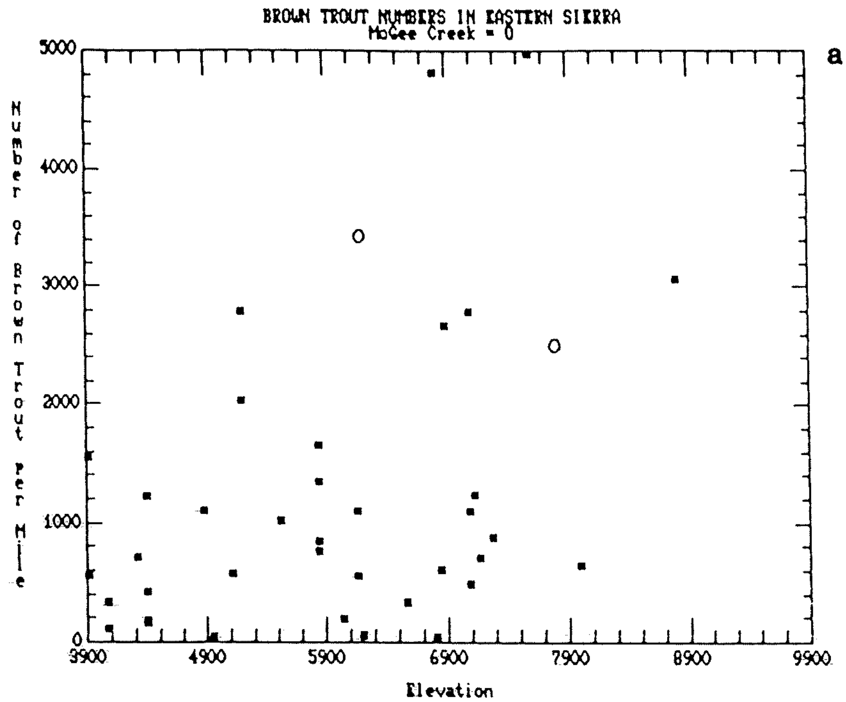


Figure 15. Pounds per mile of brook and brown trout combined as functions of elevation (a) and width (b) in McGee Creek compared to brown trout densities in other eastern Sierra streams.



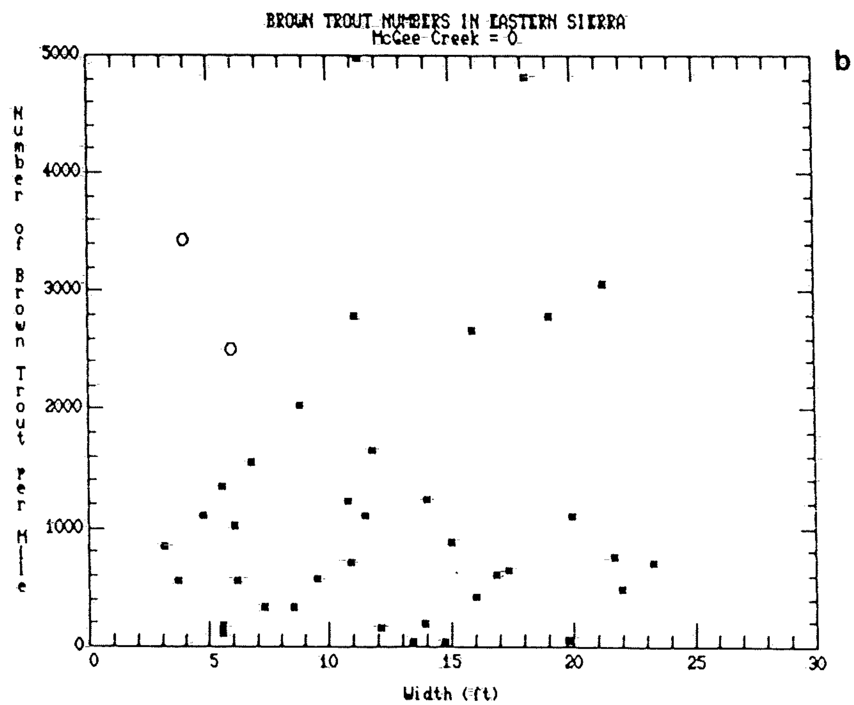


Figure 16. Number of brown and brook trout per mile in McGee Creek as functions of elevation (a) and width (b) compared to other eastern Sierra streams.

curves, and does not yet consider them final (Gary Smith, personal communication 23 January 1986). The curves, presented in Attachment 1, are much less smooth than previously published curves (cf Bovee, 1982) and many of them reflect extreme changes in habitat suitability over very narrow ranges of velocity and depth. For example, the adult brown trout curves show the suitability ranging from 0.5 to 1.0 under conditions of object cover over a velocity range of 0.2 feet per second, and the juvenile brown trout depth suitability under conditions of object cover ranges from 0.13 to 1.0 over a depth range of 0.2 feet. It is difficult for us to envision a biological mechanism that would result in such an extreme sensitivity on the part of the fish to these small changes in physical habitat.

Some of the curves also show certain sensitivities to the presence and type of cover which do not make intuitive sense to us. For example, with object cover only, juvenile brown trout are shown by the curves to find a depth of 1.5 feet ideal, but if overhead cover is present as well, the depth of 1.5 feet has a suitability of only 0.44, unless the object cover is removed, resulting in a suitability of 0.89. We can see no obvious mechanism that would render habitat less than half as good when overhead cover was added and then would return it to a suitability of 0.89 just by taking away the object cover.

It is also unclear whether the appropriate assumptions were met for conversion of the habitat utilization data to habitat preference data. While the division of the utilization frequency distributions by the frequency of available habitat makes some intuitive sense, it produces unrealistic preference curves unless the utilization distribution is influenced by a lack of sufficient ideal habitat. In other words, it is important to know if the observed fish were where they were because they found the habitat optimal, or because it was the best habitat available even though sub-optimal. This judgement cannot be made on the basis of differences in the frequency distributions of fish observations and random habitat observations. It is necessary to determine the <u>absolute</u> amount of habitat relative to the <u>absolute</u> numbers of fish. If there is more of every kind of habitat than could be occupied by the total number of fish, the frequency distributions of velocity and depth where fish were observed <u>are</u> the proper data for development of suitability index curves. Only when a particular type of habitat is completely occupied by fish, should it be reasonable to correct utilization data for preference. The data from the preliminary report (Aceituno et al. 1985) suggest that there was a great deal more habitat of every type than needed by fish, and therefore the correction for preference appears to have been unnecessary. The data needed to test this hypothesis appear to exist, but have not been released by the agencies because they are continuing to analyze them (Gary Smith, personal communication, January 23, 1986). Consequently, the calculations of Weighted Usable Area as functions of flow in this report must be considered preliminary and subject to revision. Similarly, the tests of WUA and PUA as descriptors of habitat quality and as predictors of standing crop should be redone using any new Suitability Index curves that result from additional analysis of the agency data set.

Calculations of Weighted Usable Area:

Figures 13a, 14a, 15a, and 16a show the Weighted Usable Area for adults, fry, and juveniles of the fish species present or likely to be present in Birch and McGee creeks. The curves for fry, and to a lesser extent, juveniles, are somewhat erratic, and this is directly traceable to the erratic nature of the Suitability Index curves shown in Attachment 1. The effect is more prominant in this analysis than on, say, Bishop Creek, because fewer points were used along the transects (because of the narrowness of the streams), and fewer flows were used (because flows were simulated). Attachment 2 shows the distribution of depths and velocities in conjunction with the SI surves at the lowest and highest flows examined. Inspection of these curves will give some insight into the shape of the resulting WUA curves in Figures 10-13. In all cases, especially at lower flows, there was much more habitat available for fry than for adults or juveniles. In all cases, adult and juvenile habitat increased as a function of flow.

The lower graphs on Figures 10-13 reflect the average of the curves on the upper graphs, but are calculated in such a way that the absolute magnitude of the WUA for each life stage is not considered. Prior to averaging, each of the curves was normalized by dividing by its highest value. The mean normalized curves show habitat in lower Birch Creek and in upper McGee Creek increasing continuously as flow increases. In upper McGee Creek, flows of about 1 cfs result in 60% of the average maximum habitat. In lower Birch Creek, flows of 1 cfs result in 40% of the maximum average habitat. In upper Birch Creek flows of 1 cfs result in only 20% of the maximum habitat, but the habitat-flow curve is so steep that flows of 3 cfs result in 70% of the maximum habitat. Finally, in lower McGee Creek, 2 cfs resulted in nearly 70% of the maximum observed habitat.

Explanation of the Weighted Usable Area Curves:

To understand the reason for the behavior of the WUA curves, it is useful to compare the distribution of depths and velocities in the streams at various flows to the Suitability Index curves used to assess the suitability of these depths and velocities. This is done graphically in Attachment 3 for brown trout at the lowest and highest flows measured in each stream. Inspection of those figures shows that, according to the SI curves used, the depth is almost completely unsuitable for adults and juveniles at any of the measured flows in any of the four reaches, whereas velocity is nearly completely acceptable. The suitability of low velocities makes intuitive sense, but the depth curves are probably completely inappropriate. If the depths were nearly completely unsuitable, it would be most unlikely that trout populations would be of the size observed in McGee Creek. Evidently, in streams the size and shape of McGee Creek, much shallower depths than acknowledged by the SI curves are suitable, and the shape of the depth curves accounts for the low absolute Weighted Usable Area.

CONCLUSION

McGee Creek is diverted in a very steep canyon. The accretion flows immediately downstream from the diversion point result in flows of between 1 and 2 cfs at the upper study area, while accretion continues downstream. Even at total diversion, the average habitat for all life stages is between 60-70% of maximum at the low flow period, but the absolute value is low for the adult and juvenile life stages. It appears that the Suitability Index curves for depth for adults and juveniles are not appropriate for streams of this size and shape, because even with very low WUA at the existing flows, the fish populations are large and in good condition.

Birch Creek probably initially gains flow but subsequently loses it not far downstream from the upper study area, and continues to lose it until, under present conditions, it becomes intermittent throughout its length in late summer. It is probably this intermittant nature that has resulted in the presence of only brook trout which seem to do better than either brown or rainbow trout in residual pools.

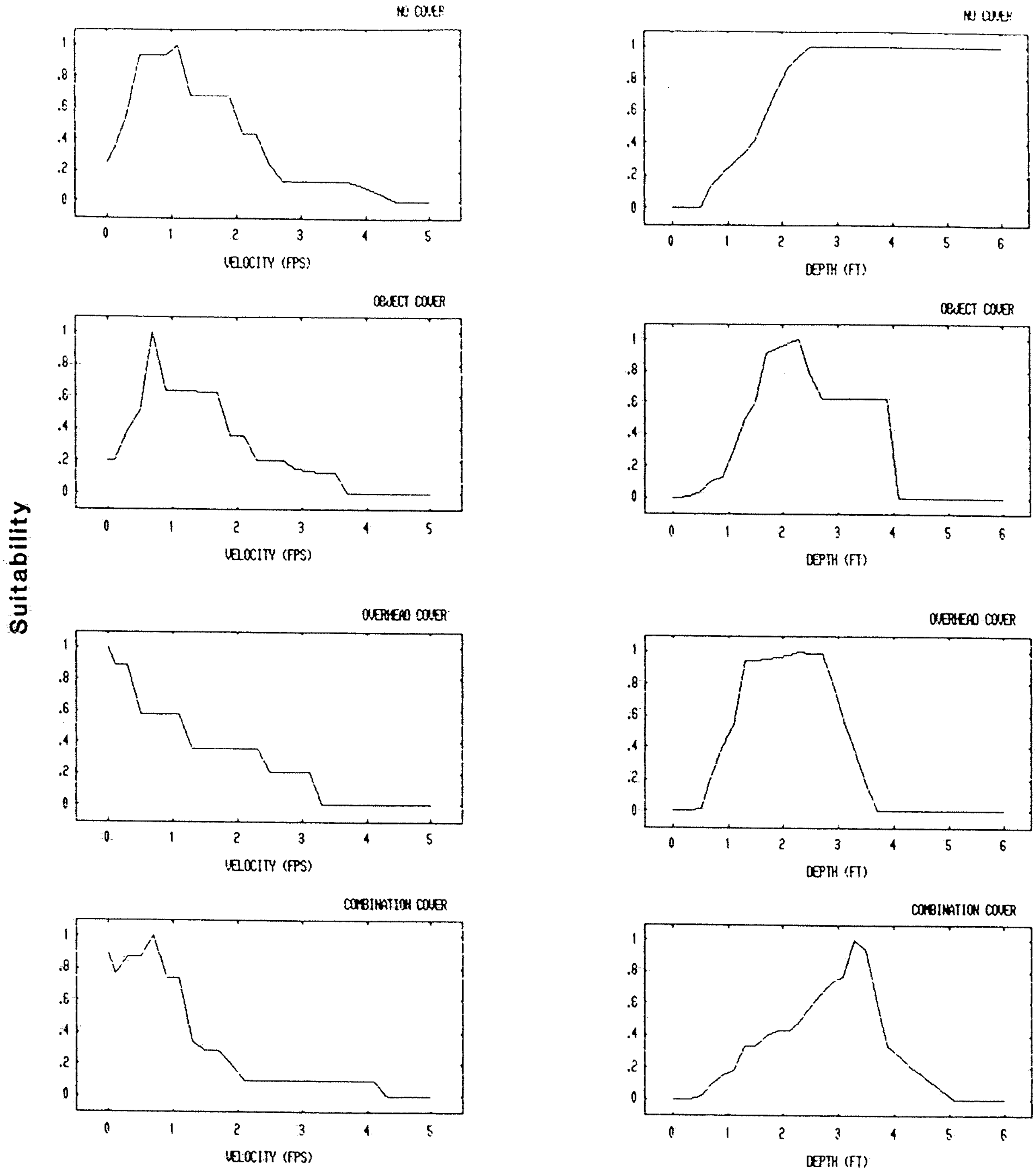
Birch Creek, under existing diversions, probably dries up yearly except for a few residual pools which have allowed brook trout populations to persist. With even small releases sufficient o maintain year round flow, brown trout could be expected to replace the brook trout.

ATTACHMENT 1

Habitat Preference Curves plotted from data supplied by M. Aceituno, U.S. Fish and Wildlife Service, for use on the McGee and Birch creeks Project instream flow studies. The data are from Appendix A of Aceituno et al., unpublished, and represent utilization data corrected for habitat availability.

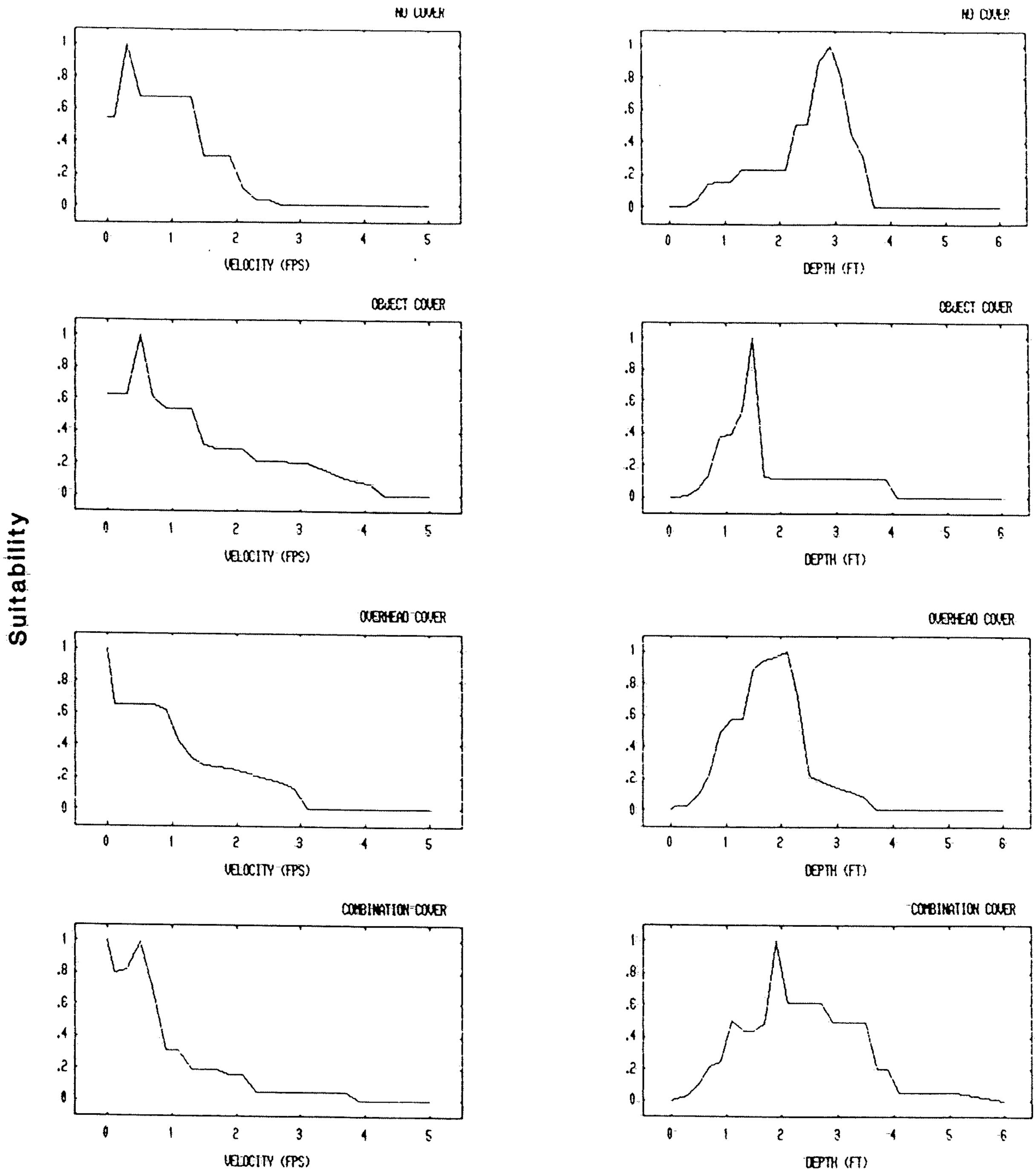
Adult Brown Trout Suitability Index Curves

(from Aceituno et al, unpublished)



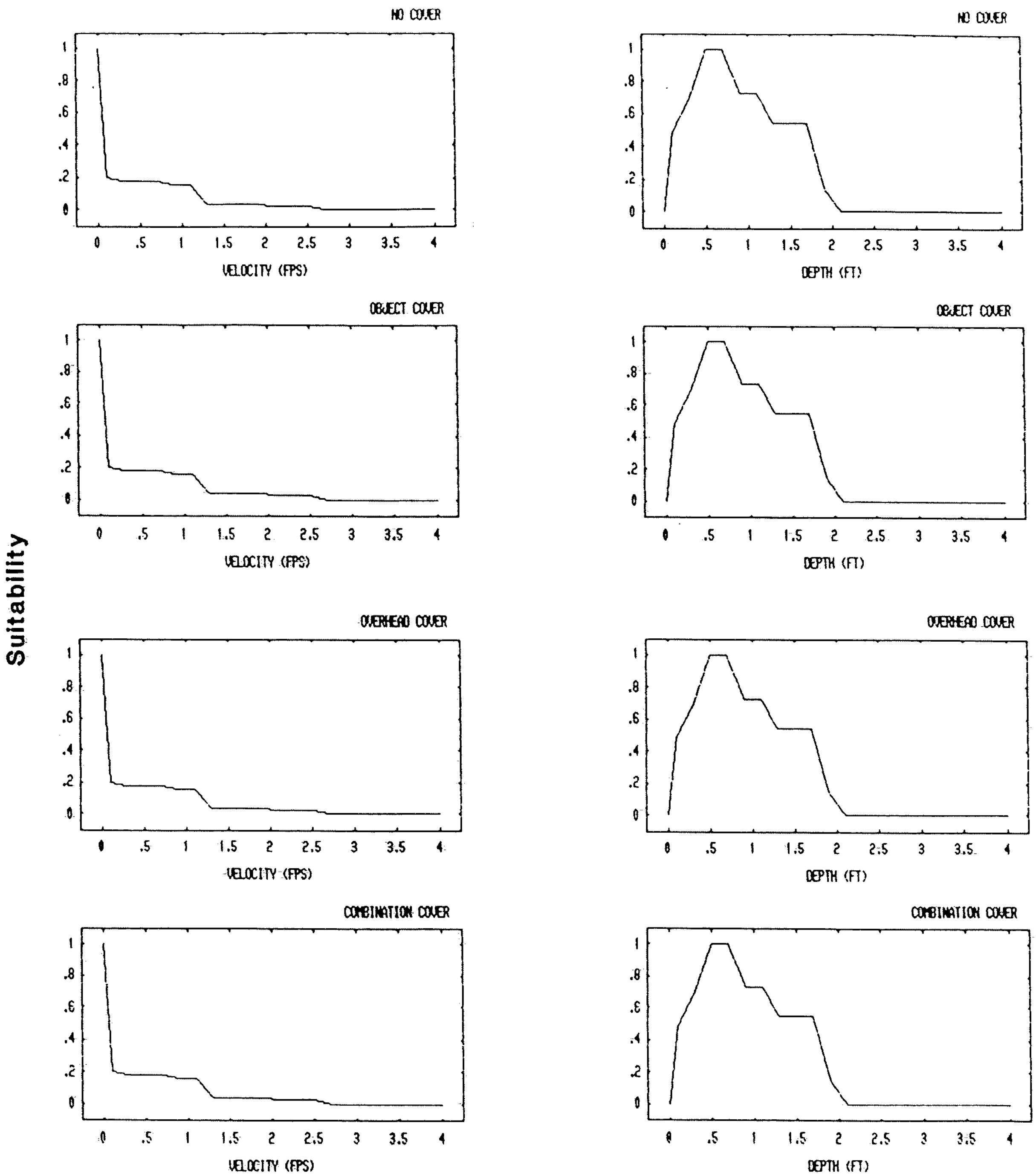
Juvenile Brown Trout Suitability Index Curves

(from Aceituno et al, unpublished)

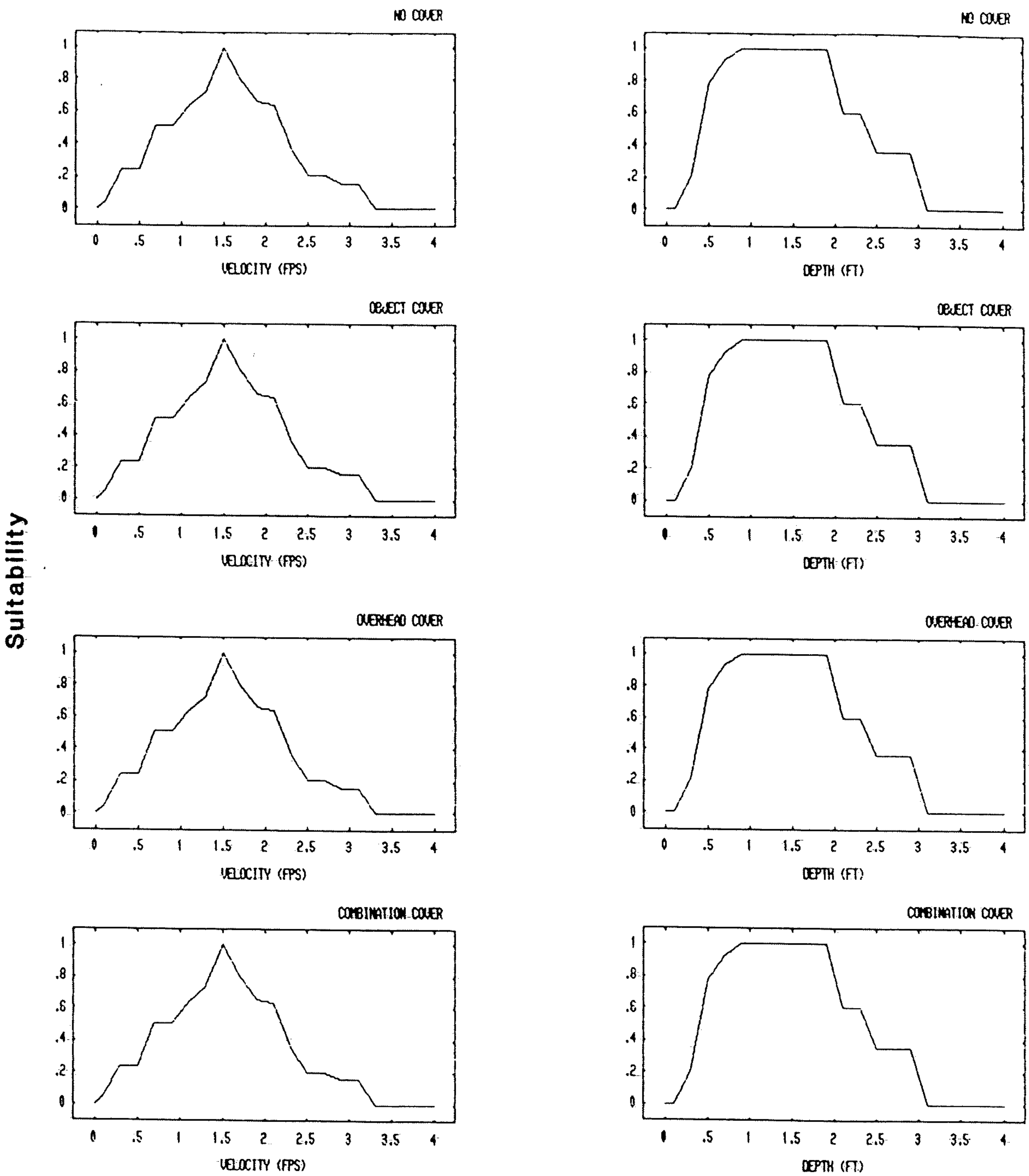


Fry Brown Trout Suitability Index Curves

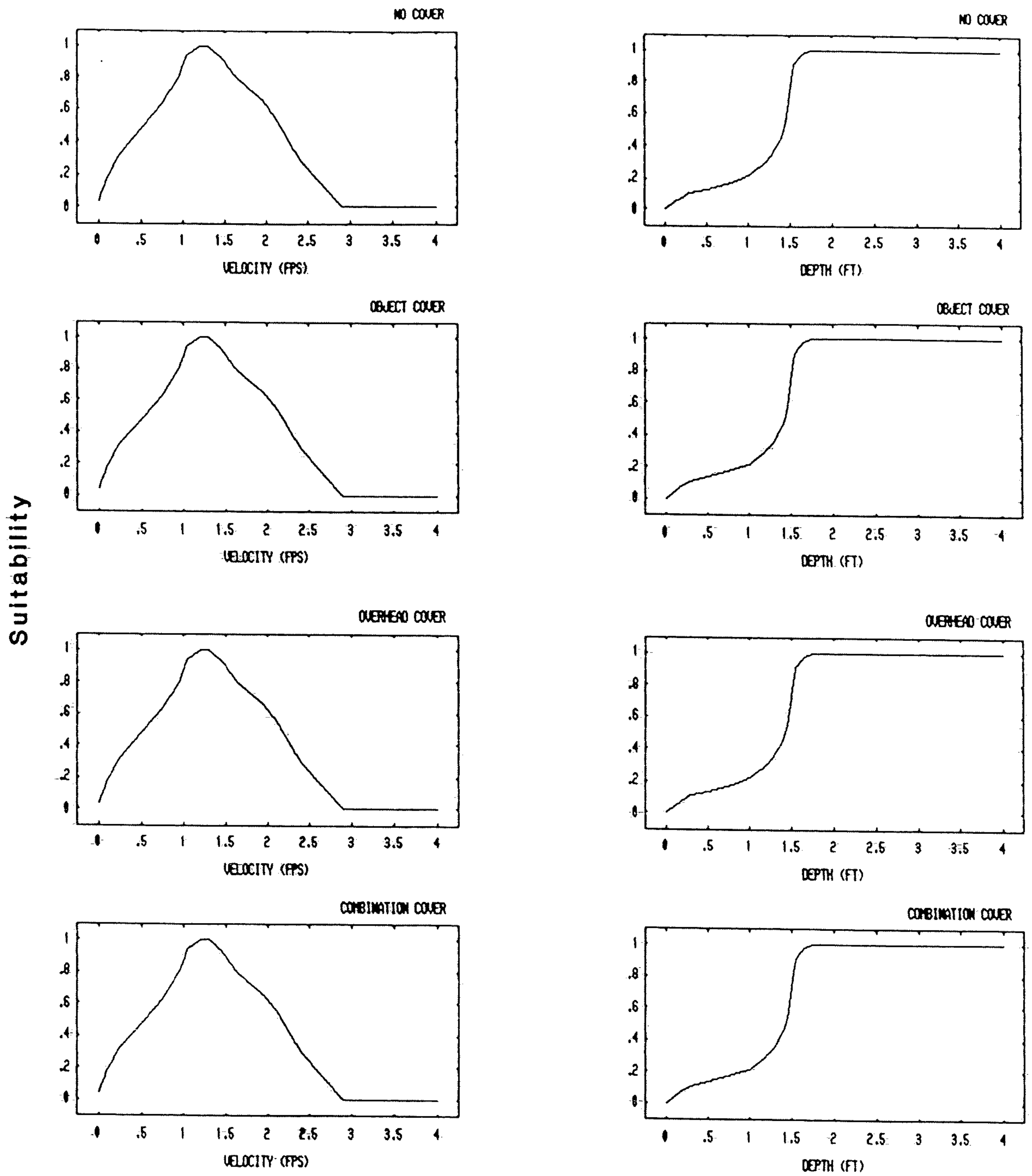
(from Aceituno et al, unpublished)



