WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Instream Flow Studies on Mill Creek, Tributary to Big Sandstone Creek in the Little Snake River Drainage

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ABSTRACT

Instream flow data were collected in 1995 on Mill Creek to determine flows needed to maintain or improve Colorado River cutthroat trout (CRC) habitat and populations. Studies were designed to complement ongoing management plans by the Wyoming Game and Fish Department (WGFD), U.S. Forest Service (USFS) and Bureau of Land Management (BLM).

Physical Habitat Simulation (PHABSIM) and Habitat Quality Index (HQI) models were used to develop instream flow recommendations. Recommendations are 1.7 cfs from October 1 to May 14, 6.8 cfs from May 15 to June 30 and 1.7 cfs from July 1 to September 30. Instream flow recommendations were applied to a 3.1 mile-long reach extending downstream from Forest Service road 871 in the NW 1/4 of Section 27, Township 14 North, Range 87 West to the confluence of Big Sandstone Creek in the NE 1/4 of Section 20, Township 14 North, Range 87 West.

INTRODUCTION

Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) is the only trout species native to the Green River and Little Snake River drainages in Wyoming. Historically, this species was relatively widely distributed and abundant in most of the headwater streams of these drainages. However, habitat degradation, hybridization and competition with introduced trout species have led to serious declines in populations of this species. Binns (1977) reviewed the distribution, genetic purity, and habitat conditions for Colorado River cutthroat trout. His report concluded that habitat loss and degradation were major factors limiting recovery of the species.

In addition to Binns (1977) the distribution and abundance of Colorado River cutthroat trout has also been described by Oberholtzer (1987, 1990). Colorado River cutthroat trout are considered a "rare" species by the Wyoming Game and Fish Department (1977) and "sensitive" by the U.S. Forest Service (USFS) (1985). Management and monitoring responsibilities for populations in the Little Snake River drainage are coordinated by WGFD fisheries personnel in the Green River regional office.

Several strategies and agreements have been developed to guide the management and recovery of this species. The WGFD developed the Comprehensive Management and Enhancement Plan for Colorado River Cutthroat Trout in Wyoming (1987) that outlines specific actions for increasing the range, habitat and numbers of the species. Obtaining adequate instream flows is one of the actions identified for addressing habitat needs. In 1987, the WGFD and U.S. Forest Service signed a memorandum of understanding that committed each agency to "protecting, maintaining, improving and managing Colorado River cutthroat trout populations" in ways that lead toward enhanced biological status. In 1994, the WGFD, USFS and Bureau of Land Management signed a cooperative agreement entitled "Conservation Plan for Colorado River Cutthroat Trout (*Oncorhynchus clarki pleuriticus*) for the Little Snake River Drainage, In Southeastern Wyoming. Pursuing opportunities to secure adequate instream flows is one of the tasks identified in that document. Habitat protection by acquiring instream flow water rights is consistent with the goals and objectives of each of these documents.

Fishery and other resource management practices could be significantly affected if actions are not taken to prevent listing Colorado River cutthroat trout as Threatened or Endangered. Acquiring adequate instream flow water rights on CRC streams is an important step to help avoid listing. In this regard, the WGFD has developed a management strategy of filing instream flow water rights on streams with populations or potential habitat for Colorado River cutthroat trout within their historic range. Studies in 1995 focused on Big Sandstone, North Fork Big Sandstone, Roaring Fork Little Snake.and East Fork Deep Creeks in addition to Mill Creek

The specific objectives of this study were to 1) investigate the relationship between discharge and physical habitat quantity and quality at various times of year for Colorado River cutthroat trout and, 2) determine an instream flow necessary to maintain or improve Colorado River cutthroat trout populations.

