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INSTREAM FLOW EVALUATION FOR SELECTED WATERWAYS OF THE BEAVERHEAD, BIG HOLE AND RED ROCK RIVER DRAINAGES OF SOUTHWEST MONTANA

by

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INTRODUCTION

The purpose of this report is to provide the Bureau of Land Management with instream flow related information for 18 trout streams and rivers in southwest Montana. These streams are generally of mutual interest to both the Montana Department of Fish, Wildlife and Parks and the Bureau of Land Management due to their high fishery, recreational and other resource values.

Two types of basic instream flow information are provided. They consist of fish population data and a quantification, in terms of cubic feet of water per second, of the instream flows needed for maintaining the existing fishery resource. Other pertinent background and descriptive information for the streams of interest is also provided.

The 18 contract streams are organized in alphabetical order by river drainage. These drainages are:

Beaverhead
Big Hole and
Red Rock.

The methodologies used in quantifying the instream flow needs, fish sampling techniques and other related information are thoroughly discussed in the following sections.

INSTREAM FLOW METHODOLOGIES

The best and most accurate method for determining the instream flow needs for fish and wildlife purposes is to derive the actual flow and biological relationships from long-term data collected in drought, normal and above normal water years. While this approach has been tried on a few selected waterways in Montana, it is not a practical means of deriving future recommendations due to the excessive time, cost and manpower required to collect field data. Consequently, flow recommendations for most waterways are derived from instream flow methods that are more compatible with existing budget and time constraints, yet provide acceptable and defendable recommendations.

The method of the MDFWP divides the annual flow cycle for the headwater streams and rivers into two separate periods. They consist of a relatively brief snow runoff or high flow period, when a large percentage of the annual water yield is passed through the system, and a nonrunoff or low flow period which is characterized by relatively stable base flows maintained primarily by groundwater outflow. For headwater rivers and streams, the high flow period generally includes the months of May, June and July while the remaining months (approximately August through April) encompass the low flow period.

Separate instream flow methodologies are applied to each period. Further, it is necessary to classify a waterway as a stream or river and to use a somewhat different approach when deriving low flow recommendations for each. A waterway is considered a stream if the mean annual flow is less than approximately 200 cfs. The vast majority of waterways discussed in later sections have mean annual flows less than 100 cfs.

Methodology for Low Flow Period - Streams

The methodology chosen for deriving low flow recommendations for headwater trout streams is primarily based on the assumption that the food supply is a major factor influencing a stream's carrying capacity (the numbers and pounds of trout that can be maintained indefinitely by the aquatic habitat). The principal food of both the juvenile and adult trout inhabiting the headwater streams of Montana is aquatic invertebrates which are primarily produced in the riffle areas of most streams. The methodology assumes that the trout carrying capacity is proportional to food production which in turn is proportional to the wetted perimeter in riffle areas. This method is a slightly modified version of the Washington Method (Collings, 1972 and 1974) which is based on the premise that the rearing of juvenile salmon is proportional to food production which in turn is proportional to the wetted perimeter in riffle areas. The Idaho Method (White and Cochnauer, 1975 and White, 1976) is also based on a similar premise.

Wetted perimeter is the distance along the bottom and sides of a channel cross-section in contact with water (Figure 1). As the flow in the stream channel decreases, the wetted perimeter also decreases, but the rate of loss of wetted perimeter is not constant throughout the entire range of flows. An example of a relationship between wetted perimeter and flow for a riffle cross-section is illustrated in Figure 2 .

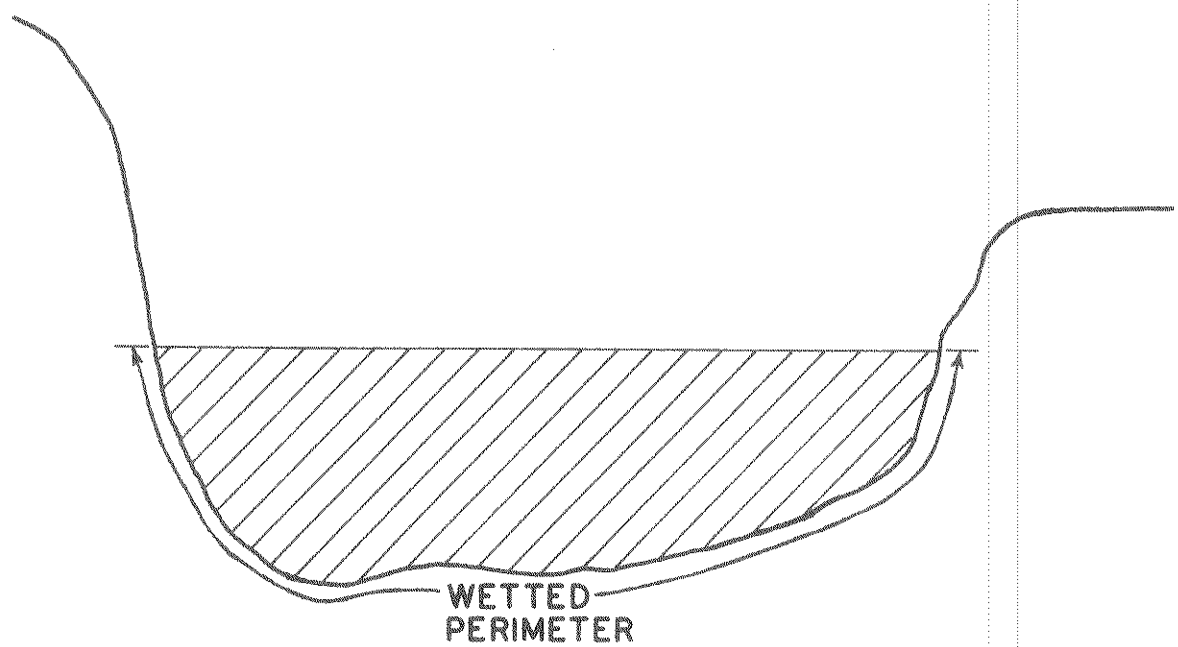

Figure 1. The wetted perimeter in a channel cross-section.

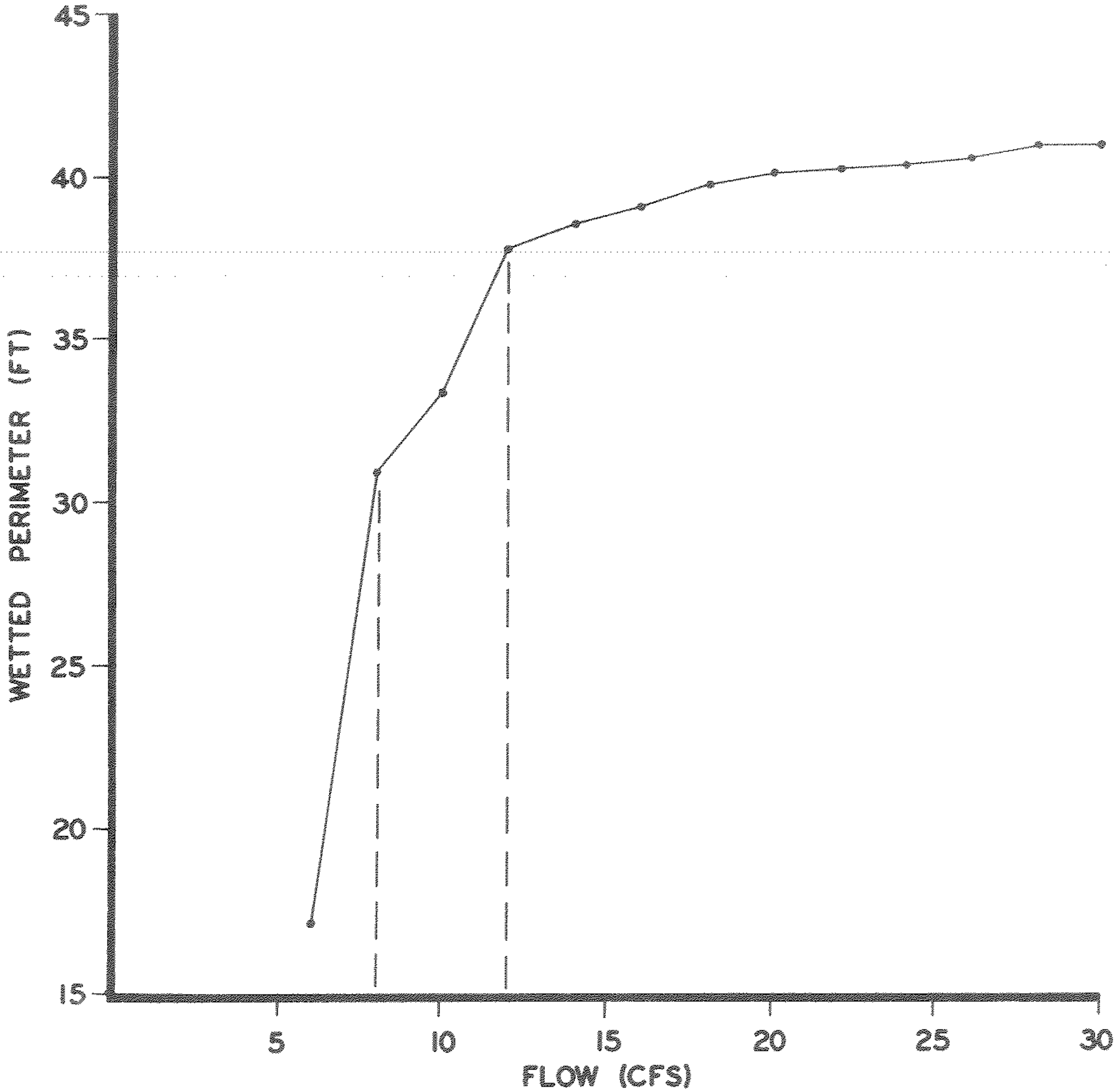

Figure 2. An example of a relationship between wetted perimeter and flow for a riffle cross-section.

There are generally two points, called inflection points, on the plot of wetted perimeter versus flow at which the rate of loss of wetted perimeter is significantly changed. In the example (Figure 2), these inflection points occur at approximate flows of 8 and 12 cfs. Beyond the upper inflection point, large changes in flow cause only very small changes in wetted perimeter. The area available for food production is considered near optimal beyond this inflection point. Below the upper inflection point, the stream begins to pull away from the riffle bottom. At the lower inflection point, the rate of loss of wetted perimeter begins to rapidly accelerate. Once flows are reduced below the lower inflection point, the riffle bottom is being exposed at an accelerated rate and the area available for food production greatly diminishes.

The wetted perimeter-flow relationship may also provide an index of other limiting factors that influence a stream's carrying capacity. One such factor is cover. Cover, or shelter, has long been recognized as one of the basic and essential components of fish habitat. Cover serves as a means for avoiding predators and provides areas of moderate current speed used as resting and holding areas by fish. It is fairly well documented that cover improvements will normally increase the carrying capacity of streams, especially for larger size fish. Cover can be significantly influenced by streamflow.

In the headwater streams of Montana, overhanging and submerged bank vegetation is an important component of trout cover. The wetted perimeter-flow relationship for a stream channel may bear some similarity to the relationship between bank cover and flow. At the upper inflection point, the water begins to pull away from the banks, bank cover is lost and the stream's carrying capacity declines. Flows exceeding the upper inflection point are considered to provide near optimal bank cover. At flows below the lower inflection point, the water is sufficiently removed from the bank cover to severely reduce its value as fish shelter. It is reasonable to assume that this premise would be more acceptable if the wetted perimeter-flow relationships were also derived for pools and runs, areas normally inhabited by adult trout. However, cross-sections through pools and runs may not be necessary. When the wetted perimeter-flow relationship for riffles and the composite of all habitat types (pools, runs and riffles) comprising a study section are compared, as illustrated in Figure 3 , the shape of the curves and, consequently, the flows at which the inflection points occur, are very similar. This similarity is probably explained by the fact that most headwater streams, due to their high gradients, tend to be mainly comprised of riffle areas. Pools are generally few in number and poorly developed. A riffle area, therefore, describes the typical habitat type that normally occurs throughout most headwater streams.

It has been demonstrated that riffles are also critical areas for spawning sites of brown trout and shallow inshore areas are required for the rearing of brown and rainbow trout fry (Sando, 1981). It is, therefore, assumed that, in addition to maximizing bank cover and food production, the flows exceeding the upper inflection point would also provide favorable spawning and rearing conditions.

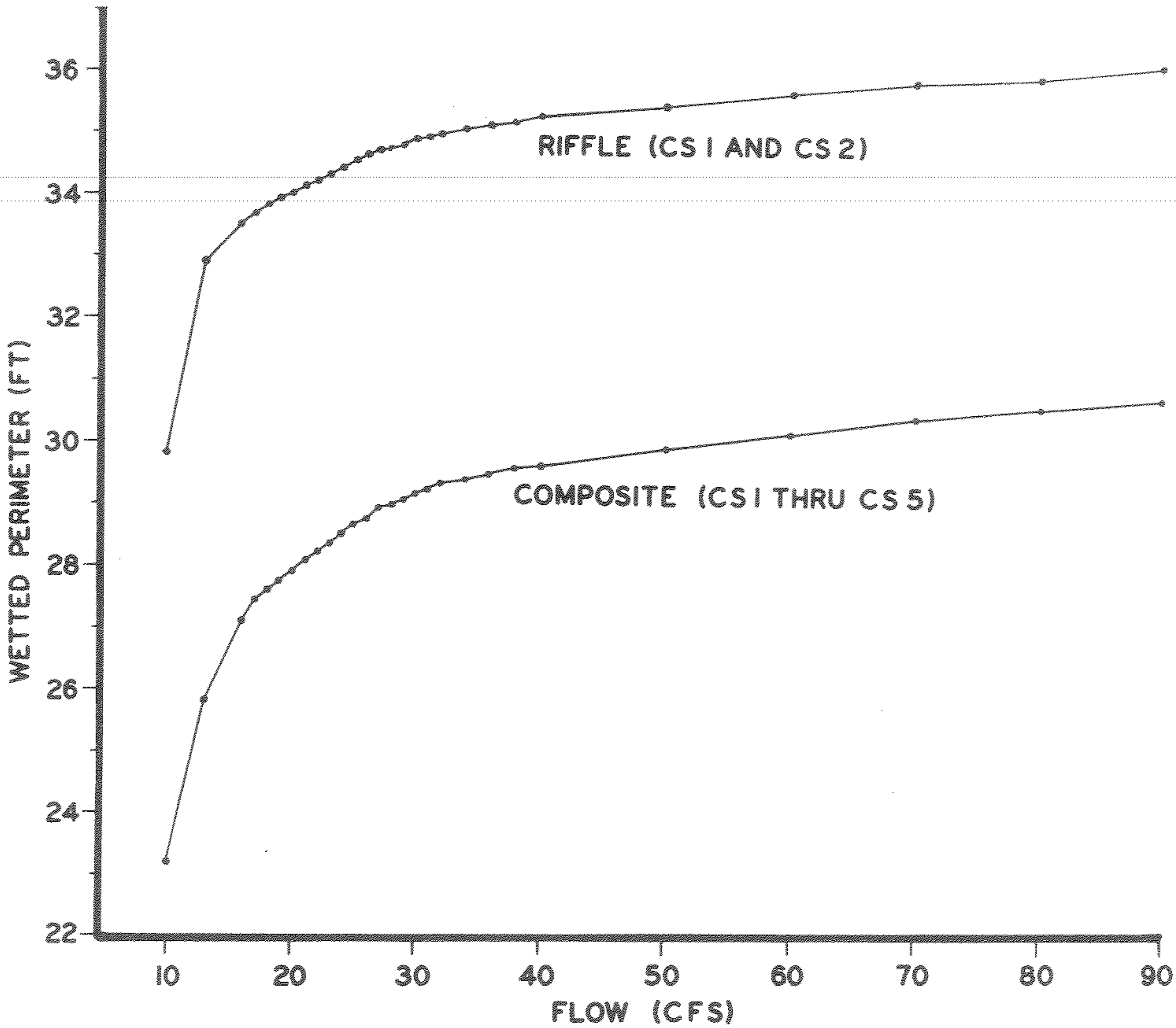

Figure 3. Comparison of the relationships between wetted perimeter and flow for a composite of five cross-sections encompassing various habitat types and a composite of two riffle cross-sections in a subreach of Cherry Creek, Madison River drainage.

Riffles are the area of a stream most affected by flow reductions (Bovee, 1974 and Nelson, 1977). Consequently, the flows that maintain suitable riffle conditions will also maintain suitable conditions in pools and runs, areas normally inhabited by adult trout. Because riffles are the habitat most affected by flow reductions and are essential for the well-being of both resident and migratory trout populations, they should receive the highest priority for instream protection.

The wetted perimeter/inflection point method provides a range of flows (between the lower and upper inflection points) from which a single instream flow recommendation can be selected. Flows below the lower inflection point are judged undesirable based on their probable impacts on food production, bank cover and spawning and rearing habitat, while flows exceeding the upper inflection point are considered to provide a near optimal habitat for trout. The flows at the lower and upper inflection points are believed to bracket those flows needed to maintain the low and high levels of aquatic habitat potential. These flow levels are defined as follows:

1. High Level of Aquatic Habitat Potential - That flow regime which will consistently produce abundant, healthy and thriving aquatic populations. In the case of game fish species, these flows would produce abundant game fish populations capable of sustaining a good to excellent sport fishery for the size of stream involved. For rare, threatened or endangered species, flows to accomplish the high level of aquatic habitat maintenance would: 1) provide the high population levels needed to ensure the continued existence of that species, or 2) provide for flow levels above those which would adversely affect the species.

2. Low Level of Aquatic Habitat Potential - Flows to accomplish a low level of aquatic habitat maintenance would provide for only a low population abundance of the species present. In the case of game fish species, a poor sport fishery could still be provided. For rare, threatened or endangered species, their populations would exist at low or marginal levels. In some cases, this flow level would not be sufficient to maintain certain species.

The final flow recommendation is selected from this range of flows by the fishery biologist who collected, summarized and analyzed all relevant field data for the streams of interest. The biologist's rating of the stream resource forms the basis of the flow selection process. Factors considered in the biologist's evaluation include recreational usage, the existing level of environmental degradation, water availability and the magnitude and composition of existing fish populations. The fish population information, which is essential for all streams, is a major consideration. A nonexistent or poor fishery would likely justify a flow recommendation at or near the lower inflection point unless other considerations, such as the presence of species of special concern (arctic grayling and cutthroat trout), warrant a higher flow. In general, only streams with exceptional resident fish populations or those providing crucial spawning and/or rearing habitat for migratory populations would be considered for a recommendation at or near the upper inflection point.

For those streams that support resident salmonid populations and provide crucial spawning and/or rearing habitat for migratory populations as well, the flow recommendations derived from the wetted perimeter/inflection point method would, in addition to maintaining the resident population at the existing level, also serve to:

1) facilitate the movement of adults to upstream spawning areas and their return to downstream residencies,

2) maintain favorable spawning and incubation habitat,

3) maintain favorable habitat for the rearing of fry and juveniles, and

4) facilitate the movement of juveniles to downstream adult residencies.

The process of deriving the flow recommendation for the low flow period, thusly, combines a field methodology (wetted perimeter/inflection point method) with a thorough evaluation by a field biologist of the existing stream resource.

The wetted perimeter-flow relationships are derived using a wetted perimeter predictive (WETP) computer program developed in 1980 by the Montana Department of Fish, Wildlife and Parks (Nelson, 1980). This program was designed to eliminate the relatively complex data collecting procedures associated with the hydraulic simulation computer models in current use while providing more accurate wetted perimeter predictions.

Description of the WETP Program and Data Collecting Procedures

The WETP program uses at least two sets of stage (water surface elevation) measurements taken at different know discharges (flows) to establish a least-squares fit of log-stage versus log-discharge. Once the stage-discharge rating curve for each cross-section is determined, the stage at a flow of interest can be predicted. This rating curve, when coupled with the cross-sectional profile, is all that is needed to predict the wetted perimeter at most flows of interest.

The program should be run using three sets of stage-discharge data collected at a high, intermediate and low flow. Additional data sets are desirable, but not necessary. The three measurements are made when runoff is receding (high flow), near the end of runoff (intermediate flow) and during late summer-early fall (low flow). The high flow should be considerably less than the bankful flow while the low flow should approximate the lowest flow that normally occurs during the summer-fall field season. Sufficient spread between the highest and lowest calibration flows is needed in order to compute a linear, sloping rating curve (Figure 4).

The WETP program can be run using only two sets of stage-discharge data. This practice is not recommended since substantial "two-point" error can result. However, when only two data sets are obtainable, the higher discharge should be at least twice as high as the lower discharge.

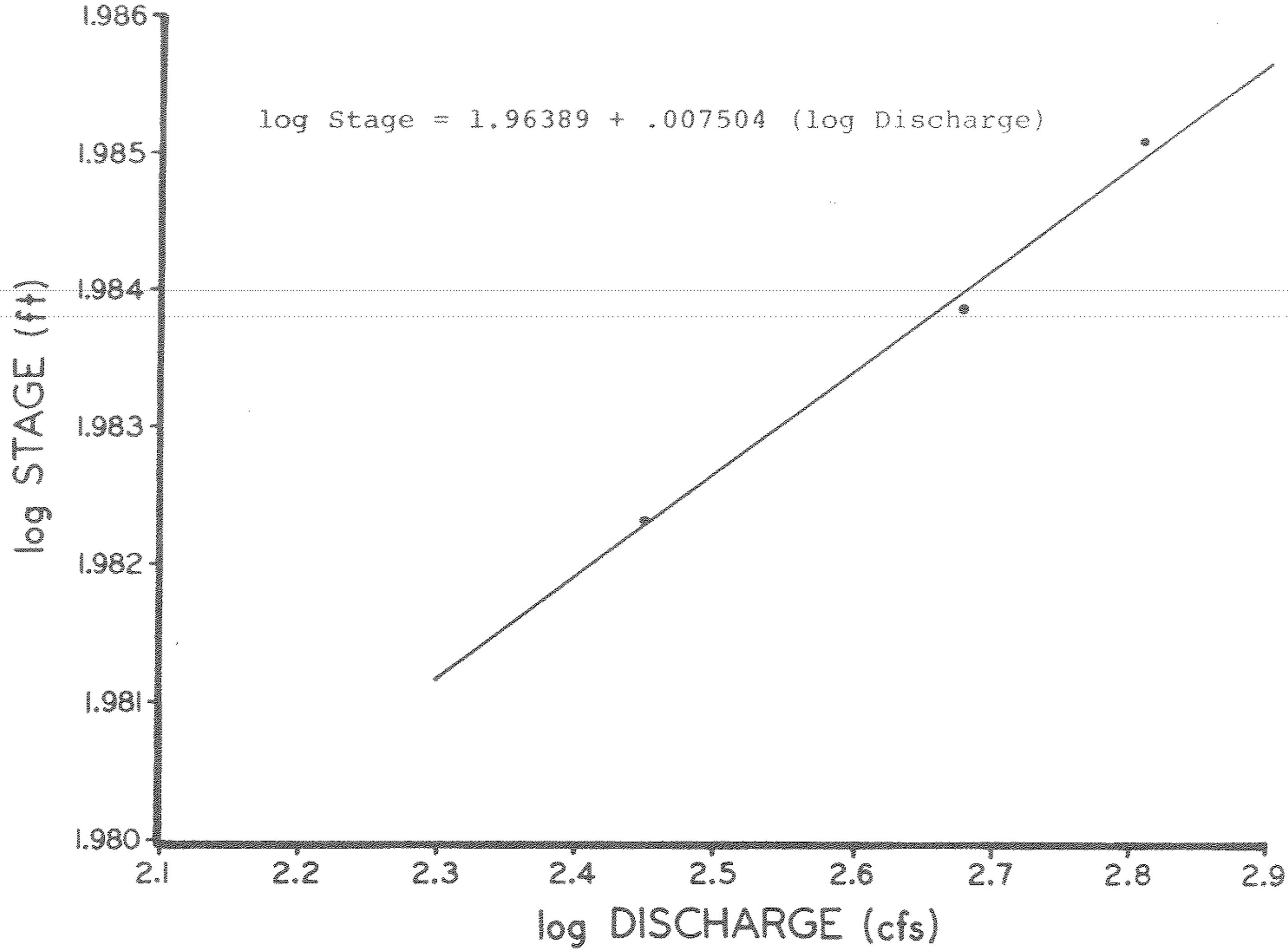

Figure 4. An example of a "three point" stage-discharge rating curve for a riffle cross-section.

The WETP model is invalidated if channel changes occur in the study area during the data collecting process. For this reason, the collection of the field data needed for calibrating the program should be completed during the period beginning when runoff is receding and ending with the onset of runoff the following year. The stream channel is expected to be stable during this period.

Cross-sections were placed in an area that typified the stream reach for which instream flow recommendations were to be derived. For the headwater streams, this would mean a sequence from the head of a riffle to the head of the next riffle. This sequence was described using from 5 to 10 cross-sections. The cross-sections were placed to describe the typical habitat types in the proportion that they occurred within each sequence. The cross-sections were classified as riffles, runs or pools and recorded. The cross-sections through pools and runs were subsequently eliminated from the analyses since, as previously explained, there appears to be little justification or advantage for their use in the flow recommendation process.

The recommendations were selected solely from the wetted perimeter-flow relationships for riffle areas. If two or more riffle cross-sections were available, the computed wetted perimeters for all riffle cross-sections at each flow of interest were averaged and the recommendation selected from the wetted perimeter-flow relationship for the composite of all riffle cross-sections.

The limitations and advantages of the WETP program, as well as field data requirements and surveying techniques, are discussed by Nelson (1980).

Methodology for Low Flow Period - Rivers

The wetted perimeter/inflection point method will, if used correctly, provide defendable flow recommendations for the headwater trout streams. While the underlying assumptions of this method appear valid, it cannot yet be said that the method enables the biologist to accurately predict the effects of flow reductions on the trout standing crops and the carrying capacity of the aquatic habitat. The validation of this method can only be accomplished by comparing the range of possible flow recommendations generated by the method to those recommendations derived from the actual relationships between trout standing crops and flow.

The Montana Department of Fish, Wildlife and Parks completed a study in 1980 that validated the wetted perimeter method as applied to the trout rivers of southwest Montana (Nelson, 1980a, 1980b and 1980c). In this study, the actual trout standing crop and flow relationship were derived from long-term data collected for five reaches of the Madison, Gallatin, Big Hole and Beaverhead Rivers, all nationally acclaimed wild trout fisheries. These relationships provided a range of flow recommendations for each reach. Flows less than the lower limit were judged undesirable since they led to substantial reductions of the standing crops of adult trout or the standing crops of a particular group of adults, such as trophy-size trout. Flows greater than the upper limit supported the highest adult standing crops during the study period. Flows between the lower and upper limits are broadly defined as those flows supporting intermediate standing crops or those standing crops that normally occur within each reach. The final recommendation was selected from this range of flows.

The range of flows derived from the trout-flow relationships for the five river reaches were compared to those derived from the wetted perimeter method as applied to riffle areas. The study results showed that the inflection point flows had a somewhat different impact on the trout standing crops of rivers than previously assumed for streams. For rivers, the flow at the upper inflection point is a fairly reliable estimate of the lower limit of the range of flows derived from the trout-flow relationships or, in other terms, flows less than the upper inflection point are undesirable as recommendations since they lead to substantial reductions of the standing crops of adult trout.

The flow at the upper inflection point is not necessarily the preferred recommendation for all trout rivers. The "Blue Ribbon" rivers would generally require a higher flow in order to maintain the sport fishery resource at the existing level. For those rivers having a lower resource rating, the flow at the upper inflection point may be a satisfactory recommendation. In general, flows less than the upper inflection point are undesirable as flow recommendations regardless of the existing state of the river resource.

Methodology for High Flow Period - Streams and Rivers

Several major components of aquatic habitat in river systems are related to the physical features and form of the river channel itself. Over time, aquatic populations have adapted and thrived within the physical contraints of channel configuration and flow. Basic to the maintenance of the existing aquatic populations is the maintenance of the existing habitat that has historically sustained them.

It is generally accepted that the major force in the establishment and maintenance of a particular channel form in view of its bed and bank material is the annual high flow characteristics of the river. It is the high spring flows that determine the shape of the channel rather than the average or low flows.

Most unregulated headwater streams and rivers in Montana are characterized by an annual spring high water period which normally occurs during May, June and July and results from snowmelt in the mountainous headwaters. Annual spring flow conditions on unregulated streams are heavily dependent upon snowpack and its rate of thawing. On regulated streams, the occurrence and magnitude of the high water period may vary depending upon reservoir operation and storage capacity.

The major functions of the high spring flows in the maintenance of channel form are bedload movement and sediment transport. It is the movement of the bed and bank material and subsequent deposition which forms the mid-channel bars and, subsequently, the islands. High flows are capable of covering already established bars with finer material which leads successively to vegetated islands. Increased discharge associated with spring runoff also results in a flushing action which removes deposited sediments and maintains suitable gravel conditions for aquatic insect production, fish spawning and egg incubation.

Reducing the high spring flows beyond the point where the major amount of bedload and sediment is transported would interrupt the ongoing channel processes and change the existing channel form and bottom substrates. A significantly altered channel configuration would affect both the abundance and species composition of the present aquatic populations by altering the existing habitat types.

Several workers (Leopold, Wolman and Miller 1964, US Bureau of Reclamation 1973, and Emmett 1975) adhere to the concept that the form and configuration of river channels are shaped by and designed to accommodate a dominant discharge. The discharge which is most commonly referred to as a dominant discharge is the bankful discharge (Leopold, Wolman and Miller 1964, Emmett 1975). Bankful discharge is defined as that flow when water just begins to overflow onto the active flood-plain.

Bankful discharge tends to have a constant frequency of occurrence among rivers (Emmett 1975). The recurrence interval for bankful discharge was determined by Emmett (1975) to be 1.5 years and is in close agreement with the frequency of bankful discharge reported by other studies (Leopold, Wolman and Miller 1964, Emmett 1972).

The bankful discharge for streams and rivers was estimated by using the 1½ year frequency peak flow. The 1½ year frequency peak flow was determined by interpolation between the 1.25 and 2 year frequency peak flows as supplied by the USGS for the streams and rivers in question.

It is not presently known how long the bankful flow must be maintained to accomplish the necessary channel formation processes. Until studies further clarify the necessary duration of the bankful discharge, a duration period of 24 hours is chosen.

A gradual rising and receding of flows should be associated with the dominant discharge and the shape of the spring hydrograph should resemble that which occurs naturally. USGS flow records were used to determine the time when the high flow period and peak flow normally occur on a given stream. The dominant discharge is requested for that period when it normally occurs. Flows are increased from a base flow level to the dominant discharge in 2-week intervals at the 80th percentile flow level, corresponding to the natural timing of the high flow period.

The 80th percentile is the flow that is exceeded in 8 of 10 years or, in other terms, in 8 years out of 10 there is more water than the 80th percentile flowing in the stream. The 80th percentile was chosen in part because of its compatability with irrigation development. To economically develop efficient, full-service irrigation systems, a good water supply is considered necessary in about 8 years out of 10, on the average (MDNRC, 1976). It is also our belief that the high flow months can withstand substantial withdrawals and not alter the basic functions of channel maintenance. The 80th percentile flows allow for substantial water depletions.

The above instream flow method, which is termed the dominant discharge/channel morphology concept, can only be applied to those streams and rivers having at least 9 years of continuous USGS gauge records. While 10 years is the minimum period of record the USGS considers adequate for deriving reliable estimates of the 80th percentile flows, a minimum period of 9 years is used for this report.

High flow recommendations cannot be derived for the vast majority of streams and rivers considered in this report because most lack long-term flow records.

FISH POPULATIONS

The salmonid populations within the contract streams and rivers of the Beaverhead, Big Hole and Red Rock River drainages primarily consist of year-round residents. These fish are non-migratory, completing all of their life functions and stages in a relatively short stretch of stream. Unlike resident populations, migratory populations reside as adults and/or subadults in a river, lake or reservoir and use the tributaries for spawning and the rearing of their young. The only contract streams in which rearing trout and grayling are known to comprise portions of the existing stream populations are found in the Centennial Valley of the Red Rock River drainage. A description of the Centennial Valley fishery is provided in the following section.

Centennial Valley Fishery

Fish populations of the Centennial Valley in southwest Montana have been investigated since the beginning of the century. As early as 1899, investigations of the life history and habitat requirements of the Centennial Valley arctic grayling were reported by Henshall (1907). Brown (1938) continued to examine this species, expanding his studies into their breeding habits, fecundity, fry emergence and growth. Beginning in 1951, Nelson (1954a) evaluated the status of the existing grayling populations, postulated on the causes of their apparent decline and formulated management goals for their continued survival.

