

WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Instream flow studies on Dirtyman Fork, Carbon County
PROJECT: IF-4494-07-9402
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ABSTRACT

Instream flow studies were conducted on Dirtyman Fork 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 Dirtyman Fork.

Physical habitat modeling and habitat retention methods were used to determine instream flows necessary for Colorado River cutthroat trout habitat maintenance. Instream flow recommendations are: October 1 to April 30, 0.5 cfs; May 1 to June 30, 1.4 cfs; and, July 1 to September 30, 0.5 cfs. The instream flow applies to a 1.1-mile stream reach extending from the confluence of the North and South Forks of Dirtyman Fork in R87W, T15N, S28, SW1/4 downstream to the fish barrier in R87W, T15N, S29, NW1/4.

INTRODUCTION

Colorado River cutthroat trout Oncorhynchus clarki pleuriticus are classified as Category 2 taxa by the U.S. Fish and Wildlife Service. Species in this category may be appropriate for listing as threatened or endangered if significant habitat losses or declines in population size continue. Colorado River cutthroat trout are 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 trout, 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 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). Appropriate protective measures such as acquisition of adequate instream flow water rights could help avoid the listing of Colorado River cutthroat trout as threatened or endangered.

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 Dirtyman Fork and 2) to determine an instream flow regime in Dirtyman Fork for the maintenance Colorado River cutthroat trout habitat.

STUDY AREA

Dirtyman Fork originates on the west slope of the Sierra Madre Mountains at elevations in excess of 9,000 feet mean sea level. The North and South branches flow about 1.0 mile before joining to form the mainstem of Dirtyman Fork. Dirtyman Fork then flows into Savery Creek. The headwaters of Dirtyman Fork are located on the Medicine Bow National Forest; from the National Forest, the stream flows through private land and lands administered by the U.S. Bureau of Land Management.

Dirtyman Fork has an average slope of about 6.0% in the upper reaches. The class A3 channel (Rosgen 1985) is relatively stable with substrates of small boulders and cobbles being dominant. Several beaver dams ranging in size from about 0.2 acres to 1.0 acres in the upper reaches of the watershed create localized discontinuities in channel gradient and stream morphometry.

Hydrology

Dirtyman Fork, like most small streams in the Medicine Bow National Forest, is ungaged; therefore, site-specific stream flow records are not available for Dirtyman Fork. Periodic stream flow measurements have been collected by WGFD personnel through the years. In 1984 when precipitation and snow pack levels exceeded normal conditions in the Little Snake River basin (USGS 1985), Conder (WGFD, pers. obs.) measured flows of 13.2 cfs (20 June), 0.8 cfs (19 July), and 0.2 cfs (8 September). Oberholtzer (1987) reported flows of 2.5 cfs and 0.5 cfs on 23 July 1985 and 7 August 1985. Snow pack levels in 1985 were below average, but summer precipitation conditions exceeded normal levels (USGS 1986). Braaten (this report) recorded stream

flows of 1.6 cfs (9 June), 0.3 cfs (1 July) and 0.1 cfs (22 September) during the 1994 drought. These hydrologic records indicate stream flows in Dirtyman Fork exhibit major annual and seasonal variability and are dependent on precipitation levels in the watershed.

Fisheries

Colorado River cutthroat trout occur predominantly in the upper reaches of Dirtyman Fork above the fish barrier. Beaver ponds provide the majority of physical habitat for adult Colorado River cutthroat trout; naturally-occurring, large pools for adults are limited in abundance in the stream. Physical habitat throughout the non-beaver dam impounded stream areas is most suitable for fry and juveniles. Based on these physical habitat characteristics, instream flow protection is necessary to maintain or improve suitable spawning areas and physical habitat for fry and juvenile life stages.

Though quantitative, site-specific data for Dirtyman Fork do not exist, studies by Remmick (WGFD, pers. comm.) and other WGFD biologists indicate Colorado River cutthroat trout exhibit dynamic changes in population density in response to natural fluctuations in stream discharge. 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 0.3 miles of stream, a study site was established about 300 feet upstream from the fish barrier in R87W, T15N, S29, NW1/4. The elevation of the study site is 7,920 feet mean sea level. Within the 300-foot-long study site, nine transects were established in riffles, runs and pools to represent habitat types, except large beaver ponds, found throughout the upper reaches of Dirtyman Fork. Riffles supported spawning habitat, and runs and pools supported pocket water suitable for fry and juvenile life stages.

