WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Instream flow studies on Deep Creek, Carbon County

PROJECT: IF-4494-07-9401

AUTHORS: Patrick J. Braaten and Thomas C. Annear

DATE: March 1995

ABSTRACT

Instream flow studies were conducted on Deep Creek in 1994 as part of an ongoing monitoring and enhancement program for Colorado River cutthroat trout in streams of the Little Snake River basin. The goal of this study was to determine instream flows necessary for maintaining or improving Colorado River cutthroat trout habitat in Deep Creek.

Physical habitat simulations were conducted for spawning, fry, juvenile and adult life stages of Colorado River cutthroat trout. Based on results from physical habitat simulations, the instream flow recommendations are: October 1 to April 30, 0.5 cfs; May 1 to June 30, 4.6 cfs; July 1 to September 30, 0.5 cfs. The instream flow applies to a 3.4-mile stream reach extending from the confluence of the East and West Forks of Deep Creek in R87W, T14N, S4, NE1/4 downstream to U.S. Forest Service road #801 (Deep Creek Road) in R87W, T14N, S18, NW1/4.

INTRODUCTION

Colorado River cutthroat trout Oncorhynchus clarki pleuriticus are classified as Category 2 taxa by the U.S. Fish and Wildlife Service indicating this species may be appropriate for listing as threatened or endangered. This subspecies is considered a species of special concern by the Wyoming Game and Fish Department (WGFD) and Region 2 of the U.S. Forest Service. Although Colorado River cutthroat trout were historically distributed throughout streams of the Colorado River drainage in Wyoming, Colorado, Utah, Arizona and New Mexico, they now occupy less than 1% of their historic range (Speas et al. 1994). In Wyoming, populations of Colorado River cutthroat trout occur predominantly in small headwater streams of the Green, Little Snake and Blacks Fork River watersheds. Several factors including poor land management practices, limited stream flows, displacement by non-native

trouts, fishing pressure and habitat fragmentation have contributed to the reduced distribution and abundance of Colorado River cutthroat trout throughout their native range (Trotter 1987).

In the Little Snake River watershed, water management activities pose the greatest threat to Colorado River cutthroat trout. Water quality violations and habitat fragmentation following completion of the City of Cheyenne's Stage I and Stage II water diversions have occurred in Colorado River cutthroat trout streams (Hipple 1986, Schmal 1986, Wilcox 1989). Additional flow diversions in other streams of the Little Snake River drainage (Savery Creek drainage) have been considered as part of the City of Cheyenne's Stage III water development plan which could further impact this species. Depending on the magnitude, these types of impacts could contribute to the listing of this species as threatened or endangered unless adequate protective measures are implemented. The potential effects of these flow diversions are discussed in Miller (1980) and Wyoming Game and Fish Department (1986). The importance of protecting habitat and populations of Colorado River cutthroat trout on lands administered by Forest Service was formally acknowledged by an April 22, 1987 Memorandum of Understanding between the Forest Service and WGFD.

In 1994, a management plan for Colorado River cutthroat trout in the Little Snake River watershed was cooperatively prepared by the U.S. Forest Service, the WGFD, and the U.S. Bureau of Land Management (Speas et al. 1994). This plan calls for the protection, maintenance, and re-establishment of Colorado River cutthroat trout in streams of the Little Snake River drainage. Within this plan, the acquisition of instream flows water rights for maintenance and protection of critical Colorado River cutthroat trout habitat was listed as a primary objective.

The objectives of this study were 1) to examine relationships between discharge and physical habitat quantity and quality available to Colorado River cutthroat trout in Deep Creek and 2) to determine an instream flow regime in Deep Creek to maintain or improve Colorado River cutthroat trout populations.

