WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Instream Flow Studies on North Fork Smiths Fork Creek, a Bonneville Cutthroat Trout (*Oncorhynchus clarki utah*) Stream.

PROJECT: IF-PE97-07-9702

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DATE: March 1997

ABSTRACT

Studies were conducted in 1996 on North Fork Smiths Fork Creek to determine instream flows necessary for maintaining Bonneville cutthroat trout (BRC) habitat and populations. Studies corresponded with ongoing population and habitat monitoring of BRC streams (Remmick et al. 1994).

Physical Habitat Simulation (PHABSIM), the Habitat Quality Index (HQI), and the Habitat Retention Method were used to derive instream flow water right recommendations. Recommendations are: October 1 - May 14 = 2.1 cfs, May 15 - June 30 = 16 cfs, and July 1 - September 30 = 2.1 cfs.

INTRODUCTION

Wyoming Bonneville cutthroat trout (*Oncorhynchus clarki utah*) populations occur primarily in the Thomas Fork and Smiths Fork watersheds. These major Bear River tributaries and associated waterways were surveyed for physical, chemical, and biological characteristics between 1966 and 1977 (Miller 1977). Binns (1981) reviewed the distribution, genetic purity, and habitat conditions for Bonneville cutthroat trout populations. Recent population and habitat survey results are in Remmick (1981, 1987) and Remmick et al. (1994).

In general, populations are limited by seasonally low flows, lack of riparian cover, thermal pollution arising in conjunction with low flows and reduced riparian vegetation, and silt pollution (Binns 1981). Livestock grazing on both private and public lands is an important contributor to degraded habitat conditions. However, despite habitat challenges, significant populations remain throughout the native range and a recent review categorized Wyoming's populations as "95% secure, stable" (Duff 1996).

Population status in other Bonneville basin states including Utah, Idaho and Nevada is less secure. Therefore, Bonneville cutthroat trout were recently petitioned for listing under the Endangered Species Act but are not listed at this time. Status review was initiated in response to concerns expressed by the Idaho Fish and Game Department, the Desert Fishes Council and the Utah Wilderness Association. This species is considered "rare" in Wyoming by the Wyoming Game and Fish Department (WGFD 1977).

A 5-year management plan for Wyoming, developed by the Wyoming Game and Fish Department (WGFD) in coordination with the U.S. Forest Service (USFS) and U.S. Bureau of Land Management (BLM), outlines management goals and provides criteria for listing Bonneville cutthroat trout as threatened (Remmick et al. 1994). The plan's purpose is to outline management practices to prevent listing by moving toward wider distribution and higher populations. The plan recommends that status decisions be made after five-years of population and habitat monitoring. Habitat protection by acquiring instream flow water rights will help prevent additional population declines.

Resource management practices could be significantly affected by listing Bonneville cutthroat trout as Threatened or Endangered. Instream flow water right identification and acquisition on Bonneville cutthroat trout streams is important to help avoid listing. Therefore, since 1993 the WGFD has filed for instream flow water rights on most non-ephemeral tributaries with documented BRC presence in the Thomas and Smiths Fork drainages. Studies in 1996 focused on Poker Hollow Creek, North Fork Smiths Fork Creek, Lander Creek, Trespass Creek, Packstring Creek, and Little White Creek.

Study objectives were to 1) investigate the relationship between discharge and physical habitat quantity and quality for Bonneville cutthroat trout and, 2) determine an instream flow regime necessary to maintain or improve Bonneville cutthroat trout populations.

METHODS

Study Area

North Fork Smiths Fork Creek is a tributary to the Smiths Fork River (Figure 1). The North Fork Smiths Fork Creek basin is managed by the Bridger-Teton National Forest for multiple use. The valley generally has a southerly aspect and the lower 1 mile is bordered by a gravel forest service road (Smiths Fork Road). Riparian communities downstream from the road crossing are alternately sagebrush-grass or willow dominated. Willows become increasingly abundant in the riparian zone above the road crossing. Coniferous communities predominate on hill-side slopes at higher elevations while aspens occur sporadically and in hillside valleys. Stream gradient from a USGS 7.5 minute quadrangle map averages 3.0% downstream of the Smiths Fork bridge but varies between about 2% and 8%. Channel type was rated as B2(Rosgen 1985)indicating a moderately entrenched channel that is well confined by its valley and has bed material composed of large cobble, course gravel and sand.