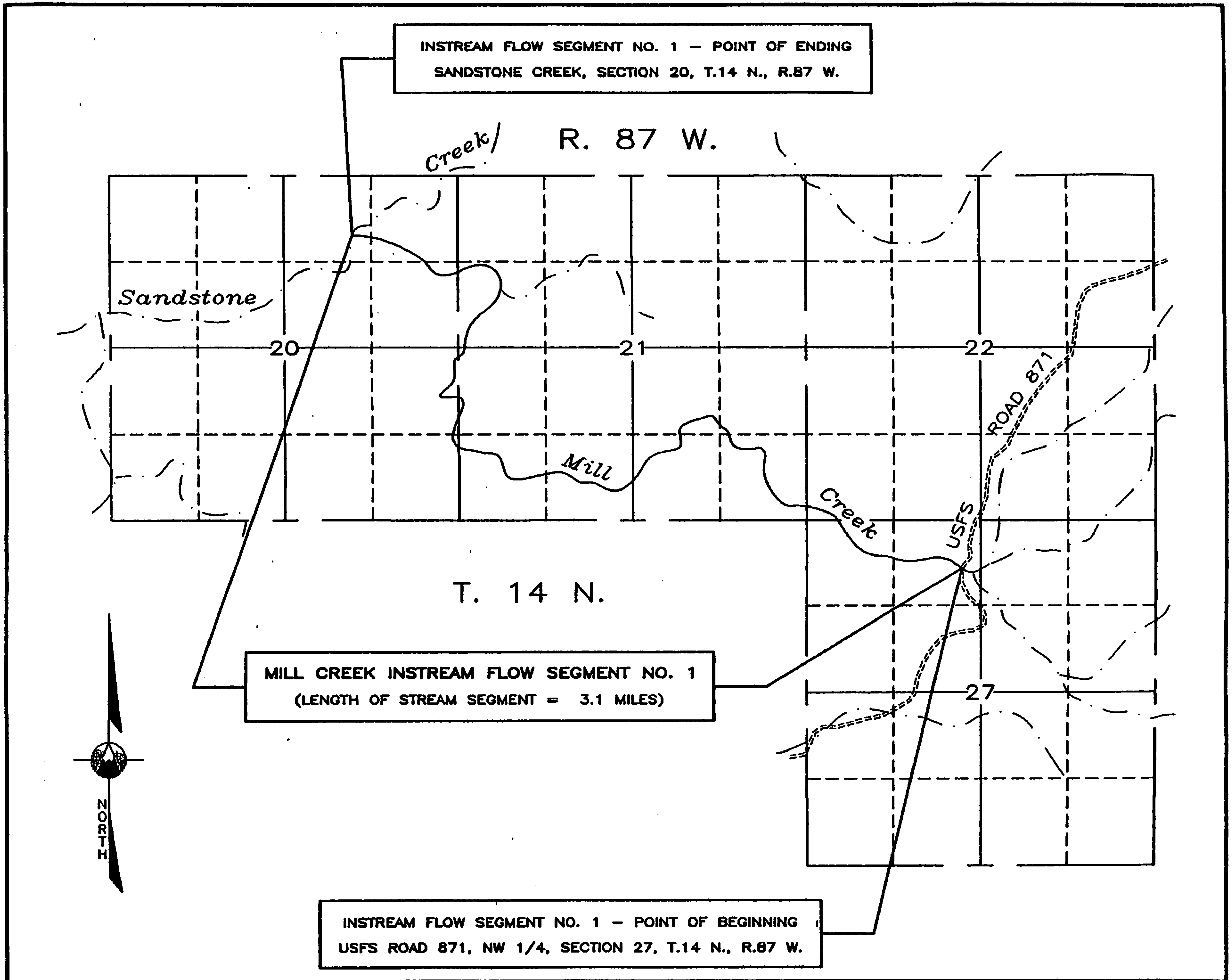
METHODS

Study Area

Mill Creek is a tributary to Big Sandstone Creek in the Little Snake River drainage(Figure 1). The entire length of the instream flow segment is administered by the USFS and the majority of lands within the drainage basin are publicly owned. Mixed aspen and conifers predominate uplands throughout the reach. Willow are scattered in the riparian zone and beaver activity has resulted in several old and new ponds. Overall stream gradient is moderate (<2.5 %) and the channel type was rated as B2 (Rosgen 1985). This rating indicates a moderately entrenched channel that is well confined by its valley and has bed material composed of large cobble, course gravel, and sand.