METHODS

Study Area Description

Deep Creek originates on the west slope of the Sierra Madre Mountains at elevations in excess of 9,200 feet msl. The East and West branches flow 2.0 and 1.7 miles, respectively, before joining to form the mainstem of Deep Creek. Deep Creek then flows for about 5.6 miles to its confluence with Big Sandstone Creek. The entire Deep Creek watershed lies within the Medicine Bow National Forest and encompasses 6.33 square miles.

From the confluence of the East and West branches to the terminus, Deep Creek has an average slope of about 3.5%. The class B1 channel (Rosgen 1985) is relatively stable with substrates of small boulders, cobble, and gravel being dominant. Numerous beaver dams scattered throughout the length of the channel create localized discontinuities in channel gradient and stream morphometry.

Hydrology

Deep Creek, like most small streams in the Medicine Bow National Forest, is ungaged. Therefore, site specific flow records for Deep Creek not exist. Discharge records for adjacent Big Sandstone Creek do exist for water years 1956, 1957, 1958, 1985, 1986, 1987 and 1988 (USGS gage # 09255900). This gage was located 300 feet downstream from the Douglas Creek confluence with Big Sandstone Creek.

Big Sandstone Creek flow data were used to estimate monthly flow patterns in Deep Creek. Flow patterns in Deep Creek were obtained by applying a monthly water yield to drainage area ratio from Big Sandstone Creek to Deep Creek. For all watershed size vs. flow relationships, an area of 9.85 square miles and gaged flows were used for Big Sandstone Creek. Flows were estimated for Deep Creek using a watershed size of 4.47 square miles (area above the study site, see below).

Based on this hydrologic simulation technique and average flow conditions of 15.89 cfs in Big Sandstone Creek, average daily flows in Deep Creek are 7.21 cfs; greatest mean daily flows (37.89 cfs) in Deep Creek would occur in June (Figure 1). In 1987 (lowest flows on record for Big Sandstone Creek), average daily flow in Deep Creek would have been 4.47 cfs and greatest mean daily flows (28.29 cfs) would have occurred in May (Figure 1). The average daily minimum flow in Deep Creek for the Big Sandstone Creek period of record was 0.64 cfs (range 0.5 cfs-0.82 cfs).

A water diversion (Deep Creek ditch) exists about 1.4 miles downstream from the confluence the East and West branches in R87W, T14N, S9, NW1/4. The diversion carries an adjudicated water right of 0.10 cfs with a priority date of September 4, 1919. The above flow analysis did not include consideration of potential irrigation diversions in this ditch.

Fisheries

Colorado River cutthroat trout occur throughout the entire Deep Creek drainage. Past electrofishing surveys (Miller 1980; Oberholtzer et al. 1990; Speas et al. 1994) indicate Deep Creek provides important habitat for all life stages of Colorado River cutthroat trout because collections revealed the presence of several size classes.