Spawning Brown Trout Suitability Index Curves
(from Aceituno et al, unpublished)

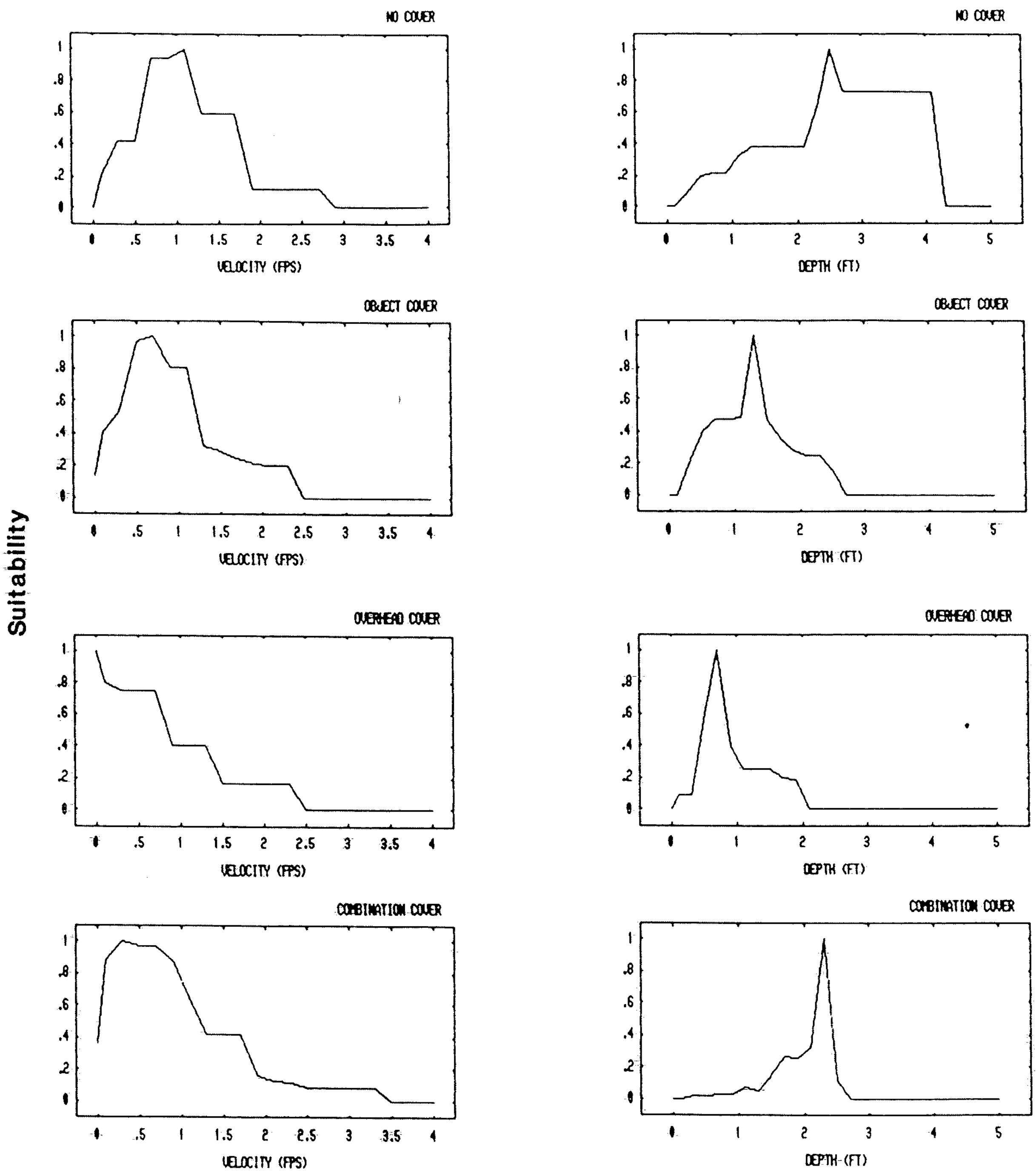


Adult Rainbow Trout Suitability Index Curves
(from Aceituno et al, unpublished)



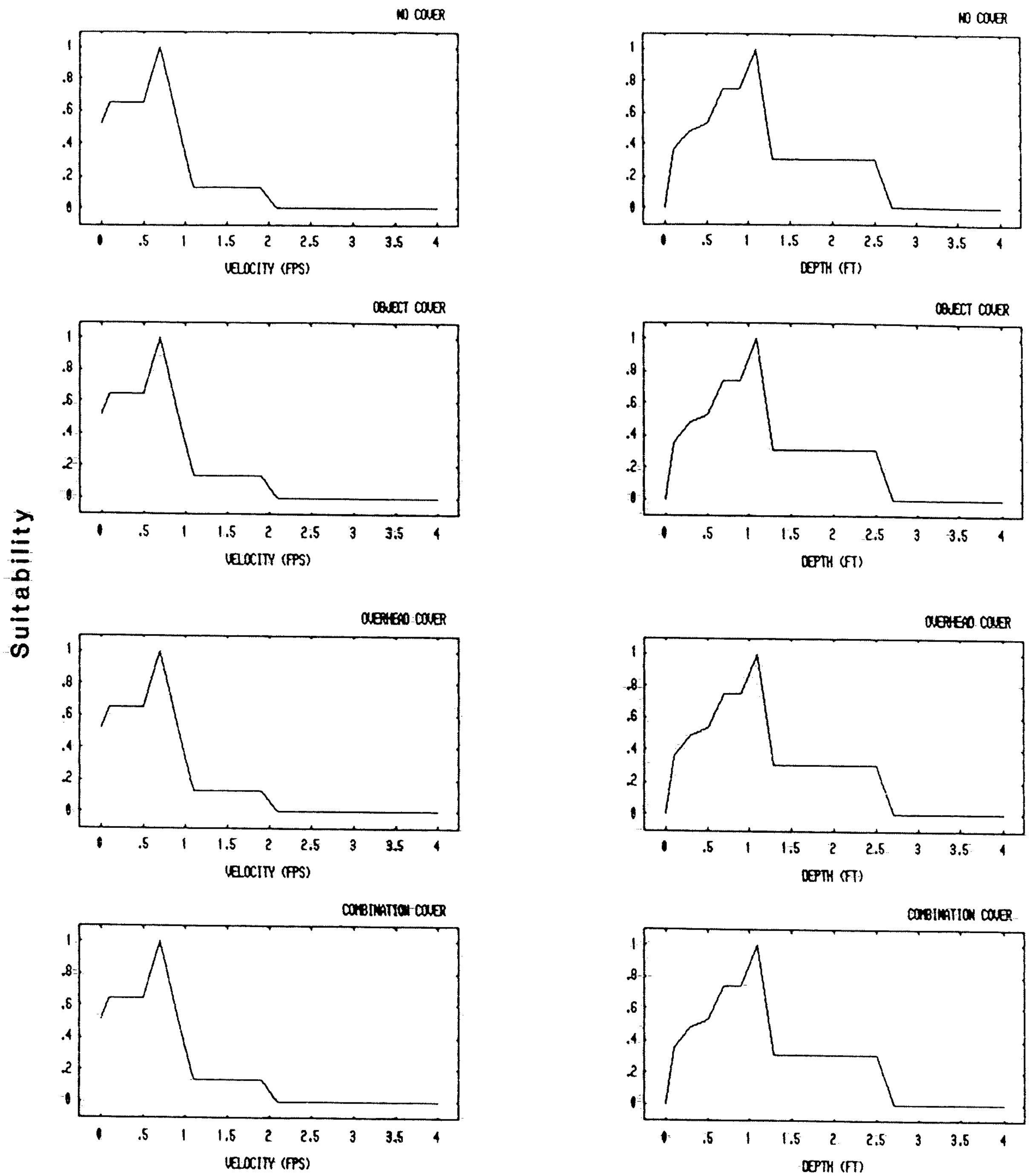
Juvenile Rainbow Trout Suitability Index Curves

(from Aceituno et al, unpublished)

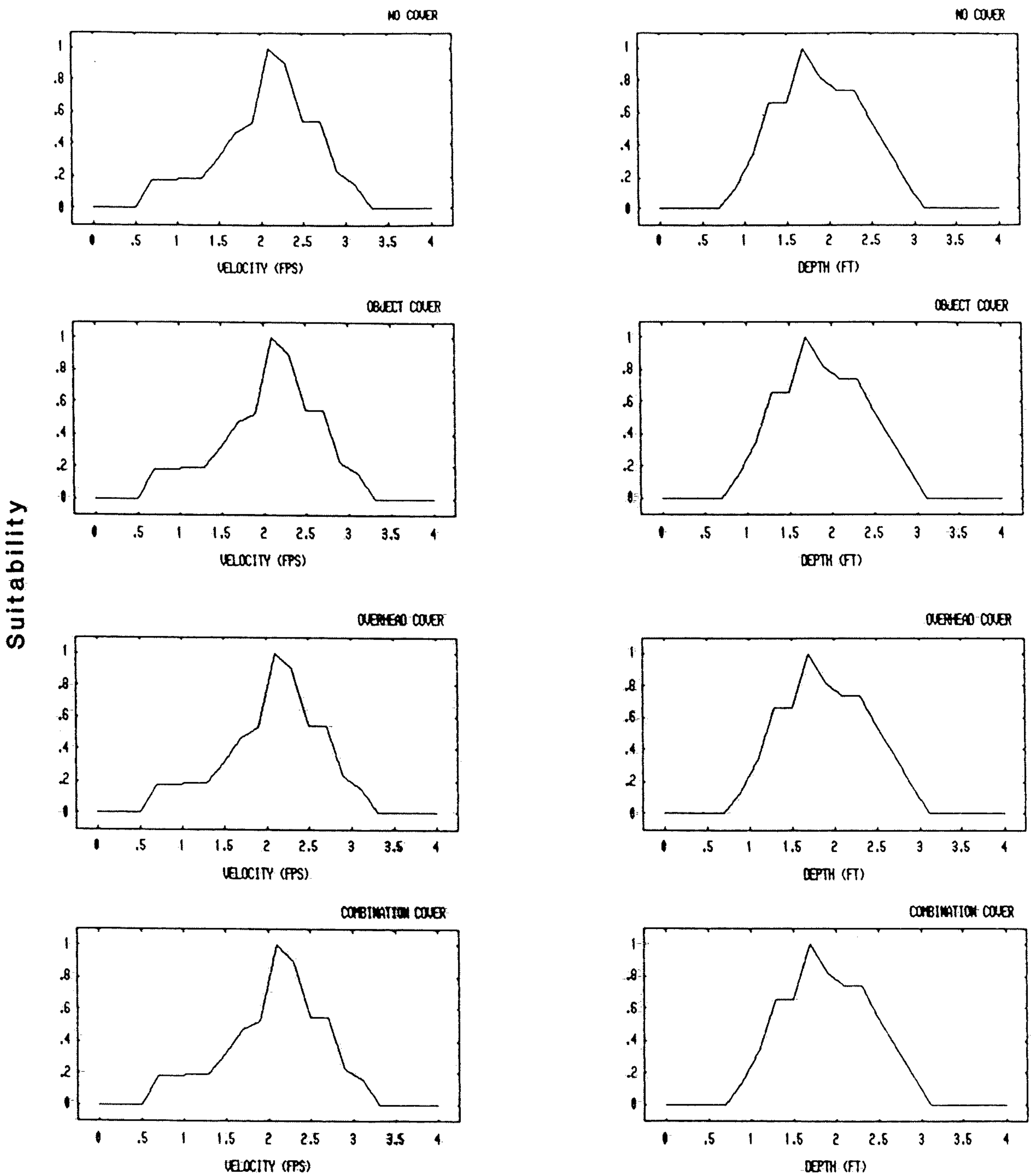


Fry Rainbow Trout Suitability Index Curves

(from Aceituno et al, unpublished)

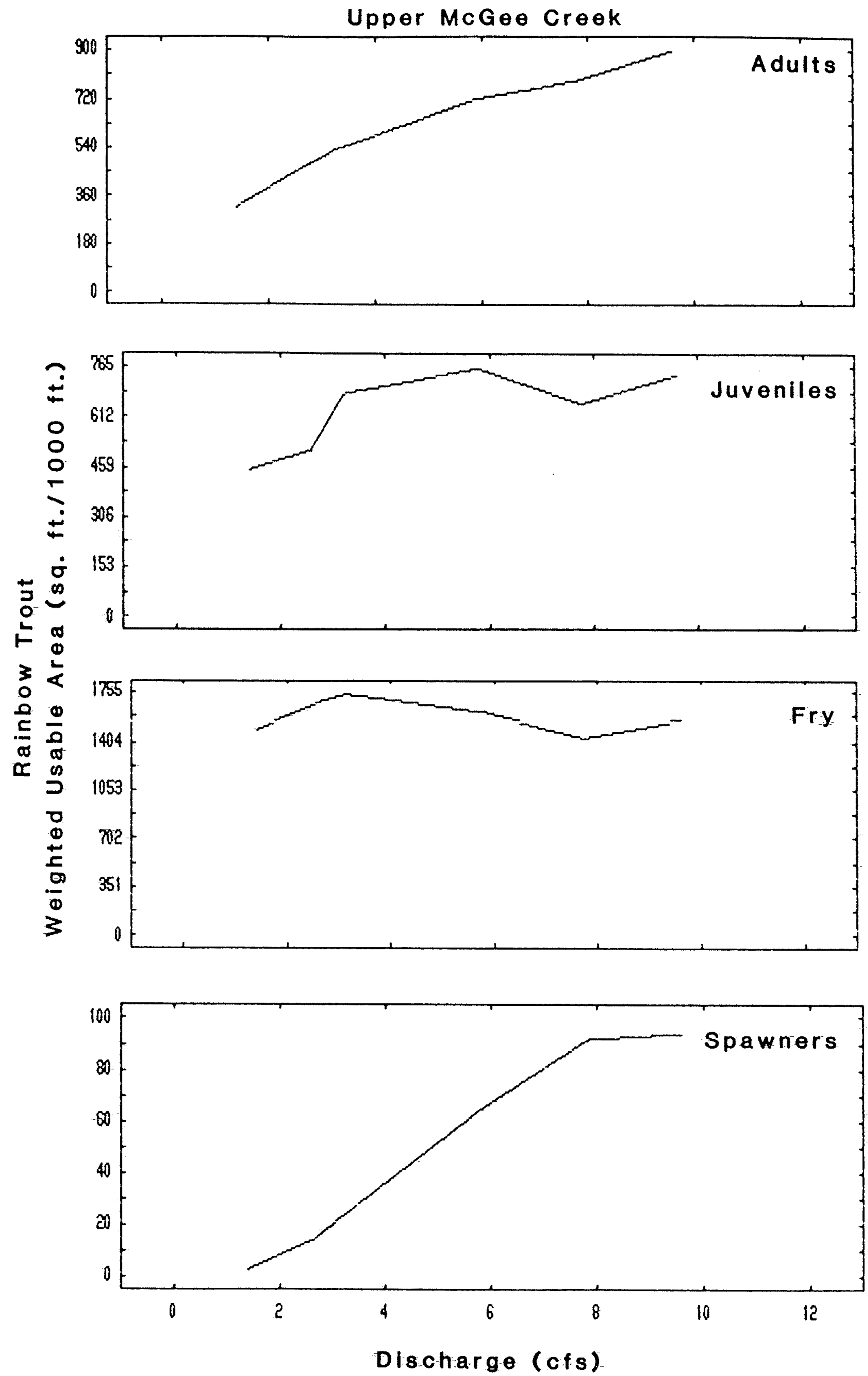


Spawning Rainbow Trout Suitability Index
(from Aceituno et al, unpublished)

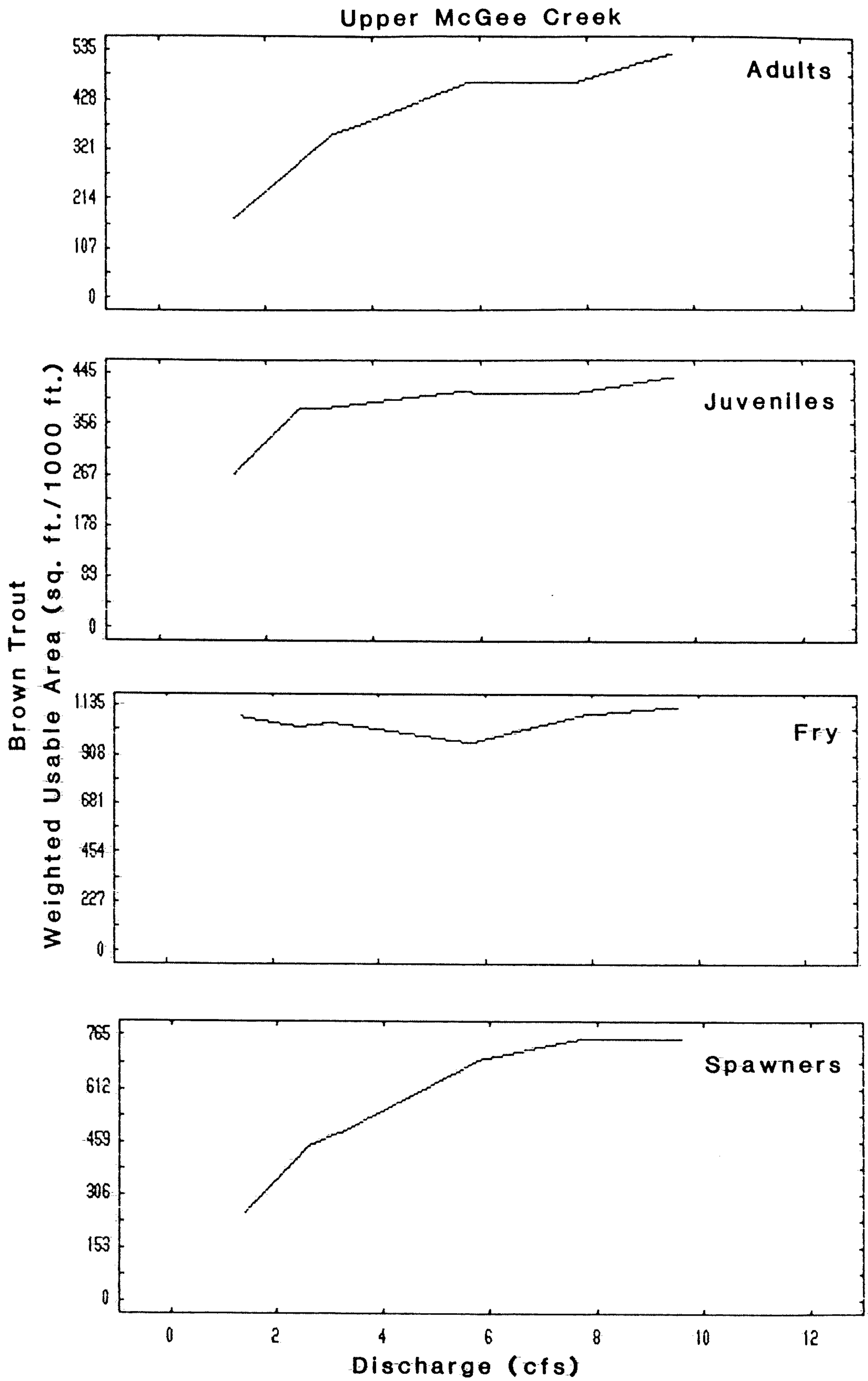


ATTACHMENT 2

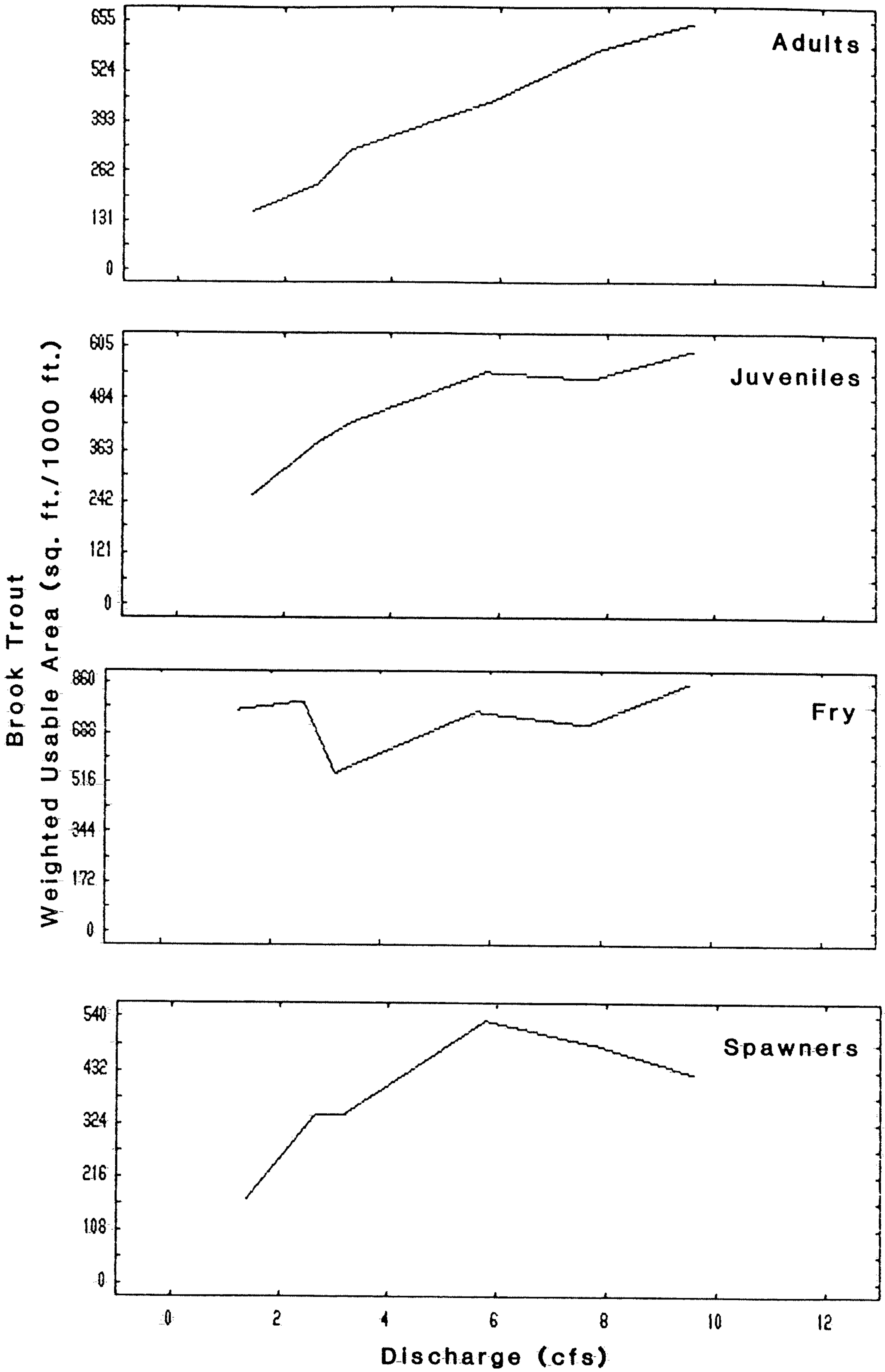
Curves of Weighted Usable Area for brown and brook trout in Birch and McGee creeks, using the Suitability Index curves from Aceituno, et al. (unpublished) shown in Attachment 1.

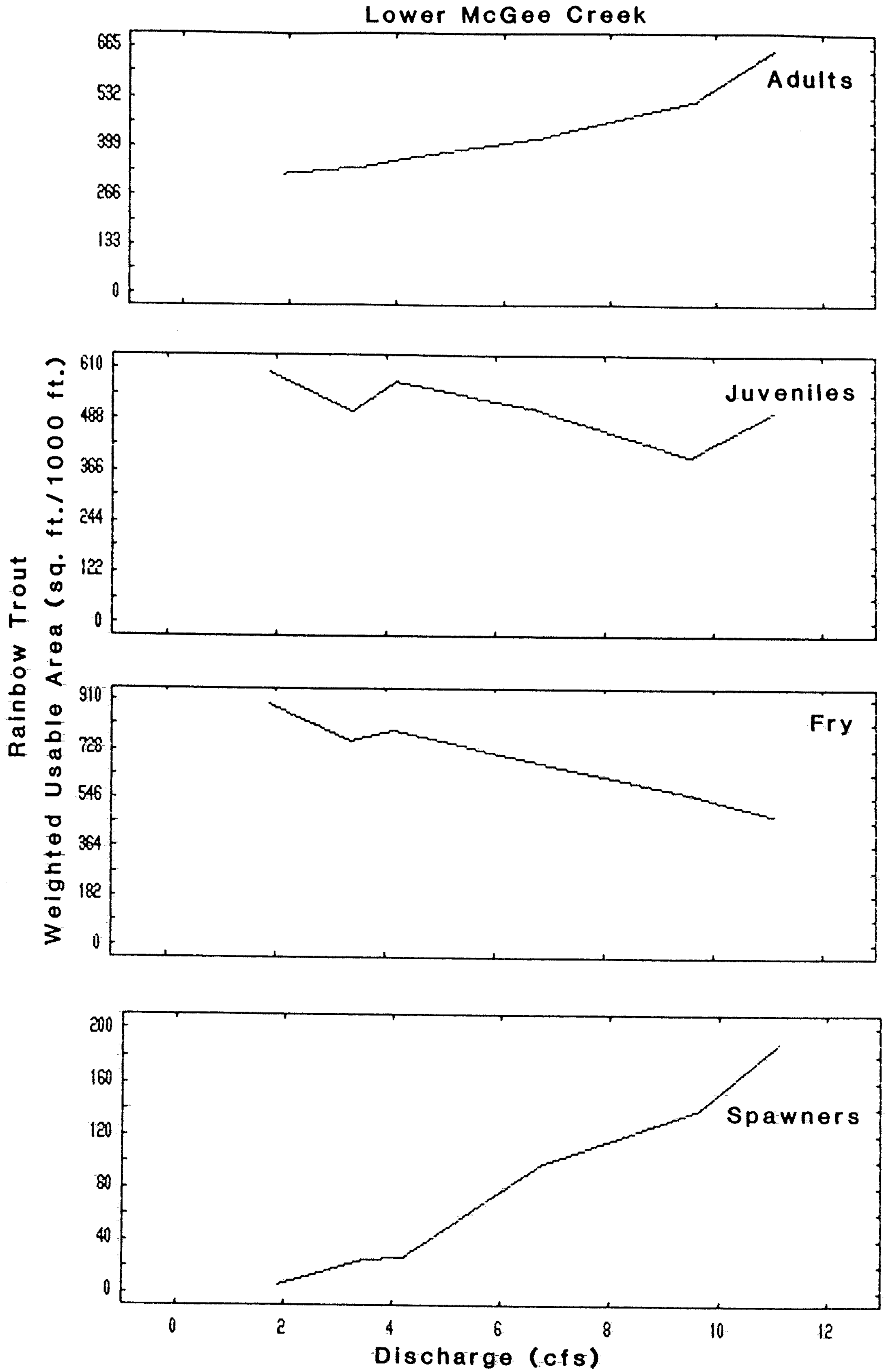


Upper McGee Creek
Adults
900
720
540
360
180
0
Juveniles
765
612
459
306
153
0
Fry
1755
1404
1053
702
351
0
Spawners
100
80
60
40
20
0
0
2
4
6
8
10
12
Rainbow Trout
Weighted Usable Area (sq. ft./1000 ft.)
Discharge (cfs)

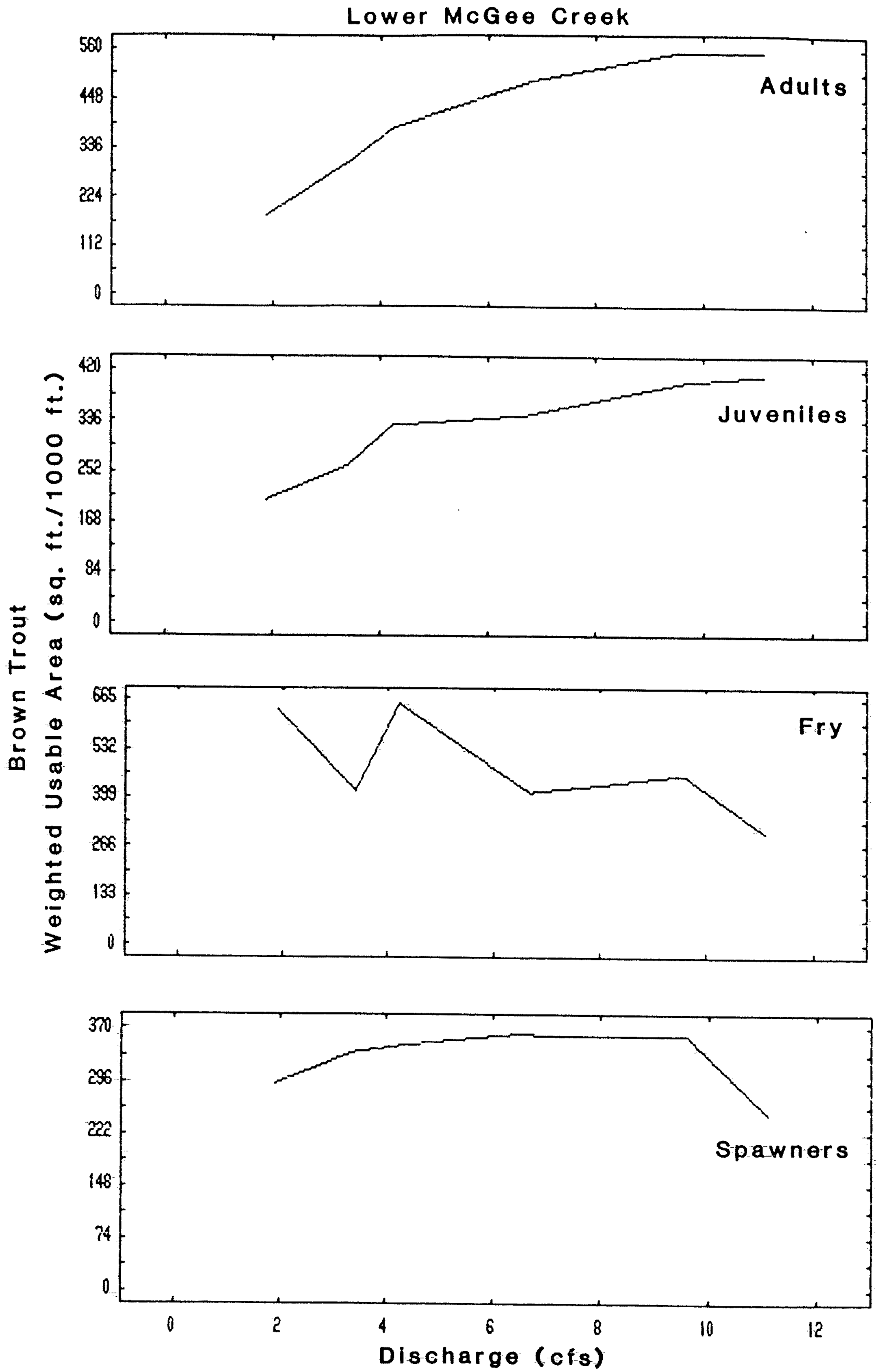

Upper McGee Creek
Adults
535
428
321
214
107
0
Juveniles
445
356
267
178
89
0
Fry
1135
908
681
454
227
0
Spawners
765
612
459
306
153
0
0
2
4
6
8
10
12
Discharge (cfs)
Brown Trout
Weighted Usable Area (sq. ft./1000 ft.)