METHODS

Instream flow data were collected in Dirtyman Fork on the dates and discharge listed in Table 1. Instream flow information derived from the study site was applied to a 1.1-mile stream reach extending from the confluence of the North and South Forks of Dirtyman Fork in R87W, T15N, S28, SW1/4 downstream to the fish barrier in R87W, T15N, S29, NW1/4. The land through which the instream flow segment passes is administered by the U.S. Forest Service and the Bureau of Land Management.

Table 1. Dates and discharges when hydraulic data were collected in Dirtyman Fork.

<u>Date</u>	<u>Discharge (cfs)</u>
June 9, 1994	1.6
July 1, 1994	0.3
<u>September 22, 1994</u>	<u>0.1</u>

A Habitat Retention method (Nehring 1979; Annear and Conder 1984) was used to identify a maintenance flow in Dirtyman Fork. This flow is defined as the continuous volume of water required to maintain at least two of three hydraulic criteria in riffles (Table 2). Maintenance of these criteria ensures fish passage between

habitats and promotes adequate survival and production of benthic invertebrates. Maintenance flows are applicable on a year-round basis except when greater flows are required to maintain or improve the biological potential for trout.

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 to spawning, fry, and juvenile life stages of 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 ($\text{ft}^2/1,000$ feet of stream length).

Table 2. Hydraulic criteria for determining a maintenance flow with the Habitat Retention method.

Category	Criteria
Mean depth (ft)	Top width ^a X 0.01
Mean velocity (ft/s)	1.00
Wetted perimeter (%) ^b	50

a - Average daily flow. Minimum depth = 0.20 feet
 b - Percent of bankfull wetted perimeter

The physical habitat model was calibrated for all nine 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 3.0 cfs. Habitat suitability criteria from Bovee (1978), Bozek and Rahel (1992) and Braaten et al. (in preparation) were used in the spawning, fry and juvenile physical habitat simulations, respectively.

Jespersen (1979) and Quinlan (1980) found the majority of spawning by Colorado River cutthroat trout occurred on the descending limb of the hydrograph during June, and in some instances spawning continued through the first week of July in streams of the Little Snake River drainage. Depending on flow and temperature conditions, spawning may begin in May. Suitable physical habitat for spawning is most critical during this time period. Following egg maturation through July, physical habitat for fry is important from early August through September. Most age-0 Colorado River cutthroat attain the juvenile life stage by September. Based on the biology of Colorado River cutthroat trout, Table 3 illustrates the biologically critical times of the year to which instream flow modeling methodologies apply in Dirtyman Fork.

Table 3. Methods used to determine instream flow recommendations at different times of the year based on various life stages of Colorado River cutthroat trout.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning					1	1						
All	2	2	2	2			2	2	2	2	2	2

1 - PHABSIM
 2 - Habitat Retention

RESULTS

Habitat Retention Analysis

Results from the habitat retention analysis indicate a flow of 0.5 cfs is required to maintain hydraulic criteria in riffles to provide passage for all life stages (Table 4). Maintenance of naturally occurring flows up to this flow is necessary at all times of the year.

Table 4. Simulated hydraulic criteria for riffles on Dirtyman Fork. Average daily flow = 0.9 cfs. Bankfull discharge = 5.8 cfs.

	Mean depth (ft)	Mean velocity (ft/s)	Wetted perimeter (ft)	Discharge (cfs)
Riffle 1	0.42	1.11 ¹	12.9	5.8
	0.37	0.90	12.6	4.0
	0.32	0.76	12.5	3.0
	0.30	0.62	11.2	2.0
	0.28	0.42	8.6	1.0
	0.28	0.40	8.5	0.9
	0.26	0.25	6.5 ¹	0.4 ²
	0.20 ¹	0.16	6.0	0.2
	0.17	0.11	5.4	0.1
Riffle 2	0.39	2.19	7.2	5.8
	0.27	1.00 ¹	5.7	1.5
	0.26	0.94	5.4	1.3
	0.25	0.82	5.0	1.0
	0.20 ¹	0.54	4.8	0.5 ²
	0.19	0.47	4.6	0.4
	0.16	0.31	4.3 ¹	0.2
	0.16	0.24	2.6	0.1

1 - Minimum hydraulic criteria met

2 - Discharge at which 2 of 3 hydraulic criteria are met

Spawning Physical Habitat

The relationship between discharge and weighted usable area for spawning Colorado River cutthroat trout is illustrated in Figure 1. Physical habitat is maximized at 1.4 cfs. Physical habitat for spawning is reduced about 13% from 1.4 cfs down to 0.8 cfs. At flows less than 0.8 cfs, physical habitat for spawning is reduced substantially with incrementally small reductions in flows. Flows up to the highest simulated flow (3.0 cfs) will maintain no less than about 50% of maximum physical habitat.