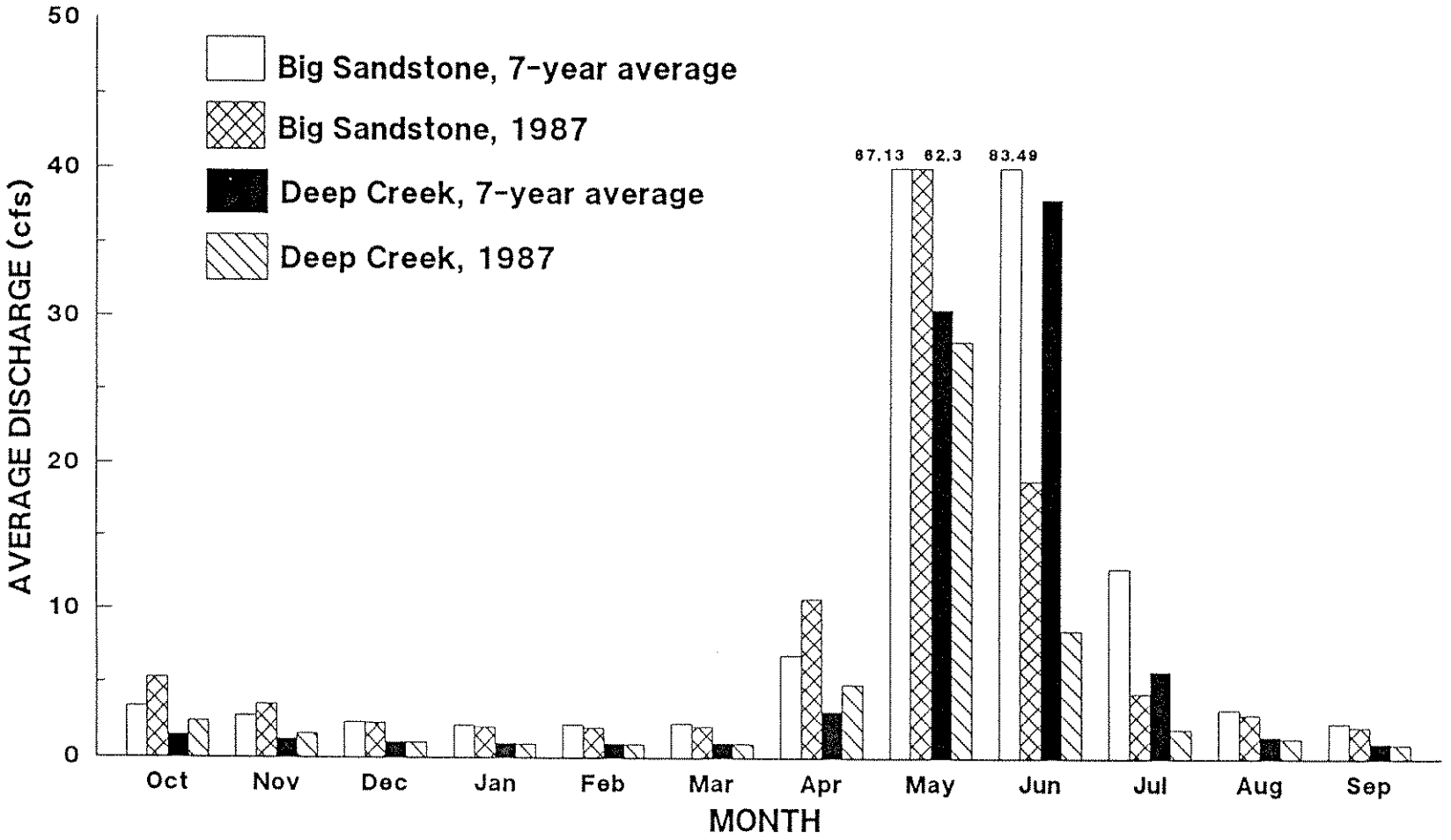

Figure 1. Mean daily flows in Big Sandstone Creek and Deep Creek. Big Sandstone Creek data were compiled from USGS gage number 09255900 for water years 1956, 1957, 1958, 1985, 1986, 1987 and 1988. Discharge in Deep Creek was estimated from Big Sandstone Creek data (see text for an explanation of methods).

Though quantitative, site-specific data for Deep Creek do not exist, studies by Remmick (WGFD, pers. comm.) and other WGFD biologists indicate Colorado River cutthroat trout typically exhibit dynamic changes in population density in response to discharge fluctuations. Present management theory is based on the phenomenon that fish populations in small streams are dependent on strong year classes produced in good flow years which may occur every three to five years. Without the benefit of periodic high flows, populations in some streams would decline or cease to exist.