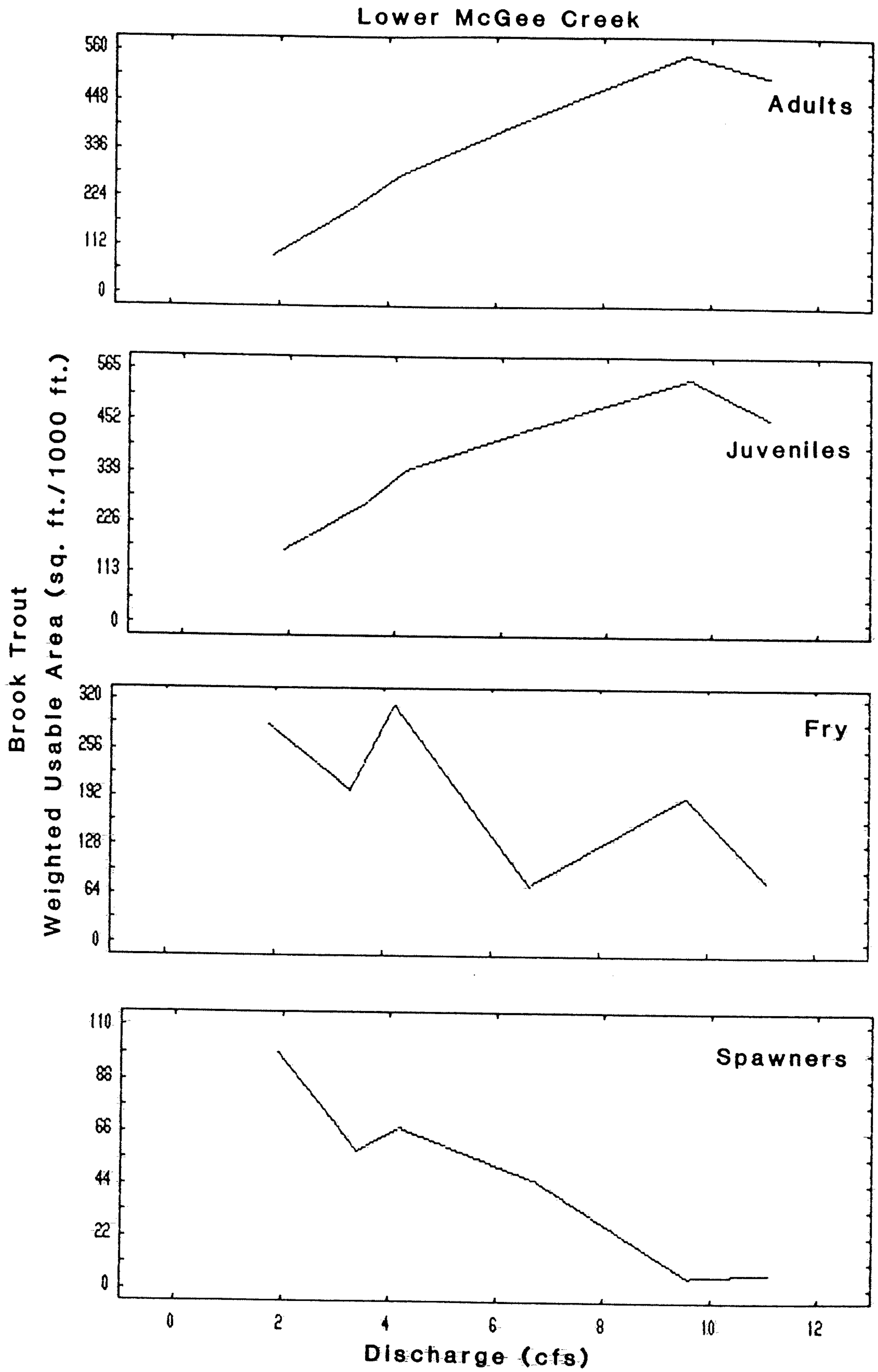
Upper McGee Creek

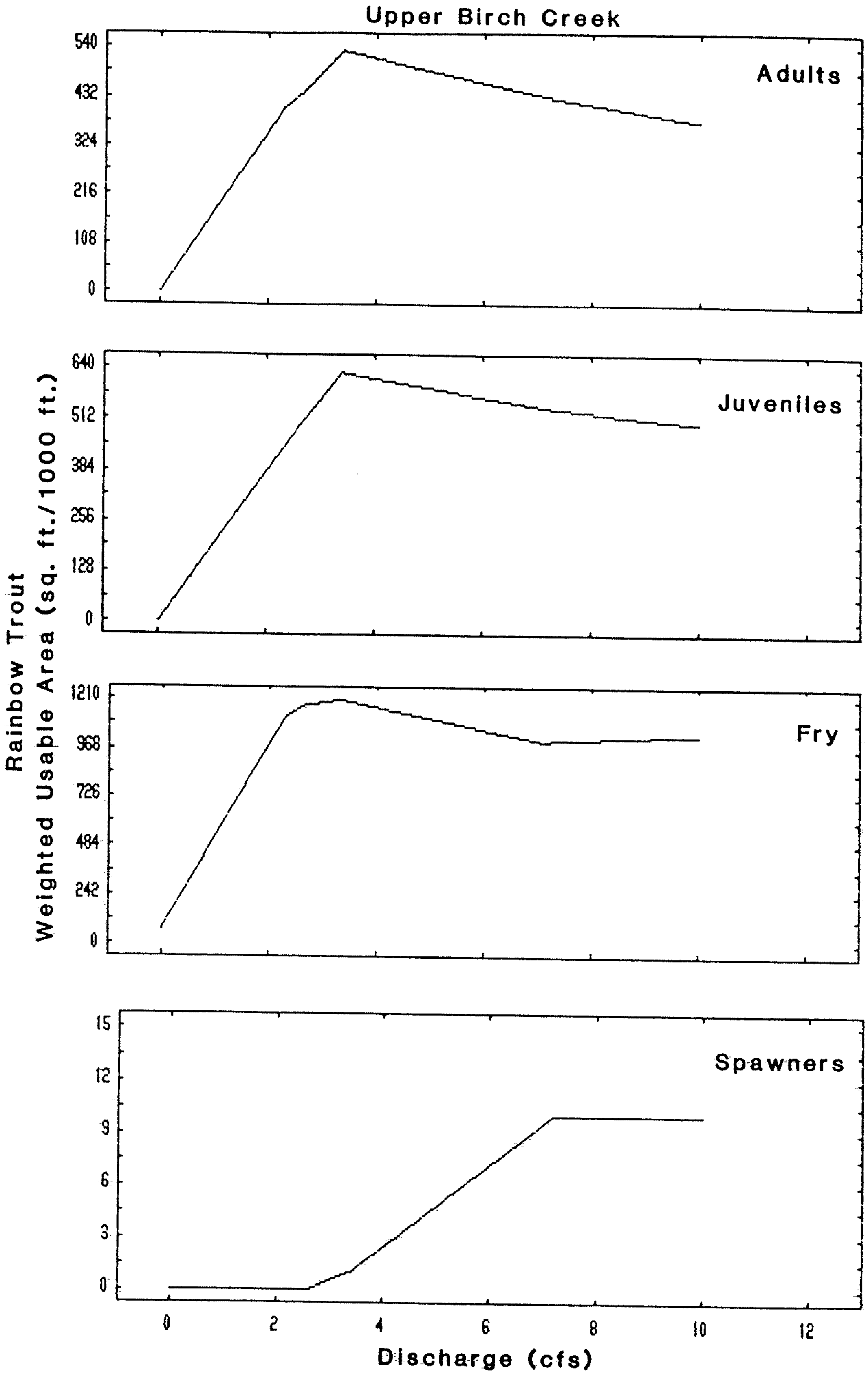


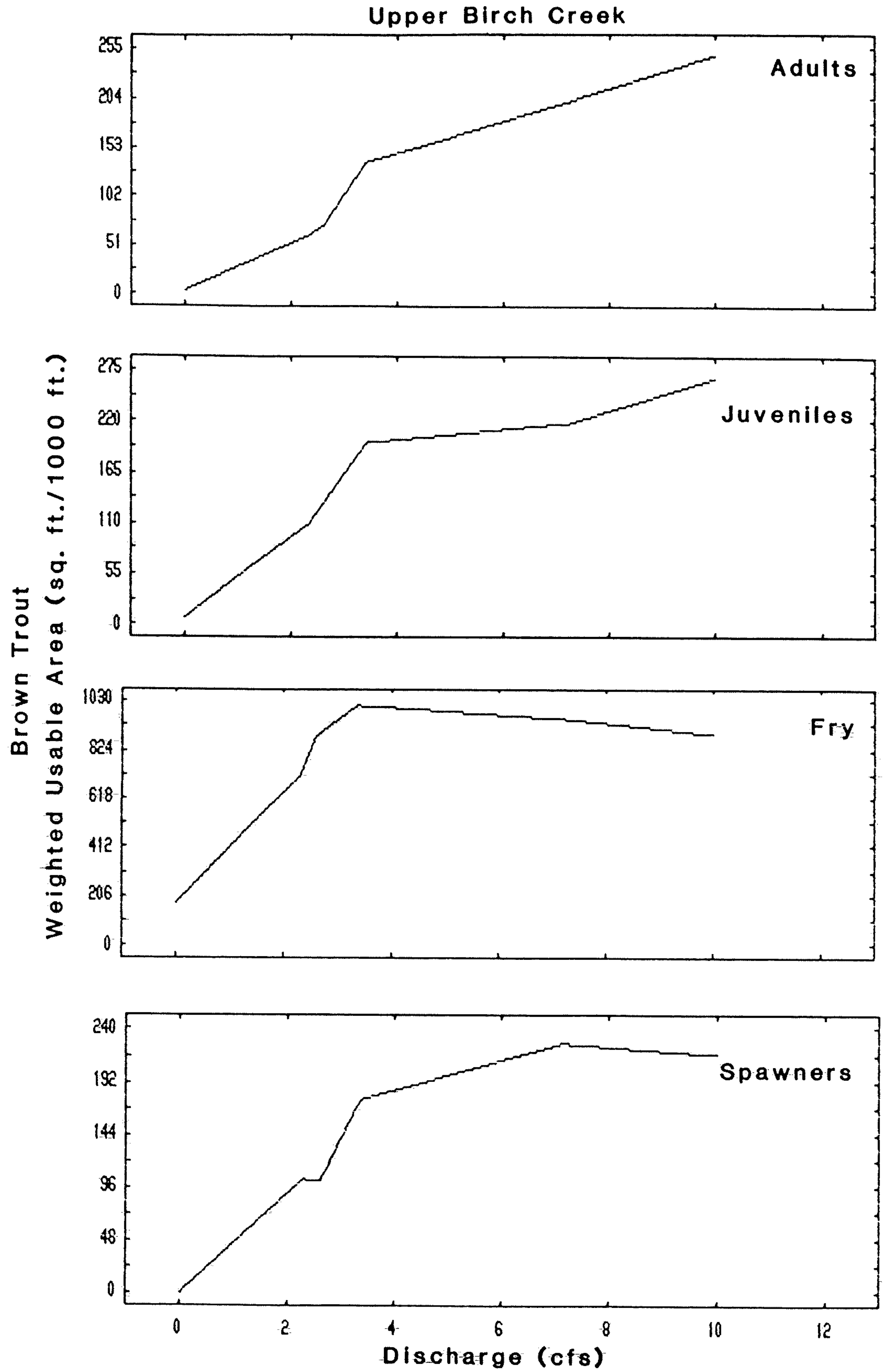


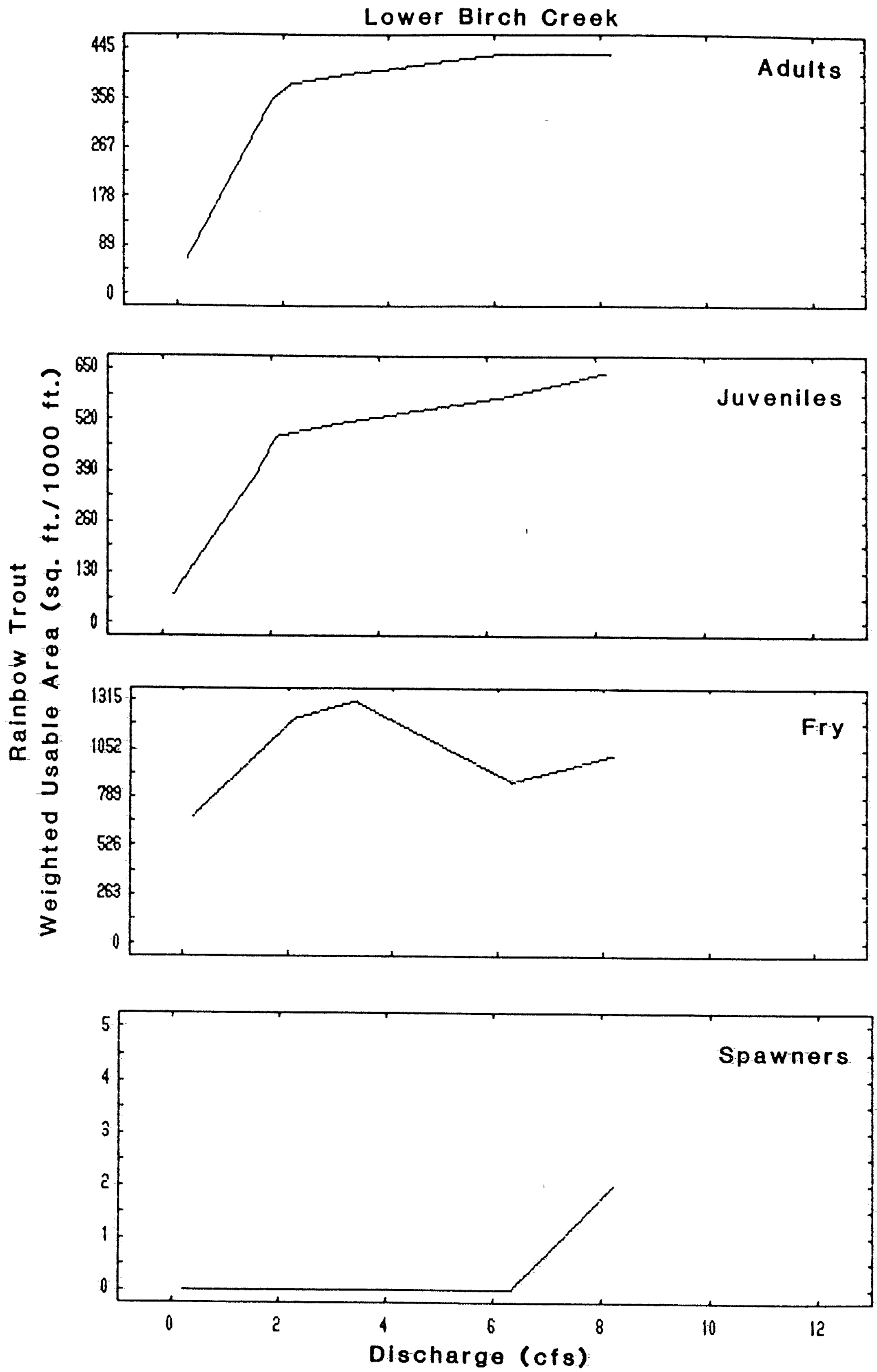
Lower McGee Creek
Adults
Juveniles
Fry
Spawners
Rainbow Trout
Weighted Usable Area (sq. ft./1000 ft.)
Discharge (cfs)
0
133
266
399
532
665
0
122
244
366
488
610
0
182
364
546
728
910
0
40
80
120
160
200
0
2
4
6
8
10
12


Lower McGee Creek
Adults
560
448
336
224
112
0
Juveniles
420
336
252
168
84
0
Fry
665
532
399
266
133
0
Spawners
370
296
222
148
74
0
0
2
4
6
8
10
12
Discharge (cfs)
Brown Trout
Weighted Usable Area (sq. ft./1000 ft.)

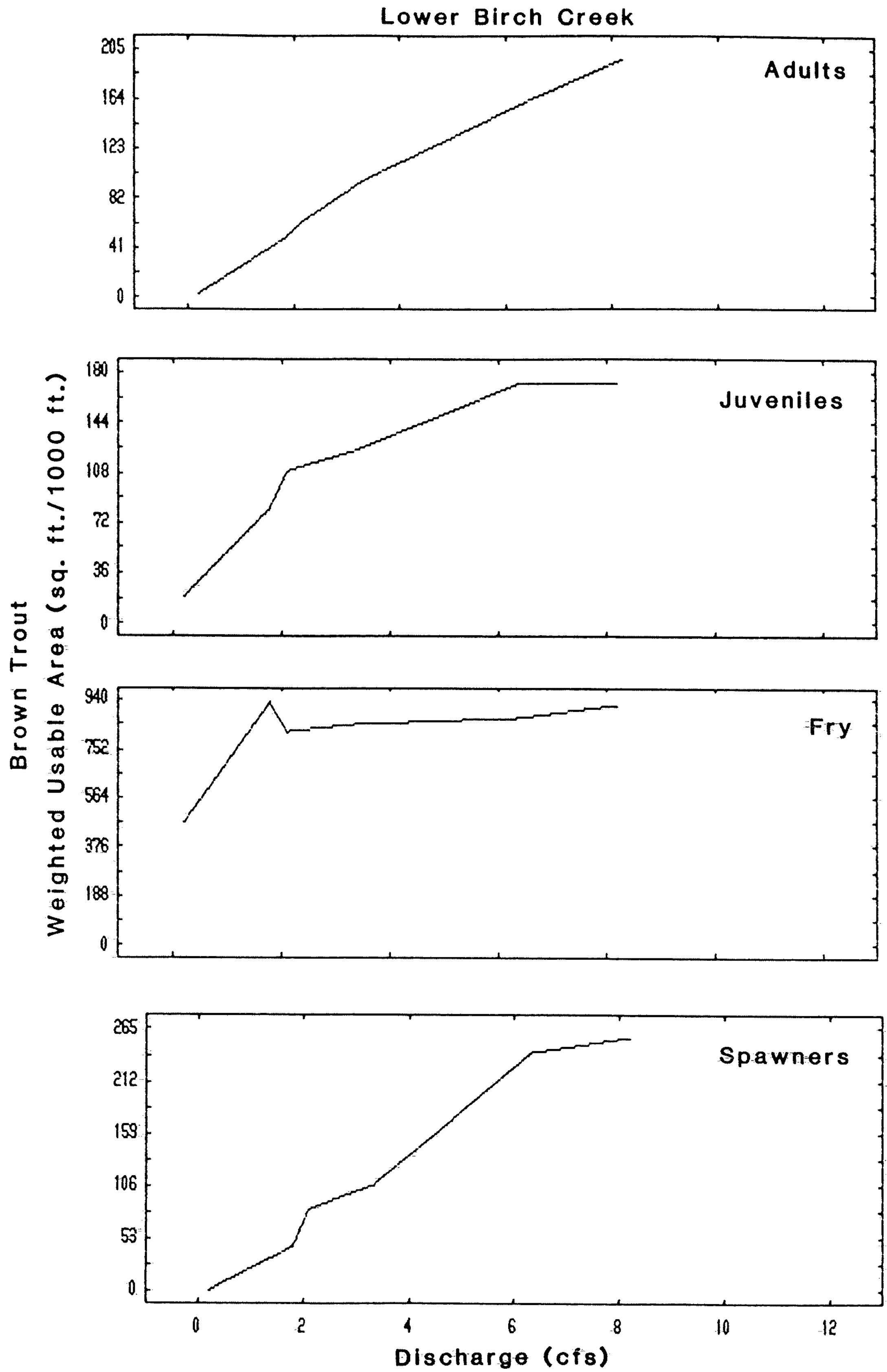

Lower McGee Creek
Brook Trout
Weighted Usable Area (sq. ft./1000 ft.)
560
448
336
224
112
0
Adults
565
452
339
226
113
0
Juveniles
320
256
192
128
64
0
Fry
110
88
66
44
22
0
Spawners
0
2
4
6
8
10
12
Discharge (cfs)

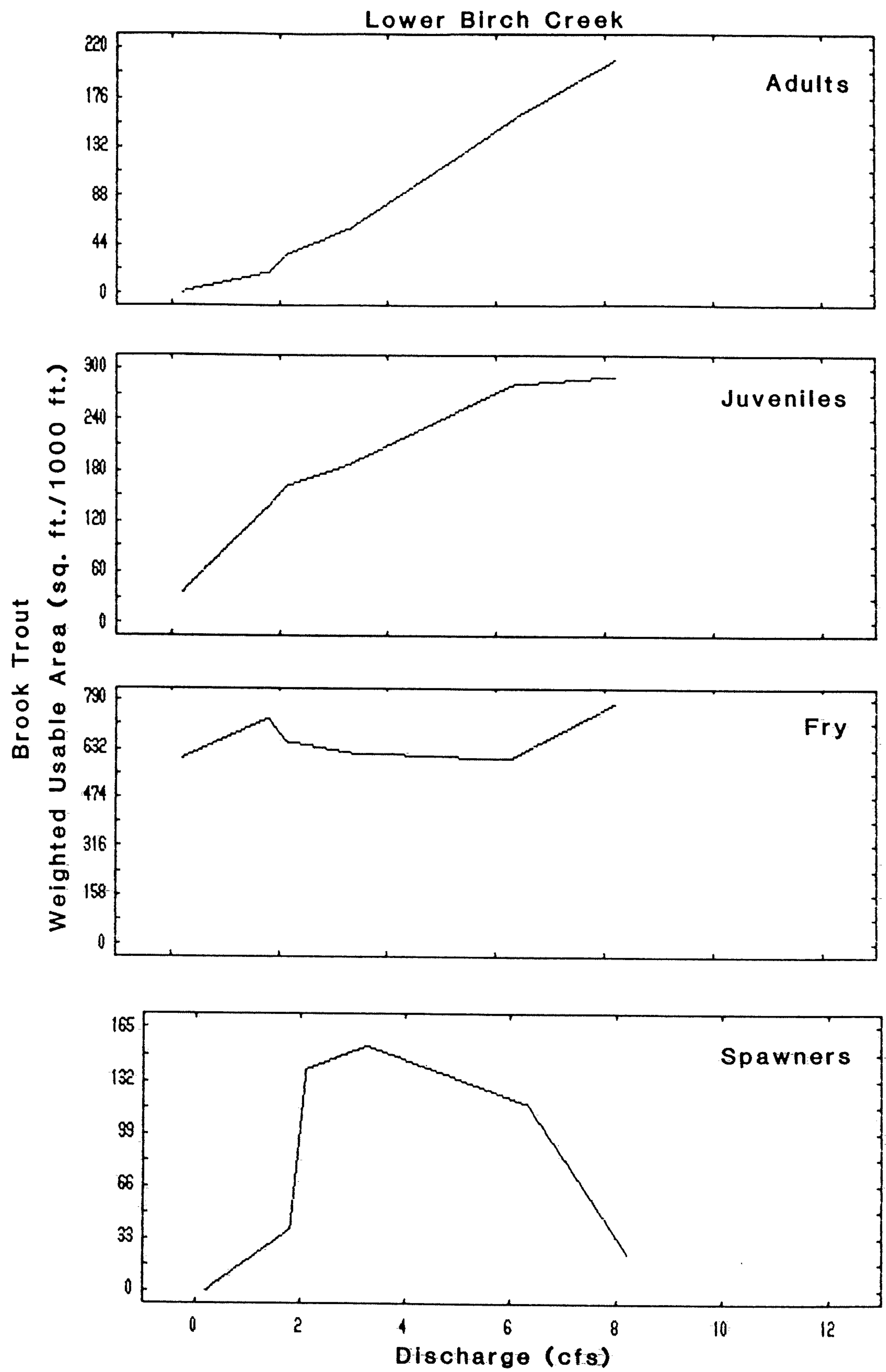

Upper Birch Creek
Adults
540
432
324
216
108
0
Juveniles
640
512
384
256
128
0
Fry
1210
968
726
484
242
0
Spawners
15
12
9
6
3
0
0
2
4
6
8
10
12
Discharge (cfs)
Rainbow Trout
Weighted Usable Area (sq. ft./1000 ft.)


Upper Birch Creek
Adults
Juveniles
Fry
Spawners
Brown Trout
Weighted Usable Area (sq. ft./1000 ft.)
255
204
153
102
51
0
275
220
165
110
55
0
1030
824
618
412
206
0
240
192
144
96
48
0
0
2
4
6
8
10
12
Discharge (cfs)



Lower Birch Creek
Adults
445
356
267
178
89
0
Juveniles
650
520
390
260
130
0
Fry
1315
1052
789
526
263
0
Spawners
5
4
3
2
1
0
0
2
4
6
8
10
12
Discharge (cfs)
Rainbow Trout
Weighted Usable Area (sq. ft./1000 ft.)

