CALIFORNIA DEPARTMENT OF FISH AND GAME
Environmental Services Division
Stream Flow and Habitat Evaluation Program

INSTREAM FLOW REQUIREMENTS

TRUCKEE RIVER BASIN

LAKE TAHOE TO NEVADA

Prepared for

U.S. Fish and Wildlife Service
Reno, Nevada

August 1996

SUMMARY

The Truckee River system downstream of Lake Tahoe, has been significantly altered by various water projects and their operation. These alterations have resulted in deterioration and loss of many instream resources. Public Law 101-618 authorizes renegotiation of the operation of these water projects, in part, to correct existing impacts (e.g., recovery of the federally listed Cui-ui).

For any new operating agreement to be acceptable to California, it must maintain instream public trust resources of the Truckee River system in good condition, per California Fish and Game Code Section 5937 - requiring the correction of existing, water development related problems.

The water project related impacts upon California's instream resources can be generalized as alteration to flow regimes, deterioration of instream habitats and isolation of historic spawning and rearing habitats. The results of the instream habitat investigations summarized in this report, indicate that mitigation of these impacts cannot be feasibly achieved solely through project reoperation. To do so would compromise water supply and other project purposes.

We propose a strategy integrating reoperation with habitat restoration to provide the foundation for a new operating agreement to resolve water project impacts. This approach includes: 1) the establishment of minimum flow conditions for each of the impacted stream reaches; 2) modification of operating criteria to balance flow conditions throughout the impacted area; and, 3) habitat rehabilitation (to reduce the instream flows that would otherwise be needed to maintain appropriate instream habitat conditions) (Table 1).

The management objectives are to maintain habitat within **ALL** reaches in as good as condition as is practical, to prevent alternating high and low flow conditions between reaches that effectively negate short lived good conditions with prolonged poor conditions, and to eliminate the negating effect of extreme, high flow releases upon sustained habitat conditions. Flow management would ideally be targeted to sustain preferred flows within all identified reaches. Continuous maintenance of preferred flow conditions, however, is obviously infeasible. Therefore, flow conditions will be maintained in all reaches at or above identified minimum flow conditions with the preferred flow being a targeted flow condition. Since minimum flow conditions will likely dominate the flow regime of the impacted streams, the management objectives can only be achieved by improving the quality of channel-habitat conditions to increase habitat availability at low flow; by balancing flow releases among the reaches to sustain comparable, suitable flow-habitat conditions within all reaches; and, by ramping flow releases to ameliorate impacts, or, where high flow releases are unavoidable, improve channel conditions to protect resident fishes from flushing and stranding.

Table 1. Instream flow recommendations for fishery resources in the Truckee River system, California

REACH	BROWN TROUT				RAINBOW TROUT			
	OCT - JAN		FEB - MAR		APR - JUL		AUG-SEP	
	SPAWNING & INCUBATION		REARING		SPAWNING & INCUBATION		REARING	
	PREFERRED	MINIMUM	PREFERRED	MINIMUM	PREFERRED	MINIMUM	PREFERRED	MINIMUM
Truckee R - Reach 1 Nevada to Boca	200	150	250	150	200	150	250	150
Truckee R - Reach 2 Boca to Donner Ck.	300	100	250	100	300	100	250	100
Truckee R - Reach 3 Donner Ck. to Lake Tahoe	250	75	150	75	300	75	150	75
Donner Ck., Donner Lake to Truckee R.	50	8	20	8	50	8	10	8
Prosser Ck., Prosser Reservoir to Truckee R.	50	16	35	16	75	16	30	16
Lower Little Truckee R, Stampede Reservoir to Boca Reservoir	125	45	100	45	125	45	100	45
Upper Little Truckee R, upstream of Stampede Reservoir	90	30	50	14	90	35	30	14
Independence Ck., Independence Lake to Little Truckee R	20	7	10	4	20	8	10	4

Minimum flow conditions require improved spawning and rearing conditions at low flows within the mainstem and listed tributaries.

Preferred flows represent optimum flow versus habitat conditions.

Controlled releases exceeding twice the highest, preferred flows in the Little Truckee River downstream of Stampede Reservoir and in Prosser Creek will require channel modifications to prevent stranding in secondary channels and shelter from high flows.

Target flows should be identified based upon storage and projected runoff conditions such that flow conditions will be sustained during the life stage period to as close to preferred conditions as possible.

Balanced system should be pursued to ameliorate fluctuation in flow conditions resultant from the alternating, exclusive use of reservoirs to accommodate downstream needs. Percent variation in flow between regulated reaches should be minimized. Percent variation is the percentage difference between minimum and preferred flow.

INTRODUCTION

Flow in the Truckee River and most of its tributaries is regulated by a series of dams and diversions for water supply, power production and flood protection. This regulation has altered seasonal hydrologic patterns causing unseasonable flow reductions and flow increases throughout most of the drainage. Regulation has also caused extreme, unnatural rates of flow change throughout the drainage. The dams have blocked access to trout spawning and rearing areas. The combination of flow regulation and impoundment with various land use activities has also induced changes in channel form. These physical alterations have changed the system's fish biota and have significantly affected the general health of remaining fisheries.

Competition for water from the Truckee River drainage continues to raise conflict between water users. Litigation, negotiation and legislation attempting to resolve conflicts have and will continue to change water use patterns throughout the drainage. Fish and wildlife resources dependent upon the streams' various habitats will be affected. Resolution of many of these conflicts is the subject of Federal Legislation (P.L. 101-618). Operation changes of existing facilities to protect Pyramid Lake and its fishery resources and to provide a more secure municipal water supply in western central Nevada are intended results of this legislation. But, before any water management changes can be made, evaluation of their environmental consequences and consideration of potential alternatives must be done. Informed decision-making will require technical information that identifies the environmental requirements necessary to protect public trust resources. Many basic questions concerning conditions necessary to protect such resources in the Truckee River system have been the subject of investigations conducted by the California Department of Fish and Game and the US Forest Service, Tahoe National Forest.

Historically, water development in the Truckee River system completely ignored fish resources. As a result, the Pyramid Lake cutthroat has become extinct and the Cui-ui, endemic only to Pyramid Lake, is endangered and potentially on the brink of extinction. Recent concern for the latter's continued existence has forced significant changes in operation of the system, causing further changes in stream habitat conditions in the Truckee River system. In California, rapid change in flow downstream of reservoirs has caused massive losses of fish and other aquatic resources. Chronic, long term modification of flow and channel have severely reduced the abundance and diversity of the fish population.

The California portion of the Truckee River system has supported a diverse assemblage of fish resources including many endemic fishes unique to the Truckee River system. Unfortunately, a severe decline in these fish resources has occurred during the past century, coinciding closely with increased water development (Snider, DFG file report). The Truckee River and its tributaries once supported superlative trout fisheries. The potential to restore such fisheries still exists, and, as such, part of the

Truckee River is a state designated Wild Trout Stream. Strong public support exists to extend designation to the entire Truckee River and many of its tributaries. Designated waters require utmost protection to promote naturally, self-sustaining trout fisheries through progressive fishery management and intensive environmental protection.

The value of the Truckee River system's fishery resources required a comprehensive evaluation of the system's fish habitat relationships including the potential and existing impacts of water development and management. The opportunity to improve instream habitat conditions and the potential effect of operation changes resulting from the new federal legislation and the resultant Truckee River Operating Agreement (TROA) need to be adequately assessed. Alternatives potentially available to protect and restore instream habitat conditions need to be properly identified and adequately evaluated. Potentially, a combination of flow and instream habitat modifications should be identified to allow optimum water allocation for both instream and consumptive uses. A comprehensive fish habitat relationship evaluation was therefore conducted to provide such determinations.

The California Department of Fish and Game and the U.S. Forest Service recently (1987-1995) conducted fish habitat evaluations throughout the Truckee River system. The evaluations identified: 1) basin wide habitat distribution, using a channel and habitat typing procedure developed for this study, 2) species-life stage distribution relative to channel and habitat type and 3) the relationship between flow and habitat utility. A model was developed to predict changes in habitat utility as a function of habitat availability and flow. Results from these evaluations have been used to identify habitat conditions potentially limiting Truckee River basin fish populations. Much of this information has been integrated into this report to identify general affects of water development and management upon habitat conditions and to make recommendations on modifying channel and flow conditions to optimize available flow.

MANAGEMENT GOALS AND OBJECTIVES

The overall management goal is to provide flow and channel habitat conditions necessary to protect stream dependent public trust resources in the Truckee River system. We believe this goal would be achieved by providing habitat conditions necessary to support self-sustained rainbow and brown trout fisheries throughout the study area. We identified two stream types relative to this goal: streams providing habitat for all life stages necessary to sustain a healthy trout population and streams providing spawning and nursery rearing habitats essential to maintaining healthy trout populations downstream. Two primary objectives were based upon the overall function of the individual streams or stream reaches: 1) maintain self-sustaining brown and rainbow trout populations, and 2) provide recruitment to other, tributary trout populations. Streams being managed per Objective 1 included the three reaches of the Truckee River and lower Little Truckee River below Stampede Reservoir. Streams managed to meet Objective 2 included Donner and Prosser creeks (both supporting spawning and nursery habitats essential to the mainstem Truckee River), and upper Little Truckee River, above Stampede Reservoir, and Independence Creek (both supporting spawning and nursery habitats for Stampede Reservoir).

METHODS

General Location

The study area encompassed all stream reaches within the California portion of the Truckee River system that are presently flow regulated (Figure 1). The study streams included the mainstem Truckee River from Lake Tahoe to the California-Nevada state-line (35 miles) and various reaches of three of its primary tributaries: Donner Creek, downstream of Donner Lake, Prosser Creek downstream of Prosser Reservoir and the Little Truckee River between Stampede and Boca Reservoir and between the confluence of Independence Creek and Stampede Reservoir. Independence Creek downstream of Independence Lake was also included.

Study Reaches

Study reaches within each stream were defined generally based upon flow and channel morphology. Points of significant accretion or flow manipulation were primarily used to designate the study reach boundaries. Significant changes in channel morphology, such as stream gradient and confinement were secondarily used to delineate study reaches.

General Approach - Flow versus Habitat Availability

The relationship between flow and habitat availability was developed using the physical habitat simulation model (PHABSIM)[1/] developed by the US Fish and Wildlife Service (FWS), Instream Flow Group (Bovee 1982). Our approach involved establishing modeling transects across representative habitats to collect hydraulic and physical data to define habitat availability. We identified the representative transect sites by: 1) classifying habitat types within the study reach to identify dominant and critical habitat types, 2) selecting at least three replicate habitat types to represent the dominant and critical types, and 3) systematically establishing transects across the selected sites to collect the required data. Data were collected at each transect at three distinct flows. Transect data were then entered into the PHABSIM model (segregated by habitat type), calibrated, then modeled to identify flow versus habitat relationships for each habitat type. The model results were then combined using a spreadsheet to identify flow versus habitat relationships for the entire study reach.

1/ PHABSIM = Physical Habitat Simulation modeling system developed by the FWS, National Ecology Research Center, Ft. Collins, CO.

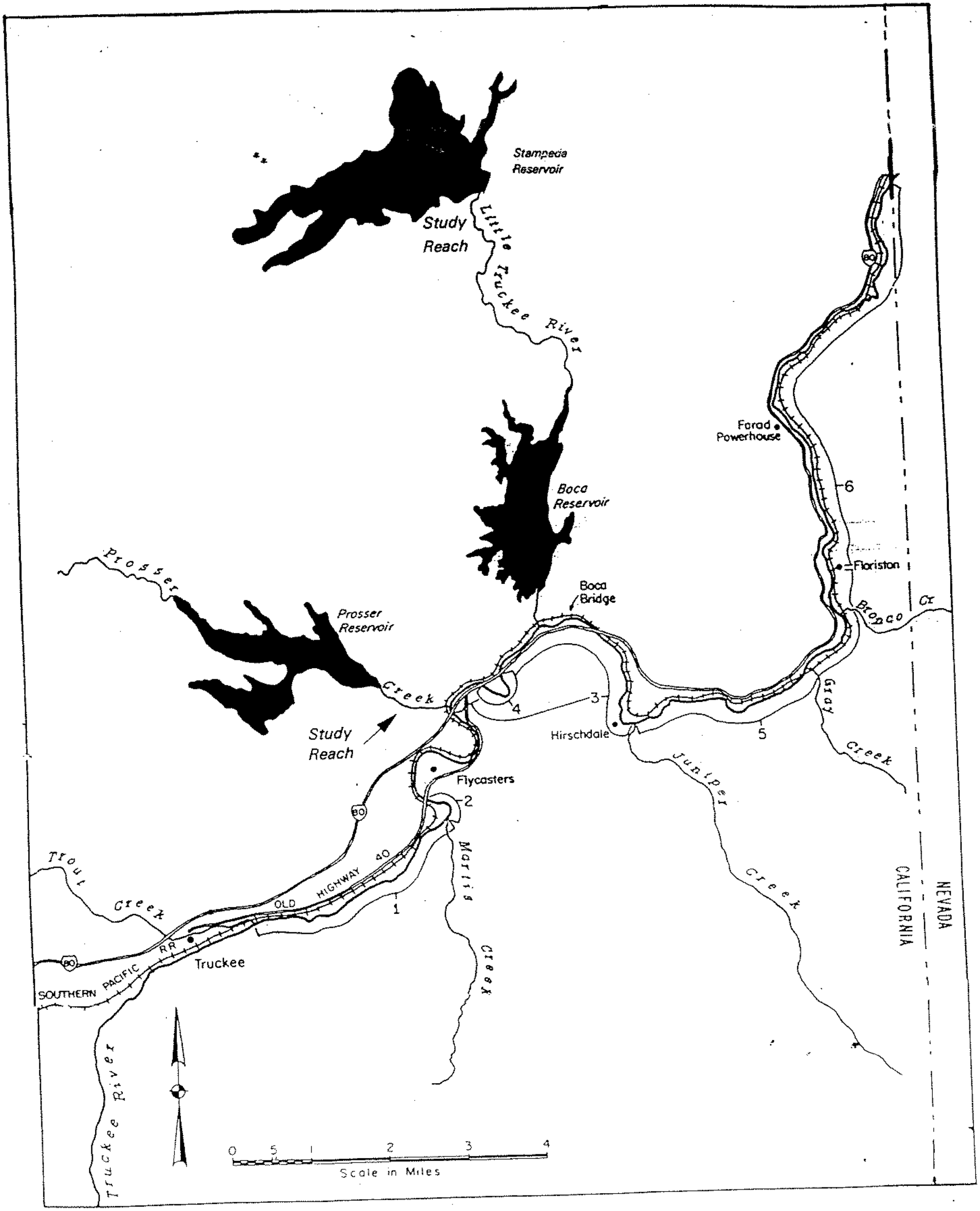

FIGURE 1. Truckee River Drainage

Field Methods

Habitat Classification

A geomorphically-based classification system was used to delineate instream habitat in each study stream.

Three hierarchical levels of classification were used to characterize instream habitat:

Level 1 - *general channel morphology* (geomorphically determined)
Level 2 - *major channel feature* (geomorphically determined)
Level 3 - *habitat unit* (geomorphically determined)

The **general channel morphology** classification followed the procedures outlined by Rosgen (1994). The stream channels were generally categorized as: 1) *A-type* - steep and well confined, 2) *B-type* - low gradient and slightly confined, or 3) *C-type* - low gradient and unconfined.

The ***major channel features*** classification includes: 1) *bar complexes* - the repeated sequence of depositional areas forming hydraulic controls; 2) *flat-water areas* - low gradient, intervening areas between the controls, and 3) run areas - steep gradient, intervening areas between the controls. This level of classification was only used on the Truckee River where these features were large enough to allow further classification at the third level.

The smallest scale of classification involved stratification of channel features into ***habitat units***, defined as *riffle, run, glide,* or *pool*. Classification of *habitat units* was based on channel morphology and gradient, substrate composition, and hydraulic characteristics. Representatives of all the *habitat units* were typically found in most major-channel features types (riffles are not found in flat-water areas). Pools were further classified as lateral scour pools, main channel pools or backwater pools. Pool structure was also described to define habitat complexity.

The Truckee River was classified as to habitat type using a combination of aerial photographs and ground surveys. Major channel features (e.g., bar complex, flatwaters and runs) were first identified on aerial photographs (scale 1:1200). The photographs were taken into the field and adjustments to major-channel feature boundaries were made on the aerial photographs as needed. Each habitat unit (i.e., *riffle, run, glide, pool*) was classified and delineated on the base maps in the field. Habitat units were delineated on the copies of the aerial photographs. The smaller, tributary streams were classified from ground surveys.

Transect Selection and Placement

At least three representatives each of the three habitat types identified in each study reach were selected as PHABSIM study sites. These were termed *Transect Areas*. Transects were numbered sequentially within areas. Most habitat types were generally represented by a single transect. The more complex habitats, typically pools, were represented by up to three transects.

Data Acquisition

The hydraulic data required for PHABSIM modeling were measured at three nominal flow levels. Water depth, water velocity, water surface elevations (WSL), water surface elevations at the stage of zero flow [2/] (SZF), and bed elevation profile were measured at low and high flow, when possible (Trihey and Wegner 1981). Only WSL's were collected at high flow in most of the Truckee River study reaches due to extreme flow conditions.

Hydraulic data acquisition and data recording format followed guidelines established for IFIM field techniques by the FWS (Trihey and Wegner 1981; Milhous *et al.* 1981). Techniques for measuring discharge followed the guidelines outlined by the U.S. Geological Survey Water Supply Paper No. 2175 (Rantz *et al.* 1982). A permanent benchmark and permanent head-stakes were installed for all transects. The cell boundaries along each transect were usually distributed at even increments, but significant changes in water velocity and depth occasionally required additional cell stationing.

Total water depth was measured to the nearest 0.1 ft with a top-setting wading rod. The standard method of determining mean column velocity was a single measurement at the proportional 0.6 depth from the water surface in depths less than 2.0 ft, and at proportional 0.2 and 0.8 depths from the water surface for total water depths between 2.0 and 4.0 ft (Buchanan and Somers 1969). Water velocities at all three proportional depths (i.e., 0.2, 0.6, and 0.8) were measured when total water depth exceeded 4 ft, when water velocity distribution in the water column was highly variable, or when one or two points of measurement were not adequate to derive an accurate mean column water velocity (Bovee and Milhous 1978).

2/ SZF is the water surface elevation when the flow equals zero. This is either the elevation of the deepest point of the cross section (i.e., thalweg) or the downstream hydraulic control.

Marsh McBirney Flowmate Model 2000 electromagnetic velocity meters (can provide both instantaneous readout of positive and negative water velocity values) were used to measure water velocity to the nearest 0.001 feet per second, rounded to the nearest 0.01 feet when recorded.

Temporary staff gages were installed and frequently monitored for changes in stream discharge (water surface elevation); discharge remained constant during transect measurements. Headpin, tailpin, dry bed elevation and water surface elevations (WSL) were measured to the nearest 0.01 feet using a surveyor's auto level, tripod, and stadia rods.

Analytical Techniques

Data Proofing & Quality Control

Field data sheets were proofed by the field crew leader at the end of the field day, or on the first available work day immediately following a period of field work. Field data sheets in various formats for dry-land profiles, velocity/depth profiles, and WSL surveys were transcribed onto one data entry sheet in the lab, and cross-checked immediately by the transcriber. Two separate data-entry sheets were developed for a low-flow and mid-flow calibration data deck. These data sheets were made from a combination of the dry-land profiles, stage-discharge data, and the individual respective subsurface profile and velocities from either the low or mid-flow velocity data set.

Two IFG4 data decks (low flow and mid or high-flow) were created for each individual transect using IFG4IN. The keypunch operator proofed for data entry errors during the keypunching process. If the discharge calculated by IFG4IN was more than 5% off from the one calculated in the field, the keypunch operator rechecked the velocity computations on the original field data sheet, making corrections to all paper and computer records as necessary.

Data Screening & Adjustments

Each individual transect's IFG4 data deck was run through TREVI4, which runs the subroutines CKI4 and REVI4. Fatal formatting errors uncovered by CKI4 were corrected. The graphical output from REVI4 was reviewed to detect aberrant: 1) trends in velocity with depth, 2) trends in roughness with depth, 3) channel profiles, such as mid-channel points above the WSL, and 4) velocity distributions across the channel, 5) trends in WSL with discharge. Anomalies were noted and the raw data and data entry sheets were checked for errors that could have created the observed aberration. Errors were corrected on all paper and computer records, as necessary.

Stage - Discharge Calibrations & WSL Modeling

Stage-discharge calibrations and predictions of WSL's at modeled flows were made for each individual transect using either IFG4 or MANSQ. Those transects that spanned only one individual arm of a divided channel (split-channel transects) were modeled separately using a range of modified calibration and modeling flows calculated for each split-channel transect. Transects with only two stage-discharge measurements were calibrated via MANSQ and those with three stage-discharge measurements were calibrated via IFG4.

Interpolation of Split-Channel Flows

We measured actual discharges in each split-channel transect at low and mid-flows, and took full-channel discharge measurements at nearby transects during the same period. At high flows, discharge was measured for general reaches of habitat in a full-channel section of the river. The fraction of full-channel flow measured in each split-channel transect at low and mid-flows was used to compute a linear interpolation for the fraction of flow predicted to pass through that transect at high flow. We calculated the slope of a line between two points describing the relationship between "Y = fraction of flow in a split channel transect" and "X = the actual full channel discharge measured for that area." This slope value was multiplied by the full channel discharge at high flow, measured for the split-channel area, to compute the fraction of flow in the split channel at high flow.

A simplified example is as follows: If a split-channel transect has 1 cfs of flow when full-channel flow is 10 cfs (fraction = 10%), and 4 cfs flow when full-channel flow is 20 cfs (fraction = 20%), linear interpolation using the slope of this relationship predicts that the transect will have 40% of the full channel flow at 40 cfs, which is a predicted flow of 16 cfs.

Tolerances Used for Modeling Decisions

Residual Error Levels in IFG4

The mean square error term (MSE) from REVI4 and IFG4 were reviewed to determine the degree to which the transects with three sets of stage-discharge data fit the IFG4 model for WSL prediction. Standard FWS criteria suggest that transects with MSE's greater than 10% be recalibrated with MANSQ.

WSL Predicted vs. Measured in MANSQ

Transects with only two sets of stage-discharge data were calibrated with MANSQ. Initial runs of MANSQ were made using the exponent from the conveyance factor (CFAC) equation in REVI4 as an estimate for Beta. Adjustments were made to Beta until WSL-predicted differed from WSL-measured by less than or equal to 0.1 ft.

Velocity Calibrations

Velocity calibration is composed of two general screening and evaluation approaches. First is a review of the pattern and magnitude of the velocity values and Manning's N (roughness) values produced during the calibration and production runs of IFG4. Excessive roughness values along any portion of the transect, except the shallow water edges, are a potential problem and should be modified. Excessive roughness values are defined as N values that greatly exceed the common level of roughness values seen in areas other than very shallow, channel-edge cells. Velocity distributions are also reviewed for any abnormal or inconsistent patterns. If anomalies are detected, the raw data is cross-checked for accuracy and N values are checked to see if they are inconsistent with the range of N's in the rest of the transect and may have caused an abnormal velocity. This process is often a qualitative one. For the second part of a velocity calibration, the two velocity data sets for each transect (low or mid-flow) are used to predict each other's velocities. If the pattern and amount of the predicted velocities were not similar to the measured values (using each velocity data set to predict values at the discharge measured in the complementary data set) then the appropriate approach to velocity modeling would be to split the range of flows to be modeled in two. Separate ranges of flows would then be modeled with each low or mid-flow data set.

No anomalous trends were observed in the velocities predicted by IFG4. Adjacent cells had similar, but gradually changing velocities. Rapid changes in velocity and roughness only occurred where there were abrupt changes in substrate elevation, as expected.

Highly elevated N values only occurred in shallow water over mid-channel bars or in lateral, shallow-water habitats, as is appropriate. Thus, no attempt was made to limit them. Artificially restricting N values (roughness) in lateral, shallow-water habitats has the effect of accelerating modeled water velocities in the habitat areas most valuable to juvenile fish, and functions to depress the value the model assigns to these areas for the juvenile life stage.

IFG4 Production Runs

Actual habitat lengths measured for each transect in the field were used on the XSEC line for each transect's IFG4 run, except for pools. Since pools typically had three transects for each habitat unit, the length of the habitat unit was apportioned equally (1/3) to each sub-transect in that pool habitat.

We used IOC codes 5=1 and 8=0 for production runs with data decks whose WSL's were calibrated and predicted via IFG4, and the default IOC codes for MANSQ runs with data decks whose WSL's were calibrated and predicted via MANSQ. Then we used WSEI4 and Tape 4 output from IFG4 and MANSQ runs with to merge the WSLs produced by these tow separate programs back into the original IFG4 data deck. All IFG4 data decks with WSL cards were merged with a text editor and run through a final production run of IFG4 using IOC codes 5=1 and 8=1 to produce tape3 and TP4 files necessary for our HABTAT modeling runs. We set IOC code numbers 1, 2, & 13 equal to 1 during the calibration phases to get expanded model output and Velocity Adjustment Factors (VAFs) to use in the screening process. All other IOC codes were left at their default values.

The FWS guidelines recommend that VAFs range between 0.6 and 1.4 for calibrations using a single velocity set. However, these are guidelines **not** binding rules or fixed assumptions, which if violated would invalidate the model. Some PHABSIM/IFIM practitioners advocate a wider range of acceptable VAFs (0.1 to 1.9), and are only truly concerned with VAFs greater than 3.0. We used a VAF criteria of 3.0.

Habitat Suitability Curves

Habitat suitability curves developed by Bovee (1978) were used to define habitat criteria in the PHABSIM model.

Habitat Modeling Runs

We used HABTAT to model weighted usable area (WUA), and made separate runs with each of the two types of data sets produced by the IFG4 production runs (split-channel transects with WSL's from MANSQ or IFG4, and full-channel transects with WSL's from MANSQ and IFG4). We ran HABTAT with ZHABIN IOC Code numbers 2, 3, 8, 10, and 19 = 1. The two sets of WUA curves produced by this output were combined in a Quattro Pro spreadsheet. This was done by multiplying each set of WUA data by the decimal percent of total habitat in the study reach.

Flow Management Criteria

Optimum Flow Determination - To optimize conditions under Objective 1 we identified flows that would maximize habitat availability for brown and rainbow trout spawning and incubation and for adult rainbow trout. Rainbow trout adult rearing was identified as the critical life stage occurring between spawning periods due to a substantial decline in rainbow trout populations that has apparently occurred throughout the Truckee River system beginning in the 1960's. To optimize habitat conditions per Objective 2, we identified flows that would maximize spawning and incubation and fry habitats. Since flow influences habitat availability differently for all life stages, we wanted to make sure that the selected, optimizing flow did not severely affect the amount of habitat available for the other life stages present at the time. Therefore, we compared the amount of habitat that would be available for each life stage at the selected flow with the maximum amount potentially available. We concluded that reductions should not drop below 50% of optimum for any life stage in order to maintain minimum habitat conditions for the overall population. These latter criteria were not applied to adult rearing habitat for streams being managed to meet Objective 2.

Minimum Flow Determination - Minimum flow conditions were also identified for each stream and stream reach based upon the stream's management objective. Minimum flows in streams being managed per Objective 1 were determined based primarily on juvenile rainbow trout habitat availability and secondarily on maintaining at least 50% of optimum conditions for all other life stages. Studies conducted by the Forest Service and Department of Fish and Game in the Truckee River basin have shown that spawning and incubation habitats can substantially limit potential trout production. These studies also showed that when spawning and incubation conditions are sufficient, juvenile rearing habitat is the primary factor limiting eventual adult production. Therefore, we identified minimum flow conditions within every period as the flow required to maximize juvenile rearing habitat availability - often substantially reducing habitat available under optimum flow conditions. In streams managed per Objective 2, we identified minimum flow conditions that would not reduce any life stage (except adult rearing habitat availability) below 50% of optimum during any period (see Appendix 1).

Due to the substantial reduction in habitat availability at minimum flows (to 50% of optimum), it is imperative that flow management providing other than optimum flow conditions be accompanied by a spawning and rearing habitat improvement program. The specific needs of such a program are discussed under the individual stream recommendation sections below.

The life stage periods and criteria used to determine optimum flow conditions for streams being managed to meet Objective 1 were:

October through January - Maximize brown trout spawning and incubation (assumed equal to spawning habitat). No life stage less than 50% of optimum.

February through March - Maximize rainbow trout adult rearing. No life stage less than 50% of optimum.

April through July - Maximize rainbow trout spawning and incubation. No life stage less than 50% of optimum.

August through September - Maximize rainbow trout adult rearing. No life stage less than 50% of optimum.

The criteria used to determine minimum flow conditions for streams being managed to meet Objective 1 were:

All Year - Maximize rainbow trout juvenile rearing. No life stage less than 50% of optimum.

The life stage periods and criteria used to determine optimum flow conditions for streams being managed to meet Objective 2 were:

October through January - Maximize brown trout spawning and incubation (assumed equal to spawning habitat). No life stage less than 50% of optimum (except adult rearing).

February through March - Maximize rainbow trout fry rearing. No life stage less than 50% of optimum (except adult rearing).

April through July - Maximize rainbow trout spawning and incubation. No life stage less than 50% of optimum (except adult rearing).

August through September - Maximize rainbow trout fry rearing. No life stage less than 50% of optimum (except adult rearing).

The criteria used to determine minimum flow conditions for streams being managed to meet Objective 2 were:

All Year - Maintain at least 50% of optimum habitat for all life stages except adult rearing habitat.

RAMPING AND MAXIMUM FLOWS

High flows can cause stranding and isolation of trout and other fishes. This problem has been observed in Prosser Creek, downstream of Prosser Creek Reservoir and the Little Truckee River downstream of Stampede Reservoir when unseasonably high flows were released for various water management needs. Rapid changes in flow can exacerbate the stranding and isolation problems. Such conditions have been observed in Donner Creek, downstream of Donner Lake, in the Truckee River, downstream of Lake Tahoe and downstream of the Floriston and Fleisch hydropower diversions.