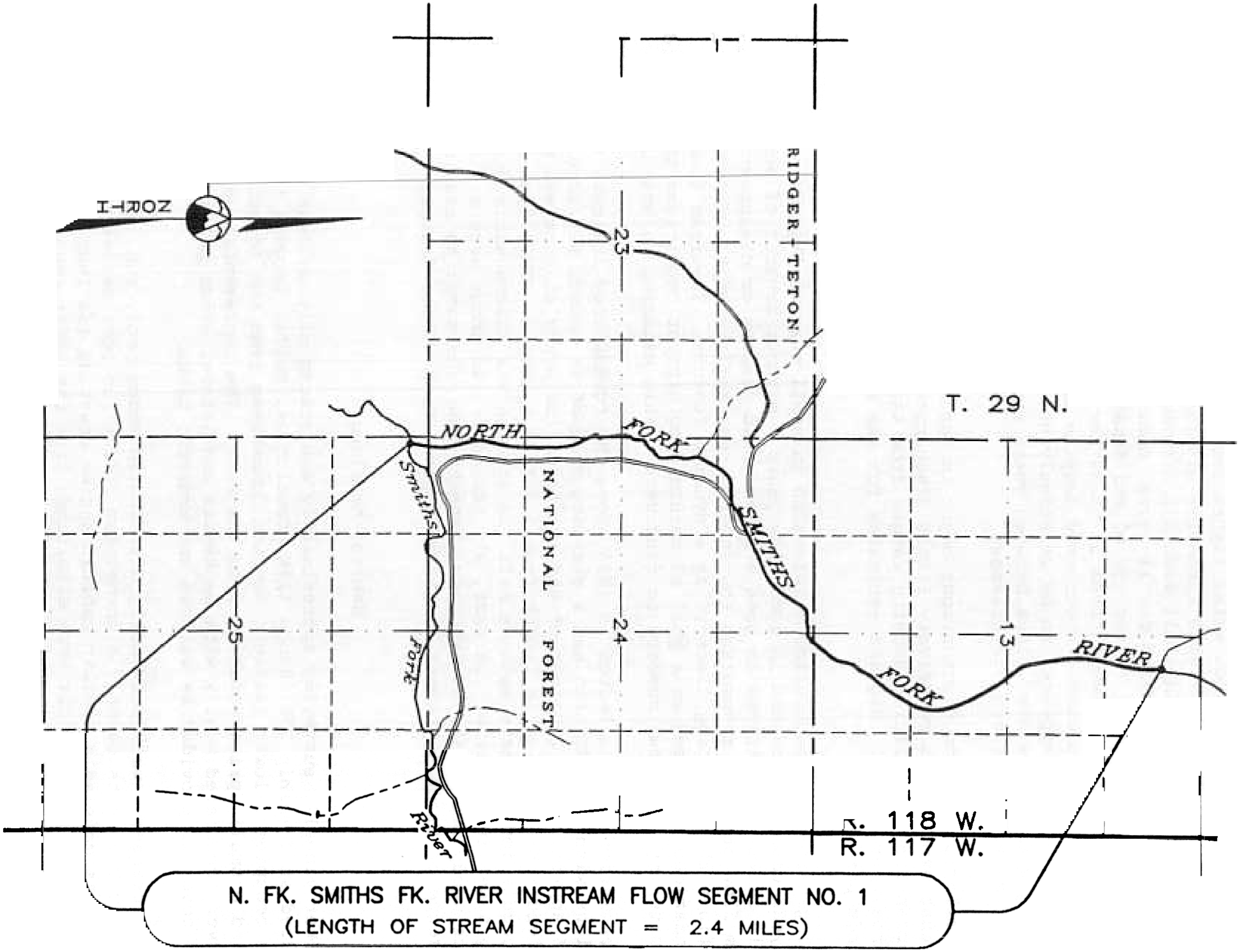

Figure 1. North Fork Smiths Fork River Instream Flow Segment No

Fisheries

The term "fishery" refers to fish populations and their associated habitat in a defined area. Instream flow water rights are intended to maintain or improve habitat conditions so that viable fisheries are maintained or improved. Trout populations, particularly in small mountain streams, normally fluctuate widely. 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 overwinter 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.