During 1975 and 1976, an interagency team comprised of personnel of the BLM, USFS, USFWS and MDFWP began an intensive study of the status of the present habitat and fish populations of the Centennial Valley. Emphasis was placed on the adfluvial and fluvial populations of arctic grayling and their seasonal movements. Although the interagency investigation was completed in 1976, the MDFWP continues to annually monitor grayling spawning migrations and the status of fish populations of selected lakes and streams in the valley.

The arctic grayling population of the Centennial Valley appears to be almost entirely adfluvial. These fish reside as adults and subadults in the Red Rock Lakes (primarily the upper lake) and use the tributaries for spawning and rearing of their young. Adult grayling begin moving into the tributaries as early as late April and complete spawning by early June (Nelson, 1954a). Males dominate the first half of the run while the females are more numerous in the second half. Age III grayling comprise approximately 90% of the run (Nelson, 1954a and Peterson, 1979). Optimum spawning temperatures are between 45-50°F. The fish primarily spawn in clean gravels of riffle areas. The fry emerge 14-19 days after fertilization. Fry are numerous throughout June in stream backwaters and areas of low current velocities. By mid-July most fry have drifted to the Red Rock Lakes. Low water temperatures (<55°F) may cause the fry to drift downstream more rapidly.

In 1951, as a result of beaver activity and irrigation practices, only five tributaries were accessible to spawning grayling (Nelson, 1954a). After the removal of 85 beaver structures prior to the 1952 spawning season, arctic grayling were observed in 12 of the 48 streams that drain the Centennial Valley (Nelson, 1954a). These included Red Rock, Odell, Tom, Battle, Antelope, Elk Springs, Corral, West, Metzel, Long and Hellroaring Creeks. The historic and present use of some of these streams by adfluvial arctic grayling will be discussed in subsequent sections.

Henshall (1907) reported that arctic grayling were observed year-round in several streams of the Centennial Valley. These resident or fluvial grayling reside in the tributaries year-round, completing their entire life cycle within a relatively short stretch of stream. Recent fall electrofishing surveys confirm that a resident population appears only to exist in Odell Creek (Peterson, 1979).

From 1890-1920, both the native arctic grayling and cutthroat trout were reported as abundant in the upper valley (Blair, 1897, Brower, 1897, and Henshall, 1907). The decline of the arctic grayling, which was first observed in 1935, is attributed to a combination of man-caused and natural changes to their habitat. Ranches began to appear in the valley in the late 1800's (Brower, 1897). Water was diverted from the streams for the irrigation of hay meadows and riparian zones were grazed. Spawning beds were dewatered and spawned-out grayling and fry were lost to ditches and hay meadows. After the Red Rock Lakes area was acquired by the USFWS as a refuge in 1935, habitat destruction resulting from agricultural practices intensified (Nelson, 1954a). Presently, grazing on the refuge has been decreased by 50 percent and little land is being irrigated.

Severe reductions in the depth of Upper Red Rock Lake, resulting from accelerated erosion rates within the drainage and the natural deposition of organic matter, have occurred in the last century. Presently, the lake has a maximum depth of 7.1 ft as compared to depths of 10-25 ft reported in 1897 (Paullin,1973). Due to high summer water temperatures and low winter oxygen supplies, the lake has become marginal for arctic grayling and cutthroat and brook trout. The high numbers of suckers that compete for the limited winter oxygen supply may also be affecting the grayling population. The lower lake is extremely shallow and supports few gamefish.

Other factors possibly contributing to the decline of grayling include the competition from introduced salmonid species (brook, rainbow, brown and Yellowstone cutthroat trout) and the increased beaver activity on the tributary streams to the lakes. Beaver dams are presently blocking seasonal spawning migrations on many of these tributaries.

Both fluvial and adfluvial cutthroat trout inhabit the Centennial Valley. Fluvial or resident cutthroat are non-migratory, completing all their life functions and stages in a relatively short stretch of stream. Adfluvial cutthroat reside as adults and subadults in the Red Rock Lakes and utililze Red Rock, Hellroaring and Odell Creeks for spawning and the rearing of their young. Spawning begins in mid-April and continues through May (Randall, 1978). Fingerlings have been observed in the tributaries through late-July (MDFWP, unpublished data). The movement of these fingerlings to the lakes has not been documented.

FISH POPULATION ESTIMATES

As previously discussed, an evaluation of existing fish populations is an essential component of the flow recommendation process. In addition to providing a means for partially justifying the selection of a particular flow recommendation, the fish data also serve to document the state of the existing fishery resource. Personnel of the Montana Department of Fish, Wildlife and Parks expended considerable time and effort in collecting this information and summarizing it for use in the recommendation process and for comparison with the populations of other streams and rivers.

Bank and boat-mounted electrofishing units were used in surveying fish populations and estimating standing crops. The electrofishing technique is discussed as follows.

Electrofishing

Fish populations in the streams of the Beaverhead, Big Hole and Red Rock River drainages were sampled using a bank electrofishing unit basically consisting of a 110 volt Honda gas generator, a Fisher shocker box, a 500 ft cord, a stationary negative electrode, and a hand-held, mobile positive electrode. For the larger waterways, a boat mounted electrofishing unit was sometimes required to effectively sample the population. A mild electric shock temporarily immobilizes the fish located in the immediate vicinity of the positive electrode, allowing them to be dip netted. The fish capturing efficiency of the units is highly variable since efficiency rates are influenced by stream size, the magnitude of the flow, water clarity, specific conductance, water temperature, cover types and the species and size of fish. For the waterways considered in this report, up to approximately 47 percent of the total population was captured during a single electrofishing run.

The fish population is enumerated using a mark-recapture method which allows for the estimation of the total numbers and pounds (the standing crops) of fish within a stream section. For most streams, standing crop estimates were obtained for 1,000 ft study sections. The larger waterways sometimes required longer sections in order to obtain reliable estimates.

The standing crop estimates require at least two electrofishing runs through each study section. During the first or marking run, all captured fish are anesthetized, marked with a partial caudal fin clip so they can be later identified, then released after individual lengths and weights are recorded. It is desirable to make the second or recapture run at least two weeks after the marking run. This two week period allows the marked fish to randomly redistribute themselves throughout the population. During the recapture run, all captured fish are again anesthetized and released after the lengths and weights of all new (unmarked) fish and the length only of all marked fish are recorded. The population estimate is basically obtained using the formula $P = \frac{MC}{R}$; where P is the estimated number of fish, M is the number initially marked, C is the number of marked and unmarked fish collected during the recapture run, and R is the number of marked fish collected during the recapture run. This formula, although somewhat modified in its final form for statistical reasons, is the basis of the mark-recapture technique.

The numbers of fish are actually estimated by length groups. Those ½ inch length intervals having similar or equal recapture efficiencies comprise a length group. This grouping is necessary because recapture efficiencies are dependent on fish size. Generally, electrofishing is more effective for capturing larger fish due to their greater surface area and their higher visibility when in the electric field. Because recapture efficiencies are length related, the numbers of fish must be estimated by length groups, then added to obtain the total estimate. Generally, at least seven recaptures are needed per length group in order to obtain a statistically valid estimate.

Pounds of fish are obtained by multiplying the average weight of the fish within each length group by the estimated number, then adding to obtain the total pounds. Estimates can also be obtained for different age-groups of fish. This mark-recapture technique, which is thoroughly discussed by Vincent (1971 and 1974), has been adapted for computer analyses by the DFWP.

Only electrofishing survey data, consisting of the species, numbers and length ranges of captured fish, are provided for those streams in which fish populations are too sparse to reliably estimate using the mark-recapture method. These comprise approximately 10 percent of the streams discussed in this report.

WATER AVAILABILITY

The instream flow recommendations presented in later sections will, if enacted, limit the availability of water for future consumptive users and water development projects. For future planning, it is desirable to define the period in which water in excess of the recommendations is available and to quantify this excess. This information is presented where available in later sections. However, the discussion of water availability is limited for the vast majority of streams since a thorough evaluation requires long-term flow records which are presently lacking for all but a few contract streams.

The discussions of water availability basically consist of comparisons of the monthly flow recommendations to the monthly median and mean flows of record. These statistics provide a measure of the normal or typical flow condition. The median is the flow that is exceeded in 5 of 10 years or in 5 years out of 10 there is more water than the median flowing in the stream. The median is preferred over the mean because it is less readily influenced by unusually high flows which tend to cause the mean to over estimate the norm. The mean rather than the median, however, is more commonly used as an indicator of normal flows because it is an easier statistic to derive.

Although biased by high flows, the monthly means still compare favorably to the medians if derived from long-term gauge records. The similarity of these two values is illustrated in Table 1 which compares the mean and median flows of record on a monthly and annual basis for a typical unregulated stream (Bridger Creek) and river (Big Hole River) of the Upper Missouri drainage of southwest Montana. While monthly means and medians are similar, as indicated in Table 1 , the annual means greatly exceed the annual medians. This is characteristic of unregulated headwater streams and rivers in which a large percentage of the annual water yield is passed during a relatively brief snow runoff period. For these waterways, the median annual flow is vastly superior to the mean annual flow as an indicator of the normal condition. For regulated streams, the annual mean and median values are generally more similar.

Median monthly flows are only available for comparing to the flow recommendations for those streams having at least 9 years of continuous USGS gauge records. While ten years is the minimum period the USGS considers adequate for deriving reliable estimates of monthly medians, a minimum period of 9 years is used for this report. For those streams having one to nine years of continuous flow records or more than 9 years of discontinuous records, the mean monthly flows are substituted. The relatively short period of time for which most of the monthly means were derived detracts somewhat from their reliability as indicators of the norm. These monthly means, while varying in reliability, still provide some insight into water availability and, consequently, are a meaningful addition to the report. For the vast majority of contract streams which are ungauged by the USGS, water availability information is generally limited to a relatively few sporadic flow measurements collected by various state and federal agencies.

Table 1 . Comparison of mean and median flows of record (cfs) derived from USGS gauge records for Bridger Creek and the Big Hole River.

	Bridger Creek[a]		Big Hole River[d]	
	Mean[b]	Median[c]	Mean[e]	Median[f]
Jan	7.2	5.6	349	344
Feb	8.9	6.7	363	328
Mar	15.5	10.5	445	400
Apr	64.7	52.0	1,526	1,290
May	158.0	141.0	3,449	3,150
Jun	104.0	75.5	4,121	3,970
Jul	31.9	28.3	1,347	1,330
Aug	13.6	12.2	482	445
Sep	10.9	9.2	377	305
Oct	10.8	8.9	507	447
Nov	10.3	9.0	508	475
Dec	8.7	6.2	398	348
Annual	36.6	12.0	1,157	480

a/ Bridger Creek near Bozeman, Montana.
b/ Derived for a 24-year period of record (1946-69).
c/ Derived for a 19-year period of record (1950-68).
d/ Big Hole River near Melrose, Montana,
e/ Derived for a 54-year period of record (1924-77).
f/ Derived for a 49-year period of record (1925-73).

The final monthly flow recommendations selected for the streams discussed in later sections of this report generally exceed the normal water availability, as measured by the monthly mean and median flows of record, for the months of November through March. This is the winter period when the natural flows are lowest for the year. These naturally occurring low flows, when coupled with the adverse effects of surface and anchor ice formation and the resulting scouring of the river channel at ice-out, can impact the fishery. Consequently, water depletions during this crucial low flow period have the potential to be extremely harmful to the already stressed trout populations. If trout populations are to be maintained at existing levels, little or no water should be removed during the crucial winter period.

RULES OF THUMB

Various nonfield or office methods that utilize historical flow records as a means of deriving instream flow recommendations are described in the literature. Of these methods, the most often used is the Tennant Method (Tennant, 1975). Recommendations of the Tennant Method are based on a fixed percentage of the mean annual flow of record with the following percentages recommended for both cold and warm water streams:

Narrative Description of Flows[a]	Recommended Base Flow Regimens Oct-Mar	: Apr-Sept	Fisheries Classification
Flushing or Max.	200% of the average flow		-
Optimum Range	60%-100% of the average flow		-
Outstanding	40%	60%	I
Excellent	30%	50%	II
Good	20%	40%	III
Fair or Degrading	10%	30%	IV
Poor or Minimum	10%	10%	-
Severe Degradation	10% of average flow to 0 flow		-

a/ Most appropriate description of the streamflow for fish, wildlife, recreation and related environmental resources (adapted from Tennant, 1975).

Thirty percent of the mean is described as the base flow recommended to sustain good survival habitat for most aquatic species and 60 percent as providing excellent to outstanding habitat for most aquatic species during their primary periods of growth and for the majority of recreational uses. The percentages selected from the table depend on the stream's numerical rating in a fisheries classification system. The higher the rating, the greater the percentage recommended.

Data presented by Nelson (1980c) suggest that recommendations derived from a fixed percentage method may be valid for the "Blue Ribbon" trout rivers of southwest Montana. His data suggested that the percentage of the mean annual flow selected as a recommendation depends on the channel morphology with the wider, shallower rivers requiring a higher percentage of the mean. The more typical rivers of the study area required instream flows approximately equal to at least 33% of the mean in order to maintain the high quality, wild trout fishery at an acceptable, but far from the most desirable, level.

The purpose of this section is to determine if a fixed percentage method is applicable to the headwater trout streams of Montana. Any rules of thumb that should emerge from this evaluation would provide guidelines for deriving flow recommendations for those streams in which time, budget and/or manpower constraints limit the use of an accepted field methodology.

For this evaluation, the flows at the lower and upper inflection points, as derived from the wetted perimeter method applied to 38 streams of the upper Missouri River drainage of southwest Montana, are expressed as a percentage of the mean annual flow (Table 2). The mean annual flow is the summary flow statistic most readily obtainable for gauged streams. For ungauged streams, the mean can be estimated using various simulation models. While the mean is not necessarily an indicator of the normal flow condition, it does provide a measure of the amount of water that is passed by the stream channel. The mean flows listed in Table 2 reflect the means at the cross-sectional sites from which the wetted perimeter data were collected.

Table 2. Inflection point flows expressed as percentages of the mean annual flow for selected streams of the upper Missouri River drainage of southwest Montana.

	Mean Annual Flow in cfs	Percentage of Mean Flow Lower Inflection	Percentage of Mean Flow Upper Inflection
Beaverhead and Red Rock River Tribs.			
Big Sheep Cr.	65.0(26) a/	31	77
Blacktail Deer Cr.	54.0(18)	67	93
Bloody Dick Cr.	70.2 b/	26	37
Grasshopper Cr.	51.6(23)	43	54
Horse Prairie Cr.	109.0(7)	22	35
Medicine Lodge Cr.	35.5 b/	28	34
Big Hole River Tribs.			
Birch Cr.	29.4(28)	41	82
Canyon Cr.	31.8 c/	6	16
Johnson Cr.	39.2 c/	13	22
Miner Cr.	39.1(1)	8	26
Pattengail Cr.	48.5 c/	41	49
S. Fork Big Hole R.	52.1(3)	23	46
Trail Cr.	85.3(8)	16	29
Willow Cr.	20.6(4)	39	63
Wise R.	187.0(7)	24	32
Gallatin River Tribs.			
Big Bear Cr.	14.3(2)	28	63
Bozeman Cr.	35.9 d/	17	39
Bridger Cr.	36.6(24)	55	82
Hyalite Cr. (upper reach)	67.2(47)	22	60
Hyalite Cr. (at mouth)	69.5 d/	29	36
Porcupine Cr.	24.3 d/	53	66
Reece Cr.	14,1(2)	43	128
Rocky Cr.	35.8(2)	22	67
Spanish Cr.	73.6 d/	61	109

Table 2. Continued.

	Mean Annual Flow in cfs		Percentage of Mean Flow Lower Inflection	Upper Inflection
Jefferson River Tribs.				
Boulder R.	67.5	b/	27	33
Little Boulder R.	17.5	b/	46	109
S. Boulder R.	51.1	b/	29	78
Whitetail Cr.	19.3(1)		21	36
Madison River Tribs.				
Beaver Cr.	74.6	e/	32	64
Cabin Cr.	74.2	e/	15	27
Cherry Cr.	35.2	e/	37	85
Grayling Cr.	80.0	f/	39	75
Hot Springs Cr.	8.8	e/	51	80
Indian Cr.	77.9	e/	26	62
Jack Cr.	46.1(6)		65	134
W. Fork Madison R.	91.9(2)		49	74
Mainstem Missouri R. Tribs.				
Crow Cr.	47.7(15)		23	52
Sixteenmile Cr.	16.7(4)		30	90

a/ Derived from USGS gauge records. Years of record are in parentheses.

b/ Estimate from Farnes and Schafer, 1975.

c/ Estimate from the Dept. of Natural Resources and Conservation, 1981.

d/ Estimate from Farnes and Schafer, 1972.

e/ Estimate from the Soil Conservation Service, 1976a.

f/ Estimate from Horpestad, 1976.

The lower and upper inflection point flows for the 38 streams average 33 and 62%, respectively (Table 3). The percentages derived for an individual stream vary greatly as indicated by the wide ranges and relatively large standard deviations in Table 3. Consequently, the averages derived from this analysis (33 and 62% of the mean) are only useful in deriving preliminary or reconnaissance level flow recommendations and should not be used in place of an accepted field methodology.

Other investigators have also examined the fixed percentage technique. Swank and Phillips (1976) indicated that an optimum instream flow for streams within the area of the Blue, Wallowa and Cascade Mountains of Oregon ranged from about 60-100% of the mean annual flow. Wesche (1974) found that the rate of loss of the available trout cover in Wyoming's smaller streams (mean annual flows less than 100 cfs) is reduced at its greatest rate at flows less than 25-27% of the mean.

Table 3. Summary of inflection point flows expressed as percentages of the mean annual flow for selected streams of the upper Missouri River drainage of southwest Montana.

	Number of Observations	Percentage of Mean Annual Flow		
		Range(%)	Average(%)	Std. Deviation(%)
Lower Inflection Flow	38	6- 67	33	15.3
Upper Inflection Flow	38	16-134	62	29.3

The analysis presented in this section will be expanded and refined as data become available for additional streams and drainages in Montana. Better defined trends may be found in the future if the streams are subdivided by drainage, morphological types or other yet undefined categories. At present, it appears that the fixed percentage technique is of limited value for deriving flow recommendations for the trout streams of southwest Montana.

BEAVERHEAD RIVER TRIBUTARIES

1. STREAM

East Fork Blacktail Deer Creek

2. DESCRIPTION

The East Fork Blacktail Deer Creek originates in the Snowcrest Range in southwest Montana, approximately 35 miles south of Dillon, Montana. It flows for 15.5 miles in a northeasterly direction before joining the West Fork to form Blacktail Deer Creek, a tributary of the Beaverhead River. Land ownership of the 56 square mile drainage is shared by the USFS (43%), Montana Department of Fish, Wildlife and Parks (36%) and BLM (14%). The East Fork flows in a 15-25 ft wide channel having an average gradient of 19 ft per 1,000 ft. The riparian zone is vegetated with conifers, willow, birch, grasses and sedges. Extensive beaver dam development within the middle reach causes the stream to lose much of its fluvial nature. Major tributaries include Alkali, Indian, Rough, Meadow and Lawrence Creeks. The drainage is characterized by sagebrush/grassland slopes and conifer covered headwater ridges.

Lands within the drainage are primarily used for wildlife winter range, recreational activities, including hunting, fishing and camping, and livestock grazing. Access is provided by an unimproved road paralleling the stream for its lower 12 miles and a trail system along the upper three miles. In 1974, the MDFWP acquired 20,000 acres within the drainage for the protection of critical elk winter range. Antelope, moose, mule deer, game birds, waterfowl and many nongame species are also found within the game range. Hunting District 324, which includes the East Fork Blacktail Deer drainage, is one of the most heavily used hunting areas in the state. In 1979, elk hunting pressure in the district was estimated at 13,083 hunter-days (MDFWP, 1980a).

Field checks of anglers over a period of approximately 20 years have shown this stream to be a highly popular sport fishery for pan-sized gamefish. Brook, rainbow and cutthroat trout, rainbow x cutthroat hybrids and mountain whitefish comprise the game fish creeled by anglers. A creel census in 1974 showed a catch rate of 1.5 fish/hour for the East Fork Blacktail Deer Creek during the summer months (MDFWP, unpublished data). Brook trout, which averaged 10.2 inches in length, comprise 97% of the catch reported in angler logs (MDFWP, 1980b).

All lands within the East Fork drainage are publicly owned. Only USFS and BLM lands within the upper drainage are currently being grazed by livestock. Streambank stability and riparian zones are in fair to good condition throughout the drainage (MDFWP, unpublished data and Foggin et al., 1978).

Flow information was collected for the East Fork Blacktail Deer Creek 2.5 miles below the USFS boundary from May - November of 1977 and 1978 (Foggin et al., 1978). Mean, minimum, and maximum recorded flows in 1977 were 16.7, 13.0 and 149 cfs, respectively. The mean flow for the seven-month period in 1978 was 60.6 cfs. The minimum and maximum recorded flows were 13 cfs in November and 266 cfs in June, respectively.

Suspended sediment yields during 1977 and 1978 were measured 2.5 miles below the USFS boundary and 4.5 miles above the convergence with the Middle and West Forks (Foggin et al., 1978). Average sediment yields in pounds/acre were 306 and 352 for the upper and lower stations, respectively. Water quality at these two stations was characterized by a moderate specific conductance, a slightly alkaline pH and low levels of sulfate and major nutrients. All measured parameters were slightly higher at the lower station.

Macroinvertebrate sampling at the upper station reveal an insect community typical of high elevations and velocities (Foggin et al., 1978). The lower station supported taxa more tolerant to high turbidity and warmer water. The biomass and diversity were greater at the lower station.

Elser and Marcoux (1972) found average turbidity readings for stations located on the lower reaches of the East Fork to be among the lowest of 39 stations sampled in the Beaverhead drainage.

3. FISH POPULATIONS

Because extensive fisheries information was collected in 1974 and 1975 on two sections of the East Fork Blacktail Deer Creek, no further electrofishing was conducted (Peterson, 1976). One of the sections was established to measure changes in fish populations over a long period (10-20 years) in a portion of stream that was previously heavily grazed by livestock. Grazing was discontinued in 1974 when the property was purchased by the DFWP. A relatively undisturbed section located 2.2 miles upstream served as a control.

Game fish species present in both sections in descending order of abundance were brook trout, rainbow trout and mountain whitefish. Cutthroat trout are also present in small numbers. The mottled sculpin was the only nongame species present. The electrofishing survey data for 1975 only are summarized for both sections in Table 4 .

Table 4 . Summary of electrofishing survey data collected in a 3,650 ft control section (T11S, R5W, Sec. 3) and a 4,860 ft disturbed section (T11S, R5W, Sec. 8) of East Fork Blacktail Creek in August, 1975.

Fish Species	No. Captured		Length Range (inches)	
	Control	Disturbed	Control	Disturbed
Brook Trout	599	208	4.0-14.9	4.0-13.7
Rainbow Trout	34	24	6.4-16.1	6.9-16.1
Mountain Whitefish	46	160	9.4-18.1	6.6-16.4
Mottled Sculpin	-	-	-	-

The standing crops of trout in both sections in 1974 and 1975 were estimated using a mark-recapture method. The brook trout, the predominant trout species, comprised over 87% of the total trout numbers and biomass in both sections during both years. In 1975, the control (undisturbed) section supported about 164 brook and rainbow trout, weighing 52 pounds, per 1,000 ft of stream. The trout population in the control section was about two times greater than in the disturbed section (Table 5). The control section is characterized by the presence of a greater number of larger trout.

Standing crops of trout in a 2,650 ft section near the mouth of East Fork Blacktail Deer Creek were estimated in 1970 (Elser and Marcoux, 1972). The brook trout, the predominant trout species, accounted for 88% of the total trout numbers. The rainbow trout was the other game fish species captured. This section supports an estimated population of 114 trout, weighing 34 pounds, per 1,000 ft.

Table 5 . Estimated standing crops of trout in a 3,650 ft control section (T11S, R5W, Sec. 3) and a 4,860 ft disturbed section (T11S, R5W, Sec. 8) of East Fork Blacktail Deer Creek in August, 1975. Eighty percent confidence intervals are in parentheses.

		Control Per 1,000 Ft		Disturbed Per 1,000 Ft	
Species	Length Range (inches)	Numbers	Pounds	Numbers	Pounds
Brook Trout	4.0- 5.9	43		49	
	6.0- 9.9	67		35	
	10.0-14.9	46		18	
		156(±11)	48(±2)	102(±12)	23(±2)
Rainbow Trout	6.4- 9.9	5		5	
	10.0-16.1	3		2	
		8(±1)	4(±1)	7(±3)	3(±1)
Total Trout		164(±11)	52(±2)	109(±12)	26(±2)

4. FLOW RECOMMENDATIONS

Cross sectional data were collected for an 81 ft riffle-pool sequence located near stream mile 14.0 (T11S, R5W, Sec. 34A). Five cross sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 19.9, 35.6 and 49.6 cfs.

The relationship between wetted perimeter and flow for the composite of five cross-sections is illustrated in Figure 5. Lower and upper inflection points occur at 16 and 26 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 20 cfs is recommended for the low flow period (July 16 - May 15). A recommendation for the high flow period (May 16 - July 15) cannot be derived due to the lack of long-term data for the East Fork Blacktail Deer Creek.

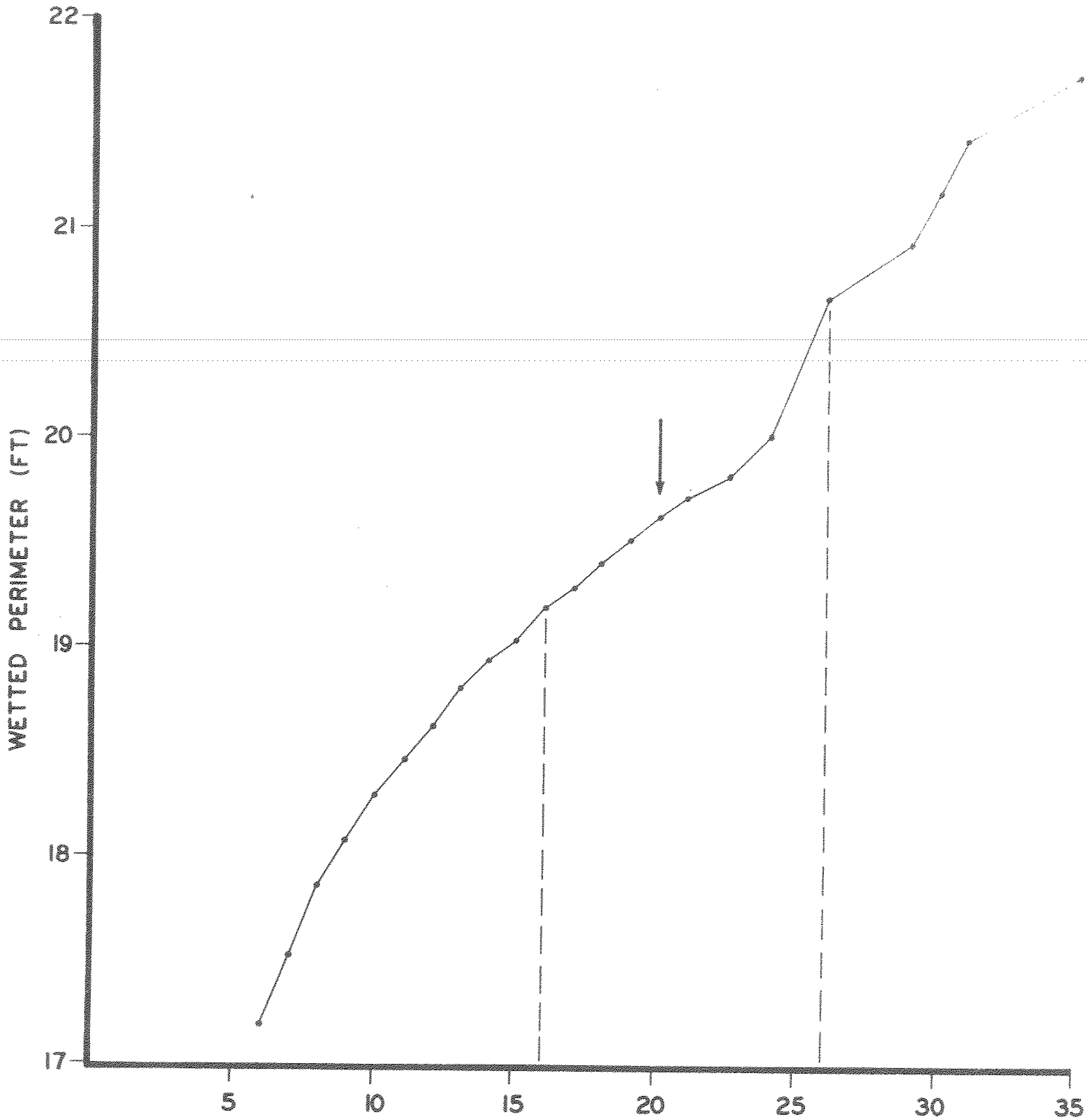

Figure 5. The relationship between wetted perimeter and flow for a composite of five cross-sections in the East Fork Blacktail Deer Creek.

1. STREAM

Grasshopper Creek

2. DESCRIPTION

Grasshopper Creek originates in the Rainy and Saddleback Mountains of the Pioneer Range and the Big Hole Divide of southwest Montana. It flows in a southeasterly direction for approximately 50 miles before converging with the Beaverhead River, 14 miles southwest of Dillon, Montana. Between its headwaters and mouth, the stream changes from a narrow willow-lined channel draining steep, forested slopes to a meandering small river draining sagebrush/grassland benches. The average gradient of the 36 ft wide channel is approximately 6 ft/1,000 ft. Control of the 350 square mile drainage is shared by the USFS (32%), BLM (31%), private individuals (30%) and the State of Montana (7%). Of the 50+ tributaries to Grasshopper Creek, major ones include Dyce, Taylor, Buffalo, Divide, Cold Springs, Blue and Hot Springs Creeks.

A USGS gauge station located at stream mile 1.4 (T8S, R10W, Sec. 26B) was operated intermittently from 1921-1961. The average annual flow for a 23-year period of record was 51.6 cfs. No flow in July and August, 1930 and August, 1931 and a maximum of 1,870 cfs in March, 1956 were the extremes during the period of record. There are diversions for the irrigation of about 12,500 acres above the station.

Lands within the Grasshopper Creek drainage are currently used for livestock grazing, hay production and recreation in the form of fishing, hunting, skiing, snowmobiling, hiking and sight-seeing. Access is provided by a county road which parallels the stream for all but 4 miles of its length.

Fishing pressure on Grasshopper Creek from May, 1975 to April, 1976 was estimated at 3,302 person-days (MDFG, 1976). This amounts to approximately 66 person-days per stream mile per year. Catches reported in angler logs consist of 41% rainbow trout, averaging 13 inches in length, 32% brown trout, averaging 14 inches, and 27% brook trout, averaging 10 inches (MDFWP, 1980a). The drainage is also popular for hunting elk, mule deer and sage and blue grouse. Hiking, camping, snowmobiling and cross-country and downhill skiing are popular activities along the upper reaches. A commercial hot springs resort and a downhill ski area are located within the drainage.

Historically, the major activity within the Grasshopper Creek drainage was placer mining. Gold was first discovered in 1862 (Lyden, 1948). By 1905, gold valued at $2,500,000 had been recovered. With the flurry of mining activity came 5,000 prospectors and the founding of the town of Bannack, Montana's first state capital. By 1930, the gold was depleted and the people had moved on to Virginia City and other boom towns. Today, the town of Bannack is a state park.

The scars of past mining activity remain within the drainage. Major impacts on the stream were the loss of riparian habitat, toxic metals pollution and the destruction of instream habitat by dredging.

Approximately 17 miles of stream have been damaged as a result of mining (Wipperman, 1969b).

Toxic metals began leaching into Grasshopper Creek when the stream began eroding old tailing piles on the banks (SCS, 1976). No trace of the metals could be detected in the waters of Grasshopper Creek. However, extremely high concentrations of mercury, arsenic, zinc and other metals were found in the stream sediments (Peterson, 1979). In 1970, the MDFWP documented the presence of elevated mercury levels in the flesh of some trout from Grasshopper Creek and the Beaverhead River below its confluence (SCS, 1976). After further investigation, it was hypothesized that mercury was assimilated into the food chain and then into the fish through the ingestion of aquatic organisms (Peterson, 1979). All orders of macroinvertebrates below the tailings area on Grasshopper Creek are depressed (MDFWP, unpublished data). Plecoptera and Ephemerptera are the orders most adversely affected.

In 1976, through a cooperative effort between the SCS and the Montana Department of Fish, Wildlife and Parks, Grasshopper Creek was diverted from the tailings area and riprapped (SCS, 1976). This project was initiated to reduce the level of metals pollution in Grasshopper Creek.