High flows that can force fish out of the main channel resulting in stranding and isolation are, for the purposes of this report, considered to occur at twice the highest, optimum flow, unless otherwise noted below. When flows are greater than this flow, ramping can occur essentially at any rate without causing additional damage. When flow changes occur at flows less than this threshold the following ramping schedule should apply:

> Increasing flows - Flows should not be increased more than 100% during a 24-hour period; the change during the 24-hour period should occur in a minimum of three, proportional amounts(i.e., one-third the total 24-hour change per 8 hours).
>
> Decreasing flows - Flows should not be decreased more than 50% during a 24-hour period; the change during the 24-hour period should occur in a minimum of three, proportional amounts (i.e., one-third the total 24-hour change per 8 hours).

BALANCED SYSTEM

A balanced system will be achieved when percent variation between preferred and minimum flows is comparable and sustained in all regulated reaches. Percent variation is defined as the percentage difference between minimum and high flow. A balanced system should be maintained to avoid higher than necessary, or lower than necessary flows in any regulated reach. The present practice of providing downstream water needs through exclusive use of the various reservoirs has resulted in the localized cycling of extremely high flows followed by extremely low flows throughout the regulated portion of the system.

RECOMMENDATIONS

The flow versus habitat results obtained from the PHABSIM model that met the criteria discussed above are presented for each stream and stream reach based upon the corresponding management objective.

MAINSTEM TRUCKEE RIVER

EXISTING PROBLEMS

- Loss of historic spawning and rearing habitats in the major tributaries: Donner Creek, Martis Creek, Prosser Creek, Little Truckee River and its tributaries.

- Deterioration of spawning and rearing habitat within the mainstem including loss of habitats critical to juvenile survival (e.g., complex pool habitats)

- Reduced flow, especially above Boca and between hydropower diversions.

- Fluctuating flow downstream of Lake Tahoe and hydropower diversions.

GENERAL RECOMMENDATIONS

Study reaches have been defined relative to the location of storage facilities. Flows are to be maintained at or above the minimum conditions described below. These minimum flow requirements are acceptable, contingent upon incorporation of a spawning and rearing habitat improvement program in TROA for the mainstem and the remaining spawning tributaries (Prosser and Donner creeks). These improvements will increase the amount of useable habitat available for critical life stages at flows lower than preferred (i.e., at minimum flow conditions).

Habitat improvement will include spawning, fry and juvenile habitats in tributaries and spawning, juvenile and adult habitats in the mainstem. Gravel and cover (structure management) will be necessary.

Careful ramping of flows is essential especially under controlled conditions when flow is within the minimum to preferred range (i.e., non-flood or spill conditions). During the non-spawning periods, controlled flow fluctuations should be ramped as described above. During spawning seasons, flows must be maintained through incubation.

FLOW RECOMMENDATIONS

Reach 1 - Nevada State Line to Boca

Management Objective 1 was applied to this reach of the Truckee River. Optimum flows were identified for brown and rainbow trout spawning and incubation and adult rainbow trout rearing as listed. Minimum flow conditions were identified based upon juvenile rainbow trout rearing.

Maximizing flow conditions:

Brown trout spawning and incubation - 200 cfs
Rainbow trout spawning and incubation - 200 cfs
Rainbow trout adult rearing - 250 cfs
Rainbow trout juvenile rearing - 150 cfs

Flows providing 50% of optimum habitat conditions

Life stage	Rainbow trout	Brown trout
Spawning and incubation	55 cfs	60 cfs
Fry rearing	10 cfs	10 cfs
Juvenile rearing	20 cfs	65 cfs
Adult rearing	60 cfs	10 cfs

Recommended Flows for mainstem Truckee River - Reach 1

PERIOD	OPTIMUM FLOW	CRITERIA	MINIMUM FLOW	CRITERIA
October - January	200 cfs	Brown trout spawning	150 cfs	Juvenile rainbow trout rearing
February - March	250 cfs	Adult rainbow trout rearing	150 cfs	Juvenile rainbow trout rearing
April - July	200 cfs	Rainbow trout spawning	150 cfs	Juvenile rainbow trout rearing
August - September	250 cfs	Adult rainbow trout rearing	150 cfs	Juvenile rainbow trout rearing

Reach 2 - Boca to Donner Creek

Management Objective 1 was applied to this reach of the Truckee River. Optimum flows were identified for brown and rainbow trout spawning and incubation and adult rainbow trout rearing as listed. Minimum flow conditions were identified based upon juvenile rainbow trout rearing.

Maximizing flow conditions:

Brown trout spawning and incubation - 300 cfs
Rainbow trout spawning and incubation - 300 cfs
Rainbow trout adult rearing - 250 cfs
Rainbow trout juvenile rearing - 100 cfs

Flows providing 50% of optimum habitat conditions

Life stage	Rainbow trout	Brown trout
Spawning and incubation	95 cfs	100 cfs
Fry rearing	15 cfs	10 cfs
Juvenile rearing	20 cfs	65 cfs
Adult rearing	75 cfs	30 cfs

Recommended Flows for the mainstem Truckee River - Reach 2

PERIOD	OPTIMUM FLOW	CRITERIA	MINIMUM FLOW	CRITERIA
October - January	300 cfs	Brown trout spawning	100 cfs	Juvenile rainbow trout rearing
February - March	250 cfs	Adult rainbow trout rearing	100 cfs	Juvenile rainbow trout rearing
April - July	300 cfs	Rainbow trout spawning	100 cfs	Juvenile rainbow trout rearing
August - September	250 cfs	Adult rainbow trout rearing	100 cfs	Juvenile rainbow trout rearing

Reach 3 - Donner Creek to Lake Tahoe

Management Objective 1 was applied to this reach of the Truckee River. Optimum flows were identified for brown and rainbow trout spawning and incubation and adult rainbow trout rearing as listed. Minimum flow conditions were identified based upon juvenile rainbow trout rearing.

Maximizing flow conditions:

Brown trout spawning and incubation - 250 cfs
Rainbow trout spawning and incubation - 300 cfs
Rainbow trout adult rearing - 150 cfs
Rainbow trout juvenile rearing - 250 cfs

Flows providing 50% of optimum habitat conditions

Life stage	Rainbow trout	Brown trout
Spawning and incubation	15 cfs	40 cfs
Fry rearing	<10 cfs	<10 cfs
Juvenile rearing	20 cfs	25 cfs
Adult rearing	45 cfs	40 cfs

Recommended Flows for the mainstem Truckee River - Reach 3

PERIOD	OPTIMUM FLOW	CRITERIA	MINIMUM FLOW	CRITERIA
October - January	250 cfs	Brown trout spawning	75 cfs	Juvenile rainbow trout rearing 1/
February - March	150 cfs	Adult rainbow trout rearing	75 cfs	Juvenile rainbow trout rearing
April - July	300 cfs	Rainbow trout spawning	75 cfs	Juvenile rainbow trout rearing
August - September	150 cfs	Adult rainbow trout rearing	75 cfs	Juvenile rainbow trout rearing

1/ Maximum juvenile rainbow trout habitat occurs at 250 cfs, however since this flow was nearly equal to optimum flows for all period (higher than adult rainbow trout rearing) and since the flow versus habitat relationship for this reach showed two peaks for juvenile rainbow trout rearing, we selected the first (lower flow) peak which provides nearly 90% of optimum juvenile rearing for both rainbow and brown trout.

DONNER CREEK

Donner Creek is one of only two major tributaries with potential to provide spawning and nursery rearing areas for trout resident to the mainstem Truckee River. Such habitat conditions are critically lacking for the mainstem fishery resources.

EXISTING PROBLEMS

- Below minimum low flow conditions

- Severely degraded channel/habitat conditions

- Highly variable flow fluctuations

GENERAL RECOMMENDATIONS

Identified preferred and minimum flow conditions are based upon providing spawning and nursery rearing habitat critical to mainstem brown and rainbow trout per PHABSIM results. Minimum flow conditions are based upon improved spawning and rearing conditions at low flow. Habitat rehabilitation will be required, including gravel and structure management, to provide acceptable habitat conditions at the recommended flows. Sustained spawning flows will be required through incubation. Flow fluctuation outside the identified spawning periods will follow the guidelines defined above.

FLOW RECOMMENDATIONS

Management Objective 2 was applied to Donner Creek downstream of Donner Lake. Optimum flows were identified for brown and rainbow trout spawning and incubation and fry rearing dependent upon the season (e.g., brown trout fry following brown trout spawning). Minimum flow conditions were identified based upon providing at least 50% of optimum habitat availability for all life stages, except adult rearing.

Maximizing flow conditions:

Brown trout spawning and incubation - 50 cfs
Rainbow trout spawning and incubation - 50 cfs
Brown trout fry rearing - 20 cfs
Rainbow trout fry rearing - 10 cfs

Flows providing 50% of optimum habitat conditions

Life stage	Rainbow trout	Brown trout
Spawning and incubation	6 cfs	5 cfs
Fry rearing	3 cfs	2 cfs
Juvenile rearing	8 cfs	~1 cfs

Recommended Flows for Donner Creek

PERIOD	OPTIMUM FLOW	CRITERIA	MINIMUM FLOW	CRITERIA
October - January	50 cfs	Brown trout spawning	8 cfs	50% juvenile rainbow trout rearing
February - March	20 cfs	Brown trout fry rearing	8 cfs	50% juvenile rainbow trout rearing
April - July	50 cfs	Rainbow trout spawning	8 cfs	50% juvenile rainbow trout rearing
August - September	10 cfs	Rainbow trout fry rearing	8 cfs	50% juvenile rainbow trout rearing

PROSSER CREEK

Prosser Creek is one of only two major tributaries with potential to provide spawning and nursery rearing areas for trout resident to the mainstem Truckee River. Such habitat conditions are critically lacking for the mainstem fishery resources.

EXISTING PROBLEMS

- Below minimum low flow conditions

- Severely degraded channel/habitat conditions

- Extremely variable flow fluctuations

GENERAL RECOMMENDATIONS

Identified preferred and minimum flow conditions are based upon providing spawning and nursery rearing habitat critical to mainstem brown and rainbow trout per PHABSIM results. Minimum flow conditions are based upon improved spawning and rearing conditions at low flow. Habitat rehabilitation will be required, including gravel and structure management, to provide acceptable habitat conditions at the recommended flows. Sustained spawning flows will be required through incubation, Flow fluctuation outside the identified spawning periods will follow the guidelines defined below.

Prosser Creek fish are extremely vulnerable to the potentially high, controlled releases from Prosser Creek Reservoir. Stranding in secondary channels and flushing will occur if flows exceed twice the preferred flow conditions. Increased structure abundance and complexity will provide shelter from high flows. Channel modifications to isolate fish from secondary channels will reduce or prevent stranding. Such modifications will be necessary to sustain Prosser Creek as a viable spawning and nursery stream and potentially, a high quality resident trout fishery. The proposed flow regime and spawning and rearing habitat rehabilitation will only be effective if stranding and flushing are avoided.

FLOW RECOMMENDATIONS

Management Objective 2 was applied to Prosser Creek downstream of Prosser Creek Reservoir. Optimum flows were identified for brown and rainbow trout spawning and incubation and fry rearing dependent upon the season (e.g., brown trout fry following brown trout spawning). Minimum flow conditions were identified based upon providing at least 50% of optimum habitat availability for all life stages, except adult rearing.

Maximizing flow conditions:

- Brown trout spawning and incubation - 50 cfs
- Rainbow trout spawning and incubation - 75 cfs
- Brown trout fry rearing - 35 cfs
- Rainbow trout fry rearing - 30 cfs

Flows providing 50% of optimum habitat conditions

Life stage	Rainbow trout	Brown trout
Spawning and incubation	28 cfs	25 cfs
Fry rearing	<10 cfs	<10 cfs
Juvenile rearing	16 cfs	<10 cfs

Recommended Flow for Prosser Creek

PERIOD	OPTIMUM FLOW	CRITERIA	MINIMUM FLOW	CRITERIA
October - January	50 cfs	Brown trout spawning	16 cfs	50% juvenile rainbow trout rearing
February - March	35 cfs	Brown trout fry rearing	16 cfs	50% juvenile rainbow trout rearing
April - July	75 cfs	Rainbow trout spawning	16 cfs	50% juvenile rainbow trout rearing
August - September	30 cfs	Rainbow trout fry rearing	16 cfs	50% juvenile rainbow trout rearing

LITTLE TRUCKEE RIVER - BELOW STAMPEDE

EXISTING PROBLEMS

- Below minimum low flow conditions

- Severely degraded channel/habitat conditions

- Extremely variable flow fluctuations

RECOMMENDED MODIFICATION

Identified preferred and minimum flow conditions are based upon providing spawning and rearing habitat for brown and rainbow trout per preliminary PHABSIM results. Minimum flow conditions are based upon improved spawning and rearing conditions at low flow. Habitat rehabilitation will be required, including gravel and structure management to provide acceptable habitat conditions at the recommended flows. Sustained spawning flows will be required through incubation. Flow fluctuation outside the identified spawning periods will follow the guidelines in Table 1.

Little Truckee River fish are extremely vulnerable to the potentially high, controlled releases from Stampede Reservoir. Stranding in secondary channels and flushing will occur if flows exceed twice the preferred flow conditions. Increased structure abundance and complexity will provide shelter from high flows. Channel modifications to isolate fish from secondary channels will reduce or prevent stranding. Such modifications will be necessary to sustain the Little Truckee River as a high quality resident trout fishery. The proposed flow regime and spawning and rearing habitat rehabilitation will only be effective if stranding and flushing are avoided.

FLOW RECOMMENDATIONS

Management Objective 1 was applied to this reach of the Little Truckee River. Optimum flows were identified for brown and rainbow trout spawning and incubation and adult rainbow trout rearing as listed. Minimum flow conditions were identified based upon juvenile rainbow trout rearing.

Maximizing flow conditions:

Brown trout spawning and incubation - 125 cfs
Rainbow trout spawning and incubation - 125 cfs
Rainbow trout adult rearing - 100 cfs
Rainbow trout juvenile rearing - 45 cfs

Flows providing 50% of optimum habitat conditions

Life stage	Rainbow trout	Brown trout
Spawning and incubation	20 cfs	20 cfs
Fry rearing	<20 cfs	<10 cfs
Juvenile rearing	20 cfs	25 cfs
Adult rearing	25 cfs	<20 cfs

Recommended Flows for Little Truckee River (downstream of Stampede Reservoir)

PERIOD	OPTIMUM FLOW	CRITERIA	MINIMUM FLOW	CRITERIA
October - January	125 cfs	Brown trout spawning	45 cfs	Juvenile rainbow trout rearing
February - March	100 cfs	Adult rainbow trout rearing	45 cfs	Juvenile rainbow trout rearing
April - July	125 cfs	Rainbow trout spawning	45 cfs	Juvenile rainbow trout rearing
August - September	100 cfs	Adult rainbow trout rearing	45 cfs	Juvenile rainbow trout rearing

LITTLE TRUCKEE RIVER - ABOVE STAMPEDE

EXISTING PROBLEMS

Below minimum low flow conditions

Severely degraded channel/habitat conditions

GENERAL RECOMMENDATIONS

Identified preferred and minimum flow conditions are based upon providing spawning and rearing habitat for brown and rainbow trout per PHABSIM results. Minimum flow conditions are based upon improved spawning and rearing conditions at low flow. Habitat rehabilitation will be required, including gravel and structure management, and bank restoration to provide acceptable habitat conditions at the recommended flows. Sustained spawning flows will be required through incubation.

Minimum flow conditions could be sustained downstream of Independence Creek by spreading the amount of controlled flow generally released over a longer period, increasing the duration by suitable flow conditions in Independence Creek and the Little Truckee River downstream. from Independence Creek. The Sierra Valley diversion severely reduces flow-habitat conditions in the reach between Independence Creek and the diversion. The minimum flow requirements at this diversion should be increased. Channel restoration within this reach would increase the spawning and rearing habitat available under low flow conditions.

FLOW RECOMMENDATIONS

Management Objective 2 was applied to this reach of the Little Truckee River. Optimum flows were identified for brown and rainbow trout spawning and incubation and brown and rainbow trout fry rearing, as listed. Minimum flow conditions were identified based upon maintaining at least 50% of optimum habitat for all life stages (except adult).

Maximizing flow conditions:

Brown trout spawning and incubation - 90 cfs
Rainbow trout spawning and incubation - 90 cfs
Brown trout fry rearing - 50 cfs
Rainbow trout fry rearing - 30 cfs

Flows providing 50% of optimum habitat conditions

Life stage	Rainbow trout	Brown trout	Kokanee
Spawning and incubation	35 cfs	30 cfs	12 cfs
Fry rearing	7 cfs	<5 cfs	na
Juvenile rearing	14 cfs	<5 cfs	na
Adult rearing	35 cfs	20 cfs	na

Recommended Flows for Little Truckee River (upstream of Stampede Reservoir)

PERIOD	OPTIMUM FLOW	CRITERIA	MINIMUM FLOW	CRITERIA
October - January	90 cfs	Brown trout spawning	30 cfs	50% brown trout spawning
February - March	50 cfs	Brown trout fry rearing	14 cfs	50% rainbow trout juvenile rearing
April - July	90 cfs	Rainbow trout spawning	35 cfs	50% rainbow trout spawning rearing
August - September	30 cfs	Rainbow trout fry rearing	14 cfs	50% rainbow trout juvenile rearing

1/ Since the flow optimizing juvenile rainbow trout rearing (100 cfs) equaled the highest, optimum flow recommended, we used the 50% of optimum criteria applied to Objective 2 to determine the minimum flow requirement.

INDEPENDENCE CREEK

EXISTING PROBLEMS

- Below minimum low flow conditions

RECOMMENDED MODIFICATION

The proposed flow conditions (TABLE 1) are based upon estimated flows required to sustain resident trout spawning and rearing conditions and on flow releases required to sustain necessary flow in the Little Truckee River between Independence Creek and Stampede Reservoir.

FLOW RECOMMENDATIONS

Management Objective 2 was applied to Independence Creek. Optimum flows were identified for brown and rainbow trout spawning and incubation and brown and rainbow trout fry rearing, as listed. Minimum flow conditions were identified based upon maintaining at least 50% of optimum habitat for all life stages (except adult).

Maximizing flow conditions:

Brown trout spawning and incubation - 20 cfs
Rainbow trout spawning and incubation - 20 cfs
Brown trout fry rearing - 10 cfs
Rainbow trout fry rearing - 10 cfs

Flows providing 50% of optimum habitat conditions

Life stage	Rainbow trout	Brown trout
Spawning and incubation	8 cfs	7 cfs
Fry rearing	<2 cfs	<2 cfs
Juvenile rearing	4 cfs	<1 cfs
Adult rearing	6 cfs	6 cfs

Recommended Flows for Independence Creek

PERIOD	OPTIMUM FLOW	CRITERIA	MINIMUM FLOW	CRITERIA
October - January	20 cfs	Brown trout spawning	7 cfs	50% brown trout spawning
February - March	10 cfs	Brown trout fry rearing	4 cfs	50% rainbow trout juvenile rearing
April - July	20 cfs	Rainbow trout spawning	8 cfs	50% rainbow trout spawning
August - September	10 cfs	Rainbow trout fry rearing	4 cfs	50% rainbow trout juvenile rearing

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APPENDIX 1

Rationale used to determine minimum flows

Institutional Approach - Since evaluation of project impacts upon instream resources requires the ability to measure relative impacts of various project options, some form of measurement equating habitat to project impacts is essential. No absolute, biological means presently exists that accurately identifies habitat conditions necessary to maintain fish populations in good condition. Various tools have been developed to measure relative changes in habitat condition versus changes in phsyical conditions. These tools have been developed using assumptions, concepts and some biological validation to allow attching a number to habitat condition as a function of some physical condition. IFIM is such a tool. It provides an approach to determining the relative change in habitat quality versus flow for the purpose of identifying relative impacts. However, the accuracy and precision of the approach in defining habitat conditions, and and even more so, how to use the results of the tool in making flow impact determinations, continue to be the subjects of debate.

Maintenance of conditions that provide 100% of optimum habitat availability is the best one can do per IFIM; similarly, providing 0% habitat availabilty would not sustain a population. In terms of probability of providing sufficient habitat conditions to maintain a population in good conditions, 100% habitat availability would have a probability of 1, 0% would have a probability of 0. The lowest, reasonable probability for the maintenance of a fish population would be 0.5 - i.e., a 50% chance that conditions would be sufficient to maintain fish population in good condition. A 0.5 probability equates to 50% habitat availability.

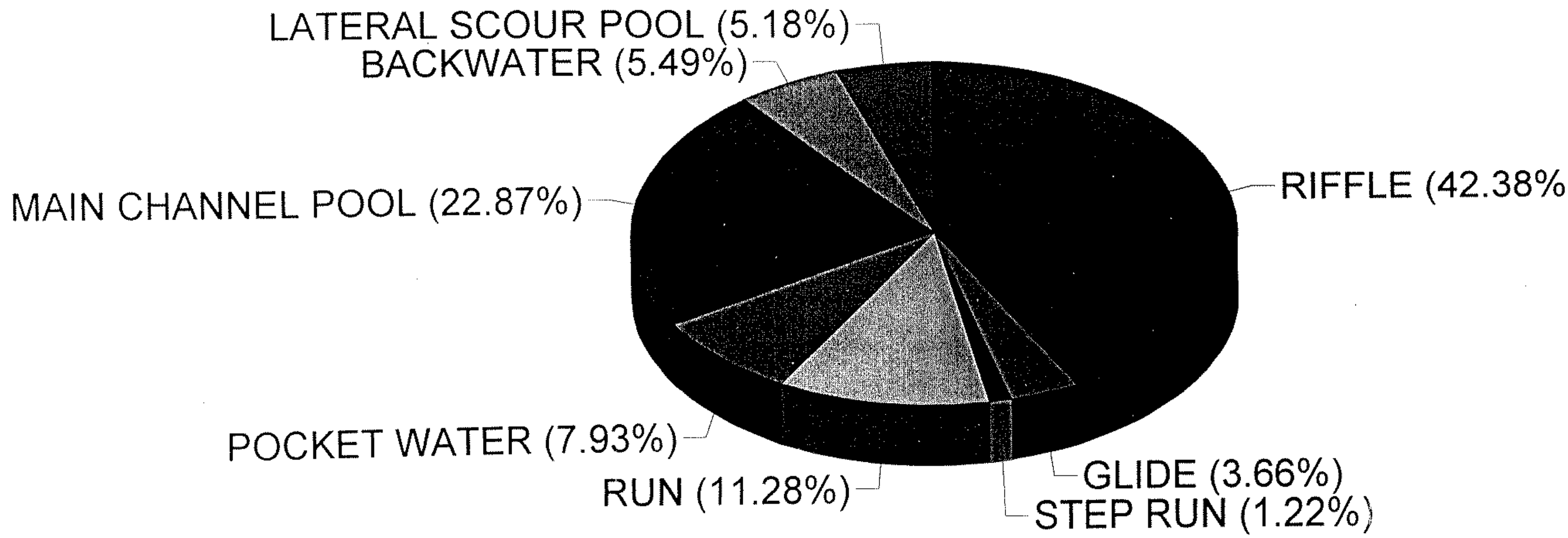
Biological Approach - Studies conducted in the Truckee River basin between 1987 and 1995 included evaluation of survival of various trout life stages. Mark and recapture investigations on the Little Truckee River, downstream of Stampede Reservoir indicate that survival from spawning to adult is strongly influenced by juvenile and subadult habitat availbility. Survival rates for juvenile to fry were typically less than 5%, often less than 3%. Based upon the results of the studies and studies reported in the literature, we developed a survival model. Assuming that conditions that would support production of less than 1 adult per spawning pair would not sustain a population equal to the initial population, the model indicates that reductions in habitat to less than 50% of habitat available to the original population. Assuming that at 100% habitat availability (per IFIM) represents the conditions required to maintain the population in good condtion (i.e., 1 pair of adults would produce 1 pair of adults), less than 50% habitat availability of any life stage would not maintain the population in good condition.