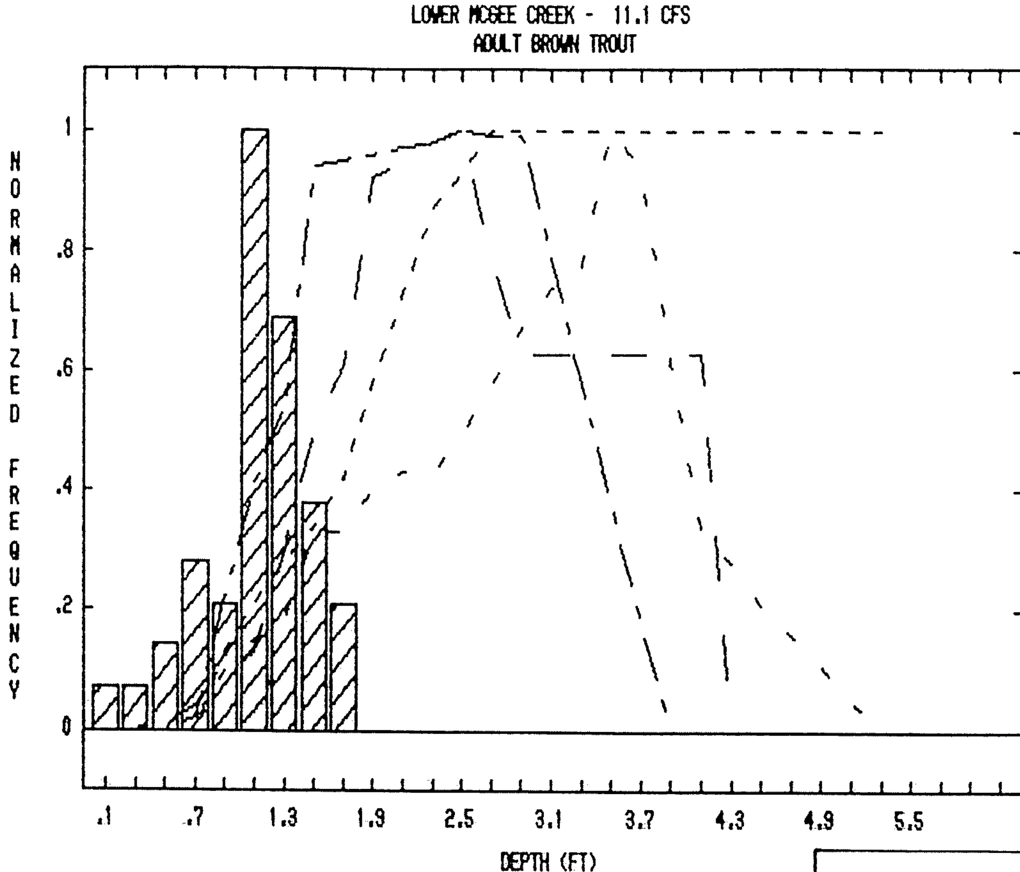

Lower Birch Creek
Adults
205
164
123
82
41
0
Juveniles
180
144
108
72
36
0
Fry
940
752
564
376
188
0
Spawners
265
212
159
106
53
0
0
2
4
6
8
10
12
Discharge (cfs)
Brown Trout
Weighted Usable Area (sq. ft./1000 ft.)



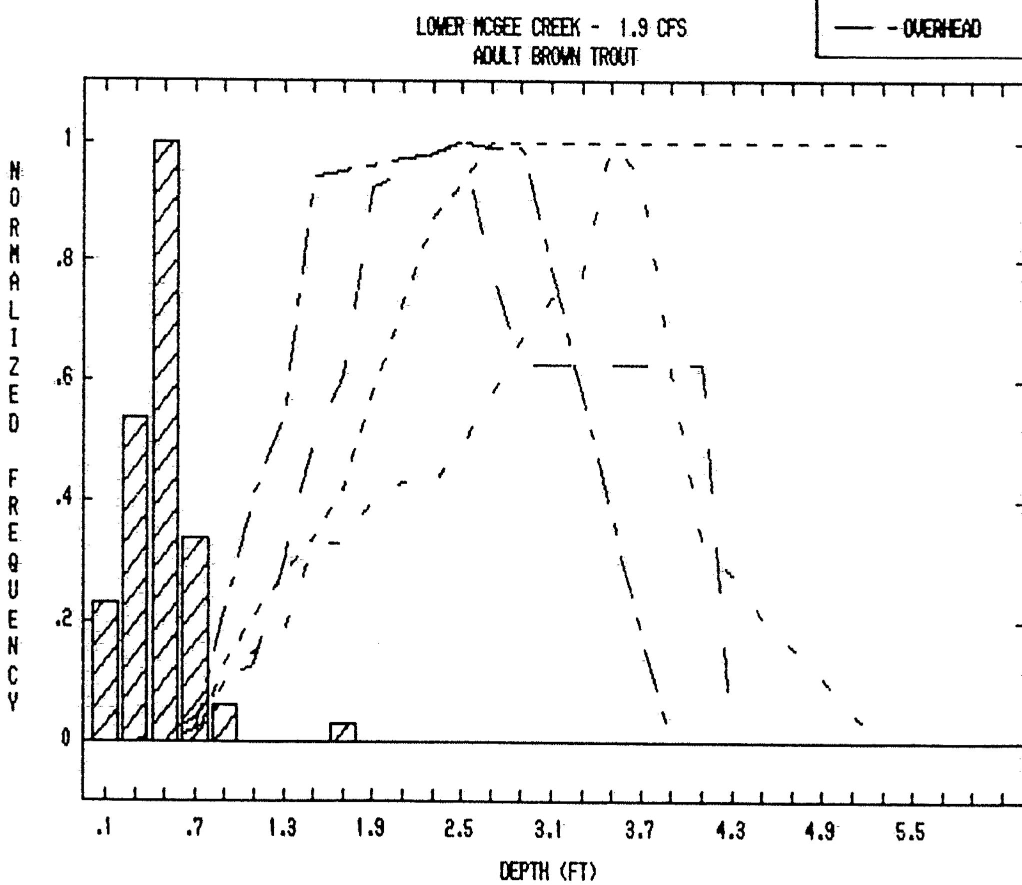
Lower Birch Creek
Adults
Juveniles
Fry
Spawners
Brook Trout
Weighted Usable Area (sq. ft./1000 ft.)
220
176
132
88
44
0
300
240
180
120
60
0
790
632
474
316
158
0
165
132
99
66
33
0
2
4
6
8
10
12
Discharge (cfs)

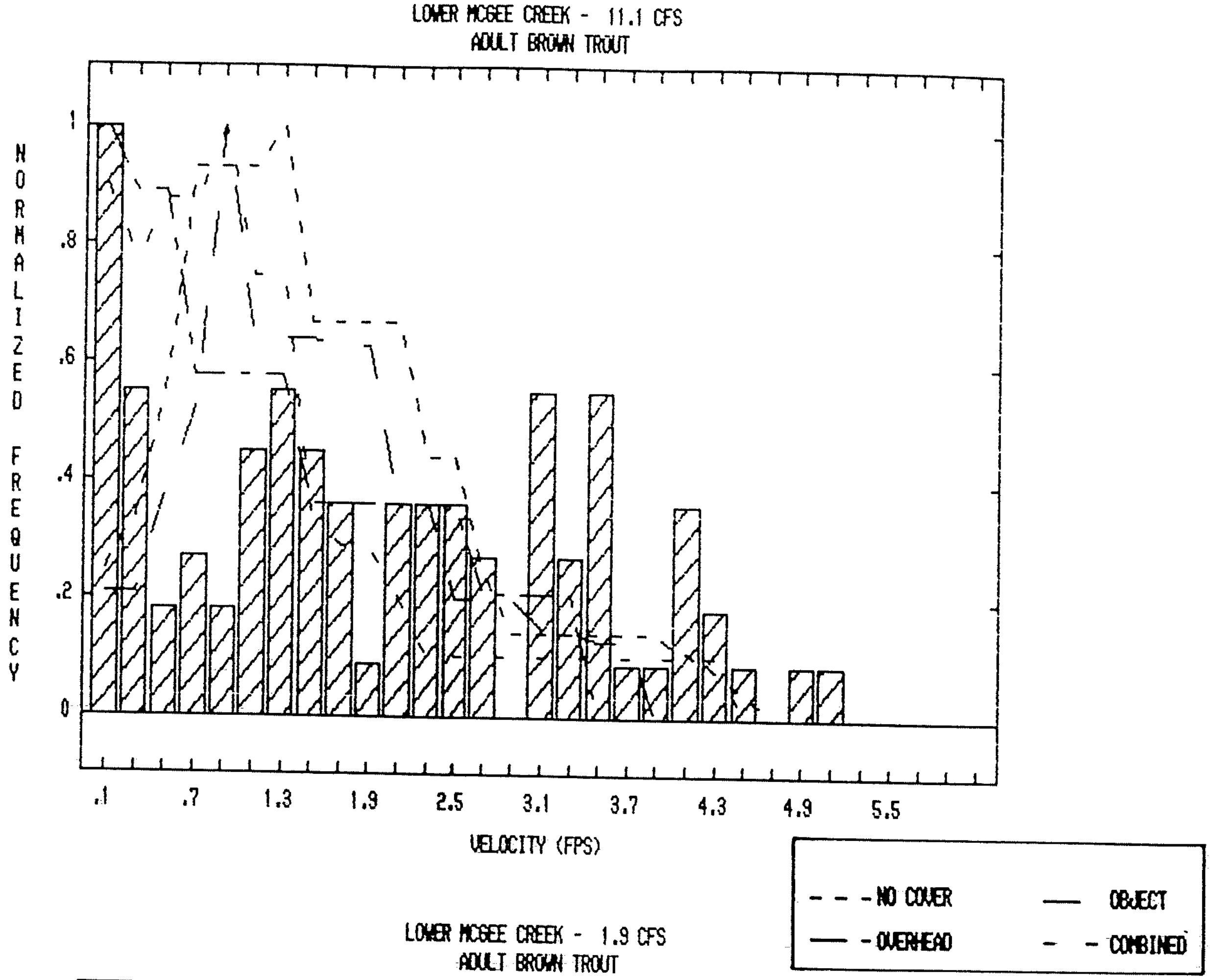
ATTACHMENT 3

Frequency distributions of depth and velocity at the highest and lowest flows measured in Birch and McGee creeks, overlaid with the Suitability Index curves from Aceituno et al. (unpublished) shown in Attachment 1.

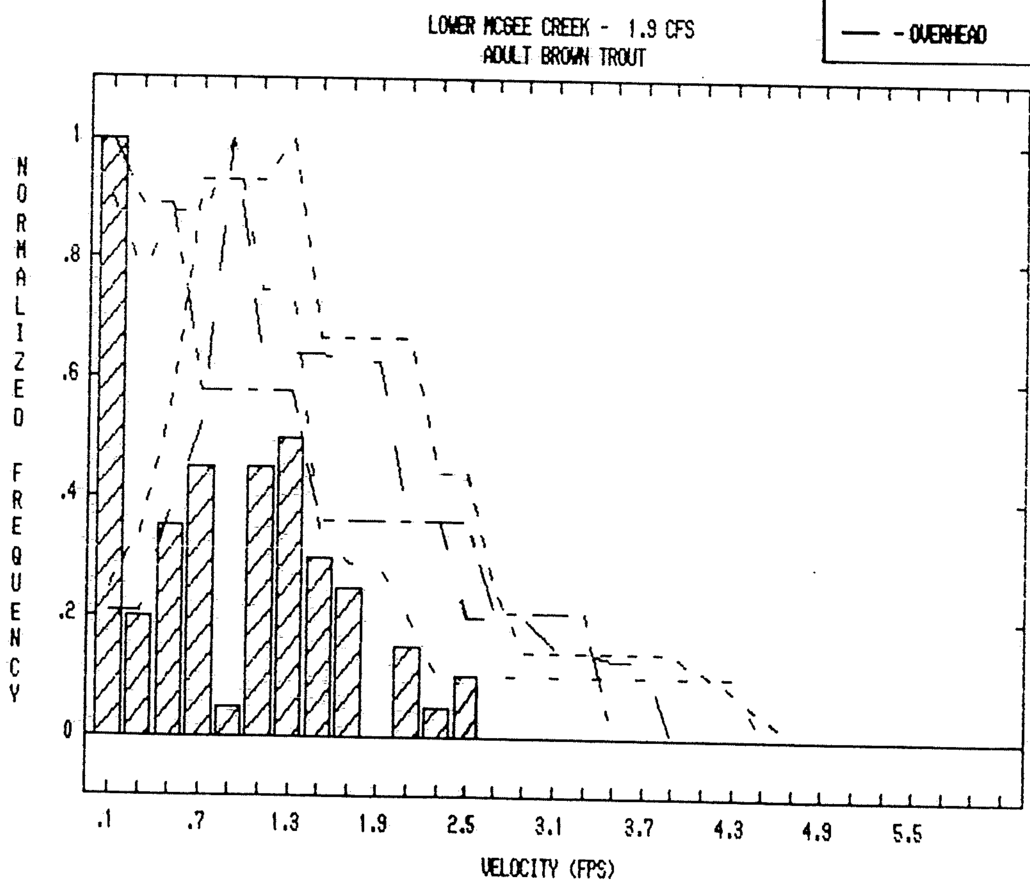


- - - NO COVER — OBJECT
—— - OVERHEAD - - COMBINED

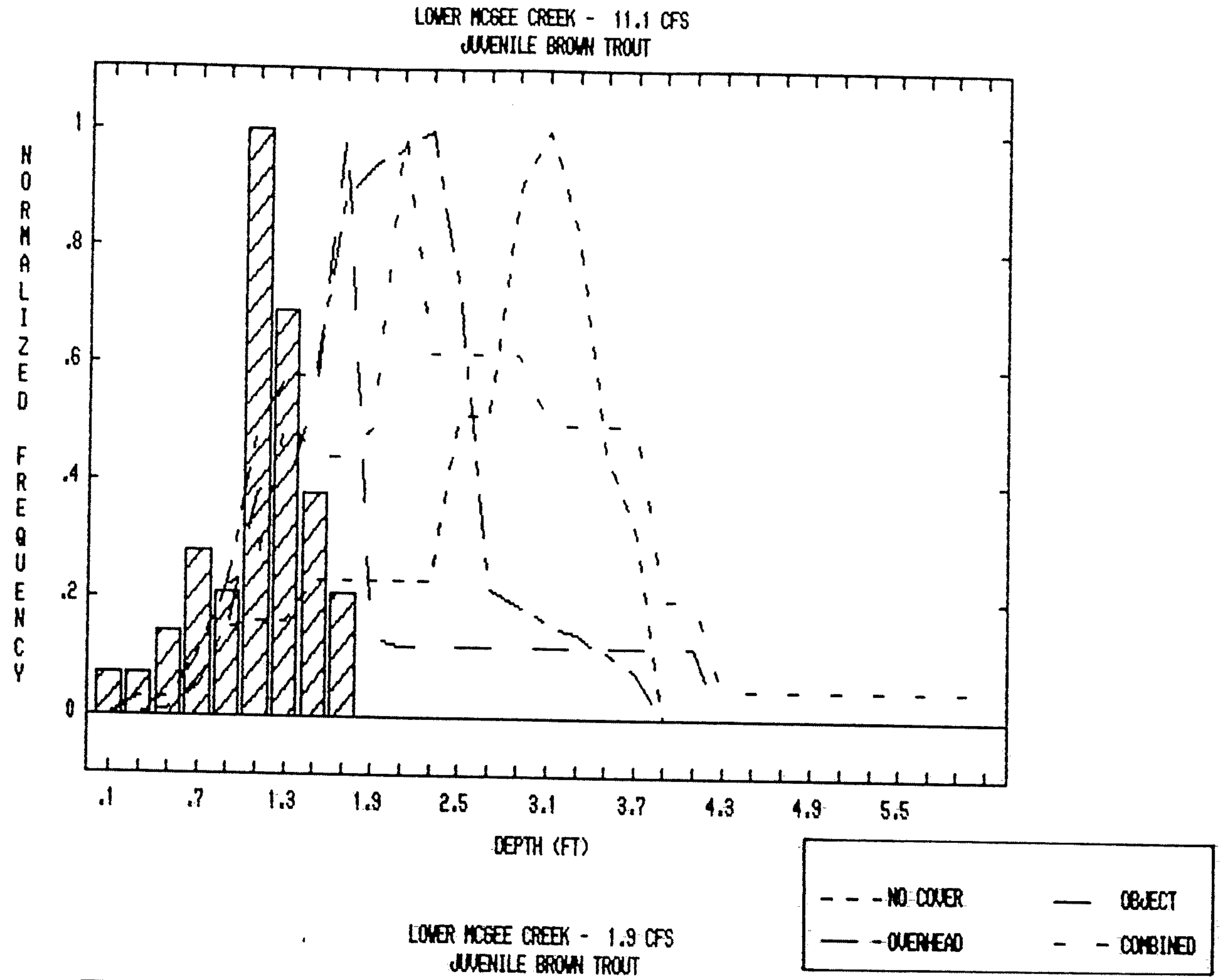


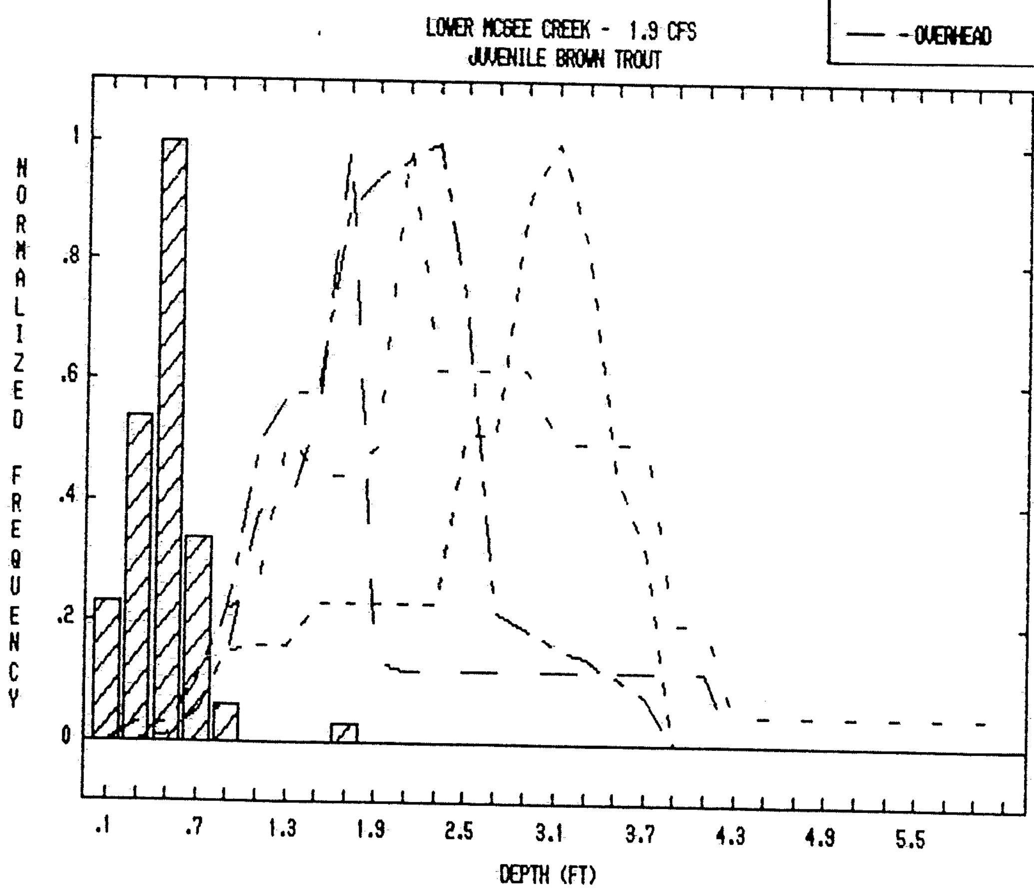


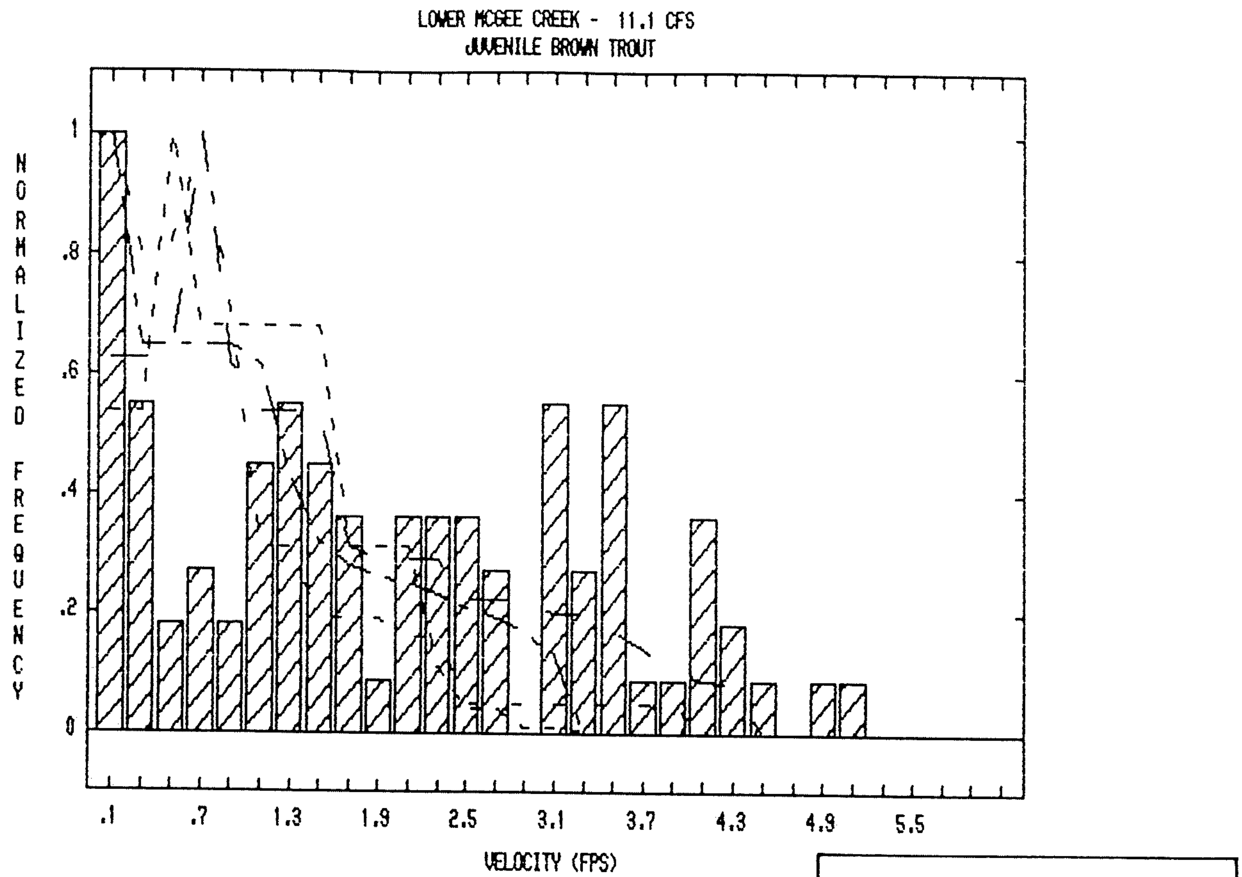
LOWER MCGEE CREEK - 11.1 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
1
.8
.6
.4
.2
0
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)
- - - NO COVER
— - OVERHEAD
— OBJECT
- - COMBINED

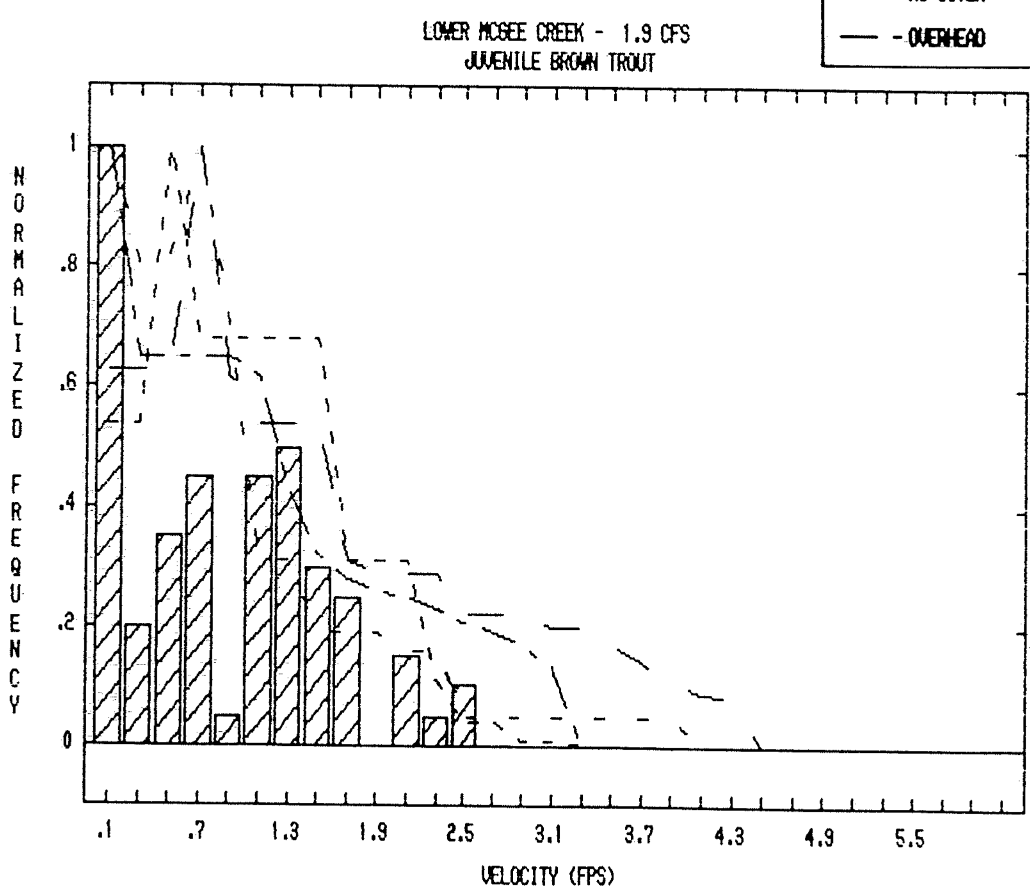


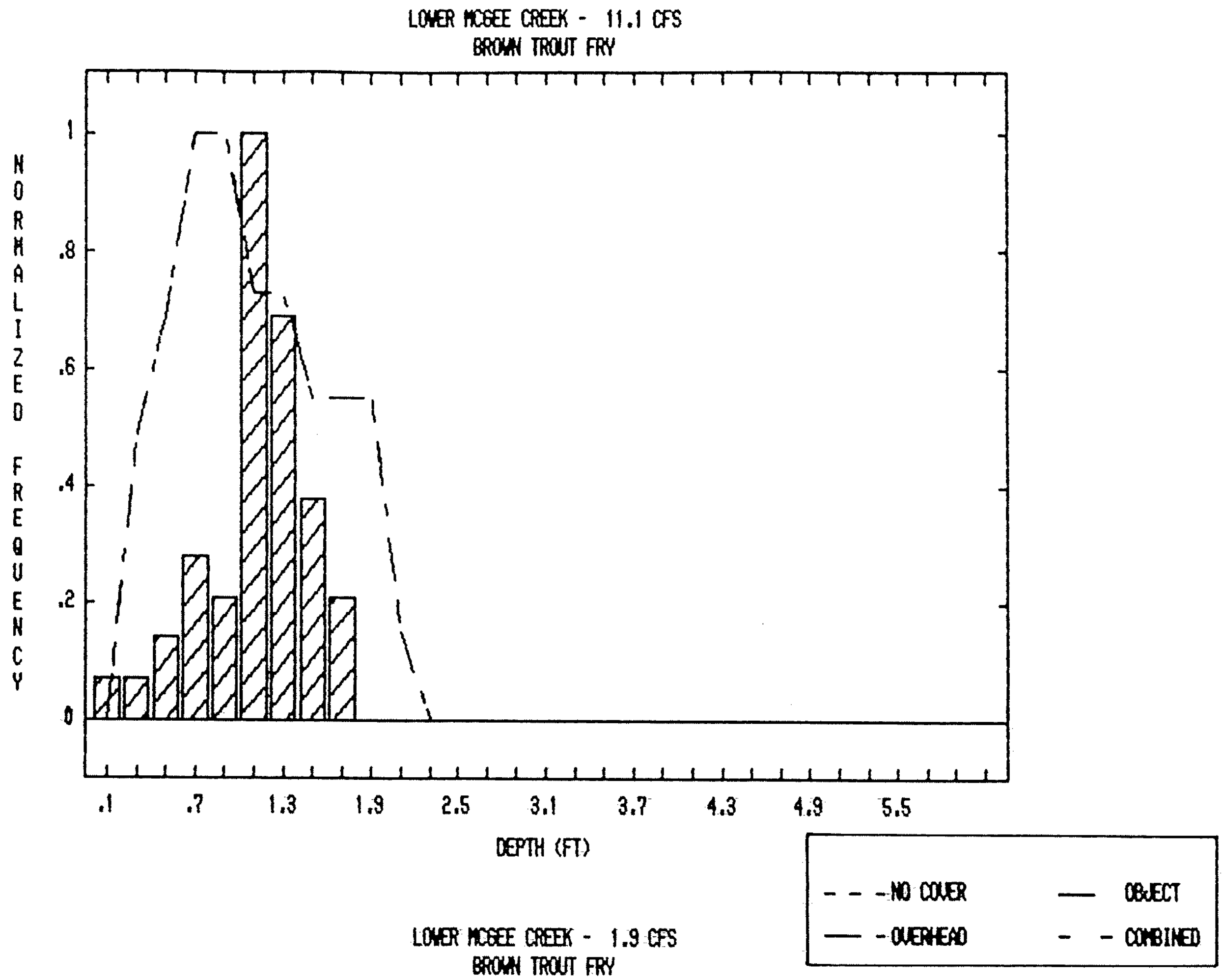
LOWER MCGEE CREEK - 1.9 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
1
.8
.6
.4
.2
0
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)