Fry Physical Habitat

Physical habitat for fry increases from a minimum of about 450 ft²/1,000 at 0.1 cfs to a maximum of 924 ft²/1,000 at 2.1 cfs (Figure 2). Physical habitat remains relatively constant up to the maximum simulated discharge (3.0 cfs).

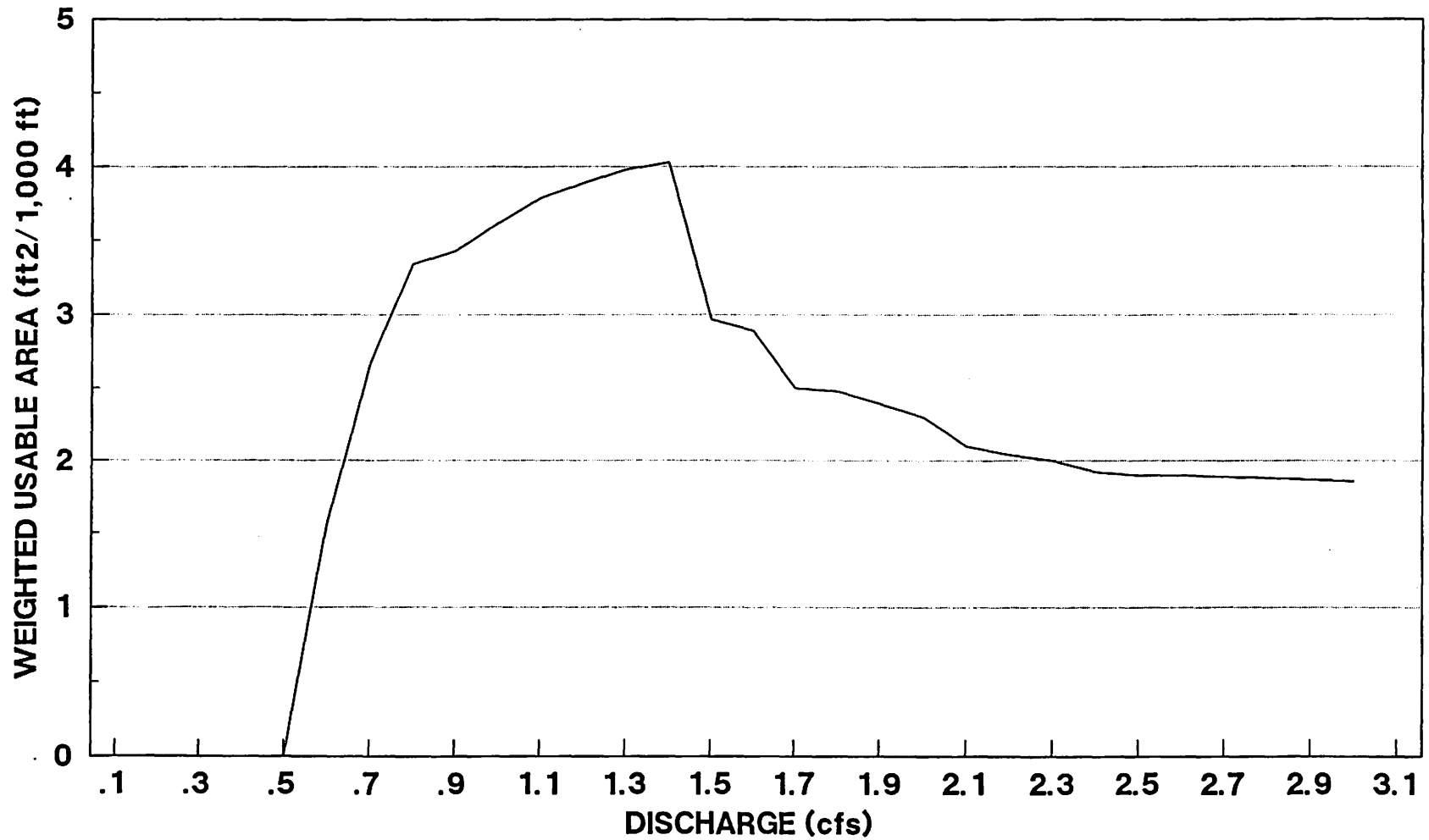


Figure 1. Relationship between discharge and physical habitat for spawning Colorado River cutthroat trout in Dirtyman Fork.