Study site

After surveying about 0.75 miles of Deep Creek, a study site was established about 125 feet upstream from Forest Service Road #801 (Deep Creek Road) in R87W, T14N, S18, NW1/4. The elevation of the study site is about 7,760 feet mean sea level. Within the 108-foot-long study site, ten transects were established in riffles, runs and pools to represent habitat found throughout the middle reaches of Deep Creek. Instream flow information derived from this site was applied to a 3.4-mile stream reach extending from the confluence of the East and West Forks of Deep Creek in R87W, T14N, S4, NE1/4 downstream to U.S. Forest Service road #801 (Deep Creek Road) in R87W, T14N, S18, NW1/4. The land through which the instream flow segment passes is administered by the U.S. Forest Service.

Physical habitat simulation

A physical habitat simulation model (PHABSIM; Bovee 1982; Milhous et al. 1989) was used to quantify relationships between stream discharge and the amount of physical habitat available for Colorado River cutthroat trout. This model is the mostly widely used method for assessing relationships between instream flow and physical habitat for fish (Reiser et al. 1989). In PHABSIM, physical habitat is reported as weighted usable area (WUA; square feet/1,000 feet of stream length).

The physical habitat model was calibrated for all ten transects using hydraulic characteristics of depth, velocity and substrate measured on the dates and discharges listed in Table 1. Based on these data, physical habitat simulations were conducted for flows ranging from 0.1 cfs to 7.0 cfs.

Table 1. Dates and discharges when hydraulic data were collected in Deep Creek.

Date	Discharge (cfs)
June 7, 1994	3.5
June 30, 1994	0.5
September 20, 1994	0.2

Because this section of Deep Creek provides habitat for all life stages of Colorado River cutthroat trout, relationships between WUA and discharge were generated for spawning, fry (individuals less than 1.5 inches total length), juveniles (individuals 2 to 5 inches total length) and adults (individuals greater than 6 inches total length). Jesperson (1979) and Quinlan (1980) found the majority of spawning by Colorado River cutthroat trout in streams of Little Snake drainage occurs primarily in mid to late June following peak discharge. Depending on flow and temperature conditions, spawning may begin as early as May and continue through the first week of July.

Following egg maturation, fry emerge from the redds from early August through September (Jesperson 1979). By October, most age-0 Colorado River cutthroat trout are about 1.25 inches in length. Table 2 illustrates the biologically critical times of the year for all life stages to which PHABSIM modeling was applied.

Table 2. Critical flow months for various life stages of Colorado River cutthroat trout in Deep Creek.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning					X	X						
Fry							X	X	X			
Juvenile	X	X	X	X			X	X	X	X	X	X
Adult	X	X	X	X			X	X	X	X	X	X

Habitat suitability curves used in the PHABSIM model were from several sources. Fry suitability curves from Bozek and Rahel (1992) were generated from data in Colorado River cutthroat trout streams of the Little Snake River drainage. Juvenile and adult suitability curves were generated from data collected during the summer of 1994 in streams of the Little Snake River drainage (Braaten et al. in prep). Suitability curves depicting cutthroat trout spawning habitat were taken from Bovee (1978).

RESULTS

Spawning Physical Habitat

Relationships between discharge and weighted usable area for Colorado River cutthroat trout spawning are illustrated in Figure 2. Physical habitat is maximized at 4.6 cfs. At flows less than 4.0 cfs, the amount of physical habitat for spawning declines sharply.