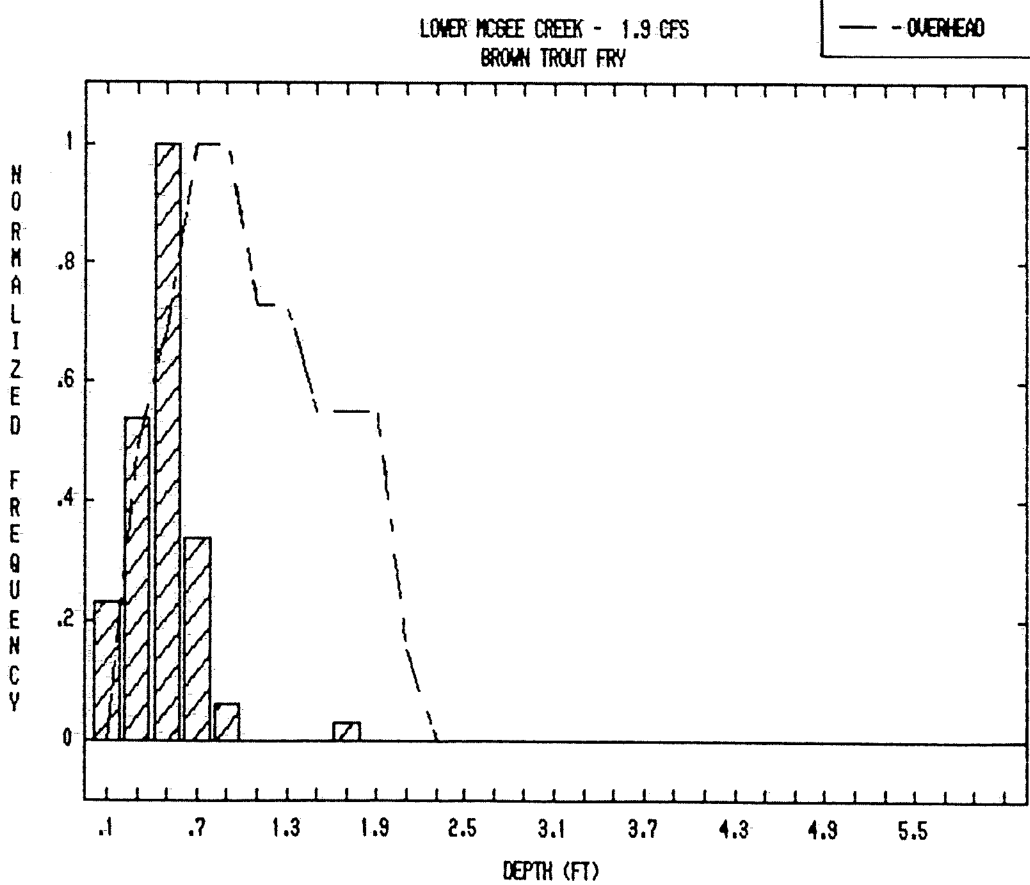

LOWER MCGEE CREEK - 11.1 CFS
JUVENILE BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)
NO COVER
OBJECT
OVERHEAD
COMBINED

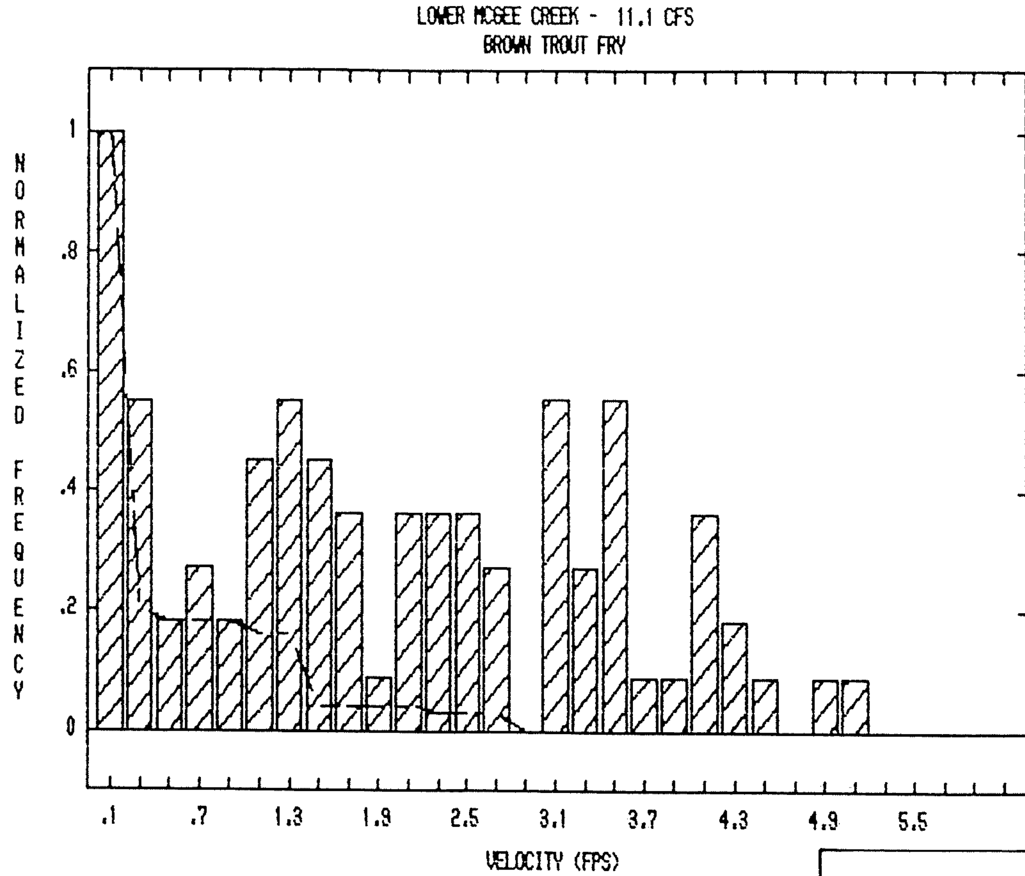

LOWER MCGEE CREEK - 1.9 CFS
JUVENILE BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)


LOWER MCGEE CREEK - 11.1 CFS
JUVENILE BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)
NO COVER
OBJECT
OVERHEAD
COMBINED

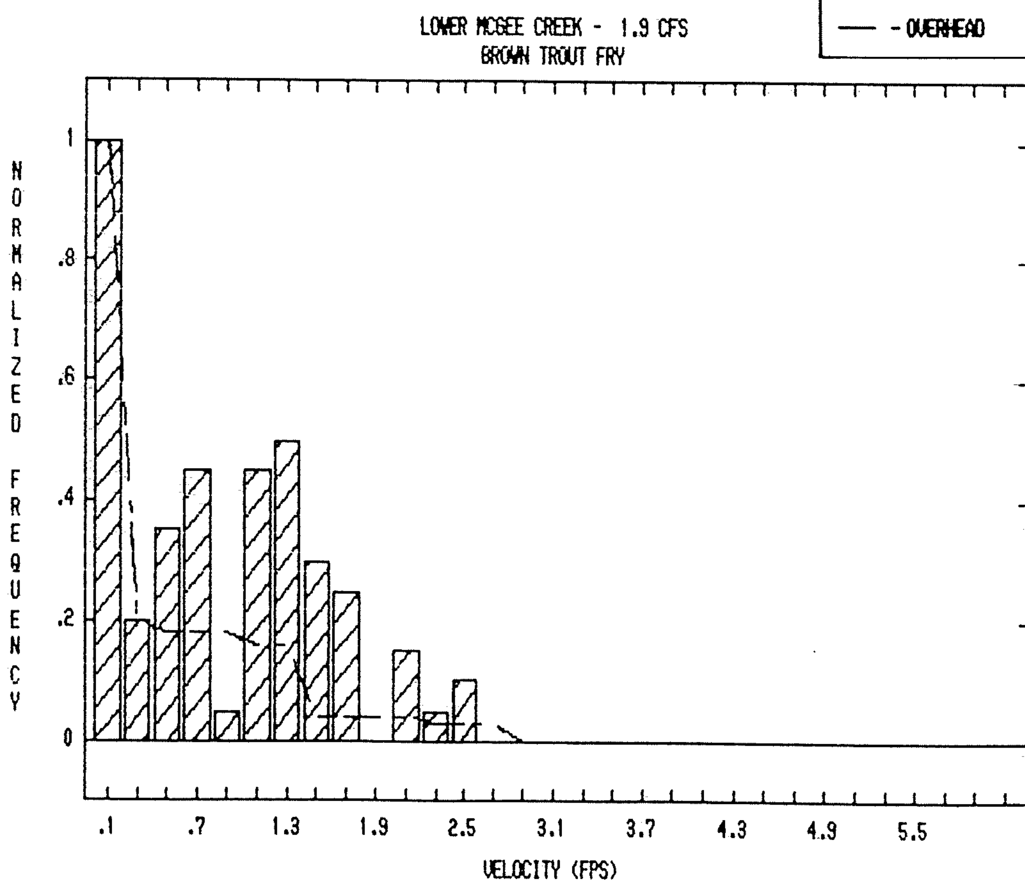

LOWER MCGEE CREEK - 1.9 CFS
JUVENILE BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)

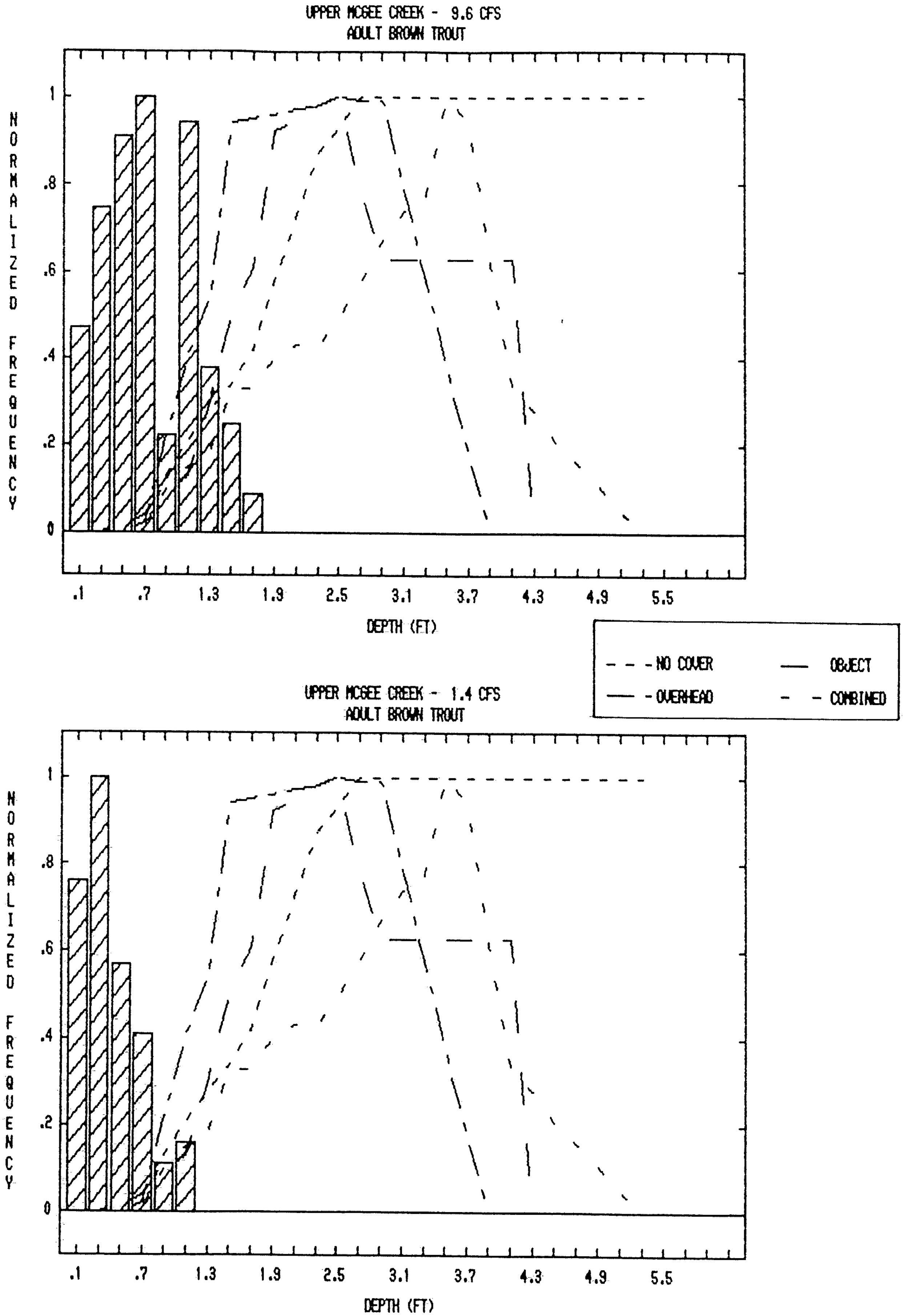

LOWER MCGEE CREEK - 11.1 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
1
.8
.6
.4
.2
0
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)
NO COVER
OBJECT
OVERHEAD
COMBINED

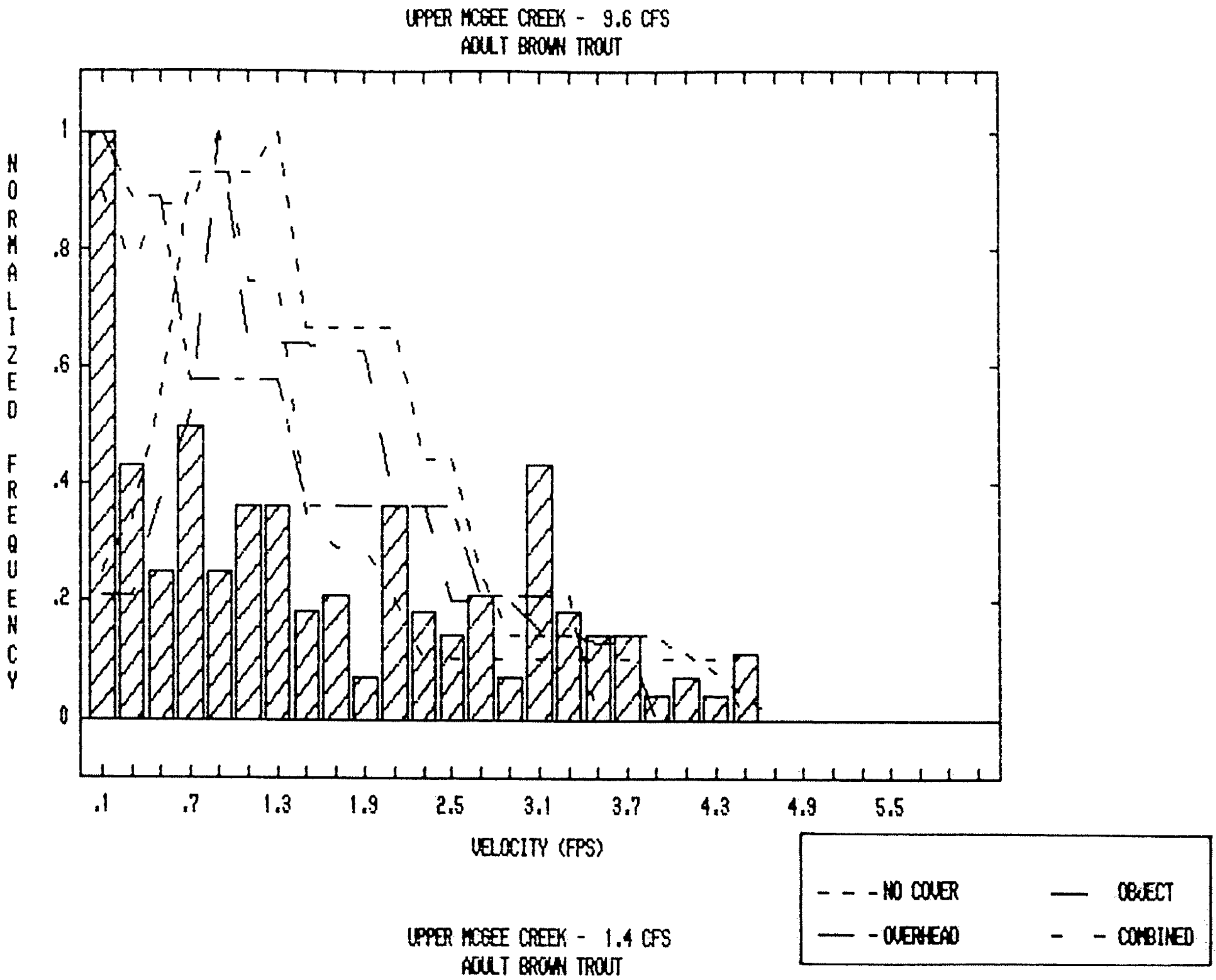

LOWER MCGEE CREEK - 1.9 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
1
.8
.6
.4
.2
0
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)

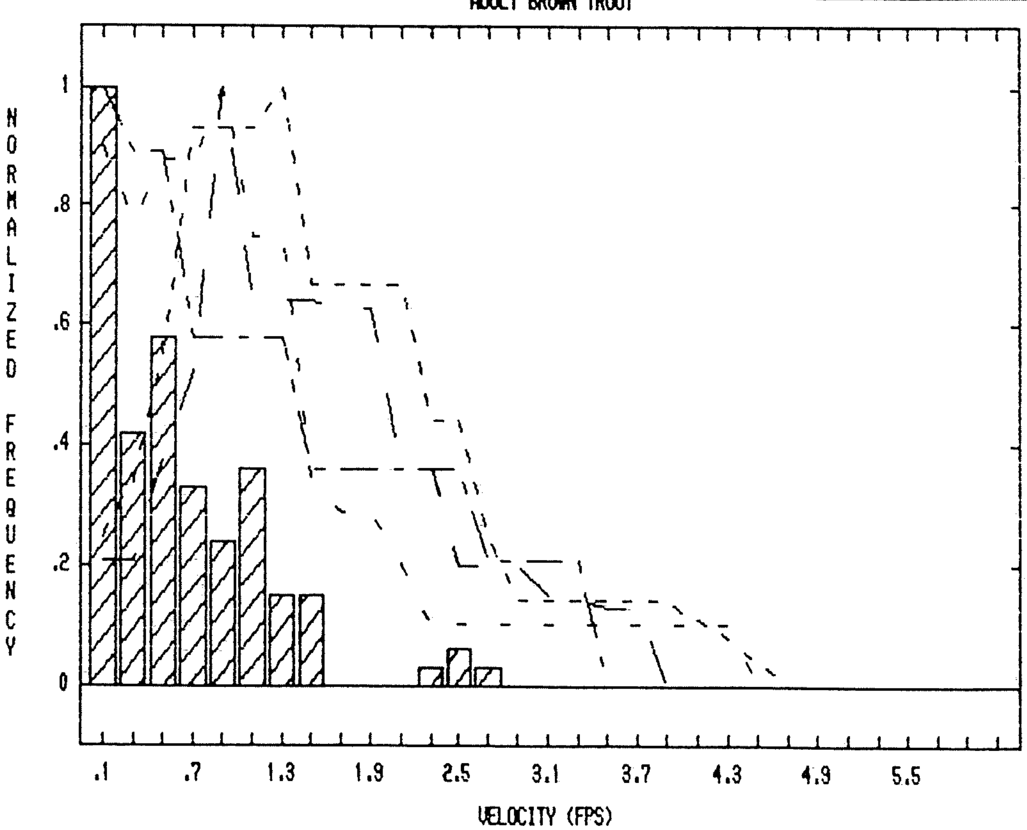


- - - NO COVER
—— OBJECT
—— - OVERHEAD
- - COMBINED

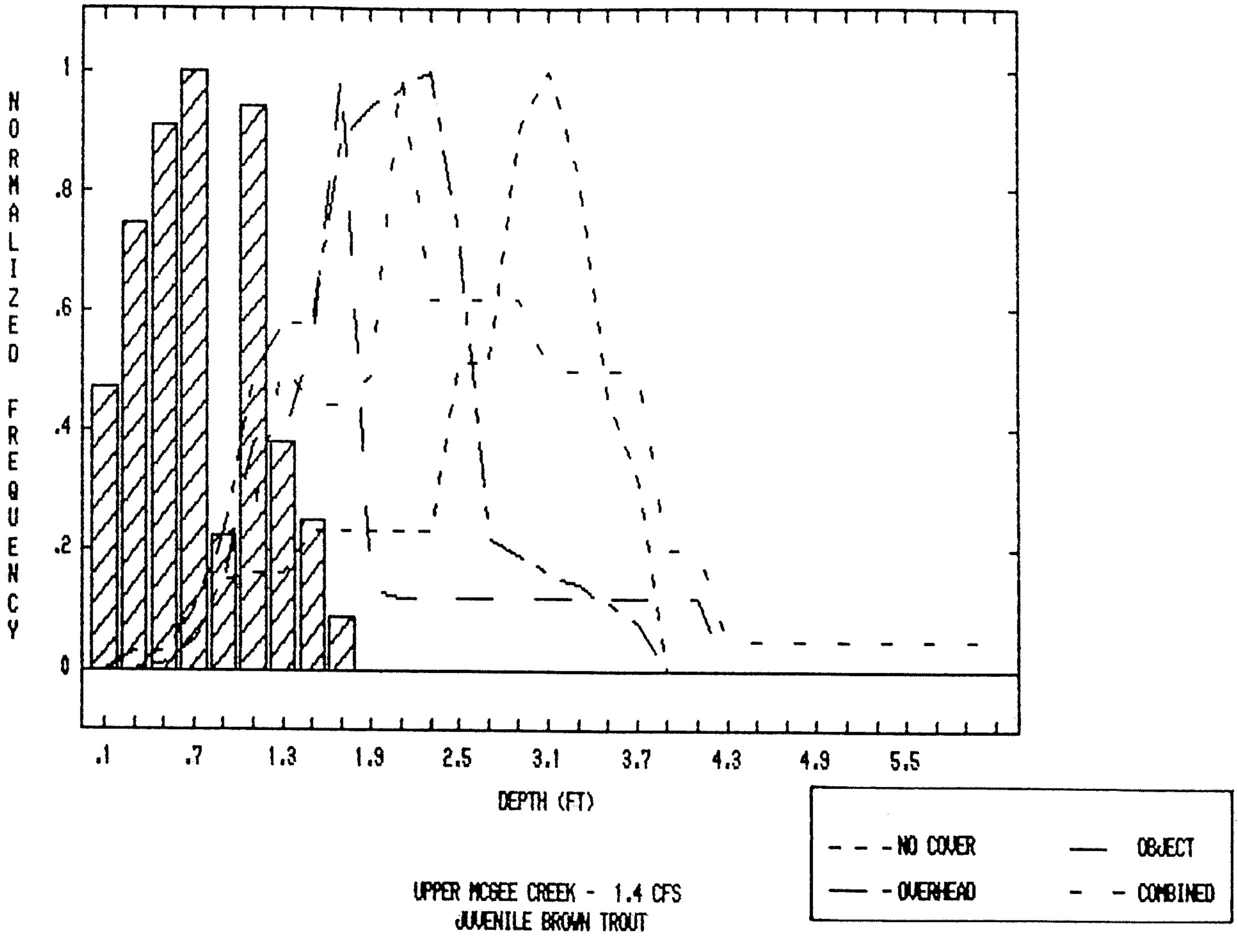



UPPER MCGEE CREEK - 9.6 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)
NO COVER
OBJECT
OVERHEAD
COMBINED
UPPER MCGEE CREEK - 1.4 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)

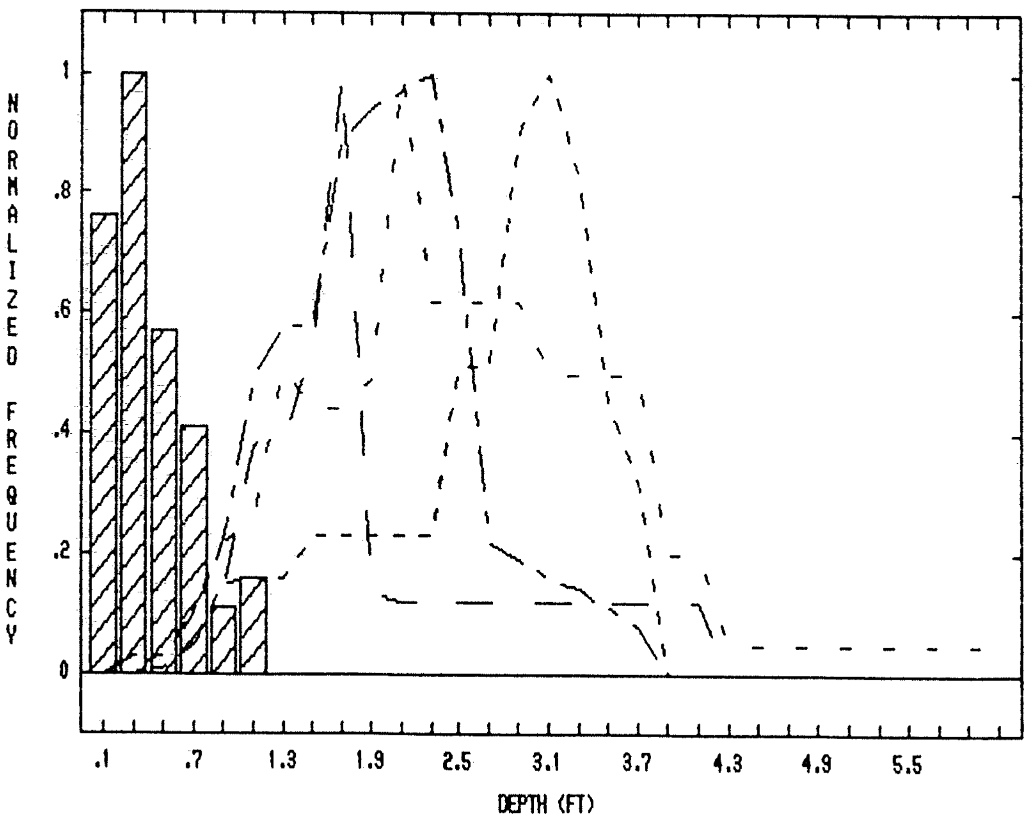

UPPER MCGEE CREEK - 9.6 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)
- - - NO COVER
— OBJECT
— - OVERHEAD
- - COMBINED


UPPER MCGEE CREEK - 1.4 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)

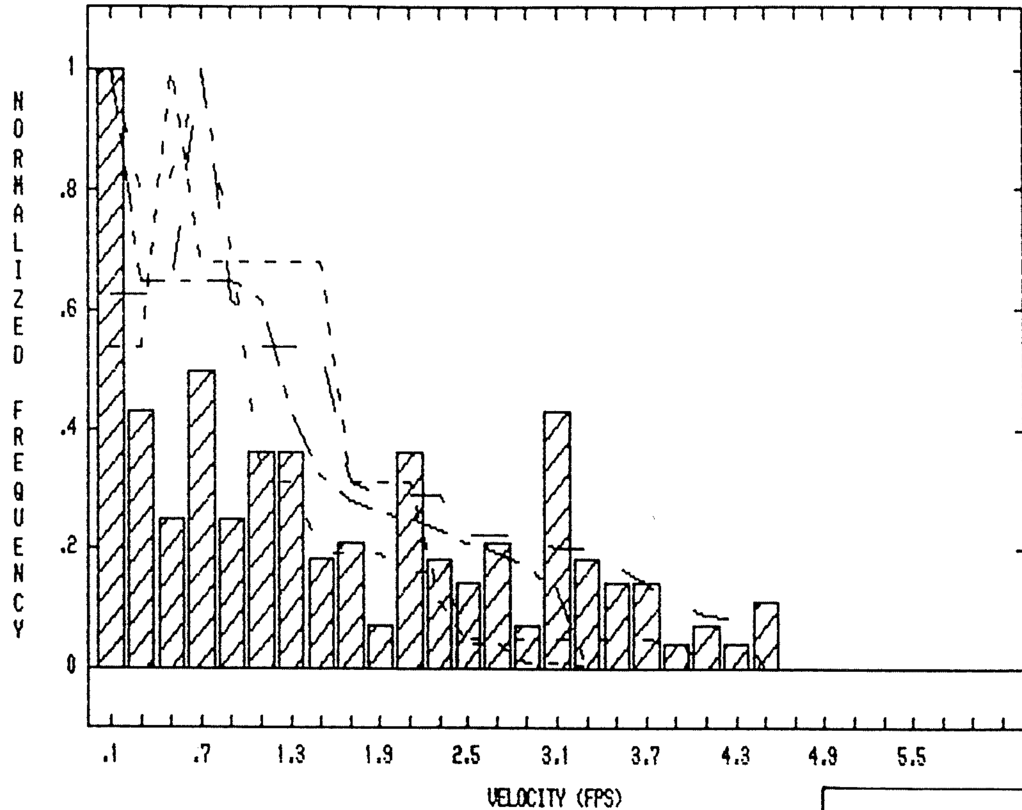
UPPER MCGEE CREEK - 9.6 CFS
JUVENILE BROWN TROUT

