WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Gilbert Creek Instream Flow Studies

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ABSTRACT

Studies conducted during 1997 determined instream flows necessary for maintaining Colorado River cutthroat trout (CRC) habitat and populations. The Habitat Quality Index (HQI) and the Habitat Retention Method were used in determining a year-round instream flow water right recommendation of 1.3 cfs.

INTRODUCTION

Wyoming's instream flow law (W.S.41-3-1001) defines the Wyoming Game and Fish Department's (WGFD) role in identifying instream flow levels necessary to maintain important fisheries. According to the law, unappropriated flowing water "may be appropriated for instream flows to maintain or improve existing fisheries..." (W.S.41-3-1001(b)). WGFD instream flow recommendations must be for specific stream segments and seasons. These recommendations are incorporated into an instream flow water right application and, as provided by statute, may become an instream flow water right held by the state of Wyoming. This process ensures that adequate stream flow is protected when it is available in priority so that important fisheries will persist.

Since the law was passed in 1986 and through 1997, 76 instream flow water right applications have been filed, 7 approved by the state engineer, and 2 formally adjudicated. Initially, efforts focused on WGFD class 1 and 2 waters, which are highly productive and provide popular recreational opportunities. More recently, efforts have shifted toward small headwater streams supporting native cutthroat trout.

Wyoming has historic ranges for Bonneville cutthroat trout (*Oncorhynchus clarki utah*, sometimes locally referred to as "Bear River" cutthroat trout), Colorado River cutthroat trout (*O.clarki pleuriticus*), and Yellowstone cutthroat trout (*O.clarki bouvieri*). A variant of Yellowstone cutthroat trout, the Snake River cutthroat trout, also occurs in the northwest portion of the state. Since the early 1990s, instream flow studies have been done on many stream segments throughout the native range of Bonneville and Colorado River cutthroat trout.

This report includes results and recommendations from studies on Gilbert Creek, a Colorado River cutthroat trout stream.

The historic distribution and conservation status of Colorado River cutthroat trout is reviewed in Young (1996) and Nesler et al. (1999). In Wyoming, historic range includes streams tributary to the Green River: the Little Snake River drainage on the west side of the Sierra Madre mountains, Green River tributaries draining the east face of the Wyoming Range mountains, the Blacks Fork River and its tributaries arising in the Uinta mountains, and a few tributaries that flow directly into the Green River from the east. Prior to 1997, instream flow studies were conducted in the major drainages of the Wyoming Range and Sierra Madre mountains. During 1997, additional studies were performed in remaining streams such as Gilbert Creek, a tributary to the Blacks Fork River.

A conservation plan was developed by Wyoming, Colorado, and Utah state wildlife agencies, in coordination with the U.S. Fish and Wildlife Service, to guide conservation efforts in the tri-state area through three primary activities: protecting existing and restored ecosystems, restoring degraded ecosystems, and planning (Nesler et al. 1999). The process of acquiring and maintaining appropriate instream flows is listed as a strategy for restoration. Obtaining instream flow water rights to be held by the state of Wyoming will provide assurance that available water will be reserved when it is available in priority for providing CRC habitat. Such efforts do not increase habitat from present levels or ensure that adequate habitat is available; instead, they act to avoid future water depletions up to the limits established by instream flow water rights. Instream flow water right acquisition is just one step in a comprehensive process of protecting and conserving native cutthroat trout habitat and populations.

Study objectives were to 1) investigate the relationship between discharge and physical habitat quantity and quality for Colorado River cutthroat trout in Gilbert Creek and, 2) determine an instream flow regime that will help maintain the Gilbert Creek Colorado River cutthroat trout fishery.