Long-term trout population maintenance in small streams depends on periodic strong year classes produced in good flow years. Without benefit of periodic favorable flows, populations in some streams would 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.

Population data collected in 1994 above the forest road indicate fair populations with 178 BRC/mile and a standing crop of 16 pounds BRC/acre. On August 26, 1996 approximately 200 feet of the instream flow study station was electrofished and yielded 6 BRC ranging in length from 3.5 to 6.4 inches. This does not represent a good population estimate because half the station was inaccessible due to beaver building a dam in the site. In fact, all the collected trout were associated with the thick woody debris at the dam base. Nonetheless, the sampling results confirm the presence of trout and their continued reproduction in the drainage.

Habitat Modeling

After visually surveying approximately one stream mile on June 5, a study site was located at Township 29N, Range 118W, Section 24, NW1/4. (Figure 1-3). This location occupies a lower gradient section downstream from the forest service road bridge and a small spring entering from the west. The representative site contained trout cover associated mostly with backwater and lateral scour pools. Infrequent overhead cover is provided by willows and undercut banks.

Nine transects were originally distributed among pool, run, and riffle habitat types. Four transects covered a downstream riffle-run-pool series while another five transects modeled a similar habitat series starting 150 feet upstream. On the second visit, three transects were eliminated from the upper segment because high flow had changed channel geometry. These transects were replaced with new transects to model hydraulic control riffles and pool habitat. Following the second visit, beaver colonized the study segment and flooded most of the study site. On the third