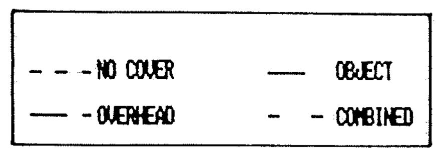


UPPER MCGEE CREEK - 1.4 CFS
JUVENILE BROWN TROUT

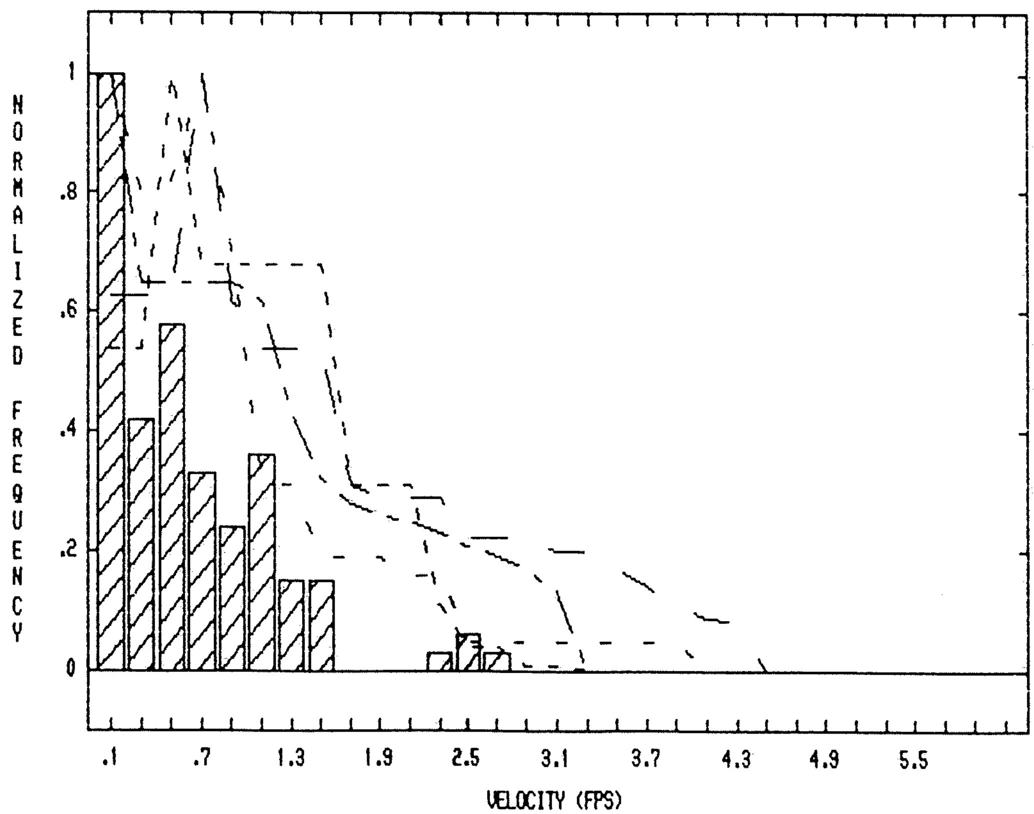


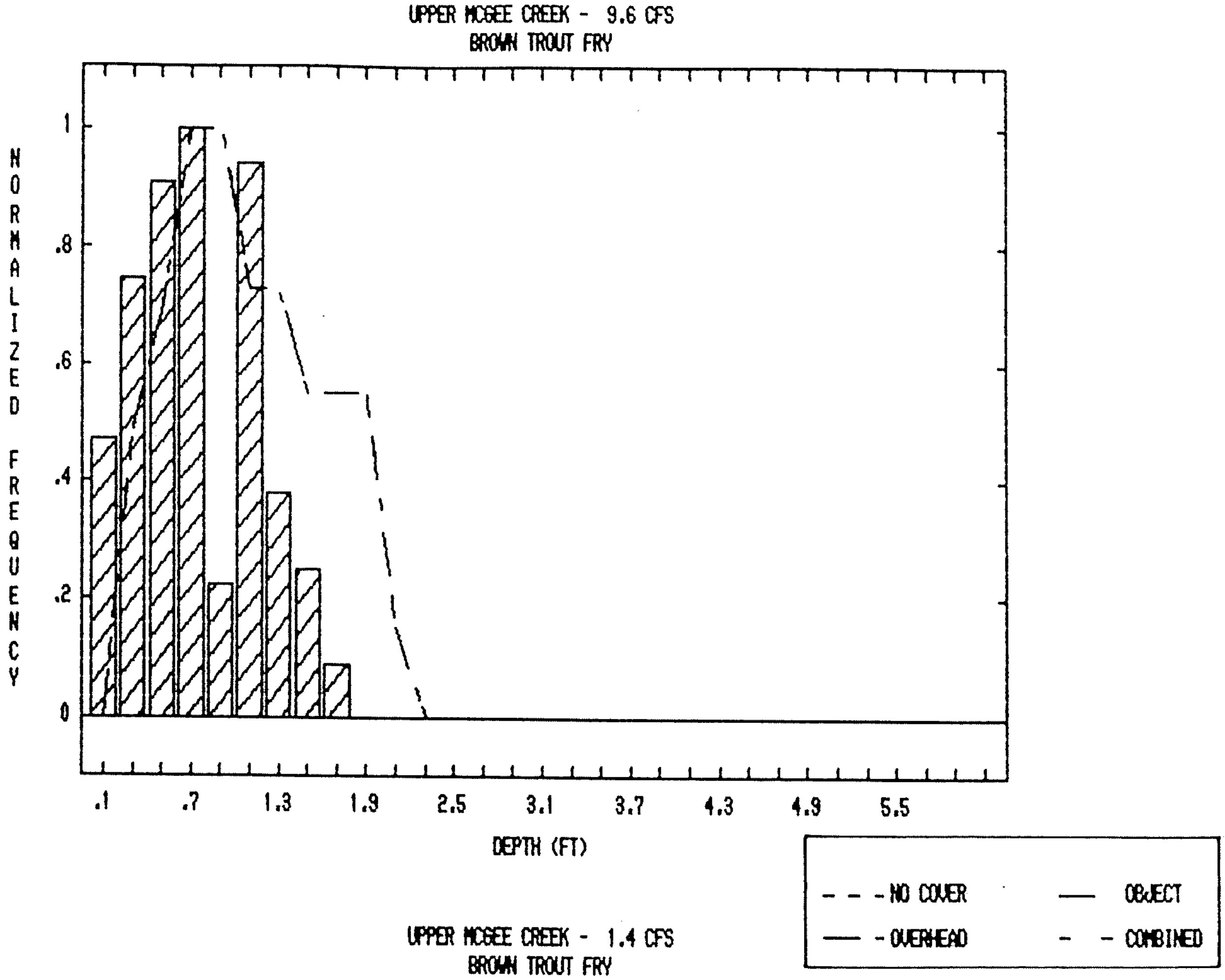
UPPER MCGEE CREEK - 9.6 CFS
JUVENILE BROWN TROUT

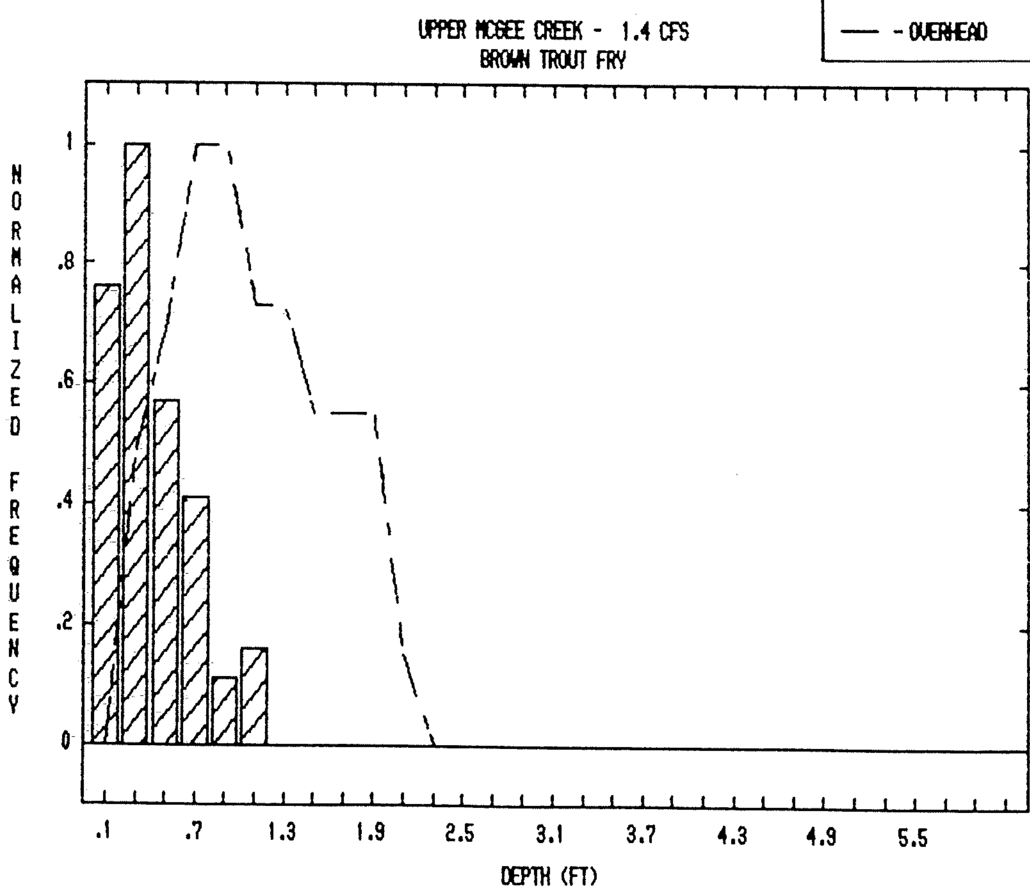




UPPER MCGEE CREEK - 1.4 CFS
JUVENILE BROWN TROUT




UPPER MCGEE CREEK - 9.6 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)
- - - NO COVER
—— OBJECT
—— - OVERHEAD
- - COMBINED


UPPER MCGEE CREEK - 1.4 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
0
.2
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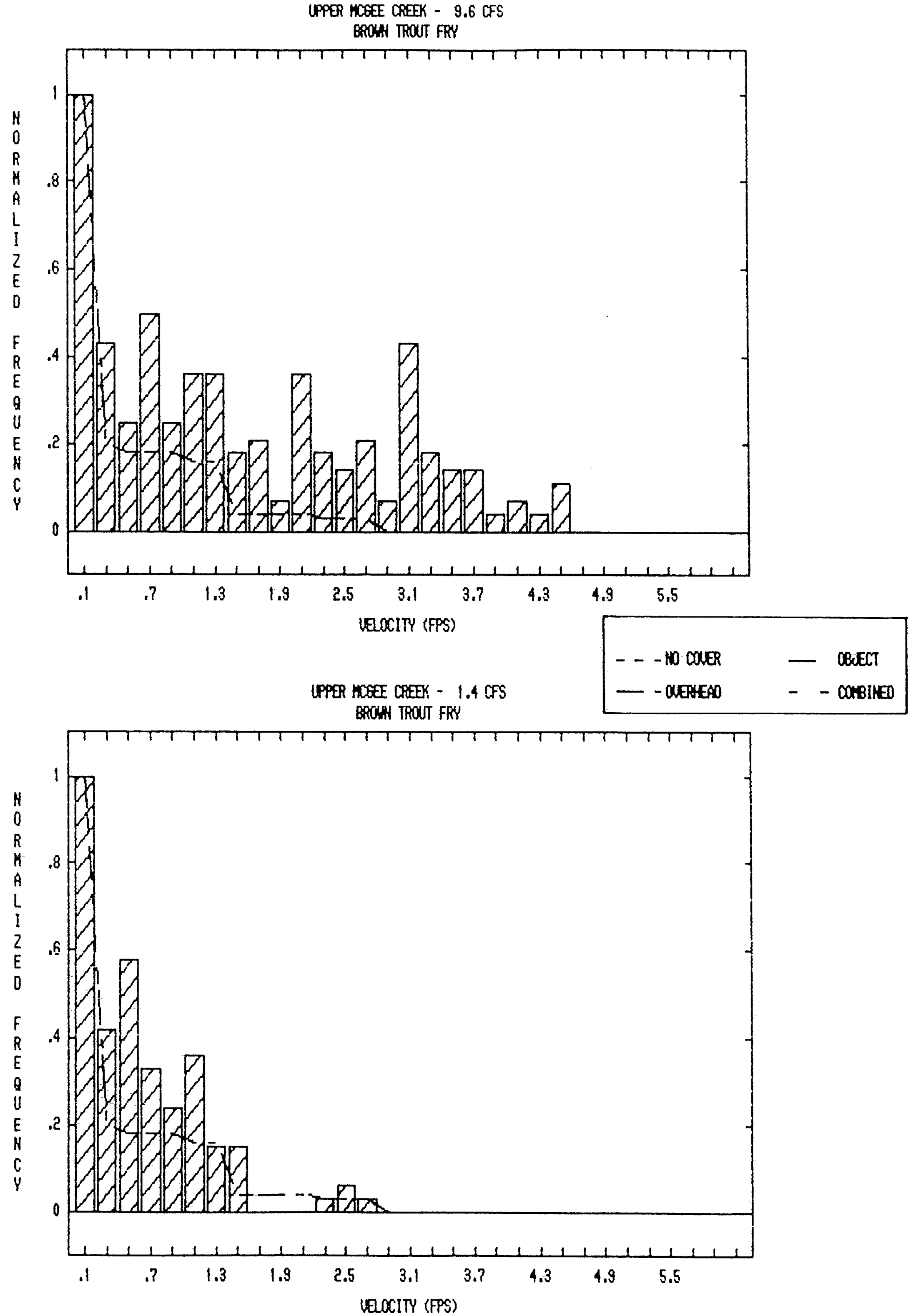
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)


UPPER MCGEE CREEK - 9.6 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
1
.8
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0
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.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)
- - - NO COVER
—— OBJECT
—— - OVERHEAD
— — COMBINED
UPPER MCGEE CREEK - 1.4 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
1
.8
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.4
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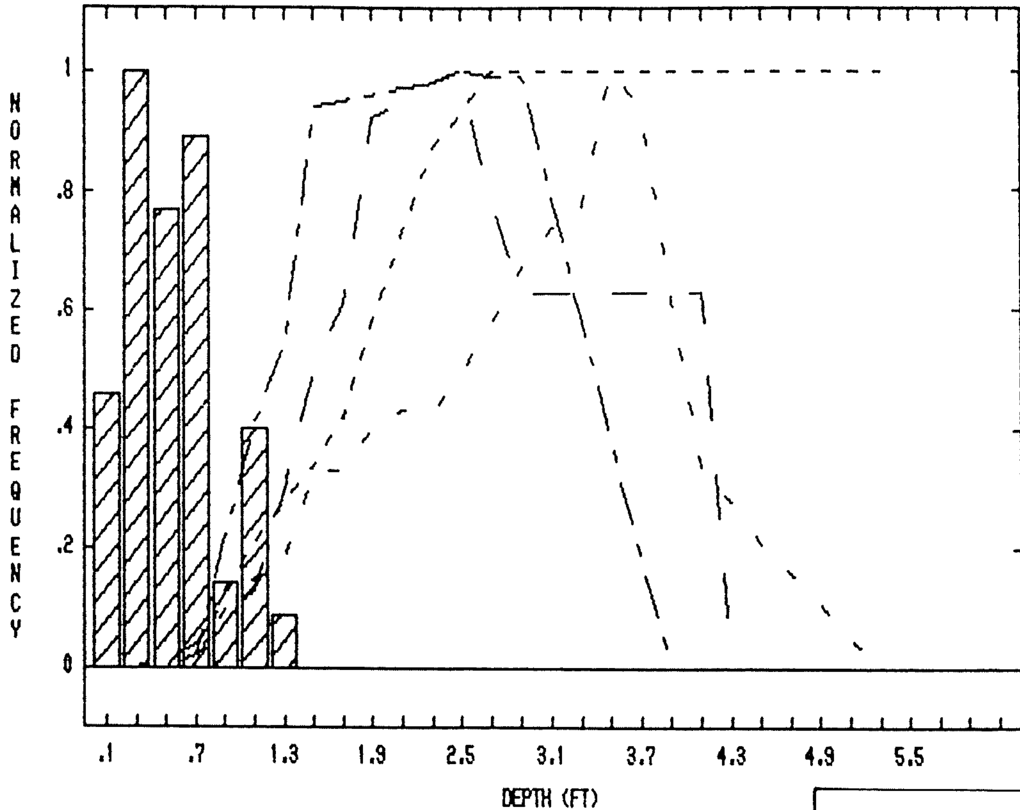
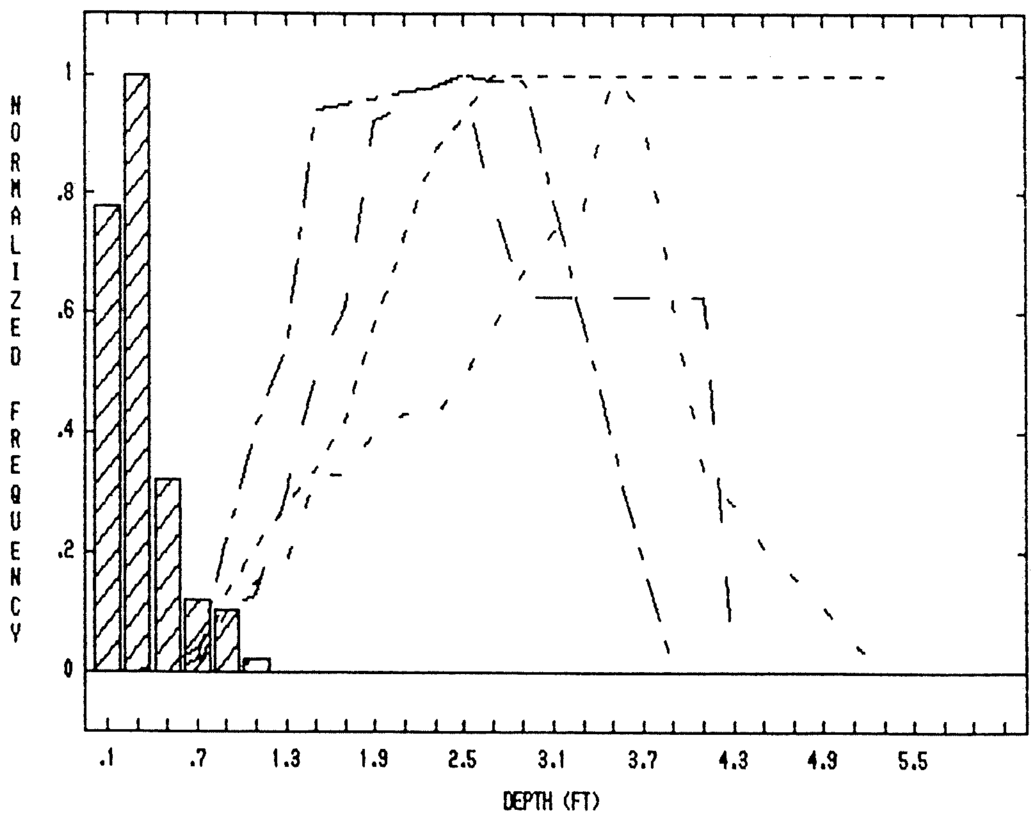
0
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)

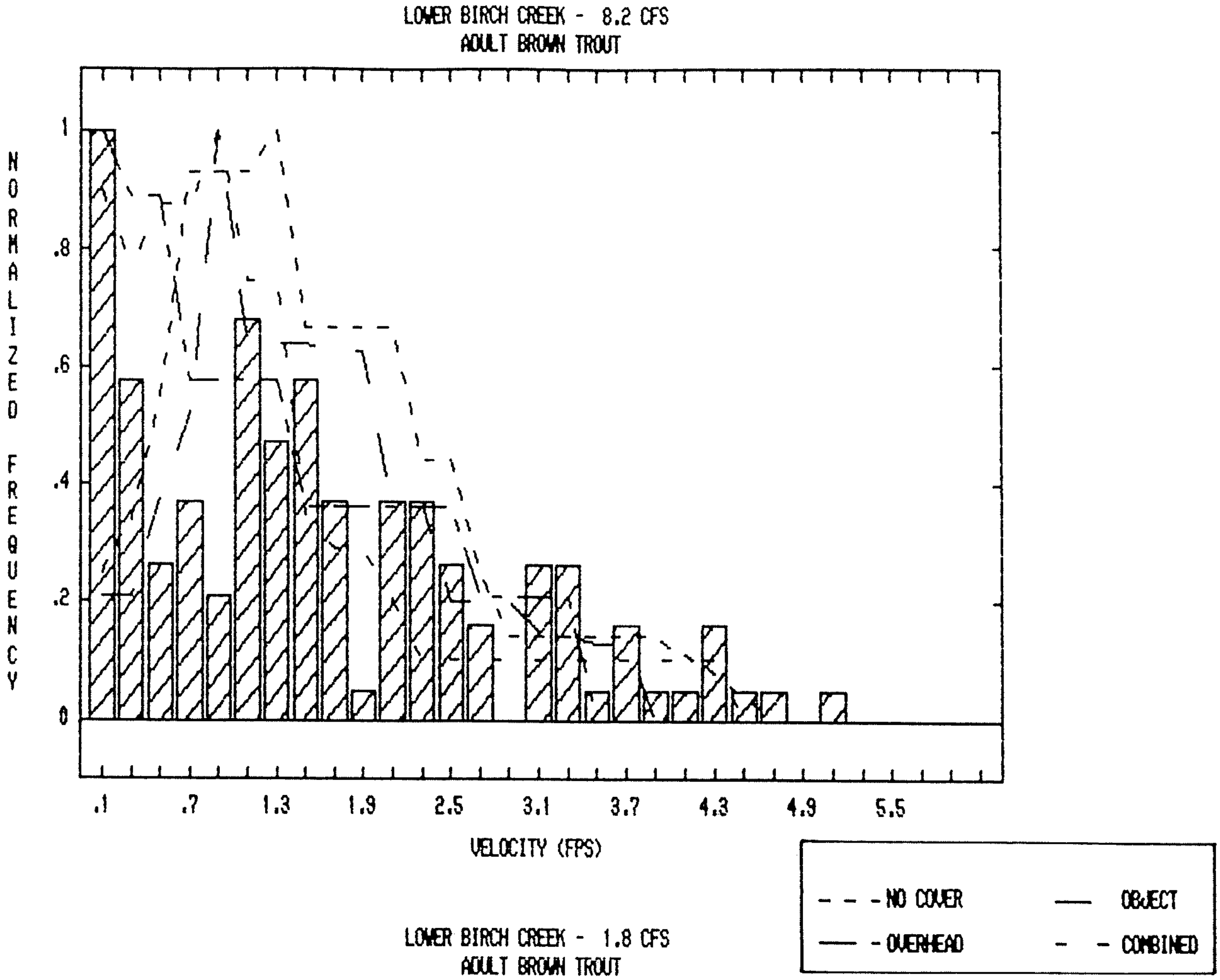
LOWER BIRCH CREEK - 8.2 CFS
ADULT BROWN TROUT



- - - NO COVER — OBJECT
— - OVERHEAD - - COMBINED

LOWER BIRCH CREEK - 1.8 CFS
ADULT BROWN TROUT




LOWER BIRCH CREEK - 8.2 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
1
.8
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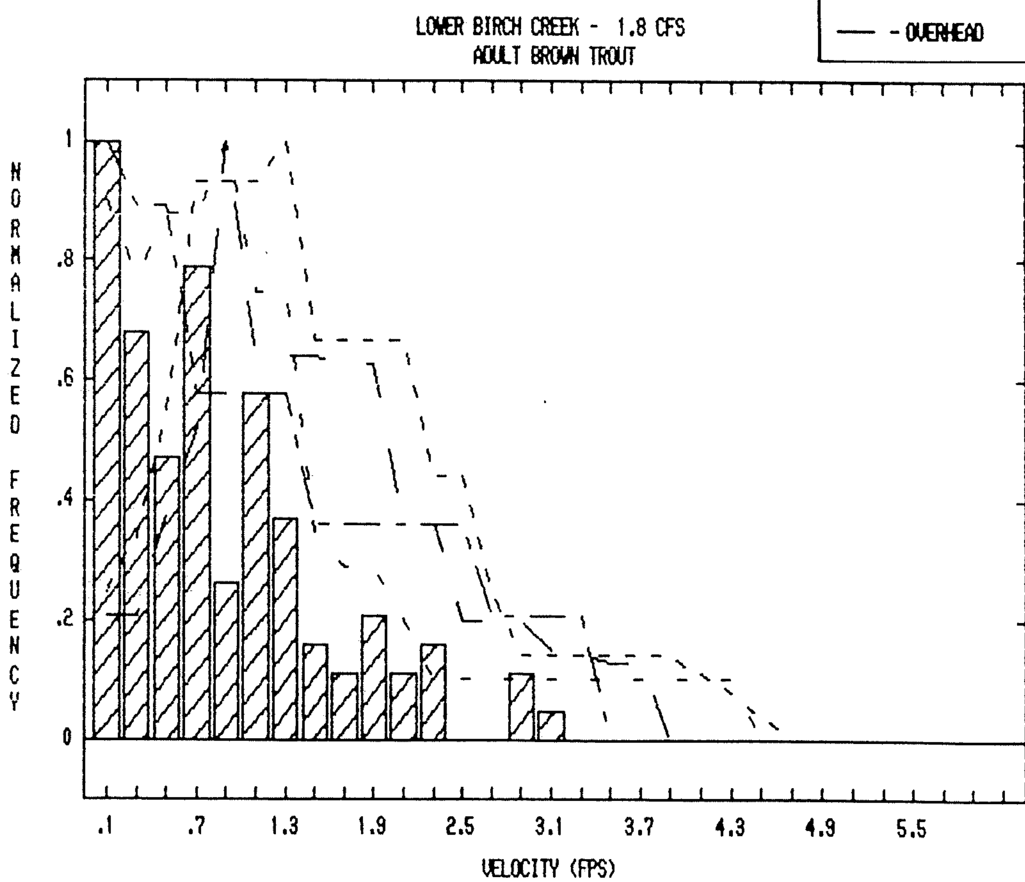
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)
- - - NO COVER
—— - OVERHEAD
—— OBJECT
- - COMBINED