The water quality of Grasshopper Creek above the tailings area (near Polaris, Montana) was sampled sporadically during 1973-76 (USFS, unpublished data). The overall quality is excellent and is characterized by a low specific conductivity, low alkalinity and hardness levels, a neutral pH and low levels of suspended sediments.

3. FISH POPULATIONS

An 8,072 ft section of Grasshopper Creek was electrofished on July 29 and August 11, 1980. The section was located approximately 9 miles below Bannack, the source of the toxic metals found in the stream sediments. Gamefish present in descending order of abundance were brown trout, mountain whitefish and rainbow trout. Longnose sucker, longnose dace and mottled sculpin were the nongame species captured. Table 6 summarizes the electrofishing survey data.

Table 6 . Summary of electrofishing survey data collected for a 8,072 ft section of Grasshopper Creek (T8S, R10W, Sec. 28N½) on July 29 and August 11, 1980.

Species	Number Captured	Length Range (inches)
Brown Trout	57	6.5 - 17.4
Mountain Whitefish	25	4.1 - 14.4
Rainbow Trout	9	6.9 - 15.0
Longnose Sucker	-	-
Longnose Dace	-	-
Mottled Sculpin	-	-

The standing crop of gamefish in the section was estimated using a mark-recapture method (Table 7). This section supports about 16 gamefish, weighing a total of 8 pounds, per 1,000 ft of stream. Brown trout, the predominant game species, comprised about 69% and 75% of the total gamefish numbers and biomass, respectively. Mountain whitefish accounted for approximately 45% of the numbers and 25% of the biomass. The population of rainbow trout was too sparse to estimate using the mark-recapture method.

The condition (length to weight ratio) of brown trout in Grasshopper Creek was below average when compared to other streams and rivers in the Beaverhead drainage. It is apparent that the past mining activity within the drainage is still impacting the fishery of Grasshopper Creek.

Table 7 . Estimated standing crop of gamefish in a 8,072 ft section of Grasshopper Creek (T8S, R10W, Sec. 28N½) on July 29, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Brown Trout	6.5 - 9.9	4	
	10.0 - 13.9	5	
	14.0 - 17.4	2	
		11(±2)	6(±1)
Mountain Whitefish	4.1 - 14.4	5(±2)	2(±1)
Total Gamefish		16(±3)	8(±1)

Grasshopper Creek above the town of Bannack is predominantly a brook trout fishery. Wipperman and Needham (1965) made two electrofishing passes through a 300 ft section of the upper creek in 1964. They captured 220 brook trout of which 19% were longer than 7 inches. Small numbers of rainbow and rainbow x cutthroat hybrids were also captured. The brown trout was the predominant species in three 440 ft sections below Bannack (Wipperman, 1964). Numbers of brown trout captured ranged from 9 to 26 per section. The majority of the trout were greater than 7 inches. A 6,600 ft section above and through Bannack was electrofished during 1978 (MDFWP, unpublished data). Eleven brown trout and 59 mountain whitefish, all over 7 inches, were captured. The data suggest that reproductive success is severely limited throughout the lower stretches of the stream.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in an 86 ft subreach located at stream mile 1.5 (T8S, R10W, Sec. 26D). Five cross-sections were placed within the subreach. The WETP program was calibrated to field data collected at flows of 53.9, 105.4 and 234.6 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 6. Lower and upper inflection points occur at 22 and 28 cfs, respectively. Based on the evaluation of existing fishery, water availability, recreational use and other resource information, a flow of 25 cfs is recommended for the low flow period (July 1 - April 30). Recommendations for the high flow period (May 1 - June 30) cannot be derived for Grasshopper Creek due to the lack of long-term flow data.

The low flow recommendations are compared to the mean monthly flows of record for the USGS gauge at stream mile 1.4 in Table 8. The recommended flows exceed the mean flows of record for the months of August, September, January and February.

Table 8. Instream flow recommendations derived for Grasshopper Creek using the wetted perimeter/inflection point method (low flow period) compared to the mean flows of record.

	Flow Recommendations (cfs)	Mean Flows (cfs)[a/]
January	25	23.7
February	25	24.9
March	25	48.2
April	25	72.9
May	b/	112.6
June	b/	137.1
July	25	40.4
August	25	24.6
September	25	18.9
October	25	35.4
November	25	39.5
December	25	28.7

a/ Derived for the March, 1921 through September, 1961 period of record for the USGS gauge station at stream mile 1.4 (T8S, R10W, Sec. 26).

b/ Recommendations for the high flow period (May 1 - June 30) are presently unavailable due to the lack of long-term flow records for Grasshopper Creek.

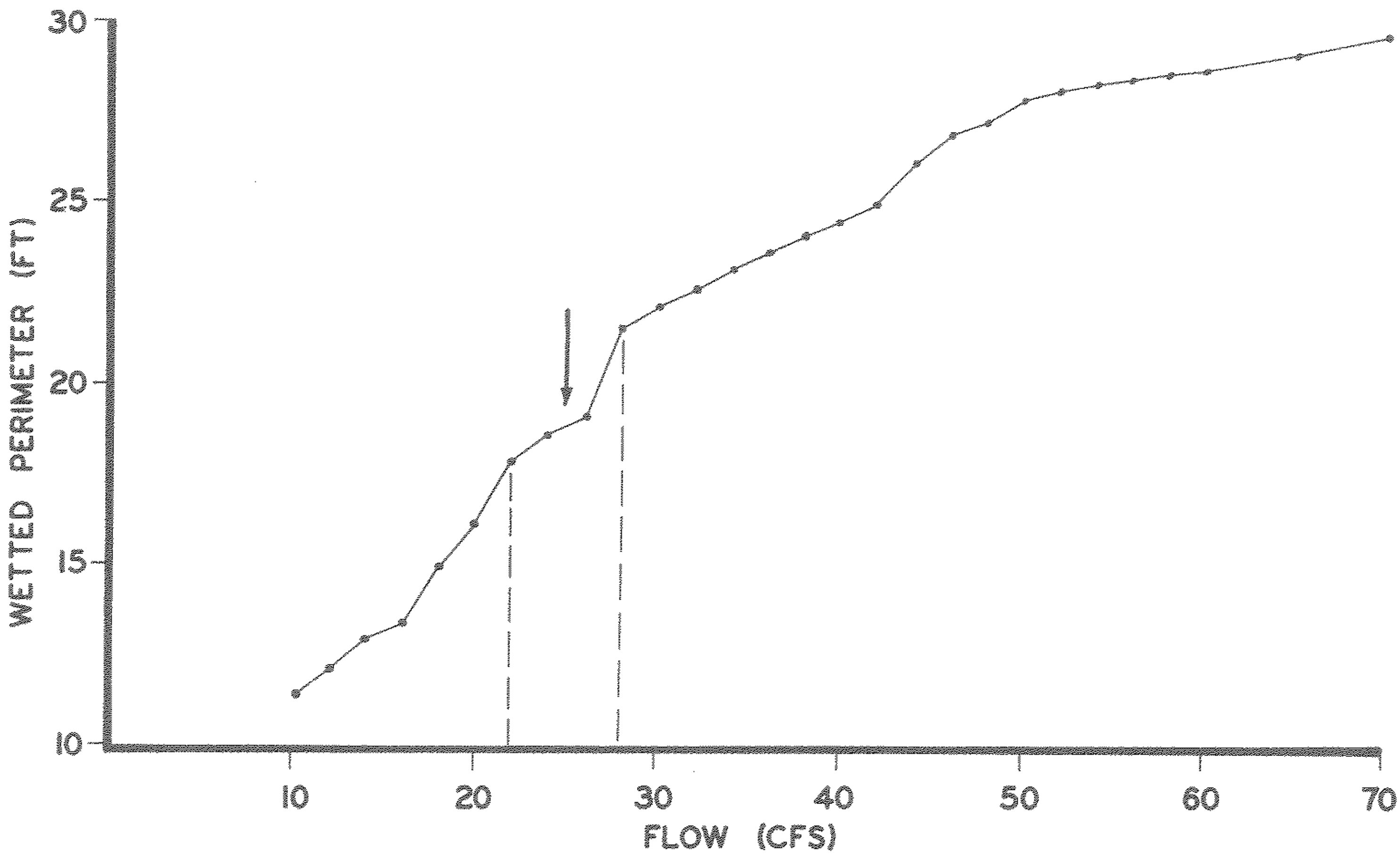

Figure 6. The relationship between wetted perimeter and flow for a single riffle cross-section in Grasshopper Creek.

1. STREAM

West Fork Blacktail Deer Creek

2. DESCRIPTION

The West Fork Blacktail Deer Creek arises in the Snowcrest Range and Clover Divide of southwest Montana. It flows for approximately 17 miles before converging with the East and Middle Forks to form Blacktail Deer Creek, a tributary of the Beaverhead River. The stream meanders in a northerly direction through a floodplain vegetated with grasses, forbs and sparse clumps of willow and birch. Average gradient of the seven ft wide channel is approximately 38 ft per 1,000 ft. Much of the narrow drainage is comprised of sagebrush/grassland plant communities. Only the upper portion is forested. Control of the 50.5 square mile drainage is shared by the State of Montana (32%), USFS (28%), BLM (22%) and private individual (19%). Major tributaries to the West Fork Blacktail Deer Creek include the South Fork and Bonita Fork. Flows are augmented by numerous springs within the drainage.

Lands within the West Fork Blacktail Deer Creek are used primarily for livestock grazing and recreation in the form of hunting, fishing and hiking. Hunting District 324, which includes the West Fork Blacktail Deer drainage, is one of the most heavily used hunting areas in the state. In 1979, elk hunting pressure was estimated at 13,083 hunter-days (MDFWP, 1980b). An improved road parallels the entire West Fork, providing access throughout the drainage.

The erosive nature of the soils in the upper West Fork Blacktail drainage coupled with grazing activities have caused considerable erosion, increasing sediment yields to the stream. Turbidity samples collected throughout the Blacktail Deer Creek drainage in 1970 showed the highest turbidity levels in the West Fork (Elser and Marcoux, 1972). Turbidity levels decreased at downstream stations. Several major slumps resulting from road construction along the channel have also contributed to the increased sediment load.

3. FISH POPULATIONS

A 1,000 ft section of the West Fork Blacktail Deer Creek was electrofished on July 21 and August 12, 1980. Gamefish captured were brook and rainbow trout. The mottled sculpin was the only nongame species present. Table 9 summarizes the electrofishing survey data.

Table 9 . Summary of electrofishing survey data collected for a 1,000 ft section of West Fork Blacktail Deer Creek (T12S, R6W, Sec. 35A) on July 21 and August 12, 1980.

Species	Number Captured	Length Range (inches)
Brook Trout	83	4.0 - 10.4
Rainbow Trout	9	3.2 - 11.2
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 10). This 1,000 ft section supports about 84 brook trout, weighing a total of 15 pounds. The population is low for a stream of this size although the condition of the trout (length to weight ratio) was above average. Only 40% of the fish captured were less than six inches, suggesting poor reproductive success. The increased sediment load may be reducing egg survival as well as decreasing the production of fish food.

Table 10. Estimated standing crop of brook trout in a 1,000 ft section of West Fork Blacktail Deer Creek (T12S, R6W, Sec. 35A) on July 21, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Brook Trout	5.0 - 5.9	26	
	6.0 - 9.9	57	
	10.0 - 10.4	1	
		84(±9)	15(±1)

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 60 ft riffle-run sequence located in T12S, R6W, Sec. 35A. Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 8.9, 18.1 and 36.8 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 7 . Lower and upper inflection points occur at 3.0 and 4.5 cfs, respectively. Based on an evaluation of existing fishery and other resource information, a flow of 4.0 cfs is recommended for the low flow period (July 16 - May 15). Due to the lack of long-term flow data,recommendations for the high flow period (May 16 - July 15) cannot be derived for the West Fork Blacktail Deer Creek.

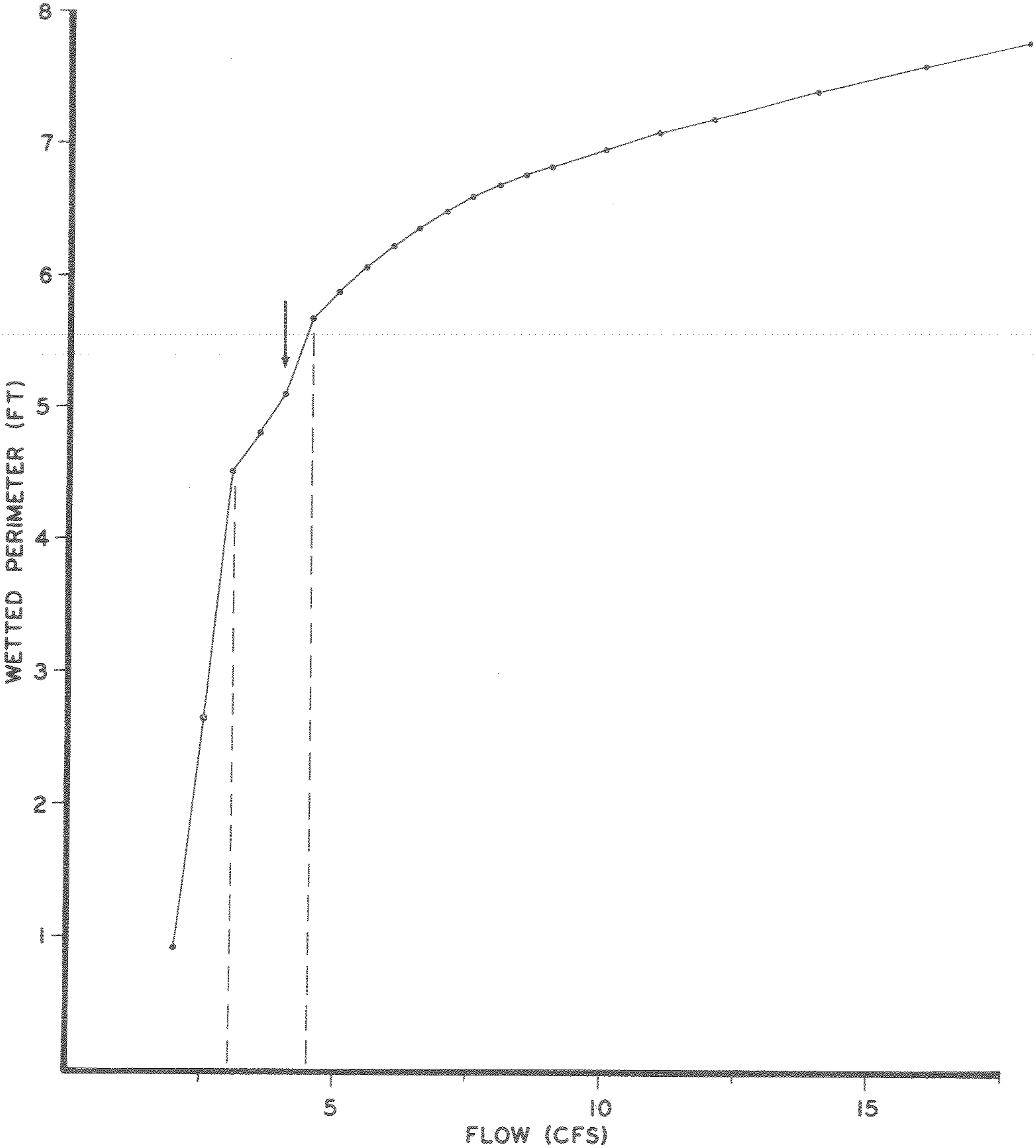

Figure 7. The relationship between wetted perimeter and flow for a single riffle cross-section in the West Fork Blacktail Deer Creek.

BIG HOLE RIVER AND TRIBUTARIES

1. RIVER

Big Hole River

2. GENERAL DESCRIPTION

The Big Hole River arises in the Bitterroot Mountains of southwest Montana near the town of Jackson and flows approximately 139 miles before joining the Beaverhead and Ruby Rivers to form the Jefferson River near Twin Bridges, Montana (Figure 8). Flowing through a deep mountain valley or hole, as the Nez Perce and early trappers called it, the river receives tributary streams from the Bitterroot Mountains on the west, the Anaconda Pintlar Range on the north and the Pioneer Mountains on the east and west. From the high mountain meadows of its headwaters to the cottonwood bottoms of the lower valley, the Big Hole is free-flowing and one of the most scenic rivers in Montana.

The headwater area is characterized by high mountain meadows, steep, timbered slopes and numerous mountain lakes. Cottonwood bottoms surrounded by sagebrush/grassland benches characterize the main river valley. Much of the valley has been converted to irrigated hay and grain fields. In addition to agriculture, lands within the drainage are also used for recreation, timber harvesting, mining and grazing. Access to the river is provided by state and county highways bordering the river for its entire length and numerous campgrounds and fishing access sites maintained by state and federal agencies. The BLM, USFS, State of Montana and private individuals share in the ownership and management of the 2,770 square mile drainage.

The Big Hole River has long been nationally acclaimed for its wild trout fishery. Large trout have made the Big Hole famous, especially from Divide to the river's mouth. In 1959, this 56-mile section of river was given "Blue Ribbon" status in recognition of its national importance as a fishery and its high recreational and aesthetic values. From May, 1975 through April, 1976, the river provided over 66,000 angler-days of recreation (MDFG, 1976). Nonresidents comprised nearly 20 percent of the fishing pressure in 1975-76. Of the 10 major rivers in the upper Missouri drainage of southwest Montana, the Big Hole ranks second behind the Madison River in total fishing pressure.

Historically, the Big Hole supported populations of cutthroat trout, arctic grayling, mountain whitefish, burbot (ling), longnose dace, mottled sculpin and three species of sucker. Brook, rainbow and brown trout have been introduced to the river. Today, the cutthroat have all but disappeared, victims of dewatering and competition from introduced species. Grayling remain in small numbers in the upper river and represent the only major stream-dwelling population in the contiguous United States south of Alaska.

Many species of wildlife also depend on the Big Hole River. Moose may be found within the riparian willows along the upper river, while whitetail and mule deer thrive along the riparian zone of the lower

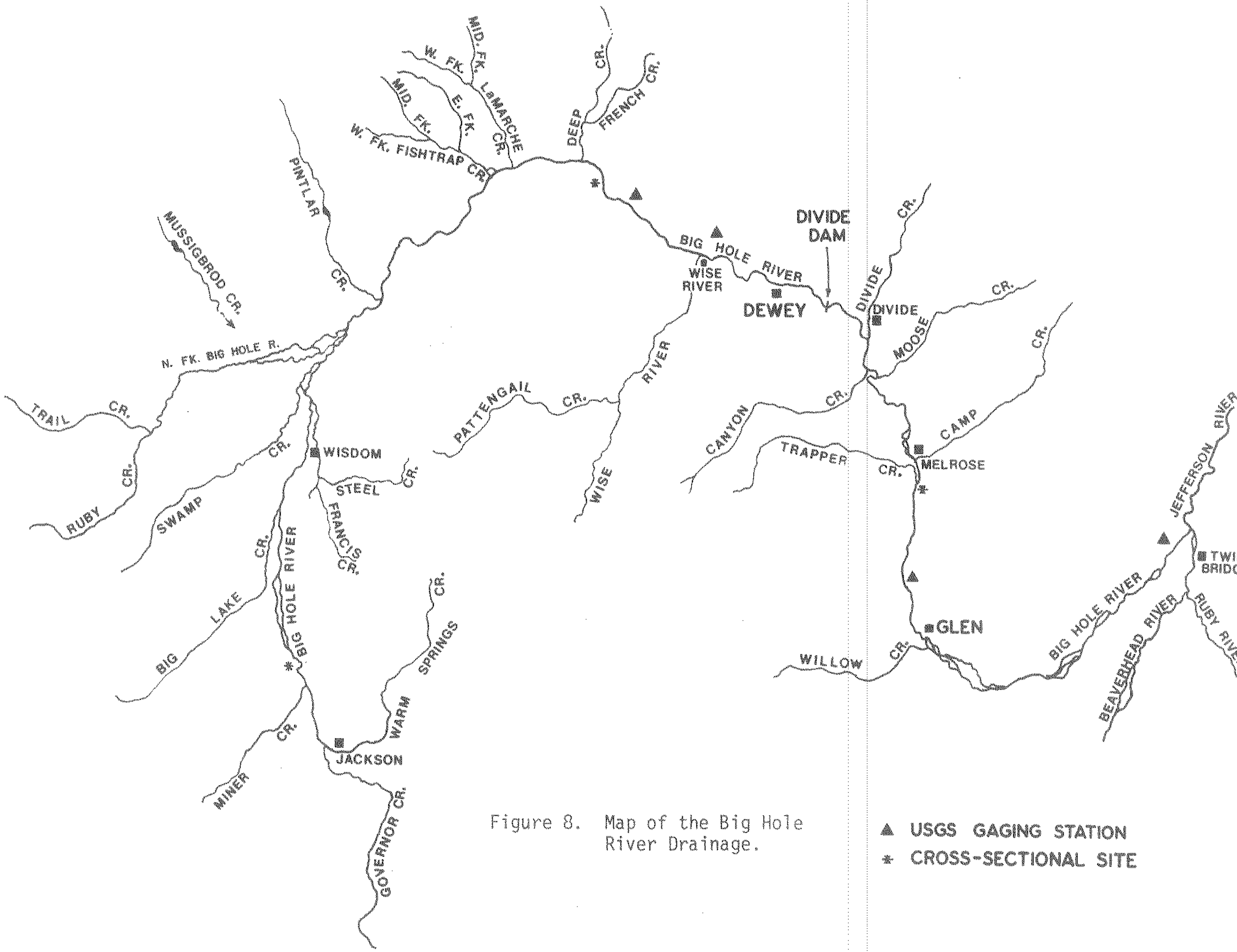

Figure 8. Map of the Big Hole River Drainage.

reaches. River otter, beaver, mink and muskrat depend on the river for their survival. Bobcat and coyote inhabit the cottonwood bottoms of the lower river. The river furnishes resting and breeding areas for many species of ducks, Canada geese and numerous nongame birds. Bald eagles and osprey seasonally fish the river with the latter species nesting along its banks.

The major limiting factor to the Big Hole River fishery is the severe dewatering that can occur during the summer irrigation season. Dewatering can adversely affect aquatic populations by reducing habitat and food supplies and increasing the summer water temperatures which, in turn, decrease oxygen supplies. Other problems affecting the aquatic resource include habitat destruction caused by channel stabilization projects and the construction of irrigation structures, the mining that is occurring along tributary streams and bank encroachment by road construction.

Water quality of the Big Hole River can generally be described as excellent although in portions of the river it is adversely affected by dewatering as indicated by increased summer water temperatures and associated decreases in dissolved oxygen concentrations. The water is generally characterized by a low specific conductance, low total alkalinity and major nutrient levels, a slightly alkaline pH and low suspended sediments. Nitrogen has been identified as the limiting nutrient in the system (Bahls et al, 1979). The periphyton community of the river near Twin Bridges reflects an environment adapted to an alkaline pH (Bahls et al, 1979). Sixty-one percent of the macroinvertebrate community is comprised of species intolerant of pollution.

The 1977 Montana Legislature requested the Department of Natural Resources and Conservation to study the feasibility of constructing an off-stream storage reservoir on a tributary of the Big Hole River. The reservoir is to be used for augmenting instream flows in the Big Hole and Jefferson Rivers, flood control and irrigation (DNRC, 1979). After four years of study, a site on Pattengail Creek in the Wise River drainage was recommended (DNRC, 1981).

Reach #1

From the mouth of the Big Hole River (T3S, R6W, Sec. 21) to the site of the old Divide Dam (T1S, R10W, Sec. 11).

This "Blue Ribbon" reach of the Big Hole River is 55.8 river miles in length. The lower 40 miles are fairly typical of a river crossing an erodible floodplain. The river meanders through cottonwood lined banks and in many places breaks up into more than one channel, creating islands. The riparian zone of the floodplain is vegetated with cottonwood, willow, rose and other deciduous shrubs. All of these are important in providing streambank stability and overhanging cover for fish.

The substrate of the river is generally of a gravel to cobble nature. Finer materials are found in deposition areas such as the inside of bends and pools.

The average gradient from the Divide Dam site to the mouth is approximately 2.6 ft per 1,000 ft. Stream width varies with location and flow, but is generally in excess of 125 ft and may exceed 225 ft in places at high flows.

Natural flow varies from year to year depending on climatic conditions with peak annual flows corresponding to peak snowpack runoff and occurring in late May or June. Low flow generally occurs in late August or September and flow remains fairly low until the onset of runoff in late March or April of the following year.

Average discharge in reach #1 of the Big Hole River from 1924-1979, as measured at the USGS gauging station near Melrose (river mile 31), was 1,160 cfs. Extremes for the period of record since the failure of the Wise River Dam in 1927 have been a maximum of 14,300 cfs on June 10, 1972 and a minimum of 49 cfs on August 17, 1931. The Melrose gauge is located downstream from all major tributaries, except Willow Creek, and flow reflects tributary input, diversions for the irrigation of about 136,000 acres above the station, the Butte municipal withdrawals and groundwater return. This gauge is located about midway between the start and end of reach #1.

The USGS also operated a gauge near the mouth of the Big Hole River (near Twin Bridges at river mile 2.8) from August, 1979 through September, 1980. This gauge is located downstream from all major tributaries and reflects diversions for agriculture and groundwater return between the Melrose and Twin Bridges stations. Daily flows for the period of record ranged from 130 to 7,460 cfs. The mean monthly flows of record for the gauges near Twin Bridges and Melrose are compared in Table 11.

Table 11. Mean monthly flows of record for the USGS gauges near Twin Bridges and Melrose on the Big Hole River.

	Mean Flows (cfs) of Record	
	Near Twin Bridges (river mile 2.8)[a/]	Near Melrose (river mile 31.1)[b/]
Jan	225	349
Feb	289	363
Mar	341	445
Apr	1,597	1,526
May	4,790	3,449
Jun	4,736	4,121
Jul	1,348	1,347
Aug	253	482
Sep	453	377
Oct	272	507
Nov	319	508
Dec	334	398

a/ Derived for a one-year period of record (1980 water year).

b/ Derived for a 54-year period of record.

The diversion of river water for irrigation occurs throughout the length of the Big Hole, but is most severe in the lower river from Melrose to Twin Bridges. Irrigation diversions generally have the greatest impact on natural flows during August, normally the most critical flow month on the lower river.

Figure 9 compares the average daily flows at the gauges near Twin Bridges and near Melrose from August 1 through October 2, 1979 (from Wells and Decker-Hess, 1981). The reduction in flow between the Melrose and Twin Bridges sites from August to October, 1979 is attributable to irrigation withdrawals and represents flow depletions of between 80 and 201 cfs.

The dewatering of the river during the summer irrigation season represents the most severe threat to the fishery of reach #1. Dewatering decreases the amount of habitat available for trout, decreases the production of fish food and increases summer water temperatures. Maximum water temperatures in the lower Big Hole River have been correlated with the lowest recorded flows and the maximum air temperatures during the months of August and September (Wells and Nelson, 1978, Wells and Rehwinkel, 1980, and Wells, unpublished data). Potentially lethal water temperatures and dissolved oxygen concentrations could result from a combination of low flows and normal or above average air temperatures. Loss of trout habitat has also resulted from streambank stabilization projects and the construction of irrigation diversions.

Sediment loads in reach #1 tend to vary with flow with peak loads usually occurring with peak flows. In general, sediment loads are presently not a major problem in reach #1.

The construction of Reichle Dam in reach #1 of the main Big Hole River between Glen and Twin Bridges has been proposed in the past. While such a dam would provide water for downstream uses, it would inundate productive agricultural land and destroy many miles of the "Blue Ribbon" portion of the river. The Bureau of Reclamation presently considers the project economically unfeasible.

Reach #2

From the site of the Old Divide Dam (T1S, R10W, Sec. 11) to the mouth of Pintlar Creek (T1S, R14W, Sec. 8).

Reach #2 of the Big Hole River is 41.7 river miles in length. Between Dewey and the site of the old Divide Dam, the river flows through a narrow, steep canyon. Upstream, it flows through meadow lands adjacent to conifer covered hillsides. The river tends to remain in one channel since it is traversing a narrower, more erosion resistant plain. Overhanging bank cover is much reduced from reach #1. Cottonwoods have nearly disappeared from the riparian zone with the increase in altitude. Willows are the most important plant providing streambank stability and overhanging cover for fish. Major tributaries to this reach include Deep, LaMarche and Fishtrap Creeks, which drain the Anaconda Pintlar Range to the north, and the Wise River, which drains the Pioneer Mountains to the south.

Figure 9. Mean daily flows of the Big Hole River at the USGS gauge stations near Melrose and Twin Bridges from August 1 through October 2, 1979 (adapted from Wells and Decker-Hess, 1981).

The average gradient of reach #2 is approximately 1.9 ft per 1,000 ft. Stream width varies with location and flow, but generally is in excess of 100 ft and may exceed 200 ft in places at high flows. The bottom substrate generally consists of gravel to cobble interspersed with finer particles in the depositional zones.

The USGS operated a gauge in reach #2 near Dewey (river mile 63) from September, 1910 through September, 1913. This gauge is located near the downstream boundary of reach #2 (7.3 miles upstream). The maximum discharge measured was 11,600 cfs. The mean flow for the three-year period of record (1911 through 1913 water years) was 1,377 cfs.

The USGS also operated a gauge near Wise River (river mile 74) from June, 1979 to the current year. The site is located 17.9 river miles upstream from the old Divide Dam, the downstream boundary of reach #2. The flow at this gauge reflects diversions for the irrigation of about 114,800 acres above the station. Daily flows ranged from 80 to 5,100 cfs. The mean monthly flows of record for the gauges near Wise River and Dewey are compared in Table 12.

Table 12. Mean monthly flows of record for the USGS gauges near Dewey and Wise River on the Big Hole River.

	Mean Flows (cfs) of Record	
	Near Dewey (river mile 63.1)[a/]	Near Wise River (river mile 73.7)[b/]
Jan	276	150
Feb	243	195
Mar	398	219
Apr	1,147	1,342
May	3,433	3,352
Jun	6,570	2,387
Jul	1,997	725
Aug	793	253
Sep	422	207
Oct	518	148
Nov	444	161
Dec	342	183

a/ Derived for the September, 1910 through September, 1913 period.

b/ Derived for the June, 1979 through September, 1980 period.

Flows were also measured weekly from July 26 through September 15, 1978 at the Wise River gauge site by the MDFWP (Wells and Rehwinkel, 1980). The flow during this period, an above average water year, did not drop below 282 cfs.

Dewatering during the irrigation season represents the greatest threat to the fishery and aquatic resource of reach #2. Additional problems include the trampling of streambanks by wintering cattle, which decreases bank stability, increases sedimentation and, in turn, may lead to the widening of the river channel. Toxic metals pollution from Elkhorn Creek in the Wise River drainage has had severe effects on the biota of Elkhorn Creek and may well be depressing the aquatic community of the Wise River, a major tributary to the Big Hole River.

Sediment loads are generally not a problem in reach #2. However, wintering cattle in the river bottom and the existence of a large feedlot operation extending into the river present localized problem areas. Logging activities in tributary drainages of the Big Hole have the potential for increasing the sediment load of the river.

Reach #3

From the mouth of Pintlar Creek (T1S, R14W, Sec. 8) to the headwaters of the Big Hole River (T5S, R15W, Sec. 26).

Reach #3 of the Big Hole is approximately 41.5 river miles in length. For most of this length, the river meanders through a wide valley and in many places breaks up into more than one channel, forming islands and numerous side channels. The width of the main channel ranges from about 40-53 ft and the gradient averages approximately 3.2 ft/1,000 ft. The bottom substrate is primarily composed of rubble and gravel. The foothills surrounding the river are vegetated with sagebrush and grasses. The land adjacent to the river is extensively irrigated for the production of hay. The riparian vegetation consists primarily of grasses, sedges and willows. Willows are extremely important in this reach for providing streambank stability, overhanging cover for fish and winter habitat and forage for moose. The removal of streambank willows by mechanical means and herbicide sprays is a common practice in the area and has the potential for increasing bank erosion and stream sedimentation. Major tributaries to reach #3 include Warm Springs, Miner, Big Lake and Steel Creeks and the North Fork Big Hole River.

The mean discharge of the upper Big Hole River at a site approximately 5 miles north of Jackson, Montana was approximately 157 cfs between July 16 and September 15, 1978 (Wells and Rehwinkel, 1980). The flow during this period, an above average water year, did not drop below 75 cfs. This site is located near the headwaters of reach #3 approximately 36 river miles upstream of Pintlar Creek.

The water in reach #3 is characterized by a low specific conductance, a neutral pH and low alkalinity and total hardness levels (Liknes, 1981). Water temperatures above Wisdom from April 21-September 1, 1979 ranged from 39-63.7 F (Liknes, 1981). The MDFWP monitored water temperatures from July-September, 1978 approximately five miles north of Jackson (Wells and Rehwinkel, 1980). Maximum daily water temperatures averaged 5-9 F less than those measured downstream near Wise River (reach #2). The maximum temperature recorded was 63 F.