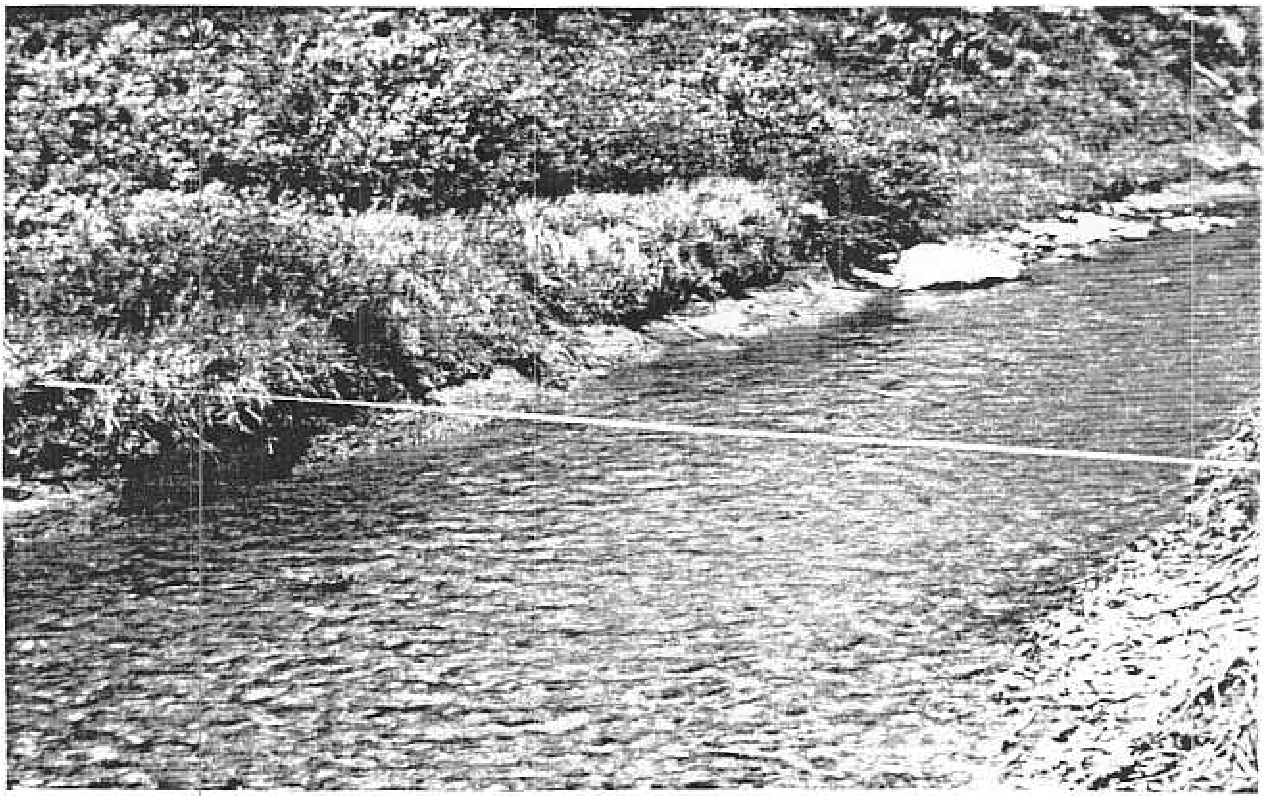

Figure 2. Transect 5 modeled for spawning habitat.