METHODS

Study Area

Gilbert Creek is located in southwest Wyoming in Uinta County, southeast of Mountain View. The headwaters are located in Utah and the stream flows generally south on Wasatch National Forest land in Wyoming before entering private lands and combining with East Fork Smiths Fork Creek (Figures 1-2). The upper boundary of the proposed instream flow segment is at about elevation 9,300 feet and is the state line between Utah and Wyoming in section 25 of Range 116W, Township 12N. This point is convenient to identify and marks a location where the creek is fully formed from its primary springs. The downstream boundary for the proposed instream flow segment is the trout movement barrier located in section 5 of Range 115W, Township 12N. at an elevation of about 8,560 feet.

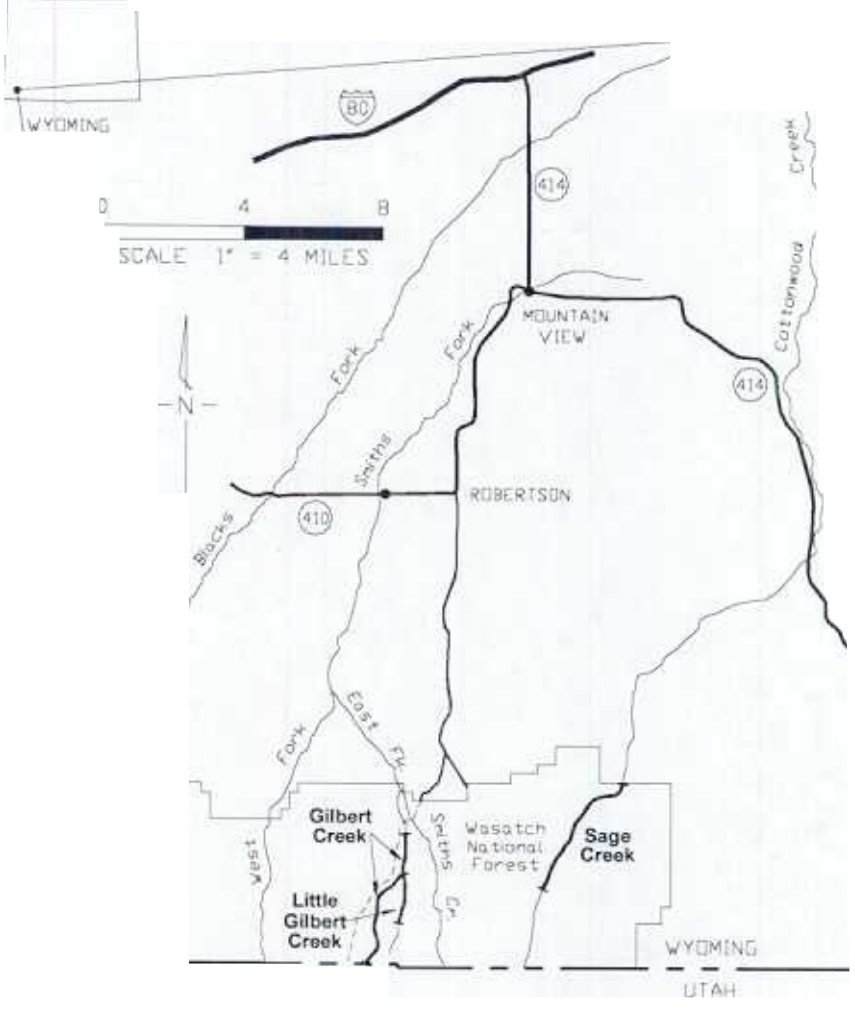
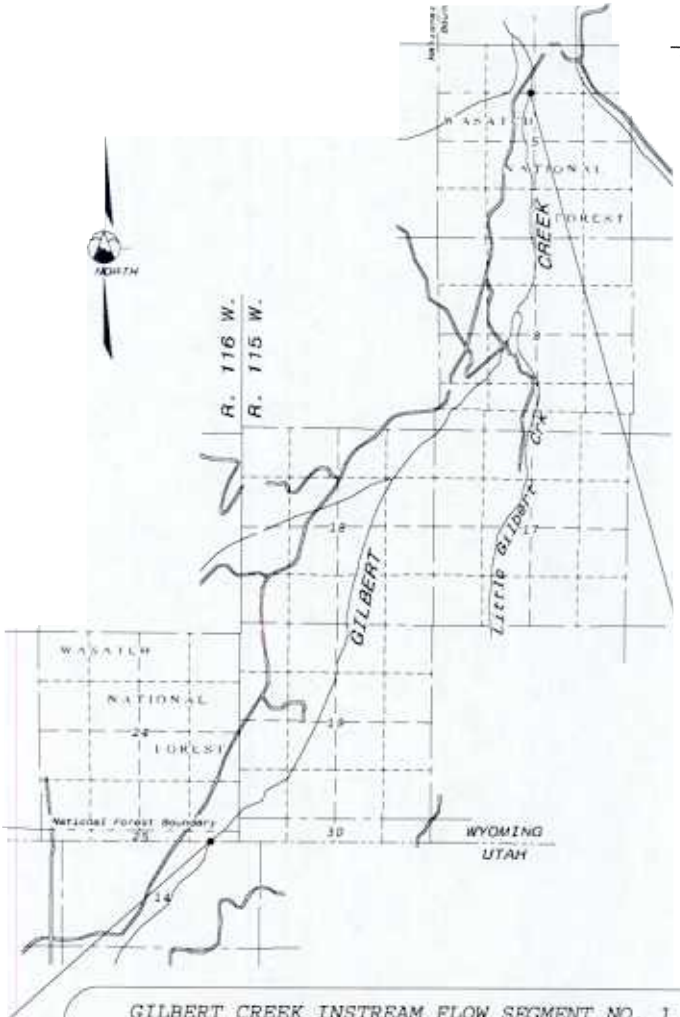