APPENDIX 2

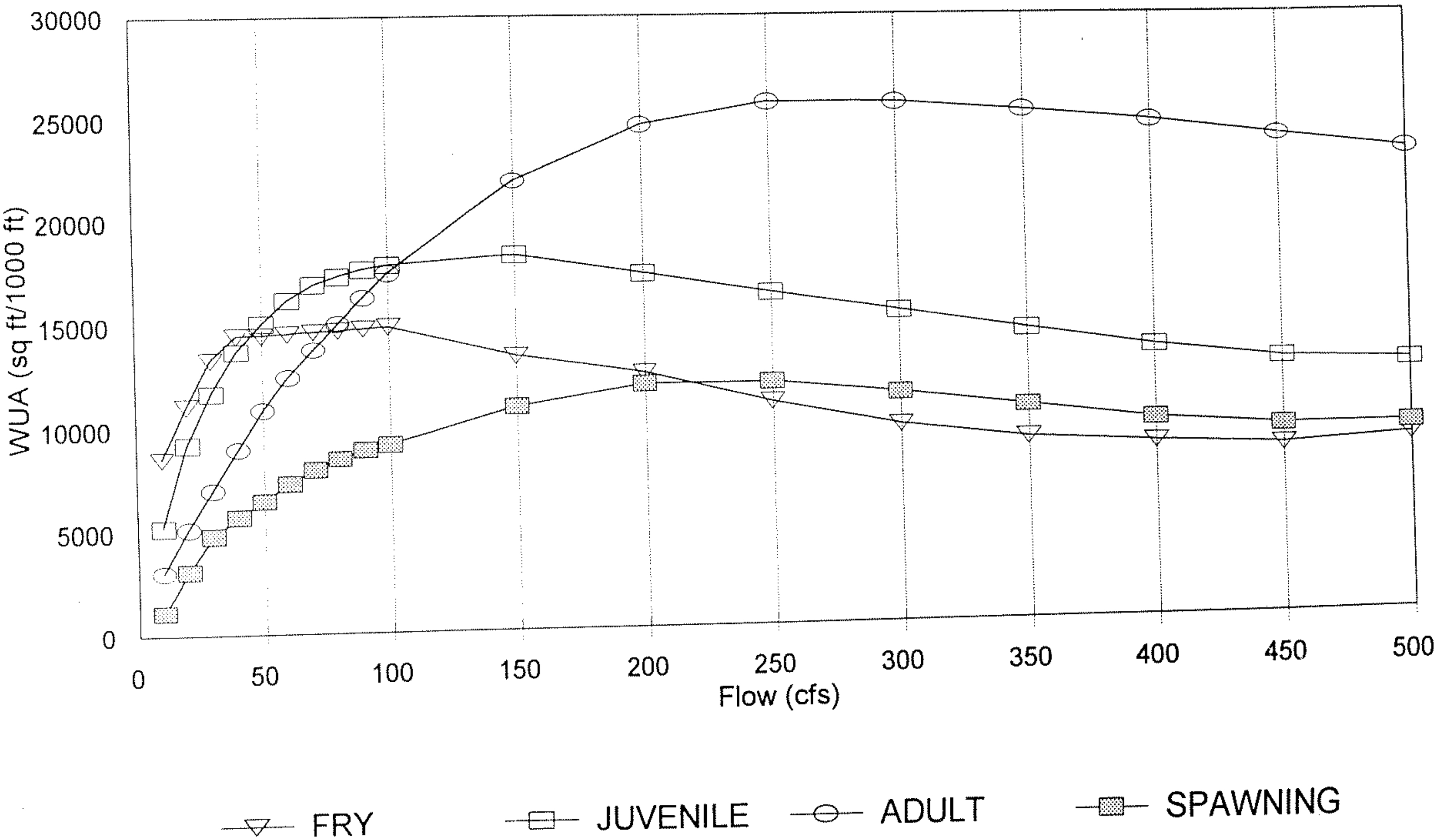
DATA USED IN THIS REPORT TO DEVELOP RECOMMENDATIONS

TRUCKEE RIVER - REACH 1
NEVADA STATE LINE to BOCA

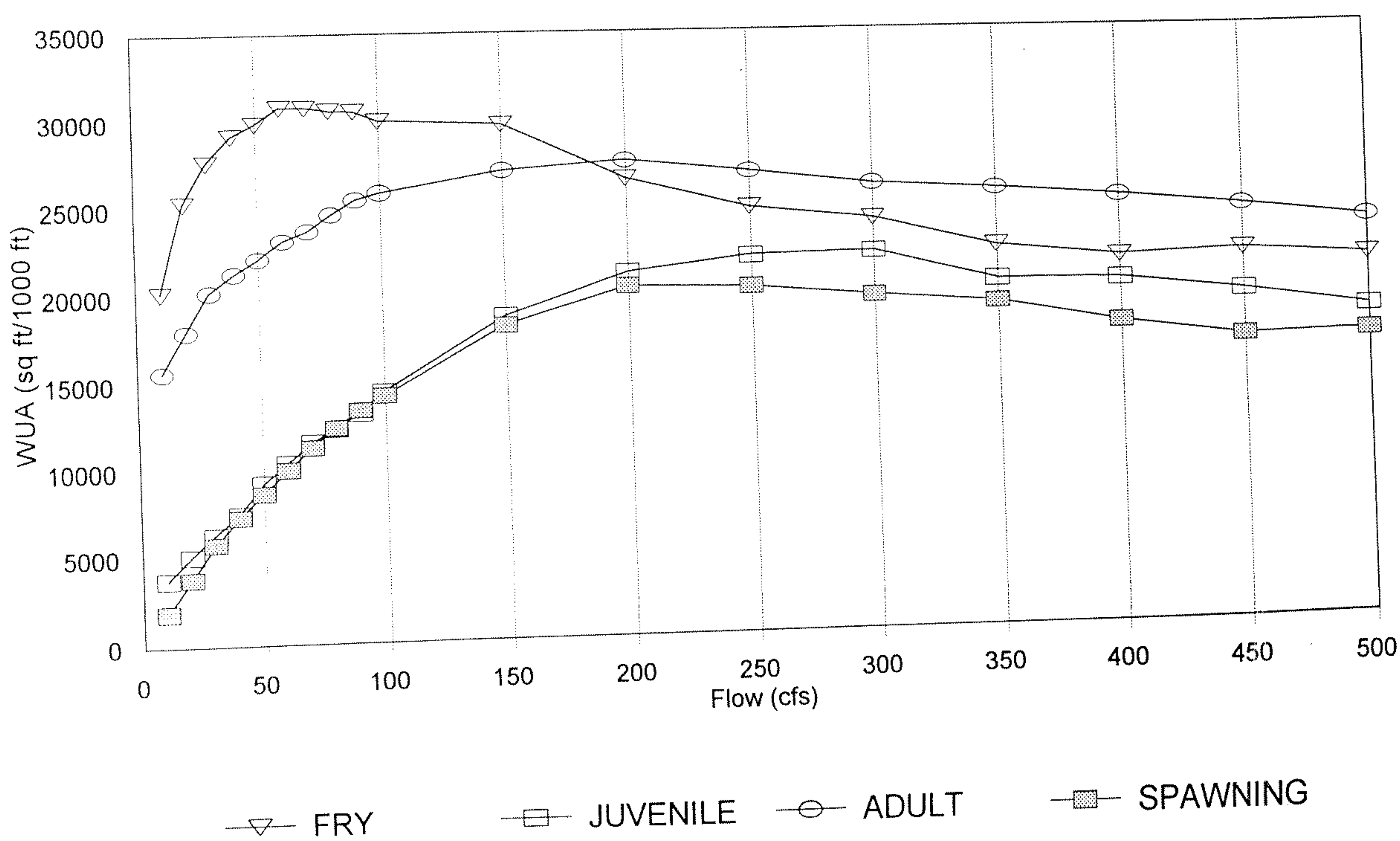
TRUCKEE RIVER - NEVADA TO BOCA
TOTAL HABITAT COMPOSITION



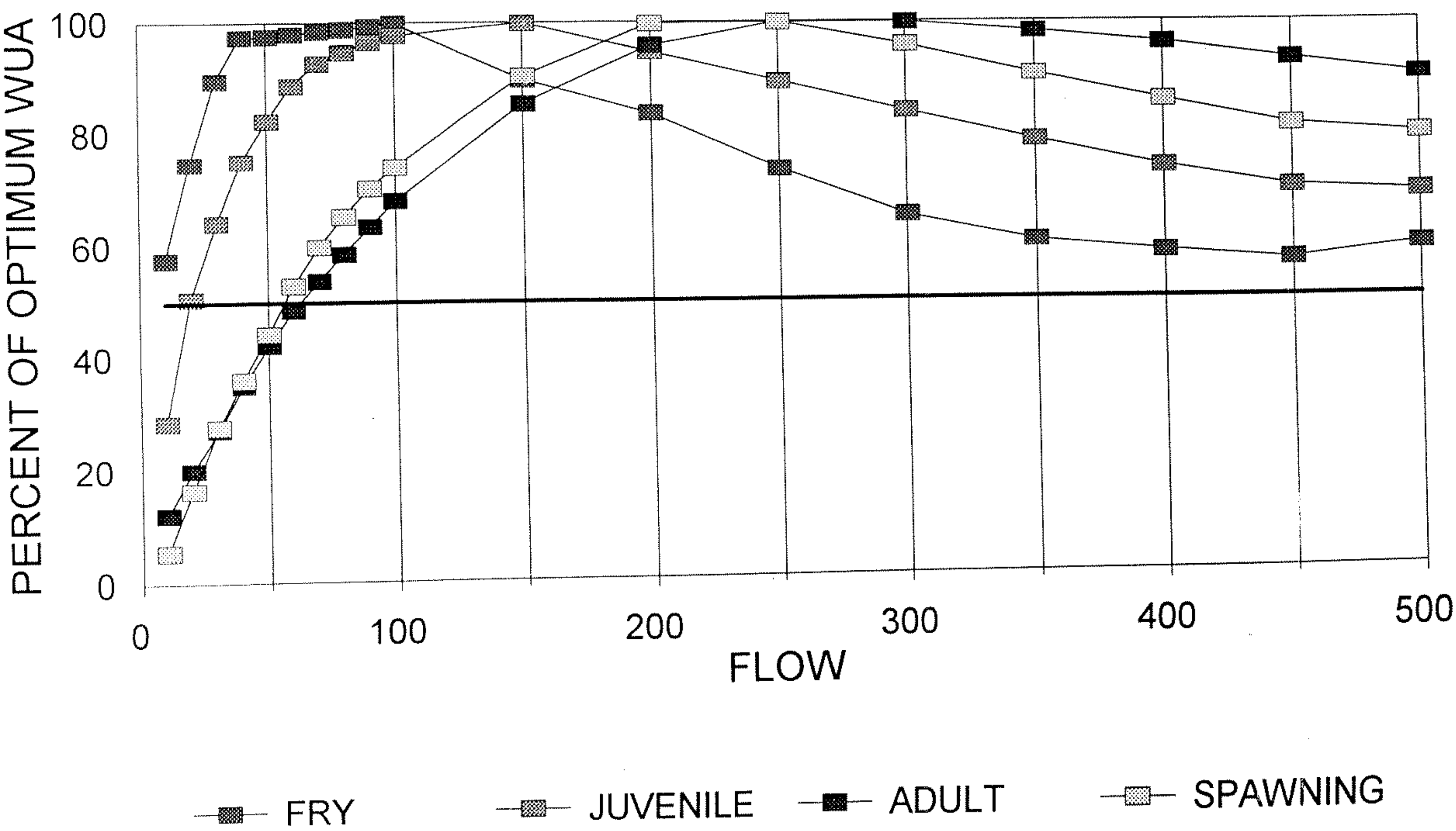
TRUCKEE RIVER, NEVADA TO BOCA
FLOW versus WUA - RAINBOW TROUT



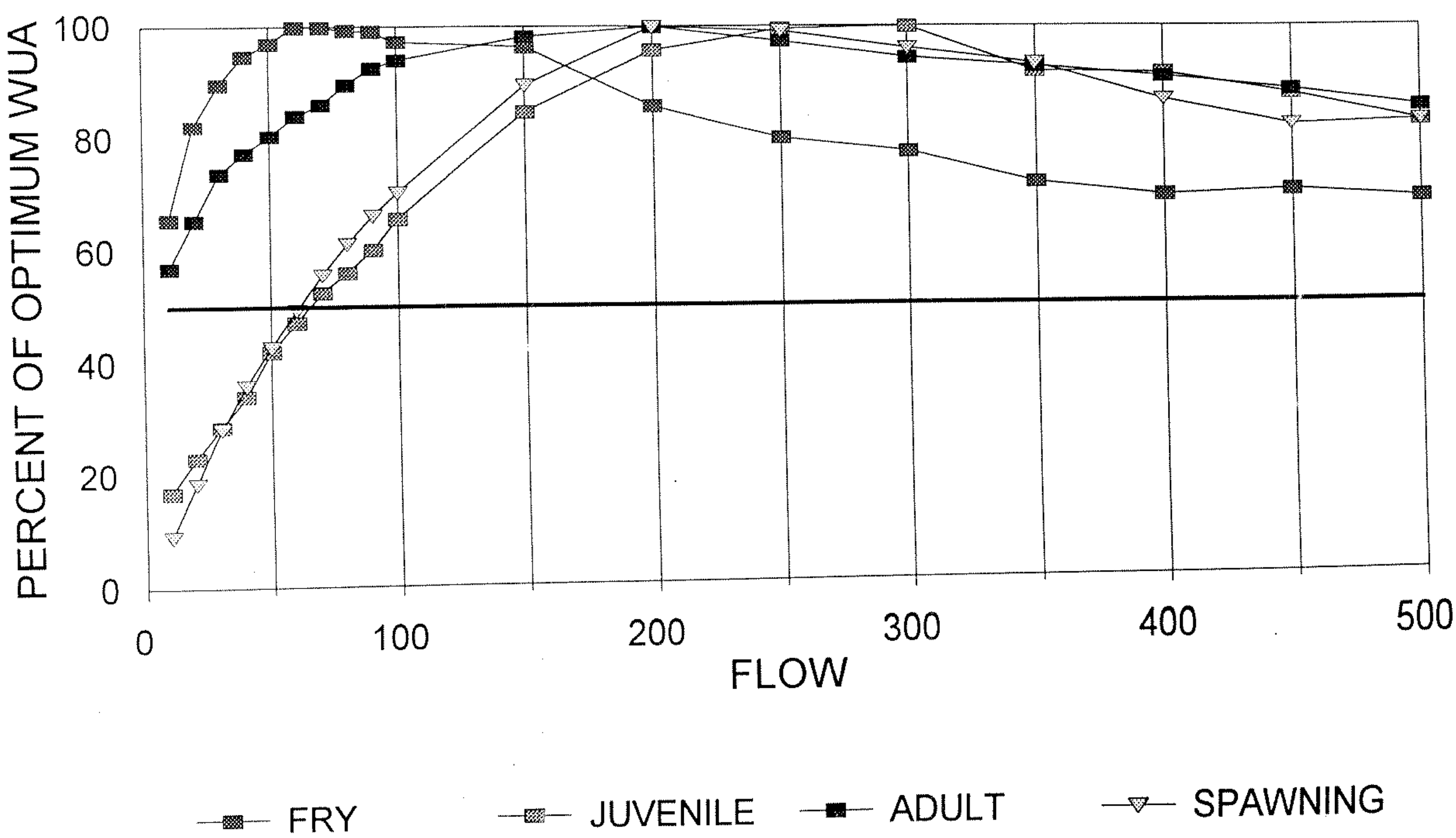
TRUCKEE RIVER, NEVADA TO BOCA
FLOW versus WUA - BROWN TROUT



TRUCKEE R REACH 1 - RAINBOW TROUT
PERCENT OF OPTIMUM WUA v FLOW



TRUCKEE R REACH 1 - BROWN TROUT
PERCENT OF OPTIMUM WUA v FLOW



TRUCKEE RIVER - NEVADA TO BOCA
WEIGHTED POOLS*.31,RUNS*.098,RIFFLES*.3976,GLIDES*.0265
RAINBOW TROUT

Q	FRY	JUVENI	ADULT	SPAWNING
10	8604	5244	3075	1127
20	11144	9295	5149	3368
30	13364	11762	7013	5720
40	14540	13781	9032	7450
50	14555	15113	10895	9156
60	14636	16249	12508	10922
70	14702	17000	13841	12355
80	14754	17366	15061	13452
90	14827	17720	16334	14496
100	14920	17926	17503	15288
150	13391	18332	21940	18629
200	12458	17359	24661	20561
250	10961	16360	25713	20605
300	9725	15375	25683	19750
350	9011	14418	25249	18659
400	8692	13517	24719	17658
450	8462	12831	23978	16731
500	8858	12633	23215	16376

TRUCKEE RIVER - NEVADA TO BOCA
WEIGHTED POOLS*.31,RUNS*.098,RIFFLES*.3976,GLIDES*.0265
RAINBOW TROUT PERCENT OPTIMUM WUA

FLOW	FRY	JUVENI	ADULT	SPAWNING
10	57.66	28.61	11.96	5.47
20	74.69	50.70	20.03	16.35
30	89.57	64.16	27.28	27.76
40	97.45	75.17	35.13	36.15
50	97.55	82.44	42.37	44.44
60	98.09	88.64	48.64	53.01
70	98.54	92.73	53.83	59.96
80	98.89	94.73	58.57	65.28
90	99.38	96.66	63.52	70.35
100	100.00	97.78	68.07	74.19
150	89.75	100.00	85.33	90.41
200	83.50	94.69	95.91	99.79
250	73.46	89.24	100.00	100.00
300	65.18	83.87	99.89	95.85
350	60.40	78.65	98.20	90.56
400	58.26	73.74	96.14	85.70
450	56.72	69.99	93.25	81.20
500	59.37	68.91	90.29	79.47

TRUCKEE RIVER NEVADA TO BOCA
WEIGHTED POOLS*.31,RUNS*.098,RIFFLES*.3976,GLIDES*.0265
BROWN TROUT

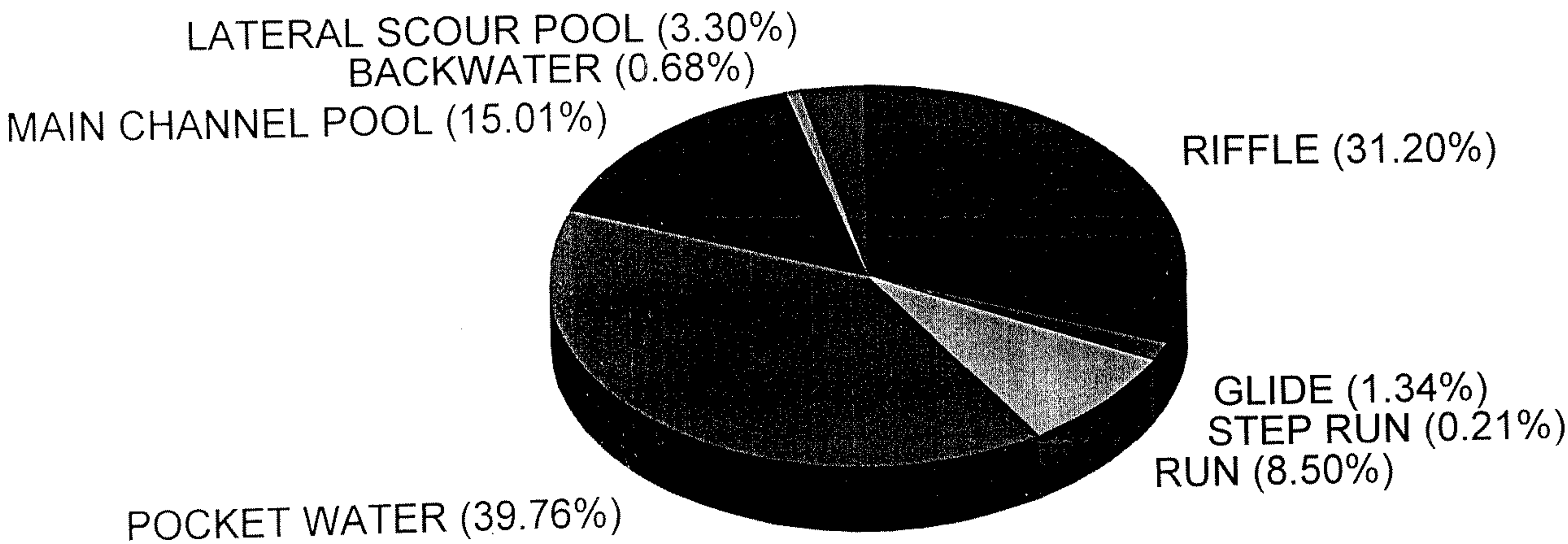
FRY	JUVENI	ADULT	SPAWNING
20231	3697	15664	1857
25390	5052	17990	3736
27716	6301	20263	5725
29249	7509	21274	7287
29954	9226	22117	8646
30888	10361	23136	9982
30860	11525	23702	11241
30696	12290	24659	12348
30633	13191	25466	13369
30053	14407	25863	14198
29766	18609	27029	18077
26480	21000	27521	20202
24673	21850	26788	20033
23864	21951	25950	19380
22127	20161	25514	18827
21404	20083	24993	17501
21684	19273	24355	16580
21236	18149	23496	16698

TRUCKEE RIVER NEVADA TO BOCA
WEIGHTED POOLS*.31,RUNS*.098,RIFFLES*.3976,GLIDES*.0265
BROWN TROUT PERCENT OPTIMUM WUA

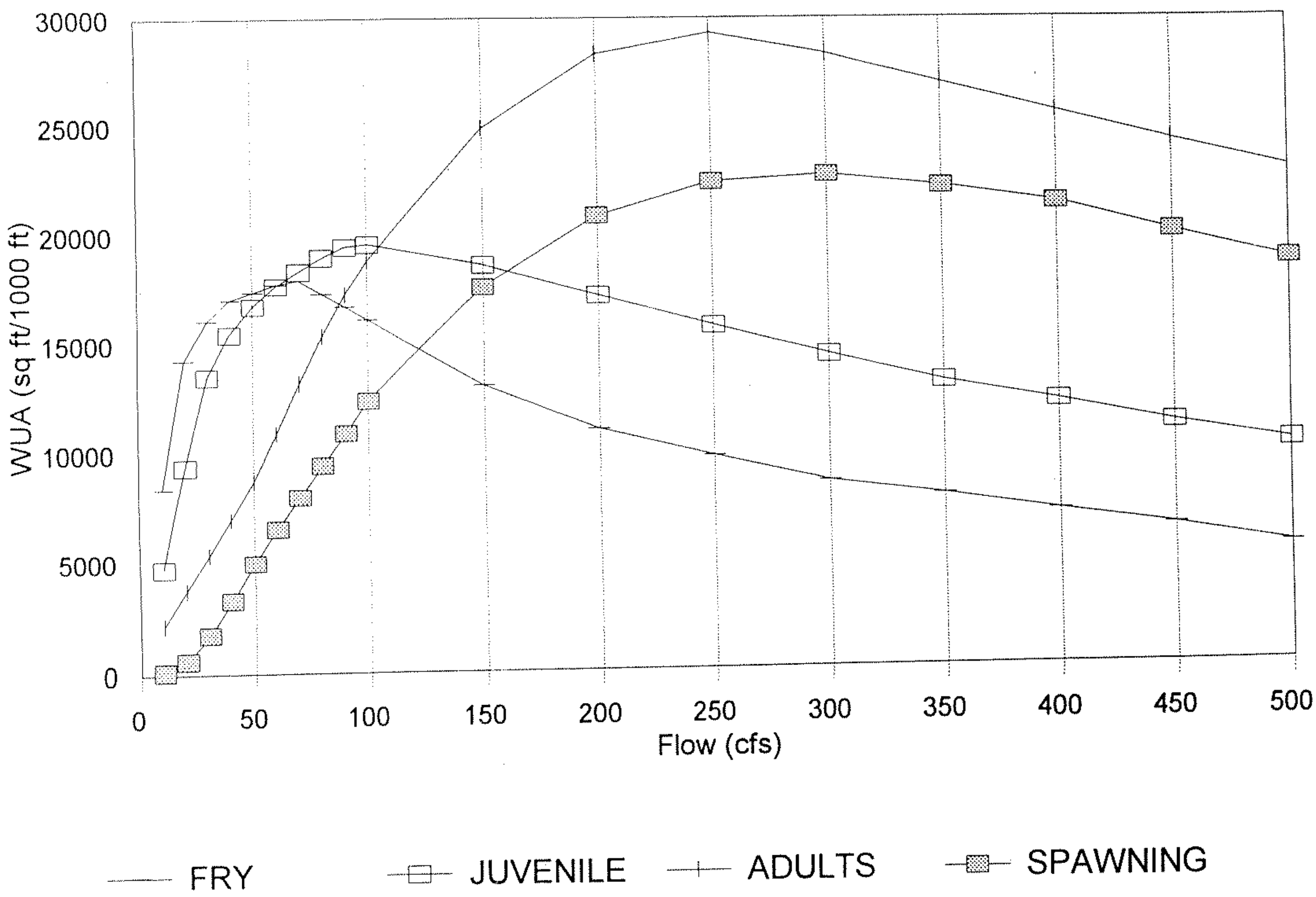
FRY	JUVENI	ADULT	SPAWNING
65.50	16.84	56.92	9.19
82.20	23.02	65.37	18.49
89.73	28.71	73.63	28.34
94.69	34.21	77.30	36.07
96.98	42.03	80.36	42.80
100.00	47.20	84.07	49.41
99.91	52.51	86.12	55.64
99.38	55.99	89.60	61.12
99.17	60.09	92.53	66.17
97.30	65.64	93.98	70.28
96.37	84.77	98.21	89.48
85.73	95.67	100.00	100.00
79.88	99.54	97.34	99.16
77.26	100.00	94.29	95.93
71.64	91.85	92.71	93.19
69.30	91.49	90.81	86.63
70.20	87.80	88.50	82.07
68.75	82.68	85.38	82.65

TRUCKEE RIVER - REACH 2
BOCA to DONNER CREEK

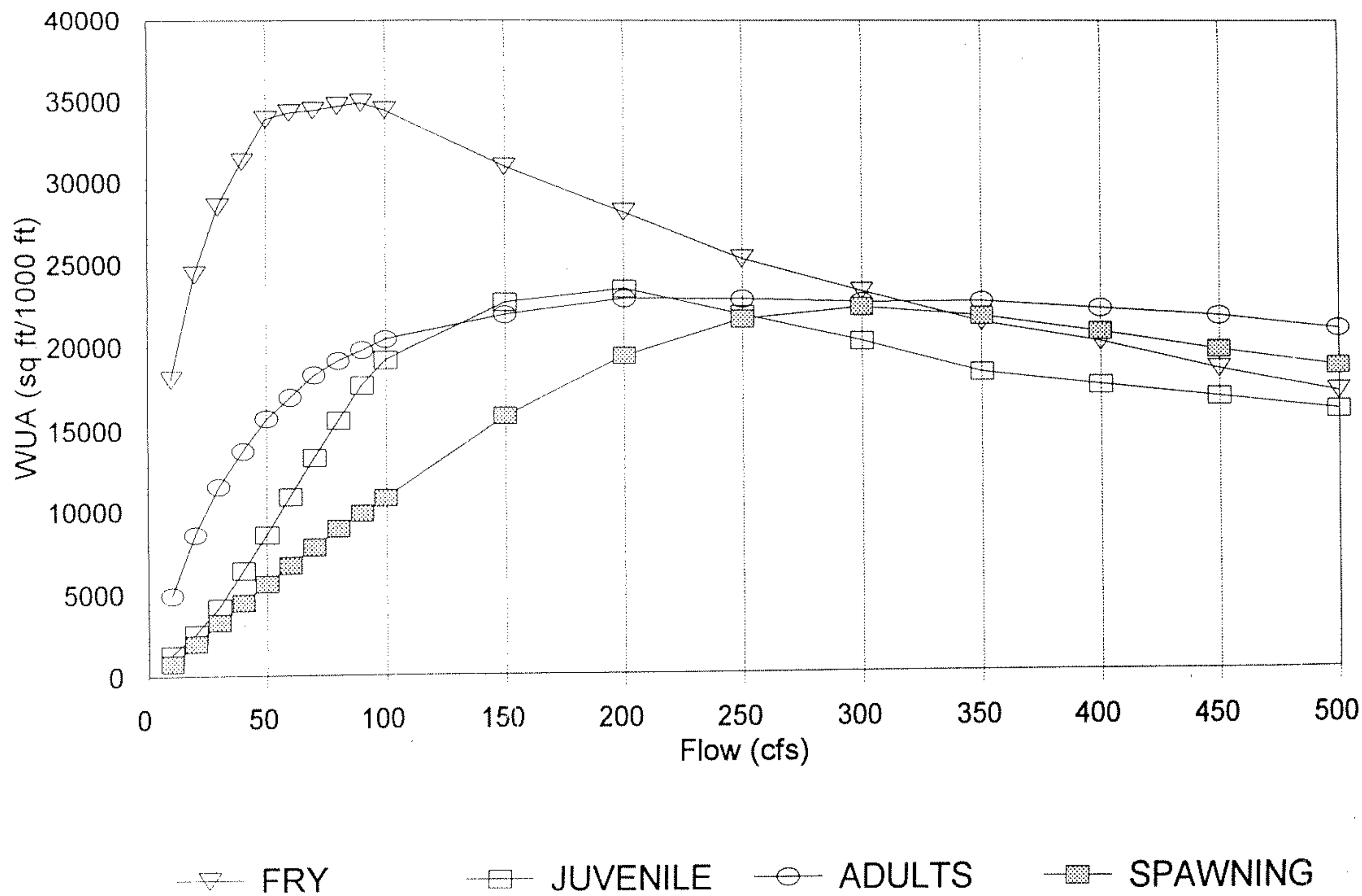
TRUCKEE RIVER - BOCA TO DONNER CREEK
TOTAL HABITAT COMPOSITION



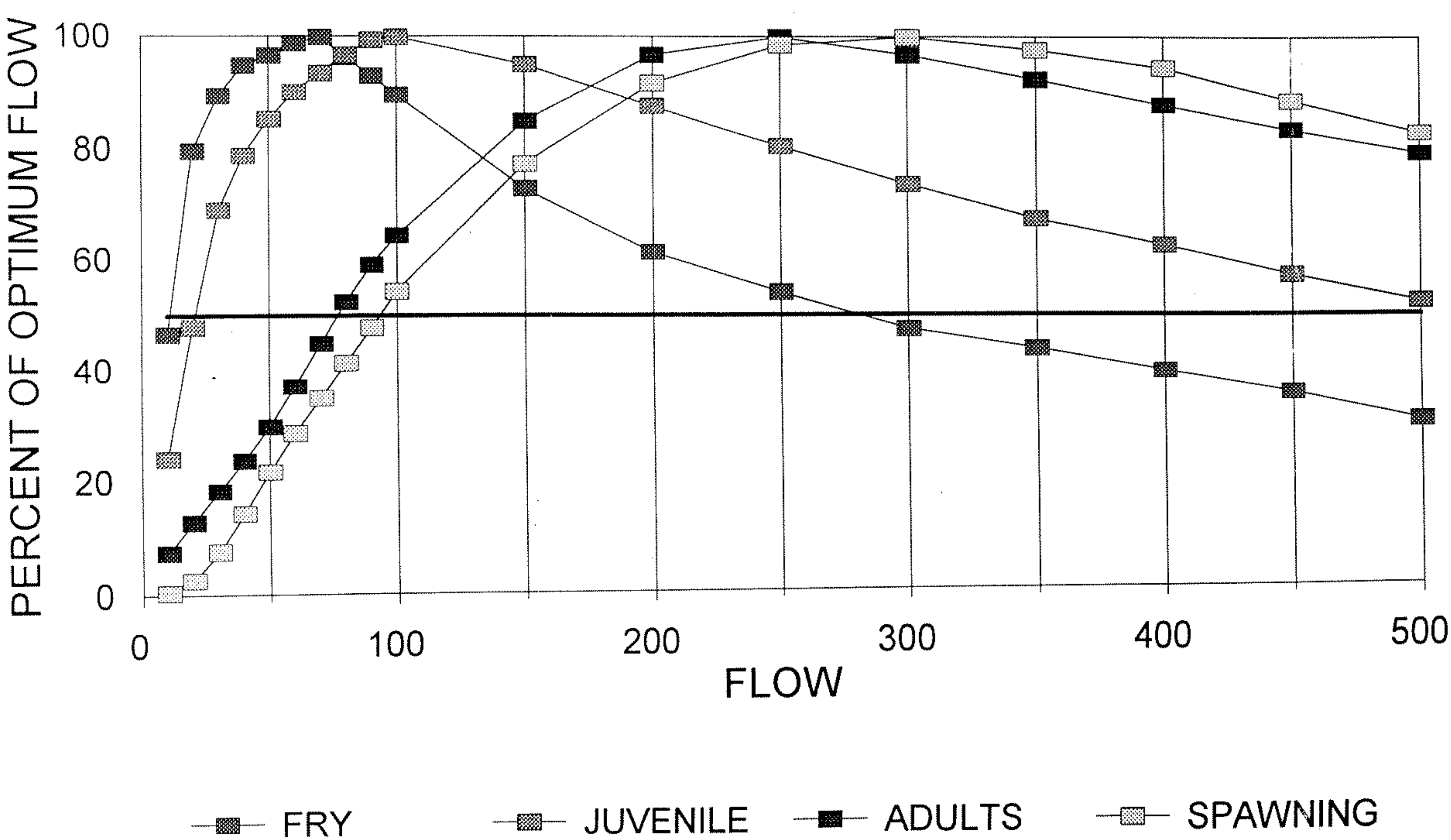
TRUCKEE RIVER, BOCA TO DONNER CK
FLOW versus WUA - RAINBOW TROUT



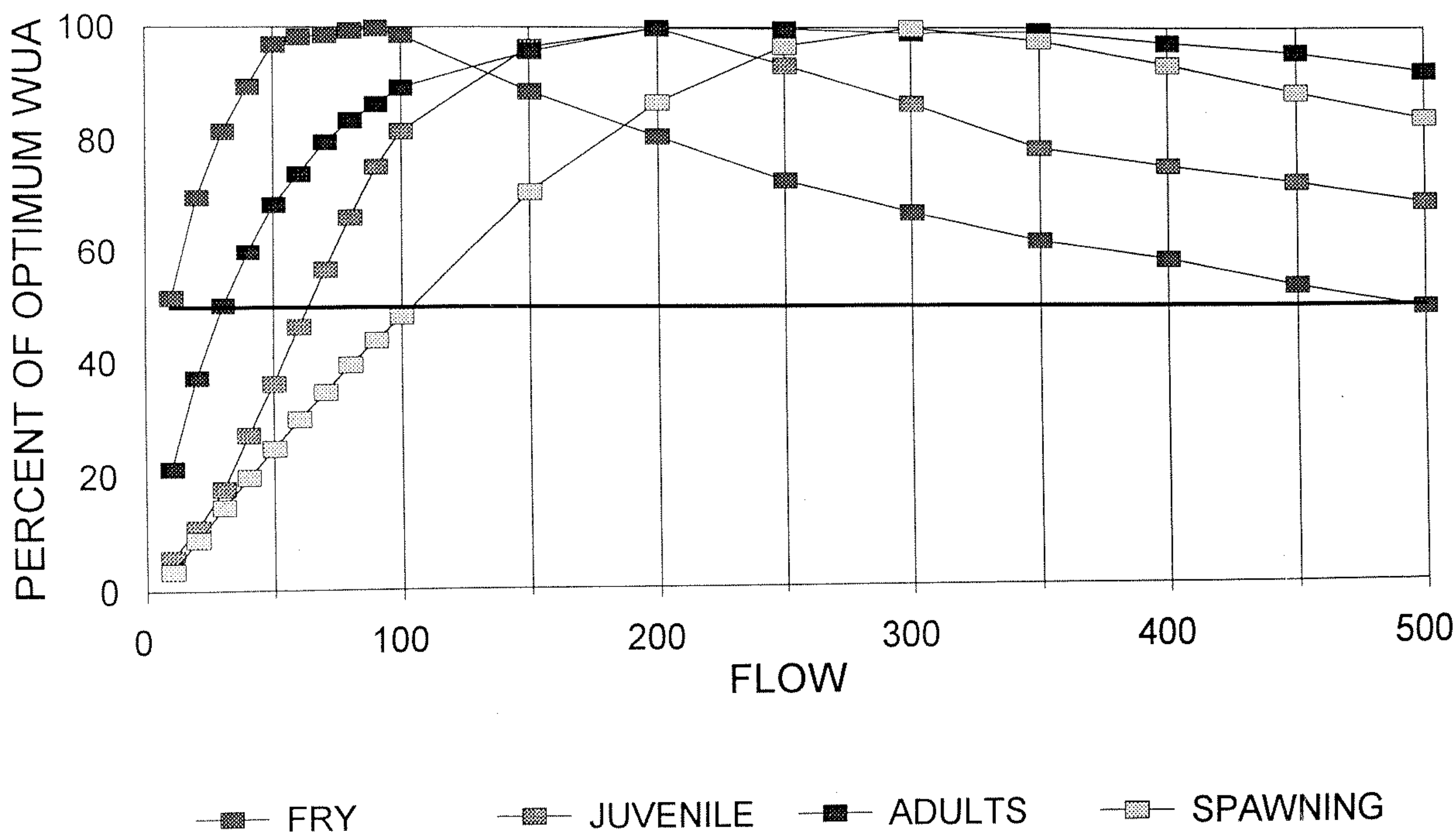
TRUCKEE RIVER, BOCA TO DONNER CK
FLOW versus WUA - BROWN TROUT