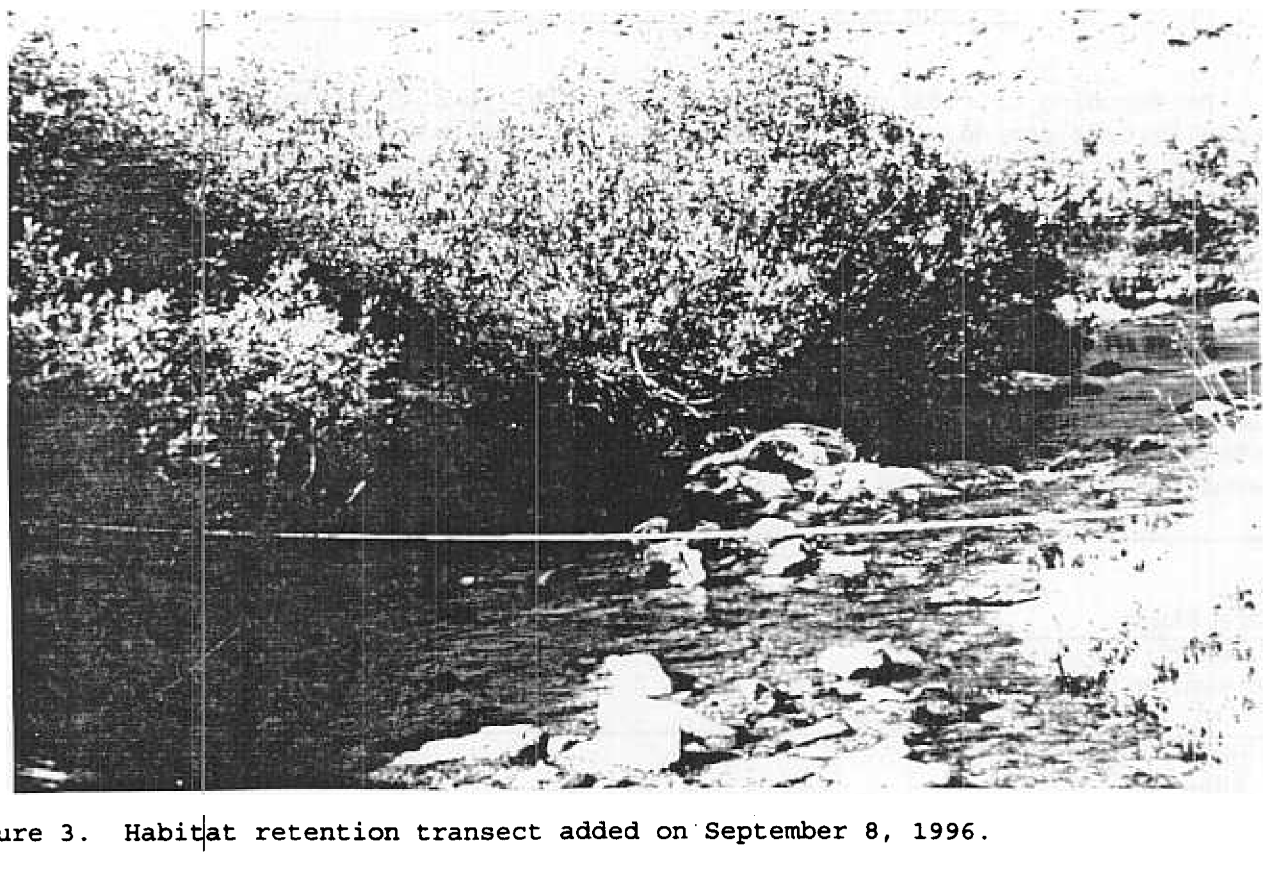

Figure 3. Habitat retention transect added on September 8, 1996.

visit no data was collected from the three transects not inundated because hydraulic characteristics may have been influenced by dam construction. Instead, data was collected from three new hydraulic control transects in an upstream area. In addition, habitat quality index data was collected from a new 345 foot station encompassing the new transects. Data treatment from the various time periods and stations is outlined below.

Instream flow filing recommendations derived from this site were applied to a 2.4 mile-long reach extending downstream from the confluence of two unnamed forks at T29N, R118W, S13 to the confluence with Smiths Fork River at T29N, R118W, S25. The land through which the proposed segment passes is under Bridger-Teton National Forest administration.

Data for calibrating simulations were collected between June 5 and September 8, 1996. Collection dates and corresponding discharges are listed in Table 1. An additional flow measurement of 2.1 cfs was made on August 26.

Table 1. Dates and discharges North Fork Smiths Fork Creek instream flow data were collected in 1996.

Date	Discharge (cfs)
June 5	103
June 26	16
August 26	2.1
September 8	1.7

Determining critical trout life stages (fry, juvenile, adult, etc.) for a particular time period aids in focusing flow recommendations. Critical life stages are those most sensitive to environmental stresses. Annual population integrity is sustained by providing adequate flow for critical life stages. In many cases, trout populations are constrained by spawning and young (fry and juvenile) life stage habitat "bottlenecks" (Nehring and Anderson 1993). Therefore, our general approach includes ensuring that adequate flows are provided to maintain spawning habitat in the spring was well as juvenile and adult habitat throughout the year (Table 2).

Table 2. Bonneville cutthroat trout life stages and months considered in North Fork Smiths Fork 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												
Spawning					2	2						
All	3	3	3	3	3	3	3	3	3	3	3	3

1 - Habitat Quality Index
2 - PHABSIM
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 the three hydraulic control riffle transects added on September 8. A maintenance flow is defined as the continuous flow required to maintain specific hydraulic criteria in stream riffles. Year-round criteria maintenance in riffles 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 ensure passage between habitat types for all trout life stages and 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 (ft)	Top Width[a] X 0.01
Mean Velocity (ft/s)	1.00
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 outlined below for hydraulic simulation in PHABSIM are also used with this technique. The major difference with this technique is that only hydraulic control riffles are examined and no direct reference is made to suitability of identified depths and velocities for trout life stages. Instead, the AVDEPTH model under PHABSIM is used to simulate average cross section depth, wetted perimeter and velocity for a range of flows on each cross section. The flow that maintains 2 out of 3 criteria for all three transects is then readily apparent.

Habitat Quality Index

The Habitat Quality Index (HQI; Binns and Eiserman 1979, Binns 1982) 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 existing levels of Bonneville 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 mean 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). North Fork Smiths Fork 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. Since representative study sites were used, it was assumed that collecting data at a new HQI site in September (due to beaver-related effects at original site) would not significantly effect HU simulations.