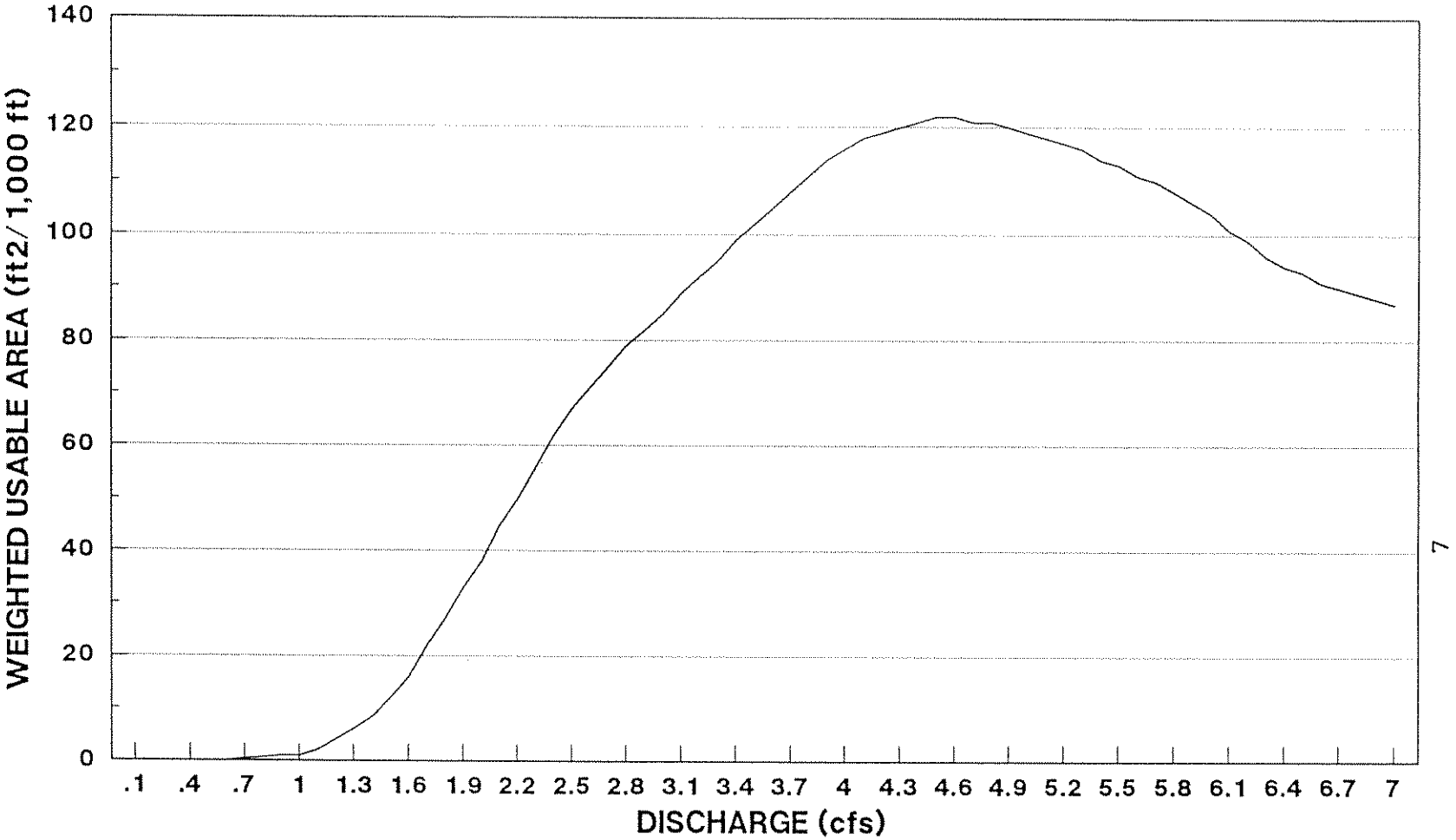

Figure 2. Relationship between discharge and physical spawning habitat for Colorado River cutthroat trout in Deep Creek.

Adult Physical Habitat

Physical habitat simulations indicate maximum WUA for adult Colorado River cutthroat trout occurs at 0.6 cfs (Figure 3). Physical habitat declines sharply at flows greater than 0.7 cfs or flows less than 0.5 cfs.

Juvenile Physical Habitat

Physical habitat for juvenile Colorado River cutthroat trout is maximized 0.4 cfs (Figure 3). Physical habitat for juveniles declines sharply at flows less than 0.2 cfs and flows greater than 0.5 cfs.

