WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Greys River Instream Flow Investigation, Lincoln County

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INTRODUCTION

Instream flow studies were conducted on a segment of the Greys River near Alpine, Wyoming (Figure 1). These studies were designed to provide the basis for determining instream flows which would maintain or improve existing fishery values in the candidate section of the Greys River. Results of these studies apply to the stream reach between the U.S. Forest Boundary (NW1/4, R118W, T37N, S33) and the confluence with Lake Creek (SW1/4, R117W, T36N, S7), a distance of 10.1 miles.

The Greys River is designated by the Wyoming Game and Fish Department (WGFD) as a Class 2 trout stream, which by definition, has statewide importance. This stream section is managed for Snake River cutthroat trout (Oncorhynchus clarki spp.) under the basic yield concept. Some hatchery fish are stocked to supplement natural recruitment derived from mainstem and tributary spawning areas. Other salmonid species present are brown trout (Salmo trutta) and mountain whitefish (Prosopium wiliamsoni).

This section of the Greys River provides significant recreational fisheries opportunities for resident and non-resident anglers (J. Kiefling, WGFD, personal communication) and is highly accessible through public lands. For these reasons, this stream reach is considered a critical segment.

The WGFD management goal for the Greys River is to maintain or improve the existing cutthroat trout fishery. Maintaining adequate instream flows is important to help realize this goal. Objectives of this study were to determine instream flows necessary to, 1) maintain adequate habitat conditions during the winter, 2) maintain physical habitat for all cutthroat trout life stages, and 3) maintain the existing quality of adult trout habitat.