Dewatering during the summer irrigation season, especially in the vicinity of Wisdom, represents the major threat to the fishery in reach #3.

Flow reductions were identified as early as 1959 as limiting fish populations in this reach. Photographs taken in August of 1959 show that the Big Hole near Wisdom was totally dewatered in one of its two channels and nearly so in the other (Heaton, 1960). Any further allocations of water during low flow periods would severely impact existing fish populations. Extensive channel alterations in reach #3 have also decreased the available habitat for fish.

3. FISHERY

Reach #1 (Mouth-Divide Dam)

Fisheries biologists from the Montana Department of Fish, Wildlife and Parks have conducted research on reach #1 of the river since the late 1950's. Early work described the change in fish populations following the introduction of exotic species. Cutthroat trout, the native trout in the Big Hole, had all but disappeared by 1959, victims of dewatering and competition from the introduced brown, rainbow and brook trout. Angler logs from 1954-1963 indicated that brown trout dominated the creel as early as 1955 and electrofishing showed that they comprised the majority of the trout population by 1962 despite the annual stocking of up to 53,000 catchable-size, hatchery rainbow trout (Wipperman, 1965). Hatchery trout have not been stocked in reach #1 since 1974.

Brown Trout

Brown trout population estimates made in a 22,500 ft section of the Big Hole River near Melrose from 1969-1971 and 1977-1979 are summarized in Table 13 (Elser and Marcoux, 1971 and 1972, Peterson, 1973, Wells and Nelson, 1978, Wells and Rehwinkel, 1980 and Wells and Decker-Hess, 1981).

Table 13. Comparisons of estimated numbers of age II and older brown trout per 1,000 ft in the Melrose study section of the Big Hole River from September, 1969 to April, 1971 and April, 1977 to September, 1979. Pounds per 1,000 ft are in parentheses.

Numbers of Brown Trout				
Sept. 1969	April 1970	Sept. 1970	April 1971	April 1977
86(119)	79(106)	96(122)	82(105)	124(114)
Sept. 1977	April 1978	Sept. 1978	April 1979	Sept. 1979
82(121)	156(178)	110(148)	143(124)	108(137)

Numbers of brown trout have varied from a low of 79 per 1,000 ft in April, 1970 to a high of 156 in April, 1978. Pounds per 1,000 ft have also varied considerably from 105 to 178.

The magnitude of the flows during the summer irrigation season appears to be a major factor influencing the fluctuating numbers and mortality rates of brown trout in the Melrose study section (Wells and Rehwinkel, 1980, Kozakiewicz, 1979 and Wells and Decker-Hess, 1981). This is particularly evident with age IV and older brown trout. Figure 10 depicts the estimated numbers of age IV and older brown trout in the fall of 1969, 1970, 1977, 1978, 1979 and the minimum August flows in the Melrose section (Wells and Decker-Hess, 1981). Numbers of age IV and older brown trout were greatest in the fall of 1978, a year when August flows did not drop below 479 cfs, and were lowest in the fall of 1977, a year when August flows dropped to 177 cfs, lowest of the study years. Simple linear regression analysis indicated that a significant ($P<0.05$) relationship existed between the minimum August flows and the estimated fall numbers of age IV and older brown trout (Wells and Decker-Hess, 1981). The minimum August flows explain 84% of the variation in estimated fall numbers of age IV and older trout.

Trout standing crops have also been estimated further downstream below the proposed Reichle Dam site (Peterson, 1973, 1974, 1974a and 1975). Between 1971 and 1974, this 4½-mile section supported between 130 and 152 age II and older trout per 1,000 ft of river. Pounds per 1,000 ft varied from 127 to 148. The brown trout was the predominant trout species, while rainbow trout comprised less than 14% of the trout population.

Population estimates were made in a 15,000 ft section of the Big Hole River near the mouth in April and September, 1979 (Wells and Decker-Hess, 1981). In April, 1979, this section supported an estimated 217 age II and older brown trout, weighing a total of 158 pounds, per 1,000 ft of river and 86 age II and older brown trout, weighing 85 pounds, in September, 1979. Rainbow trout were uncommon in the section.

Numbers of age III and age IV and older brown trout decreased by 76 and 79 percent, respectively, from April to September. These summer mortality rates are considered excessive. Late summer flow in the section was extremely low with a minimum August flow of 141 cfs recorded at the Twin Bridges gauge. These low summer flows resulted in a severe reduction in trout habitat and increased water temperatures. While quantitative water temperature data are unavailable for this section in 1979, water temperatures as high as 77 F were recorded in early September. Thermograph data collected in past years indicate that water temperatures as high as 81 F occur in this section (Miller, 1974). The combination of a severe decrease in habitat and associated increases in late summer water temperatures appear to have resulted in an extremely high summer mortality of older brown trout.

In general, the brown trout population in reach #1 of the Big Hole River, although impacted by summer dewatering, is a healthy one characterized by the presence of large numbers of 18 inch and larger trout in comparison to most other rivers in Montana.

Rainbow Trout

Catchable-size hatchery rainbows were planted extensively in reach #1 from 1954-1974. Due to the low survival of these fish (Elser and Marcoux,

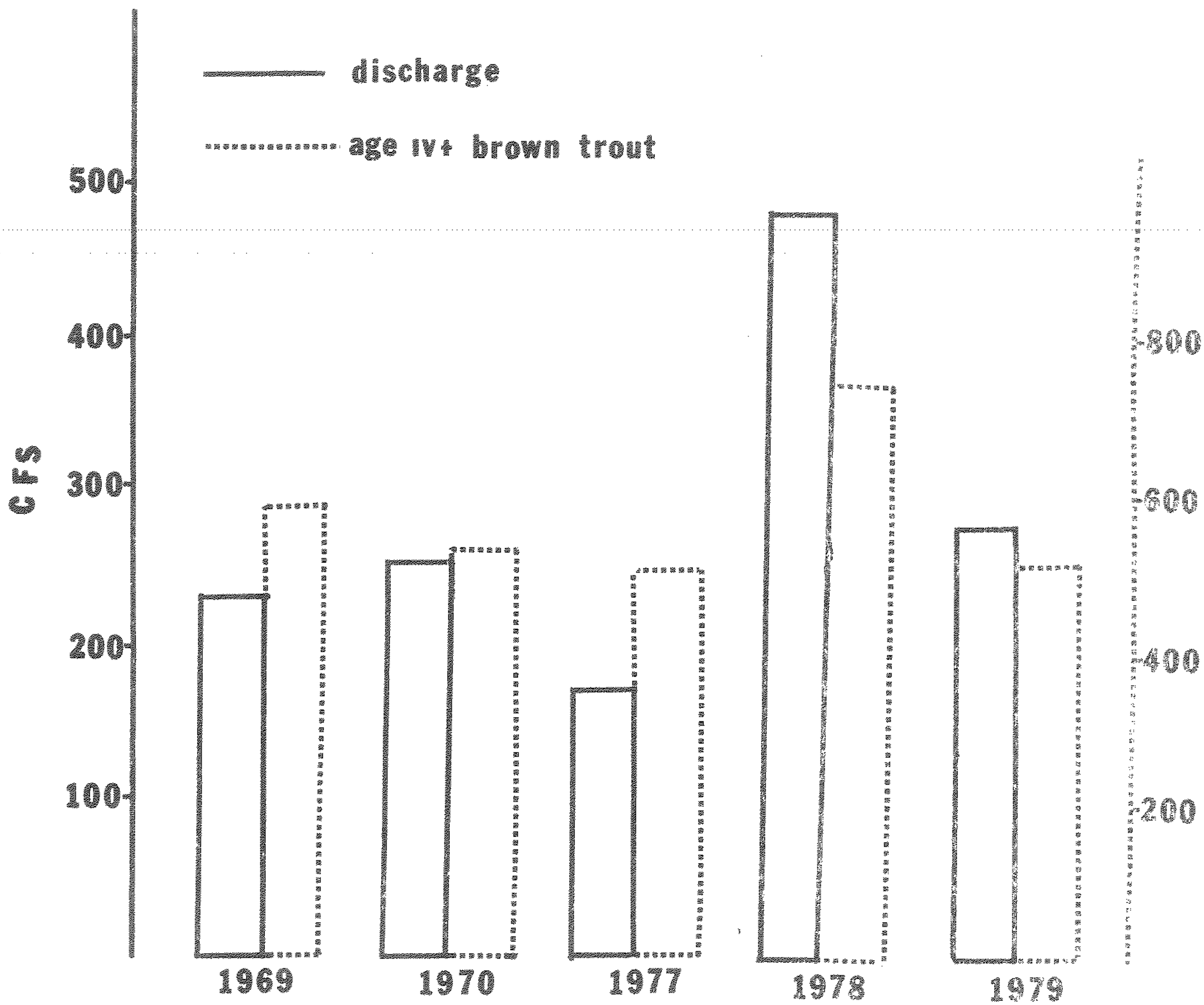

Figure 10. Minimum August flows and September numbers of age IV and older brown trout in the Melrose Section of the Big Hole River, 1969, 1970 and 1977-79 (from Wells and Decker-Hess, 1981).

1971) and stresses imposed on wild trout by their introduction, planting was curtailed in 1974. Reach #1 is now managed for wild rainbow trout.

Population estimates of wild rainbow trout for the Melrose study section from 1969-1971 and 1977-1979 are shown in Table 14 (Elser and Marcoux, 1971 and 1972, Peterson, 1973, Wells and Nelson, 1978, Wells and Rehwinkel, 1980 and Wells and Decker-Hess, 1981).

Table 14. Comparisons of estimated numbers of age II and older wild rainbow trout per 1,000 ft in the Melrose Section of the Big Hole River from September, 1969 to April, 1971 and April, 1977 to September, 1979. Pounds per 1,000 ft are in parentheses.

Numbers of Rainbow Trout				
Sept. 1969	April 1970	Sept. 1970	April 1971	April 1977
35(29)	39(42)	36(26)	38(35)	27(26)
Sept. 1977	Sept. 1978	April 1979	Sept. 1979	
21(21)	48(48)	60(42)	41(41)	

Numbers of wild rainbow trout have remained fairly low throughout the 1969-79 period. Studies on the West Gallatin and Beaverhead Rivers of southwest Montana suggest that rainbow trout are more severely affected by dewatering than are brown trout (Wells, 1977 and Nelson, 1977). The larger rainbow trout of the Big Hole River are also highly vulnerable to anglers. Angler harvest was shown to account for nearly all of the summer mortality of older rainbow trout in the Melrose section in 1977 and 1978 (Wells and Rehwinkel, 1980 and Kozakiewicz, 1979). Both angler harvest and dewatering during the summer are probably operating in conjunction with one another to limit rainbow trout numbers in reach #1.

Other Species

While population estimates have not been made for mountain whitefish in reach #1, they are the most numerous gamefish. These fish provide an unexploited winter fishery for their enthusiasts. A new state record whitefish (4.46 pounds) was captured in this reach during electrofishing work in the fall of 1978. Arctic grayling and brook trout are found in very low numbers while burbot are fairly common. Cutthroat trout are rare. Other species present include carp, longnose dace, mottled sculpin, white sucker, mountain sucker and longnose sucker.

Angler Harvest and Pressure

During the 1977 and 1978 fishing seasons,a partial creel census was conducted on a 10-mile section of reach #1 between Melrose and Glen to determine angler use and harvest (Kozakiewicz, 1979). In 1977, an estimated

5,397 anglers fished 15,698 hours on the study area. Bank anglers accounted for 80% of the total number of anglers. An estimated 3,987 anglers fished 9,945 hours in 1978. Bank anglers accounted for 62% of the anglers. A total of 3,974 and 2,746 trout were creeled in 1977 and 1978, respectively, with brown trout comprising about 75% of the harvest. A total of 1,088 boats used the study area with 41% of the boat use occurring in 1977.

Total fishing pressure on reach #1 of the Big Hole River during the period of May, 1975 through April, 1976 was estimated by the MDFWP at 33,780 angler-days or approximately 605 angler-days/river mile (MDFG, 1976). Reach #1 accounted for over 50% of the total fishing pressure on the Big Hole River during this period.

The daily angling pressure on reach #1 is generally highest during the June salmon fly hatch. The MDFWP operated a check station at the Melrose bridge on the lower Big Hole River (river mile 39) during the peak of the 1981 salmon fly hatch (June 16 through June 21) to determine angling pressure, catch rates and boat use. During this six-day period, a total of 331 boats, of which 31% were commercially operated, took out at or passed the Melrose check site. The boat fishing pressure at this site was measured at 1,672 hours. Boat anglers kept 121 brown and rainbow trout during the six-day period and released an additional 2,091 trout for a catch rate of 1.32 trout/hour.

The 17-mile section of reach #1 between the Melrose bridge and the old Divide Dam was designated a special regulation area in 1981 and is presently open to fishing with artificial lures and flies only with a daily limit of three trout under 13 inches and one over 22 inches. These restrictive angling regulations, which were advocated and overwhelmingly supported by the angling public, were initiated for the purpose of providing anglers with a greater opportunity to catch, but not keep, larger size trout in the 13 to 22 inch category. Prior to 1981, the general angling regulation for the streams and rivers of southwest Montana (daily limit of 5 trout with only one exceeding 18 inches and bait fishing allowed) applied to this section. The remainder of reach #1 and the rest of the river are still managed under the above regulation.

Reach #2 (Divide Dam-Pintlar Creek)

Warden creel census information indicated that rainbow trout dominated the creel from 1954-1963 (Wipperman, 1965). Brook trout were the next most common species creeled followed by grayling and mountain whitefish. Brown trout were evidently not caught in this reach prior to 1963. Creel data collected in 1971 showed hatchery rainbow trout to be the most common fish in the creel followed by wild rainbow trout, mountain whitefish, brook trout, grayling and brown trout (Peterson, 1973). Since 1974, the planting of hatchery rainbow trout in the Big Hole River has been heavily curtailed. Presently, hatchery rainbow are planted only in a small section of reach #2. This section receives about 1,000 catchables annually.

Electrofishing data collected in reach #2 in 1973 indicated that the mountain whitefish was the most abundant gamefish followed by rainbow trout, grayling and brook trout (Peterson, 1974a). The population of mountain whitefish was estimated at 3,002 fish per 1,000 ft of river.

The most recent electrofishing survey in reach #2 was conducted in a 26,400 ft section in September and October, 1978 (Wells and Rehwinkel, 1980). Gamefish captured in descending order of abundance were mountain whitefish, wild rainbow trout, arctic grayling, brown trout and brook trout. Mottled sculpin, longnose dace, burbot and longnose, mountain and white suckers were the other species present. Table 15 summarizes the electrofishing data for 1978.

Table 15. Summary of electrofishing survey data collected for a 26,400 ft section of reach #2 (T1N, R12W, Sec. 3B to 13C) of the Big Hole River in September and October, 1978 (data from Wells and Rehwinkel, 1980).

Species	Number Captured	Length Range (inches)
Mountain Whitefish	1,205	2.0 - 19.9
Rainbow Trout	79	7.2 - 23.9
Arctic Grayling	19	8.5 - 13.5
Brown Trout	8	12.7 - 27.0
Brook Trout	3	10.0 - 11.1
Burbot	-	-
Mottled Sculpin	-	-
Longnose Dace	-	-
Longnose Sucker	-	-
White Sucker	-	-
Mountain Sucker	-	-

Although the number of rainbow trout captured in the study section was low, the population is characterized by the presence of large, trophy-size fish. Rainbow trout up to 8 pounds were captured. Low numbers of brown trout were also present. These fish were all sexually mature and may have been upstream, migrating spawners. The importance of this reach to brown trout reproduction may be greater than previously thought.

The standing crop of mountain whitefish, the most numerous gamefish in the study section, was estimated using a mark-recapture method (Table 16). This section supports about 518 whitefish, weighing a total of 333 pounds, per 1,000 ft of river. This is an average of 1.5 fish per pound. The condition of the whitefish (length to weight ratio) was average for a river of this size. Due to the low numbers of other gamefish captured, meaningful population estimates were not obtainable.

Table 16. Estimated standing crop of mountain whitefish in a 26,400 ft section of reach #2 (T1N, R12W, Sec. 3B to 13C) of the Big Hole River in September, 1978. Eighty percent confidence intervals are in parentheses (data from Wells and Rehwinkel, 1980).

Species	Length Group (inches)	Per 1,000 ft	
		Numbers	Pounds
Mountain Whitefish	8.0 - 9.6	53	
	9.7 - 11.9	267	
	12.0 - 19.9	518	
		518(±143)	333(±100)

During the period from May, 1975 to April, 1976, reach #2 provided approximately 19,817 angler-days of recreation or approximately 30% of the total fishing pressure for the Big Hole River (MDFG, 1976). Recent angler log data show that the catch consists of 59% mountain whitefish, 14% brook trout, 13% rainbow trout, 8% arctic grayling and 7% brown trout. Reach #2 is also extensively used by recreational floaters during the summer months.

Reach #3 (Pintlar Creek-Headwaters)

Creel census information from 1954-1963 indicated that brook trout dominated the catch in reach #3 (Wipperman, 1965). The rainbow trout was the next most common species in the creel followed by grayling and mountain whitefish.

Electrofishing data collected during September-October of 1978 showed that the mountain whitefish was the most numerous gamefish in reach #3 followed by brook trout, rainbow trout and grayling (Wells and Rehwinkel, 1980). Cutthroat trout were rare and brown trout were not captured. Grayling numbers appeared to be greatest between Wisdom and Jackson. Other species present include burbot, longnose dace, white sucker, longnose sucker, mountain sucker and mottled sculpin. The electrofishing survey data for 1978 are summarized in Table 17.

Table 17. Numbers and length ranges of gamefish captured during two electrofishing runs in a 4-mile section of reach #3 of the Big Hole River in September-October, 1978 (data from Wells and Rehwinkel, 1980).

Species	Number Captured	Length Range (inches)
Mountain Whitefish	462	8.5 - 18.4
Brook Trout	161	6.7 - 17.1
Rainbow Trout	8	6.7 - 15.2
Arctic Grayling	5	11.1 - 13.7
Burbot	4	8.4 - 11.2
Cutthroat Trout	1	12.3

The standing crop of mountain whitefish in a 2-mile portion of the study section was estimated using a mark-recapture method (Table 18). This section of the upper river supports about 395 whitefish, weighing a total of 177 pounds, per 1,000 ft of river.

Table 18. Estimated standing crop of mountain whitefish in a 2-mile section of reach #3 of the Big Hole River in September, 1978. Eighty percent confidence intervals are in parentheses (data from Wells and Rehwinkel, 1980).

Species	Length Group (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Mountain Whitefish	8.5 - 11.9	357	
	12.0 - 18.4	38	
		395(±150)	177(±63)

Reach #3 supports the highest density of arctic grayling in the Big Hole River. In Montana, arctic grayling were once widely, but intermittently, distributed in the Missouri River and its tributaries above the Great Falls. Today the only substantial population of stream-dwelling grayling in Montana is found in the upper Big Hole River and its tributaries. The remnant grayling population of the upper Big Hole may soon be subjected to additional biological and physical impacts. Brown trout are believed to be pioneering the area and oil exploration is underway in the drainage.

A cooperative research project with the Montana Cooperative Fisheries Research Unit to determine the distribution, relative abundance and habitat requirements of stream-dwelling grayling in the upper Big Hole River was completed in 1981 (Liknes, 1981). During the study, 1.5 to 5.2 grayling were captured per electrofishing run per 1,000 ft of river. A population estimate for a high density section of the upper river is as follows:

	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Grayling	9.9 - 11.7	11	4.5

Even in high density sections, grayling numbers are still relatively low.

Liknes (1981) reported that grayling were most abundant in the 26 miles of the Big Hole River above the mouth of the North Fork. Grayling were found to be more numerous in sections having summer water temperatures with significantly fewer hours above 62.6 F, suggesting that stream dewatering and the resulting temperature increases may be a major factor contributing to the decline of the Big Hole grayling population. Vincent (1962) cites agricultural practices that reduce natural streamflows, increase siltation and restrict grayling movement as contributing to the decline of the arctic grayling in Montana.

Grayling are reported to be extremely vulnerable to angling. Vincent (1962) reports that grayling are five to six times easier to catch than are brown trout. Given heavy fishing pressure, it may be possible for anglers to remove a significant portion of the grayling population before they reach sexual maturity. From an analysis of creel data collected from 1954-63, Liknes (1981) found that the majority of grayling creeled in reach #3 were prespawners, which lends support to the above hypothesis.

It appears that the decline of the arctic grayling is attributable to a number of factors including habitat alterations, stream dewatering and associated water temperature increases, overexploitation by anglers and interspecific competition with the introduced brook, brown and rainbow trout.

Liknes (1981) recommended several measures to ensure the continued existence of the fluvial grayling population of the upper Big Hole drainage. These include the reservation of instream flows in the main river and selected tributaries, removing barriers to migrating grayling on important tributaries, increasing the minimum size limit to fish greater than 11 inches to protect prespawners, and the planting of fluvial grayling in suitable habitat to further protect the unique gene pool.

During the period of May, 1975 to April, 1976, reach #3 provided approximately 12,680 angler-days of recreation, representing nearly 20 percent of the fishing pressure on the entire Big Hole River (MDFG, 1976). Reach #3 is also used by recreational floaters during the summer months.

4. FLOW RECOMMENDATIONS

Reach #1 (Mouth-Divide Dam)

Cross-sectional data in reach #1 were collected in a 984 ft subreach located at river mile 36 (T3S, R9W, Sec. 11). Six cross-sections describing the riffle-pool sequence were placed in the subreach. The WETP program was calibrated to field data collected at flows of 444, 570, 587 and 985 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 11. The upper inflection point occurs at a flow of approximately 325 cfs.

Flow and trout population data collected in the Melrose electrofishing section from 1969 through 1978 and analyzed by Nelson (1980a) strongly suggest that the standing crops of rainbow and brown trout in the section were substantially reduced by summer flows less than approximately 400 cfs. Based on this analysis, the results of the wetted perimeter method, the "Blue Ribbon" status of reach #1 and the river's exceptional sport fishery and recreational values, a flow of 400 cfs is recommended for the low flow period (July 16-April 15).

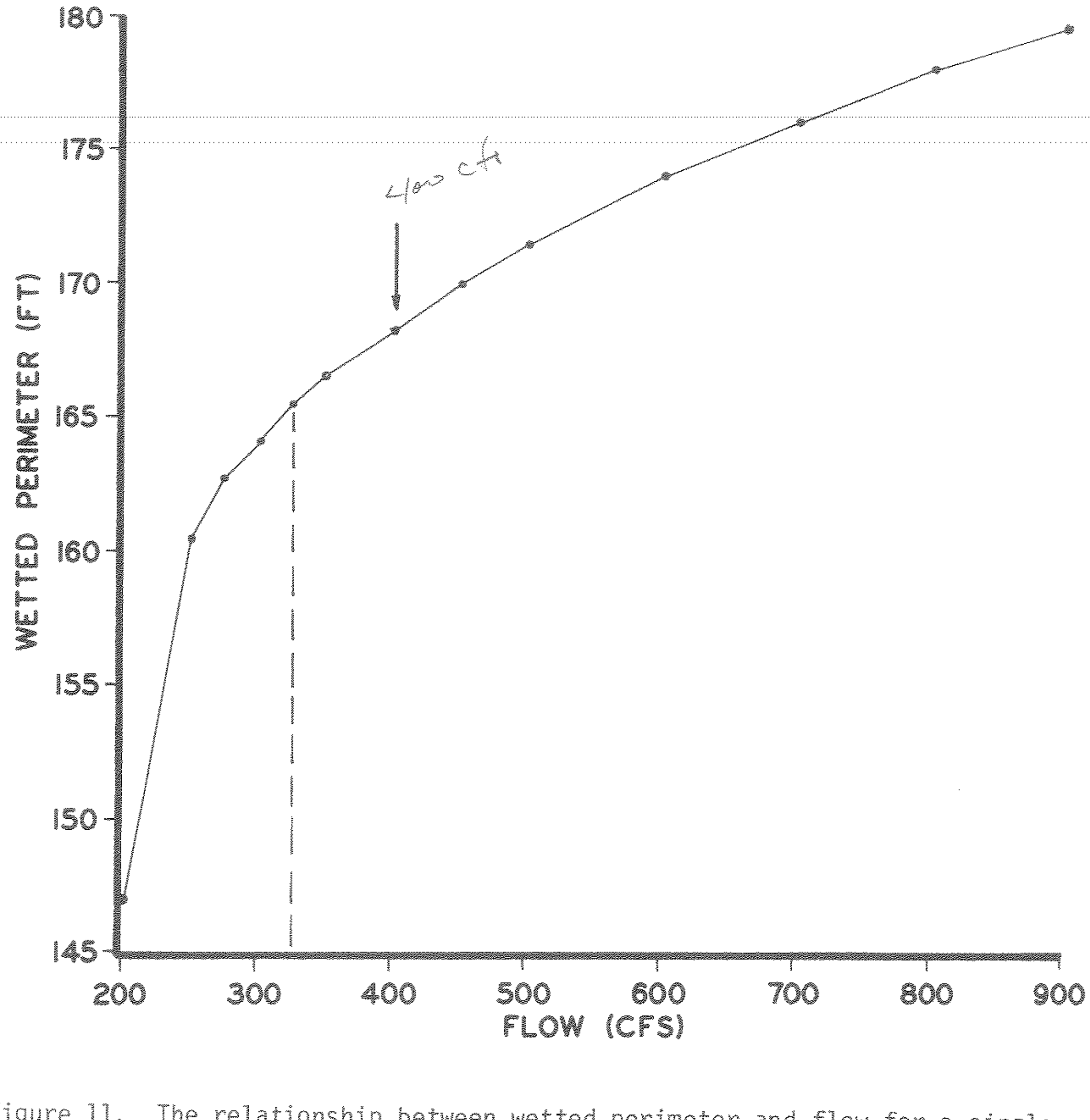

Figure 11. The relationship between wetted perimeter and flow for a single riffle cross-section in reach #1 of the Big Hole River.

Recommendations for the low and high flow periods are compared to the monthly median flows of record for reach #1, as derived for the USGS gauge near Melrose, in Table 19. The low flow recommendations exceed the median flows for the months of September, December, January and February. The monthly flow recommendations, when adjusted to the constraints of water availability during a median or normal water year, amount to 486,184 acre-feet of water per year or approximately 66% of the annual flow that is normally available at the USGS gauging site near Melrose.

Reach #2 (Divide Dam-Pintlar Creek)

Cross-sectional data were collected in a 727 ft riffle-run sequence located at river mile 76 (T1N, R12W, Sec. 3B). Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 338 and 728 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 12. Due to the morphology of the cross-section, a well defined inflection point is not present. The other four cross-sections gave similar results. Additional cross-sections will be established in an area having better riffle development. A low flow recommendation for reach #2 will not be derived until this additional cross-sectional information is collected and analyzed.

Reach #3 (Pintlar Creek-Headwaters)

Cross-sectional data in reach #3 were collected in a 244 ft subreach at river mile 132 (T4S, R15W, Sec. 33B). Five cross-sections describing the various habitat types were placed in the subreach. The WETP program was calibrated to field data collected at flows of 129 and 273 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 13. The upper inflection point occurs at approximately 100 cfs. Based on the importance of this reach to the fluvial arctic grayling and an evaluation of recreational use and other resource information, a flow of 100 cfs is recommended for the low flow period (July 16-April 15). Flow recommendations for the high flow period (April 16-July 15) cannot be derived for reach #3 due to the lack of long-term flow data.

Table 19. Comparison of the instream flow recommendations for reach #1 (Mouth-Divide Dam) of the Big Hole River to the median flows of record.

	Flow Recommendations[a/]	Approximate Median Flows[b/]	
	cfs	cfs	acre-feet
Jan	400	344	21,147
Feb	400	328	18,212
Mar	400	400	24,589
Apr 1-15	400	818	24,331
Apr 16-30	887	1,609	47,860
May 1-15	1,430	2,332	69,365
May 16-31	2,190	3,518	111,619
Jun 1-15	2,510[c/]	4,431	131,800
Jun 16-30	1,417	3,120	92,804
Jul 1-15	798	1,579	46,967
Jul 16-31	400	902	28.619
Aug	400	445	27,355
Sep	400	305	18,144
Oct	400	447	27,478
Nov	400	475	28,258
Dec	400	348	21,393
			739,941

[a/] Derived from the wetted perimeter/inflection point method and the dominant discharge/channel morphology concept.

[b/] Derived for a 49-year period of record (between 1925 and 1973 water years) for the USGS gauge station at river mile 31.1 (near Melrose, Montana).

[c/] A flow of 5,630 cfs (the approximate bankful discharge) should be maintained for 24 hours during this period.

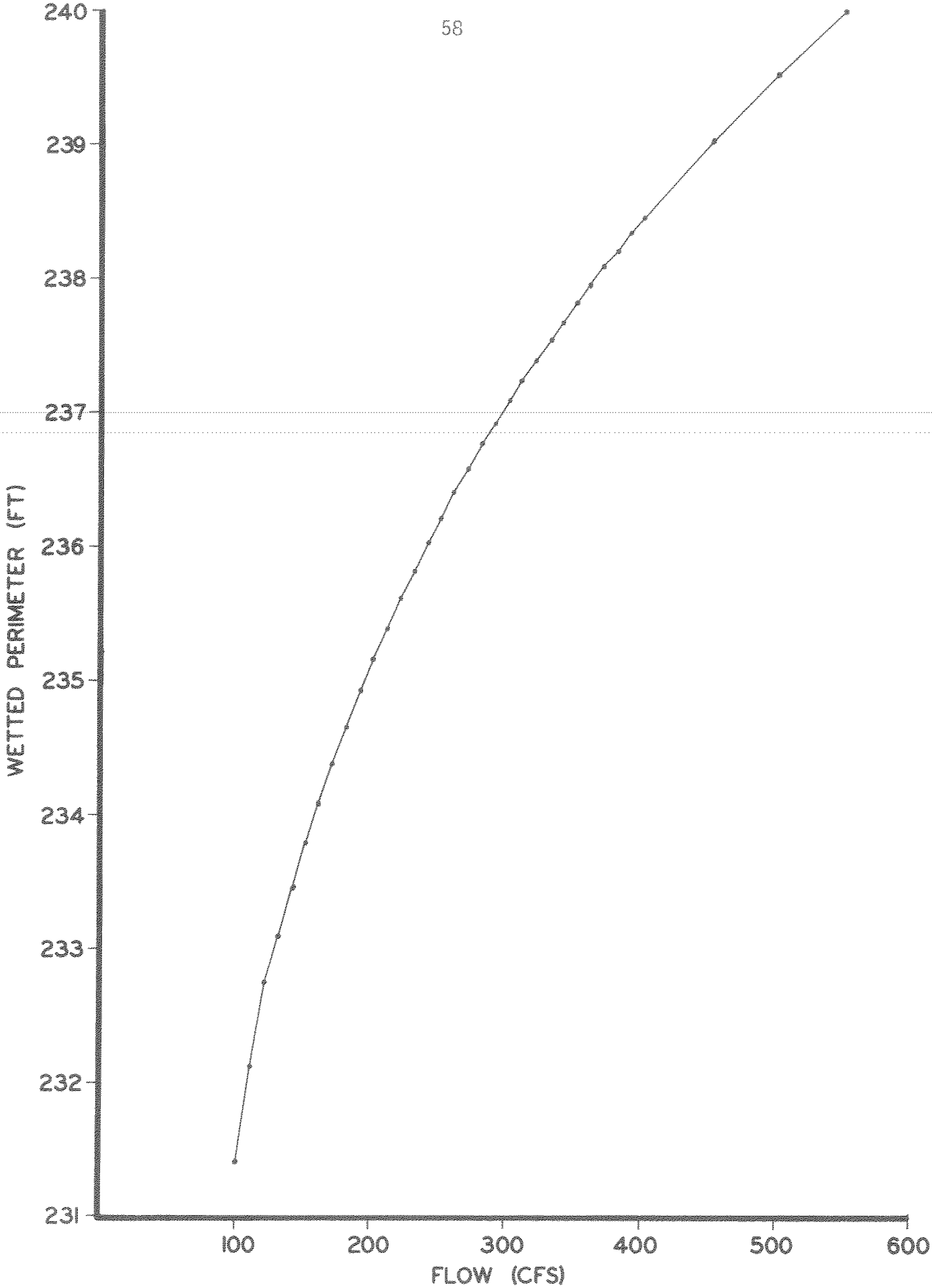

Figure 12. The relationship between wetted perimeter and flow for a single riffle cross-section in reach #2 of the Big Hole River.