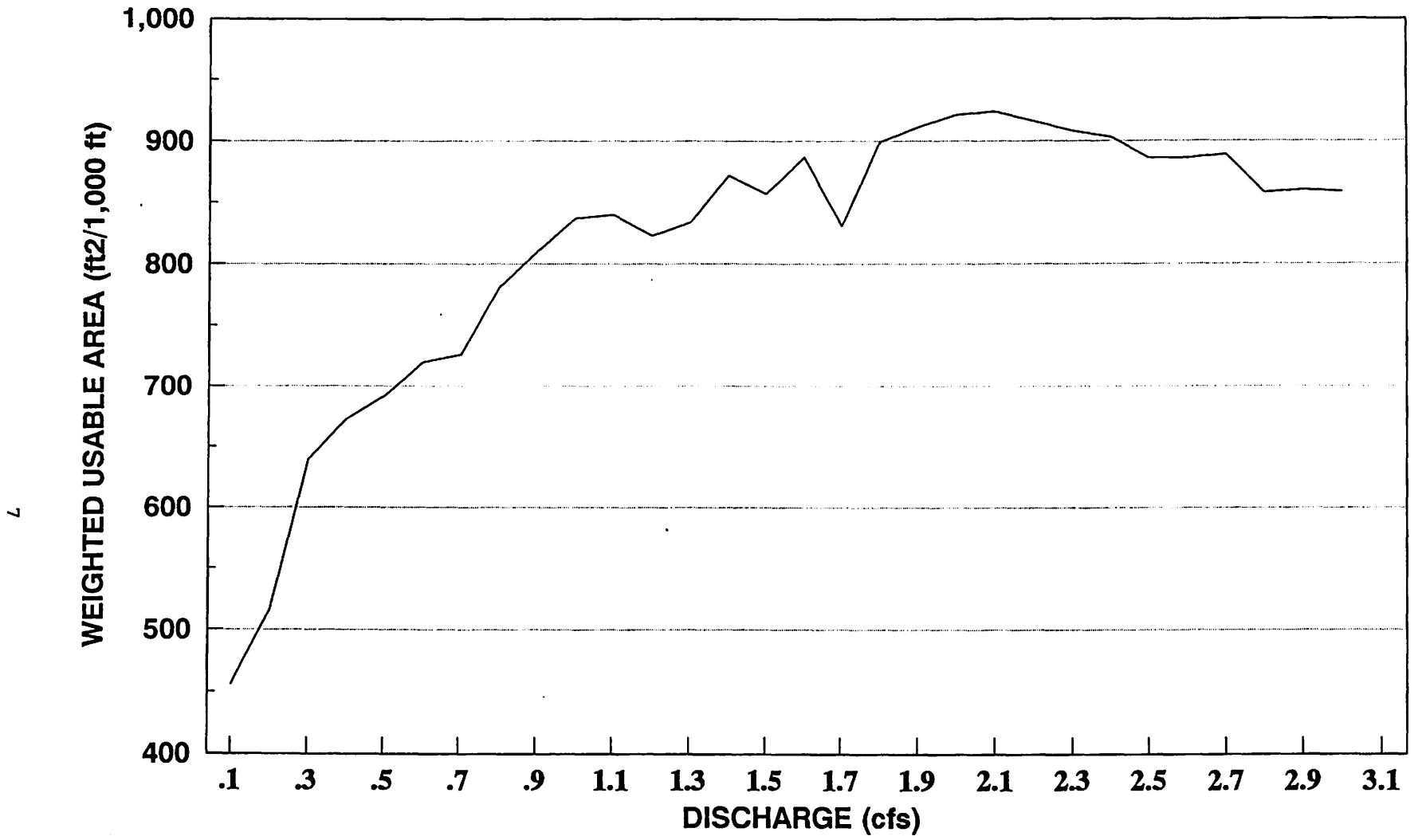


Figure 2. Relationship between discharge and physical habitat for fry Colorado River cutthroat trout in Dirtyman Fork.