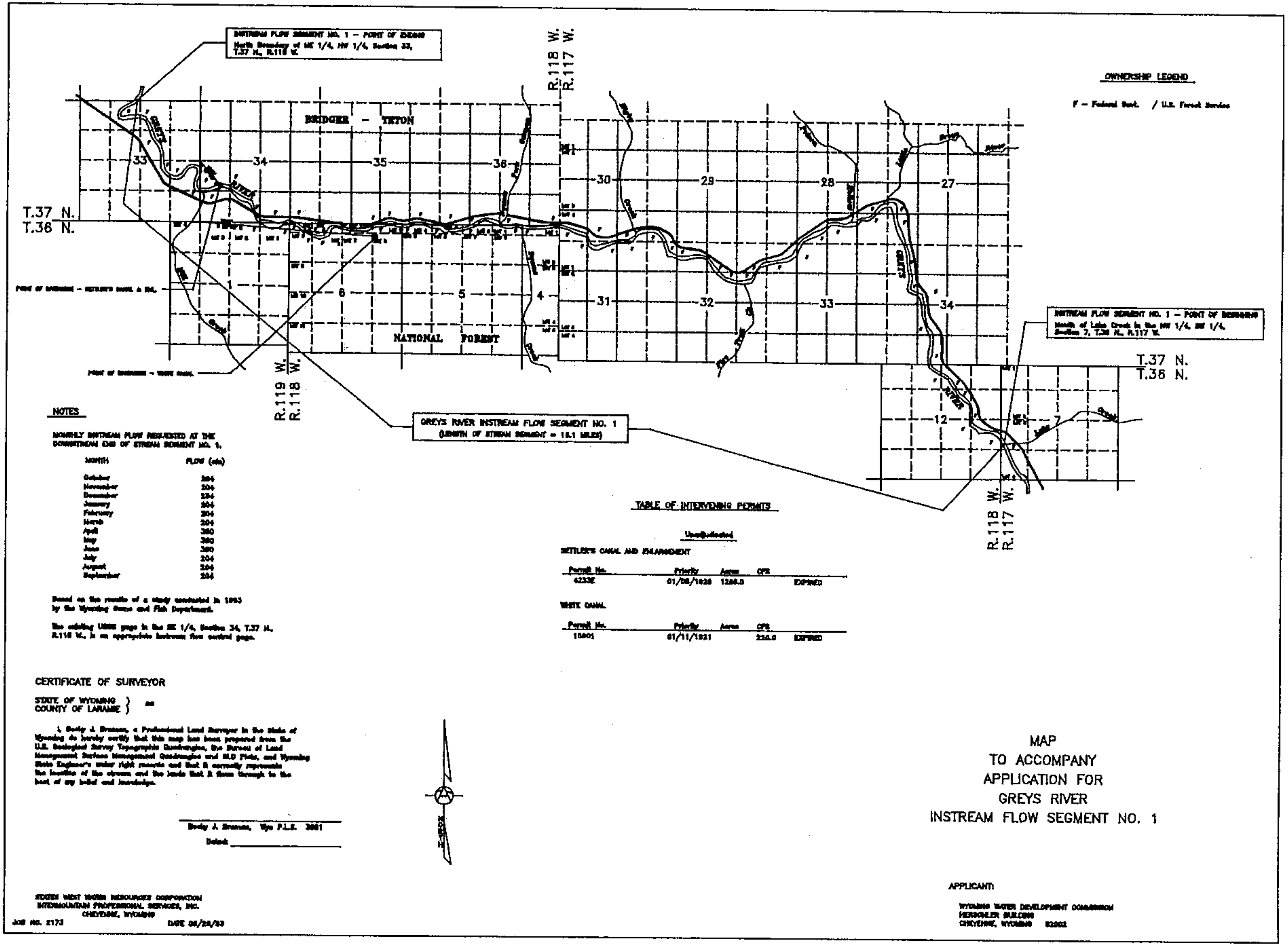

Figure 1. Greys River instream flow reach.

METHODS

Trout habitat in the candidate stream section was characterized by a 672 foot long site. This site was about 4 miles downstream from the confluence of the Greys and Little Greys Rivers (R118W, T37N, S36). Information regarding the relationship between spawning habitat and streamflow was collected from another site near the confluence of the Greys River and Lake Creek (R117W, T36N, S7). The upper site was about 110 feet long and contained physical habitat that typified much of the spawning habitat in the upper river. Habitat data were collected from both sites on three occasions after peak runoff (Table 1).

Table 1. Dates and discharge rates when instream flow data were collected from the Greys River in 1992.

Date	Discharge Cubic Feet Per Second
Lower Site	
June 12	566
July 8	283
Oct. 1	172
Upper Site	
June 12	460
July 7	295
Sep. 30	173

Three techniques were used to examine relationships between streamflows and trout habitat quantity and quality; a Habitat Retention method, the Physical Habitat Simulation Model (PHABSIM) and the Habitat Quality Index (HQI).

The Habitat Retention method (Nehring 1979, Annear and Conder 1984) was used to identify a maintenance flow. A maintenance flow is defined as a continuous flow needed to maintain minimum hydraulic criteria at riffles. Based on the extensive research of Annear and Conder (1984), the maintenance flow is further defined as the discharge at which two of three hydraulic criteria are met for all riffles in the study area (Table 2).

The Habitat Retention method was developed to identify a flow that would maintain existing survival rates of trout, provide passage for trout between different habitat types in streams, and maintain survival rates of aquatic insects in riffle areas. Maintenance of these features is important year round except when higher flows are needed at specific times to meet other requirements. Habitat Retention data were collected from two riffle transects at the lower study site, and analyzed with the PHABSIM subroutine AVPERM.

Table 2. Hydraulic criteria used to obtain an instream flow recommendation using the Habitat Retention method.

Category	Criteria
Average Depth (ft)	Top width[1] X 0.01
Average Velocity (ft per sec)	1.00
Wetted Perimeter (percent)2	75

1 - At average daily flow of 650 cfs
2 - Compared to wetted perimeter at bankfull conditions of 4200 cfs.

The PHABSIM model (Bovee and Milhous 1978) was used to examine incremental changes in physical habitat available at various discharges. This model is generally regarded as state-of-the-art technology and is the most commonly used method in North America for quantifying the relationship between physical habitat and discharge (Reiser et al. 1989).

Habitat mapping procedures modified from Morhardt et al. (1983) were used to establish PHABSIM transects at each study site. Major habitats were identified and three transects were randomly placed across each habitat type.

Riffles and slack water runs were the predominant habitat types at the lower study site. Riffles were wide, shallow and contained numerous large boulders that created pocket water. Runs were fairly swift and usually two or three feet deep, but some pool habitat was also present. The riffle at the upper site contained scattered pockets of spawning gravel but was otherwise similar to the lower riffle. Results from individual transects were combined to create composites that incorporated variation among individual transects.