LOWER BIRCH CREEK - 1.8 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
1
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1.9
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3.1
3.7
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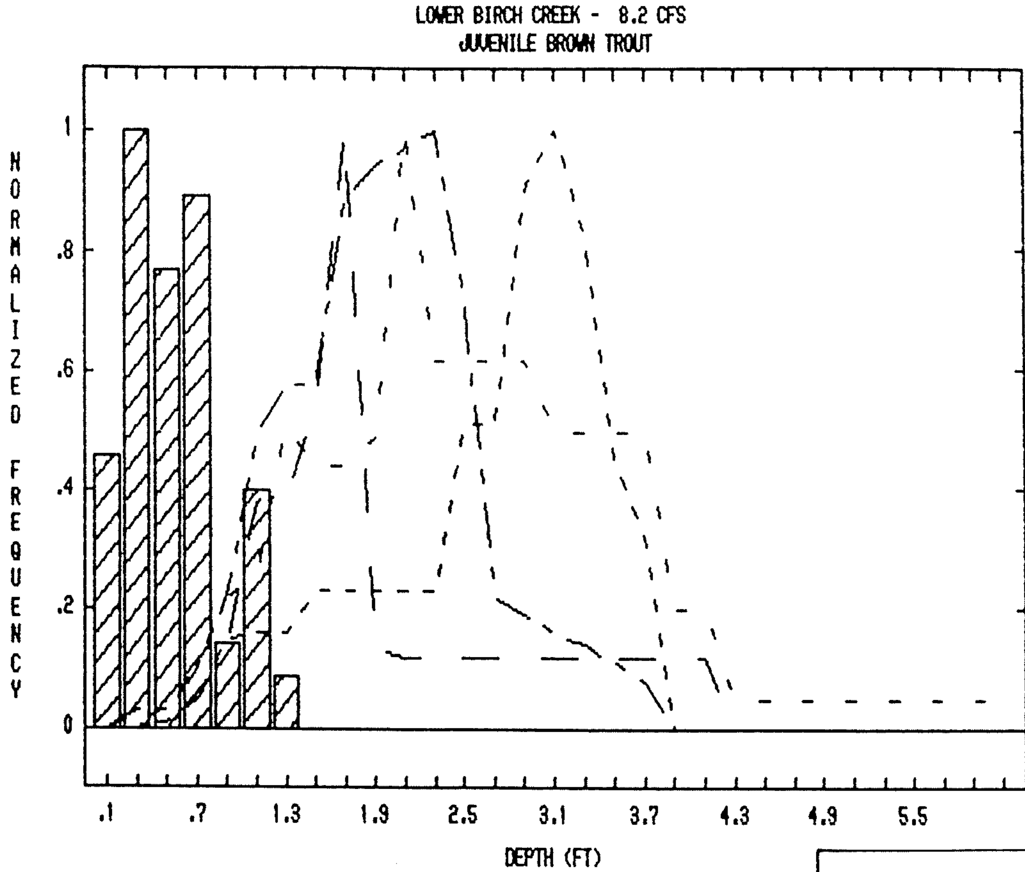
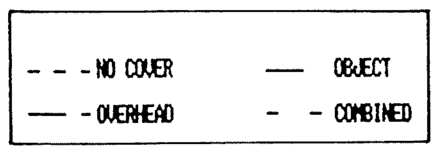
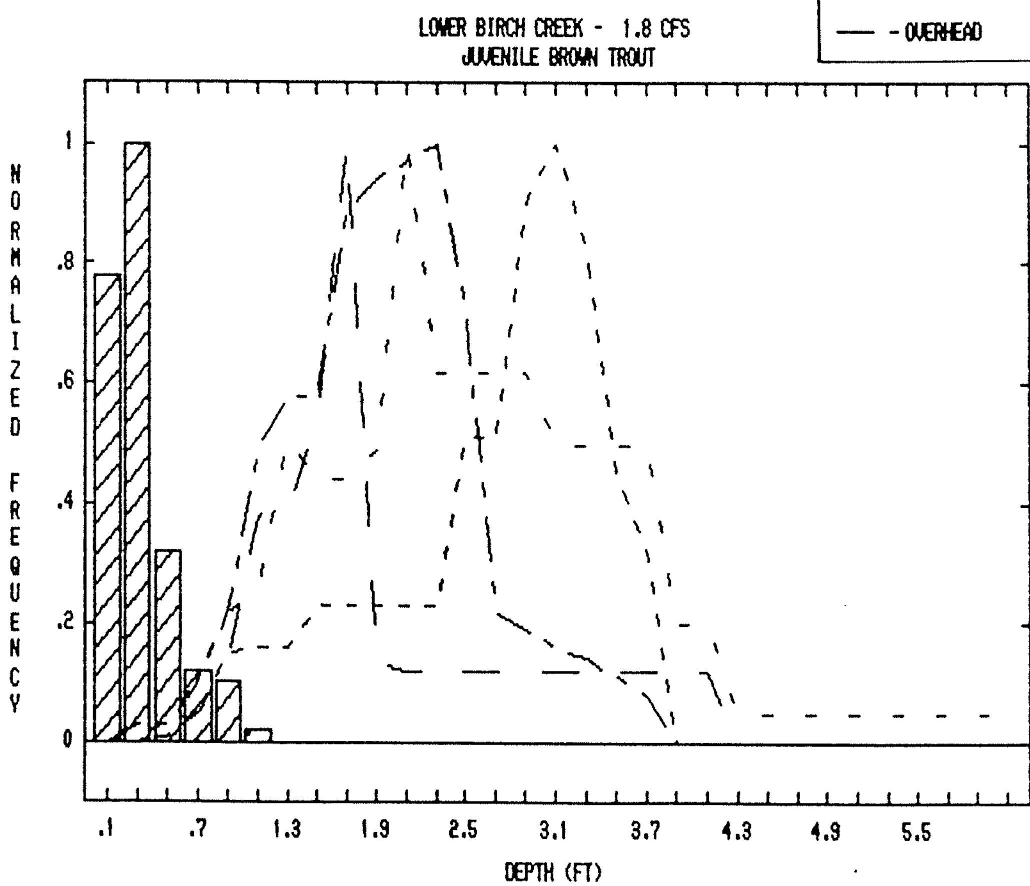
4.9
5.5
VELOCITY (FPS)


LOWER BIRCH CREEK - 8.2 CFS
JUVENILE BROWN TROUT
NORMALIZED FREQUENCY
1
.8
.6
.4
.2
0
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)


- - - NO COVER
——— - OVERHEAD
——— OBJECT
- - COMBINED


LOWER BIRCH CREEK - 1.8 CFS
JUVENILE BROWN TROUT
NORMALIZED FREQUENCY
1
.8
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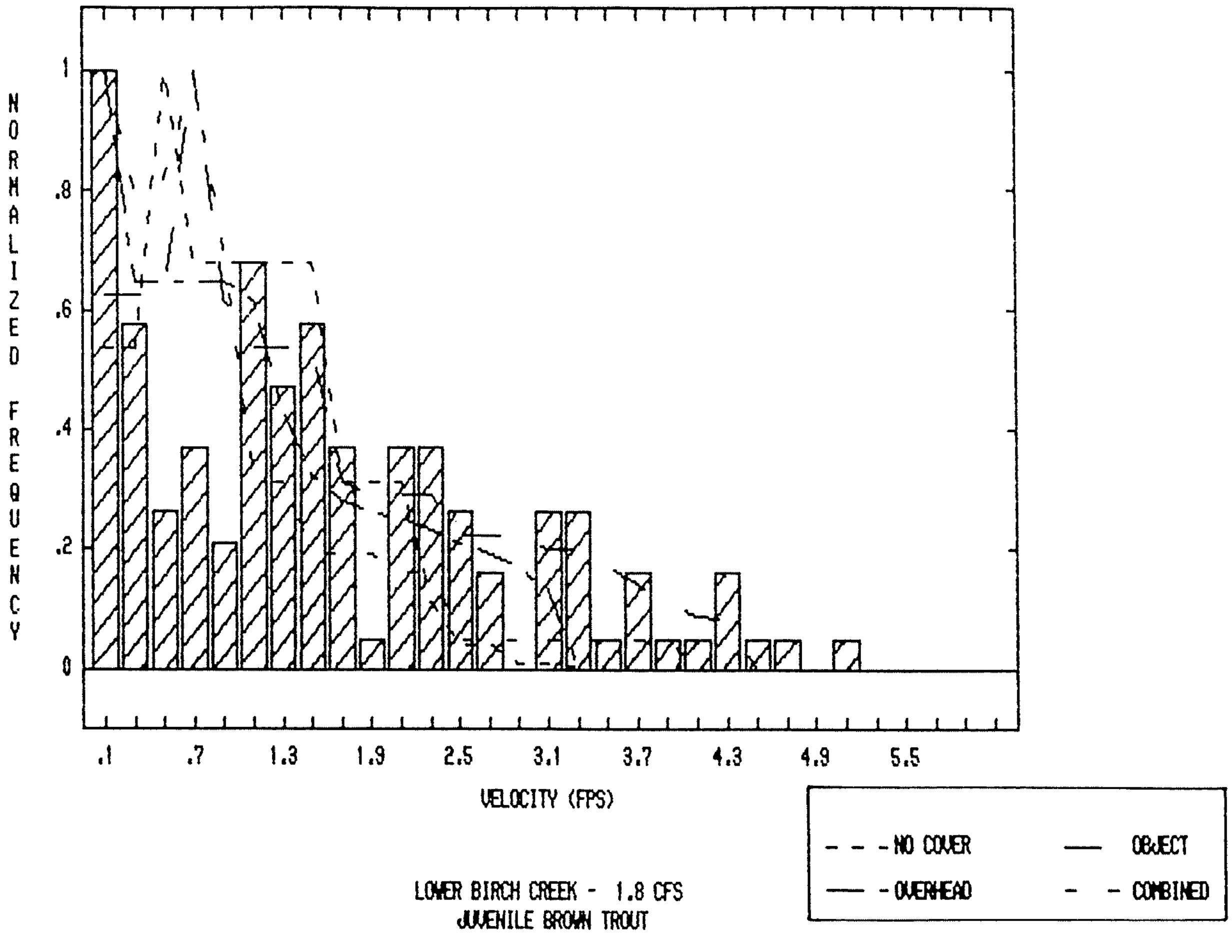
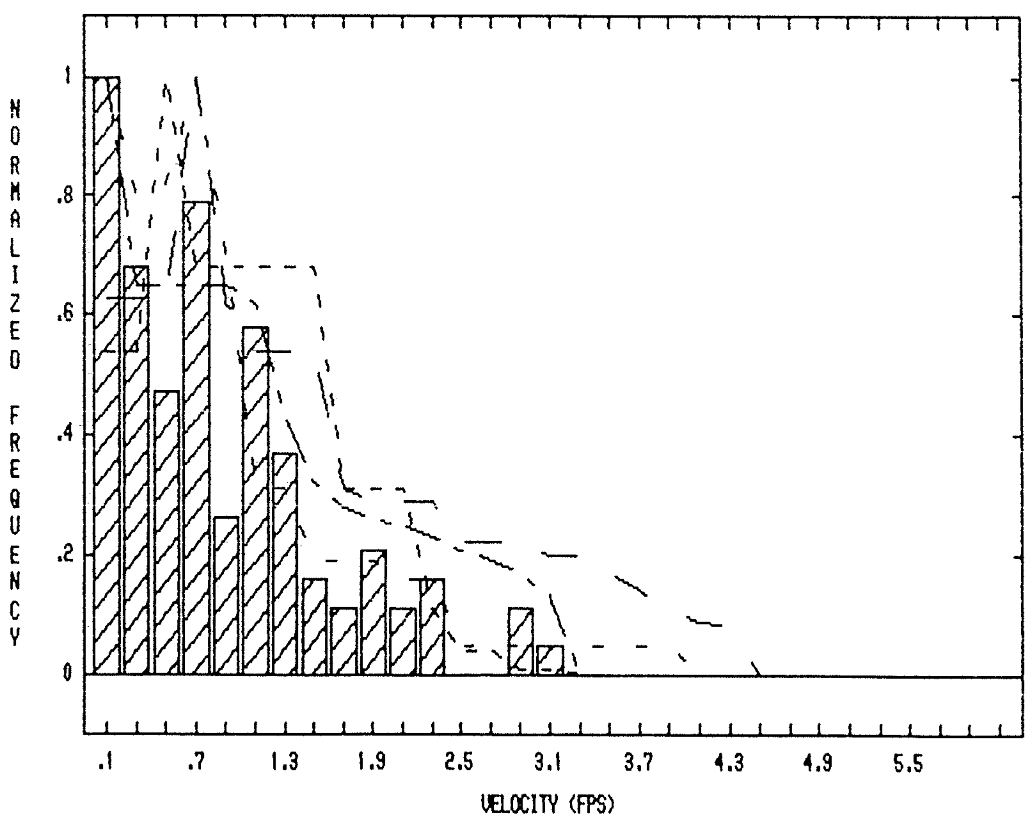
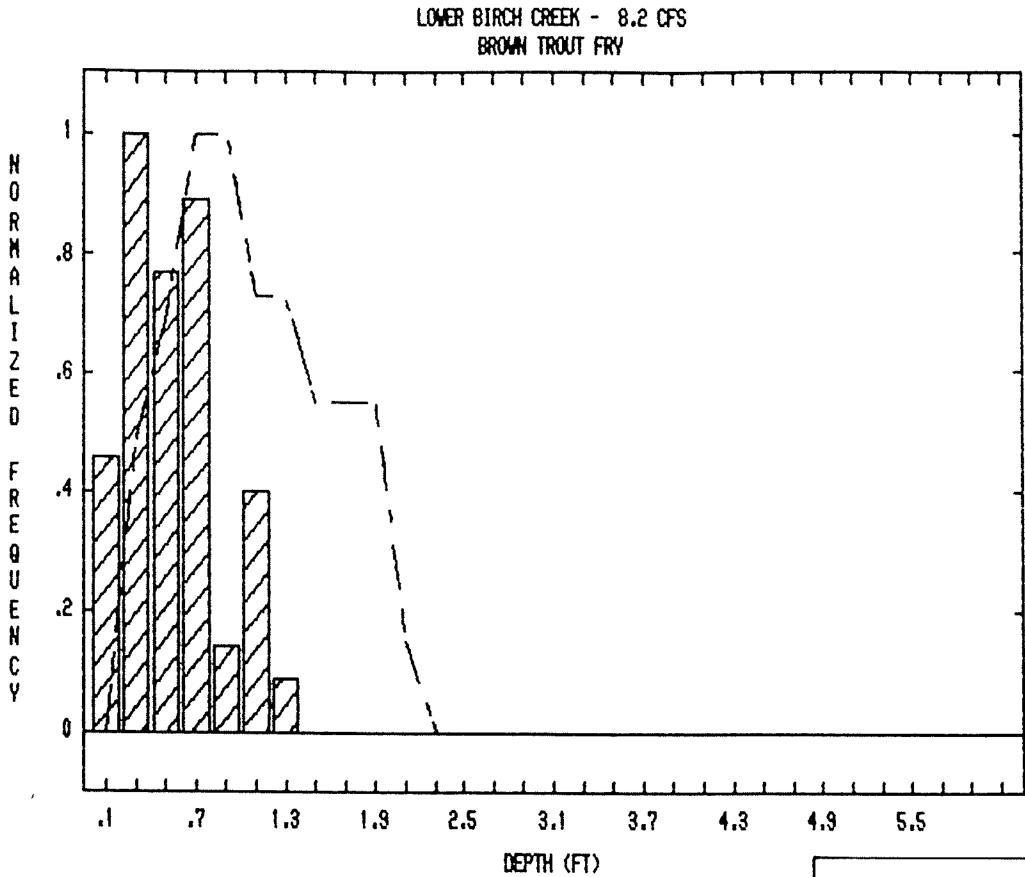
.2
0
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)

LOWER BIRCH CREEK - 8.2 CFS
JUVENILE BROWN TROUT

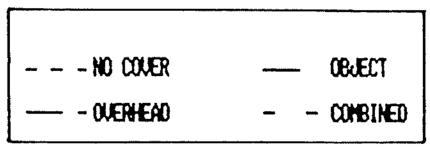


LOWER BIRCH CREEK - 1.8 CFS
JUVENILE BROWN TROUT

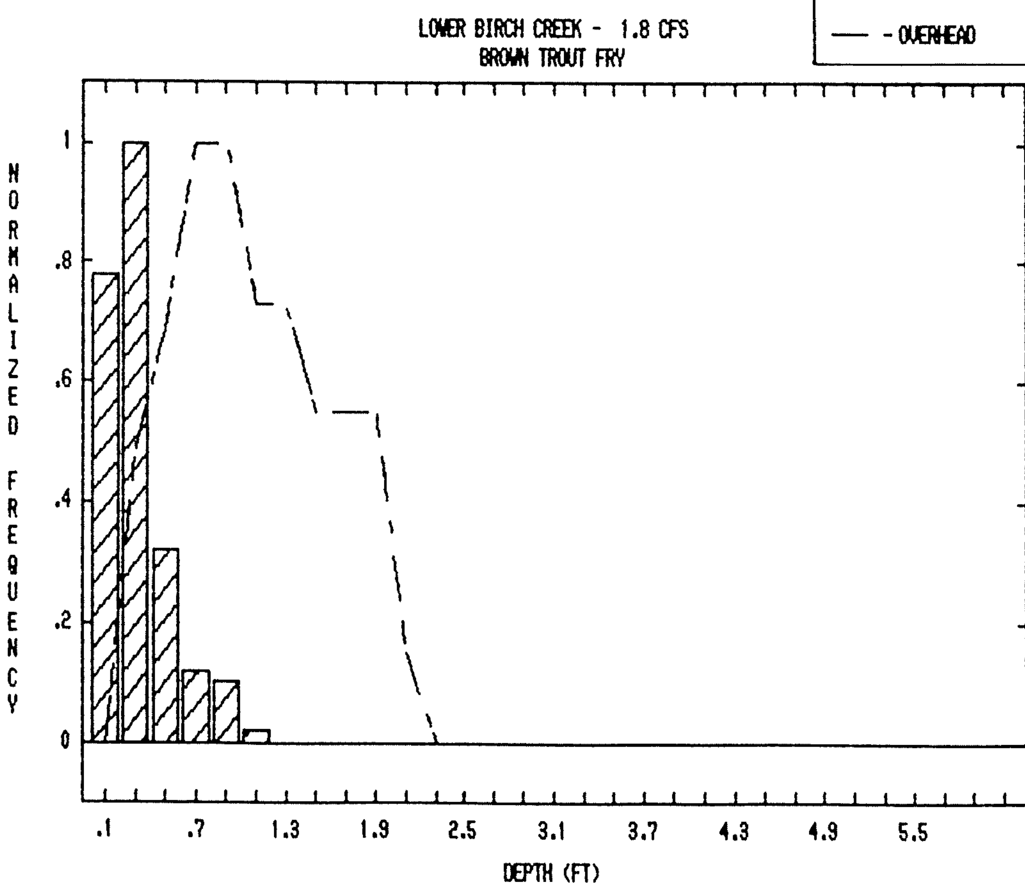




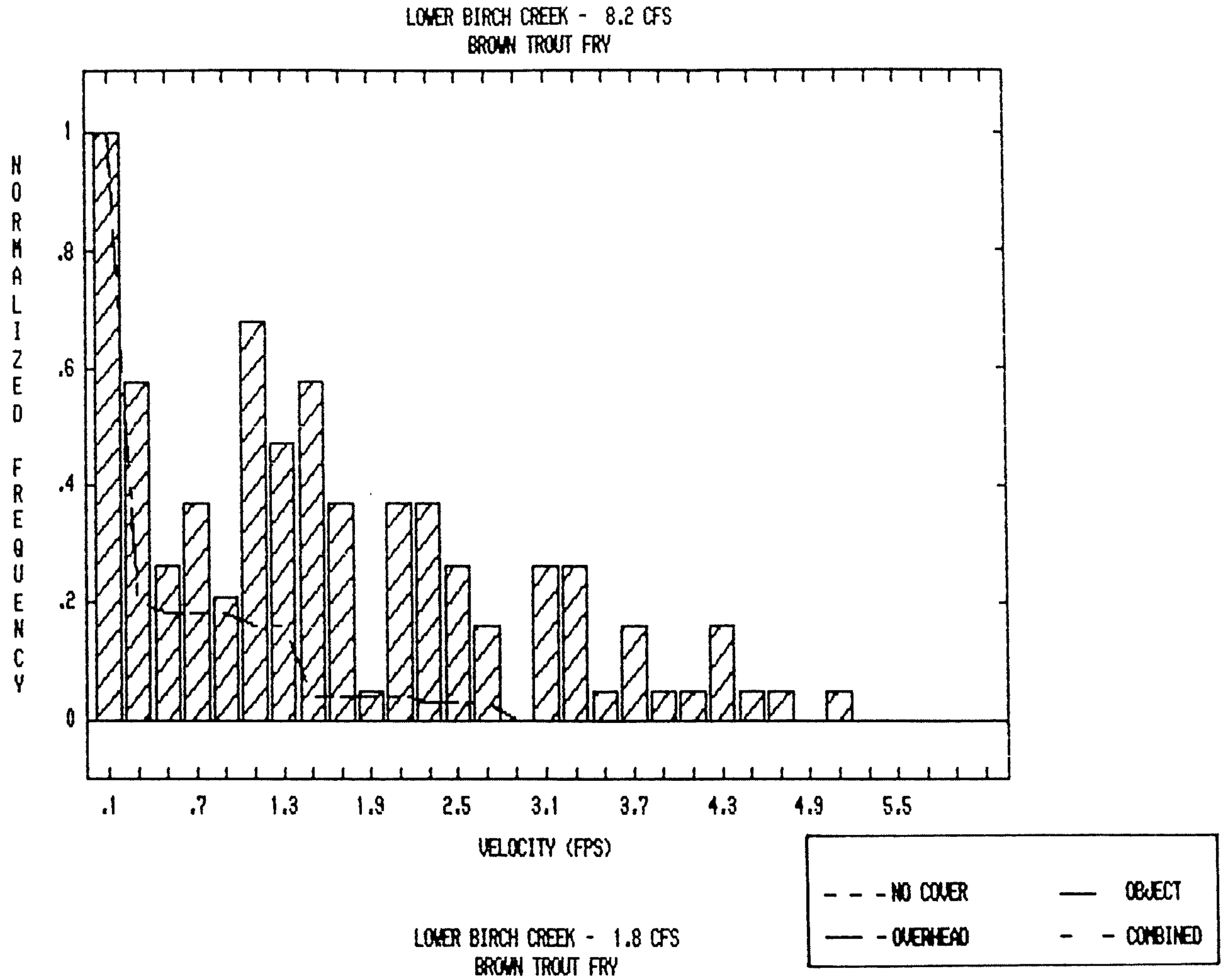
LOWER BIRCH CREEK - 8.2 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)



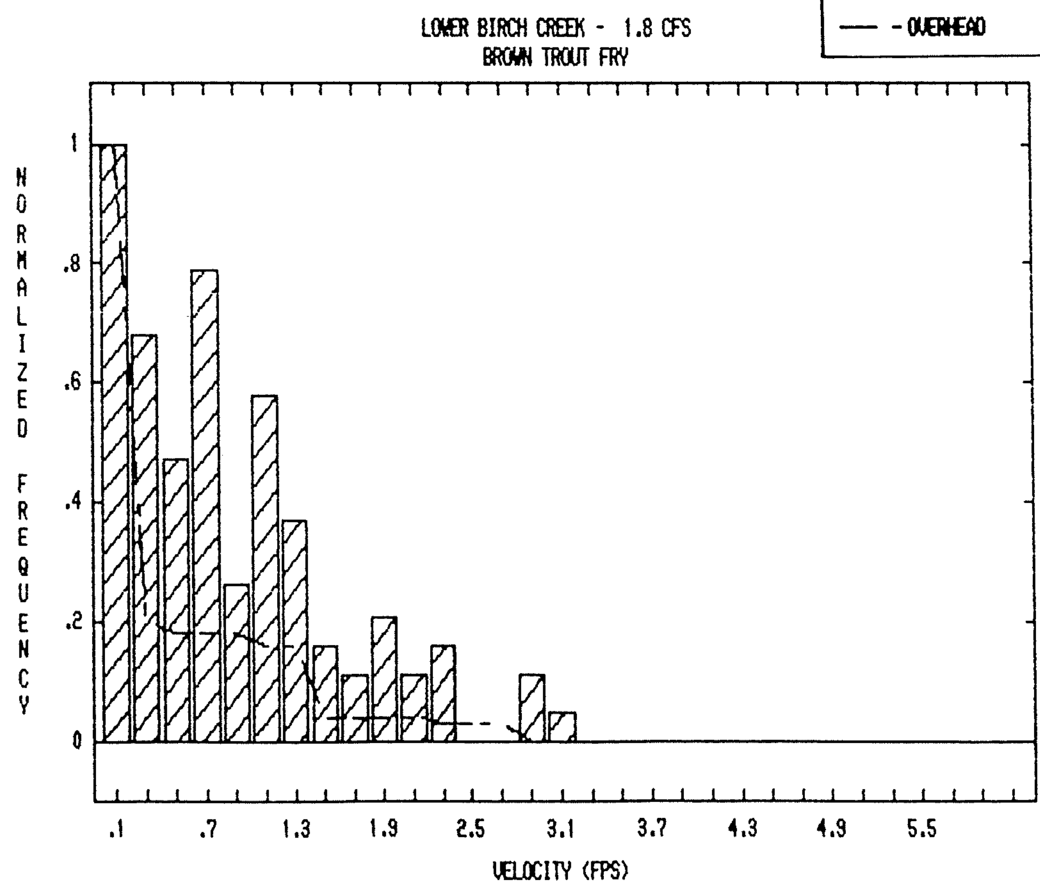
NO COVER
OBJECT
OVERHEAD
COMBINED



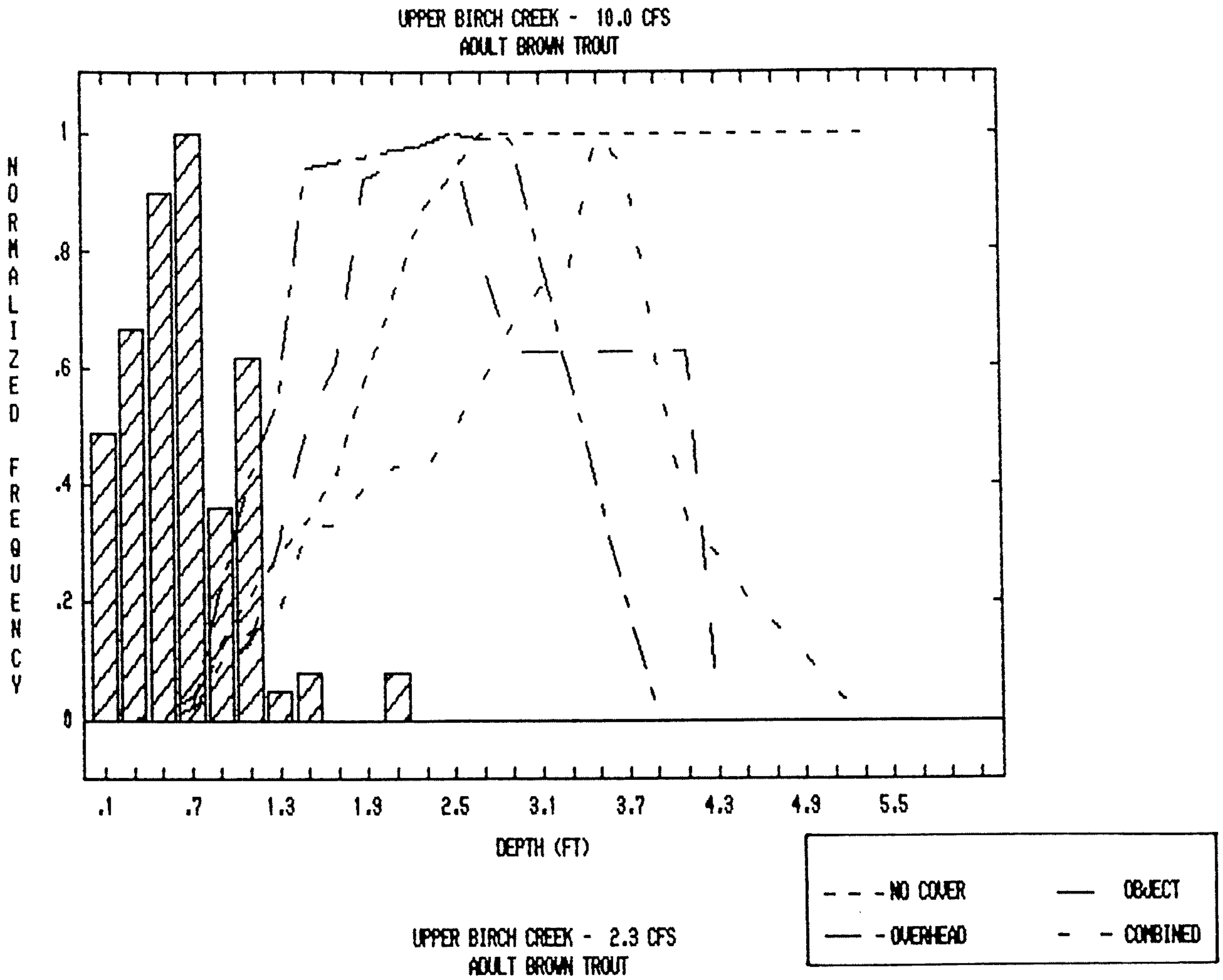
LOWER BIRCH CREEK - 1.8 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)