Figure 1 Gilbert creek instream flow segment and general vicinity



GILBERT CREEK INSTREAM FLOW SEGMENT NO. 1
(LENGTH OF STREAM SEGMENT = 4.4

occur in scattered pockets and sagebrush (*Artemesia* spp.) occurs along open side hills. Willow (*Salix spp.)* comprises the primary woody riparian species while herbaceous sedges (*Carix spp.*) and grasses (*Poa spp.)* are common near the study site.

Watershed management centers on controlling cattle grazing and timber harvest along with significant outdoor recreation. The USFS has dedicated the Gilbert Creek drainage to CRC restoration and considers it a "showcase" for sensitive species enhancement efforts. Beaver are often important for maintaining watershed integrity and function in streams and Gilbert Creek is no exception. For trout fisheries, beaver presence in a drainage provides benefits such as stabilized banks, reduced sediment sources from banks, and deep pools for over wintering trout. Beaver dams are common in the drainage and there appears to be enough willow to continue to sustain beaver colonies.

High snowmelt runoff in the spring decreases quickly to a trickle in late summer. Combining the variable hydrology with an unstable channel that meanders across the flood plain results in relatively low trout habitat. Spawning habitat is uncommon with few gravel bars and it is likely that most spawning occurs high in the drainage or in tributary streams like Little Gilbert Creek.

Fisheries

In addition to CRC, mottled sculpin (*Cottus bairdi*) and mountain sucker (*Catostomus platyrhynchus*) are native to the Gilbert Creek drainage. The stocking history for Gilbert Creek includes brook trout (*Salvelinus fontinalis*), which were last stocked in 1961. Rainbow trout (*O. mykiss*) occur downstream of a gabion trout movement barrier which was constructed near the Forest boundary in 1990 to help in cutthroat trout restoration efforts. CRC were stocked several times during the 1990's at a level of about 2,000 fish annually to bolster purity. Purity was ranked "D" (indicating substantial hybridization) during an assessment in the 1980's though no recent examinations have been performed.

The Green River fish management crew collected population data from two stations in 1988 (Keith 1997). CRC abundance ranged from 103 to 330 trout per mile. A population estimate conducted at the instream flow study site in 1997 showed a density of 461 CRC per mile (22 lbs/acre) and size ranged between 3.9 and 10 inches in length. Brook trout are also common and their numbers during the same population estimate were 501 per mile (38 lbs/acre).