Physical habitat for a given discharge is expressed as Weighted Usable Area (WUA). This reflects the composite Habitat Suitability Index (HSI) values for depth, velocity and substrate. Weighted Usable Area values are then reported as square feet of WUA per 1,000 linear feet of stream. To standardize results relative to the maximum amount of physical habitat over the range of simulated flows, WUA output were converted to percent of Maximum Usable Area (MUA). This conversion expresses WUA values as a percent of the maximum WUA value for each life stage where; $MUA = (WUA/WUA_{max}) * 100$.

Developing reasonable WUA values for a range of flows depends on site specific calibration processes described by Milhous (1984) and Milhous et al. (1989). Weighted Usable Area estimates for spawning, fry, juvenile and adult cutthroat trout were generated with these calibration techniques and HSI curves from Hickman and Raleigh (1982). Weighted Usable Area simulations for all life stages were made for flows ranging from 25 to 800 cfs. Discussions regarding WUA or PHABSIM modeling are valid only within this range.

The Habitat Quality Index (HQI) model (Binns 1982, Binns and Eiserman 1979) was used to estimate potential changes in trout habitat quality over a range of flows. The model incorporates nine attributes addressing chemical, physical and biological components of trout habitat. Results are expressed in habitat units (HU), with one HU defined as the amount of habitat quality which will support about 1 pound of trout. Results of the HQI model apply to the time of year that determines trout production, which is from July 1 to September 30.

To better define the potential impact of various late summer flow levels on trout habitat quality, estimates of HU's were made for a range of flows by measuring habitat attributes at various streamflows and considering associated habitat features as typical of late summer flow conditions (Conder and Annear 1987). Additionally, some attributes were estimated by linear regression for flows other than those which were measured. Habitat Units were estimated for flows ranging from 25 to 500 cfs.

United States Geological Survey data from a gage (#13014500) on the lower Greys River (Peterson 1988) were used to illustrate average streamflow conditions (Table 3). This stream gauge is about 3 miles upstream from Palisades reservoir and has been operated continuously since 1954. These hydrograph data were used to analyze the effects of existing and hypothetical flow conditions.

Table 3. Monthly mean, monthly mean peak, and monthly mean low flows for the Greys River near Alpine, Wyoming for the years 1954-1984.

	Average Values		
Month	Monthly	Peak	Low
October	321	472	194
November	273	455	175
December	242	366	164
January	219	315	159
February	211	293	152
March	223	348	173
April	588	1320	238
May	1830	2840	333
June	2150	4000	387
July	1020	1900	228
August	501	809	205
September	380	559	198
Annual	664	1020	259

RESULTS

Habitat Retention

Habitat Retention modeling indicated flows of 204 and 139 cfs are necessary to maintain aquatic insect production and fish passage at riffles 1 and 2 respectively (Table 4). The maintenance flow derived from this method is defined as the flow at which two of the three hydraulic criteria are met for all riffles in the study site. Based on this definition the maintenance flow for this segment of the Greys River is 204 cfs.

Table 4. Results of Habitat Retention modeling on the Greys River during 1992.

Discharge (cfs)	Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter
	Riffle 1		
25	0.58	0.86	50.7
36	0.67	1.00[1]	53.3
50	0.72	1.18	58.9
75	0.83	1.40	64.2
100	0.91	1.59	68.9
125	0.97	1.75	74.1
150	1.01	1.89	78.7
175	1.07	2.01	81.5
204[2]	1.14[1]	2.15	83.8
225	1.19	2.24	84.7
250	1.24	2.34	86.7
275	1.28	2.43	88.6
350	1.40	2.70	93.4
400	1.44	2.85	98.0
500	1.54	3.12	104.7
522	1.56	3.18	105.9[1]
600	1.63	3.36	110.2
650	1.65	3.47	114.2
	Riffle 2		
25	0.59	0.61	69.8
50	0.69	0.89	81.9
64	0.76	1.00[1]	82.9
75	0.82	1.09	83.8
100	0.91	1.27	87.2
125	0.97	1.42	90.5
139[2]	0.98	1.49	96.3[1]
152	1.00	1.56	100.9
175	1.04	1.66	101.8
196	1.09[1]	1.75	102.6
225	1.16	1.88	103.6
250	1.21	1.98	104.1
275	1.27	2.07	104.6
300	1.32	2.17	105.1
400	1.50	2.50	106.8
650	2.10	2.85	108.5