TRUCKEE R REACH 2 - RAINBOW TROUT
PERCENT OF OPTIMUM WUA v FLOW



TRUCKEE R REACH 2 - BROWN TROUT
PERCENT OF OPTIMUM WUA v FLOW



TRUCKEE RIVER - DONNER CK TO BOCA
ALL HABITATS
WEIGHTED:POOL*.1899,RIFFLE*.3119,RUN*.087,GLIDE*.0133
RAINBOW TROUT

FLOW	FRY	JUVENILE	ADULTS	SPAWNING
10	8381	4742	2187	101
20	14304	9409	3770	583
30	16098	13548	5373	1738
40	17066	15462	6970	3283
50	17397	16748	8744	4967
60	17768	17698	10905	6540
70	17979	18367	13210	7999
80	17334	19011	15379	9449
90	16746	19514	17310	10908
100	16133	19632	18873	12389
150	13086	18672	24922	17636
200	11014	17227	28389	20932
250	9713	15784	29328	22486
300	8516	14428	28399	22807
350	7874	13195	27106	22289
400	7099	12247	25767	21569
450	6373	11173	24446	20228
500	5429	10264	23192	18909

TRUCKEE RIVER - DONNER CK TO BOCA
ALL HABITATS
WEIGHTED:POOL*.1899,RIFFLE*.3119,RUN*.087,GLIDE*.0133
RAINBOW TROUT PERCENT OPTIMUM WUA

FLOW	FRY	JUVENILE	ADULTS	SPAWNING
10	46.6170	24.1557	7.4572	0.4450
20	79.5579	47.9248	12.8542	2.5807
30	89.5376	69.0091	18.3191	7.6188
40	94.9242	78.7567	23.7669	14.3936
50	96.7641	85.3074	29.8135	21.7797
60	98.8233	90.1507	37.1840	28.6733
70	100.0000	93.5583	45.0410	35.0700
80	96.4127	96.8388	52.4389	41.4281
90	93.1398	99.3987	59.0213	47.8244
100	89.7319	100.0000	64.3508	54.3202
150	72.7864	95.1102	84.9760	77.3240
200	61.2583	87.7482	96.7990	91.7789
250	54.0216	80.3968	100.0000	98.5890
300	47.3665	73.4901	96.8322	100.0000
350	43.7969	67.2132	92.4228	97.7272
400	39.4862	62.3841	87.8579	94.5686
450	35.4470	56.9143	83.3549	88.6888
500	30.1956	52.2795	79.0798	82.9078

TRUCKEE RIVER - DONNER CK TO BOCA
ALL HABITATS
WEIGHTED:POOL*.1899,RIFFLE*.3119,RUN*.087,GLIDE*.0133
BROWN TROUT

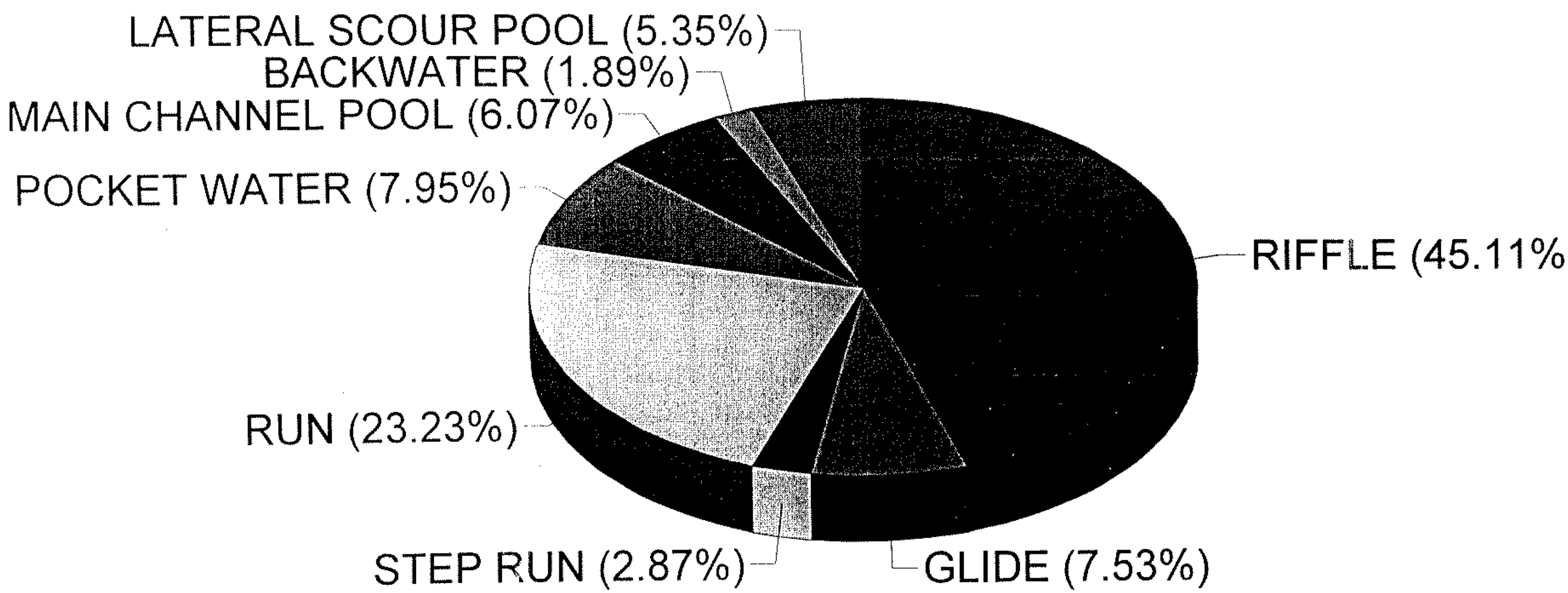
FLOW	FRY	JUVENILE	ADULTS	SPAWNING
10	18081	1353	4905	758
20	24407	2584	8588	1996
30	28556	4186	11556	3262
40	31337	6435	13754	4452
50	33950	8588	15714	5602
60	34372	10945	16994	6735
70	34493	13355	18328	7828
80	34776	15603	19203	8925
90	34956	17753	19857	9891
100	34516	19266	20534	10830
150	31025	22753	22033	15892
200	28243	23575	22970	19511
250	25413	22018	22919	21751
300	23412	20427	22768	22455
350	21584	18542	22843	21961
400	20395	17755	22378	21000
450	18726	17049	21985	19913
500	17327	16209	21218	18897

TRUCKEE RIVER - DONNER CK TO BOCA
ALL HABITATS
WEIGHTED:POOL*.1899,RIFFLE*.3119,RUN*.087,GLIDE*.0133
BROWN TROUT PERCENT OPTIMUM WUA

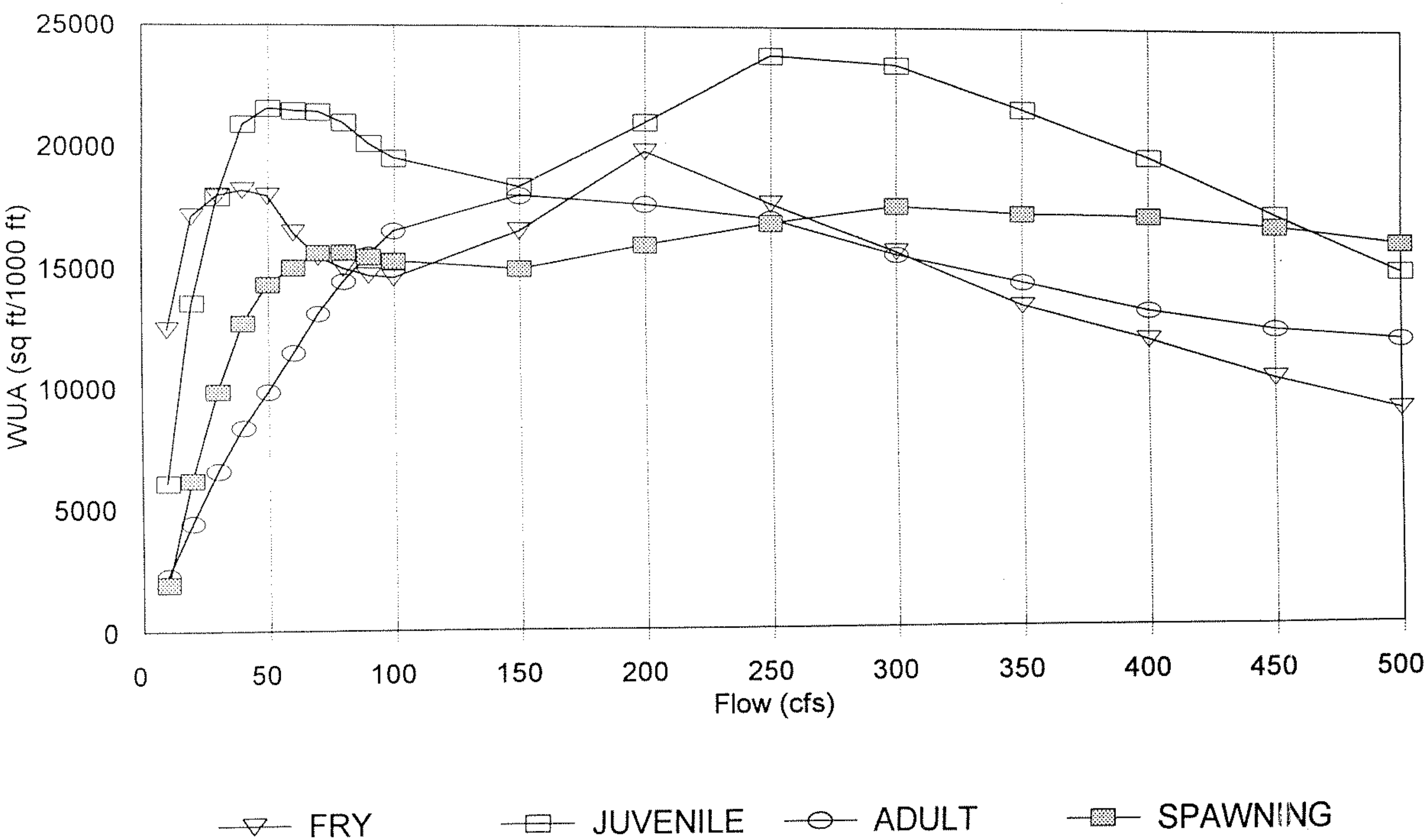
FLOW	FRY	JUVENILE	ADULTS	SPAWNING
10	51.7243	5.7383	21.3542	3.3763
20	69.8240	10.9603	37.3878	8.8875
30	81.6930	17.7545	50.3086	14.5265
40	89.6481	27.2960	59.8786	19.8280
50	97.1220	36.4286	68.4119	24.9495
60	98.3300	46.4291	73.9819	29.9939
70	98.6753	56.6486	79.7900	34.8597
80	99.4869	66.1860	83.6006	39.7480
90	100.0000	75.3047	86.4466	44.0471
100	98.7421	81.7220	89.3967	48.2317
150	88.7565	96.5147	95.9184	70.7759
200	80.7953	100.0000	100.0000	86.8929
250	72.6996	93.3962	99.7778	96.8665
300	66.9768	86.6493	99.1209	100.0000
350	61.7461	78.6518	99.4469	97.8025
400	58.3452	75.3146	97.4226	93.5221
450	53.5695	72.3187	95.7099	88.6794
500	49.5681	68.7544	92.3730	84.1548

TRUCKEE RIVER - REACH 3
DONNER CREEK to LAKE TAHOE

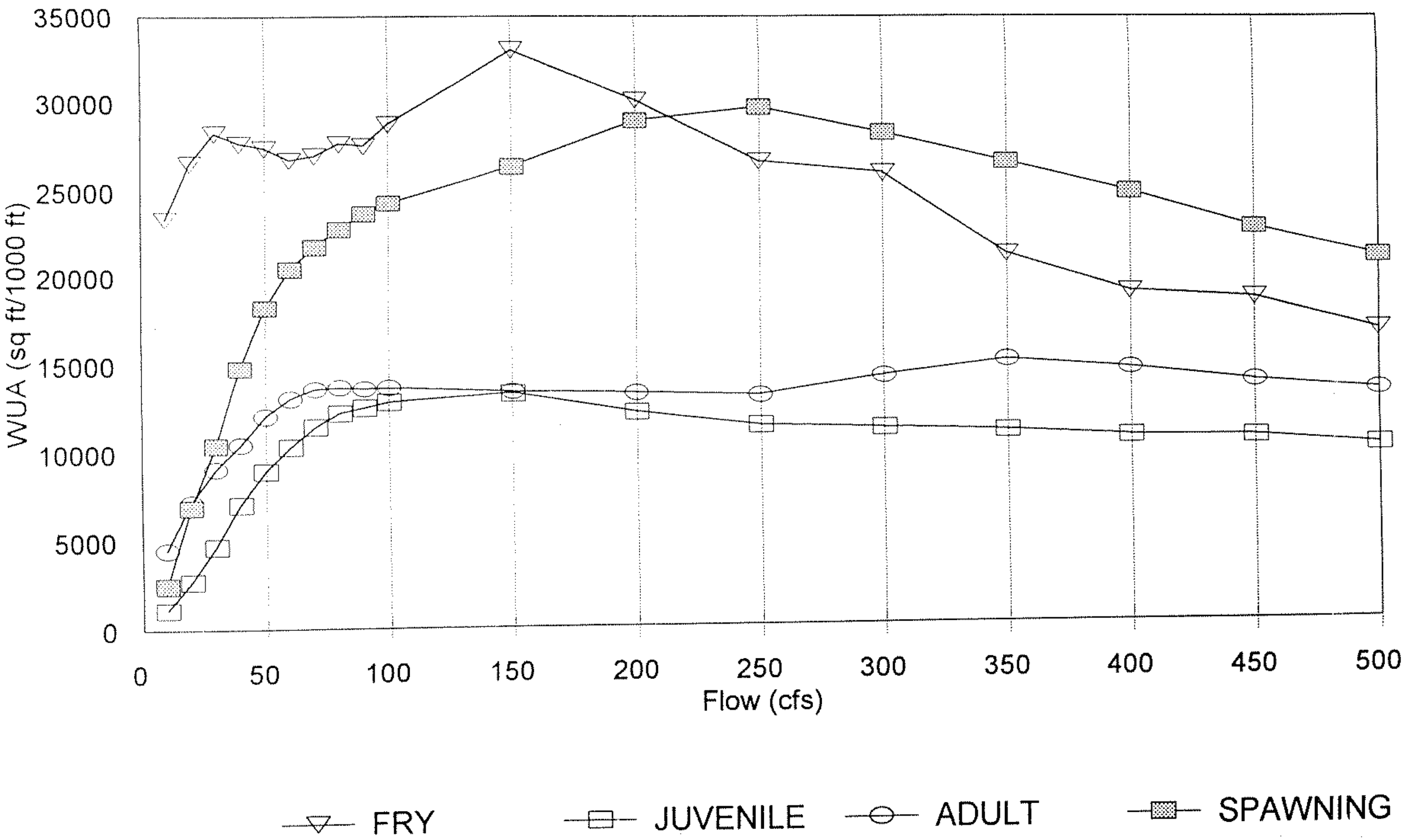
TRUCKEE R - DONNER CK TO LAKE TAHOE
TOTAL HABITAT COMPOSITION



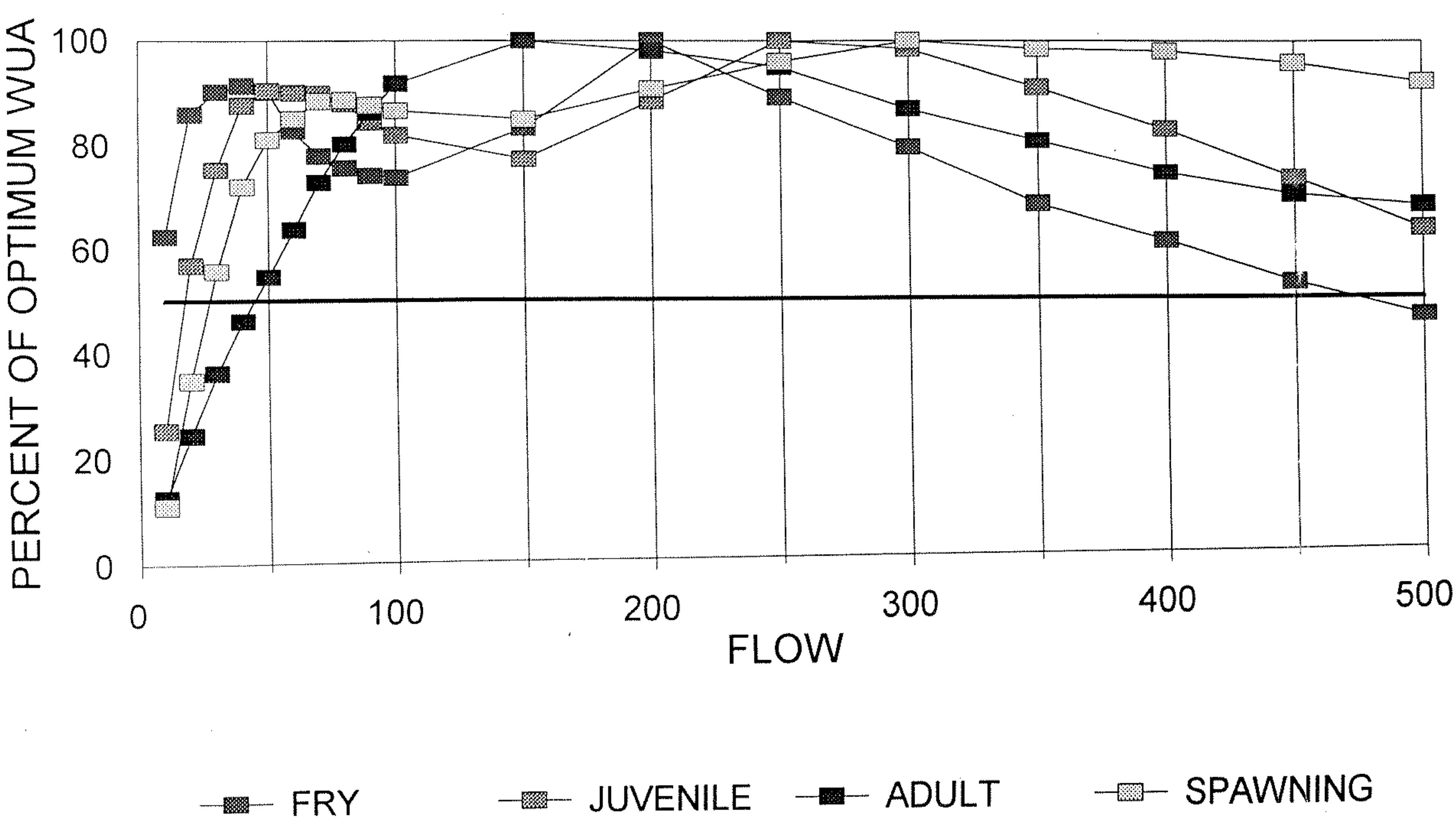
TRUCKEE RIVER, DONNER CK TO LAKE TAHOE
FLOW vesus WUA - RAINBOW TROUT



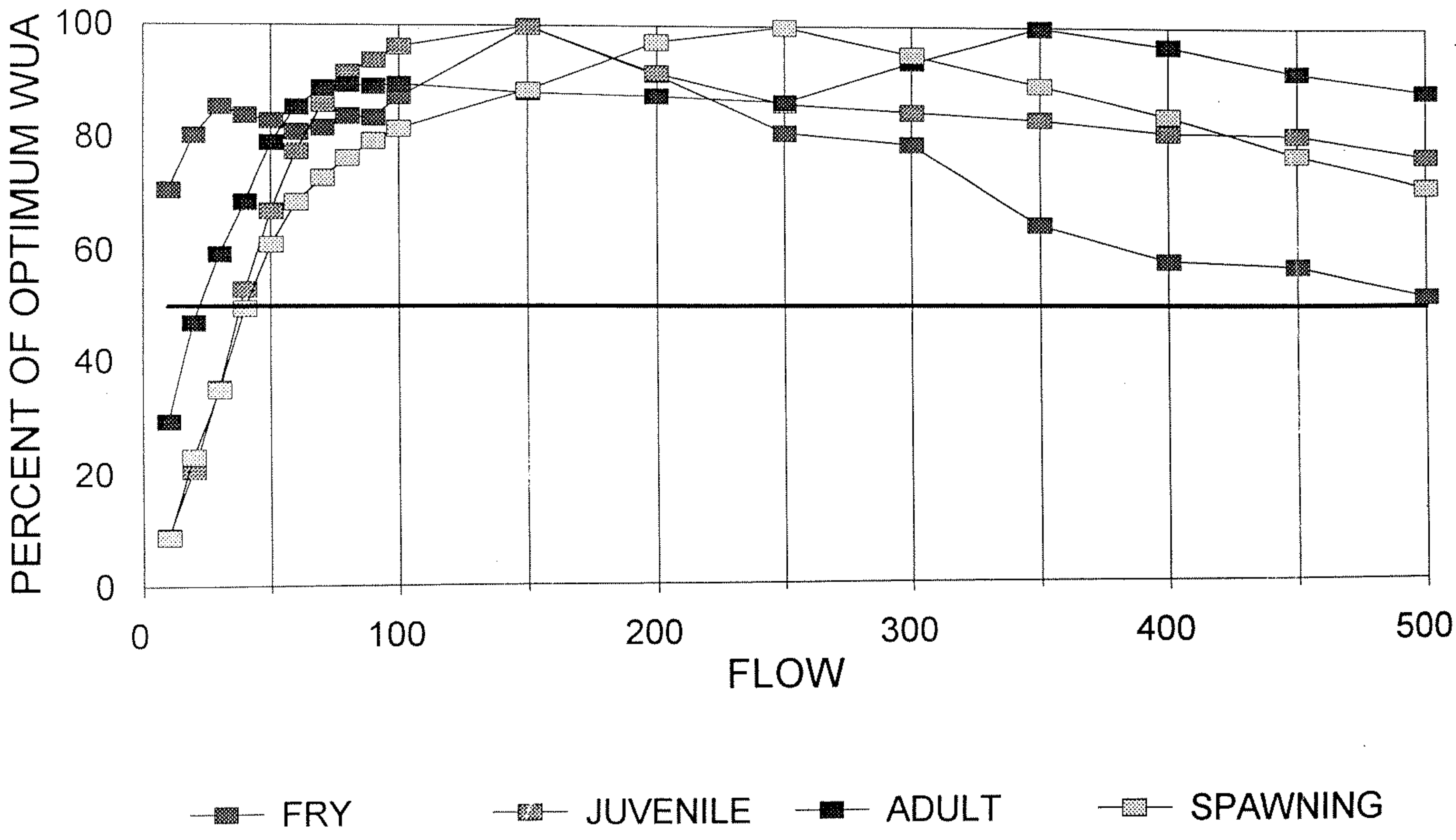
TRUCKEE RIVER, DONNER CK TO LAKE TAHOE
FLOW versus WUA - BROWN TROUT



TRUCKEE RIVER REACH 3 - RAINBOW TROUT
PERCENT OF OPTIMUM WUA v FLOW



TRUCKEE R REACH 3 - BROWN TROUT
PERCENT OF OPTIMUM WUA v FLOW



TRUCKEE RIVER- TAHOE TO DONNER CK
ALL HABITAT TYPES COMBINED/IFG4&MANSQ
WEIGHTING .13 POOL;.26 RUN;.45 RIFFLE

	RAINBOW TROUT			
Q	FRY	JUVENI	ADULT	SPAWNING
10	12450	6066	2267	2036
20	17147	13572	4418	6745
30	18039	17962	6562	11035
40	18232	20944	8336	14456
50	18001	21604	9857	16435
60	16514	21517	11503	17117
70	15536	21462	13147	17478
80	15049	21029	14502	17214
90	14751	20166	15620	16845
100	14668	19572	16602	16522
150	16617	18426	18056	15797
200	19915	21122	17725	17556
250	17778	23847	17155	18494
300	15835	23479	15716	18486
350	13584	21720	14573	17361
400	12186	19796	13414	16365
450	10583	17461	12636	15011
500	9260	15138	12257	13374

TRUCKEE RIVER- TAHOE TO DONNER CK
ALL HABITAT TYPES COMBINED/IFG4&MANSQ
WEIGHTING .13 POOL;.26 RUN;.45 RIFFLE

RAINBOW TROU	RAINBOW TROUT			
Q	FRY	JUVENI	ADULT	SPAWNING
10	62.52	25.44	12.56	10.94
20	86.10	56.91	24.47	34.82
30	90.43	75.32	36.34	55.76
40	91.55	87.83	46.17	72.00
50	90.39	90.60	54.59	81.16
60	82.93	90.23	63.71	85.16
70	78.01	90.00	72.81	88.64
80	75.57	88.18	80.32	88.80
90	74.07	84.56	86.51	87.83
100	73.66	82.07	91.95	86.82
150	83.44	77.27	100.00	85.10
200	100.00	88.57	98.17	90.92
250	89.27	100.00	95.01	96.03
300	79.51	98.45	87.04	100.00
350	68.21	91.08	80.71	98.48
400	61.19	83.01	74.29	98.06
450	53.14	73.22	69.98	95.86
500	46.50	63.48	67.88	92.25

TRUCKEE RIVER- TAHOE TO DONNER CK
ALL HABITAT TYPES COMBINED/IFG4&MANSQ
WEIGHTING .13 POOL;.26 RUN;.45 RIFFLE
BROWN TROUT

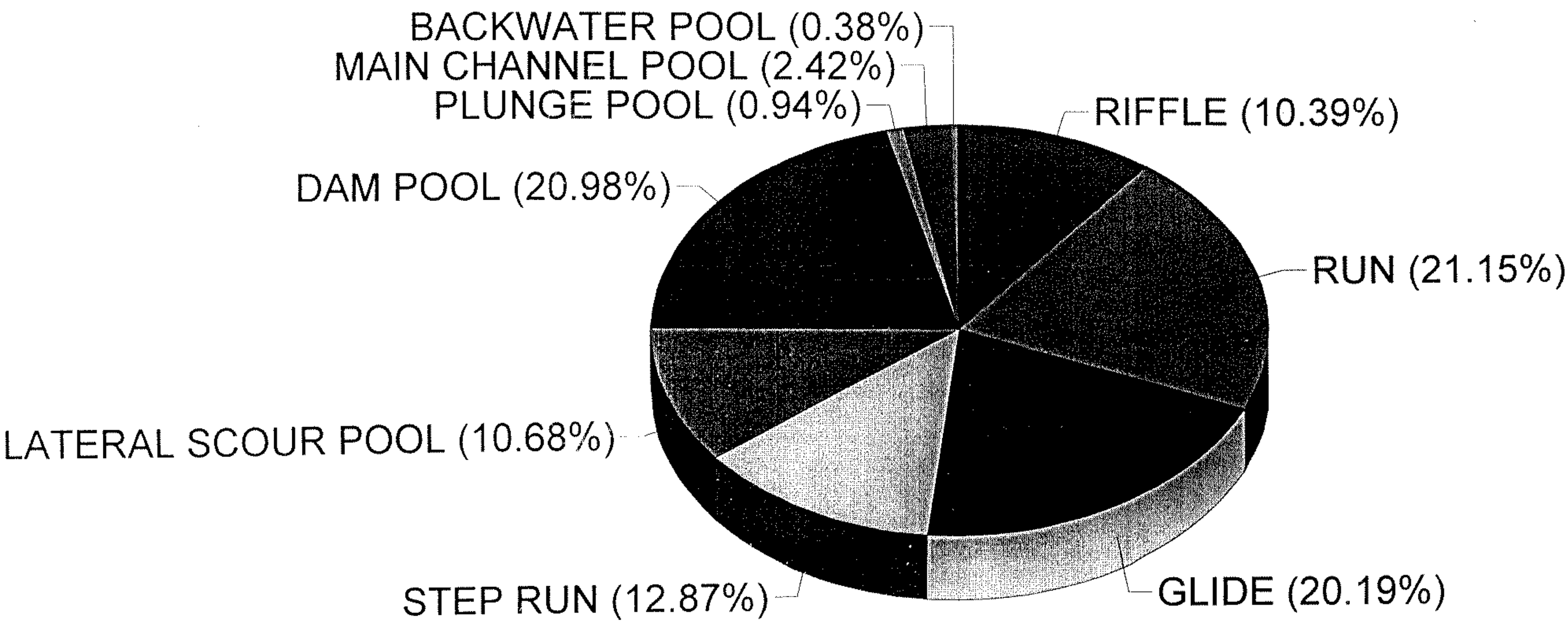
Q	FRY	JUVENILE	ADULT	SPAWNING
10	23441	1194	4528	2635
20	26654	2779	7230	6628
30	28346	4732	9122	9196
40	27800	7112	10529	11928
50	27506	9003	12144	13517
60	26849	10411	13112	14195
70	27111	11535	13653	13922
80	27790	12306	13745	13617
90	27674	12613	13690	13432
100	28928	12943	13759	13249
150	33173	13430	13518	13692
200	30314	12312	13437	15227
250	26845	11547	13271	16039
300	26178	11359	14397	15032
350	21458	11198	15365	13806
400	19245	10869	14875	12348
450	18932	10837	14149	10436
500	17169	10322	13609	9068