In a western Oregon stream studied for 11 years, density of age 0 cutthroat trout (fry, <2 inches) varied from 8 to 38 per 100 m^2 and density of age 1 cutthroat trout (juveniles, 4-4.5 inches) ranged from 16 to 34 per 100 m^2 (House 1995). In this example, population fluctuations occurred despite the fact that habitat conditions were not degraded and appeared to be relatively stable. The author suggested that small changes in peak winter flows between years would have accounted for shifts in over winter survival between age-classes. Similar population fluctuations occur in Sand Creek, a Crook County, Wyoming stream that experiences relatively little discharge variation (Mueller 1987). Sand Creek brown trout population density ranged from 646 trout/mile to 4,060 trout/mile in a three-year period. Biomass estimates for the same period ranged between 48 and 142 pounds per acre.

These two examples illustrate that trout populations, particularly in small mountain streams, are expected to fluctuate. Long-term trout population maintenance depends on periodic strong year classes produced in good flow years. Without benefit of periodic favorable flows, populations might decline or disappear. The WGFD instream flow strategy recognizes the inherent variability of trout populations and thus defines the "existing fishery" as a dynamic feature. Instream flow recommendations are based on a goal of maintaining habitat conditions that provide the opportunity for trout numbers to fluctuate within existing natural levels.

Habitat Modeling

A representative study site was established on May 20, 1997 a short distance upstream of the Little Gilbert Creek confluence at Township 12N, Range 115W, Section 8, SW1/4 (Figure 1). Three habitat retention (see description below) transects were established on riffles and a representative Habitat Quality Index (HQI; see description below) station was delineated. The study site selected contained trout cover associated with woody debris, boulders and lateral scour pools. Data were collected between May 20 and August 27, 1997 (Table 1).

Table 1. Dates and discharges Gilbert Creek instream flow data were collected in 1997. An additional flow measurement in August 1996 was collected during site reconnaissance.

Date	Discharge (cfs)
May 20	28
June 5	11
July 24	1.4
August 27	1.1
August 20, 1996	1.2

A common strategy for determining instream flow needs is to focus on the requirements of critical life stages like fry, juvenile, or spawning. However, a different approach was used in Gilbert Creek. Since spawning habitat was found to be nearly non-existent in this portion of Gilbert Creek, it was assumed that most spawning likely occurs in headwater reaches and tributaries. Therefore, no attempt was made to model spawning habitat or estimate instream flows to maintain spawning cutthroat trout. Instead, effort focused on identifying flows needed to maintain fish movement and late-summer adult habitat (Table 2).

Habitat Retention Method

A Habitat Retention method (Nehring 1979; Annear and Conder 1984) was used to identify a maintenance flow by analyzing data from hydraulic control riffle transects. A maintenance flow is defined as the continuous flow required to maintain specific hydraulic criteria in stream riffles. Maintaining criteria in riffles at all times of year when flows are available in priority ensures that habitat is also maintained in other habitat types such as runs or pools (Nehring 1979). In addition, maintenance of identified flow levels may facilitate passage between habitat types for all trout life stages and maintain adequate benthic invertebrate survival.

Table 2 Colorado River cutthroat trout life stages and months considered in Gilbert Creek instream flow recommendations. Numbers indicate method used to determine flow requirements

Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult							1	1	1			
All	2	2	2	2	2	2	2	2	2	2	2	2

1 = Habitat Quality Index; 2 = Habitat Retention

A maintenance flow is realized at the discharge for which any two of the three criteria in Table 3 are met for all riffle transects in a study area. The instream flow recommendations from the Habitat Retention method are applicable year round except when higher instream flows are required to meet other fishery management purposes (Table 2).

Table 3 Hydraulic criteria for determining maintenance flow with the Habitat Retention method.