Fry Physical Habitat

Based on physical habitat simulations, a discharge 0.1 cfs maximizes the amount of physical habitat available to Colorado River cutthroat trout fry (Figure 3). Physical habitat for fry declines rapidly at flows greater than 0.1 cfs.

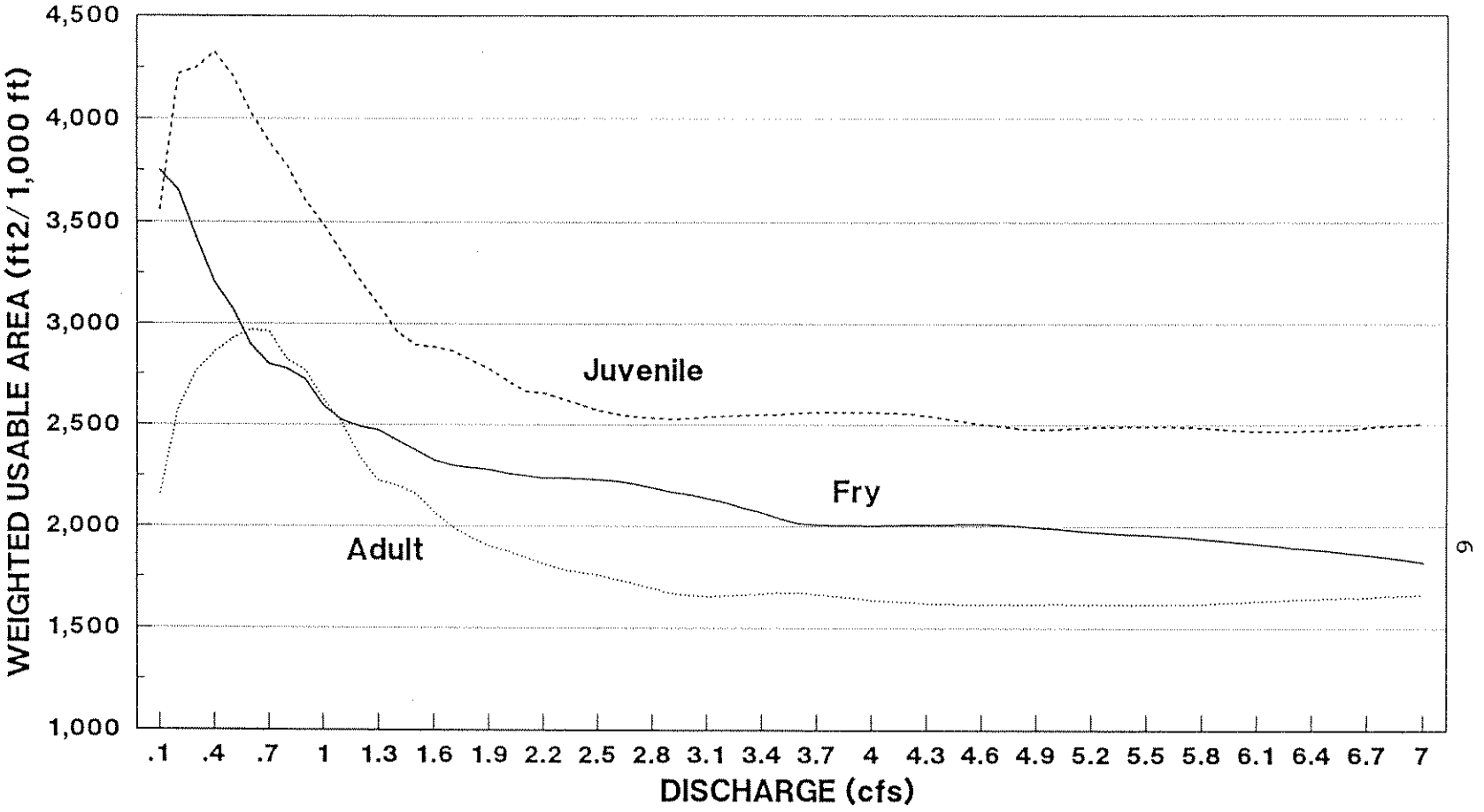

Figure 3. Relationships between discharge and physical habitat for fry, juvenile and adult life stages of Colorado River cutthroat trout in Deep Creek.