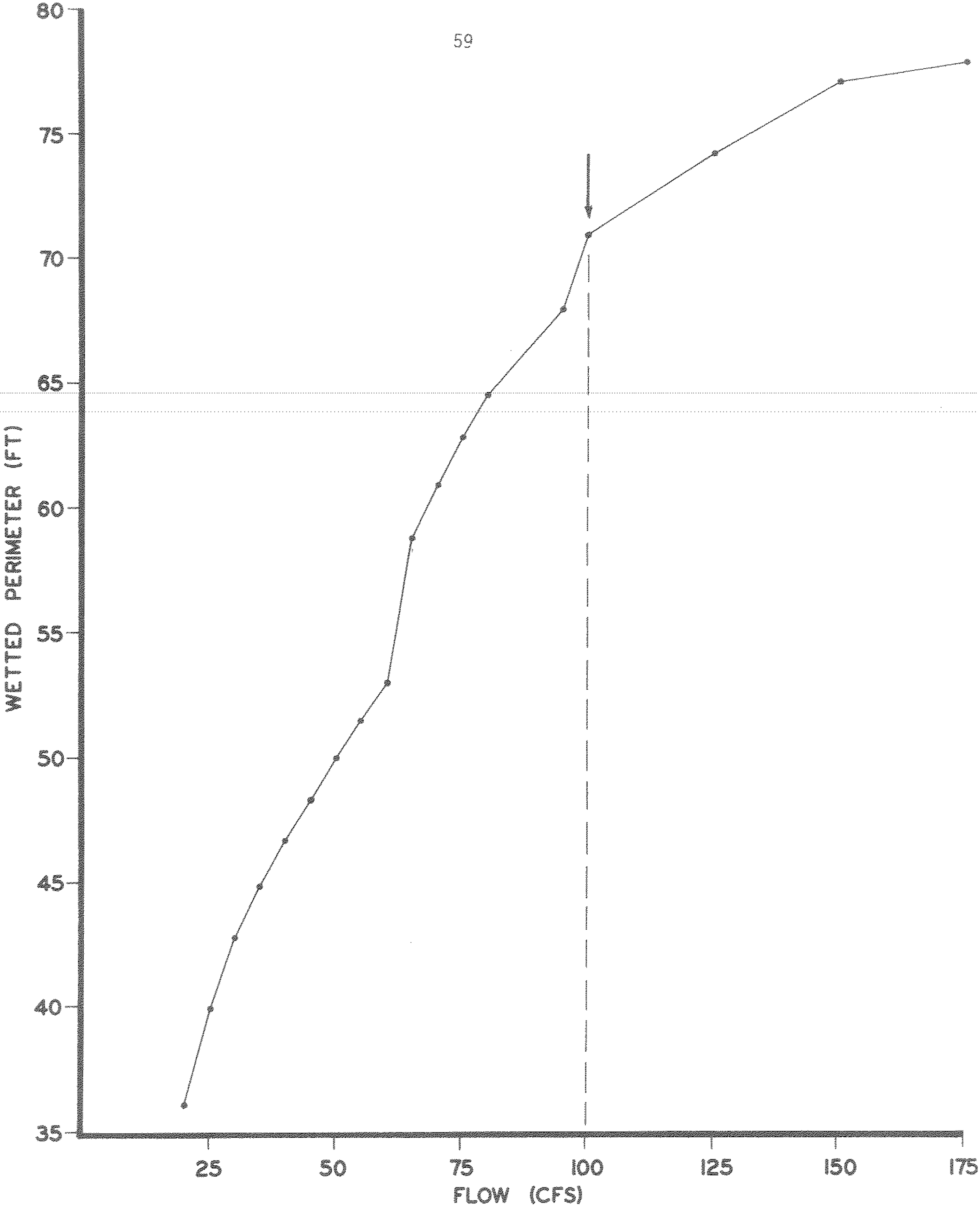

Figure 13. The relationship between wetted perimeter and flow for a single riffle cross-section in reach #3 of the Big Hole River.

1. STREAM

Camp Creek

2. DESCRIPTION

Camp Creek originates on the eastern slopes of the Highland Mountains of southwest Montana and flows in a southwesterly direction for approximately 14.5 miles before entering the Big Hole River at Melrose, Montana. A small irrigation reservoir is located on Camp Creek at stream mile 3.8. Thirty percent of the drainage is forested, most of which is found in the steep, upper basin. The remainder of the drainage is characterized by sagebrush/grassland benches and a floodplain of dense willows. Control of the 40.5 square mile drainage is shared by the BLM (46%), the USFS (30%), private individuals (20%) and the State of Montana (5%). Major tributaries to Camp Creek include Willow, Wickiup and Little Camp Creeks. Numerous springs also contribute to the flow. Average gradient of the 12 ft wide channel is approximately 50 ft per 1,000 ft.

Lands within the Camp Creek drainage are used primarily for livestock grazing and hay production. Other uses include recreation in the form of hunting and fishing, timber harvesting and, historically, mining in the upper drainage. Public access is provided by a gravel road paralleling the stream for its entire length.

During 1977-78, the discharge of Camp Creek was measured at two sites during the snow-free months (Foggin et al., 1978). At the lower site, flows in 1977 varied from a low of 2.4 cfs in September to a high of 19 cfs in mid-April. The maximum annual flow occurred prior to the first measurement. During 1978, flows ranged from 5.0 cfs in September to 90 cfs in May.

The severe dewatering of lower Camp Creek during the summer irrigation season is the most limiting factor to the aquatic resource. Grazing within the riparian zone has resulted in the loss of undercut banks and streamside vegetation and the widening of the channel along portions of the lower stream. Past placer mining in the upper reaches has altered several stretches of the main channel and its tributaries (Wipperman, 1969b).

After an extensive investigation in 1977-89, Camp Creek was found to have good channel stability, relatively low sediment yields and increased sediment production only during spring runoff (Foggin et al., 1978). The water chemistry was characterized by a neutral to alkaline pH, a moderate specific conductance and below nuisance levels of major nutrients. Fecal coliform levels were highest during the grazing season and exceeded the Montana water quality standard 8 and 17% of the time at the lower and upper stations, respectively. Macroinvertebrate sampling on two stretches of Camp Creek revealed a low overall diversity with silt tolerant species dominating the sample.

3. FISH POPULATIONS

A 825 ft section of Camp Creek was electrofished on July 8 and 20, 1981. Gamefish captured in descending order of abundance were brook, rainbow and cutthroat trout. The mottled sculpin was the only non-game species present. The electrofishing survey data are summarized in Table 20.

Table 20. Summary of electrofishing survey data collected for a 825 ft section of Camp Creek (T2S, R8W, Sec. 19A) on July 8 and 20, 1981.

Species	Number Captured	Length Range (inches)
Brook Trout	70	4.6 - 10.4
Rainbow Trout	61	4.0 - 11.8
Cutthroat Trout	1	9.3
Mottled Sculpin	-	-

The standing crop of trout in the study section was estimated using a mark-recapture method (Table 21). The section supports approximately 208 brook and rainbow trout, weighing a total of 39 pounds, per 1,000 ft of stream. The brook trout, the predominant trout species, accounted for about 54% of the trout numbers and 46% of the biomass.

Table 21. Estimated standing crops of trout in a 825 ft section of Camp Creek (T2S, R8W, Sec. 19A) on July 8, 1981. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Brook Trout	5.0 - 5.9	21	
	6.0 - 9.9	91	
	10.0 - 10.4	1	
		113(±21)	18(±4)
Rainbow Trout	5.0 - 5.9	7	
	6.0 - 9.9	75	
	10.0 - 11.8	13	
		95(±18)	21(±5)
Total Trout		208(±28)	39(±6)

In June of 1976, four sections of Camp Creek were electrofished by the BLM (BLM, unpublished data). Brook, rainbow and cutthroat trout and rainbow X cutthroat hybrids were captured. The brook trout was the dominant game species in the lower most section while cutthroat dominated the upper section. The number of trout captured varied from 4 to 30 per 600 ft of stream.

4. FLOW RECOMMENDATIONS

Cross-sectional data for Camp Creek were collected in a 53 ft riffle-pool sequence at approximate stream mile 2.7 (T2S, R8W, Sec.19A). Five cross-sections describing the riffle-pool habitat were placed within the sequence.

Only one set of calibration data at a flow of 14.2 cfs was collected due to the extensive beaver construction that occurred in the subreach after the cross-sections were established. Consequently, the WETP computer program could not be used in the analysis. However, the Water Surface Profile (WSP) computer program of the Bureau of Reclamation, which requires only one set of calibration data, was used in place of the WETP program to generate the wetted perimeter and flow relationships. The WSP program was calibrated and run by Rick DeVore of the Bureau of Reclamation, Billings, Montana.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 14. Lower and upper inflection points occur at 4.0 and 5.0 cfs, respectively. Based on an evaluation of existing fishery, water availability and other resource information, a flow of 4.5 cfs is recommended for the low flow period (July 1 - April 30). Recommendations for the high flow period (May 1 - June 30) cannot be derived for Camp Creek due to the lack of long-term flow data.

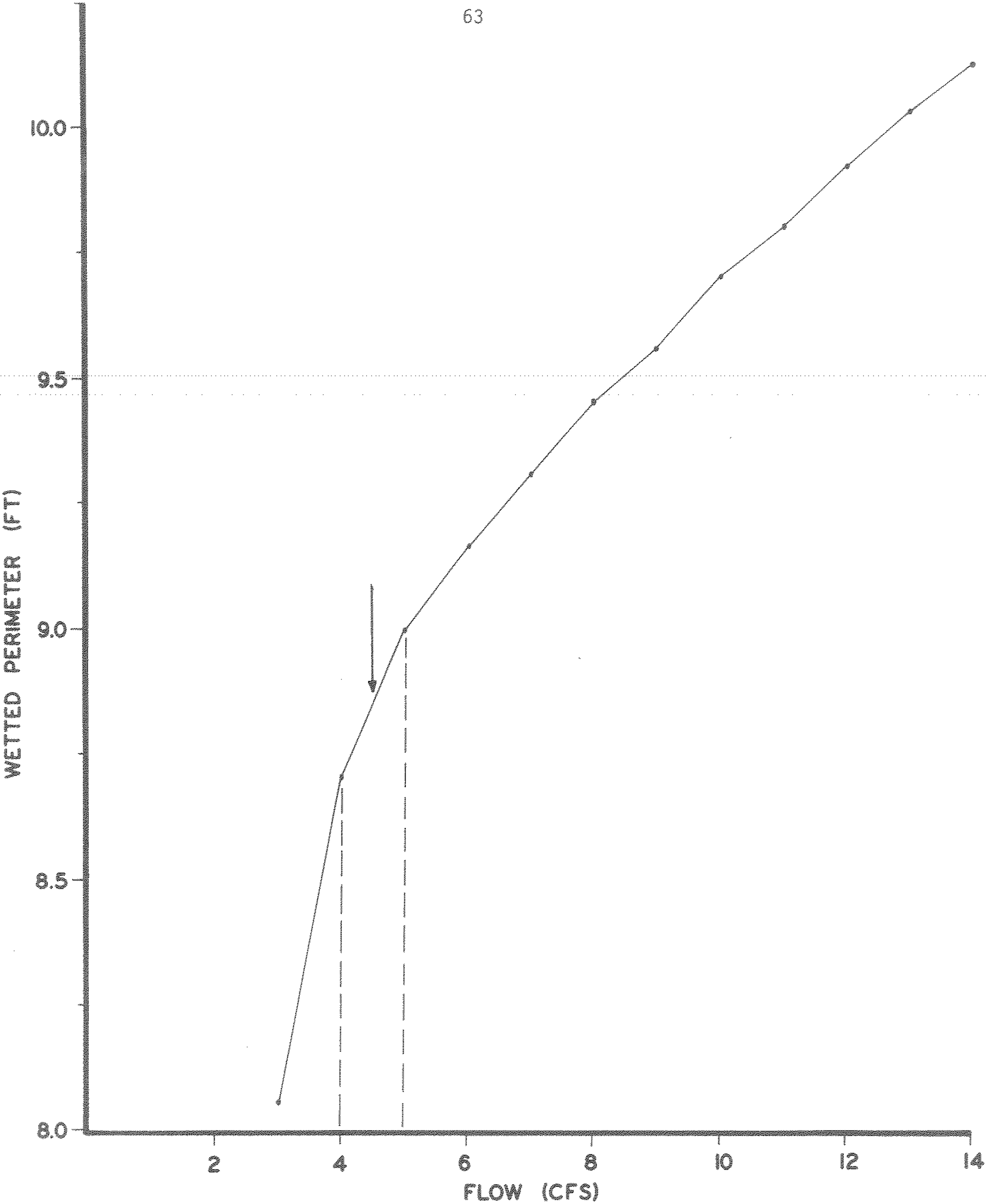

Figure 14. The relationship between wetted perimeter and flow for a single riffle cross-section in Camp Creek.

1. STREAM

Canyon Creek

2. DESCRIPTION

Canyon Creek originates in the Pioneer Mountains, southeast of the town of Divide, Montana. The stream flows in a northeasterly direction for 16 miles before joining the Big Hole River. For the majority of its length, Canyon Creek cascades through a forested canyon containing numerous limestone caves. It flows through cottonwood and willow bottoms in its lower few miles. The stream gradient averages 36 ft/1,000 ft. Ownership of the 51 square mile drainage is shared by the USFS (97%), BLM (2%) and private landowners (1%). The only named perennial tributaries are Lion and Vipond Creeks. Numerous high mountain lakes and intermittent streams drain the headwater area. The substrate within the 12 ft wide channel is composed primarily of gravel and rubble.

Lands within the Canyon Creek drainage are used for cattle grazing, mining, and recreational activities including fishing, hunting and camping. An improved gravel road,which parallels the lower 12 miles of stream, ends at a USFS campground. A guest ranch is located along the stream.

Fishing pressure on Canyon Creek in 1975-76 was estimated at 432 person-days per year (MDFG, 1976). This amounts to about 27 person-days/stream mile/year. Angler log data compiled by the DFWP shows that the catch consists entirely of cutthroat trout, averaging 7.5 inches in length (MDFWP, 1980b). The drainage is a popular area for hunting mule deer and elk and provides important mule deer winter range as well. Presently, the Canyon Creek drainage is being managed under the USFS rest rotation grazing allotment system (USFS, unpublished data).

Beginning in the late 1800's, the mining boom swept through the Canyon Creek drainage and the Trapper Creek drainage, the adjacent drainage to the south. A large smelter was built at the town of Glendale along Trapper Creek, for processing the ore mined in the area. Charcoal and coke were used to operate the smelter. Thirty-eight charcoal kilns, producing 1,000,000 bushels of charcoal per year, were built in the Canyon Creek drainage.

The Vipond Park and Quartz Hill Mining Districts are located in the drainage. From 1902-1965, total recorded production from this district was 57,261 tons of ore containing silver, lead, copper, gold and zinc (Geach, 1972). Presently, an exploration group is studying the feasibility of reopening the area for silver and copper production (USFS, unpublished data).

The 1977 Montana Legislature requested the Department of Natural Resources and Conservation to study the feasibility of constructing an off-stream storage reservoir on a tributary to the Big Hole River. The reservoir is to be used for augmenting instream flows in the Big Hole and Jefferson Rivers, irrigation and flood control (DNRC, 1979). A site on Canyon Creek was selected for further study. The Canyon Creek site was later eliminated due to potential seepage problems (DNRC, 1981).

The water of Canyon Creek has a low specific conductance, a low hardness and alkalinity, a neutral pH and low suspended sediments. This is typical for the tributaries of the Big Hole River (USFS, unpublished data).

The aquatic resource is relatively unaffected by mans' activities. Minor losses of riparian habitat and undercut banks have occurred on several isolated sections of the stream. Although the headwater area was extensively mined and left unreclaimed and toxic metals may be leaching into the stream, their effect on the aquatic resource appears negligible.

3. FISH POPULATIONS

A 1,000 ft section of Canyon Creek was electrofished on July 9 and 31, 1979. Game fish captured were rainbow trout, rainbow x cutthroat hybrids and brook trout. The mottled sculpin was the only nongame species captured. Table 22 summarizes the electrofishing survey data for Canyon Creek.

Table 22 . Summary of electrofishing survey data collected for a 1,000 ft section of Canyon Creek (T2S, R10W, Sec. 15A) on July 9 and 31, 1979.

Species	No. Captured	Length Range (inches)
Rainbow Trout and Rainbow x Cutthroat Hybrids	92	2.6-12.7
Brook Trout	64	4.0-11.7
Mottled Sculpin	-	-

The standing crop of trout in the section was estimated using a mark-recapture method (Table 23). This 1,000 ft section supports about 211 trout, weighing 27 pounds. Rainbow trout and rainbow x cutthroat hybrids were the predominant game fish. They comprised about 54% of the total trout numbers and 59% of the total biomass. Brook trout accounted for 46% of the trout numbers and 41% of the biomass.

Table 23. Estimated standing crop of trout in a 1,000 ft section of Canyon Creek (T2S, R10W, Sec. 15A) on July 9, 1979. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Number	Pounds
Rainbow Trout and Rainbow x Cutthroat Hybrids	4.0- 5.9	43	
	6.0- 9.9	64	
	10.0-12.7	6	
		113(±29)	16(±4)

Table 23 continued. Estimated standing crop of trout in a 1,000 ft section of Canyon Creek (T2S, R10W, Sec. 15A) on July 9, 1979. Eighty percent confidence intervals are in parentheses.

Brook Trout	4.0- 5.9	59	
	6.0- 9.9	36	
	10.0-11.7	3	
		98(±28)	11(±2)
Total Trout		211(±40)	27(±5)

Wipperman and Needham (1965) electrofished a 340 ft section of Canyon Creek located 2.5 miles upstream from the present section. The brook trout was the dominant trout species with 95 individuals captured. Twenty-one cutthroat x rainbow hybrids, three rainbow trout and two cutthroat trout were also captured. Of the 121 trout captured, only 14% were longer than 7 inches.

Gill netting data show that rainbow and cutthroat trout and rainbow x cutthroat hybrids are present in Canyon, Cresent, Grayling and Vera Lakes, mountain lakes within the headwaters of the Canyon Creek drainage. (Wipperman and Elser, 1968).

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were collected in a 96 ft riffle-pool sequence in T2S, R10W, Sec. 12A. Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 4.2, 15.3 and 48.2 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is illustrated in Figure 15 . Lower and upper inflection points occur at flows of 2 and 5 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 4 cfs is recommended for the low flow period (July 16 - May 15). Due to the lack of long-term flow data for Canyon Creek, recommendations for the high flow period (May 16 - July 15) cannot be derived.

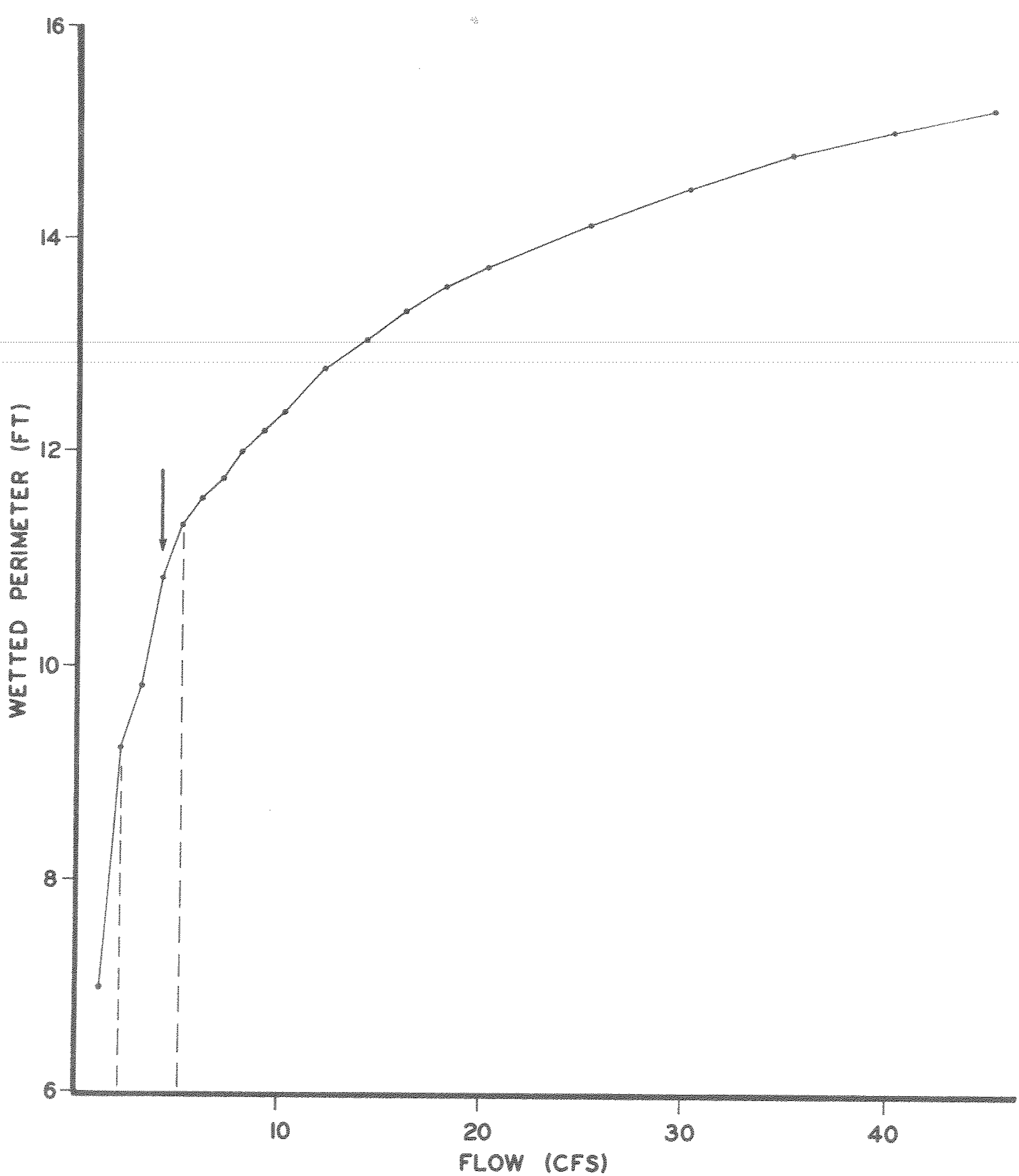

Figure 15. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Canyon Creek.

1. STREAM

Deep Creek

2. DESCRIPTION

Deep Creek arises on the southern slope of the Anaconda-Pintlar Range of southwest Montana, 12 miles west of Wise River, Montana. Deep Creek is formed at the confluence of Ten Mile and Seven Mile Creeks, then meanders through dense willow and alder bottoms in a southerly direction for 9 miles before entering the Big Hole River. Other tributaries of Deep Creek include French, Sullivan, Slaughter-house and Twelve Mile Creeks. Vegetative cover in the 100 square mile drainage consists of conifer forests in the upper portion, changing to sagebrush/grasslands at the lower elevations. The majority of the drainage (63%) was acquired by the Montana Department of Fish, Wildlife and Parks in 1976 as a wildlife management area, which protects an important deer and elk migration route and winter habitat for moose. The remainder of the drainage is divided between the USFS (30%), private landowners (5%) and the BLM (2%). Average gradient of the 30 ft wide channel is 8.4 ft/1,000 ft.

Lands within Deep Creek drainage are primarily used for wildlife management, recreation in the form of hunting, fishing and skiing, timber harvesting, cattle grazing and hay production along the lower reaches. The Mt. Haggin Wildlife Management Area is presently one of the more popular elk and mule deer hunting districts in the state. Hunting pressure in 1979 was estimated at 33,644 hunter-days (MDFWP, 1980a). There is presently a grazing contract with the Mt. Haggin Livestock Company and a logging contract with Louisiana Pacific on the Mt. Haggin WMA. Prior to the acquisition of the Mt. Haggin property by the DFWP, willows within the riparian zone were physically and chemically removed to increase the grazing area (Wipperman, 1967). A small ski area primarily used by local residents is also located in the drainage.

During the irrigation season, the lower reaches of Deep Creek are diverted causing severe dewatering. Damage to the stream caused by the trampling of banks and grazing in the riparian zone is evident on the lower reaches. A subdivision presently being developed on Deep Creek could contaminate ground water through improper use or placement of septic tanks, affect the stream recharge rate through well production and alter the floodplain through the drainage of marshy areas.

The water chemistry of Deep Creek above the confluence of French Creek was analyzed during the summer of 1980 at three different flows (Oswald, 1981). In general, Deep Creek exhibits the typical chemical pattern for streams of the Big Hole drainage of a low specific conductance, low hardness and alkalinity levels, a neutral pH and low suspended sediments.

3. FISH POPULATIONS

A 1,000 ft section of Deep Creek above the mouth of French Creek was electrofished on August 26 and September 9, 1980. A 1,000 ft section below the mouth was electrofished on July 11 and August 2, 1979. Game fish present in both sections were brook trout, rainbow trout, mountain whitefish and burbot. Longnose sucker, longnose dace, and mottled sculpin were the nongame species captured. Table 24 summarizes the electrofishing survey data for the two sections.

Table 24. Summary of electrofishing survey data collected for two 1,000 ft sections of Deep Creek above (T2N, R12W, Sec. 9A) and below (T2N, R12W, Sec. 20D) the mouth of French Creek on August 26 and September 9, 1980 and July 11 and August 2, 1979, respectively.

	No. Captured		Length Range (inches)	
Species	Above French	Below French	Above French	Below French
Brook Trout	131	16	2.2- 9.9	1.6- 9.9
Rainbow Trout	12	18	2.5-11.0	5.2-10.2
Mountain Whitefish	6	19	8.4-13.1	10.2-12.5
Burbot	13	10	7.2-13.0	7.6-10.7
Longnose Sucker	25	66	4.5-12.4	4.6-10.1
Longnose Dace	-	-	-	-
Mottled Sculpin	-	-	-	-

In comparing the two sections, approximately eight times more brook trout were captured above the mouth of French Creek than were captured below.

Due to the low numbers of fish captured in the lower section, the standing crop of brook trout could only be estimated in the section above the mouth of French Creek (Table 25). This section supports about 167 brook trout, weighing 18 pounds. The condition factors for brook trout (length to weight ratio) were below average for streams sampled in the present study.

Table 25. Estimated standing crop of brook trout in a 1,000 ft section of Deep Creek located above the mouth of French Creek (T2N, R12W, Sec. 9A) on August 26, 1980. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Numbers	Pounds
Brook Trout	4.0-5.9	63	
	6.0-9.9	104	
		167 ($\pm$35)	18 ($\pm$3)

Electrofishing surveys conducted in 1964 (Wipperman and Needham, 1965) and 1966 (Wipperman, 1967) show similar results. In both years, numbers of brook trout captured above the French Creek confluence were considerably greater than those below.

Within the 2.5 miles between the upper and lower sections, some factor or combination of factors are depressing the trout population. French Creek, whose fishery is also depressed, is the only major tributary entering Deep Creek between these sections.

Although not captured during the 1979 or 1980 electrofishing surveys, low numbers of arctic grayling have been found in the lower reaches of Deep Creek (Wipperman and Needham, 1965 and Wipperman, 1967). The fluvial arctic grayling is classified as a species of special concern (Deacon et al., 1979). Once widely distributed throughout the upper Missouri River drainage, remnant populations of fluvial arctic grayling are now only found in the upper Big Hole drainage. Vincent (1962) cites agricultural practices that reduce natural streamflows, increase siltation and restrict grayling movement as possible causes for the apparent decline of this species in recent years. It is imperative that instream flow protection is secured for those streams still supporting arctic grayling populations.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were collected in a 158 ft subreach located near stream mile 2.0 (T2N, R12W, Sec. 20D). Five cross-sections describing the riffle-pool habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 33.8 and 187.5 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 16. Lower and upper inflection points occur at 20 and 40 cfs, respectively. Based on an evaluation of existing fishery and other resource information, a flow of 30 cfs is recommended for the low flow period (July 16 - May 15). Recommendations for the high flow period (May 16 - July 15) cannot be derived for Deep Creek due to lack of long-term flow data.

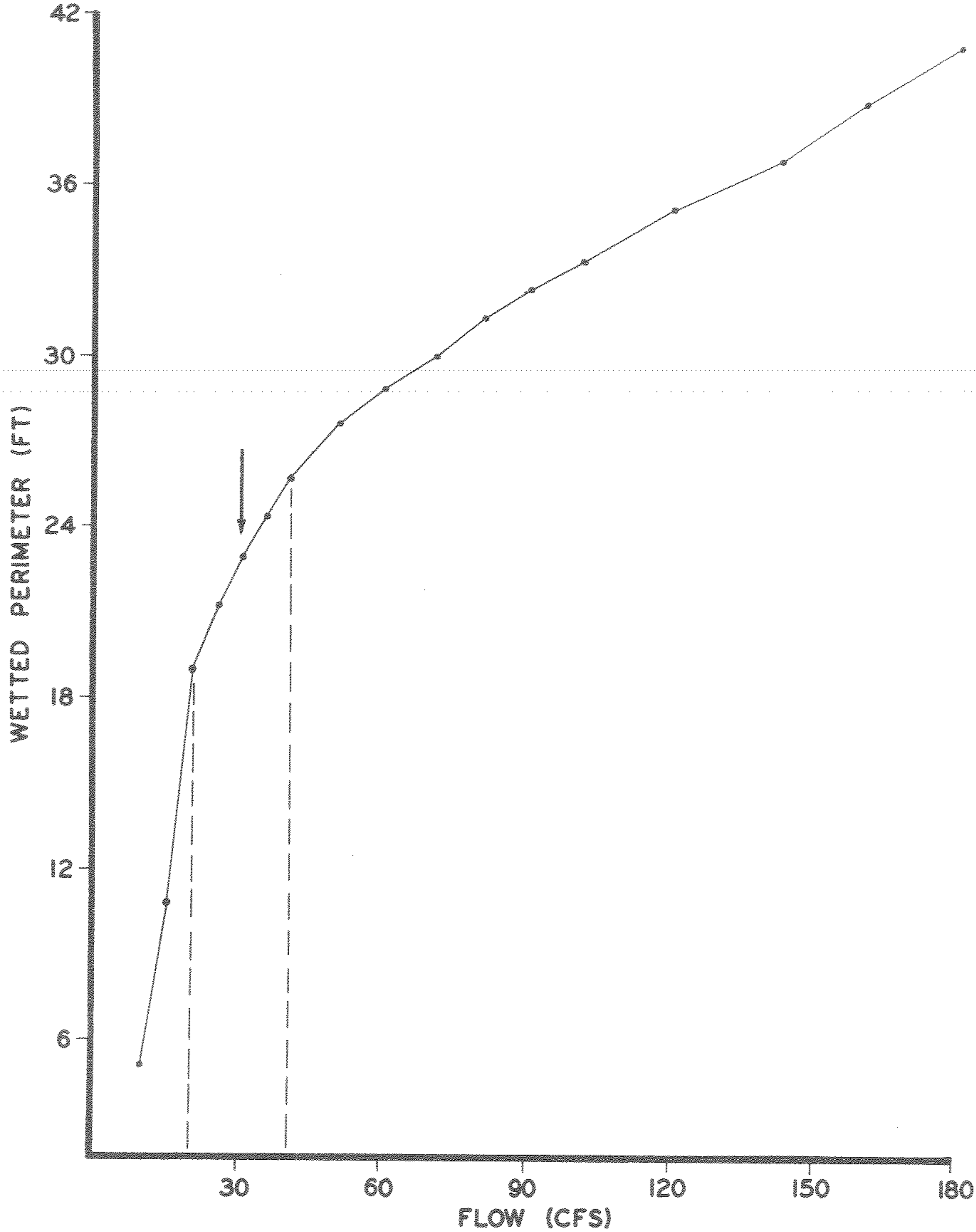

Figure 16. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Deep Creek.

1. STREAM

Moose Creek

2. DESCRIPTION

Moose Creek originates on the eastern slopes of the Highland Mountains of southwest Montana and flows in a southwesterly direction for approximately 14.5 miles before entering the Big Hole River, 10 miles north of Melrose, Montana. Moose Creek flows through a riparian zone of willows, alder, aspen, grasses and forbs. The average gradient of the 13 ft wide channel is approximately 40 ft per 1,000 ft. Ninety percent of the fan-shaped drainage is forested. The remaining 10 percent is comprised of sagebrush/grassland hillsides and benches. Control of the 36.4 square mile drainage is shared by the BLM (44%), USFS (43%), and private individuals (13%). Of the portion of the drainage managed by the BLM, 45 percent lies within the boundaries of the Humbug Spires Primitive Area. Major tributaries to Moose Creek include McLean, Chicken Gulch and the Middle Fork and North Fork Moose Creeks.

The BLM operated a staff and crest-stage gauge at approximate stream mile 4.5 of Moose Creek (T1S, R9W, Sec. 23D) from April through October, 1977 and 1978 (Foggin et al., 1978). Minimum and maximum recorded flows during 1977 were 3.0 cfs in July and 103 cfs in May. Flows during 1978 ranged from a low of 8.6 cfs in August to a high of 122 cfs in May. As with most tributaries of the Big Hole River, the lower reaches of Moose Creek are dewatered during the summer irrigation season.