Average daily flow (ADF;5.2 cfs) and peak flow (69 cfs) estimates for determining critical period stream flow and annual stream flow variation are based on elevation and basin area (Lowham 1988). Although some variation exists around these flow estimates, the fact that a dimension-less index (Habitat Units) is produced from combining attributes suggests that this variation can be ignored. A Ryan temperature recorder monitored water temperature at 4 hour intervals between June 25 and September 7.

Physical Habitat Simulation

Physical Habitat Simulation (PHABSIM) methodology was used to quantify physical habitat (depth and velocity) availability for spawning trout over a range of discharges. The 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 0.2 and 3 cfs on each of the three new transects added in September. Spawning habitat was also modeled in the ranges 8-150 cfs and 8-45 cfs on transect 2 and 5, respectively, from the original site. Modeling precision declines outside these ranges; however, the ranges accommodate typical North Fork Smiths Fork Creek flows during the spawning period.

The curve describing depth, velocity and substrate suitability for spawning Bonneville cutthroat trout is an important component of the PHAMSIM modeling process. This suitability curve was used for deriving recommendations and is listed in Appendix 1. Since adequate data could not be collected from pool and run habitat due to beaver activities, only the spawning life stage was evaluated with PHABSIM.

Binns (1981) estimated that peak Bonneville cutthroat trout spawning occurs during periods of maximum run-off and average water temperatures between 45° and 48° F. These conditions are most likely to occur during late May and June in North Fork Smiths Fork Creek (stream elevation 7400-7800+ feet). 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 before the end of this period, maintaining flows at a selected level throughout June will benefit trout egg incubation by preventing dewatering. The PHABSIM model was used in making flow recommendations for maintaining BRC spawning habitat from May 15 to June 30 (Table 2).

The time periods selected for spawning flow recommendations differ among streams. Because it is the highest elevation stream examined, Poker Hollow Creek's spawning flow recommendation is for June only. On North Fork Smiths Fork, the lower elevation means that spawning may begin in late May hence the recommended May 15 to June 30 period. Spawning recommendations for many BRC streams cover the entire May through June period. The lowest elevation streams (Huff Ck., Howland Creek, Salt Creek) have spawning recommendations applied from April 15 through June 30.

RESULTS AND DISCUSSION

Habitat Retention Analysis

Habitat retention analysis indicates that 2.1 cfs is required to maintain hydraulic criteria at all riffles (Table 4). Maintenance of naturally occurring flows up to this flow is necessary at all times of the year. However, results from the HQI and PHABSIM methods may indicate that higher flows are needed during June through September to support spawning and adult life stages (below, Table 2).

Table 4. Simulated hydraulic conditions on three North Fork Smiths Fork riffles. Average daily flow = 5.2 cfs. Bank full flow = 69 cfs.

	Mean Depth (ft)	Mean Velocity (ft/s)	Wetted Perimeter (ft)	Discharge (cfs)
Riffle 1	0.87	2.07	19.4	33
	>0.41	**>0.70**[a]	>10.9	>3.0
	0.41	0.70	10.9	3.0
	0.40	0.68	10.7	2.8
	0.39	0.63	10.3	2.4
	0.38	0.61	9.9	2.2
	0.38	0.60	**9.7**[a]	**2.1**[b]
	0.38	0.58	9.5	2.0
	0.37	0.55	8.8	1.7
	0.29	0.32	5.5	0.5
	<0.29[a]	<0.32	<5.5	<0.5
Riffle 2	0.93	1.78	20.9	33
	>0.37	**>0.60**[a]	>13.9	>3.0
	0.37	0.60	13.9	3.0
	0.36	0.57	13.8	2.8
	0.37	0.55	12.1	2.4
	0.37	0.51	10.9	2.0
	0.37	0.48	**10.3**[a]	**1.8**[2]
	0.38	0.44	9.4	1.5
	0.25	0.26	7.8	0.5
	0.20[a]	0.22	6.9	0.3
	0.19	0.18	5.8	0.2
Riffle 3	0.92	1.91	19.6	33
	>0.49	**>0.82**[a]	>15.4	>6.0
	0.49	0.82	15.4	6.0
	0.39	0.59	13.5	3.0
	0.37	0.53	13.2	2.5
	0.29	0.42	12.5	1.5
	0.23	0.31	11.5	0.8
	0.20[a]	0.27	11.2	**0.6**[b]
	0.16	0.20	**9.9**[a]	0.3
	0.13	0.16	9.6	0.2