1 - Hydraulic criteria from Table 2 met
2 - Flow meets two of three criteria for individual transect

Natural mortality during the winter can often be a significant factor limiting a trout population. Kurtz (1980) found that the loss of winter habitat due to low flow conditions was an important factor affecting mortality rates of trout in the upper Green River, with mortality approaching 90% during some years. Needham et al. (1945) documented average overwinter brown trout mortality of 60% and extremes as high as 80% in a California stream. Butler (1979) reported significant trout and aquatic insect losses caused by anchor ice formation. Reimers (1957) considered anchor ice, collapsing snow banks and fluctuating flows resulting from the periodic formation and breakup of ice dams as the primary causes of winter trout mortality.

Causes of winter mortality discussed above are all greatly influenced by the quantity of winter flow in terms of its ability to minimize anchor ice formation (increased velocity and temperature loading) and dilute and prevent snow bank collapses and ice dam formation respectively. Because any reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish that the stream could support, maintenance of natural flows is considered critical. As a consequence, the fishery management objective for the time period from October 1 to March 31 is to protect all available natural stream flows in the instream flow segment up to the maintenance flow of 204 cfs.

Streamflow data for the Greys River show the average and average minimum monthly flows during the winter are always in excess of 204 cfs (Table 2). However, instantaneous low flows during the winter are occasionally lower than 204 cfs and the maintenance flow is not always present in the winter. Because the existing fishery is adapted to natural flow patterns, occasional periods of shortfall during the winter do not imply the need for storage. Instead, they illustrate the need to maintain all natural winter streamflows, up to 204 cfs, in order to maintain existing survival rates of trout populations.

PHABSIM

Physical habitat for cutthroat trout spawning was maximized at 75 cfs and quickly reduced at lower flows (Figure 2). It was also reduced at higher flows up to 175 cfs, but between 175 cfs and 350 cfs there was an increase in physical habitat. Decreases in WUA were consistent at flows beyond 350 cfs. Spawning habitat in the upper study reach was generally confined to small isolated pockets of suitable gravels behind or adjacent to larger cobbles and boulders. Variation in spawning habitat quantity at different flows reflects this distribution of spawning gravels.

Maximum spring flows coincide with Snake River cutthroat trout spawning which usually occurs from April through June (Hayden 1967, Kiefling 1978). Flows at this time often exceed the upper limit of stream flows for which hydraulic simulations were possible. The trend in suitability at the upper range of simulated flows suggests that suitability for spawning may be relatively low at these high flows.

In large rivers like the Greys, spawning fish must contend with high velocities and shifting substrates which can destroy redds. Although many Snake River cutthroat trout avoid these problems by ascending tributaries to spawn, some mainstem spawning also occurs. Because natural reproduction is critical to successful wild fishery management it is important to maintain all cutthroat trout spawning opportunities. This includes both tributary and mainstem spawning areas.

Although spawning habitat in the Greys River is maximized at 75 cfs, a flow of 350 cfs is recommended for the spawning period from April 1 through June 30. These data suggest that this flow will maintain or improve physical habitat for cutthroat trout spawning. This amount is also needed to maintain habitat characteristics addressed by the maintenance flow of 204 cfs.