DISCUSSION

Results from physical habitat simulations indicate a flow of 4.6 cfs from May 1 to June 30 is the flow at which physical habitat for spawning is maximized. Based on the seven years of flow records for Big Sandstone Creek, average monthly flows in Deep Creek during May and June approximate 30.46 cfs and 37.89 cfs, respectively. Mean daily flows of 28.27 cfs (May) and 8.53 cfs (June) in Deep Creek occur during the driest year on record (1987). This preliminary analysis of flow patterns in Deep Creek indicates the recommended spawning flow of 4.6 cfs during May and June should naturally be available even during dry water years and would maintain or improve existing levels of physical habitat for spawning.

Although the availability of fry habitat is a major population-limiting factor in some streams (Nehring and Anderson 1993), results from this study suggest physical habitat for fry is not a limiting factor in Deep Creek. Fry are typically present in Deep Creek between July and September. During this time period, natural flows in Deep Creek (based Big Sandstone Creek basin area vs. water yield models) average 1.47 cfs and 1.06 cfs, respectively (Figure 1). Under these natural flow regimes, fry WUA is about 30% less than maximum WUA for fry which occurs at 0.1 cfs. These results indicate populations of Colorado River cutthroat trout have persisted in Deep Creek despite the absence of a physical habitat-maximizing flow for fry in late summer. Based on these results, populations of Colorado River cutthroat trout in Deep Creek are probably regulated by the amount and quality of physical habitat available to juveniles and adults. Although fry physical habitat is maximized at 0.1 cfs, the permanent limitation of discharge at this level would seriously limit other important life stages (see below). As a consequence, instream flow recommendations based soley on the fry life stage are inappropriate.

Results from physical habitat simulations indicate instream flows of 0.4 cfs and 0.6 cfs are needed to maximize physical for juveniles and adults, respectively, from July 1 to April 30 when physical habitat is most critical to these life stages (Table 2). Because Colorado River cutthroat trout are sensitive species, maximizing physical habitat suitability is critical for maintenance of their populations. Therefore, flows of 0.5 cfs from July 1 to April 30 are recommended for juveniles, adults, and fry. This flow maintains greater than 90% of maximum physical habitat for adults and juveniles and also provides about 85% of maximum physical habitat for fry.

Mean daily flows in Deep Creek (based on Big Sandstone Creek basin are vs. water yield models) from July 1 to April 30 range from 0.96 cfs to 5.8 cfs under normal conditions (averaged over the 7 years of data). During the driest year on record (1987), mean daily flows from July 1 to April 30 range from 0.89 cfs to 4.86 cfs. Therefore,

the recommended flow of 0.5 cfs from July 1 to April 30 should naturally be available even during dry water years.

A summary of Deep Creek flow recommendations is listed in Table 3. These flows will nearly maximize physical habitat for all life stages, and maintain or improve existing physical habitat suitability. However, the consistency of the recommended flows may contribute to a decline in habitat quality over the long-term. For example, substrate fines may accumulate in spawning gravels due to the lack of cyclical major runoff events (e.g., bankful discharge) which could reduce spawning success. The absence of high runoff flows in the spring could also limit the recruitment of spawning gravels from the upper watershed. The lack of channel maintenance flows may also lead to encroachment of stream banks and a gradual narrowing of the stream channel. This process would reduce the total space available to trout, and in combination with the above processes, lead to a reduction in the existing fishery.

The WGFD does not presently have the expertise with methods used to determine appropriate channel maintenance flows. When this expertise is acquired, supplemental water rights for channel maintenance should be pursued.

Table 3. Summary of instream flow recommendations for Deep Creek.