Fisheries

Observations by fisheries managers in Wyoming and other western states indicate that trout populations in small mountain streams often fluctuate considerably among consecutive years. In a western Oregon stream studied for 11 years, the 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 to 4.5 inches) ranged from 16 to 34 per 100 m^2 (House 1995). In this example, population fluctuations occurred despite the fact that structural habitat conditions and water quality were not degraded and remained relatively stable. The author suggested that changes in


INSTREAM FLOW SEGMENT NO. 1 — POINT OF ENDING
SANDSTONE CREEK, SECTION 20, T.14 N., R.87 W.
R. 87 W.
Creek
Sandstone
20
21
22
ROAD 871
USFS
Mill
Creek
T. 14 N.
MILL CREEK INSTREAM FLOW SEGMENT NO. 1
(LENGTH OF STREAM SEGMENT = 3.1 MILES)
27
NORTH
INSTREAM FLOW SEGMENT NO. 1 — POINT OF BEGINNING
USFS ROAD 871, NW 1/4, SECTION 27, T.14 N., R.87 W.

winter flows between years accounted for part or all of the observed variation in overwinter survival of the different age classes.

In western Wyoming, Binns (1981) noted large declines in trout numbers in several Bonneville cutthroat trout streams following drought in 1977. Similar observations have been made by Remmick (1995, WGFD, personal communication) in more recent years. Department records for Mill Creek show that CRC populations (fish greater than 6 inches long) within the instream flow segment have ranged from 31 fish per mile in 1985 to 287 fish per mile in 1987. The fishery has not been sampled in the past three years.

Long-term trout population maintenance in small streams depends on periodic strong year classes produced in good flow years. Without the benefit of periodic favorable flows, populations in some streams would decline or disappear and genetic diversity could be compromised. The WGFD instream flow strategy recognizes the inherent variability of trout populations as shown in Mill Creek and other streams throughout the state and Western U.S. (House 1995) and thus defines the "existing fishery" as a dynamic feature. This basic concept has also been incorporated into instream flow strategies developed by the Endangered Fish Recovery Program for recovery of endangered fishes in the Colorado River system where high flows are recommended in high flow years and lower flows are recommended during normal and below normal flow periods. Summarily, instream flow recommendations for Mill Creek are based on a goal of maintaining the existing dynamic trout population characteristics of a stream segment as affected by naturally variable flow conditions. The specific flow recommendations are for the lowest flow needed at various times of year to provide this beneficial use of water.

Habitat Modeling

After visually surveying about 1.0 mile of the stream, a study site was located in Range 87 West, Township 14 North, Section 27, NW1/4 at an elevation of about 8180 feet (Figure 1). The representative site had adult and juenile trout cover associated mostly with lateral scour pools and undercut banks. Nine transects were distributed among pool, run, and riffle habitat types (Appendix 1).

Data were collected on June 7 and 27, 1994 and June 22, 1995. Sampling was also attempted on September 21, 1994; however, flow had ceased in the stream at that time which prevented collection of usable hydraulic data. Although flow had ceased, the numerous pools and beaver ponds in the instream flow reach still contained standing water that provided refuge for some adult fish. Collection dates and corresponding discharges are listed in Table 1. Instream flow filing recommendations derived from data collected at this site were applied to a 3.1 mile-long reach extending downstream from Forest Service road 871 in the NW 1/4 of Section 27, Township 14 North, Range 87 West to the confluence of Big Sandstone Creek in the NE 1/4 of Section 20, Township 14 North, Range 87 West.

Table 1. Dates and discharges when instream flow data were collected on Mill Creek in 1994 and 1995.

Date	Discharge (cfs)
June 7, 1994	3.3
June 27, 1994	0.3
September 21, 1994	0.0
June 22, 1995	40.3

While continuous, adequate instream flows are critically important for maintaining the population integrity of stream fisheries, maximum population development can be limited by habitat limitations or "bottlenecks" for certain sensitive life stages and/or times of year. In many cases, habitat for young (fry and/or juvenile) and spawning life stages are significant "bottlenecks" (Nehring and Anderson 1993). As a consequence, the department's general approach to flow quantification includes ensuring adequate flows to maintain spawning habitat in the spring as well as adult and juvenile habitat throughout the remainder of the year. (Table 2).