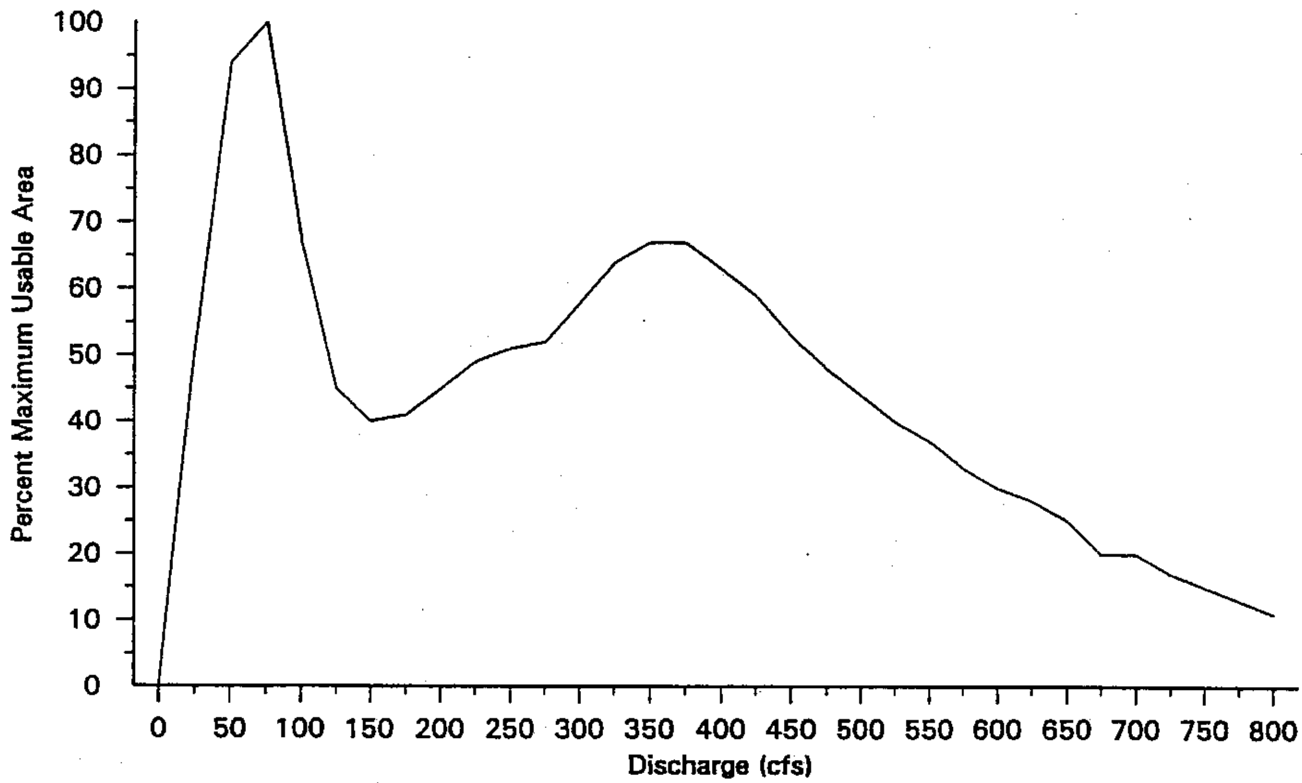

Figure 2. Percent of maximum weighted usable area (MUA) for cutthroat trout spawning at the upper Greys River study site as a function of discharge.

Physical habitat for fry, juveniles and adults is maximized at progressively higher flows for each life stage (Figure 3). These flows are 75, 150 and 200 cfs for each respective life stage. At other flows, physical habitat is reduced for each life stage and rates of change are similar. At 450 cfs and higher, physical habitat is reduced by 50% to 60% from the maximum for all life stages. The amount of physical habitat remains fairly constant at these higher flows.

Physical habitat for fry is maximized between 50 and 75 cfs, but these flows are below the lowest instantaneous flow on record (Peterson 1988) and would not protect the important habitat characteristics addressed by the maintenance flow (204 cfs).

The maintenance flow of 204 cfs would maintain about 65% of the maximum WUA for fry, and although it would be desirable to maintain higher amounts of physical habitat for fry, it is critical to prevent increases in frazil and anchor ice formation during the winter. At flows that maximize physical habitat for fry (150 cfs), ice formation is more likely than at higher flows, and other habitat features addressed by the Habitat Retention method are not protected. Therefore, the maintenance flow of 204 cfs is more appropriate for protecting cutthroat trout fry.

Physical habitat for juveniles is maximized at 150 cfs which is also less than the maintenance flow recommendation. However, about 93% of the maximum physical habitat for juveniles is maintained at a flow of 204 cfs. Because the maintenance flow recommendation identified by the Habitat Retention method retains a high percentage of physical habitat and also protects other important habitat features, it is appropriate for juvenile cutthroat trout.

The progeny of cutthroat trout that spawn in tributaries migrate downstream to main river channels during the fall and winter (Hayden 1967). This occurs when streamflows are falling to their lowest levels. Streamflows in the Greys River average about 220 cfs from December through March (Table 3). A maintenance flow of 204 cfs during this period would ensure adequate habitat availability for immature cutthroat trout when they migrate from tributary streams, and would protect other habitat characteristics addressed by the Habitat Retention method. At other times of year when flows are higher physical habitat for these life stages is reduced.