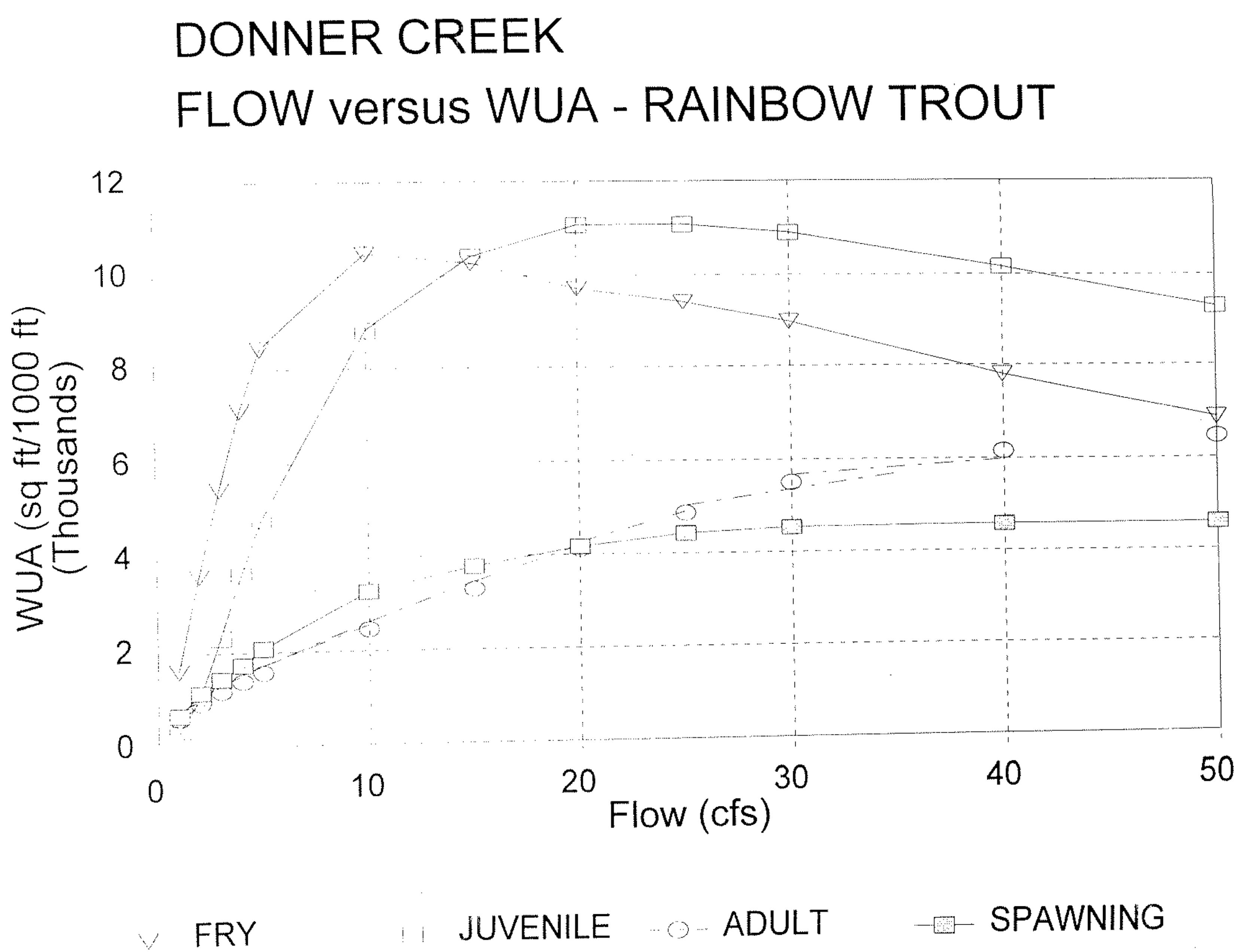
TRUCKEE RIVER- TAHOE TO DONNER CK
ALL HABITAT TYPES COMBINED/IFG4&MANSQ
WEIGHTING .13 POOL;.26 RUN;.45 RIFFLE
BROWN TROUT PERCENT OPTIMUM WUA

Q	FRY	JUVENILE	ADULT	SPAWNING
10	70.66	8.89	29.47	8.55
20	80.35	20.69	47.06	23.17
30	85.45	35.24	59.37	35.00
40	83.80	52.96	68.53	49.56
50	82.92	67.04	79.04	61.04
60	80.94	77.52	85.34	68.59
70	81.72	85.89	88.86	72.80
80	83.77	91.64	89.46	76.30
90	83.42	93.92	89.10	79.40
100	87.20	96.37	89.55	81.50
150	100.00	100.00	87.98	88.46
200	91.38	91.68	87.46	97.27
250	80.93	85.98	86.37	100.00
300	78.91	84.58	93.70	95.11
350	64.69	83.38	100.00	89.61
400	58.01	80.93	96.81	84.04
450	57.07	80.70	92.09	77.09
500	51.76	76.86	88.57	71.42

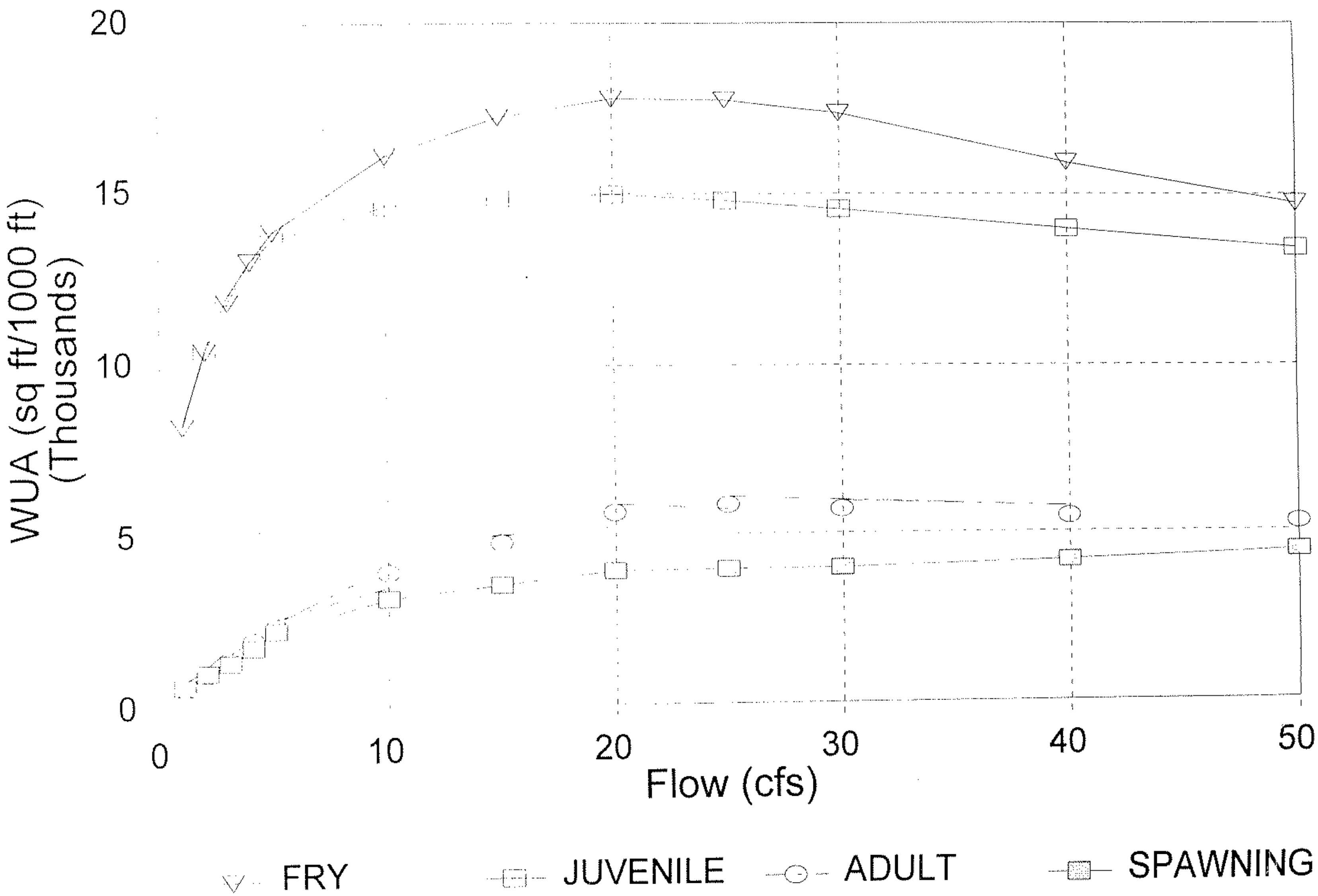
DONNER CREEK

DONNER CREEK
TOTAL HABITAT COMPOSITION

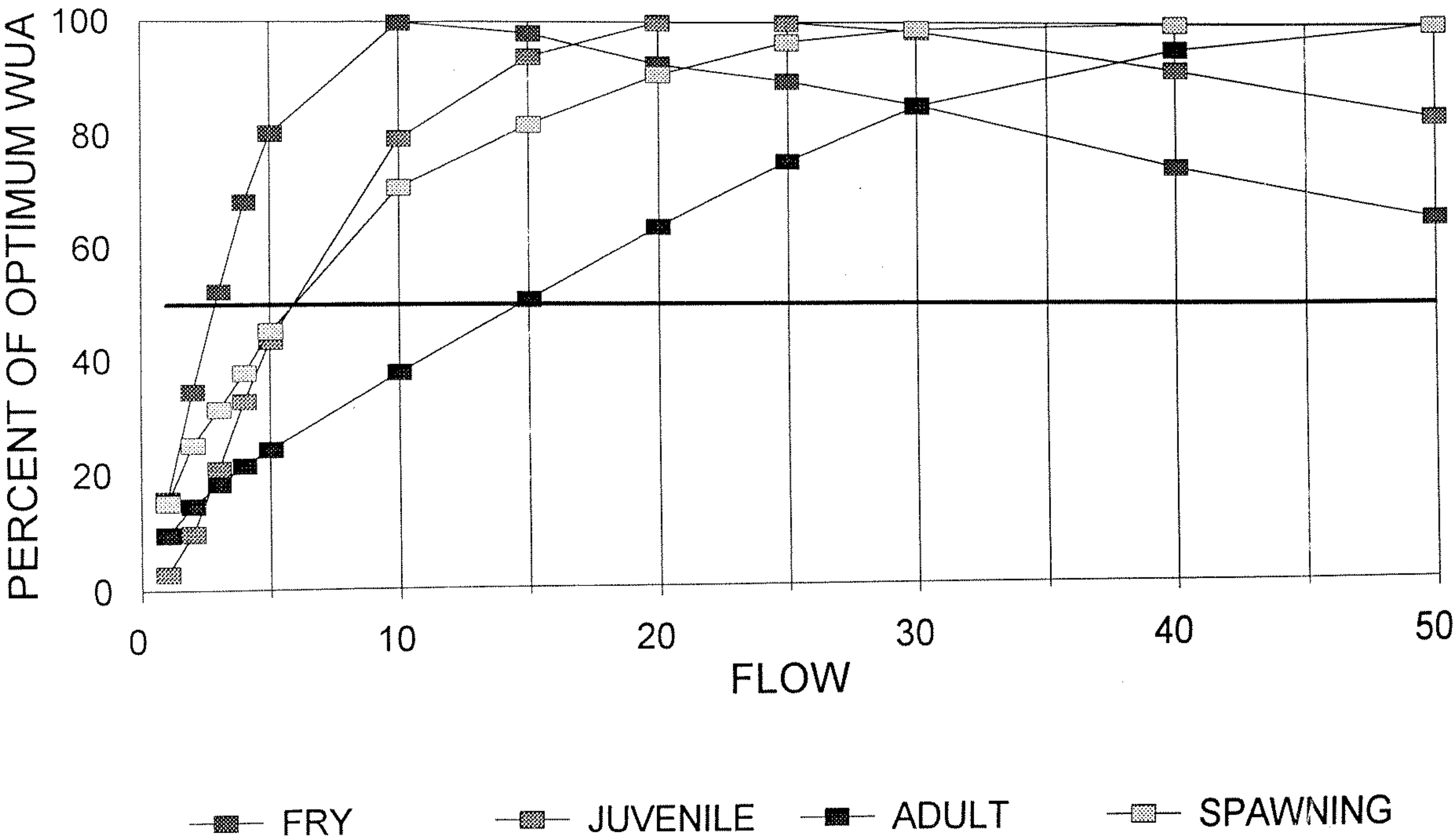



DONNER CREEK
FLOW versus WUA - RAINBOW TROUT
WUA (sq ft/1000 ft)
(Thousands)
0
2
4
6
8
10
12
0
10
20
30
40
50
Flow (cfs)
FRY
JUVENILE
ADULT
SPAWNING

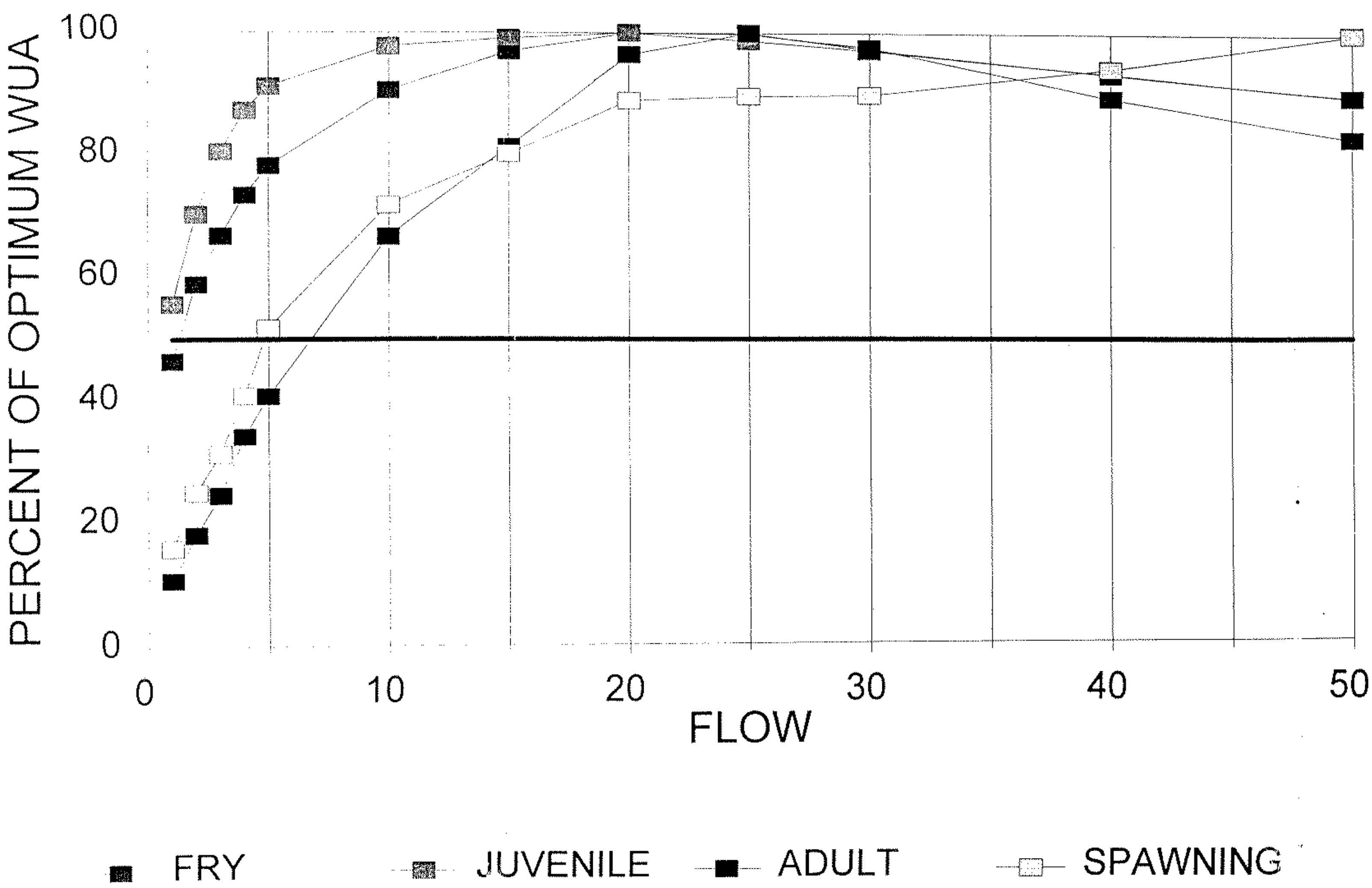
DONNER CREEK
FLOW versus WUA - BROWN TROUT



DONNER CK - RAINBOW TROUT
PERCENT OF OPTIMUM WUA v FLOW



DONNER CK - BROWN TROUT
PERCENT OF OPTIMUM WUA v FLOW



DONNER CREEK
SUMMARY OF ALL FOUR HABITAT TYPES (WEIGHTED)
run*.3402, riffle*.1039,pool*.354,glide*.2019
RAINBOW TROUT

FLOW	FRY	JUVENILE	ADULT	SPAWNING
1	1643.002	323.0836	621.2149	688.2824
2	3634.456	1087.06	944.1194	1160.987
3	5482.663	2324.339	1184.671	1450.546
4	7146.783	3650.897	1392.67	1745.936
5	8443.021	4831.883	1576.93	2079.422
10	10482.72	8816.681	2458.482	3253.351
15	10274.94	10420.36	3281.617	3765.006
20	9709.836	11078.53	4117.757	4170.758
25	9402.124	11083.23	4873.61	4433.833
30	8954.625	10909.8	5511.331	4539.422
40	7803.916	10170.18	6166.673	4586.712
50	6865.304	9270.561	6464.621	4591.4

DONNER CREEK
SUMMARY OF ALL FOUR HABITAT TYPES (WEIGHTED)
run*.3402, riffle*.1039,pool*.354,glide*.2019
RAINBOW TROUT PERCENT OPTIMUM WUA

FLOW	FRY	JUVENILE	ADULT	SPAWNING
1	15.67344	2.915068	9.609455	14.99069
2	34.67094	9.808155	14.6044	25.28612
3	52.30193	20.97169	18.32545	31.59267
4	68.17683	32.94075	21.54295	38.02623
5	80.5423	43.59636	24.39324	45.28951
10	100	79.54978	38.0298	70.85749
15	98.01791	94.01922	50.76271	82.00128
20	92.6271	99.95767	63.6968	90.83849
25	89.69168	100	75.38894	96.56821
30	85.42276	98.43521	85.25374	98.86794
40	74.44555	91.76195	95.39109	99.89791
50	65.49165	83.64498	100	100

DONNER CREEK
SUMMARY OF ALL FOUR HABITAT TYPES (WEIGHTED)
run*.3402, riffle*.1039,pool*.354,glide*.2019
BROWN TROUT

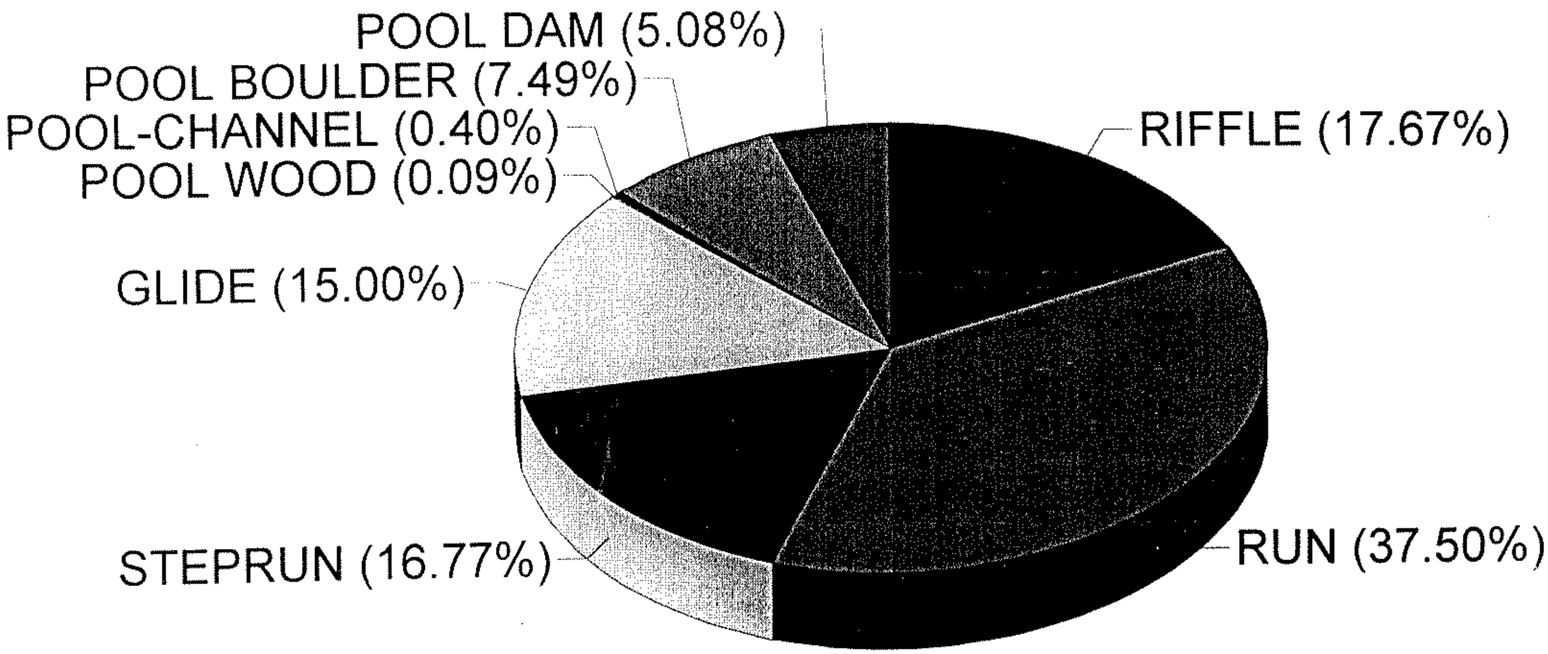
FLOW	FRY	JUVENILE	ADULT	SPAWNING
1	8274.072	8341.771	628.773	699.609
2	10477.43	10532.6	1057.986	1089.916
3	11892.84	12077.54	1432.716	1366.913
4	13063.72	13086.6	1992.574	1788.217
5	13931.84	13675.66	2387.253	2268.531
10	16118.91	14665.39	3916.663	3150.696
15	17256.52	14872.46	4780.924	3519.329
20	17808.83	14998.04	5667.119	3903.033
25	17777.98	14814.99	5874.17	3934.778
30	17391.34	14566.73	5717.288	3942.725
40	15925.73	14001.36	5478.639	4135.44
50	14740.61	13437.13	5269.387	4387.346

DONNER CREEK
SUMMARY OF ALL FOUR HABITAT TYPES (WEIGHTED)
run*.3402, riffle*.1039,pool*.354,glide*.2019
BROWN TROUT PERCENT OPTIMUM WUA

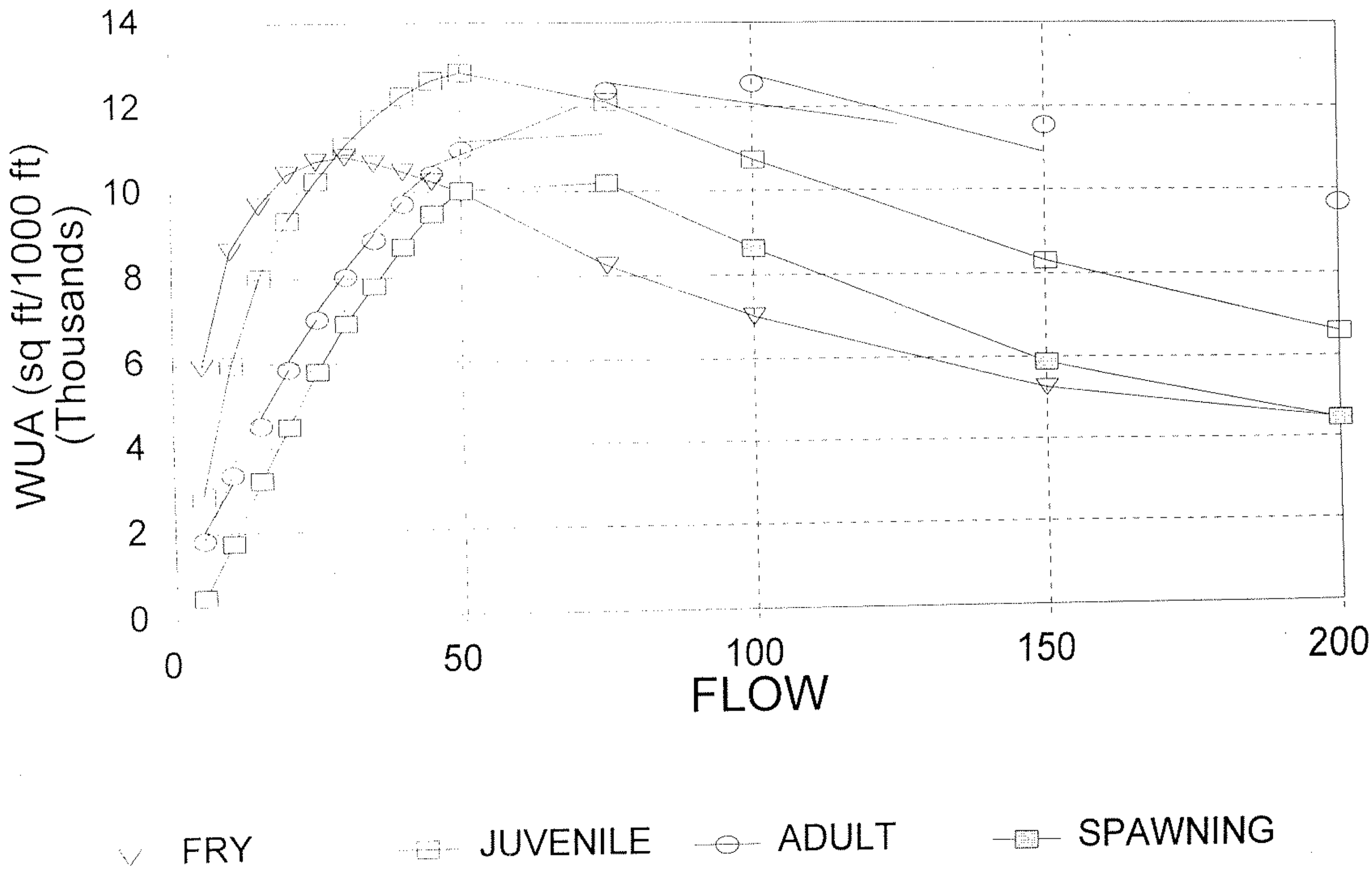
FLOW	FRY	JUVENILE	ADULT	SPAWNING
1	46.46051	55.61906	10.70403	15.94606
2	58.83278	70.22648	18.01082	24.84227
3	66.78061	80.52746	24.3901	31.1558
4	73.3553	87.2554	33.92094	40.75851
5	78.22996	91.18297	40.63984	51.70623
10	90.51077	97.78203	66.67602	71.81325
15	96.89871	99.16264	81.38892	80.21543
20	100	100	96.47523	88.96113
25	99.82677	98.77945	100	89.68469
30	97.65575	97.12422	97.32929	89.86584
40	89.42603	93.35459	93.26661	94.25834
50	82.77135	89.59253	89.70436	100