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

Trout populations are naturally limited by extreme winter conditions (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988, Cunjak 1996). Formation of frazil ice (suspended ice crystals formed from super-chilled water) in high gradient stream reaches can be both a direct mortality source through gill abrasion and subsequent suffocation or an indirect mortality source as resultant anchor ice limits habitat, causes localized de-watering, and extracts 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 emigration is blocked by low winter flows or ice dams.

In high gradient systems, groundwater influx areas, ice covered pools not close to frazil sources, heavy snow cover with stream bridging, and pools with little woody debris offer refugia from frazil ice (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. North Fork Smiths Fork Creek's high elevation, relatively narrow width and moderate slope likely means that heavy snow fall will result in snow bridging. Frazil ice formation is likely a concern mainly in early winter before sufficient insulating snow is present or in late winter when snow melt becomes superchilled by flowing over snow and ice before entering the stream. Therefore, natural winter flow levels up to the identified 2.1 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 and effectively reduce the number of fish the stream could support.

The 2.1 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 a need for additional storage. Instead, they illustrate the necessity of maintaining all natural winter stream flows, up to 2.1 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. At the measured late summer flow of 1.7 cfs, HQI analysis indicates approximately 23 trout HUs (Figure 4). This level of habitat is maintained between flows of 1.4 and 2.1 cfs. However, 1.4 cfs (the minimum flow with the same level of HU's as measured) is below the year-round maintenance flow of 2.1 cfs determined above with the habitat retention method. Therefore, the minimum flow to *maintain* the fishery during late summer is 2.1 cfs.

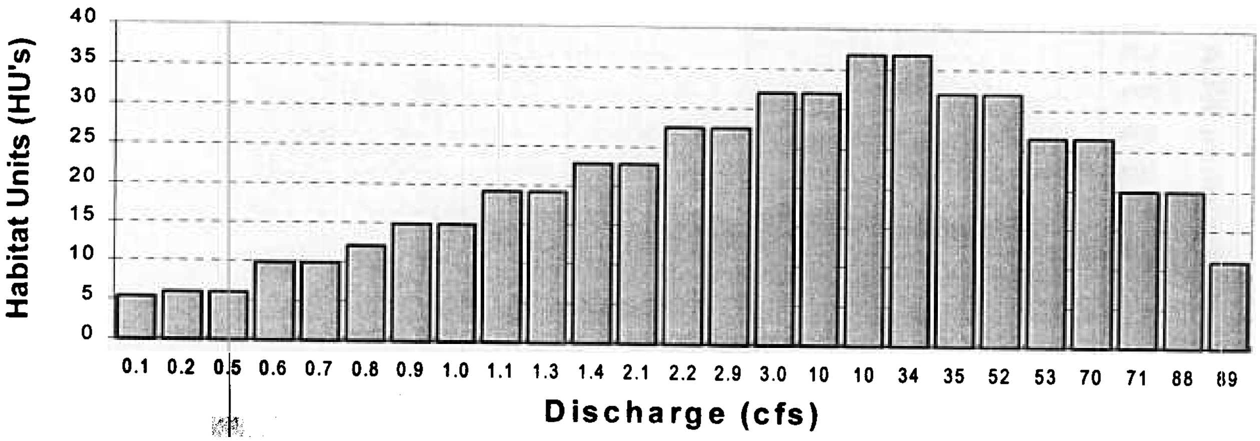

Figure 4. Trout habitat units at several late summer North Fork Smiths Fork Creek flow levels. X-axis discharges are not to scale.