Lands within the Moose Creek drainage are currently used for livestock grazing, hay production, timber harvesting in the upper portion and recreation in the form of hunting, fishing and hiking. During the last century, mining for metals occurred throughout the upper drainage. Placering for gold was intermittently productive (Lyden, 1948). Between 1866 and 1904, several hundred thousand dollars worth of gold was recovered. Since 1904, production has been insignificant. Approximately 2,000 ft of channel in the upper reaches has been straightened as a result of past placer mining (Wipperman, 1969b).

Fishing pressure on Moose Creek from May, 1975 to April 1976 was estimated at 1,242 person-days/year (MDFG, 1976). This amounts to approximately 86 person-days/stream mile/year. Data from angler logs indicate that the catch consists entirely of brook trout, averaging 7 inches in length (MDFWP, 1980a). When compared to other streams in the Big Hole basin, Moose Creek is one of the most highly used by anglers. A gravel road skirting the Humbug Spires Primitive Area provides access to the Moose Creek drainage.

The water chemistry of Moose Creek was evaluated during 1977-78 (Foggin et al., 1978). In general, Moose Creek exhibits the typical pattern of tributaries to the Big Hole River. The water is characterized by a slightly alkaline pH, a low specific conductance and low levels of suspended sediment. The average annual sediment yield for the Moose Creek drainage during 1977-78 was 355 tons. Channel stability is rated good (Foggin et al., 1978).

Macroinvertebrate sampling of Moose Creek at two sites was characterized by high diversities and biomasses (Foggin et al., 1978). Ephemeroptera was the dominant order during the three seasonal samples.

3. FISH POPULATIONS

A 1,000 ft section of Moose Creek was electrofished on July 2 and 31, 1979. Gamefish present in descending order of abundance were rainbow, brook and cutthroat trout and rainbow x cutthroat hybrids. The mottled sculpin was the only nongame species captured. The electrofishing survey data are summarized in Table 26.

Table 26. Summary of electrofishing survey data collected for a 1,000 ft section of Moose Creek (T1S, R9W, Sec. 23D) on July 2 and 31, 1979.

Species	Number Captured	Length Range (inches)
Rainbow Trout	157	1.0 - 11.9
Brook Trout	73	1.0 - 11.9
Cutthroat Trout	6	5.9 - 8.5
Rainbow x Cutthroat Hybrid	1	9.5
Mottled Sculpin	-	-

The standing crop of trout in the section was estimated using a mark-recapture method (Table 27). This 1,000 ft section supports about 223 trout, weighing a total of 27 pounds. The rainbow trout was the predominant game fish, contributing 61 percent of the total numbers and 59 percent of the total biomass. Brook trout accounted for about 39 percent of the numbers and 41 percent of the biomass. The average condition (length to weight ratio) of the brook trout was greater than that of the rainbow trout. Populations of cutthroat and hybrid trout were too sparse to estimate using the mark-recapture method.

Table 27. Estimated standing crop of trout in a 1,000 ft section of Moose Creek (T1S, R9W, Sec. 23D) on July 2, 1979. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Rainbow Trout	4.0 - 5.9	81	
	6.0 - 9.9	53	
	10.0 - 11.9	3	
		137(±32)	16(±3)

Table 27. Continued.

Species	Length Group (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Brook Trout	4.0 - 5.9	35	
	6.0 - 9.9	49	
	10.0 - 11.9	2	
		86(±27)	11(±3)
Total Trout		223(±42)	27(±4)

4. FLOW RECOMMENDATIONS

A 53 ft subreach located near stream mile 4.5 of Moose Creek (T1S, R9W, Sec. 23D) was selected for the collection of cross-sectional data. Five cross-sections describing the riffle-pool sequence were placed within the subreach. The WETP program was calibrated to field data collected at flows of 13.1 and 35.2 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 17. Lower and upper inflection points occur at 3 and 8 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 6 cfs is recommended for the low flow period (July 1 - April 30). Recommendations for the high flow period (May 1 - June 30) cannot be derived due to the lack of long-term flow data for Moose Creek.

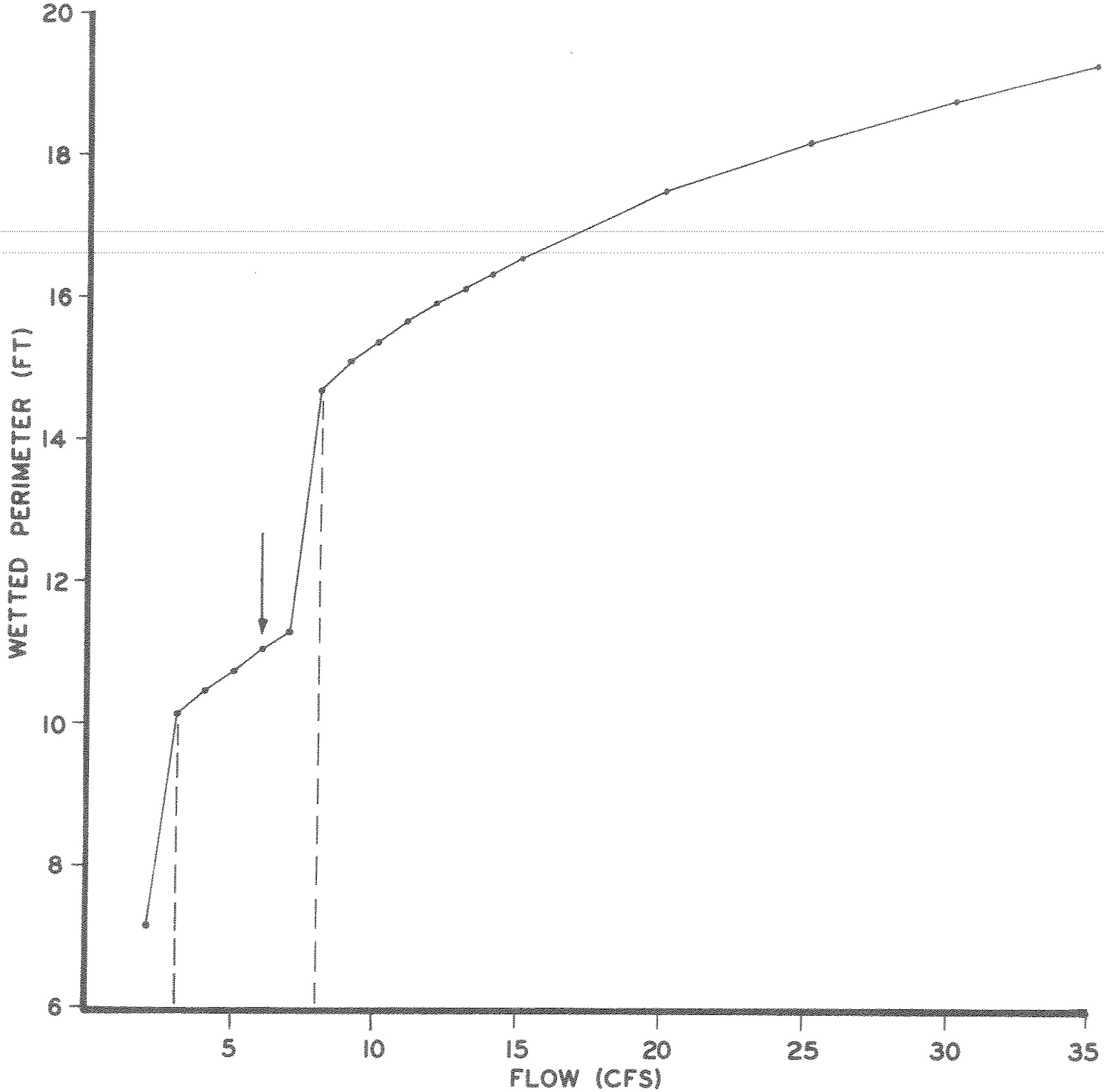

Figure 17. The relationship between wetted perimeter and flow for a single riffle cross-section in Moose Creek.

RED ROCK RIVER TRIBUTARIES

1. STREAM

Big Sheep Creek

2. DESCRIPTION

Big Sheep Creek originates in the Bitterroot and Tendoy Mountains of southwest Montana. It is bordered on the south and west by the Continental Divide. The stream flows for approximately 18.5 miles before entering the Red Rock River near the town of Dell, Montana. The drainage is characterized by steep, timbered limestone cliffs and grassland/sagebrush valleys and hillsides. The stream flows in a northeasterly direction through a floodplain vegetated with willow, alder, birch, grasses and forbs. The 295.5 square mile drainage is controlled by the USFS (57%), BLM (23%), private individuals (15%), and the State of Montana (5%). Major tributaries of Big Sheep Creek include Muddy, Cabin, Deadman and Nicholia Creeks. Several alpine lakes, including Deadman, Morrison and Harkness Lakes, dot the headwater area. Numerous springs drain into the stream at approximately stream mile 12. These springs provide about 56% of the flow during the early fall months (BLM, unpublished data). The 20 ft wide channel has an average gradient of 8 ft/1,000 ft.

A USGS gauge station located at stream mile 8.7 of Big Sheep Creek below the mouth of Muddy Creek (T13S, R10W, Sec. 35D) was operated from May-September, 1936, June, 1946 through September, 1953, and intermittently during 1961-1976. Mean, minimum and maximum flows during the period of record were 65.0, 26.0 and 909 cfs, respectively. There are diversions for the irrigation of about 6,600 acres above the station.

Lands within the drainage are primarily used for livestock grazing, hay production, logging, mining and recreation in the form of fishing, hunting, hiking and camping. Access is provided by a gravel road which parallels the stream for its entire length. Numerous secondary roads provide good access throughout the drainage. Cattle and sheep ranches are located in the lower and upper valley bottom.

Fishing pressure on Big Sheep Creek from May, 1975 to April, 1976 was estimated at 250 person-days/year (MDFG, 1976). This amounts to approximately 14 person-days/stream mile/year. Angler logs show that the catch consists of 64% rainbow trout and 36% brown trout, both averaging 12 inches (MDFWP, 1980a). The Big Sheep drainage is one of the more popular sage grouse hunting areas in the state. During big game season, elk, mule deer and antelope are also hunted.

The lower four miles of Big Sheep Creek are severely dewatered during the irrigation season. Little of the stream's natural flow remains in the channel at its confluence with the Red Rock River. Most of the water enters the river through subsurface irrigation return.

Extremely high sediment loads from the Muddy Creek drainage are increasing sediment yields of the lower Big Sheep drainage. Suspended sediment levels in Muddy Creek in 1977-78 ranged from 44-5,680 ppm (Foggin et al., 1978). There was over a two fold increase in maximum levels of suspended sediment in Big Sheep Creek between stations above and below the confluence of Muddy Creek during 1977-78 (Foggin et al., 1978).

Although stock use along Big Sheep Creek ranges from light to heavy, channel stability was rated good throughout the stream's length (Foggin et al, 1978). Bahls et al (1979) ranked the overall water quality of Big Sheep Creek as good. Muddy Creek received a poor rating.

Maximum summer water temperatures of 72-77 F occur in upper Big Sheep Creek (Foggin et al, 1978). These elevated temperatures are undesirable for the growth and propagation of salmonids.

Macroinvertebrate diversity decreased while biomass increased in a downstream direction in Big Sheep Creek (Foggin et al, 1978). The macroinvertebrates of Muddy Creek were characterized by silt tolerant species and a low diversity and biomass. The macroinvertebrate communities of Big Sheep and Muddy Creeks reflect the adverse effects from naturally occurring silt, elevated temperatures and high nutrient levels compounded by improper land use practices (Foggin et al, 1978).

3. FISH POPULATIONS

Two sections of Big Sheep Creek were electrofished on May 2 and 21, 1980. The upper 7,128 ft section was located below the numerous springs entering Big Sheep Creek and above the confluence of Muddy Creek. The lower section, 6,600 ft in length, was approximately eight miles downstream from the upper section and below the confluence of Muddy Creek. Gamefish present in both sections were rainbow and brown trout and mountain whitefish. Mottled sculpin, longnose dace and longnose sucker were the nongame species present. Table 28 summarizes the electrofishing data for both sections.

Table 28. Summary of electrofishing survey data collected in the upper 7,128 ft section (T14S, R10W, Sec. 15 center - 22 center) and the lower 6,600 ft section (T13S, R9W, Sec. 30C - T13S, R10W, Sec. 36A) of Big Sheep Creek on May 2 and 21, 1980.

Species	No. Captured		Length Range (inches)	
	Upper	Lower	Upper	Lower
Brown Trout	74	175	4.5 - 24.4	5.0 - 18.9
Rainbow Trout	144	14	4.5 - 20.4	6.9 - 15.6
Mountain Whitefish	-	-	-	-
Mottled Sculpin	-	-	-	-
Longnose Dace	-	-	-	-
Longnose Sucker	-	-	-	-

The standing crops of trout in both sections were estimated using a mark-recapture method (Table 29). The standing crops were almost identical in the two sections. Both sections supported approximately 76 trout, weighing about 65 pounds, per 1,000 ft of stream. In the upper section, rainbow trout contributed 68% of the total numbers and 51% of the total biomass. Brown trout, the secondary species in numbers and biomass, comprised 32% and 49%, respectively. In the lower section, the brown trout was the predominant species. A rainbow trout estimate could not be obtained for the lower section due to the low numbers present.

Although the growth rates and the standing crop of trout in both sections were nearly identical, the condition of the fish (length to weight ratio) was considerably less in the lower section. Although more information is needed to thoroughly explain these differences, several factors appear to be influencing the trout populations of the two study sections. The numerous springs and low sediment loads appear to be positively effecting the fishery of the upper section while the high sediment load below Muddy Creek appears to be impacting the fishery of the lower section.

Table 29. Estimated standing crops of trout in the upper 7,128 ft section (T14S, R10W, Sec. 15 center - 22 center) and the lower 6,600 ft section (T13S, R9W, Sec. 30C - T13S, R10W, Sec. 36A) of Big Sheep Creek on May 2, 1980. Eighty percent confidence intervals are in parentheses.

	Upper Section	Per 1,000 ft	
Species	Length Group	Numbers	Pounds
Rainbow Trout	8.0 - 9.9	12	
	10.0 - 13.9	35	
	14.0 - 20.5	5	
		52(±16)	33(±10)
Brown Trout	8.0 - 9.9	2	
	10.0 - 13.9	12	
	14.0 - 24.4	10	
		24(±9)	32(±14)
Total Trout		76(±18)	65(±17)
	Lower Section		
Brown Trout	9.0 - 9.9	4	
	10.0 - 13.9	54	
	14.0 - 18.9	18	
		76(±23)	63(±17)

Various sections of Big Sheep Creek have been electrofished in the past 25 years. Nelson (1954b) electrofished a 300 ft section above Muddy Creek in 1953. Sixty rainbow trout, averaging 10.3 inches in length, were captured. The mountain whitefish was the only other gamefish present. During 1963, Wipperman (1964) electrofished three 440 ft sections of Big Sheep Creek, all below the confluence of Muddy Creek. The brown trout was the dominant trout species in all three sections, with 14-52 trout captured per section. Rainbow trout decreased in a downstream pattern, with three fish captured in the lower-most section and 10 in the upper section. The mountain whitefish was the other gamefish present. In 1970, Elser and Marcoux (1972) electrofished a 3,200 ft section in the vicinity of the present lower section. The section supported an estimated standing crop of 106 brown trout, weighing 74 pounds, per 1,000 ft of stream. Rainbow and rainbow x cutthroat hybrids comprised about 4% of the total trout population.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 197.5 ft subreach located in T13S, R10W, Sec. 36A. Five cross-sections were placed within the subreach to describe various habitat types. The WETP program was calibrated to field data collected at flows of 57.3, 72.0 and 99.6 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 18. The lower and upper inflection points occur at 20 and 50 cfs, respectively. Based on an evaluation of existing fishery, recreational use and water availability information, a flow of 40 cfs is recommended for the low flow period (July 1 - April 30).

Monthly flow recommendations for both the low and high flow periods are listed in Table 30. The median monthly flows of record for the USGS gauge at stream mile 8.7 are also listed for comparison. These median flows reflect the water diverted above the station to irrigate approximately 6,600 acres. The recommendations for the months of January and February exceed the median flows of record.

The monthly flow recommendations, when adjusted to fall within the constraints of water availability during a median water year, amount to approximately 28,952 acre-feet of water per year. This is about 72% of the annual flow that is normally available at the USGS gauge site on Big Sheep Creek.

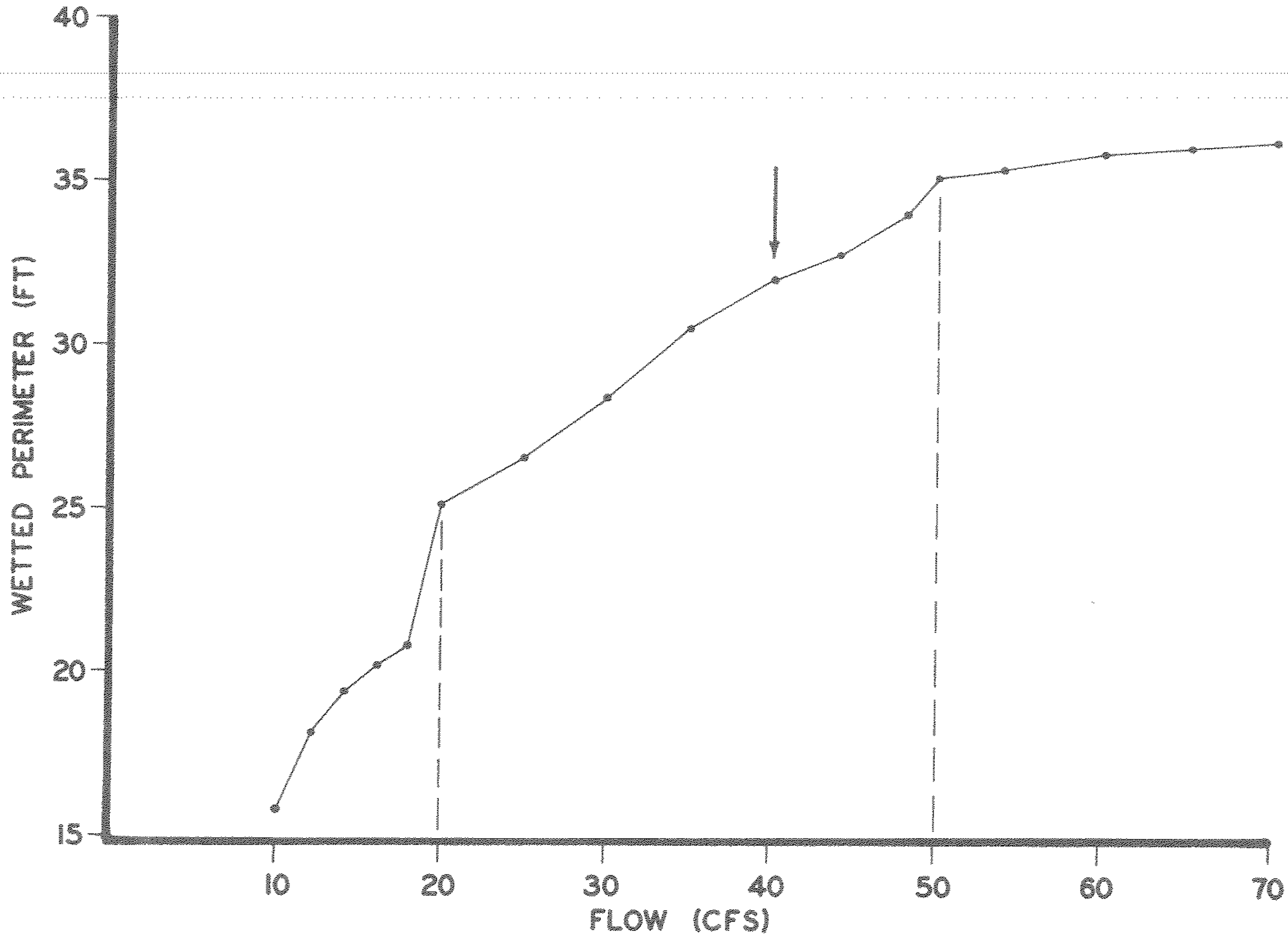

Figure 18. The relationship between wetted perimeter and flow for a single riffle cross-section in Big Sheep Creek.

Table 30. Instream flow recommendations derived for Big Sheep Creek using the wetted perimeter/inflection point method (low flow period) and the dominant discharge/channel morphology concept (high flow period) compared to the median flows of record.

	Recommended Flows	Approximate Median Flows[a]	
	CFS	CFS	AF
January	40	39.2	2,410
February	40	36.5	2,027
March	40	41.5	2,551
April	40	75.7	4,503
May 1-15	40[b]	63.9	1,901
May 16-31	40[b]	54.5	1,729
June 1-15	40[b/c]	90.7	2,698
June 16-30	40[b]	119.4	3,552
July	40	53.8	3,307
August	40	57.9	3,559
September	40	44.0	2,618
October	40	54.4	3,544
November	40	54.0	3,212
December	40	44.5	2,736
			40,147

a/ Derived for a 9-year period of record (1961-69 water years) for the USGS gauge at stream mile 8.7 (T13S, R10W, Sec. 35C).

b/ Flow recommendations for the high flow period (the 80th percentile flows) are less than 40 cfs, the low flow recommendation. Consequently, a flow recommendation of 40 cfs is substituted for the high flow period.

c/ The bankful flow, which is presently undefined, should be maintained for 24 hours during this period.

1. STREAM

Bloody Dick Creek

2. DESCRIPTION

Bloody Dick Creek originates in the Bitterroot Mountains of southwest Montana and flows in a southeasterly direction for approximately 24 miles before joining Horse Prairie Creek, a tributary of Clark Canyon Reservoir. The stream meanders through a riparian zone consisting of dense willows, grasses and forbs. The gradient of the 30 ft wide channel averages 11 ft/1000 ft. Land ownership of this 135.5 square mile drainage is shared by the USFS (70%), private individuals (21%), BLM (6%), and the State of Montana (3%). Major tributaries of Bloody Dick Creek include Selway, Park, Lake, Eunice and U-Turn Creeks. Major lakes within the drainage are Selway, Swift and Reservoir.

Lands within the Bloody Dick drainage are used for hay production, livestock grazing, timber harvesting, mining and recreational activities such as fishing, hunting and camping. Access to the drainage is provided by an unimproved gravel road paralleling the stream. A campground on Reservoir Lake is heavily used during the summer months and big game season. Fishing pressure on Bloody Dick Creek during May, 1975 through April, 1976 was estimated by mail survey at 2,380 person-days (MDFG, 1976). This amounts to about 99 person-days/stream mile/year. Data collected from angler logs show that the catch is entirely comprised of brook trout which average 7.1 inches in length (MDFWP, 1980b). Hunting pressure during 1979 for the district encompassing the Bloody Creek drainage amounted to 3,433 man-days for elk and 2,130 for mule deer (MDFWP, 1980a).

Historically, mining for gold and silver has occurred in the lower reaches of the Bloody Dick valley (Geach, 1972). Productivity of the mining operations is unknown.

Environmental problems within the Bloody Dick drainage are mainly related to livestock grazing. Grazing within the riparian zone along portions of the stream has caused loss of vegetative cover, widening of the channel and minor erosion and mass wasting on outside meanders. The lower reaches of Bloody Dick Creek are dewatered during the summer irrigation season. Logging on private land in 1978 caused considerable erosion on a mile of the west slope bordering the stream. Stream channel stability was evaluated by the BLM as good in 1977 (BLM, unpublished data). Excessive peak flows are believed to be impacting the lower watershed.

The SCS (Farnes and Schafer, 1975) estimates the mean annual water yield for the Bloody Dick drainage at 50,800 acre-feet (70.2 cfs). The 25 and 50 year instantaneous peak flows are estimated at 1,600 and 1,840 cfs, respectively.

Sporadic water chemistry measurements have been collected by the USFS during 1976-1980 (USFS, unpublished data). Bloody Dick Creek has excellent water quality characterized by a low specific conductance, a neutral pH, and low concentrations of suspended sediment.

3. FISH POPULATIONS

A 3,540 ft section of Bloody Dick Creek was electrofished on July 24 and August 7, 1974 (Peterson, 1975). Game fish captured in descending order of abundance were brook trout, rainbow trout and mountain whitefish. The mottled sculpin was the only nongame species present. The electrofishing survey data are summarized in Table 31.

Table 31. Summary of electrofishing survey data collected for a 3,540 ft section of Bloody Dick Creek (T9S, R15W, Sec. 26A-36B) on July 24 and August 7, 1974.

Species	No. Captured	Length Range (inches)
Brook Trout	568	3.5-12.5
Rainbow Trout	168	2.9-14.9
Mountain Whitefish	80	9.1-18.3
Mottled Sculpin	-	-

The total salmonid standing crop was estimated for the section using a mark-recaptured method (Table 32). Estimates were obtained for all three species of gamefish. The stream supports about 618 game fish, weighing 102 pounds, per 1,000 ft. Brook trout, the dominant game species, comprise about 78% of the total numbers and 53% of the total biomass. Rainbow trout accounted for 16% of the total numbers and 11% of the total biomass. Although trout were abundant in Bloody Dick Creek, their condition (length to weight ratio) was below average for streams surveyed. The mountain whitefish accounted for 6% of the total game fish numbers, but 36% of the total biomass. Of the streams surveyed in the BLM Butte District, Bloody Dick Creek supports one of the highest populations of gamefish.

Table 32. Estimated standing crops of gamefish in a 3,540 ft section of Bloody Dick Creek (T9S, R15W, Sec. 26A-36B) on July 24, 1974. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Brook Trout	4.0- 5.9	254	
	6.0- 9.9	218	
	10.0-12.5	9	
		481 (±99)	54 (±8)
Rainbow Trout	4.0- 5.9	69	
	6.0- 9.9	25	
	10.0-14.9	6	
		100 (±33)	12 (±2)

Table 32 continued. Estimated standing crops of gamefish in a 3,540 ft section of Bloody Dick Creek (T9S, R15W, Sec. 26A-36B) on July 24, 1974. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Mountain Whitefish	9.1-14.9	30	
	15.0-18.3	7	
		37 (±10)	36 (±9)
Total Gamefish		618 (±105)	102 (±11)

An electrofishing survey was completed on a 300 ft section of Bloody Dick Creek in 1953 (Nelson, 1954b). The brook trout was the only game species present. Two hundred and fifty-four brook trout, weighing a total of 12.7 pounds and averaging 4.8 inches in length, were captured.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 66 ft subreach of Bloody Dick Creek (T9S, R15W, Sec. 14C). Five cross-sections defining the riffle-pool habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 20.0, 123.3, and 209.3 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 19. Lower and upper inflection points occur at 18 and 26 cfs, respectively. Based on an evaluation of existing fishery and recreational use information, a flow of 24 cfs is recommended for the low flow period (July 16 - May 15). Due to lack of long term flow records for Bloody Dick Creek, recommendation for the high flow period (May 16 - July 15) cannot be derived.

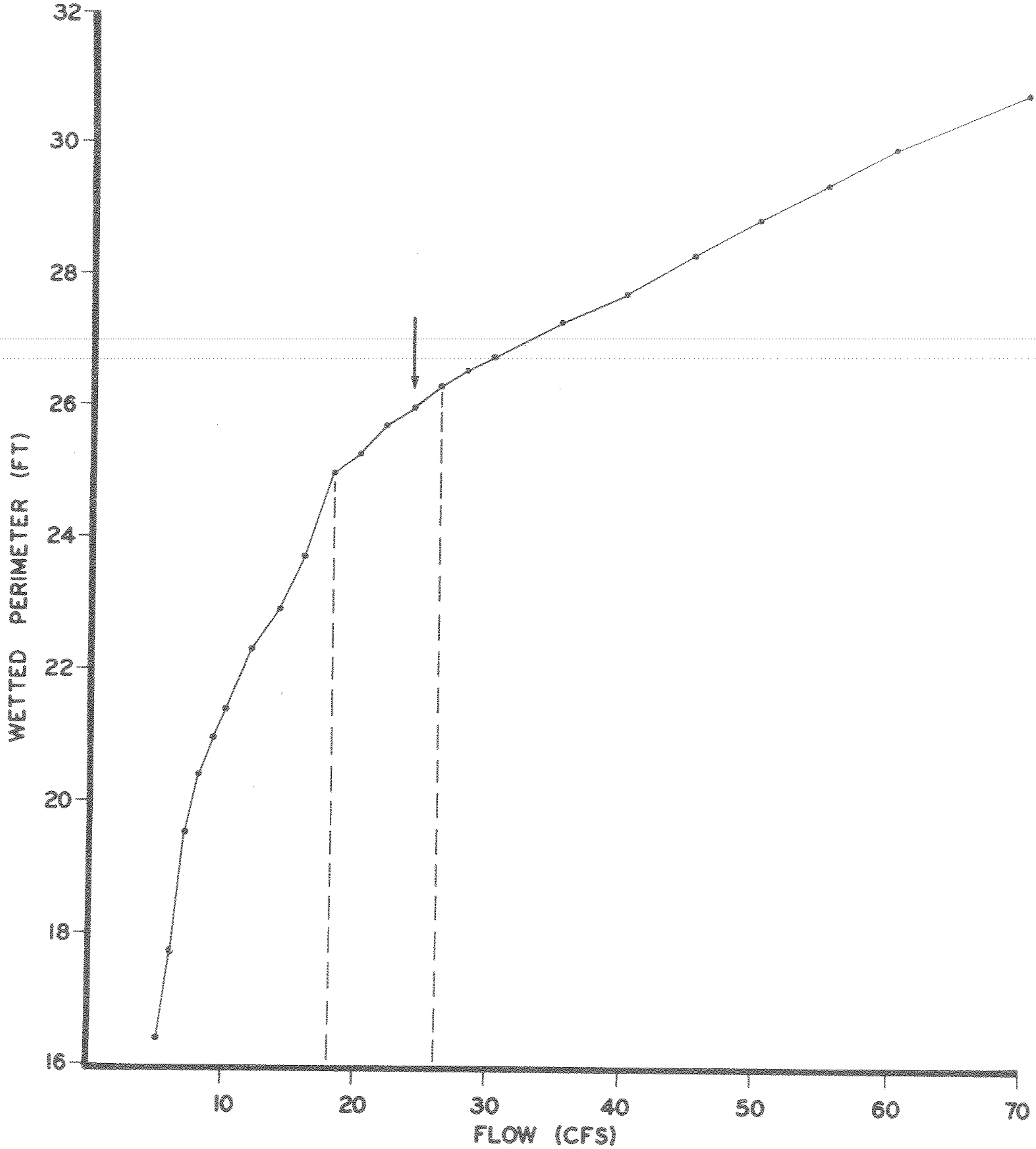

Figure 19. The relationship between wetted perimeter and flow for a single riffle cross-section in Bloody Dick Creek.

1. STREAM

Corral Creek

2. DESCRIPTION

Corral Creek originates in the Centennial Mountains of southwest Montana and flows in a northerly direction for approximately 4.6 miles before entering Red Rock Creek, a tributary of Upper Red Rock Lake. In its upper reaches, Corral Creek cascades through steep, timbered slopes and limestone cliffs and changes to a meandering brook draining sagebrush/grassland slopes along its lower stretches. The riparian zone is vegetated with willow, sage, grasses, conifers and forbs. Average gradient of the 6 ft wide channel is approximately 77 ft per 1,000 ft. The 2.75 square mile drainage is controlled by the BLM (55%), private individuals (27%) and the State of Montana (18%). The BLM land is divided between the Centennial Mountains Primitive Area and U.S. Sheep Experiment Station. The only major tributary of Corral Creek is Fruin Spring.

Lands within the Corral Creek drainage are used for recreation in the form of hunting, fishing and hiking, agricultural research, cattle grazing and logging in the upper reaches. The water from Corral Creek is used as the primary domestic water supply by one ranch in the valley. A salvage timber sale is presently being proposed by the BLM for the upper drainage.

Past logging activity in the upper drainage has resulted in the deposition of sediments in downstream reaches (BLM, unpublished data). The upper stream has a channel stability rating of only fair. Without proper management of the proposed BLM timber sale, further sedimentation may occur. Grazing within the riparian zone may also increase as a result of improved access to the stream created by new logging roads.

Little water chemistry data are available for Corral Creek. From the few samples taken, the water appears to have a neutral pH and a moderate specific conductance (BLM, unpublished data).