Time period	Discharge (cfs)
October 1 to April 30	0.5
May 1 to June 30	4.6
July 1 to September 30	0.5

LITERATURE CITED

Bovee, K.D. 1978. Probability of use criteria for the family Salmonidae. U.S. Fish and Wildlife Service Biological Services Program FWS/OBS-78/07.

Bovee, K.D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Methodology. Instream Flow Information Paper 12. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-82/26.

Bozek, M.A. and F.J. Rahel. 1992. Generality of microhabitat suitability models for young Colorado River cutthroat (Oncorhynchus clarki pleuriticus) across sites and among years in Wyoming streams. Canadian Journal of Fisheries and Aquatic Sciences 49:552-564.

Braaten, P.J. P.D. Dey and T.C. Annear. In preparation. Habitat suitability criteria for Colorado River cutthroat trout in streams of the Little Snake River drainage.

Hipple, B. 1986. Summary of washouts at Deadman Creek, First Creek, Second Creek, and Rose Creek on Stage II Little Snake River Diversion pipeline. Medicine Bow National Forest, unpublished.

Jespersen, D.M. 1979. Instream flow determination and impact evaluation of water diversion on the Colorado River cutthroat trout and brook trout in the North Fork and Roaring Fork of the Little Snake River drainage. U.S. Forest Service Report, Medicine Bow National Forest, Laramie, Wyoming.

Milhous, R.T., M.A. Updike and D.M. Schneider. 1989. Physical Habitat Simulation System Reference Manual - Version II. Instream Flow Information Paper No. 26. U.S. Fish and Wildlife Service Biological Report 89(16).

Miller, D.D. 1980. Quantification of trout habitat that could be impacted by Stage III of the Little Snake River Water Management Project. Wyoming Game and Fish Department Administrative Report, Fish Division, Cheyenne.

Nehring, R.B. and R.M. Anderson. 1993. Determination of population-limiting critical salmonid habitats in Colorado streams using the Physical Habitat Simulation System. Rivers 4:1-19.

Oberholtzer, M. 1990. Current status of Colorado River cutthroat trout in the Little Snake River Enclave. Wyoming Game and Fish Department, Administrative Report, Cheyenne.

Quinlan, R.E. 1980. A study of the biology of the Colorado River cutthroat trout (Salmo Clarki pleuriticus) population in the North Fork of the Little Snake River Drainage in Wyoming. Master of Science thesis, University of Wyoming, Laramie.

Reiser, D.W., T.A. Wesche and C. Estes. 1989. Status of instream flow legislation and practices in North America. Fisheries 14:22-29.

Rosgen, D. 1985. A stream classification system. Pages 91-95, In Riparian Ecosystems and Their Management; Reconciling Conflicting Uses. Proceedings of the First North American Riparian Conference, April 16-18, Tuscon, Arizona.

Schmal, R.N. 1986. Deadman Creek diversion failure assessment of changes in physical habitat and aquatic macroinvertebrates with recommendations for mitigation. Medicine Bow National Forest, unpublished.

Speas, C. and five authors. 1994. Conservation plan for Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) for the Little Snake River Drainage, in southeastern Wyoming. An inter-agency plan prepared by the Medicine Bow National Forest, Wyoming Game and Fish Department and the U.S, Bureau of Land Management.

Trotter, P.C. 1987. Cutthroat trout: Native trout of the west. Colorado Associated University Press, Boulder.

USGS (United States Geological Survey). Water resources data for Wyoming. Water years 1956, 1957, 1958, 1985, 1986, 1987 and 1988.

Wilcox, M. 1989. Green Timber Creek timber sale specialist report. Medicine Bow National Forest, unpublished.

WGFD (Wyoming Game and Fish Department). 1986. Little Snake River Water Management Project, Level III Wildlife Impact, the Collector System. Presented to the State of Wyoming, Water Development Commission.