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

LIFE STAGE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
SPAWNING								1	1			
ADULT										2	2	2
ALL	3	3	3	3	3	3	3	3	3	3	3	3

1 - PHABSIM
2 - Habitat Quality Index
3 - Habitat Retention

Habitat Retention Method

A Habitat Retention method (Nehring 1979, Annear and Conder 1984) was used to identify a maintenance flow by analyzing data from three riffle transects. A maintenance flow is defined as the continuous flow required to maintain specific hydraulic criteria in stream riffles. Year-round criteria maintenance ensures passage between habitat types for all trout life stages. In addition, the criteria maintain adequate benthic invertebrate survival. 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 (feet)	Top Width[a] X 0.01
Mean Velocity (feet/second)	1.00
Percent Wetted Perimeter[b]	50

a - At average daily flow. Minimum depth = 0.20 feet
b - Percent of bank full wetted perimeter

Habitat Quality Index

The Habitat Quality Index (HQI; Binns and Eisermann 1979) was used to estimate trout production over a range of late summer flow conditions. This model was developed by the WGFD and received extensive testing and refinement. It has been reliably used in Wyoming for trout standing stock 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 or improve existing levels of CRC 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 mean late summer flow conditions. Under this assumption, HU estimates are extrapolated through a range of potential late summer flows (Conder and Annear 1987). Mill 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 production at discharges other than those measured. Average daily flow and peak flow estimates are based on elevation and basin area (Lowham 1976).

Physical Habitat Simulation

Physical Habitat Simulation (PHABSIM) methodology was used to quantify physical habitat (depth and velocity) availability over a range of discharges. This methodology was developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) and is widely used for assessing instream flow relationships between fish and physical habitat (Reiser et al. 1989).

The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft^2 per 1000 ft of stream length) at various flows. Depth, velocity, and substrate were measured along transects (*sensu* Bovee and Milhous 1978) on the dates in Table 1. Hydraulic calibration techniques and modeling options in Milhous et al. (1984) and Milhous et al. (1989) were employed to incrementally estimate physical habitat between 0.6 and 90 cfs. Precision declines outside this range; however, the modeled range accommodates typical flows on Mill Creek.

Curves describing depth, velocity and substrate suitability for trout life stages are an important component of the PHABSIM modeling process. Suitability curves for adult, juvenile and spawning were developed by WGFD. Criteria for fry were obtained from studies by Bozek and Rahel (1992).

Observations by WGFD field biologists indicate spawning activity in most streams with CRC peaks between late May and mid June. Because spawning onset and duration varies between years due to differences in flow quantity and water temperature, spawning recommendations should extend from May 15 to June 30. Even if spawning is completed prior to June 30, maintaining flows at the recommended level throughout June will benefit trout egg incubation by preventing dewatering.

RESULTS AND DISCUSSION

Habitat Retention Analysis

Habitat retention analysis indicates that 1.7 cfs is required to maintain hydraulic criteria at all riffles to provide passage between habitats for all trout life stages (Table 4). Maintenance of naturally occurring flows up to this flow is necessary at all times of the year. Higher flows are needed during May through June to maintain or improve specific life stages (Table 2).

Based on habitat retention results, an instream flow of 1.7 cfs is recommended for the October 1 to May 14 time period. This flow level will maintain the existing fishery because it protects existing natural flow patterns up to the identified maintenance level. Trout populations are naturally limited by low flow conditions during the winter months (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988). Such factors as snow fall, cold intensity, and duration of cold periods can influence winter trout survival. Fish populations are influenced primarily through the effects of frazil ice including metabolic stress and anchor ice formation which limits habitat and may result in stranding.

These winter mortality causes are all influenced by winter flows. Higher flows minimize temperature changes and increase stream areas where trout can escape frazil ice impacts. Any artificial reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow is necessary to maintain existing survival rates of trout populations.

Table 4. Simulated hydraulic criteria for two riffles on Mill Creek. Bank full discharge = 29 cfs.