Juvenile Physical habitat

Physical habitat for juvenile Colorado River cutthroat trout is maximized at 0.9 cfs (Figure 3). At flows greater than 0.9 cfs, greater than 90% of maximum physical habitat is maintained. Physical habitat declines significantly at flows less than 0.5 cfs.

DISCUSSION

Habitat retention analysis indicates 0.5 cfs is the minimum flow which maintains hydraulic criteria for fish passage and provides suitable conditions for aquatic invertebrate production in riffles. This flow is necessary at all times of the year except when greater flows are needed to maintain or enhance spawning conditions.

Results from physical habitat simulations indicate physical habitat for spawning Colorado River cutthroat trout is limited in Dirtyman Fork. Limited spawning habitat results from the predominance of cobble and larger substrates in the channel, and the relative scarcity of suitable spawning gravel. Because spawning habitat is limited, protection of this critical habitat type is necessary to ensure adequate reproductive success. Based on PHABSIM analysis, 1.4 cfs maximizes physical habitat for spawning. Although 87% of maximum physical habitat is maintained at flows down to 0.8 cfs, maximization of physical habitat for spawning is important because spawning habitat is very limited. Slight deviations from the maximum may have deleterious effects on spawning success. Because of the relatively high risk of physical habitat loss at lower flows and the sensitive status of this species, a flow of 1.4 cfs is necessary to maximize physical habitat for spawning.

Results from PHABSIM indicate physical habitat for fry is maximized at 2.1 cfs; however, flows of this magnitude rarely, if ever exist in Dirtyman Fork during late summer. Flows during late summer under natural, average conditions probably range from 0.4 cfs to 0.5 cfs. Based on results from the habitat retention analysis, a flow of 0.5 cfs is needed to maintain hydraulic criteria. At 0.5 cfs, physical habitat for fry is about 75% of the maximum available at 2.1 cfs. These results suggest 75% of maximum physical habitat is suitable for maintaining physical habitat for fry.

Results from PHABSIM indicate physical habitat for juvenile Colorado River cutthroat trout is maximized at 0.9 cfs, but little reductions in physical habitat occur down to 0.5 cfs. At flows less than 0.5 cfs, physical habitat for juveniles declines significantly. These results are similar to those derived from the habitat retention method which indicate 0.5 cfs maintains hydraulic criteria in Dirtyman Fork. Based on these considerations, a discharge of 0.5 cfs maintains suitable physical habitat for juvenile Colorado River cutthroat trout in Dirtyman Fork.

Unlike fry and juveniles, physical habitat suitability for adult Colorado River cutthroat trout in Dirtyman Fork is not directly influenced by stream flow because adults primarily inhabit beaver ponds. Although beaver pond water levels will be influenced by changes in pond inflow, the ponds will maintain suitable physical habitat (depth). However, stream flow alterations may have indirect effects on habitat quality in the ponds. Reductions in flow to less than 0.5 cfs derived from the habitat retention analysis will negatively impact aquatic invertebrate production in riffles upstream from the beaver ponds that will reduce the amount of drifting food resources available to adults in the beaver ponds. Reduced availability of drifting food resources has been shown to limit the growth potential