3. FISH POPULATIONS

As early as 1907, a resident population of arctic grayling was reported in Corral Creek (Henshall, 1907). In 1951, adult grayling were found in the lower stretches of Corral Creek during the spawning season (Nelson 1954a). By September of the same year,only young-of-the-year were present, indicating that the stream was providing spawning and rearing habitat for the adfluvial grayling population of the Red Rock Lakes. A rancher in the Corral Creek drainage reports that "The creek was black with grayling each spring through the late 1950's and early 1960's, then they disappeared" (Randall, 1978). During 1979 and 1980, MDFWP personnel have observed adult grayling during spawning season in the lower reaches of Corral Creek (personal communication, Jerry Wells). A large beaver dam approximately 900 ft above the mouth of the creek may be a barrier to further upstream movement.

A 900 ft section of lower Corral Creek was electrofished on July 24 and August 20, 1980. Gamefish present were brook and Yellowstone cutthroat trout. Longnose sucker and mottled sculpin were the only nongame species captured. No adult or fingerling grayling were captured during the two electrofishing passes. Table 33 summarizes the electrofishing survey data for Corral Creek.

Table 33. Summary of electrofishing survey data collected for a 900 ft section of Corral Creek (T14S, R1E, Sec. 16D) on July 24 and August 20, 1980.

Species	Number Captured	Length Range (inches)
Brook Trout	325	2.0 - 12.9
Yellowstone Cutthroat Trout	9	3.9 - 6.2
Longnose Sucker	-	-
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 34). Corral Creek supports approximately 547 brook trout, weighing a total of 43 pounds, per 1,000 ft of stream. The condition (length to weight ratio) of the trout was well above average. This is one of the highest populations of brook trout for streams sampled in the BLM Butte District.

Table 34. Estimated standing crop of brook trout in a 900 ft section (T14S, R1E, Sec. 16D) of Corral Creek on July 24, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group	Per 1,000 ft	
		Numbers	Pounds
Brook Trout	4.0 - 5.9	406	
	6.0 - 9.9	135	
	10.0 - 12.9	6	
		547(±69)	43(±3)

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected for a 83 ft riffle-pool sequence located near the mouth of Corral Creek (T14S, R1E, Sec. 16D). Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 4.6 and 11.8 cfs.

The relationship between wetted perimeters and flow for a single riffle cross-section is shown in Figure 20. Lower and upper inflection points occur at 2.0 and 4.5 cfs, respectively. Based on the historic and present use of this stream as spawning and rearing habitat by adfluvial arctic grayling and an evaluation of resident fish population data, a flow of 4.5 cfs is recommended for the low flow period (July 16 - May 15). Due to the lack of long-term flow data, recommendations for the high flow period (May 16 - July 15) cannot be derived for Corral Creek.

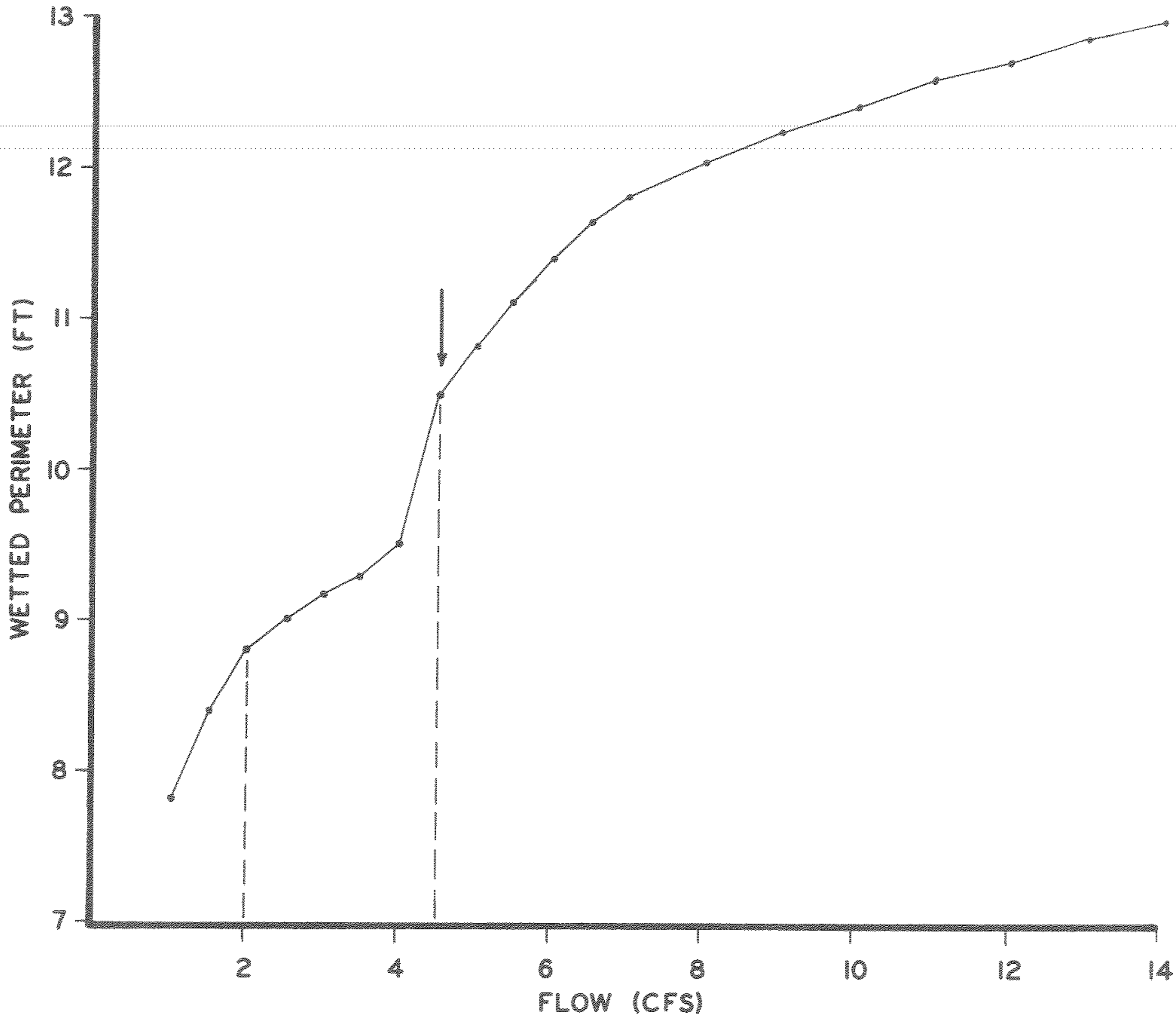

Figure 20. The relationship between wetted perimeter and flow for a single riffle cross-section in Corral Creek.

1. STREAM

Deadman Creek

2. DESCRIPTION

Deadman Creek originates in the Bitterroot Mountains of southwest Montana and flows in a northerly direction for 17 miles before converging with Big Sheep Creek, a tributary of the Red Rock River. The 25.5 square mile drainage is controlled by the USFS (88%), BLM (10%) and private landowners (2%). Deadman Creek is approximately 10 feet wide and flows through a grassland/sagebrush landscape. The gradient averages 28 ft per 1,000 ft. The riparian zone in the upper portion of the drainage is generally composed of grasses and forbs with sparse woody species. In the lower reaches, clumps of willow become more frequent. Major tributaries include Pine and Little Deadman Creeks. The bottom substrate consists primarily of rubble and coarse gravel.

Lands within the Deadman Creek drainage are mainly used for livestock grazing, timber harvesting and recreation in the form of hunting and fishing. Angler log data compiled by the MDFWP (1980b) show cutthroat trout, averaging 7.1 inches in length, to be the only species caught. The Big Sheep drainage is one of the more popular sage grouse hunting areas in Montana. Elk, mule deer and antelope are also hunted. Access to the middle reaches of Deadman Creek is provided by an unimproved road. The remainder of the stream is accessible only by foot or horseback.

Existing environmental concerns in the drainage are the loss of bank vegetation, streambank erosion and sedimentation of the channel caused by the overuse of the riparian zone by cattle and naturally occurring high-flows. Mass wasting, minor erosion and loss of undercut banks through trampling have all been identified as problems on stretches of Deadman Creek (BLM, unpublished data). A road crossing the stream in its middle reaches has caused a widening of the channel and a possible increase in stream sedimentation.

The SCS (Farnes and Shafer, 1975) estimates the 25 and 50 year instantaneous peak flows for Deadman Creek at 300 and 345 cfs, respectively.

3. FISH POPULATIONS

A 1,000 ft section of Deadman Creek was electrofished on July 25 and August 19, 1980. Game fish present were cutthroat trout, rainbow trout and cutthroat x rainbow hybrids. The mottled sculpin was the only nongame species captured. The electrofishing survey data are summarized in Table 35 .

Table 35. Summary of electrofishing survey data collected for a 1,000 ft section of Deadman Creek (T15S, R10W, Sec. 22C) on July 25 and August 9, 1980.

Species	No. Captured	Length Range (inches)
Rainbow, Cutthroat and Rainbow x Cutthroat Hybrid Trout	143	4.0-12.7
Mottled Sculpin	-	-

The standing crop of trout was estimated for the section using a mark-recapture method (Table 36). Due to the varying degrees of hybridization between the two trout species present, a total trout estimate was calculated. This 1,000 ft section supports about 202 trout, weighing 23 pounds. This is a relatively productive stream considering its size and high elevation. The condition of the trout (length to weight ratio) was above average for streams surveyed.

Table 36. Estimated standing crop of trout in a 1,000 ft section of Deadman Creek (T15S, R10W, Sec. 22C) on July 25, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Cutthroat, Rainbow and Cutthroat x Rainbow Hybrid Trout	4.0- 5.9	116	
	6.0- 9.9	83	
	10.0-12.7	3	
		202 (±34)	23 (±3)

The BLM (unpublished data) collected seven trout from Deadman Creek for meristic analyses to determine the degree of hybridization within the population. A moderately high degree of hybridization was found between the native westslope cutthroat trout and the introduced Yellowstone cutthroat and rainbow trout.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected for a 98 ft riffle-run sequence located in T15S, R10W, Sec. 22C. Five cross-sections were placed in the sequence. The WETP program was calibrated to field data collected at flows of 7.4, 10.3 and 14.8 cfs.

Figure 21 illustrates the relationship between wetted perimeter and flow for a composite of two riffle cross-sections. Lower and upper inflection points occur at 4.5 and 8.0 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 7.0 cfs is recommended for the low flow period (July 16 - May 15). A recommendation for the high flow period (May 16 - July 15) cannot be derived for Deadman Creek due to the lack of long-term flow data.

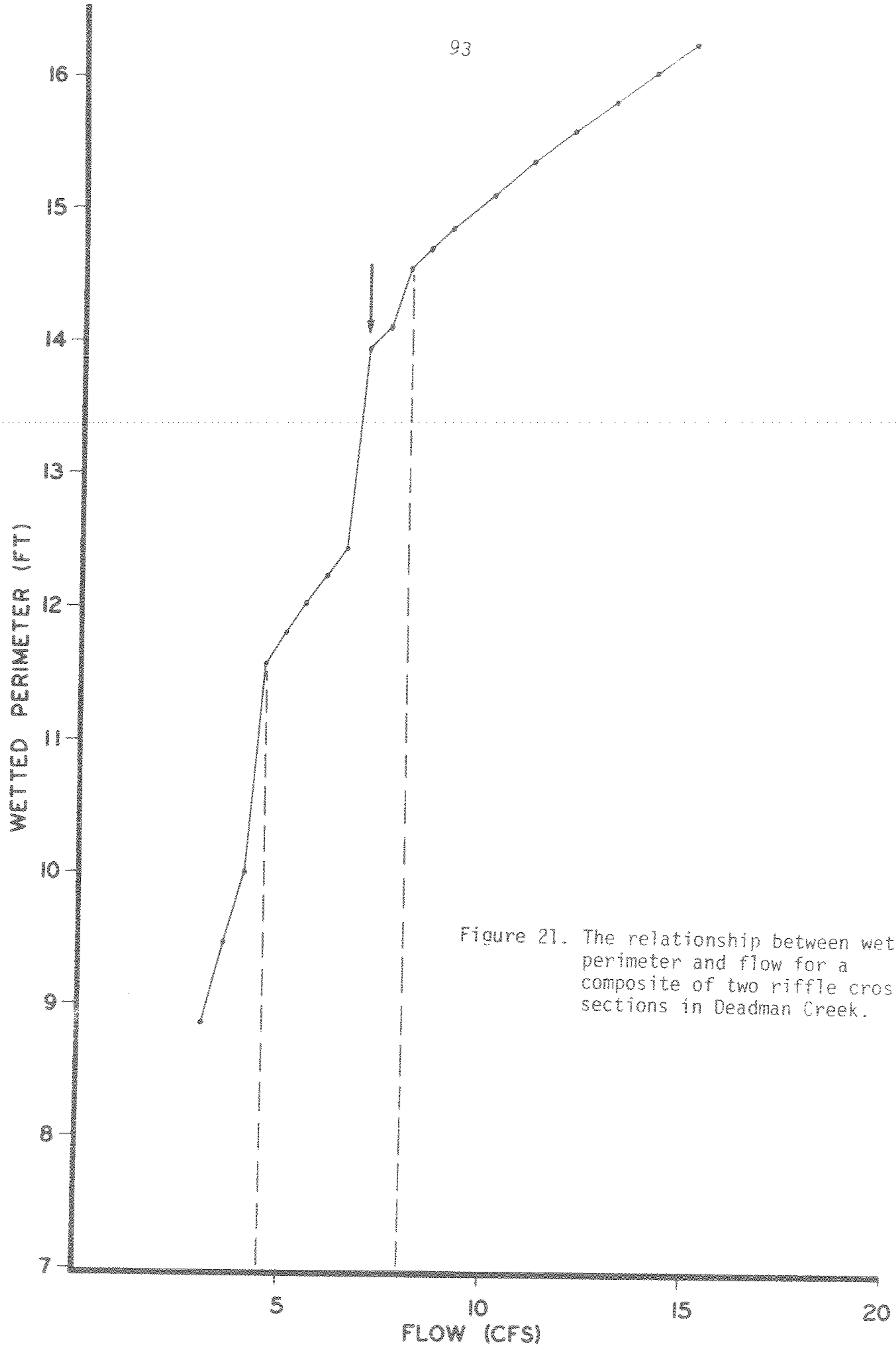

Figure 21. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Deadman Creek.

1. STREAM

Hellroaring Creek

2. DESCRIPTION

Hellroaring Creek originates on the northern slopes of the Centennial Mountains of southwest Montana and flows in a northwesterly direction for approximately 9.5 miles before converging with Red Rock Creek, a tributary of Upper Red Rock Lake. The drainage is characterized by steep, conifer-covered ridges in the upper portion and sagebrush/grassland communities in the lower portion. Control of the 9.5 square mile drainage is shared by the BLM (38%), USFS (33%), private individuals (19%) and the State of Montana (10%). The 27 ft wide channel has an average gradient of approximately 29 ft per 1,000 ft. There are no named tributaries to Hellroaring Creek.

Lands within the Hellroaring Creek drainage are used for cattle grazing, agricultural research and recreation in the form of hunting, fishing and hiking. Fifty percent of the BLM land is managed by the U.S. Sheep Experiment Station. The remainder lies within the boundaries of the Centennial Mountains Primitive Area.

Water chemistry samples from Hellroaring Creek have been sporadically collected during the 1970's (Randall, 1978). The water of the stream is characterized by a low specific conductance, moderate phosphorous levels, a neutral pH and is moderately hard. A flow of 12.0 cfs was recorded near the mouth of Hellroaring Creek in September, 1975.

During May through August, 1976, a thermograph was placed near the mouth of Hellroaring Creek (Randall, 1978). Minimum and maximum temperatures during these four months were 35.4 and 55°F, respectively. The low temperatures during May and June (36-45°F) may explain the avoidance of this stream in recent years by spawning grayling from Upper Red Rock Lake.

The grazing of the riparian zone by cattle along portions of the stream has resulted in the loss of undercut banks and streamside vegetative cover, the widening of the stream channel and increased erosion rates.

3. FISH POPULATIONS

A resident population of arctic grayling was reported in Hellroaring Creek in 1907 (Henshall, 1907). In 1951, a spawning run of grayling was present in the lower reaches of Hellroaring Creek (Nelson, 1954a). By September of the same year, only young-of-the-year were present, indicating that the stream was used as spawning and rearing habitat by the adfluvial grayling population of the Red Rock Lakes.

Peterson (1976) electrofished a 2,287 ft section of Hellroaring Creek at approximate stream mile 1.0 during June and September, 1975. Gamefish captured during both sampling periods were brook and cutthroat trout (Table 37). Brook trout were present during both sample periods, while large cutthroat trout were found only in the June survey. It appears that the brook trout is the dominant resident gamefish in Hellroaring Creek and adfluvial cutthroat trout residing in the Red Rock Lakes utilize the stream for spawning and rearing of their young.

Table 37. Summary of electrofishing survey data collected for a 2,287 ft section of Hellroaring Creek (T14S, R1E, Sec. 24B) in June and September, 1975.

Species	Number Captured		Length Range (inches)	
	June, 1975	Sept.,1975	June, 1975	Sept.,1975
Brook Trout	34	17	2.7 - 11.8	5.2 - 13.4
Cutthroat Trout	14	1	13.1 - 21.2	3.7

No arctic grayling were captured during either of the 1975 surveys. It appears that this stream, although historically used by both resident and adfluvial grayling populations, is no longer suitable for this species. Barriers are apparently not the problem since Hellroaring Creek is accessible to spawning cutthroat trout residing in the lakes.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 141 ft riffle-run sequence of Hellroaring Creek at approximate stream mile 1.0 (T14S, R1E, Sec. 24B). Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 13.5, 62.8 and 110.3 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 22. Lower and upper inflection points occur at 10 and 15 cfs, respectively. Based on the historic use of this stream by arctic grayling and its present use by adfluvial cutthroat trout for spawning and rearing habitat, a flow of 15.0 cfs is recommended for the low flow period (July 15-May 16). Due to the lack of long-term flow data, recommendations for the high flow period (May 15-July 16) cannot be derived for Hellroaring Creek.

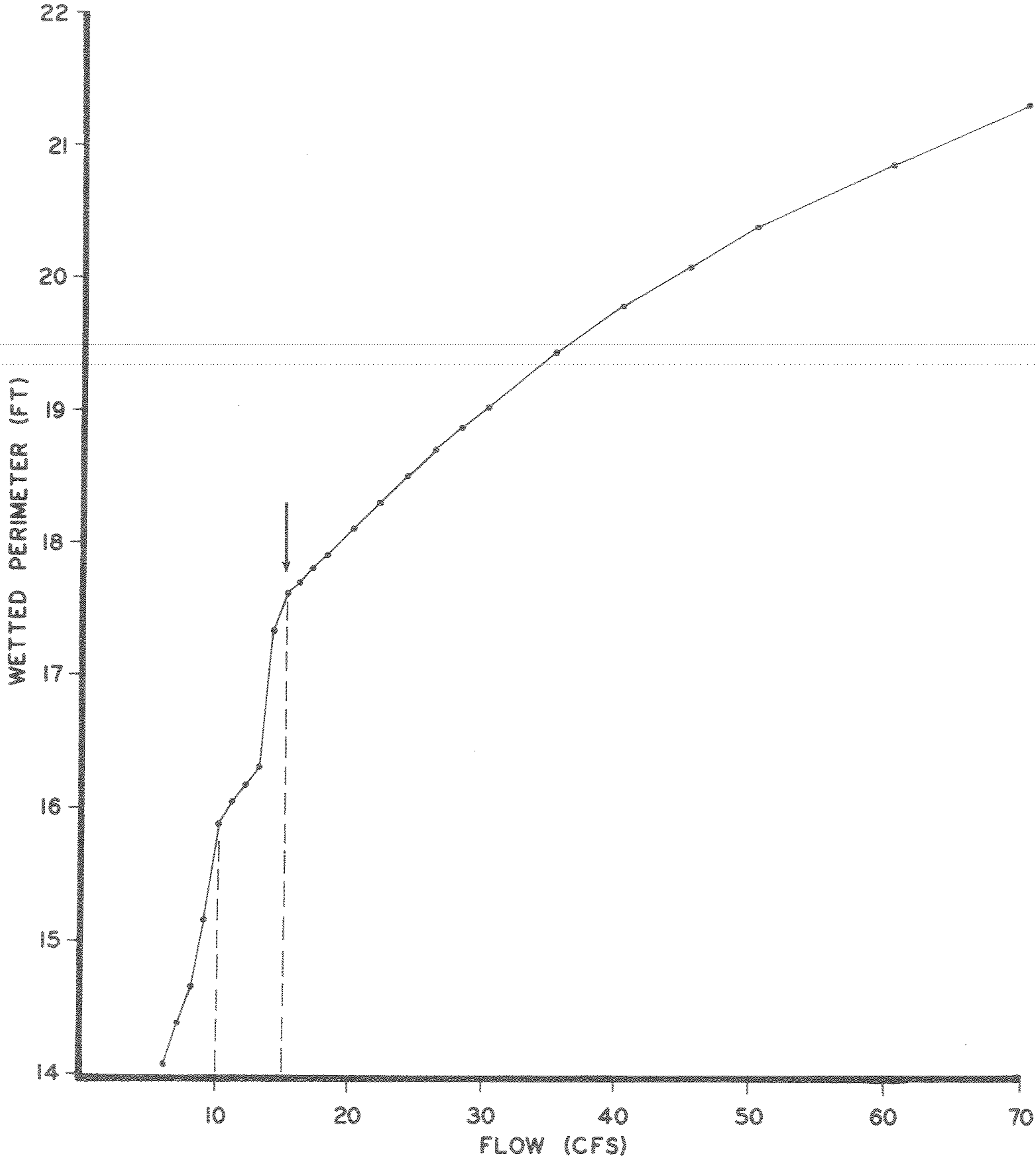

Figure 22. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Hellroaring Creek.

1. STREAM

Long Creek

2. DESCRIPTION

Long Creek originates in the Snowcrest Mountains of southwest Montana and flows in a southerly direction for approximately 14.5 miles before joining the Red Rock River, approximately three miles upstream of Lima Reservoir. Long Creek primarily drains sagebrush/grassland hillsides and benches. Control of the 45.5 square mile drainage is shared by the BLM (14%), USFS (57%), private individuals (23%) and the State of Montana (5%). Major tributaries to Long Creek include Pole, Jones, Crow, Piute and Mohican Creeks. The average gradient of the 14 ft wide channel is approximately 6 ft/1,000 ft. The riparian zone is vegetated with willow, birch, grasses and forbs. Numerous beaver dams within the channel interrupt the fluvial nature of the stream.

Lands within the Long Creek drainage are used primarily for cattle and sheep grazing, irrigated crop production and recreation in the form of hunting and fishing. Fishing pressure between May, 1975 and April, 1976 was estimated by mail survey at 180 person-days/year (MDFG, 1976). This amounts to approximately 12 person-days/stream mile/year. The Centennial Divide Road parallels Long Creek for the majority of its length, providing access throughout the drainage.

The grazing of the riparian zone by sheep and cattle has caused extensive damage to the trout habitat of Long Creek. This has been manifested in the loss of undercut banks and streambank vegetation, the widening of the stream channel and increased sediment yields. The BLM rates the channel stability of Long Creek only fair with 21% active bank erosion (BLM, unpublished data). The lack of silt-free spawning gravels appears to be a limiting factor to the fishery. Haugen (1975) identified overuse by stock as the primary limiting factor to the fishery of upper Long Creek. He felt that excessive siltation, bank instability and loss of streambank cover resulted from this overuse. In a turbidity study of 39 stations in the upper Beaverhead River drainage, Elser and Marcoux (1972) recorded the highest readings for Long Creek below its confluence with Jones Creek, a tributary overused by cattle. Turbidity readings near the mouth of Long Creek were recorded by BLM personnel at 125 JTU (Randall, 1978). These levels were high enough to be identified as a sediment source problem in the Centennial Valley.

The lower three miles of Long Creek are severely dewatered during the summer irrigation season. Little of the stream's natural flow remains in the channel at its confluence with the Red Rock River.

3. FISH POPULATIONS

A 1,000 ft section of Long Creek was electrofished on July 23 and August 13, 1980. Gamefish captured were cutthroat and brook trout. Longnose sucker, mottled sculpin and longnose dace were the nongame species present. The electrofishing survey data are presented in Table 38. It should be noted that approximately one-third of the section was inundated as a result of beaver activity. Most of the larger cutthroat trout were captured in this portion of the section.

Table 38. Summary of electrofishing survey data collected for a 1,000 ft section of Long Creek (T13S, R4W, Sec. 11B) on July 23 and August 13, 1980.

Species	Number Captured	Length Range (inches)
Cutthroat Trout	46	4.0 - 13.9
Brook Trout	5	6.0 - 14.2
Longnose Sucker	-	-
Mottled Sculpin	-	-
Longnose Dace	-	-

The standing crop of cutthroat trout was estimated using a mark-recapture method (Table 39). This 1,000 ft section supports about 138 cutthroat trout, weighing a total of 26 pounds. The condition of the trout (length to weight ratio) was considered above average for streams electrofished in the present study. The population of brook trout was too sparse to estimate using the mark-recapture method.

Table 39. Estimated standing crop of cutthroat trout in a 1,000 ft section of Long Creek (T13S, R4W, Sec. 11B) on July 23, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Cutthroat Trout	4.0 - 5.9	33	
	6.0 - 9.9	96	
	10.0 - 13.9	9	
		138(±64)	26(±13)

A 1,750 ft section of Long Creek above Piute Creek was electrofished during the summer of 1970 (Elser and Marcoux, 1972). Brook and cutthroat trout, ranging in length from 7.6 to 13.6 inches, were captured. The section supported an estimated standing crop of 11 trout, weighing 6.2 pounds, per 1,000 ft of stream. Brook and cutthroat trout each comprised about 50% of the population.

Two sections of Long Creek, totaling 800 ft in length and located above the USFS boundary, were electrofished in 1974 (Haugen, 1975). A total of 10 cutthroat trout, ranging in length from 4.3 to 7.3 inches, were captured.

The substantial increase in the trout population of Long Creek from 1970 to 1980 is believed to be partially a result of the sample section. As mentioned previously, a third of the electrofishing section was inundated as a result of beaver activity. The beaver ponds provided deeper, cooler water and more available trout habitat.

Nelson (1954a) surveyed the tributaries of the Red Rock River in 1951-52 to determine the status of arctic grayling populations. Seven young-of-the-year grayling were found in Long Creek during the fall of 1952, indicating that Long Creek has provided spawning and rearing habitat for this species in past years.

Five cutthroat trout were collected from Long Creek for meristic analyses to determine the degree of hybridization between the native westslope cutthroat and introduced Yellowstone cutthroat populations (BLM, unpublished data). The trout of Long Creek were found to have strong Yellowstone cutthroat traits, but possessed a spotting pattern more typical of westslope cutthroat.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 121.5 ft riffle-run sequence located in T13S, R4W, Sec. 2D. Five cross-sections were placed within this sequence. The WETP program was calibrated to field data collected at flows of 5.7, 10.2 and 24.6 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 23. The lower and upper inflection points occur at 4 and 6 cfs, respectively. Based on the presence of cutthroat trout and the potential use by arctic grayling for spawning and rearing purposes, a flow of 6.0 cfs is recommended for the low flow period (July 16 - May 15). Flow recommendations for the high flow period (May 16 - July 15) cannot be derived for Long Creek due to the lack of long-term flow data.

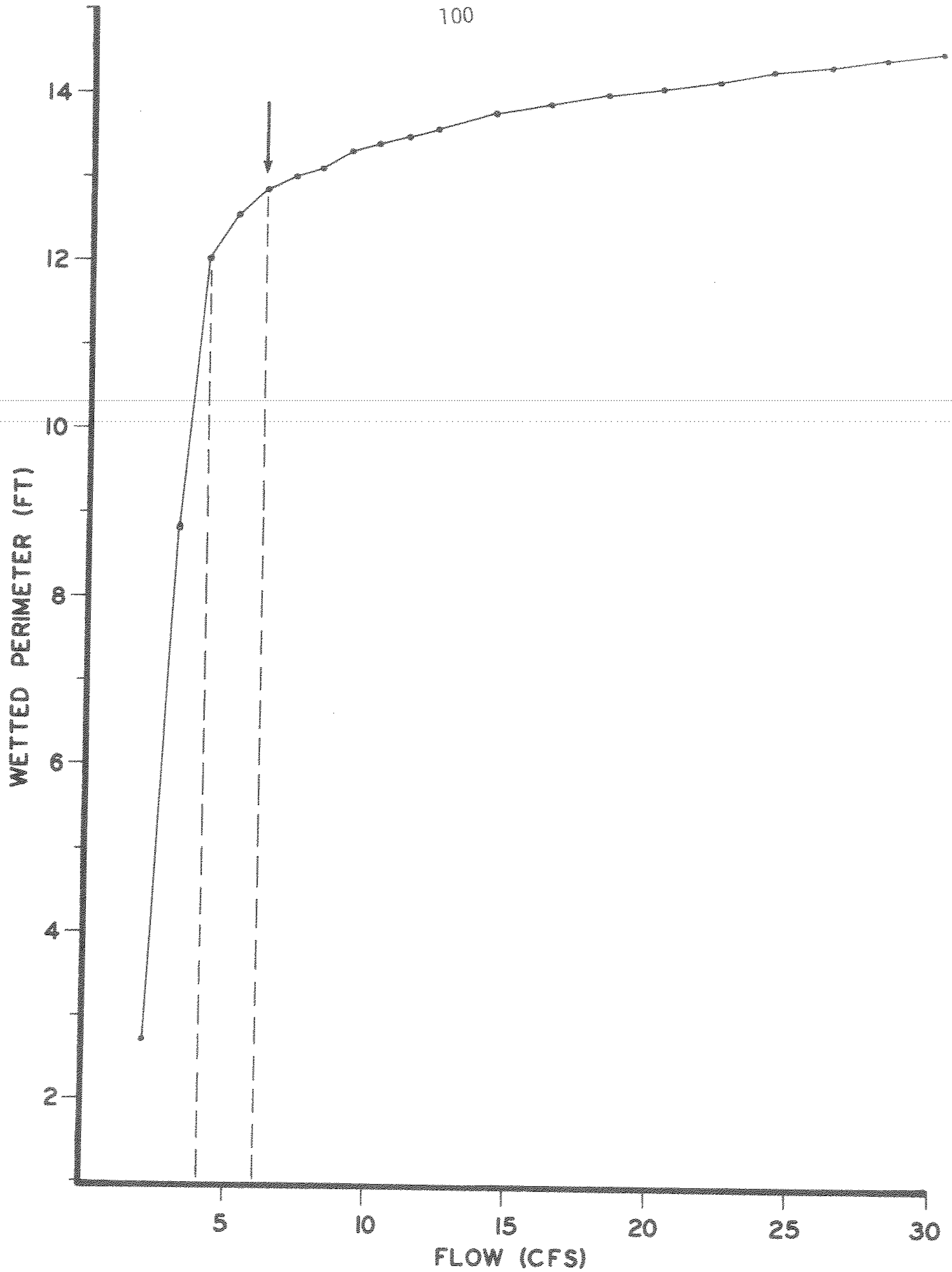

Figure 23. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Long Creek.

1. STREAM

Medicine Lodge Creek

2. DESCRIPTION

Medicine Lodge Creek drains a narrow valley bordered on the east by the Tendoy Mountains and on the west by an offshoot of the Bitterroot Mountains. The stream flows for approximately 36 miles before entering Horse Prairie Creek, a tributary of Clark Canyon Reservoir. Medicine Lodge Creek meanders in a northerly direction through a floodplain of dense willows, grasses and forbs. The 20 ft wide channel has an average gradient of approximately 10.5 ft per 1,000 ft. The drainage is characterized by an open grassland/sagebrush valley surrounded by timbered slopes. Major tributaries to Medicine Lodge Creek include Dad, Craver, Law, Morrison, Poole, Hansen and Warm Springs Creeks. Numerous lakes and springs dot the upper drainage. The 188 square mile drainage is controlled by the USFS (42%), BLM (29%), private individuals (23%) and the State of Montana (5%).

From April, 1962 - June, 1966 the SCS operated a gauge station on Medicine Lodge Creek during the irrigation season (SCS, unpublished data). The station was located at approximate stream mile 18 (T12S, R12W, Sec. 24). Minimum and maximum flows during the period of record were 0.1 cfs in April, 1963 and 88.4 cfs in June, 1965, respectively. The recorded flows were significantly affected and altered by irrigation withdrawals.

Lands within the Medicine Lodge drainage are primarily used for livestock grazing, hay production, recreation in the form of hunting and fishing, and,historically, mining. Access is provided by a gravel road paralleling the stream for its entire length.

The drainage has produced small amounts of zinc, copper, and lead (Geach, 1972). Tertiary deposits of coal have also been discovered, but production was limited for local domestic use. The majority of the mining activity occurred between 1938-1948.