PROSSER CREEK

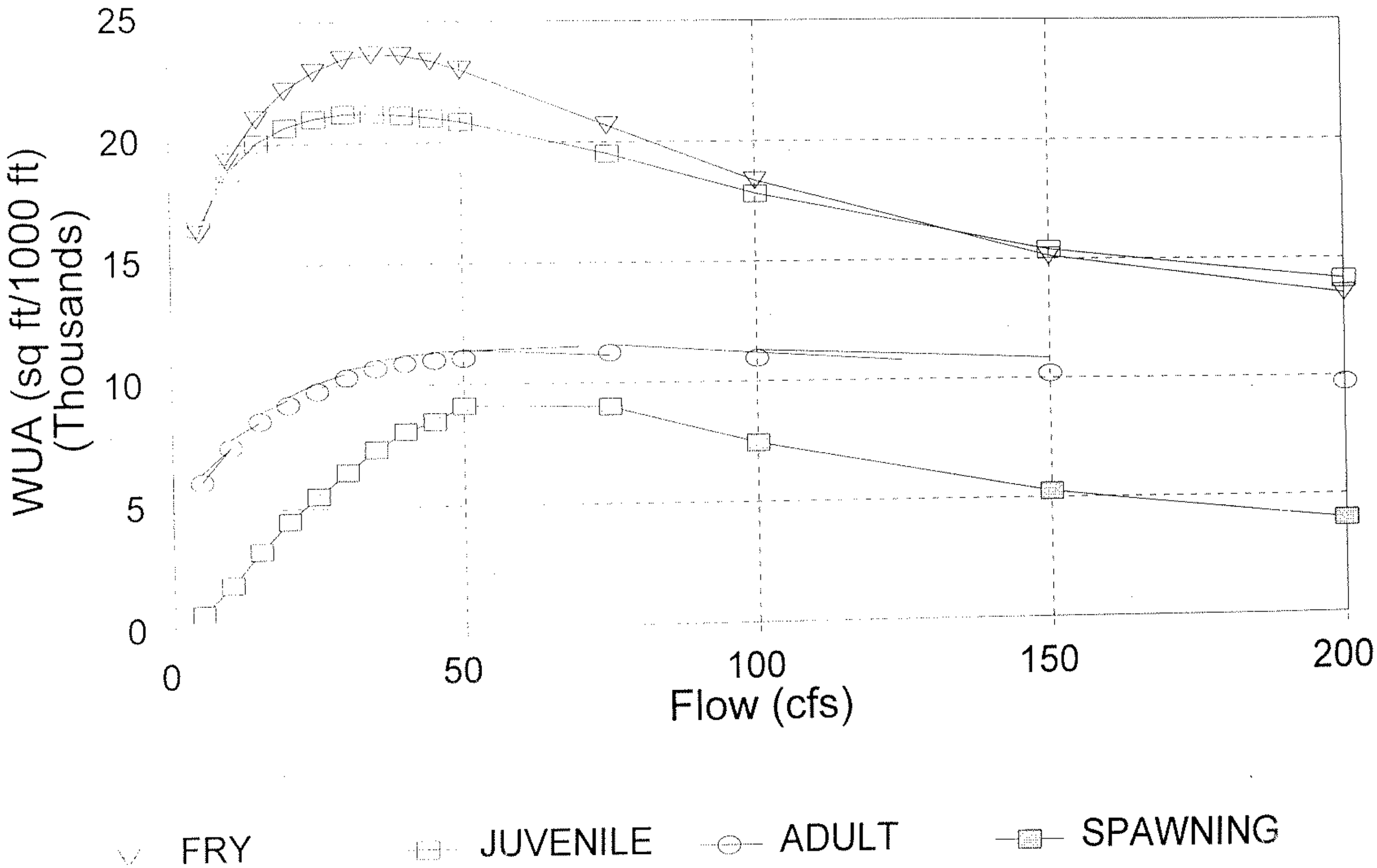
PROSSER CREEK
TOTAL HABITAT COMPOSITION



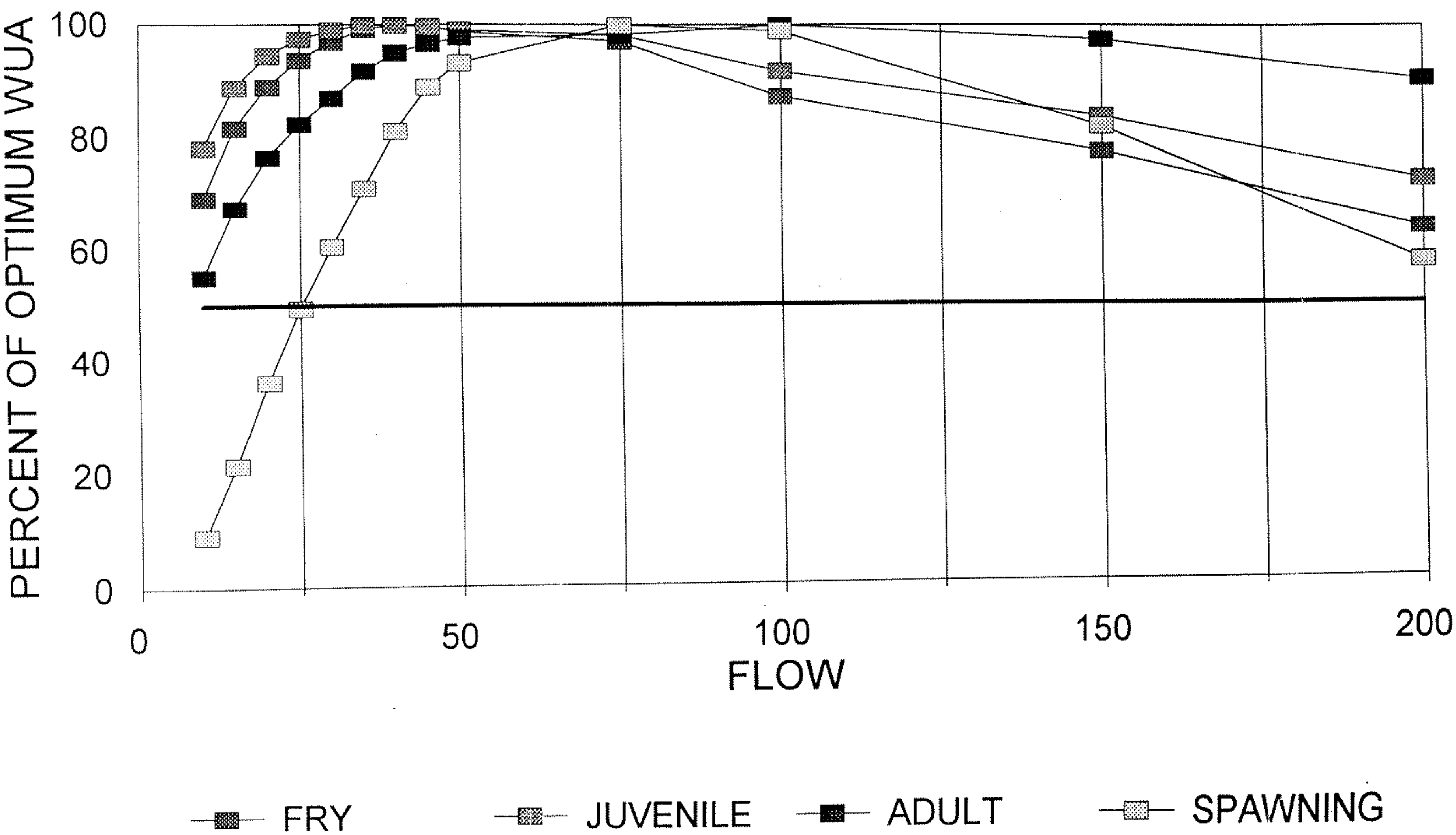
PROSSER CREEK
FLOW versus WUA - RAINBOW TROUT



PROSSER CREEK
FLOW versus WUA - BROWN TROUT

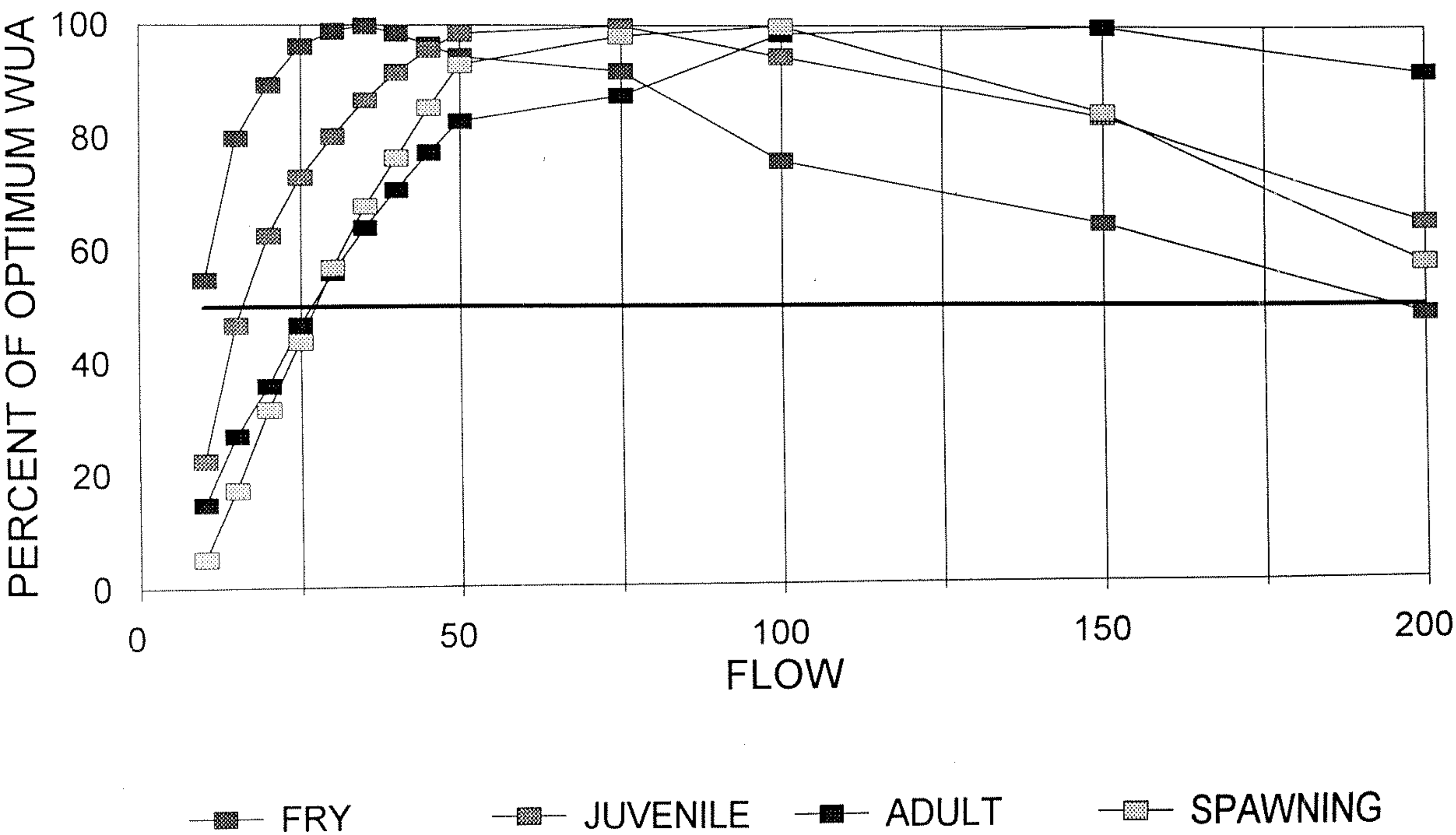


PROSSER CK - BROWN TROUT
PERCENT OF OPTIMUM WUA v FLOW



PROSSER CK - RAINBOW TROUT

PERCENT OF OPTIMUM WUA v FLOW



PROSSER CREEK BROWN TROUT
WEIGHTED USABLE AREA FOR ALL HABITAT TYPES COMBINED
WEIGHTED:RIFFLE*.2254,POOL*.1312,RUN*.4997,GLIDE*.143

FLOW	FRY	JUVENIL	ADULT	SPAWNING
5	16366.3	16614.7	6203.17	822.431
10	19347.3	18887.3	7593.69	1959.55
15	21064.6	20083.9	8624.31	3301.53
20	22204.1	20698	9287.67	4496.95
25	22970	21034.3	9810.58	5513.83
30	23476.8	21222.4	10354.8	6470.8
35	23669.6	21237.9	10722	7396.77
40	23621.1	21164.7	10905.1	8116.22
45	23380.7	21048.9	11017.9	8508.66
50	23018.1	20893	11080.6	9106.16
75	20691.8	19527	11270.8	9016.7
100	18355.9	17813.2	11002.6	7475.89
150	15133.5	15405.5	10229.3	5265.31
200	13556.6	14146.9	9749.12	3981.93

PROSSER CREEK BROWN TROUT
WEIGHTED USABLE AREA FOR ALL HABITAT TYPES COMBINED
WEIGHTED:RIFFLE*.2254,POOL*.1312,RUN*.4997,GLIDE*.143

FLOW	FRY	JUVENIL	ADULT	SPAWNING
5	69.145	78.2313	55.0374	9.03158
10	81.7389	88.9322	67.3747	21.5189
15	88.9946	94.5661	76.5189	36.256
20	93.8085	97.4576	82.4045	49.3836
25	97.0442	99.0411	87.044	60.5505
30	99.1857	99.9268	91.8728	71.0595
35	100	100	95.1302	81.2281
40	99.7952	99.6551	96.7549	89.1289
45	98.7793	99.1099	97.7561	93.4384
50	97.2478	98.376	98.3121	100
75	87.4192	91.9443	100	99.0175
100	77.5506	83.8743	97.6205	82.097
150	63.9367	72.5375	90.7594	57.8213
200	57.2742	66.6113	86.4987	43.7278

PROSSER CREEK RAINBOW TROUT
WEIGHTED USABLE AREA FOR ALL HABITAT TYPES COMBINED
WEIGHTED:RIFFLE*.2254,POOL*.1312,RUN*.4997,GLIDE*.143

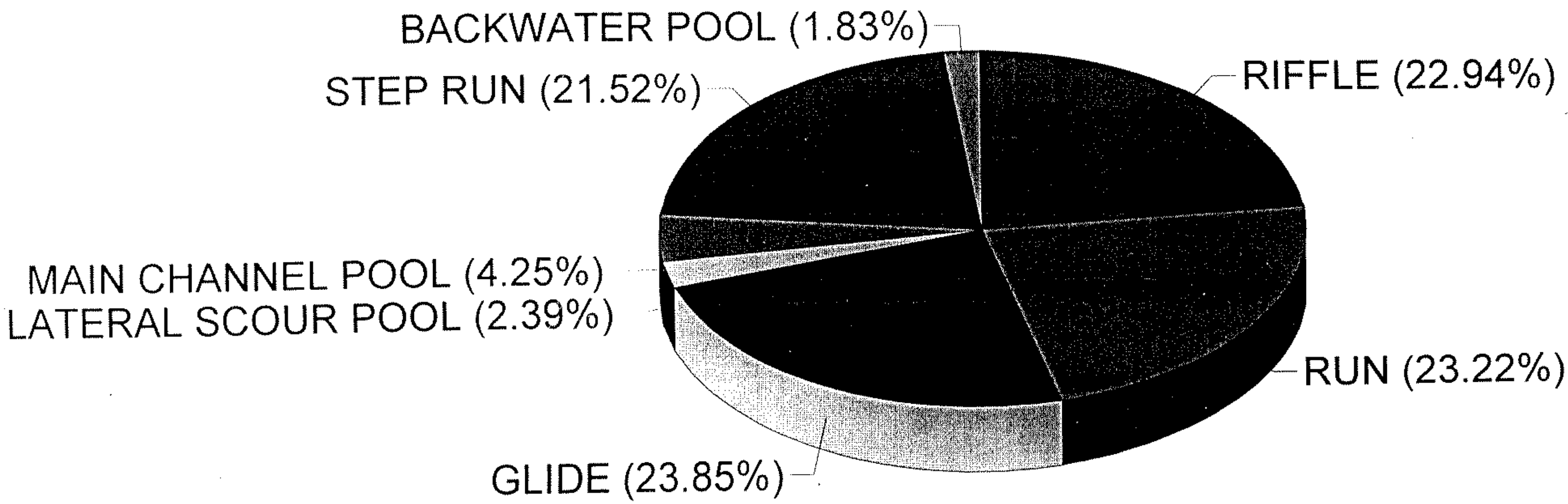
FLOW	FRY	JUVENIL	ADULT	SPAWNING
5	5950.97	2894.94	1849.56	525.799
10	8678.48	5996.15	3389.49	1709.97
15	9721.81	8032.56	4526.58	3241.83
20	10462.9	9372.9	5870.05	4483.33
25	10757.9	10299.7	7042.73	5807.72
30	10861	11130.4	8035.83	6930.84
35	10710.9	11766.6	8899.49	7813.69
40	10496.2	12293.8	9735.38	8728.45
45	10266.9	12643.4	10426.4	9507.91
50	10004.4	12823.7	11001.6	10033.3
75	8263.33	12139.2	12394.8	10211
100	7022.71	10762.5	12562.2	8646.42
150	5264.37	8323.81	11562.5	5887.42
200	4458.22	6611.57	9693.86	4443.12

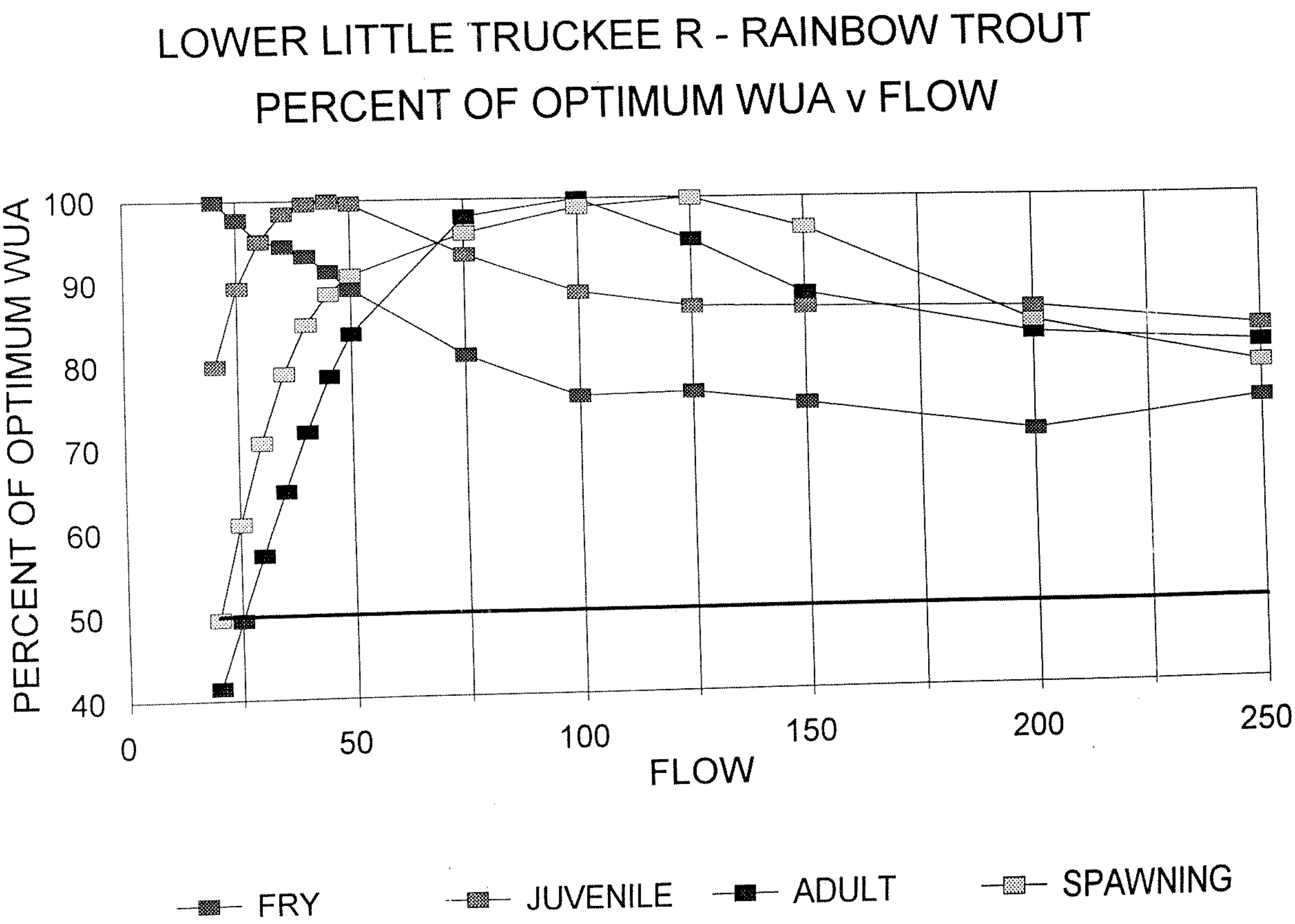
PROSSER CREEK RAINBOW TROUT
WEIGHTED USABLE AREA FOR ALL HABITAT TYPES COMBINED
WEIGHTED:RIFFLE*.2254,POOL*.1312,RUN*.4997,GLIDE*.143

FLOW	FRY	JUVENIL	ADULT	SPAWNING
5	54.7919	22.5749	14.7232	5.14936
10	79.9046	46.7582	26.9816	17.334
15	89.5109	62.6383	36.0333	31.7485
20	96.3339	73.0903	46.7277	43.907
25	99.0503	80.3179	56.0627	56.8772
30	100	86.7951	63.9681	67.8765
35	98.6175	91.7566	70.8432	76.5226
40	96.641	95.8677	77.4972	85.4812
45	94.5295	98.5934	82.9978	93.1147
50	92.1123	100	87.5768	98.2603
75	76.0823	94.6619	98.6672	100
100	64.6597	83.9265	100	84.6778
150	48.4702	64.9094	92.0421	57.6578
200	41.0478	51.5573	77.1666	43.5132

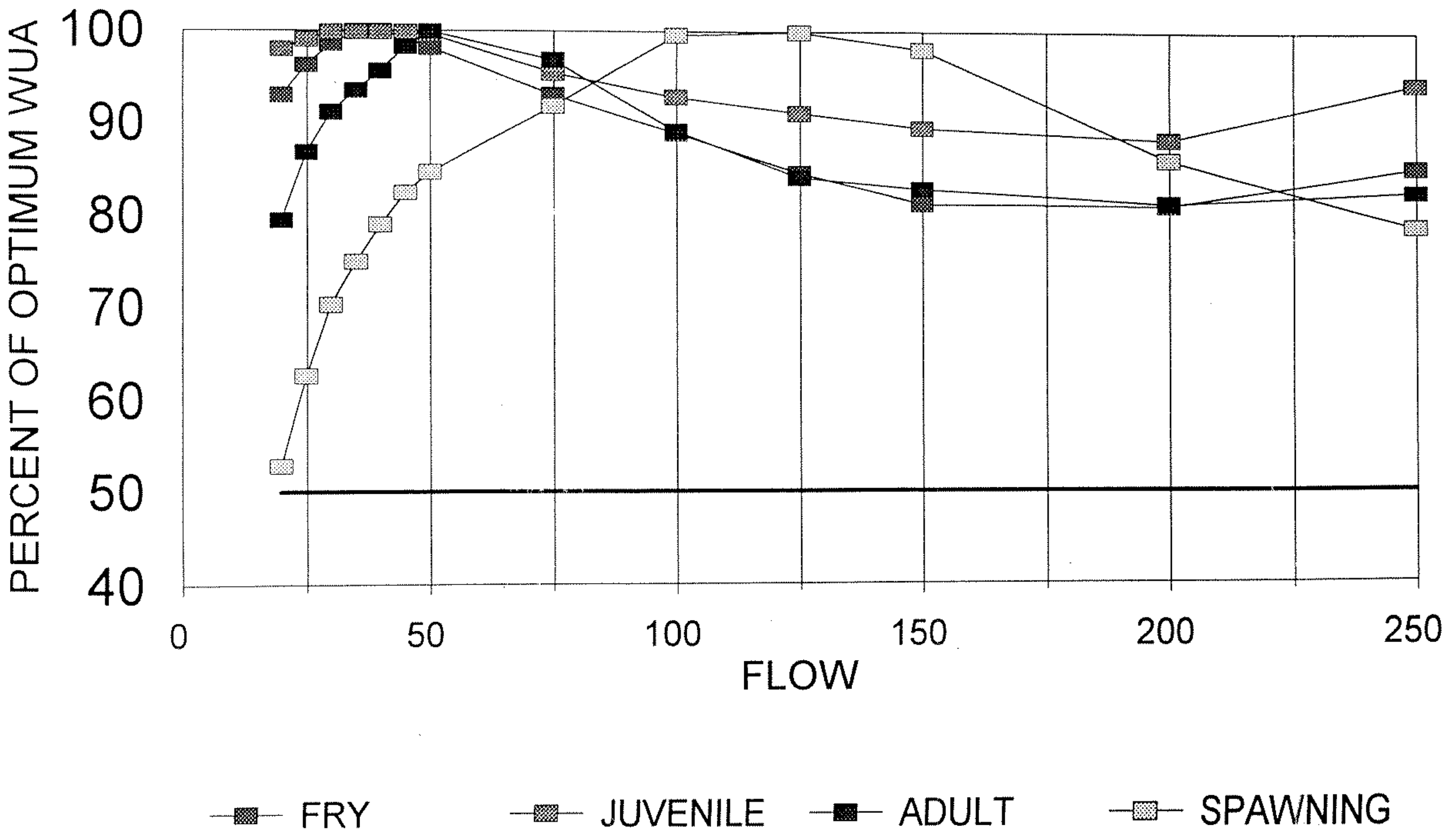
LITTLE TRUCKEE RIVER
DOWNSTREAM OF STAMPEDE RESERVOIR

LOWER LITTLE TRUCKEE RIVER
TOTAL HABITAT COMPOSITION

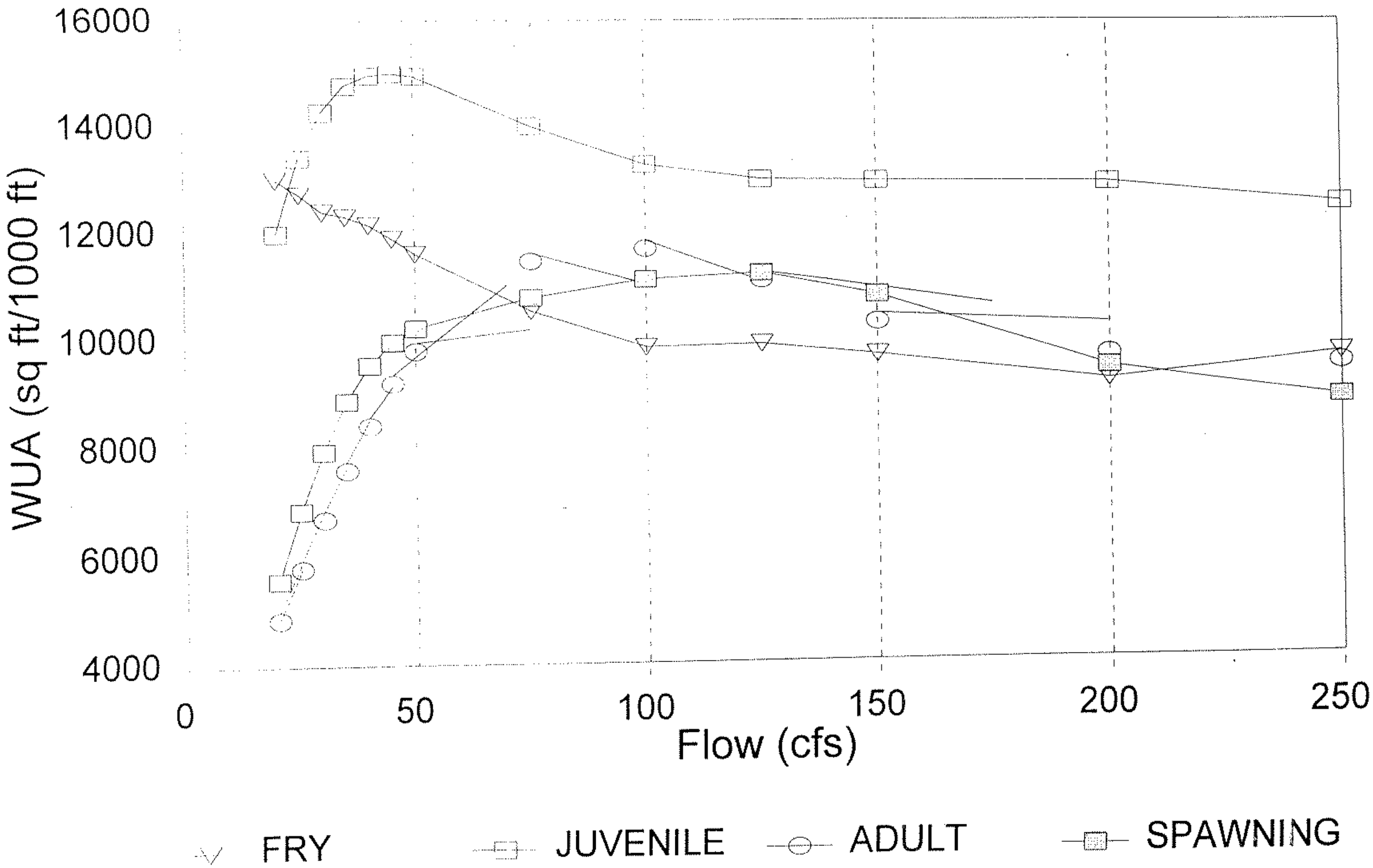


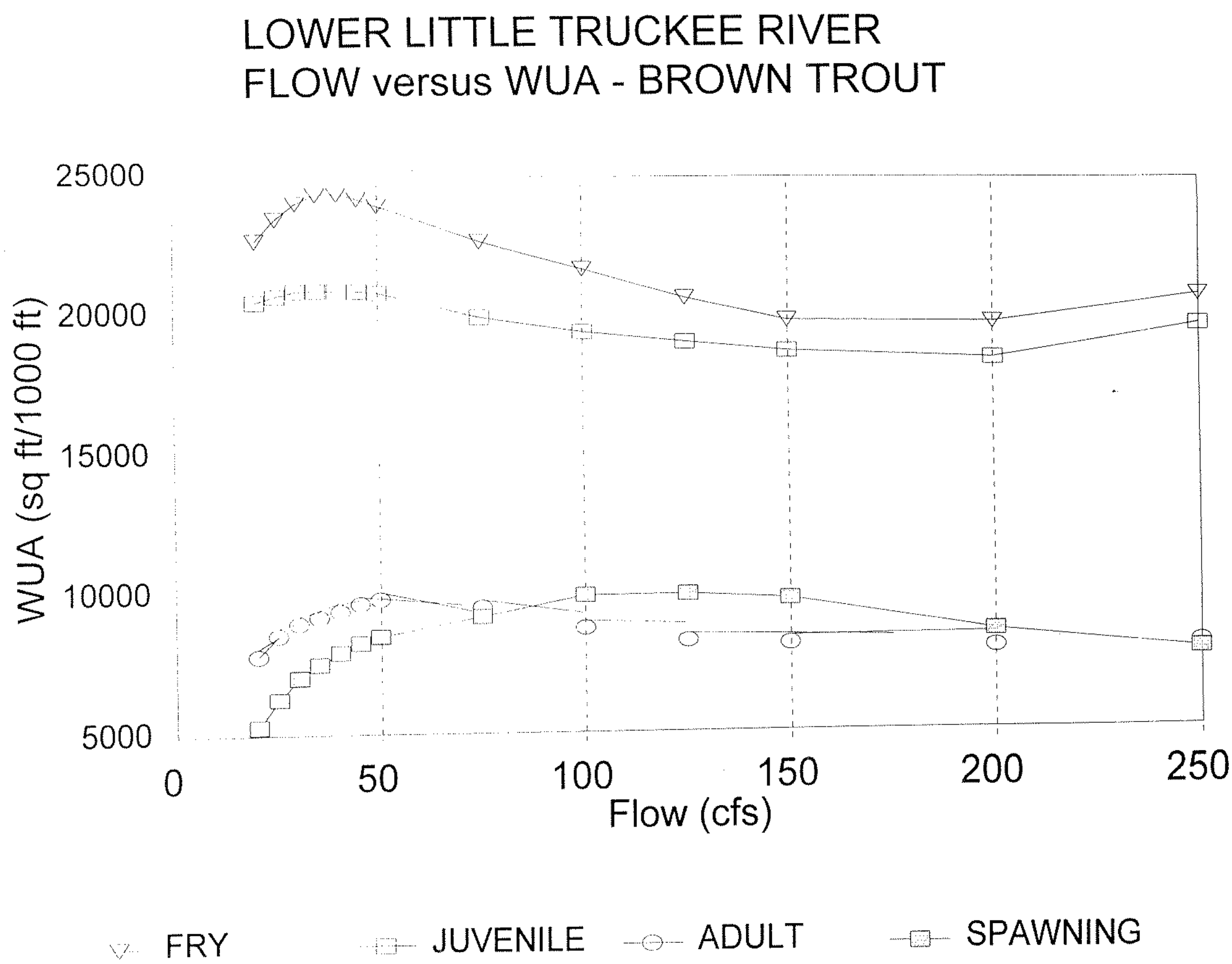

LOWER LITTLE TRUCKEE R - RAINBOW TROUT
PERCENT OF OPTIMUM WUA v FLOW
PERCENT OF OPTIMUM WUA
100
90
80
70
60
50
40
0
50
100
150
200
250
FLOW
FRY
JUVENILE
ADULT
SPAWNING