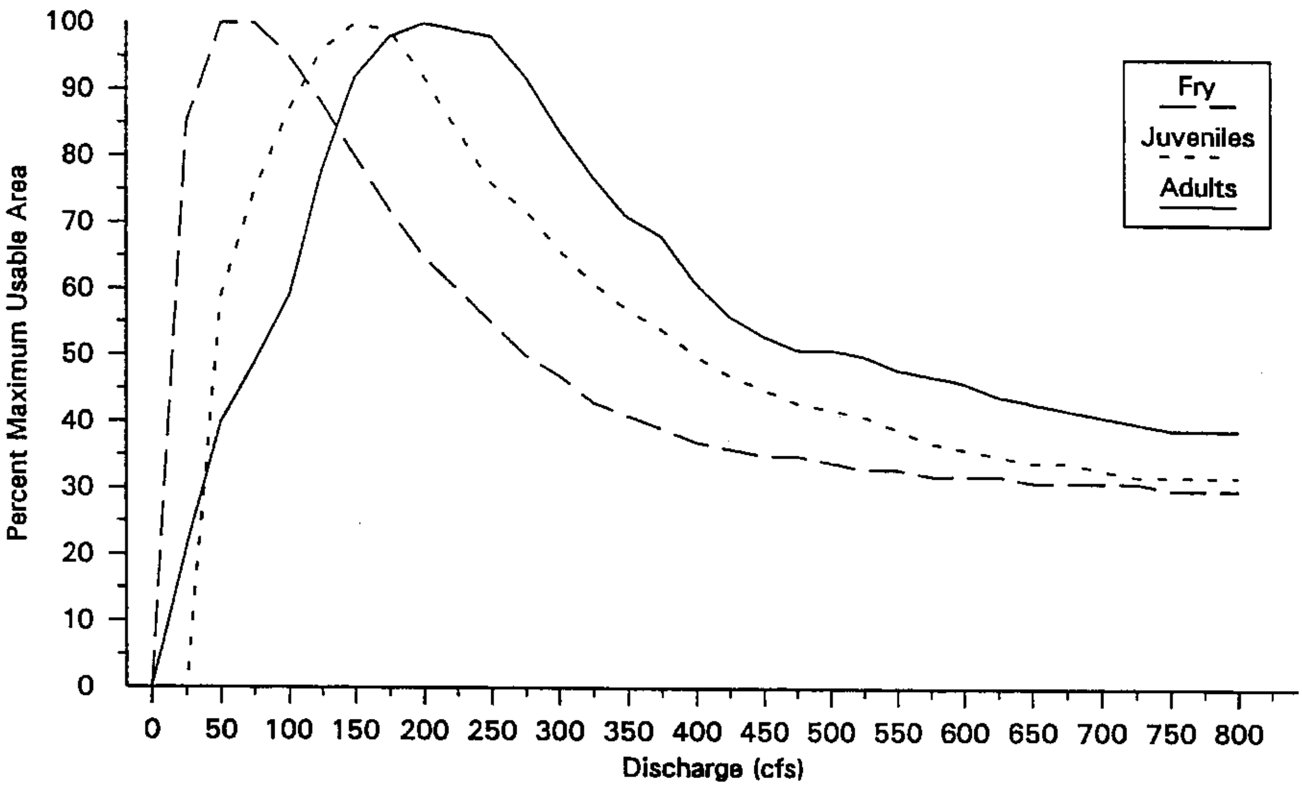

Figure 3. Percent of maximum weighted usable area (MUA) for cutthroat trout fry, juveniles and adults at the lower Greys River study site as a function of discharge.

The HQI model indicates that under existing average late summer conditions, this segment of the Greys River supports approximately 33 HU's per acre (Figure 3). A flow of 375 cfs is the minimum flow that will maintain this existing level of habitat quality. Habitat units are maximized between 175 and 225 cfs, with incremental decreases at flows above and below this range.