Fishing pressure on Medicine Lodge Creek for the period of May, 1975 to April, 1976 was estimated at 540 person-days (MDFG, 1976). This amounts to about 15 person-days/stream mile/year. Catches reported in angler logs consist of 93% brook trout, averaging 8 inches in length, and 7% rainbow trout, averaging 9 inches in length (MDFWP, 1980b). This drainage is a popular hunting area for blue and sage grouse, antelope and mule deer.

The severe dewatering that occurs during the summer irrigation season is the greatest threat to the aquatic resource of Medicine Lodge Creek. A series of irrigation ditches throughout the drainage reduce the natural flow to a trickle at its confluence with Horse Prairie Creek. Over use of portions of the riparian zone by livestock has resulted in the loss of streambank cover, has increased erosion rates and has led to the widening of the channel. Extensive deposits of sediment occur in riffle and spawning areas of the stream.

3, FISH POPULATIONS

A 1,000 ft section of Medicine Lodge Creek was electrofished on July 31 and August 18, 1980. Gamefish present were brook and rainbow trout. The mottled sculpin was the only nongame species captured. Table 40 summarizes the electrofishing survey data.

Table 40 . Summary of electrofishing survey data collected for a 1,000 ft section of Medicine Lodge Creek (T10S, R12W, Sec. 25A) on July 31 and August 18, 1980.

Species	Number Captured	Length Range (inches)
Brook Trout	49	3.0 - 12.9
Rainbow Trout	33	4.5 - 12.4
Mottled Sculpin	-	-

The standing crops of brook and rainbow trout in the section were estimated using a mark-recapture method (Table 41). This 1,000 ft section supports a total population of about 165 trout, weighing 43 pounds. The brook trout was the predominant game species, comprising 77% of the total trout numbers and biomass. Rainbow trout accounted for the remaining 23%. Although comprising a smaller portion of the total population, the condition (length to weight ratio) of the rainbow trout was much higher than that of the brook trout. Of the streams electrofished in the BLM Butte District, Medicine Lodge Creek supports one of the highest biomasses of trout. There is a potential for an excellent fishery throughout Medicine Lodge Creek if adequate instream flows are maintained.

Table 41. Estimated standing crop of trout in a 1,000 ft section of Medicine Lodge Creek (T10S, R12W, Sec. 25A) on July 31, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Brook Trout	4.0 - 5.9	22	
	6.0 - 9.9	71	
	10.0 - 12.9	34	
		127(±58)	33(±15)
Rainbow Trout	4.5 - 5.9	16	
	6.0 - 9.9	15	
	10.0 - 12.4	7	
		38(±8)	10(±2)
Total Trout		165(±59)	43(±15)

In 1964, Wipperman (1965) electrofished a 355 ft section of Medicine Lodge Creek adjacent to the present study section. Of the fifteen brook trout captured, six individuals were greater than seven inches. Three rainbow trout were also captured. Wipperman felt that the fishery of Medicine Lodge Creek was depressed by the extremely low flows that occurred during the irrigation season.

4. FLOW RECOMMENDATIONS

Cross-sectional data for Medicine Lodge Creek were collected in a 84 ft riffle-pool sequence located in T10S, R12W, Sec. 25A. Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 14.5, 28.8 and 59.8 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 24 . Lower and upper inflection points occur at 10 and 12 cfs. Based on an evaluation of the existing and potential fisheries and water availability, recreational use and other resource information, a flow of 11 cfs is recommended for the low flow period (July 1 - April 30). Recommendations for the high flow period (May 1 - June 30) cannot be derived due to the lack of long-term flow data for Medicine Lodge Creek.

The low flow recommendations are compared to the mean monthly flows of record at the SCS gauge at approximate stream mile 18 in Table 42 . Due to the sporadic operation of the gauge, approximate mean flows are only available for the months of April through November. The recommendations exceed the mean flows of record for the months of August through November. It should be noted that the gauge is located approximately 12 miles upstream from the site used for gathering cross-sectional data.

Table 42. Instream flow recommendations derived for Medicine Lodge Creek using the wetted perimeter/inflection point method (low flow period) compared to the mean flows of record.

	Flow Recommendations (cfs)	Approximate Mean flows (cfs)[a/]
Apr	11.0	15.1
May	b/	15.7
Jun	b/	48.1
Jul	11.0	20.6
Aug	11.0	9.3
Sep	11.0	7.5
Oct	11.0	6.9
Nov	11.0	6.6

a/ Derived for the April, 1962 through June, 1966 period of record for the SCS gauge at approximate stream mile 18 (T12S , R12W, Sec. 24).

b/ Recommendations for the high flow period (May 1 - June 30) are presently unavailable due to the lack of long-term flow data for Medicine Lodge Creek.

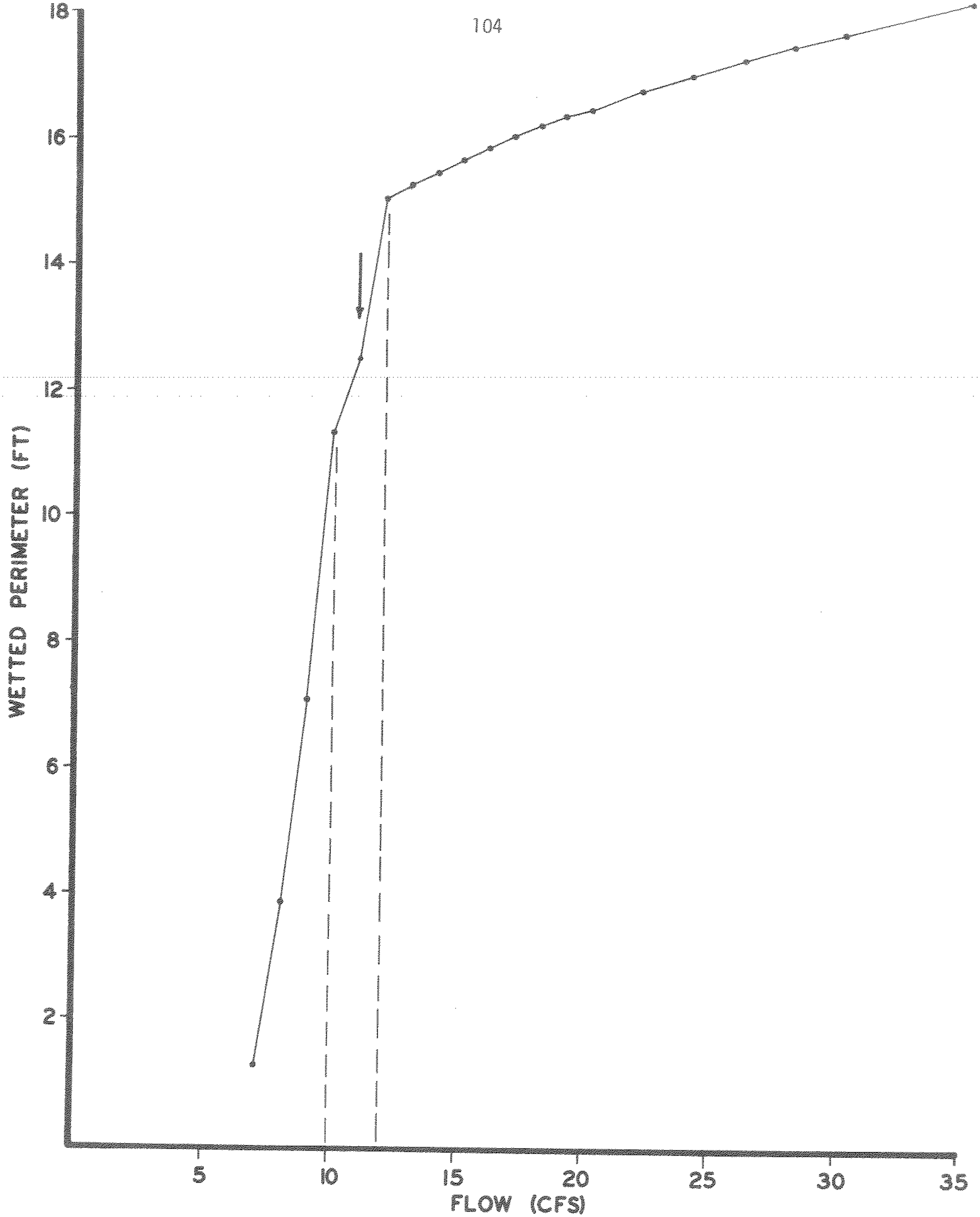

Figure 24. The relationship between wetted perimeter and flow for a single riffle cross-section in Medicine Lodge Creek.

1. STREAM

Odell Creek

2. DESCRIPTION

Odell Creek originates on the northern slopes of the Centennial Mountains of southwest Montana. It flows in a northerly direction for approximately 14.5 miles before entering Lower Red Rock Lake in the Red Rock River drainage. The 27.7 square mile drainage is characterized by steep, timbered slopes in the upper half of the basin and grassland/sagebrush and marsh communities in the lower portion. Control of the drainage is shared by the BLM (78%), USFWS (9%), private individuals (9%) and the State of Montana (4%). Spring and Shambow Creeks are the only named tributaries to Odell Creek. The average gradient of the 23 ft wide channel is approximately 16 ft per 1,000 ft. In the upper drainage, the stream cascades through a floodplain vegetated with aspen, conifers, grasses and forbs. The riparian zone along the lower meandering portion of the stream is vegetated with willow, grasses and forbs. The fluvial nature of Odell Creek is frequently interrupted in its lower reaches by beaver dams.

Lands within the Odell Creek drainage are used for agricultural research, wildlife habitat, irrigated hay production, cattle grazing and recreation in the form of hiking, camping, cross country skiing, snowmobiling and fishing. The lower portion of the creek is within the boundaries of the Red Rock Wildlife Refuge, which was created in 1935 for the protection of the then endangered trumpeter swan. Seventy-six percent of the BLM land is managed by the U.S. Sheep Experiment Station. The remainder is within the boundaries of the Centennial Mountains Primitive Area.

A creel census conducted on Odell Creek during June-September of 1975 estimated fishing pressure at 23 hours in 14 use-days (Peterson, 1976). The brook trout was the predominant game species caught by anglers at a rate of 0.5 fish per hour.

The SCS (Farnes and Schafer, 1975) estimates the mean annual water yield of Odell Creek at 26,400 acre-feet (34.0 cfs). No other flow data are available. An irrigation system above the Refuge completely dewaters a stretch of Odell Creek during low water years (MDFWP, unpublished data).

Grazing, on and off the Refuge, has resulted in trampled banks, the loss of undercut banks and streamside vegetative cover, the widening of the stream channel and an increased rate of erosion along some reaches of the stream. The deposition of sediment is severe in stretches of the lower creek due to the low stream velocities resulting from numerous beaver ponds. Because the majority of the soils within the Odell Creek drainage are classified as unstable and the channel stability is rated only fair, increased sediment loads will be a continual threat to the aquatic resource (Randall, 1978).

Water chemistry samples were collected on Odell Creek throughout the summer of 1975 (Randall, 1978). The water is generally characterized as slightly alkaline with a moderate specific conductance and hardness.

3. FISH POPULATIONS

Since 1938, Odell Creek has been stocked with both native and exotic trout species (Randall, 1978). The cutthroat trout was the first species planted, followed by arctic grayling, brown trout and rainbow trout. The last species planted in Odell Creek was the rainbow trout in 1963.

Henshall (1907) reported arctic grayling in Odell Creek in 1906. Many spawned-out grayling were lost to irrigation ditches as the valley became more settled (Brower, 1896). Although spawning adults were not observed during May and June of 1952, Nelson (1954a) captured grayling fry in Odell Creek in July of the same year. A "fair population" of small (4-5 inches) grayling was observed in Odell Creek by Refuge personnel in 1961 (Randall, 1978).

Beginning in 1972, Odell Creek was extensively electrofished by various state and federal agencies (Randall, 1978). Cutthroat trout, ranging from 2.2-12.5 inches, were the only gamefish captured in the upper reaches (T14S, R1W, Sec. 31) in 1972 by the BLM. In 1975, three 400 ft sections electrofished on the refuge produced only brook trout in very low numbers (Randall, 1978).

In the fall of 1975, the MDFWP electrofished a 3,971 ft section of Odell Creek at approximate stream mile 2.0 to determine the status of resident grayling (Peterson, 1976). Game fish captured in descending order of abundance were brook trout, arctic grayling and cutthroat trout (Table 43). Odell Creek was the only stream sampled on the refuge in which adult grayling were present in the fall of the year, suggesting that the creek supported a resident or fluvial population.

Table 43. Summary of electrofishing survey data collected for a 3,971 ft section of Odell Creek (T14S, R2W, Sec. 14D) on October 1, 1975.

Species	Number Captured	Length Range (inches)
Brook Trout	40	2.5 - 16.9
Arctic Grayling	2	2.5 - 9.2
Cutthroat Trout	2	2.5 - 16.9

The MDFWP electrofished a section of Odell Creek beginning at approximate stream mile 5.0 on June 2, 1976 to determine grayling use of this stream during spawning (Peterson, 1979). Gamefish captured in descending order of abundance were arctic grayling, brook trout and rainbow x cutthroat hybrids (Table 44). Sixty-seven mature arctic grayling, all in spawning condition, were captured. Grayling were not captured in the upper portion of the section which is severely dewatered during the irrigation season.

Table 44. Summary of electrofishing survey data collected in a 10,560 ft section of Odell Creek (T14S, R2W, Sec. 24C-Sec. 14D) on June 2, 1976.

Species	Number Captured	Length Range (inches)
Arctic Grayling	67	13.6 - 17.0
Brook Trout	39	3.7 - 14.0
Rainbow x Cutthroat Hybrids	2	4.7 - 18.5

An evaluation of the seasonal electrofishing survey data for Odell Creek indicates that the resident trout population is dominated by brook trout. The creek provides spawning and rearing habitat for the adfluvial grayling population of the Red Rock Lakes and also appears to support low numbers of fluvial or resident grayling.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected for a 202.5 ft riffle-pool sequence located in T14S, R2W, Sec. 25A. Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 12.8, 49.1 and 72.5 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 25. Lower and upper inflection points occur at 10 and 16 cfs, respectively. Based on the utilization of Odell Creek as spawning and rearing habitat by the adfluvial arctic grayling population of the Red Rock Lakes and the presence of a possible fluvial grayling population, a flow of 16.0 cfs is recommended for the low flow period (July 16 - May 15). Due to the lack of long-term flow data, recommendations for the high flow period (May 16 - July 15) cannot be derived for Odell Creek.

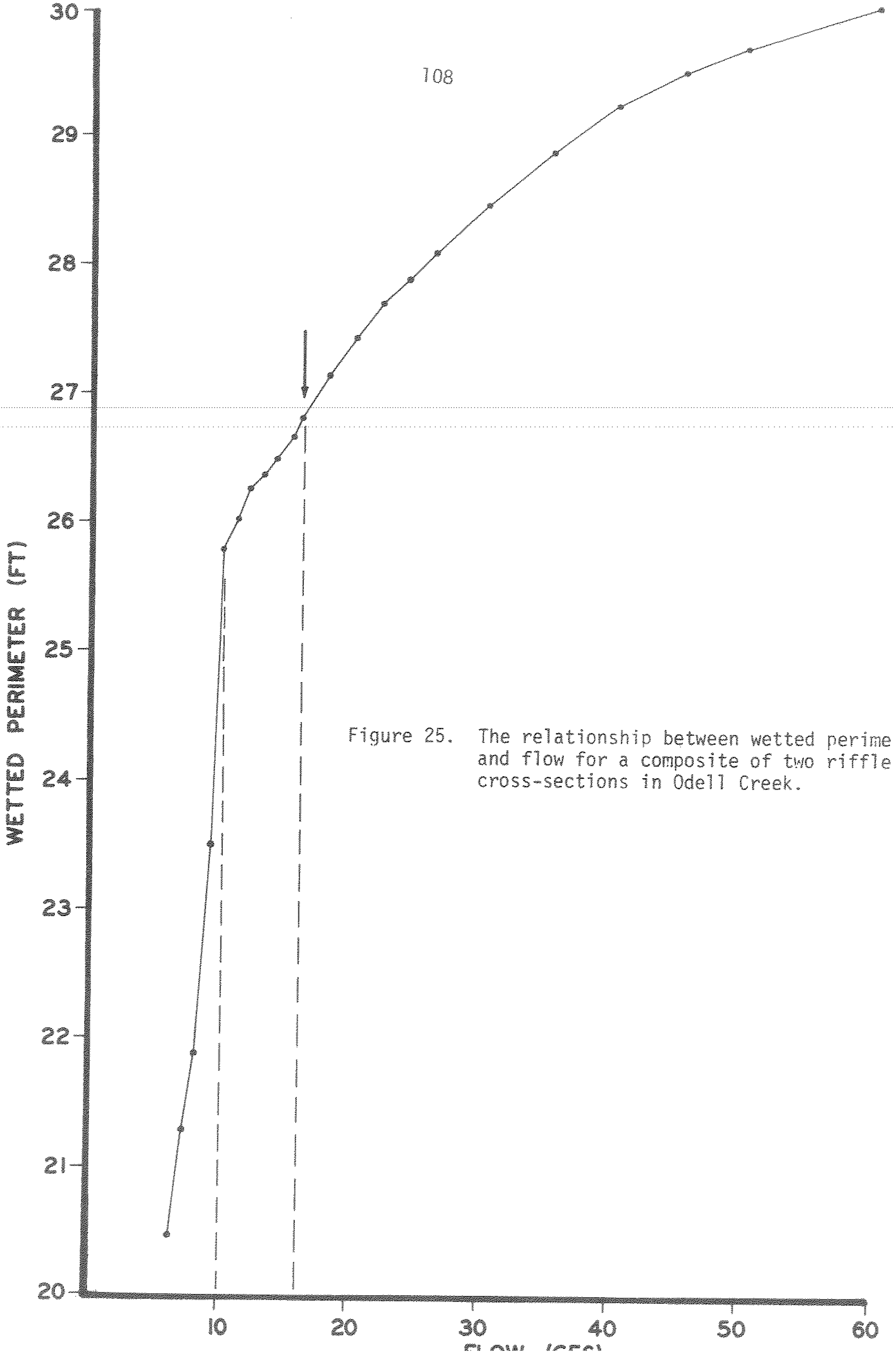

Figure 25. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Odell Creek.

1. STREAM

Tom Creek

2. DESCRIPTION

Tom Creek originates in the Centennial Mountains of southwest Montana and flows in a northwesterly direction for approximately 4.8 miles before entering Upper Red Rock Lake of the Red Rock River drainage. The stream flows through a floodplain vegetated with willows, sages, conifers, aspens, grasses and forbs. The upper drainage is steep and forested while the lower portion consists of grassland/sagebrush communities and marshlands. The 11.0 square mile drainage is controlled by the BLM (55%), USFWS (18%), private individuals (18%) and the State of Montana (9%). The 9 ft wide channel has a fairly steep gradient, averaging 28 ft per 1,000 ft. There are no named tributaries to Tom Creek.

Lands within the Tom Creek drainage are managed for wildlife habitat, recreation, agricultural research and cattle grazing. Forty-two percent of the land managed by the BLM is located within the U.S. Sheep Experiment Station. The remainder is within the Centennial Mountains Primitive Area.

A creel census completed during June through September, 1975 showed 23 fishing hours expended on Tom Creek in 11 use-days (Peterson, 1976). The catch rate was .5 fish/hour. The brook trout was the primary species creeled.

The private lands above the county road crossing Tom Creek are the major source of sediment to the drainage (BLM, unpublished data). Suspended sediment levels above and below the private land were recorded at 235 ppm and 622 ppm, respectively. Further investigation revealed 80% active bank erosion in the lower section compared to 26% above the private land (BLM, unpublished data). Due to the numerous beaver dams on the lower reaches of stream, much of the suspended sediment is being deposited in important riffle and spawning areas. In 1952, 59 beaver dams were removed from the lower quarter of Tom Creek (Nelson, 1954a).

Water chemistry samples have been collected sporadically by the BLM and USFWS (Randall, 1978). The waters of Tom Creek are slightly alkaline with a moderate specific conductance and fairly high turbidity levels during spring runoff.

3. FISH POPULATIONS

The movement of spawning arctic grayling from the Upper Red Rock Lake into Tom Creek has been documented since 1951 (Randall, 1978). Nelson (1954a) reported grayling as the only game species present in Tom Creek in 1951-52. The adults disappeared soon after spawning, but fry were abundant in July and schools of fingerlings were observed in September. In 1961, grayling were no longer observed using Tom Creek during the spawning season (Randall, 1978).

In 1972, 1973 and 1975, the BLM electrofished various sections of lower Tom Creek (Randall, 1978). The brook trout was the only game species present in significant numbers. Although the creek was electrofished during May and June when grayling spawn, only one grayling was captured. The BLM reported that beaver dams on the lower creek prohibited upstream movement. Spawning gravel was also considered marginal, with interstitial spaces filled by sand and silt. The relocation of the lower mile of the original channel through beaver activity and streambank deterioration resulting from overgrazing have also been cited as factors limiting the present use of Tom Creek by spawning grayling (Randall, 1978).

The MDFWP electrofished a 2,876 ft section of Tom Creek during the fall of 1975 (Peterson, 1976). The brook trout was the only game species present. In June of 1976, three sections of Tom Creek were electrofished by the MDFWP (Peterson, 1979). Arctic grayling and brook trout were the gamefish captured. Grayling were only present in the middle section. The lower section was extensively silted. Reasons for the lack of spawning activity in the upper section are unknown. Peterson (1979) felt that Tom Creek has a much greater potential for grayling spawning than is presently being realized. Table 45 summarizes the electrofishing survey data collected for Tom Creek in 1975 and 1976.

Table 45. Summary of electrofishing data collected for Tom Creek in a 2,876 ft section (T14S, R1W, Sec. 25) in September, 1975 and three sections of an undetermined length (T14S, R1W, Sec. 23 and 25) in June, 1976.

Species	Numbers Captured		Length Range (inches)	
	Sept., 1975	June, 1976	Sept., 1975	June, 1976
Brook Trout	53	Several	2.6 - 10.6	-
Arctic Grayling	None	4	-	14.9 - 18.0

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 56.5 ft subreach of Tom Creek located in T14S, R1W, Sec. 25A. Five cross-sections were placed within the subreach. The WETP program was calibrated to field data collected at flows of 0.7, 3.4 and 16.6 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 26. Lower and upper inflection points occur at flows of 0.4 and 2.0 cfs, respectively. Based on the historical and present use of Tom Creek by adfluvial arctic grayling for spawning and the rearing of their young, a flow of 2 cfs is recommended for the low flow period (July 16 - May 15). Recommendations for the high flow period (May 16 - July 15) cannot be derived due to the lack of long-term flow data for Tom Creek.

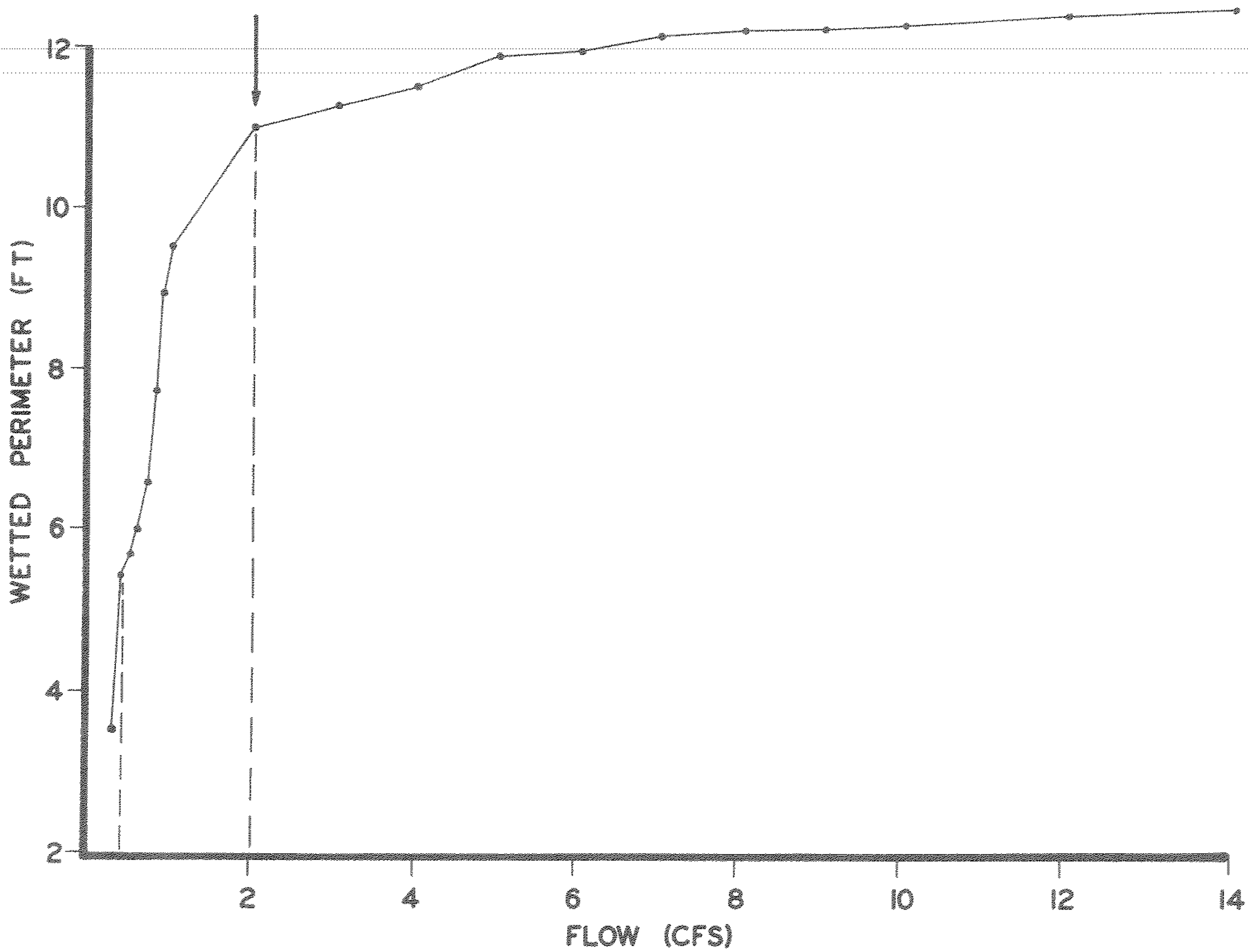

Figure 26. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Tom Creek.

1. STREAM

West Creek

2. DESCRIPTION

West Creek flows in a southerly direction for 10 miles before entering the Red Rock River above Lima Reservoir. It originates on the west slope of the Snowcrest Range and drains a 15 square mile area. The drainage is controlled by private individuals (46%), the USFS (43%), and the BLM (10%). The majority of the stream (83%) flows through private land, which is primarily used for grazing. The drainage is characterized by grassland/sagebrush covered hilsides. Only the headwater area contains timbered slopes. West Creek flows with a fairly steep gradient of 52 ft per 1,000 ft. The riparian zone is composed of willow, aspen, sage, grasses and sedges. The upper portion of the channel is characterized by extensive beaver dam construction, causing the stream to lose its fluvial nature. Major tributaries of this 6 ft wide stream are Middle and Anton Creeks.

Lands within the West Creek drainage are used for livestock grazing, hay production and recreation mainly in the form of hunting. The hunting district encompassing the West Creek drainage is one of the more heavily used areas during the big game season. Hunting pressure for elk was estimated at 13,083 hunter-days during the 1979 season (MDFWP, 1980a).

In general, the habitat and overall condition of West Creek is poor (BLM, unpublished data). The substrate is compacted with fine sediment, virtually eliminating all spawning gravels. Bank erosion is high, primarily due to bank slumping and channel scouring. This is primarily caused by livestock trampling and overgrazing of the banks. Stream crossings by vehicles are also contributing to the problem. Numerous beaver dams and debris jams are found throughout the channel creating barriers to fish movement. Although the riparian vegetation is fairly dense on many sections of stream, in areas where cattle graze only 37% of the stream is shaded and the depth of the water has decreased due to the widening of the channel.

3. FISH POPULATIONS

During 1980, five stream habitats varying from beaver ponds to riffle-run sections were electrofished on West Creek. Section lengths varied from 100-1,000 ft. All were located in T13S, R4W, Sec. 6D. No fish were captured or observed in these sections. Major factors limiting the fishery include the complete lack of spawning areas as a result of compaction by sediments and numerous beaver ponds and debris jams which hinder upstream movement (BLM, unpublished data).

In 1952-53, Nelson (1954a) surveyed various tributaries of the Red Rock River to assess the status of arctic grayling populations. Two young-of-the-year grayling were collected near the mouth of West Creek, indicating that this stream was used in the past by grayling for spawning and the rearing of young.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were collected in a 45.6 ft riffle-run sequence located in T13S, R4W, Sec. 6D. Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 2.6, 4.1 and 12.0 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 27. The lower and upper inflection points occur at 2 and 4 cfs, respectively. Based on an evaluation of existing fishery and other resource information, a flow of 2.0 cfs is recommended for the low flow period (July 16 - May 15). Because long-term flow records are unavailable for West Creek, recommendations for the high flow period (May 16 - July 15) cannot be derived.

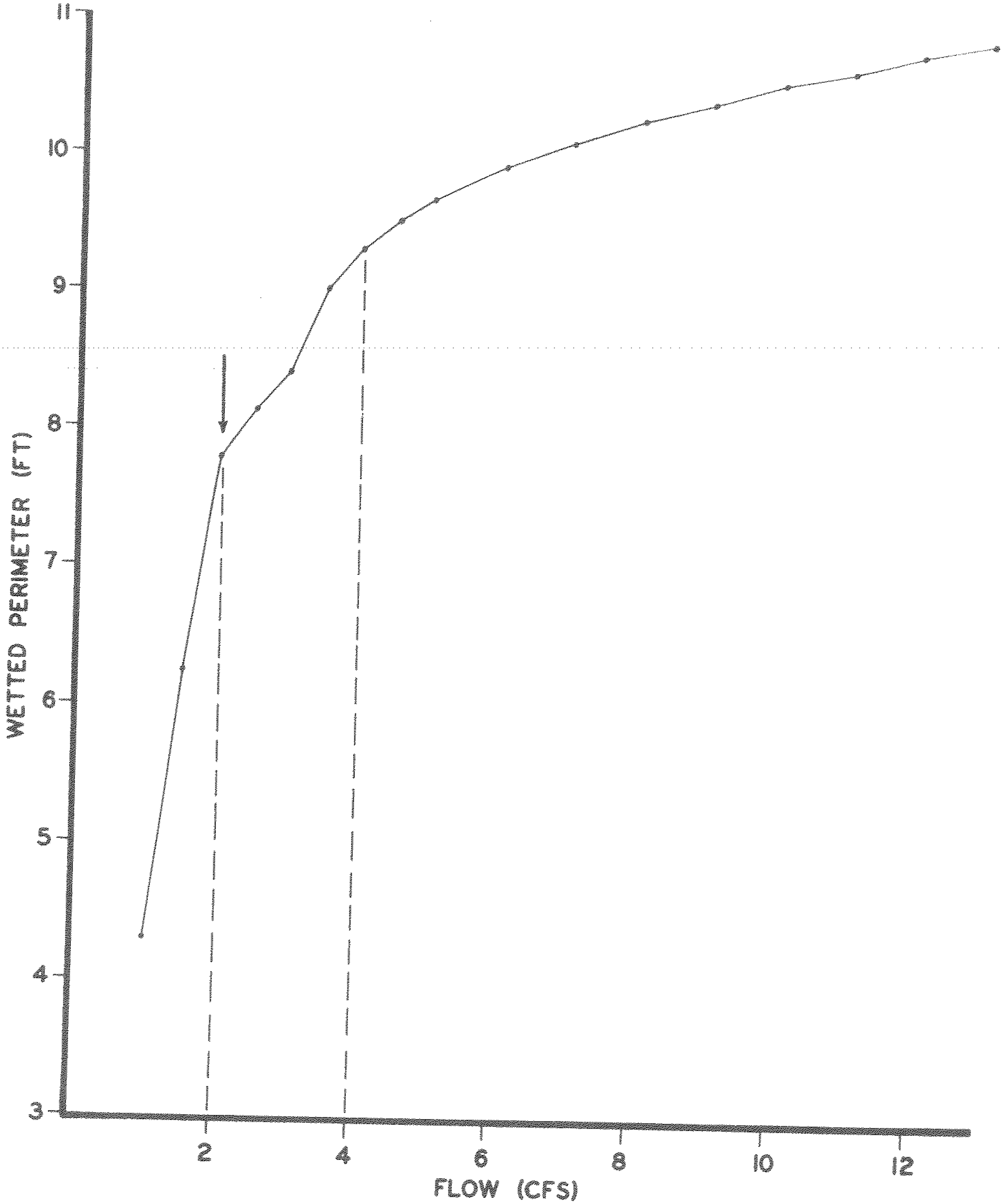

Figure 27. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in West Creek.

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