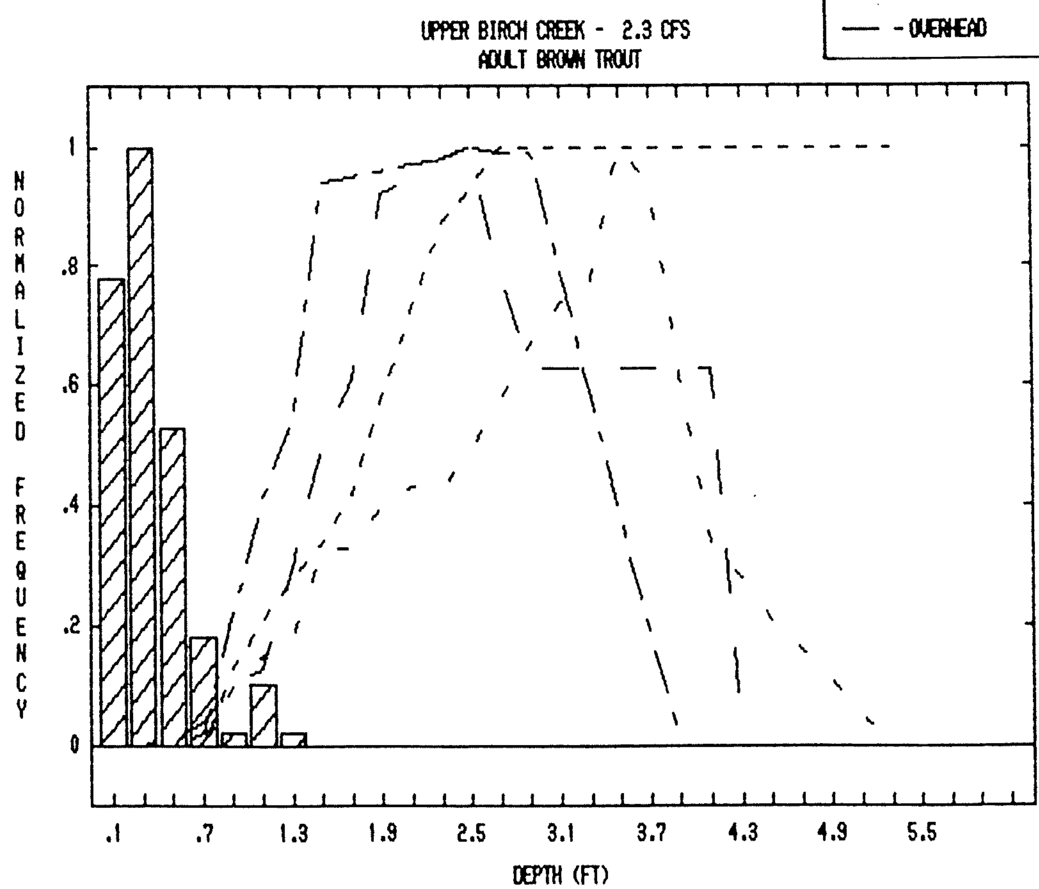


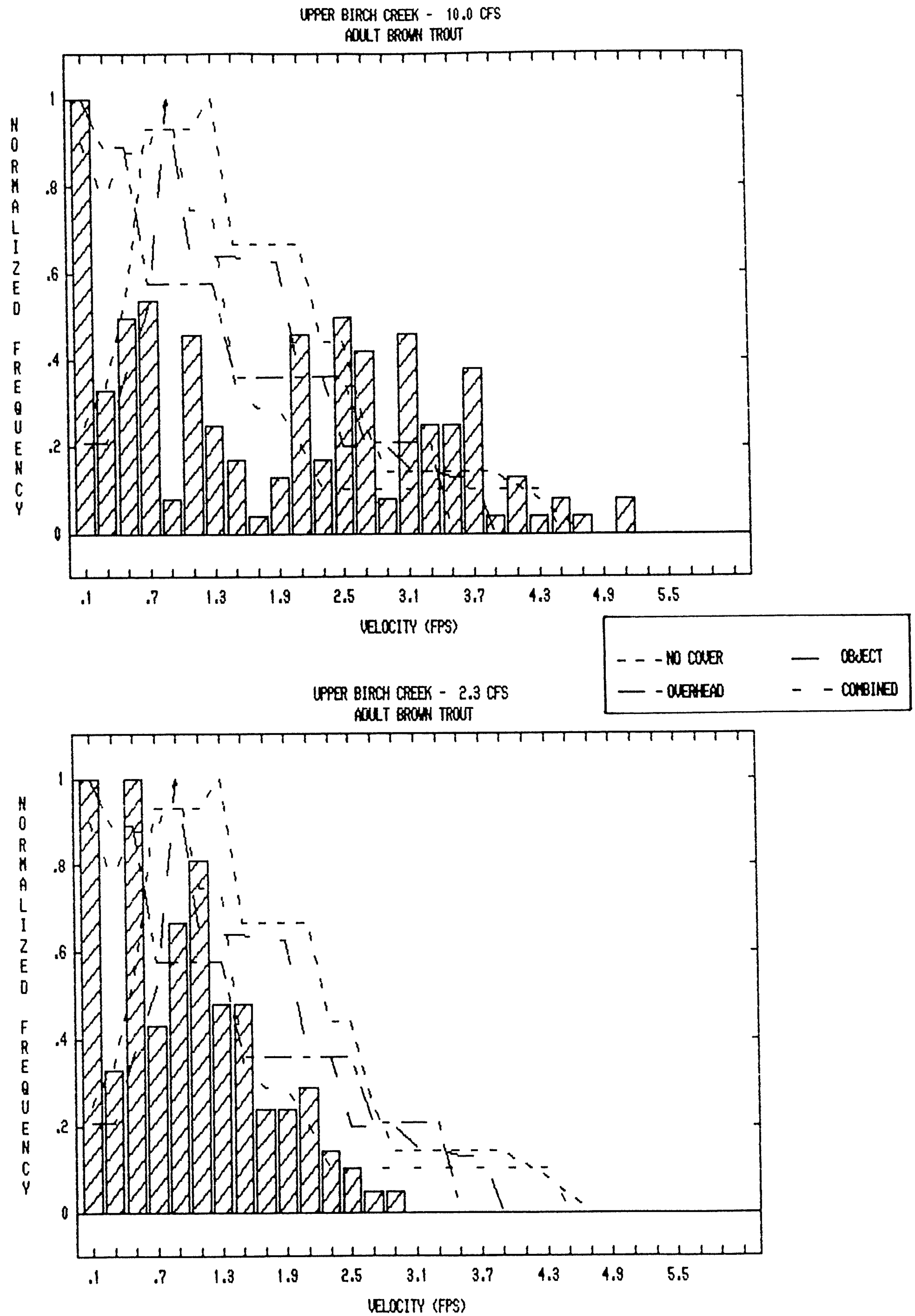
LOWER BIRCH CREEK - 8.2 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)
NO COVER
OVERHEAD
OBJECT
COMBINED

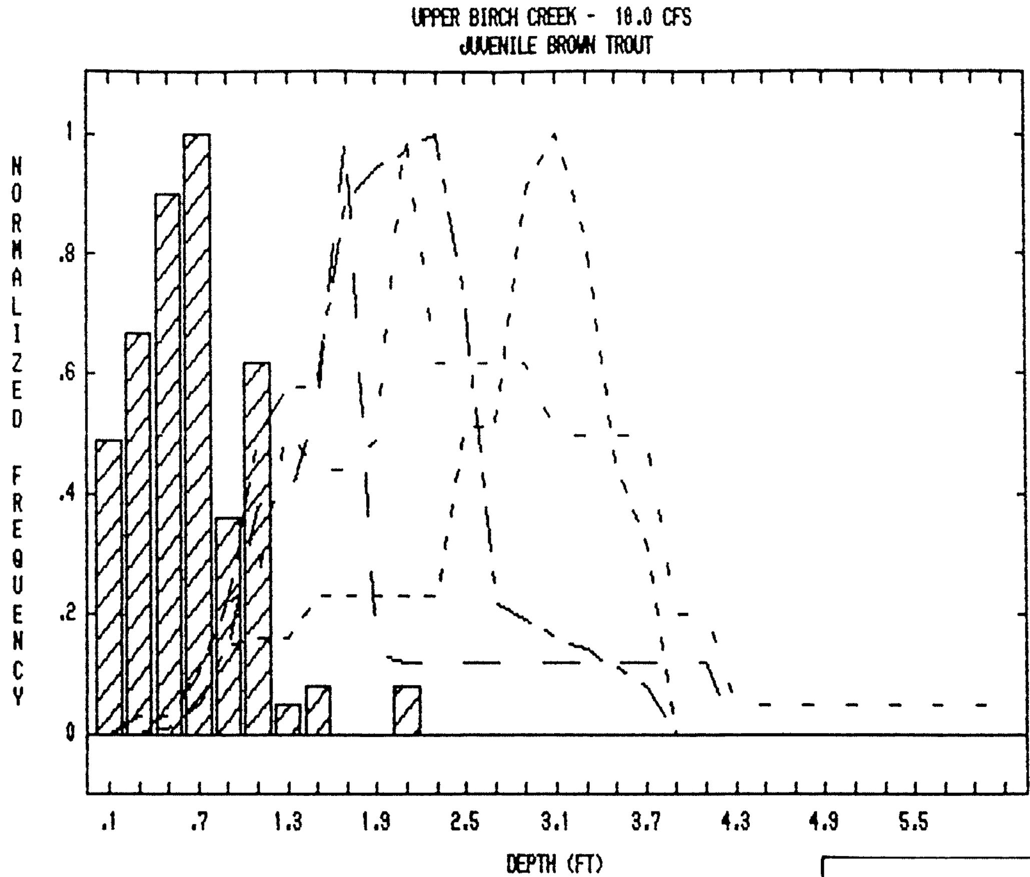


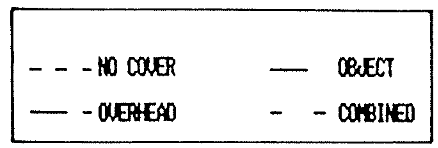
LOWER BIRCH CREEK - 1.8 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)

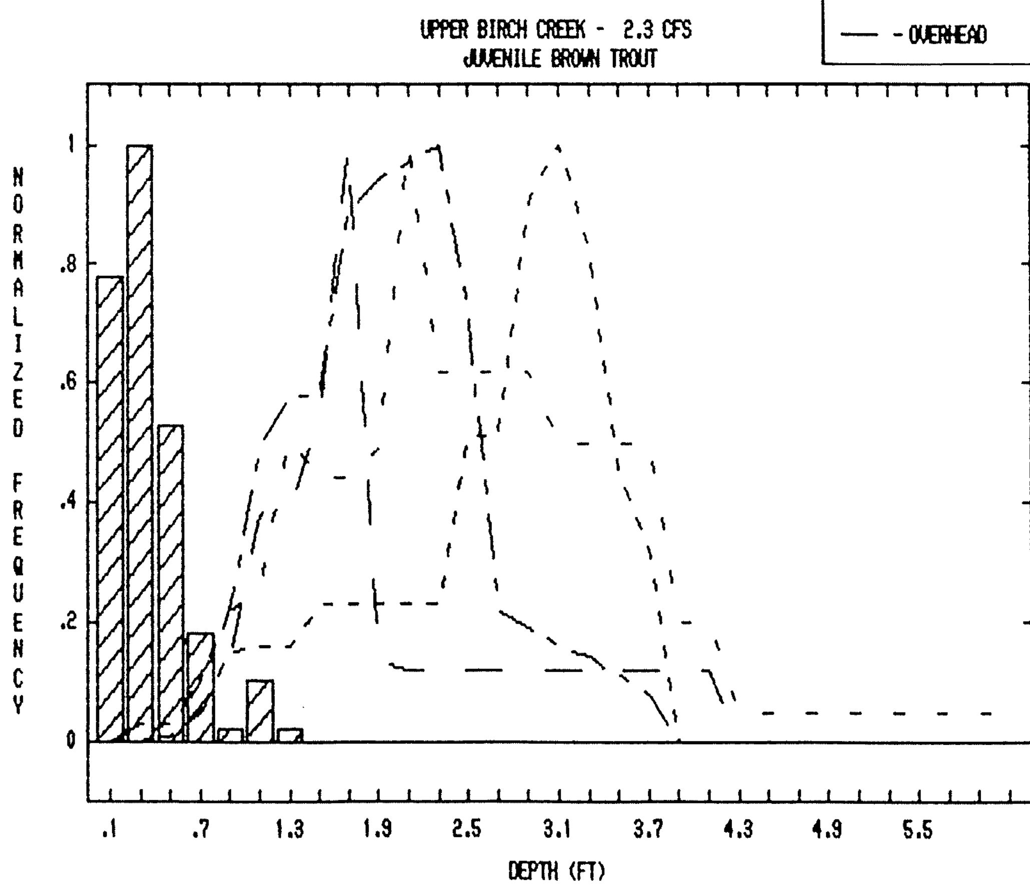

UPPER BIRCH CREEK - 10.0 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)
NO COVER
OBJECT
OVERHEAD
COMBINED


UPPER BIRCH CREEK - 2.3 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)

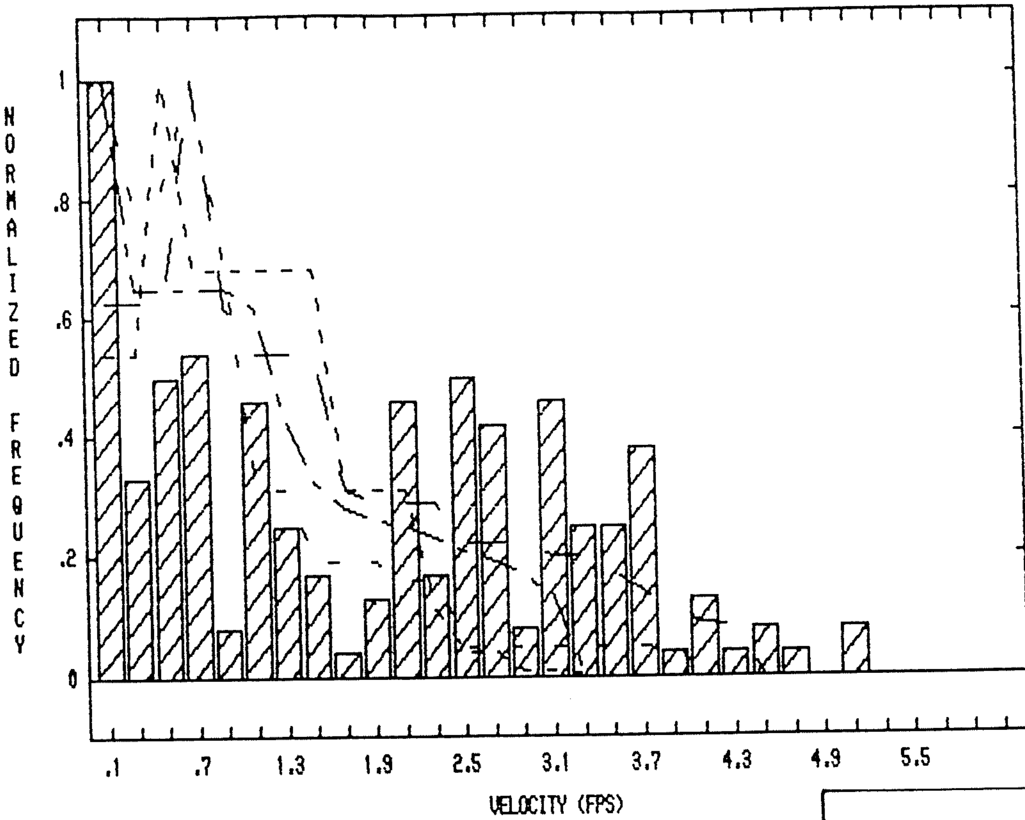

UPPER BIRCH CREEK - 10.0 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
1
.8
.6
.4
.2
0
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)
NO COVER
OBJECT
OVERHEAD
COMBINED
UPPER BIRCH CREEK - 2.3 CFS
ADULT BROWN TROUT
NORMALIZED FREQUENCY
1
.8
.6
.4
.2
0
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)


UPPER BIRCH CREEK - 10.0 CFS
JUVENILE BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)

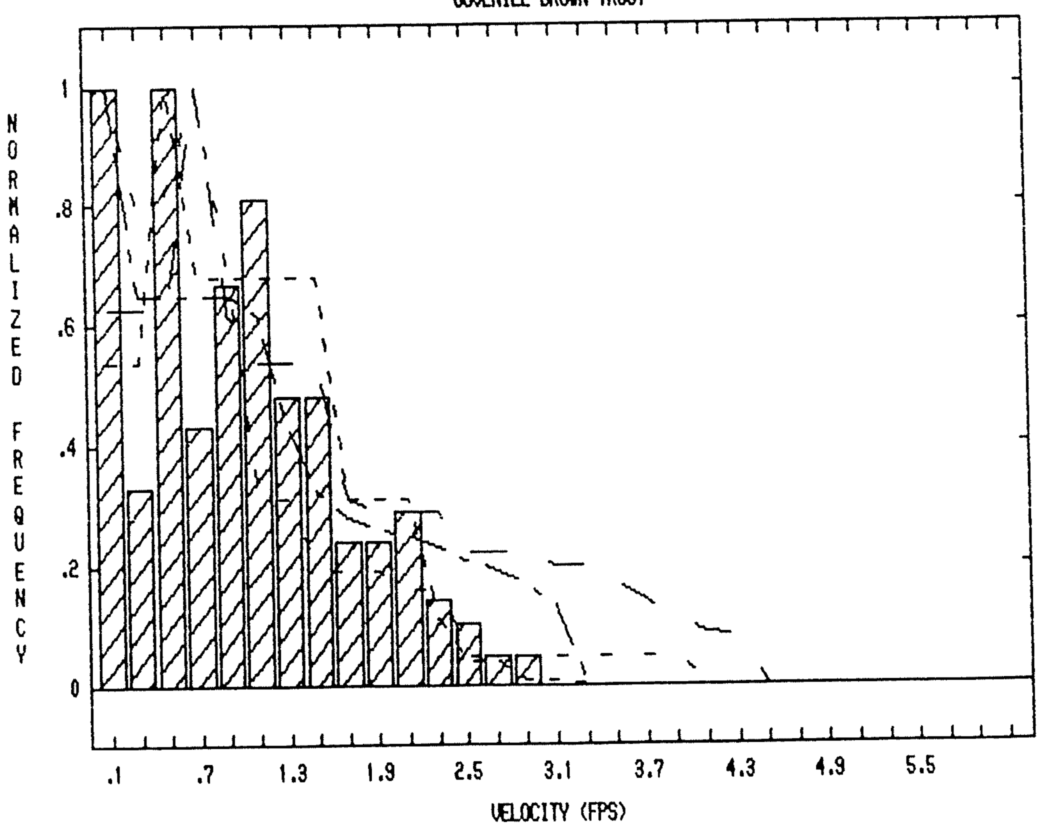

NO COVER
OBJECT
OVERHEAD
COMBINED


UPPER BIRCH CREEK - 2.3 CFS
JUVENILE BROWN TROUT
NORMALIZED FREQUENCY
0
.2
.4
.6
.8
1
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
DEPTH (FT)

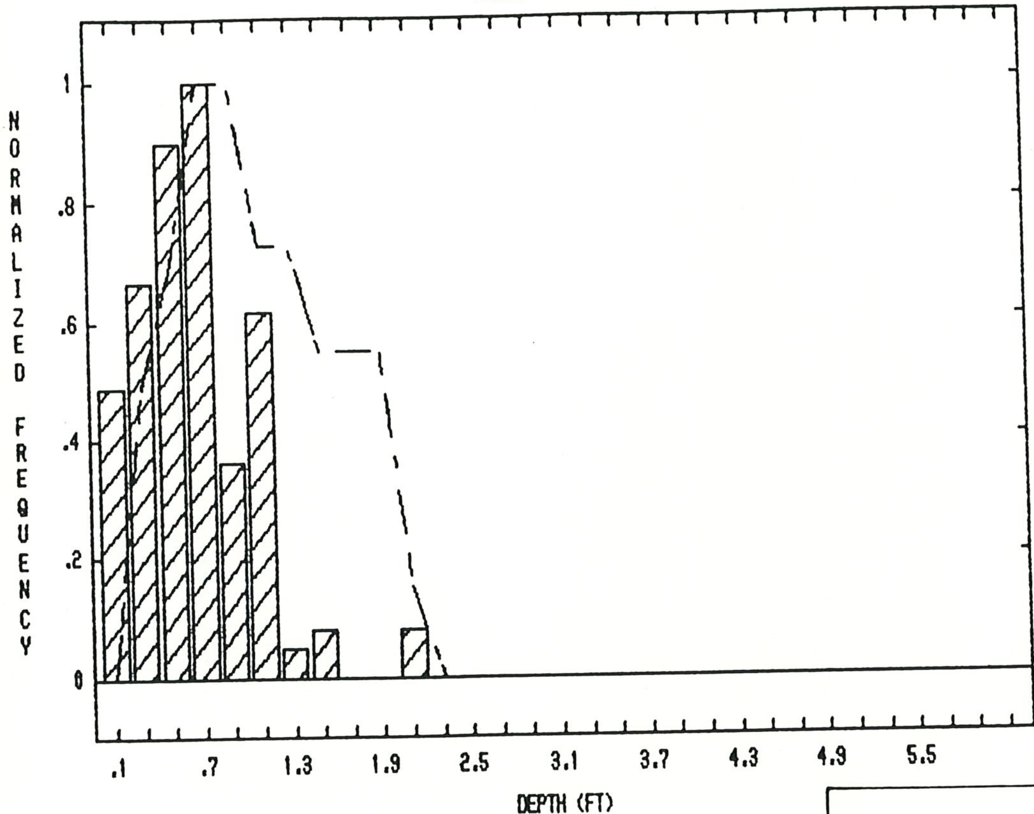
UPPER BIRCH CREEK - 10.0 CFS
JUVENILE BROWN TROUT

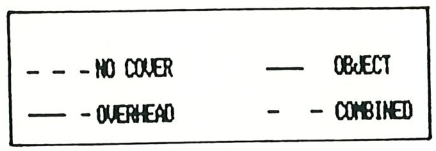


UPPER BIRCH CREEK - 2.3 CFS
JUVENILE BROWN TROUT

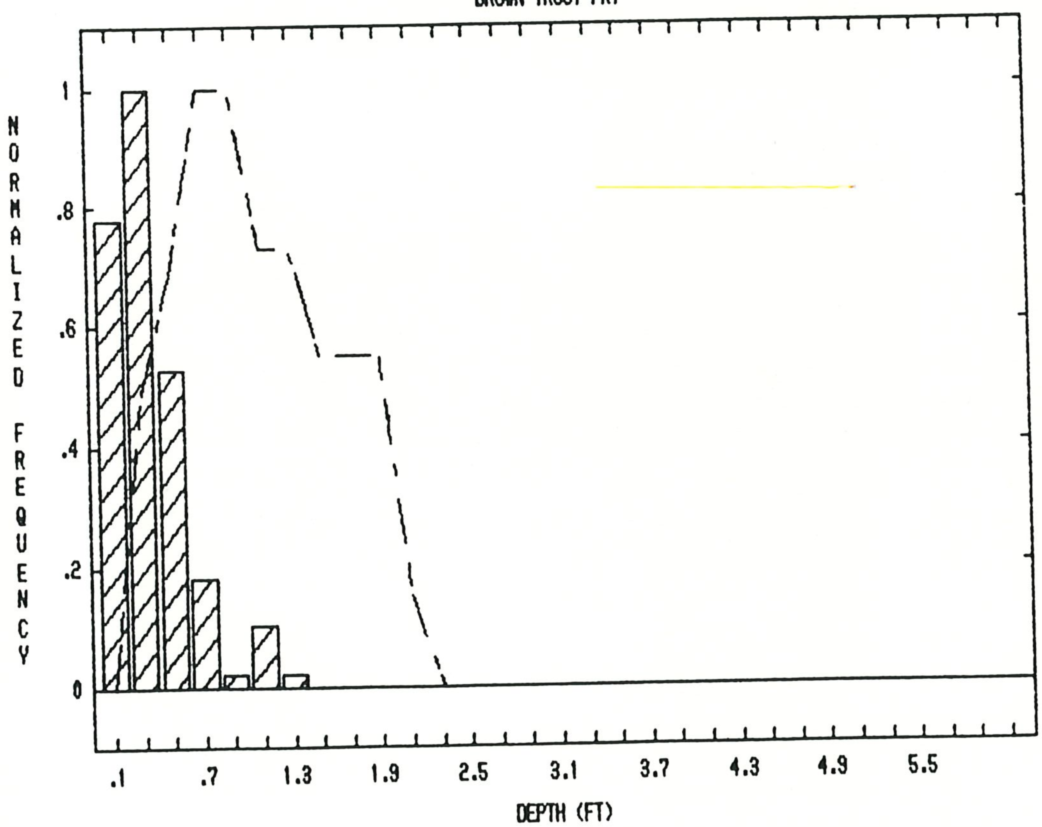


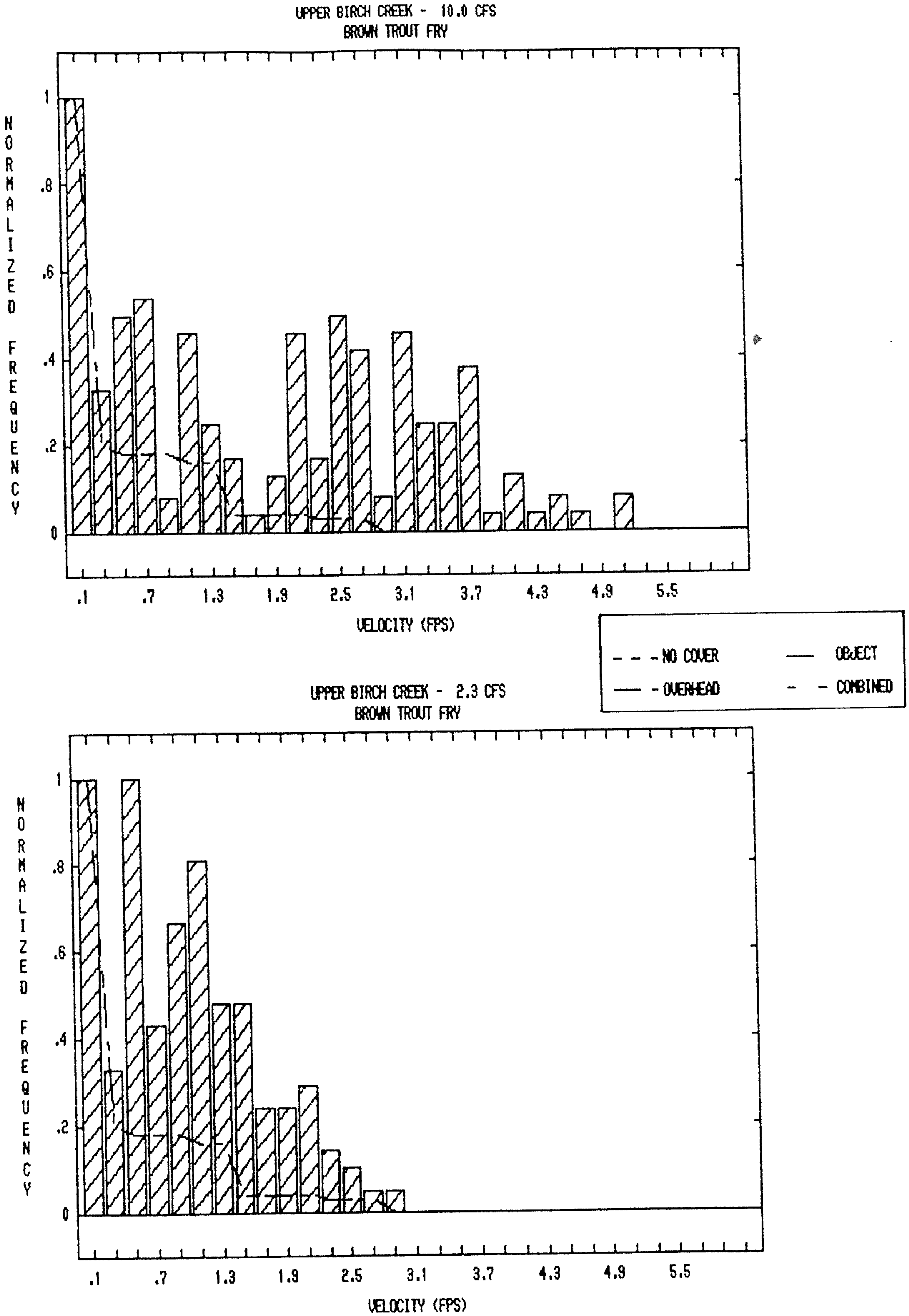
UPPER BIRCH CREEK - 10.0 CFS
BROWN TROUT FRY





UPPER BIRCH CREEK - 2.3 CFS
BROWN TROUT FRY




UPPER BIRCH CREEK - 10.0 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
1
.8
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.2
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.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)
NO COVER
OBJECT
OVERHEAD
COMBINED
UPPER BIRCH CREEK - 2.3 CFS
BROWN TROUT FRY
NORMALIZED FREQUENCY
1
.8
.6
.4
.2
0
.1
.7
1.3
1.9
2.5
3.1
3.7
4.3
4.9
5.5
VELOCITY (FPS)