LOWER LITTLE TRUCKEE R - BROWN TROUT
PERCENT OF OPTIMUM WUA v FLOW



LOWER LITTLE TRUCKEE RIVER
FLOW versus WUA - RAINBOW TROUT





LOWER LITTLE TRUCKEE RIVER
FLOW versus WUA - BROWN TROUT
WUA (sq ft/1000 ft)
25000
20000
15000
10000
5000
0
50
100
150
200
250
Flow (cfs)
FRY
JUVENILE
ADULT
SPAWNING

LOWER LITTLE TRUCKEE RIVER
ALL HABITATS COMBINED
weighted:glide*.2385,pool*.0847,riffle*.2294.run*.4474
RAINBOW TROUT

FLOW	FRY	JUVENIL	ADULT	SPAWNING
20	13027.6	12018.4	4865.23	5596.29
25	12751.8	13433.6	5806.81	6864.22
30	12417.9	14293.7	6706.8	7958.61
35	12326.4	14790.5	7608.1	8899.5
40	12170.9	14966.7	8437.37	9565.35
45	11919.5	15011.5	9225.04	9981.73
50	11628.5	14962.4	9821.11	10238.6
75	10558.1	14026.8	11488.1	10805.6
100	9884.11	13298.2	11722.1	11143.2
125	9933.82	13018.7	11136.3	11252.6
150	9728.97	12984.6	10345.8	10846.5
200	9259.62	12951.8	9740	9507.95
250	9738.11	12564.5	9568.42	8905.44

LOWER LITTLE TRUCKEE RIVER
ALL HABITATS COMBINED
weighted:glide*.2385,pool*.0847,riffle*.2294.run*.4474
RAINBOW TROUT PERCENT OPTIMUM WUA

FLOW	FRY	JUVENIL	ADULT	SPAWNING
20	100	80.0614	41.5047	49.7335
25	97.8832	89.4885	49.5371	61.0014
30	95.3197	95.218	57.2149	70.7271
35	94.6175	98.5275	64.9037	79.0887
40	93.4242	99.7011	71.9781	85.006
45	91.4944	100	78.6976	88.7063
50	89.2606	99.6726	83.7826	90.9893
75	81.0444	93.4404	98.0038	96.0276
100	75.8705	88.5864	100	99.0279
125	76.2521	86.7247	95.0021	100
150	74.6797	86.4973	88.2589	96.391
200	71.0769	86.2791	83.0907	84.4959
250	74.7498	83.6989	81.627	79.1414

LOWER LITTLE TRUCKEE RIVER
ALL HABITATS COMBINED
weighted:glide*.2385,pool*.0847,riffle*.2294.run*.4474
BROWN TROUT

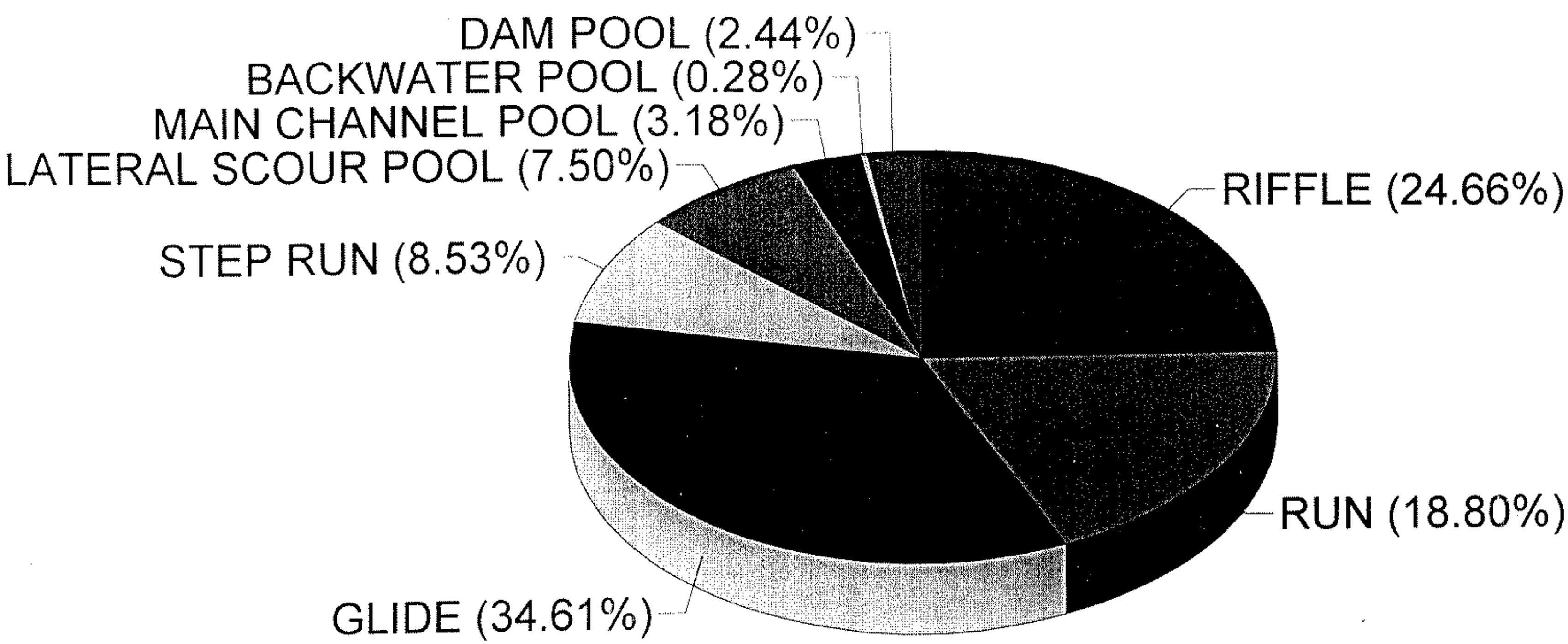
FLOW	FRY	JUVENIL	ADULT	SPAWNING
20	22658.9	20491	7819.82	5288.52
25	23447.8	20696.4	8545.77	6265.57
30	24020.6	20875.6	8968.6	7036.55
35	24337.8	20895.8	9197.91	7506.1
40	24355.7	20883	9403.23	7910.86
45	24179.2	20878.8	9668.59	8256.08
50	23919.9	20825.6	9833.12	8485.84
75	22670	19949.1	9529.61	9192.85
100	21689.7	19416.5	8775.85	9967.71
125	20665.1	19057.6	8289.52	10003
150	19843.5	18721.6	8165.48	9811.77
200	19794.3	18479.3	8019.13	8628.68
250	20805.9	19728.1	8138.03	7904.96

LOWER LITTLE TRUCKEE RIVER
ALL HABITATS COMBINED
weighted:glide*.2385,pool*.0847,riffle*.2294.run*.4474
BROWN TROUT PERCENT OPTIMUM WUA

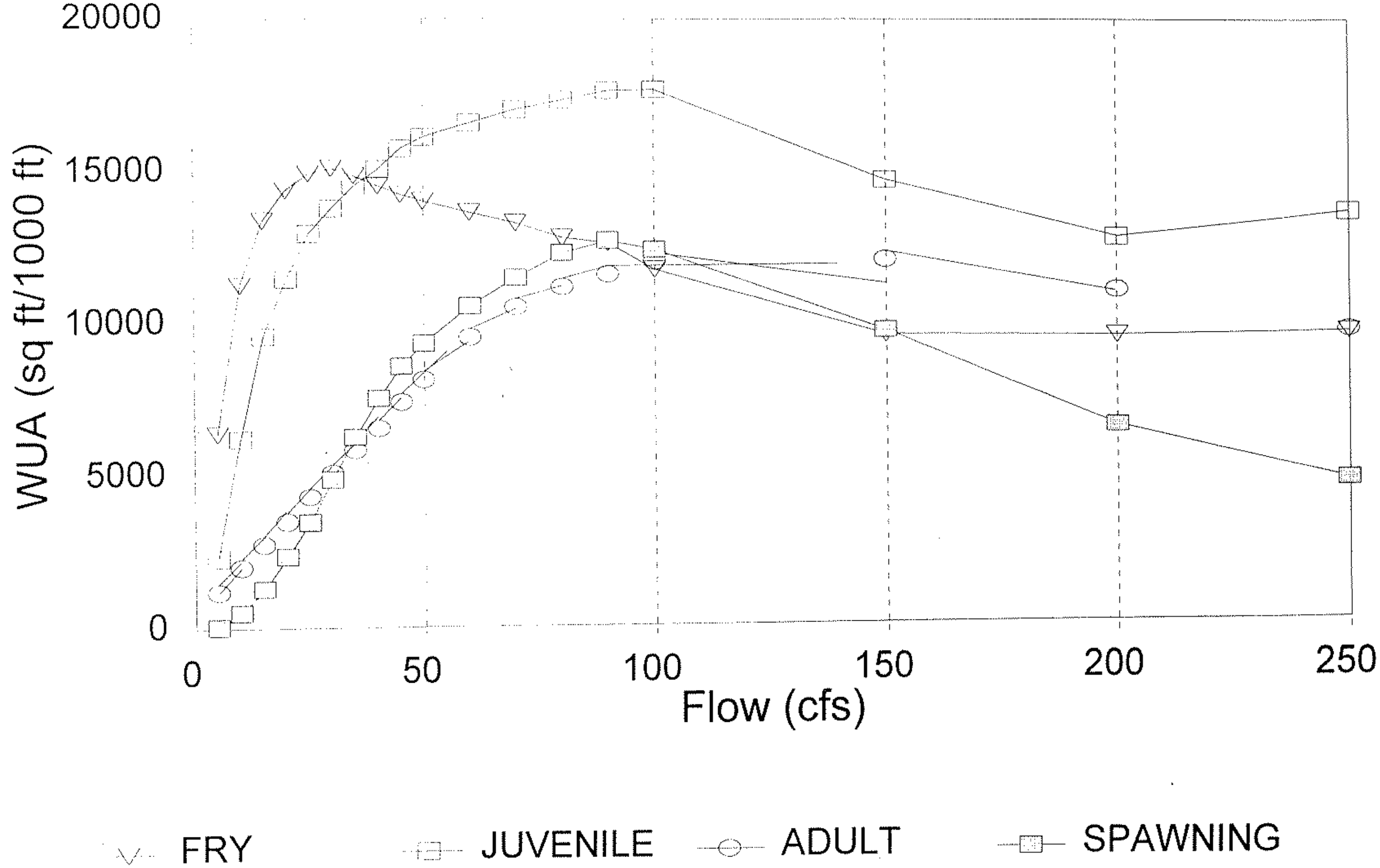
FLOW	FRY	JUVENIL	ADULT	SPAWNING
20	93.0332	98.0629	79.5254	52.8695
25	96.2724	99.0456	86.9081	62.637
30	98.6243	99.9032	91.2081	70.3445
35	99.9265	100	93.5401	75.0386
40	100	99.9386	95.6281	79.085
45	99.2752	99.9186	98.3269	82.5362
50	98.2109	99.6638	100	84.8331
75	93.0787	95.4695	96.9134	91.9011
100	89.0538	92.9204	89.2479	99.6473
125	84.8473	91.2029	84.3021	100
150	81.4738	89.5948	83.0406	98.0884
200	81.2719	88.4353	81.5522	86.2611
250	85.4252	94.4116	82.7614	79.026

LITTLE TRUCKEE RIVER
UPSTREAM OF STAMPEDE RESERVOIR

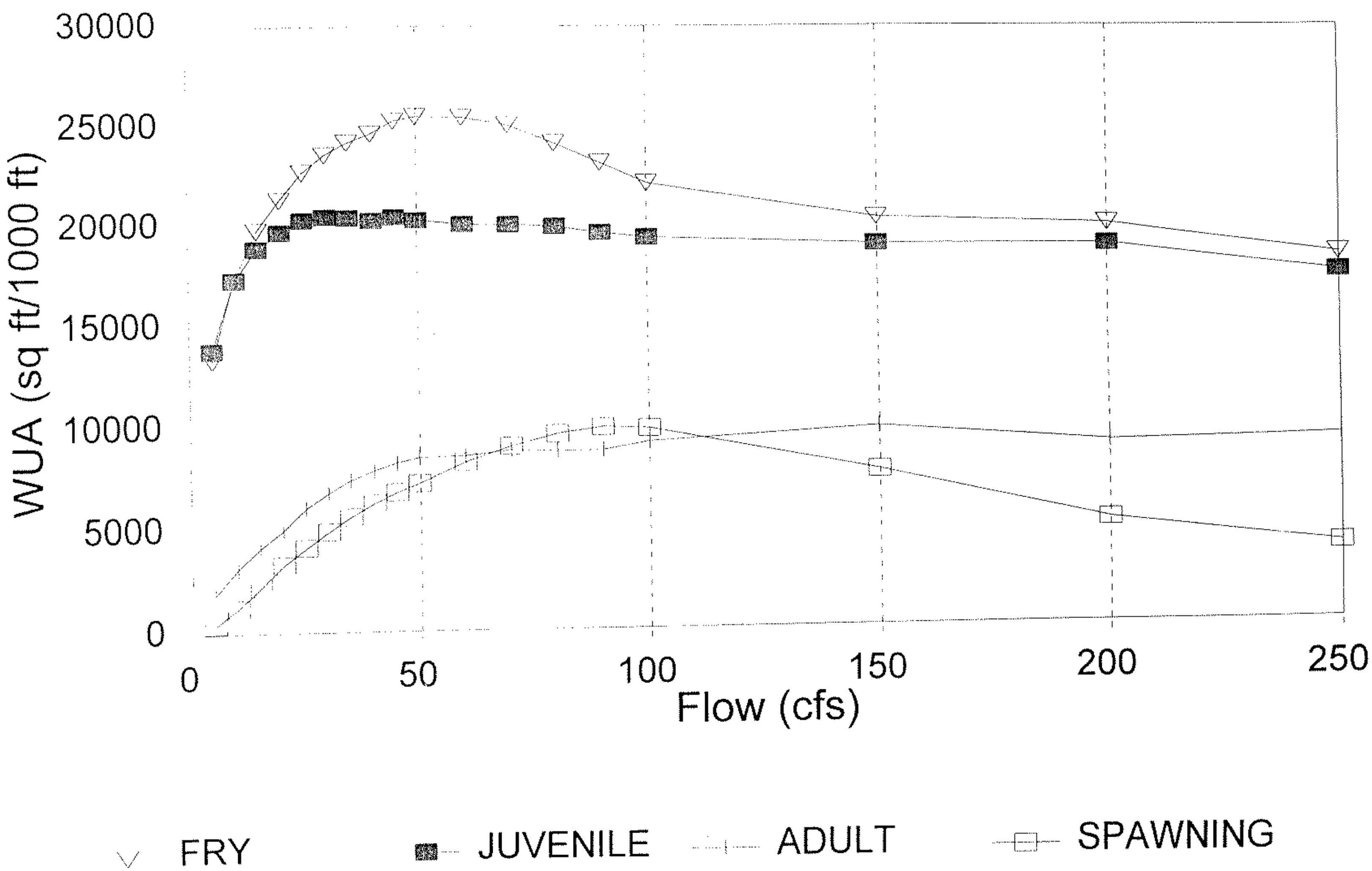
UPPER LITTLE TRUCKEE RIVER
TOTAL HABITAT COMPOSITION



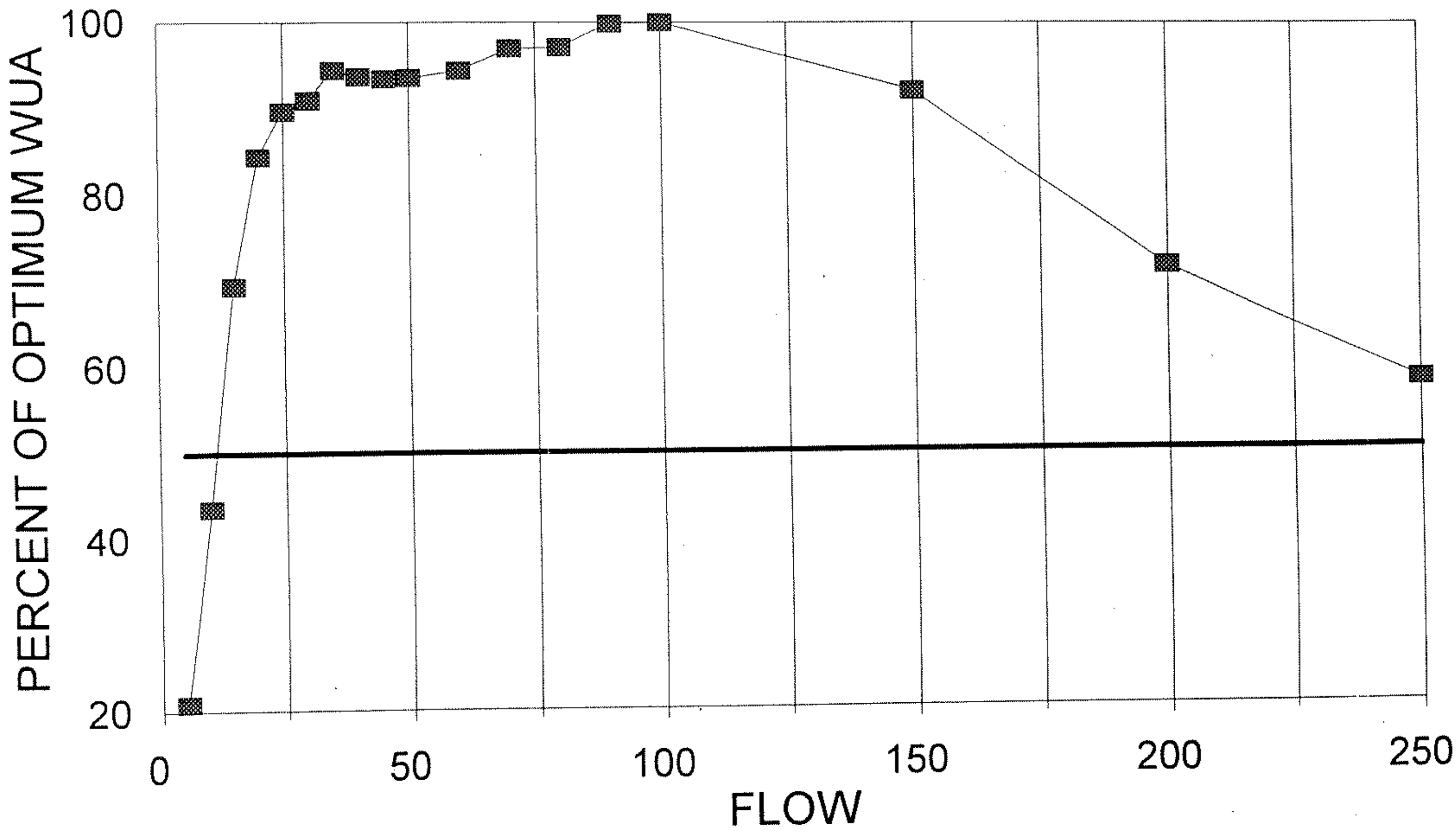
UPPER LITTLE TRUCKEE RIVER
FLOW versus WUA - RAINBOW TROUT



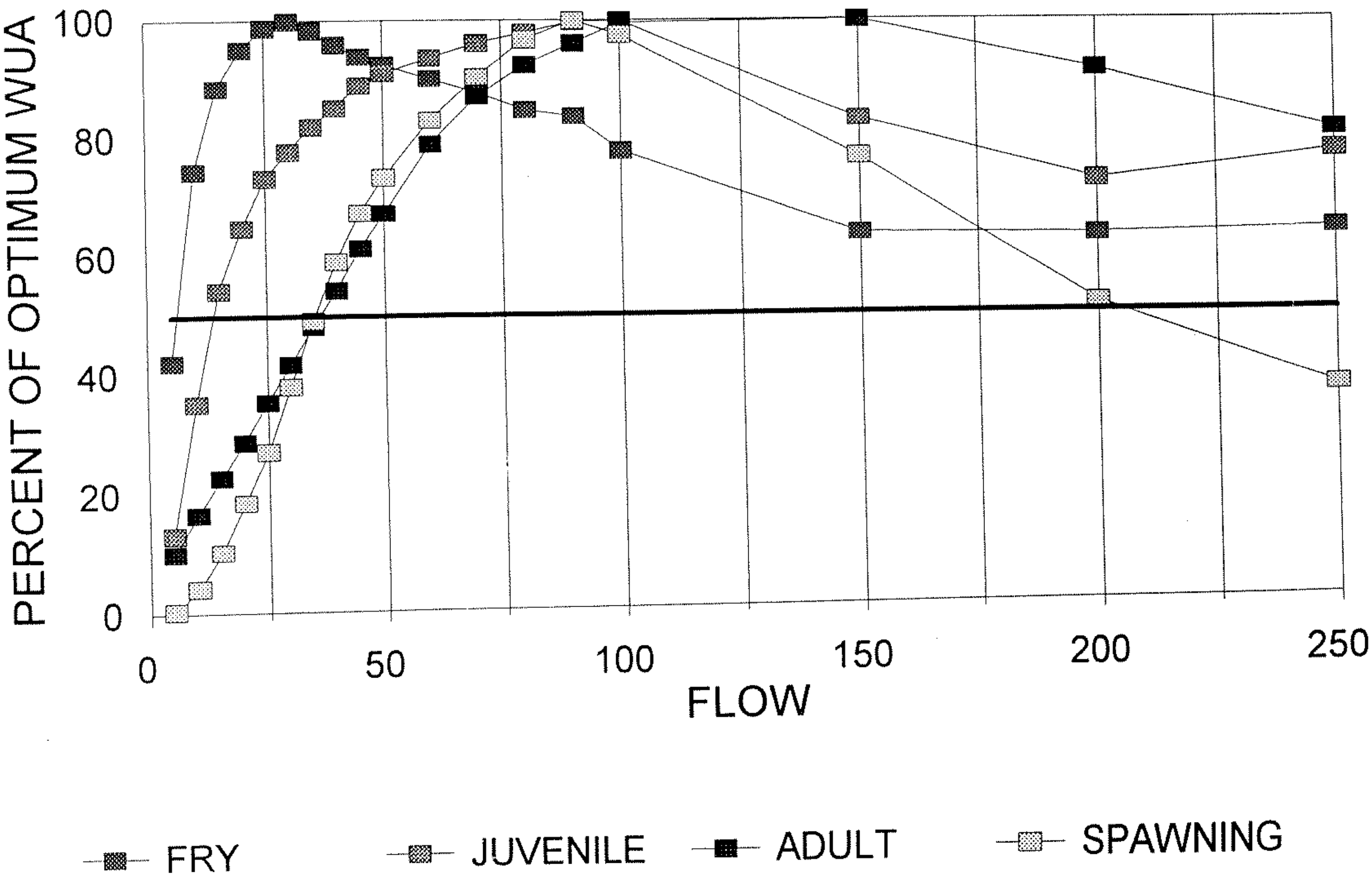
UPPER LITTLE TRUCKEE RIVER
FLOW versus WUA - BROWN TROUT



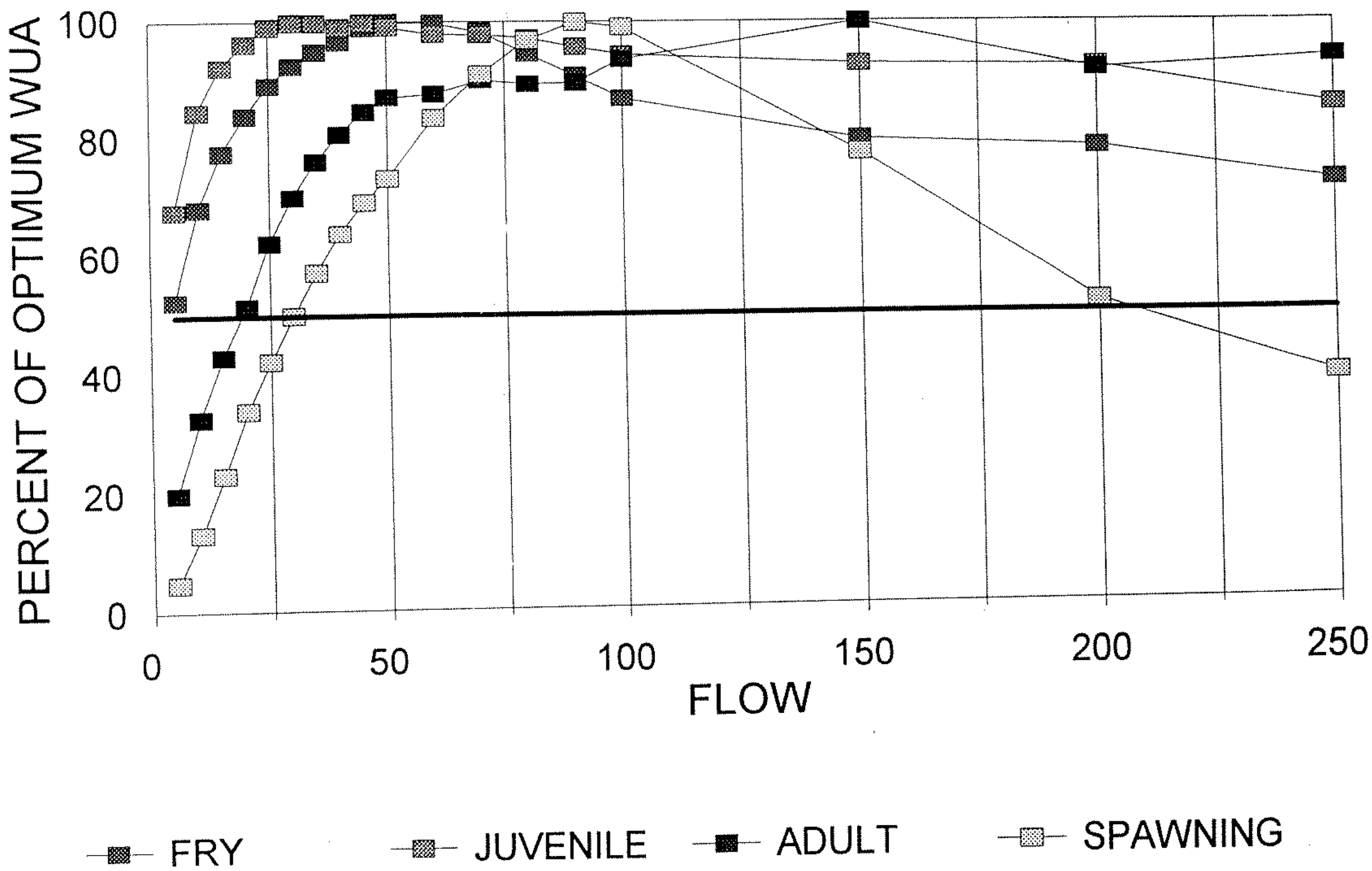
UPPER LITTLE TRUCKEE R - KOKANEE
PERCENT OF OPTIMUM SPAWNING WUA v FLOW



UPPER LITTLE TRUCKEE R - RAINBOW TROUT
PERCENT OF OPTIMUM WUA v FLOW



UPPER LITTLE TRUCKEE R - BROWN TROUT
PERCENT OF OPTIMUM WUA v FLOW



UPPER LITTLE TRUCKEE RIVER
ALL HABITAT TYPES COMBINED
WEIGHTED: RIFFLE* .2446, GLIDE*.3461,RUN*.188,POOL*.1343
RAINBOW TROUT