Category	Criteria
Mean Depth (ft)	Top Width[a] X 0.01
Mean Velocity (ft/s)	1.00
Percent Wetted Perimeter[b]	50

a - At average daily flow or mean depth = 0.20, whichever is greater
b - Percent of bank full wetted perimeter

Simulation tools and calibration techniques used for hydraulic simulation in PHABSIM (Physical Habitat Simulation) are used with this technique except the habitat retention method involves analysis of hydraulic characteristics only at hydraulic control riffles. The AVPERM model within the PHABSIM methodology is used to simulate cross section depth, wetted perimeter and velocity for a range of flows. The flow that maintains 2 out of 3 criteria for all three transects is then identified.

Habitat Quality Index

The Habitat Quality Index (HQI; Binns and Eiserman 1979; Binns 1982) was used to determine trout habitat levels over a range of late summer flow conditions. Most of the annual trout production in mountain streams occurs during the late summer, following peak runoff, when longer days and warmer water temperatures stimulate growth at all trophic levels. The HQI was developed by the WGFD to measure trout production in terms of habitat. It has been reliably used in Wyoming for habitat gain or loss assessment associated with instream flow regime changes. The HQI model includes nine attributes addressing biological, chemical, and physical aspects of trout habitat. Results are expressed in trout Habitat Units (HUs), where one HU is defined as the amount of habitat quality that

will support about 1 pound of trout. HQI results were used to identify the flow needed to maintain existing levels of Colorado River cutthroat trout production between July 1 and September 30 (Table 2).

In the HQI analysis, habitat attributes measured at various flow events are assumed to be typical of late summer flow conditions. For example, stream widths measured in June under high flow conditions are considered a fair estimate of the stream width that would occur if the same flow level occurred in the month of September. Under this assumption, HU estimates are extrapolated through a range of potential late summer flows (Conder and Annear 1987). Gilbert Creek habitat attributes were measured on the same dates PHABSIM data were collected (Table 1). Some attributes were mathematically derived to establish the relationship between discharge and trout habitat at discharges other than those measured.

Average daily flow (ADF; 6.7 cfs) and peak flow (87 cfs) estimates for determining critical period stream flow and annual stream flow variation are based on precipitation and basin area (Lowham 1988). Maximum stream temperature was estimated at 69°F based on a max-min thermometer in the stream from June through August 1997.

RESULTS AND DISCUSSION

Trout populations are naturally limited by extreme conditions during the winter months (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988, Cunjak 1996, Annear et al. *In Press*). Frazil ice (suspended ice crystals formed when water is chilled below 0°C) in high gradient stream reaches can be both a direct mortality source through gill abrasion and subsequent suffocation or an indirect mortality source when resultant anchor ice limits habitat, causes localized de-watering, and exerts excessive metabolic demands on fish forced to seek ice-free habitats (Brown et. al 1994). Pools downstream from high gradient frazil ice-forming areas can accumulate anchor ice when woody debris or surface ice provides anchor points for frazil crystals (Brown et. al 1994, Cunjak and Caissie 1994). Such accumulations may result in mortalities if low winter flows or ice dams block emigration.

Super-cooled water (<0° C) can also physiologically stress fish. As temperatures decrease below 4° C, fish gradually lose ion exchange abilities. At water temperatures near 0° C, fish have limited ability to assimilate oxygen or rid cells of carbon dioxide and other waste products. If fish are forced to be active near 0°C, such as to avoid frazil ice, direct mortalities can occur. The extent of impacts depends on the magnitude, frequency and duration of frazil events and the availability of escape habitats (Jakober et al. 1998). Juvenile and fry life stages tend to be impacted more than larger fish because younger fish inhabit shallower habitats and stream margins where frazil ice accumulates. Larger fish that inhabit deep pools may endure frazil events if they are not displaced.