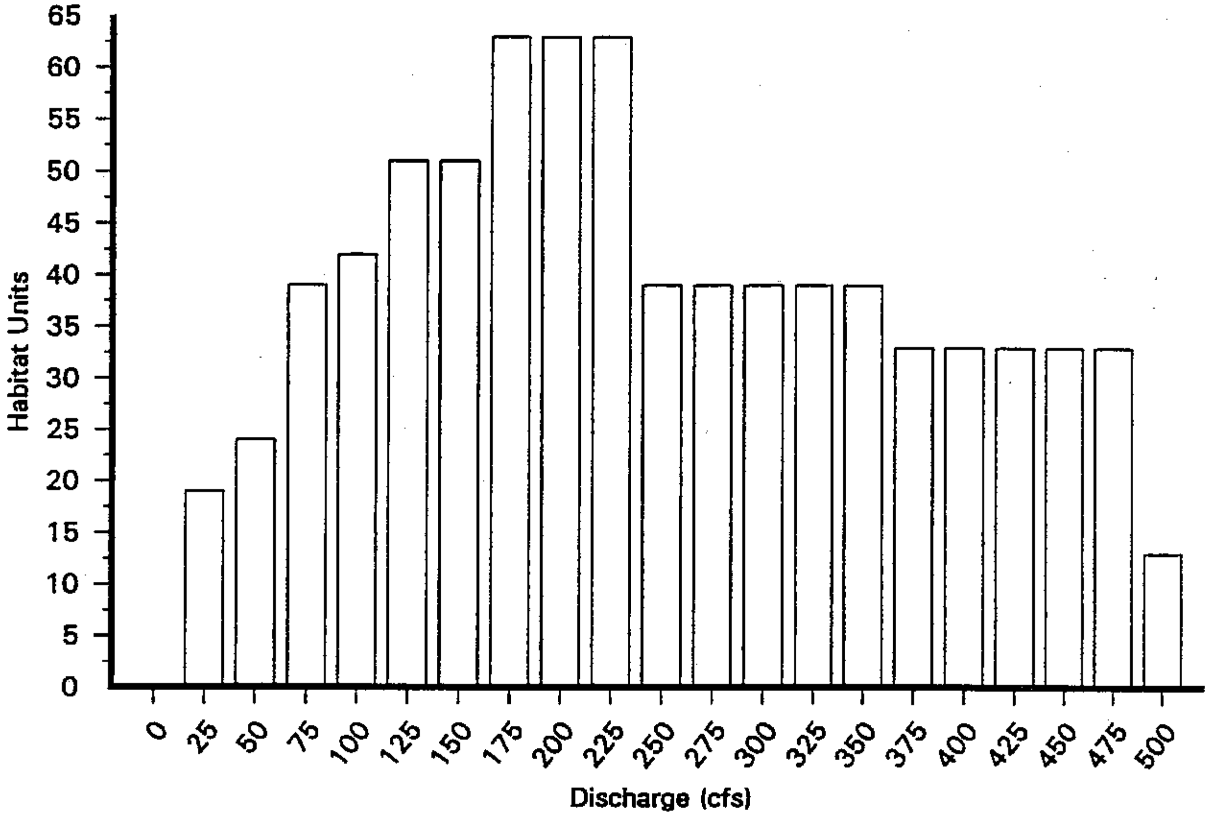

Figure 4. Adult trout habitat units (HU) as a function of discharge at the Greys River study site.

The largest incremental increase in HU's, relative to existing conditions, occurs between 175 and 225 cfs and represents about twice the existing level of HU's. The minimum flow needed to sustain this potential increase in HU's (175 cfs) is less than the maintenance flow recommendation and would not protect the important habitat features addressed by the Habitat Retention method.

A flow of 204 cfs is the minimum flow that would maintain or improve adult trout habitat quality and productive potential and simultaneously meet or exceed maintenance flow requirements. Maintaining this flow will also maintain at least 95% of the maximum amount of physical habitat for adults (Figure 3). Therefore, a streamflow of 204 cfs is recommended for the period from July 1 through September 30.

SUMMARY

The instream flow regime in Table 4 is based on results from the Habitat Retention, HQI and PHABSIM models, and displays the minimum stream flows needed to maintain or improve existing trout production levels in the Greys River at critical times of year. This stream section extends for a distance of 10.1 miles; from the U.S. Forest Service boundary (NW1/4, R118W, T37N, S33), upstream to the confluence of the Greys River and Lake Creek (SW1/4, R117W, T36N, S7).

Table 4. Summary of instream flow recommendations for the Greys River near Alpine, Wyoming.

Time Period	Instream Flow Recommendation (cfs)
October 1 to March 31	204*
April 1 to June 30	350
July 1 to September 30	204

* - To maintain existing natural flows

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