FLOW	FRY	JUVENI	ADULT	SPAWNING
5	6392	2326.7	1205.6	56.154
10	11289	6230.8	2002.5	525.64
15	13410	9606.9	2749.7	1300.1
20	14397	11500	3476.2	2356.1
25	14940	12987	4287.1	3444.9
30	15120	13782	5068.3	4847.4
35	14871	14516	5819.8	6261.2
40	14519	15088	6564.9	7543.6
45	14222	15768	7430.2	8590.4
50	14006	16138	8153.8	9351.9
60	13650	16595	9555.3	10578
70	13297	17038	10540	11522
80	12811	17343	11197	12327
90	12642	17656	11632	12728
100	11762	17696	12052	12425
150	9614.3	14702	12097	9749
200	9567.6	12833	11083	6552.8
250	9688.2	13666	9773.8	4682.3

UPPER LITTLE TRUCKEE RIVER
ALL HABITAT TYPES COMBINED
WEIGHTED: RIFFLE* .2446, GLIDE*.3461,RUN*.188,POOL*.1343
RAINBOW TROUT

FLOW	FRY	JUVENI	ADULT	SPAWNING
5	42.275	13.148	9.9661	0.4412
10	74.665	35.209	16.554	4.1298
15	88.691	54.287	22.731	10.214
20	95.22	64.984	28.737	18.511
25	98.806	73.39	35.441	27.066
30	100	77.88	41.898	38.085
35	98.355	82.03	48.111	49.193
40	96.025	85.259	54.271	59.268
45	94.059	89.101	61.424	67.493
50	92.631	91.192	67.406	73.476
60	90.274	93.777	78.991	83.108
70	87.942	96.28	87.132	90.528
80	84.731	98.004	92.566	96.852
90	83.613	99.773	96.159	100
100	77.789	100	99.63	97.624
150	63.586	83.079	100	76.596
200	63.277	72.518	91.618	51.484
250	64.075	77.224	80.798	36.788

ALL HABITAT TYPES COMBINED
WEIGHTED: RIFFLE* .2446, GLIDE*.3461,RUN*.188,POOL*.1343
BROWN TROUT

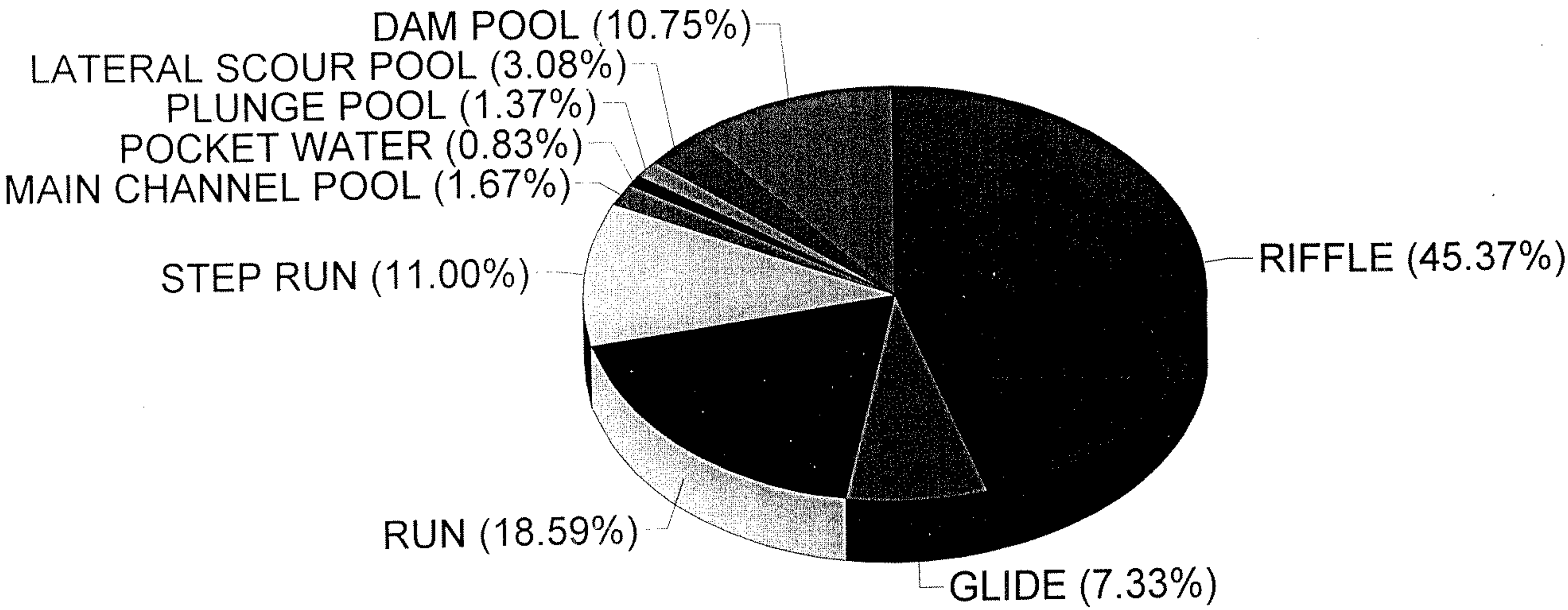
FLOW	FRY	JUVENI	ADULT	SPAWNING
5	13413	13882	1955.3	467.06
10	17384	17352	3211.6	1292.6
15	19830	18926	4237.1	2295.6
20	21407	19754	5067	3365.5
25	22753	20346	6120.7	4202.4
30	23625	20508	6880.1	4968.9
35	24227	20474	7475.6	5681.9
40	24679	20335	7939.7	6339.2
45	25303	20488	8304.2	6864.9
50	25523	20339	8548.7	7272
60	25459	20094	8603	8285.3
70	25091	20066	8839.5	9032
80	24151	19955	8778	9617.5
90	23150	19650	8789.4	9920.7
100	22140	19377	9193.8	9832
150	20354	19011	9823.3	7684.7
200	19983	18937	9013.6	5148.5
250	18434	17525	9220.7	3832.3

UPPER LITTLE TRUCKEE RIVER
ALL HABITAT TYPES COMBINED
WEIGHTED: RIFFLE* .2446, GLIDE*.3461,RUN*.188,POOL*.1343
BROWN TROUT PERCENT OPTIMUM WUA

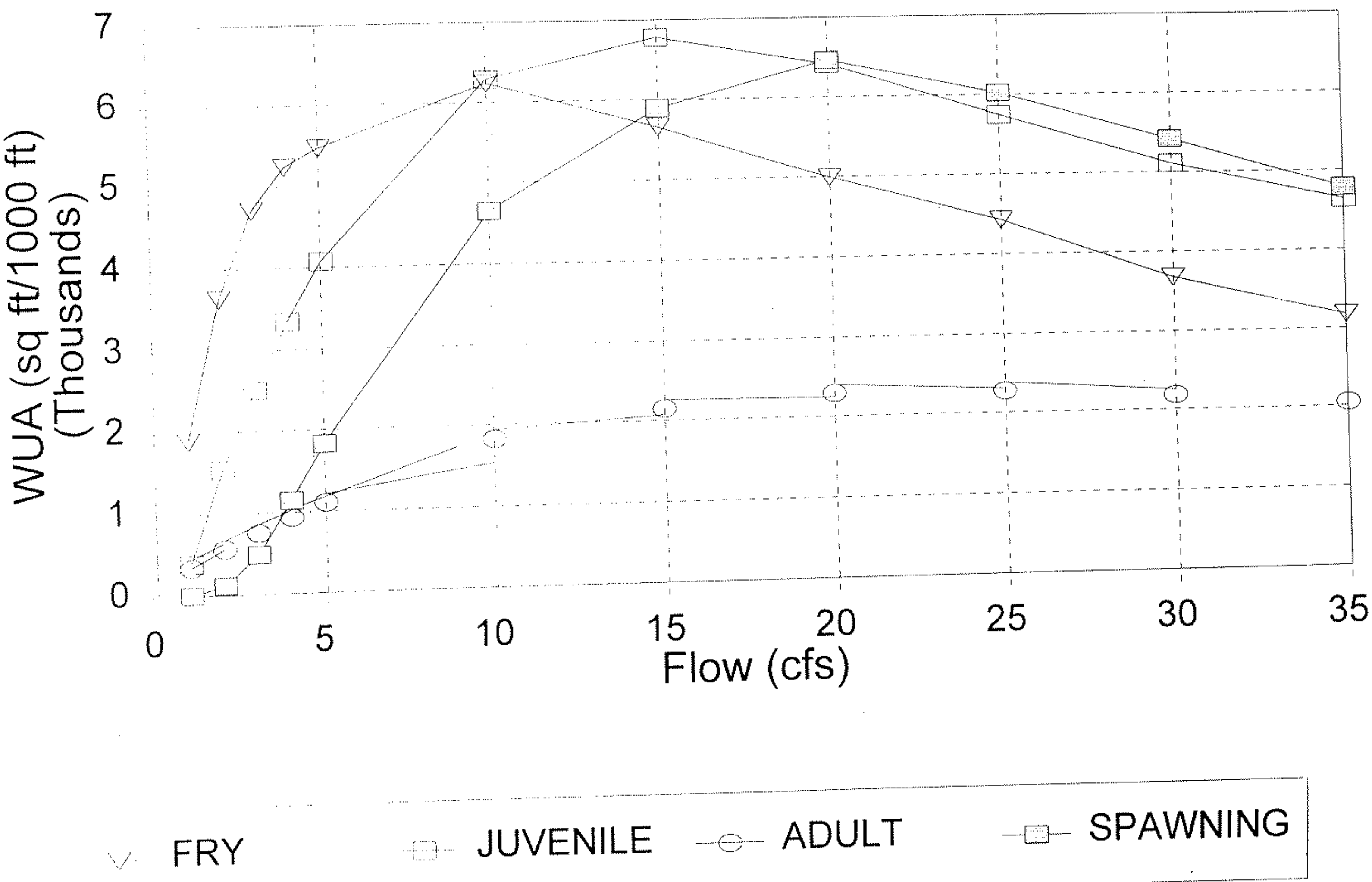
FLOW	FRY	JUVENI	ADULT	SPAWNING
5	52.553	67.691	19.905	4.7079
10	68.111	84.609	32.694	13.029
15	77.696	92.286	43.134	23.14
20	83.875	96.323	51.581	33.924
25	89.146	99.213	62.308	42.36
30	92.565	100	70.039	50.086
35	94.921	99.835	76.1	57.274
40	96.694	99.158	80.825	63.899
45	99.139	99.906	84.536	69.198
50	100	99.178	87.024	73.302
60	99.751	97.985	87.577	83.515
70	98.306	97.844	89.984	91.042
80	94.624	97.304	89.359	96.944
90	90.705	95.816	89.474	100
100	86.746	94.484	93.592	99.106
150	79.749	92.701	100	77.461
200	78.296	92.339	91.757	51.897
250	72.223	85.453	93.865	38.629

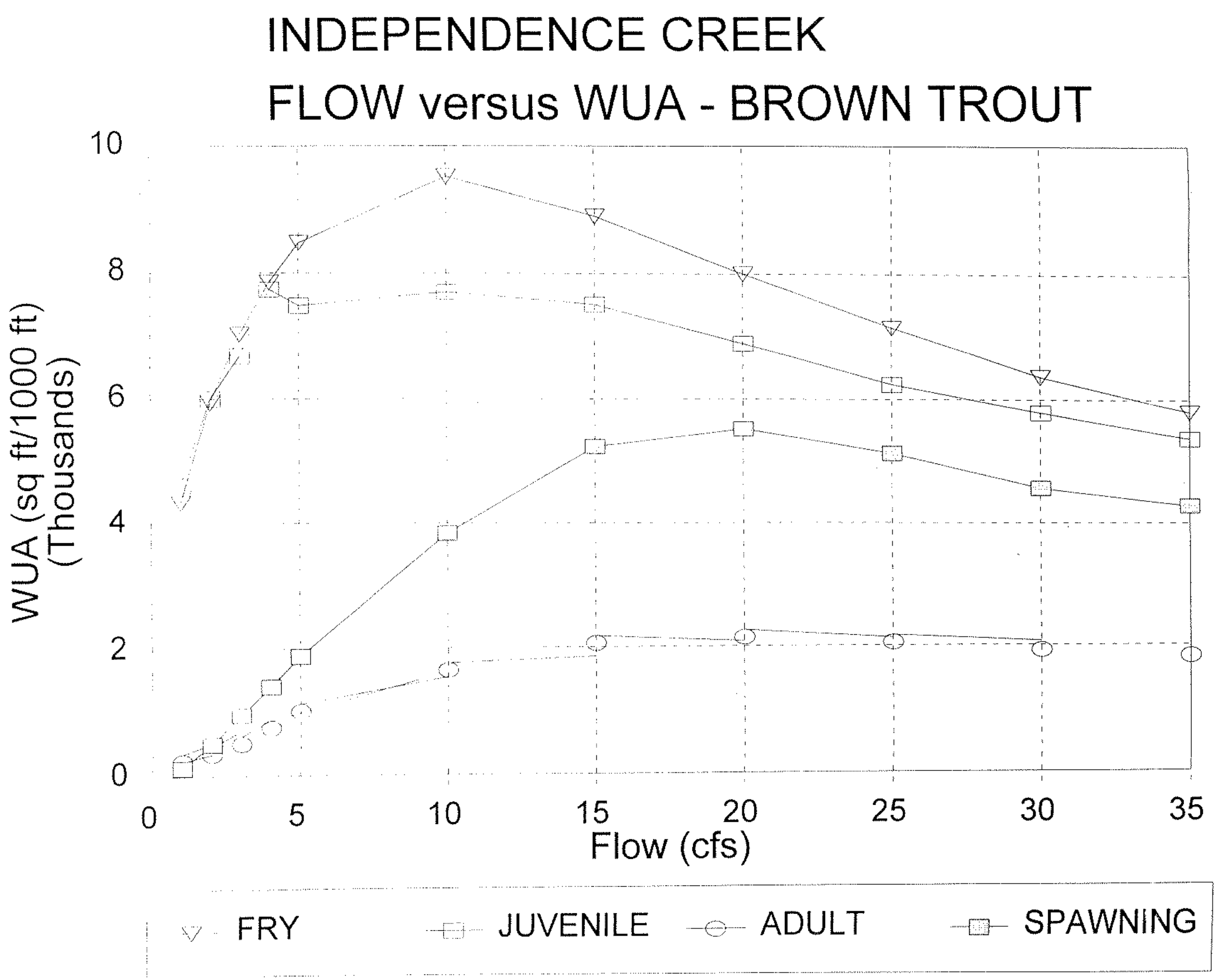
INDEPENDENCE CREEK

INDEPENDENCE CREEK
TOTAL HABITAT COMPOSITION

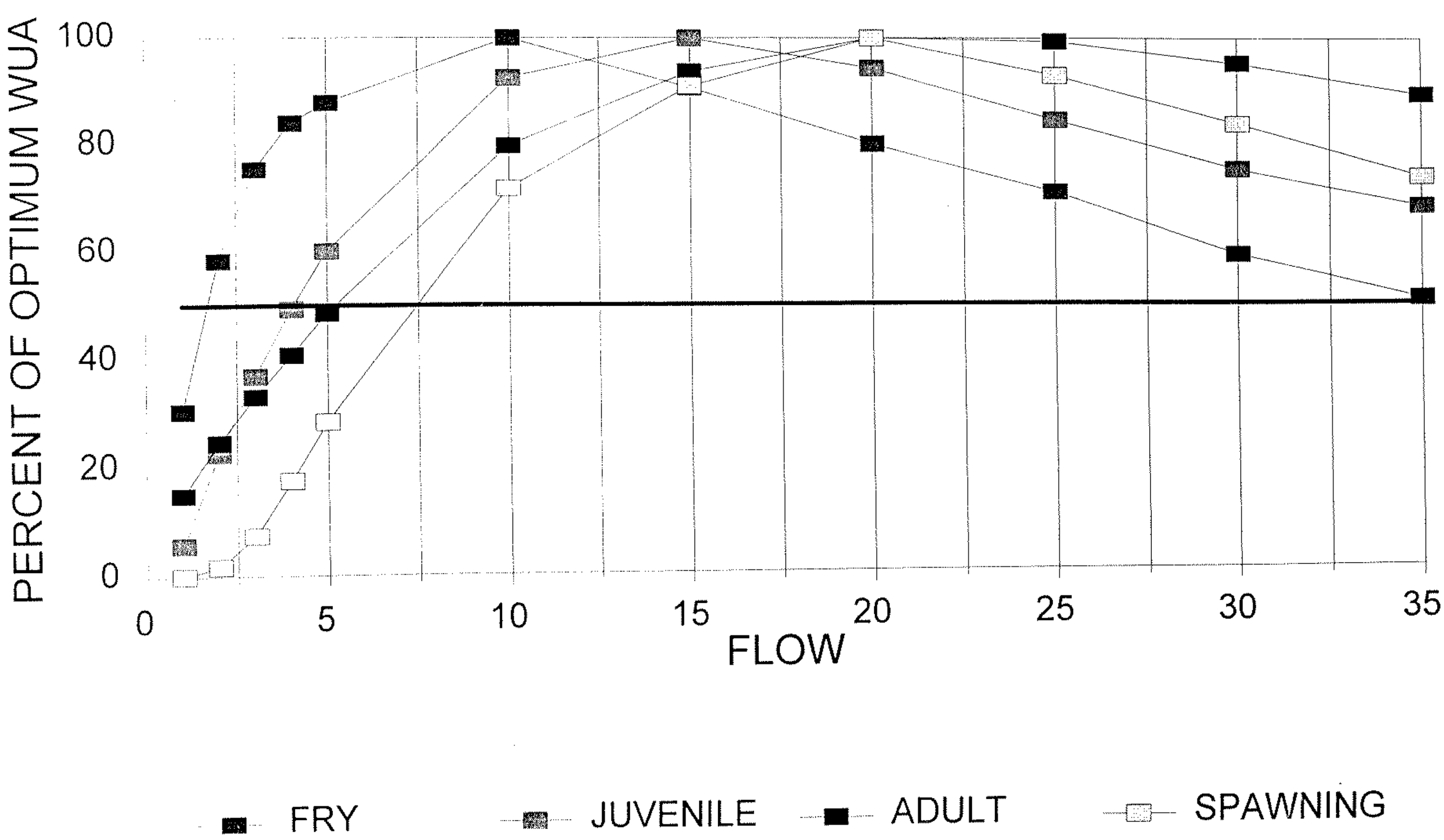


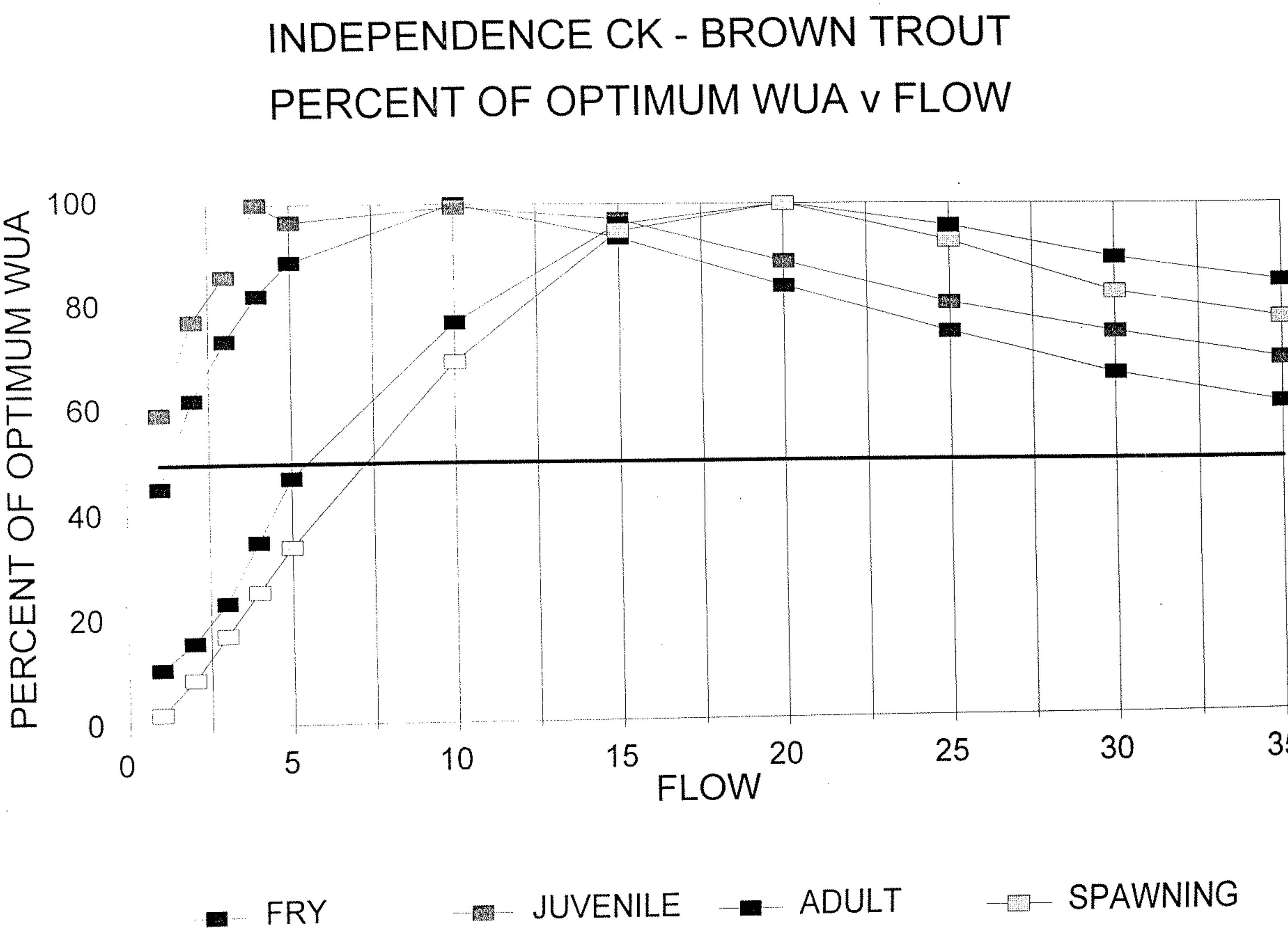
INDEPENDENCE CREEK
FLOW versus WUA - RAINBOW TROUT




INDEPENDENCE CREEK
FLOW versus WUA - BROWN TROUT
WUA (sq ft/1000 ft)
(Thousands)
10
8
6
4
2
0
0
5
10
15
20
25
30
35
Flow (cfs)
FRY
JUVENILE
ADULT
SPAWNING

INDEPENDENCE CK - RAINBOW TROUT
PERCENT OF OPTIMUM WUA v FLOW




INDEPENDENCE CK - BROWN TROUT
PERCENT OF OPTIMUM WUA v FLOW
PERCENT OF OPTIMUM WUA
100
80
60
40
20
0
0
5
10
15
20
25
30
35
FLOW
FRY
JUVENILE
ADULT
SPAWNING

INDEPENDENCE CREEK
SUMMARY OF ALL HABITAT TYPED (WEIGHTED)
RUN*.2959,RIFFLE*.4536,POOL*.1771
BROWN TROUT

FLOW	FRY	JUVENILE	ADULT	SPAWNING
1.00	4347.30	4623.31	237.51	138.02
2.00	5942.53	6005.49	346.63	501.58
3.00	7025.92	6675.49	505.71	961.32
4.00	7852.95	7741.61	755.83	1417.16
5.00	8478.64	7481.20	1017.68	1884.82
10.00	9528.86	7703.48	1658.45	3838.43
15.00	8911.58	7507.85	2066.83	5236.50
20.00	8005.09	6879.24	2150.08	5522.65
25.00	7136.73	6236.80	2055.78	5124.77
30.00	6360.01	5791.49	1923.46	4569.49
35.00	5800.00	5370.41	1824.51	4279.64

INDEPENDENCE CREEK
SUMMARY OF ALL HABITAT TYPED (WEIGHTED)
RUN*.2959,RIFFLE*.4536,POOL*.1771
BROWN TROUT PERCENT OPTIMUM WUA

FLOW	FRY	JUVENILE	ADULT	SPAWNING
1.00	45.62	59.72	11.05	2.50
2.00	62.36	77.57	16.12	9.08
3.00	73.73	86.23	23.52	17.41
4.00	82.41	100.00	35.15	25.66
5.00	88.98	96.64	47.33	34.13
10.00	100.00	99.51	77.13	69.50
15.00	93.52	96.98	96.13	94.82
20.00	84.01	88.86	100.00	100.00
25.00	74.90	80.56	95.61	92.80
30.00	66.74	74.81	89.46	82.74
35.00	60.87	69.37	84.86	77.49

INDEPENDENCE CREEK
SUMMARY OF ALL HABITAT TYPED (WEIGHTED)
RUN*.2959,RIFFLE*.4536,POOL*.1771
RAINBOW TROUT

FLOW	FRY	JUVENIL	ADULT	SPAWNING
1.00	1900.88	399.58	345.18	7.16
2.00	3637.78	1539.79	566.29	119.52
3.00	4712.47	2509.00	757.05	486.68
4.00	5246.49	3351.77	935.83	1145.56
5.00	5482.78	4080.09	1114.80	1835.68
10.00	6237.87	6285.51	1829.70	4652.76
15.00	5663.03	6788.11	2150.60	5894.76
20.00	4998.40	6412.08	2291.68	6465.54
25.00	4431.61	5745.37	2278.39	6022.30
30.00	3680.62	5115.51	2187.53	5426.61
35.00	3177.30	4635.42	2052.40	4785.79

INDEPENDENCE CREEK
SUMMARY OF ALL HABITAT TYPED (WEIGHTED)
RUN*.2959,RIFFLE*.4536,POOL*.1771
RAINBOW TROUT PERCENT OPTIMUM WUA

FLOW	FRY	JUVENIL	ADULT	SPAWNING
1.00	30.47	5.89	15.06	0.11
2.00	58.32	22.68	24.71	1.85
3.00	75.55	36.96	33.03	7.53
4.00	84.11	49.38	40.84	17.72
5.00	87.90	60.11	48.65	28.39
10.00	100.00	92.60	79.84	71.96
15.00	90.78	100.00	93.84	91.17
20.00	80.13	94.46	100.00	100.00
25.00	71.04	84.64	99.42	93.14
30.00	59.00	75.36	95.46	83.93
35.00	50.94	68.29	89.56	74.02

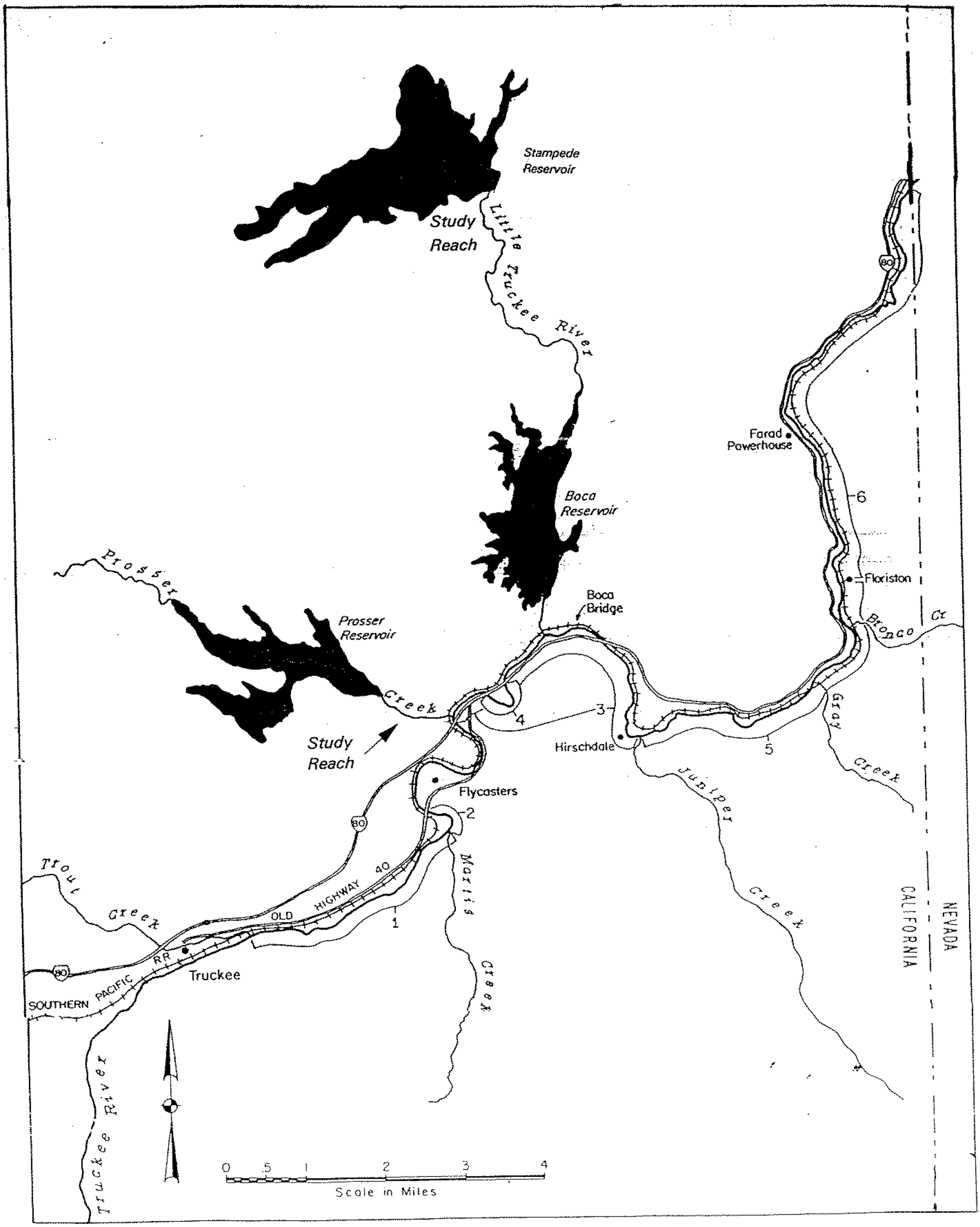


FIGURE 1. Study site locations.