Refuge from frazil ice occurs in groundwater influx areas, ice covered pools not close to frazil ice sources, and where heavy snow cover and stream bridging reduces frazil formation (Brown et al. 1994). Lower gradient streams and narrow streams are more likely to have insulating surface ice cover or at higher elevations, heavy snow cover and bridging. Gilbert Creek's high elevation, relatively narrow width and moderate slope suggest that snow bridging occurs in the headwaters. Frazil ice formation may be a concern low in the instream flow segment mainly in early winter before sufficient insulating snow is present or in

late winter when snow melt becomes super-chilled by flowing over snow and ice before entering the stream. Therefore, natural winter flow levels up to the identified 1.3 cfs should be maintained to maximize access to and availability of frazil-ice-free refugia. Any artificial reduction of natural winter stream flows could increase trout mortality, reduce the number of fish the stream could support, and degrade the existing fishery.

Habitat Retention Analysis

Maintenance of naturally occurring flows up to 1.3 cfs is necessary at all times of the year (Table 4). Two of three criteria were met on riffle 1 at 0.4 cfs. On riffle 2, 2 of 3 criteria were met at 1.3 cfs. Therefore, the flow at which 2 of 3 criteria are met for all transects is 1.3 cfs.

Table 4 Simulated hydraulic criteria for two Gilbert Creek riffles. Average daily flow = 6.7 cfs. Bank full discharge = 87 cfs

	Mean Depth (ft)	Mean Velocity (ft/s)	Wetted Perimeter (ft)	Discharge (cfs)
Riffle 1	0.81	3.50	15.9	43
	0.61	1.60	12.8	12
	0.48	1.05	12.3	6.0
	0.47	**1.00[a]**	12.2	5.5
	0.46	0.82	11.0	4.0
	0.37	0.55	10.3	2.0
	0.32	0.43	9.9	1.3
	0.29	0.27	8.9	0.7
	0.27	0.19	**7.9[a]**	**0.4[b]**
	<0.27[a]	<0.19	<7.9	<0.4
Riffle 2	0.84	3.25	18.0	43
	0.54	1.93	13.1	12
	0.33	1.15	11.8	4.0
	0.29	**1.00[a]**	10.9	2.9
	0.28	0.93	10.3	2.4
	0.26	0.86	9.9	2.0
	0.22	0.74	**8.9[a]**	**1.3[b]**
	0.20[a]	0.70	8.5	1.1
	0.18	0.62	6.9	0.7
	0.15	0.54	5.5	0.4

a - Hydraulic criteria met. b - Discharge at which 2 of 3 hydraulic criteria are met.

The 1.3 cfs identified by the Habitat Retention Method may not always be present during the winter. Because the existing fishery is adapted to natural flow patterns, occasional shortfalls during the winter do not imply any degree of infeasibility or a need for additional storage. Instead, they illustrate the necessity of maintaining all natural winter stream flows, up to 1.3 cfs, to maintain existing trout survival rates.

Habitat Unit Analysis

Article 10, Section d of the Instream Flow Act states that waters used for providing instream flows "shall be the minimum flow necessary to maintain or improve existing fisheries". One way to define "existing fishery" is by the number of habitat units that occur under normal July through September flow conditions. The Mountain View Ranger District of the Wasatch-Cache National Forest operated a gage for eleven years near the downstream end of the proposed instream flow segment. Mean monthly stream flows over this period for the months of July, August, and September were 4.1, 1.5, and 1.4 cfs. Furthermore, flows of 1.1 to 1.4 cfs were measured in late summer 1997 (Table 1). Thus, a reasonable estimate of late summer flow in Gilbert Creek is around 1.1 to 1.4 cfs. This level of flow provides about 33 habitat units (Figure 3). To maintain 33 trout habitat units, the simulation shows that flows of 1.1 cfs to 1.7 cfs are needed. For the purpose of maintaining existing fishery values, the term "minimum" means the lowest amount of flow that will provide the identified fishery benefits, whenever it is naturally available. Therefore, the minimum flow to maintain the existing fishery during late summer is 1.1 cfs.