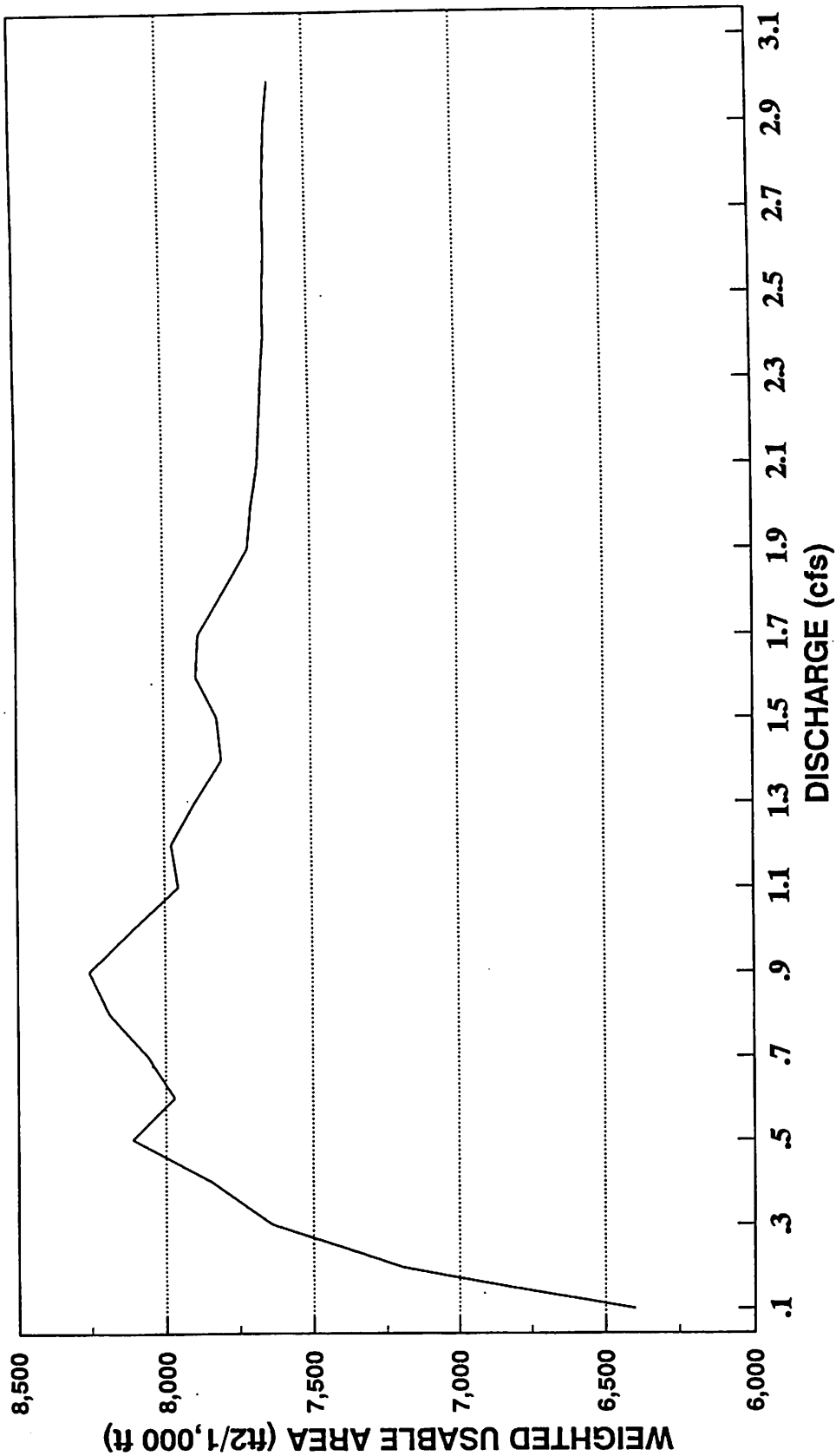


Figure 3. Relationship between discharge and physical habitat for juvenile Colorado River cutthroat trout in Dirtyman Fork.

of salmonids in streams (Fausch 1984) and may negatively impact the reproductive potential of Colorado River cutthroat trout. Significant reductions in pond flow may also increase water temperatures in the ponds to levels unsuitable for adults; however, this effect would be minimal because the stream upstream from the ponds and the ponds are extensively shaded.

Based on results from this study, the instream flows listed in Table 5 are recommended for Dirtyman Fork. The spring and early summer flow of 1.4 cfs will maximize physical habitat for spawning which is critical in Dirtyman Fork. The summer, fall and winter flow of 0.5 cfs will maintain hydraulic criteria, and provide suitable physical habitat for fry, juvenile and adult life stages of Colorado River cutthroat trout.

The limitation of stream discharge to only the recommended flows may contribute to a decline in physical habitat quality over the long-term. For example, substrate fines may accumulate in the limited spawning gravel due to a lack of cyclical major runoff events (e.g. bankfull discharge) which could reduce spawning success. The absence of high natural runoff flows in the spring could also limit the recruitment of spawning gravel from the upper watershed. The lack of these channel maintenance flows may also lead to the 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 reduced physical habitat suitability.

The WGFD does not determine appropriate channel maintenance flows. In the event that flows are regulated in the drainage, supplemental water rights for channel maintenance should be pursued.

Table 5. Summary of instream flow recommendations for Dirtyman Fork.

<u>Time period</u>	<u>Discharge (cfs)</u>
October 1 to April 30	0.5
May 1 to June 30	1.4
July 1 to September 30	0.5

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