Habitat Units are maximized between average late summer discharges of 10 and 34 cfs. Based on HQI analysis and in consideration of Management Plan goals (Remmick et al. 1994), an instream flow of 2.1 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. Storage to achieve this flow more frequently than naturally available is not needed to maintain the existing fishery.

PHABSIM Analyses

Weighted usable area estimates for Bonneville cutthroat trout life stages are illustrated in Figure 5. Peak spawning physical habitat occurs at 16 and 17 cfs for riffle 2 and riffle 5, respectively. Normal spring flows are much higher - 103 cfs was measured on June 5, 1996. Such high flows might limit spawning activity near the study site. Trout probably migrate to more favorable reaches or smaller tributaries to spawn. Though trout can usually find spawning habitat whenever temperatures are appropriate and flows allow unrestricted movement, maximum physical habitat in the study site occurs at a flow of 16 cfs. Therefore, an instream flow of 16 cfs is recommended for the period May 15 to June 30.

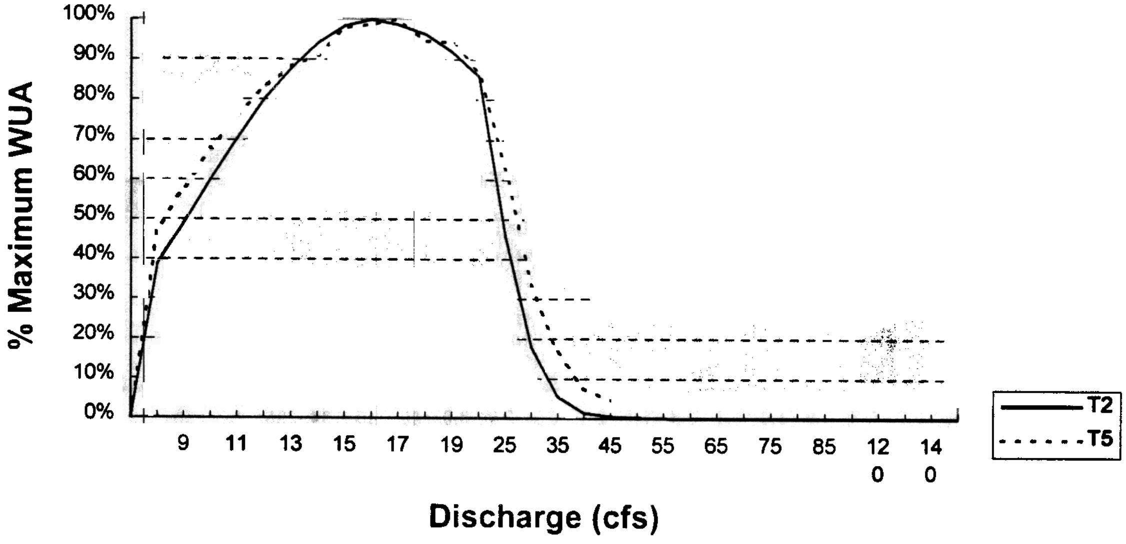

Figure 5. Weighted usable area (percent of maximum) for Bonneville cutthroat trout in North Fork Smiths Fork Creek over a range of discharges. X-axis discharges are not to scale.

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 5 will maintain the existing North Fork Smiths Fork Creek Bonneville cutthroat trout fishery. These recommendations apply to a 2.4 mile North Fork Smiths Fork Creek segment extending downstream from the confluence of two unnamed forks at T29N, R118W, S13 to the confluence with Smiths Fork River at T29N, R118W, S25. The land through which the proposed segment passes is under Bridger-Teton National Forest 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 North Fork Smiths Fork Creek trout fishery.

Time Period	Instream Flow Recommendation (cfs)
May 15 to June 30	16
July 1 to May 14	2.1

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 may be appropriate for establishing channel maintenance flow requirements.

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Appendix 1. Spawning suitability index data used in PHABSIM analysis. Index data were developed by WGFD from 1994 observations in Huff Creek.

Spawning	Velocity	Weight	Depth	Weight	Substrate	Weight