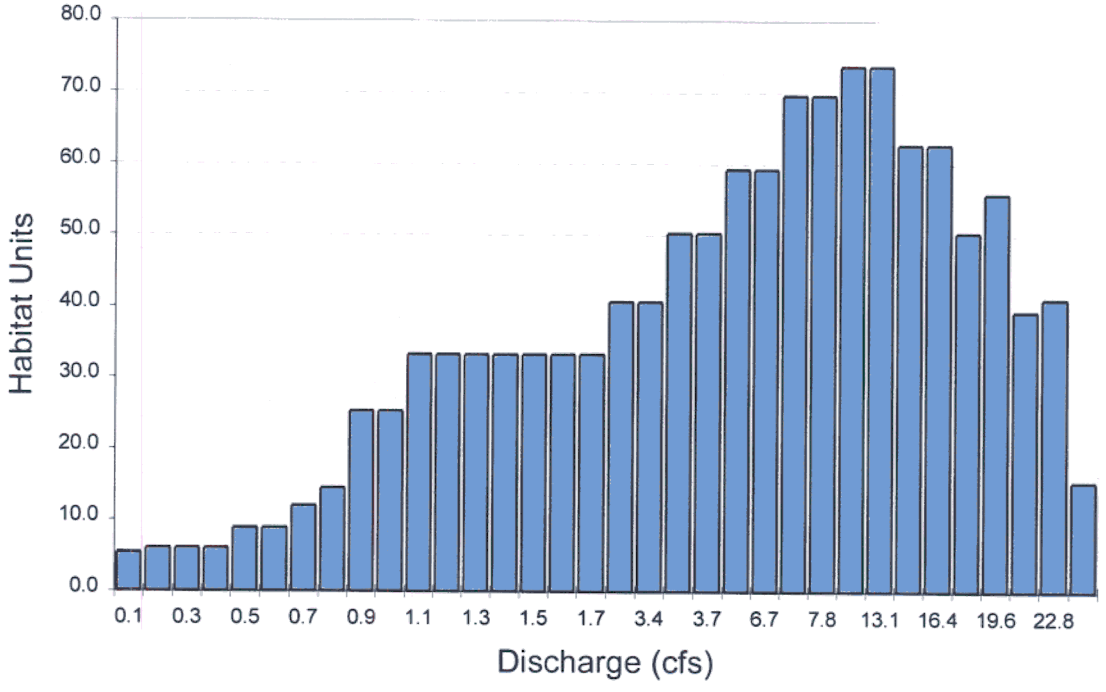


Figure 3. Trout habitat units at several late summer Gilbert Creek flow levels. X-axis discharges are not to scale.

Based on this analysis, an instream flow of 1.1 cfs between July 1 and September 30 would maintain existing trout habitat quality. The habitat retention analysis has already shown that a slightly higher flow of 1.3 cfs is necessary to maintain hydraulic criteria at riffles. Therefore, the recommendation for the late summer period is 1.3 cfs. The existing fishery is naturally dynamic as a function of stream flow availability. In years when stream flow is naturally less than 1.3 cfs in late summer the fishery can be expected to decline. Likewise, in years when late summer flow is 1.3 cfs or more, it should expand. Maintaining this existing fishery simply means maintaining existing natural stream flows up to

the recommended amount in order to maintain the natural habitat and fish population fluctuations.

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 5 will maintain the existing Gilbert Creek Colorado River cutthroat trout fishery. These recommendations apply to an approximately 4.2 mile Gilbert Creek segment extending downstream from the state line between Utah and Wyoming in section 25 of Range 116W, Township 12N. to the trout movement barrier located in section 5 of Range 115W, Township 12N. The land through which the proposed segment passes is under Forest Service administration. Because data were collected from representative habitats and simulated over a wide flow range, additional data collection under different flow conditions would not significantly change these recommendations.

Table 5 Instream flow recommendations to maintain the existing Gilbert Creek trout fishery.

Time Period	Instream Flow Recommendation (cfs)
October 1 to September 30	1.3

This analysis does not consider periodic requirements for channel maintenance flows. Because this stream is unregulated, channel maintenance flow needs are adequately met by natural runoff patterns. If regulated in the future, additional studies and recommendations are needed for establishing channel maintenance flow requirements.

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