	Mean Depth (Feet)	Mean Velocity (Feet/Sec)	Wetted Perimeter (Feet)	Discharge (cfs)
Riffle 1	1.03	2.13	19.0	40.0
	0.92	1.85	17.7	29.0
	0.83	1.57	16.0	20.0
	0.68	1.14	13.5	10.0
	0.59	**1.00**[a]	13.2	7.5
	0.49	0.83	12.8	5.0
	0.37	0.63	11.1	2.5
	0.31	0.54	10.3	1.7
	0.27	0.49	9.8	1.3
	0.26	0.45	**8.7**[a]	**1.0**[b]
	0.21[a]	0.37	7.8	0.6
	0.14	0.30	7.3	0.3
Riffle 2	0.95	2.57	17.2	40.0
	0.80	2.40	15.8	29.0
	0.68	2.19	13.8	20.0
	0.47	1.87	11.7	10.0
	0.30	1.61	10.6	5.0
	0.21	1.49	9.9	3.0
	0.22	1.42	**8.0**[a]	2.4
	0.20[a]	1.29	6.7	**1.7**[b]
	0.17	1.18	6.4	1.3
	0.14	**1.01**[a]	5.6	0.8
	0.11	0.76	4.9	0.4

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

The 1.7 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 (see above fisheries discussion), occasional periods of natural shortfall during the winter do not imply a need for additional storage. Instead, they illustrate the necessity of maintaining all natural winter stream flows, up to 1.7 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". Often, HU's measured during low flow are used to define the existing late summer fisheries. In situations where the goal is to "maintain" existing fisheries, we determine the flow range with the same HU's as measured and the minimum flow in that range becomes the recommendation. This approach proved infeasible on Mill Creek because the stream ceased flowing prior to the last field visit in September. As a consequence, the late summer recommendation was referenced to the Habitat Retention recommendation which, by definition, is the base flow for all times of year except when other appropriate methods indicate higher flows are needed for specific purposes. This flow was found to be 1.7 cfs (see above).

At a measured late summer flow of 1.7 cfs, HQI analysis indicates the stream provides 19.4 trout HU's (Figure 2). Permanently reduced summer flows (less than 1.7 cfs) would impact the fishery. Likewise, maintaining higher late summer flows (up to 14.8 cfs) on a permanent basis would increase trout habitat units.

Based on this analysis and in consideration of the various Colorado River cutthroat trout management plans and agreements among state and federal land management agencies, an instream flow of 1.7 cfs is recommended to maintain existing trout production between July 1 and September 30. This flow represents the lowest stream flow that will accomplish this objective by allowing populations to benefit from naturally occuring flows when they are available. Storage to achieve this flow on a permanent basis solely for instream flow purposes is likely not in the State's best interest.

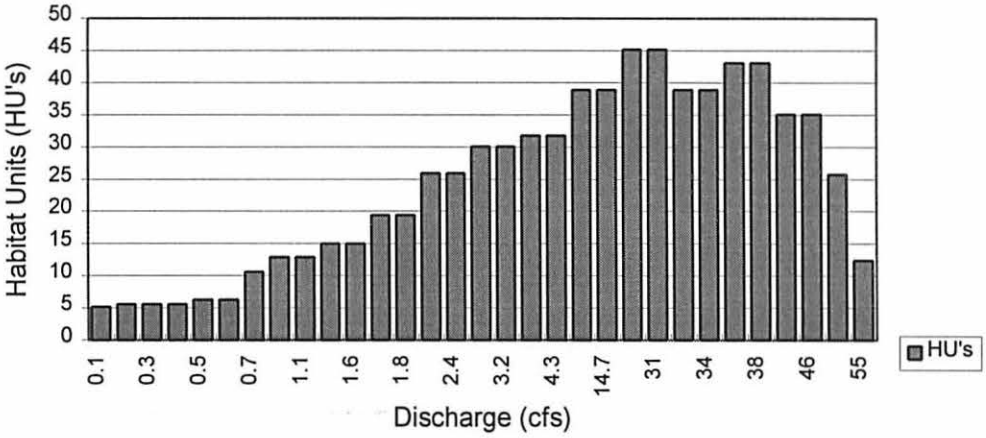


Figure 2. Trout habitat units at several late summer flow levels on Mill Creek. X-axis discharges are not to scale.

PHABSIM Analyses

The maximum amount of physical habitat for spawning occurs at 6.8 cfs (Figure 3). Normal spring flows are much higher - 40 cfs was measured in this study (Table 1). Such high flows might limit spawning activity near the study site or cause migration to more favorable (upstream) reaches. Though trout can usually find someplace to spawn whenever temperatures are appropriate and flows allow unrestricted movement, maximum physical habitat in the study site occurs at a flow of 6.8 cfs. Therefore, an instream flow of 6.8 cfs is recommended for the period May 15 to June 30.

Weighted usable area estimates for adult and juvenile CRC generally agree with HQI results (Figure 3) in as much as WUA declines at flows less than 1.7 cfs and increases at higher flows. Declines in adult WUA at flows less than 1.7 cfs are largely the result of the loss of habitat associated with undercut banks and mid-channel habitat. The recommended late-summer flow of 1.7 cfs (based on the HQI model) will maintain 82 and 85 percent of maximum adult and juvenile physical habitat (respectively). In consideration of this fact, and the fact that the HQI model cannot be used for determining instream flow needs outside the summer period, the flow recommendation from October 1 to May 15 is 1.7 cfs. This flow level will maintain the existing fishery because it protects existing natural flow patterns up to the identified maintenance level

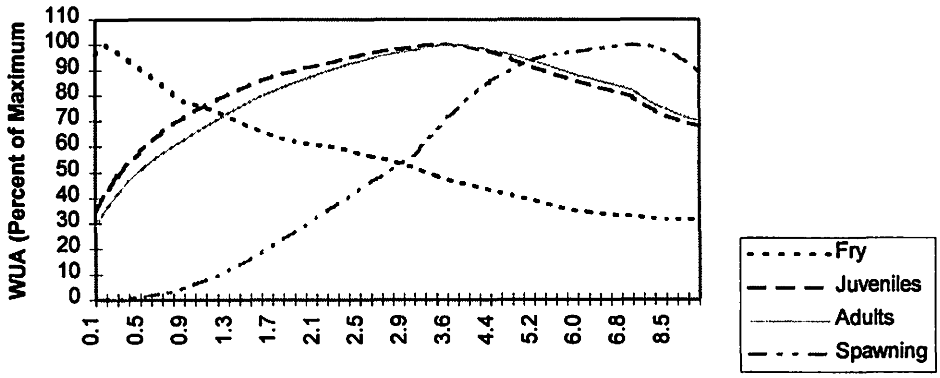


Figure 3. Percent of maximum available weighted usable area (WUA) for Colorado River Cutthroat trout life stages in Mill Creek over a range of discharges.

These mortality causes are all influenced by winter flows. Higher flows generally increase stream areas where trout can escape frazil ice impacts. Any artificial reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow is necessary to maintain existing survival rates of trout populations.

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 3 will maintain the existing Roaring Fork Colorado River cutthroat trout fishery. These recommendations apply to a 3.1 mile segment of Mill

Creek extending downstream from Forest Service road 871 in the NW 1/4 of Section 27, Township 14 North, Range 87 West to the confluence of Big Sandstone Creek in the NE 1/4 of Section 20, Township 14 North, Range 87 West. 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 3. Instream flow recommendations to maintain or improve habitat for the existing trout fishery in Mill Creek.

Time Period	Instream Flow Recommendation (cfs)
May 15 to June 30	6.8
July 1 to September 30	1.7
October 1 to May 14	1.7

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 would be needed for establishing channel maintenance flow requirements.

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Appendix 1. Description of transects used for PHABSIM Analysis on Mill Creek.

Transect	Total Length	Habitat Type
1	3.4	Riffle/Control
2	10.6	Run/Pool
3	18.6	Pool
4	23.2	Pool
5	52.0	Pool
6	51.4	Riffle/Control
7	11.3	Riffle/Control
8	9.4	Run/Pool
9	4.7	Pool