WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Sweetwater River Instream Flow Report

PROJECT: IF-2087-07-9001

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INTRODUCTION

Studies were conducted to obtain instream flow information from a segment of the Sweetwater River south of Lander, Wyoming near Wilson Bar. These studies were designed to provide the basis for determining instream flows which would maintain or improve the existing fishery in the candidate section of the Sweetwater River. Results of these studies apply to the stream segment extending upstream from Section 34, Range 97 West, Township 29 North, to the west boundary of Section 17, Range 98 West, Township 28 North. This stream section is 10.2 miles long.

This section of the Sweetwater River is designated by the Wyoming Game and Fish Department (WGFD) as a Class 3 trout stream. Class 3 streams generally support regionally important fisheries within the state. The stream is occasionally stocked with rainbow trout during spring and summer months, but brown trout comprise the majority of the fish population. Natural reproduction of rainbow and brown trout is the primary source of recruitment to the fishery. Other species present include brook and cutthroat trout. This section of the Sweetwater River provides significant recreational fisheries opportunities for both resident and non-resident anglers and is highly accessible through public lands. In addition, this is an area of outstanding scenic quality as evidenced by the past Bureau of Land Management proposal to designate all or part of the lands near this stream segment as wilderness. For these reasons, this segment of the stream is considered a critical segment.

The management goal of the WGFD is to maintain or improve the existing stream fishery in this section the Sweetwater River. Three time periods are considered critical for realizing this goal. October 1 to March 31 is considered critical because brown trout spawning and incubation occurs during this time, and because low flows can cause degradation of hydraulic characteristics necessary for trout survival, fish passage and aquatic insect production. April 1 to June 30 is a critical period for maintaining physical habitat for rainbow trout spawning; and maintenance of adequate stream flows between July 1 and September 30 is critical for sustaining trout production at existing levels.

To address the management goal, objectives of this study were to determine instream flows necessary to 1) maintain or improve hydraulic characteristics for brown trout reproductive success and survival, fish passage, and aquatic insect production, 2) maintain or improve physical habitat for rainbow trout spawning and, 3) maintain or improve adult trout production during the late summer months.

METHODS

Data for these studies were collected from a site located in the Southwest 1/4 of Section 9, Range 98 West, Township 28 North (Figure 1). These studies were conducted between June and August 1981 within a 607 foot long study site that contained trout habitat typical of that found throughout the candidate section of the Sweetwater River. Data were collected after peak runoff from a range of discharge rates (Table 1).

Table 1. Dates and discharge rates when instream flow data were collected from the Sweetwater River during 1981.

Date	Discharge Cubic Feet Per Second (cfs)
06-07-81	346
06-24-81	102
07-12-81	56
08-05-81	14

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 riffle areas in a stream segment. Based on extensive research by Annear and Conder (1984), the maintenance flow is specifically defined as the discharge at which two of three hydraulic criteria are met for all riffles in the study area (Table 2). Meeting these criteria provides passage for all life stages of trout between different habitat types and maintains survival of trout and aquatic macroinvertebrates at all times of year.

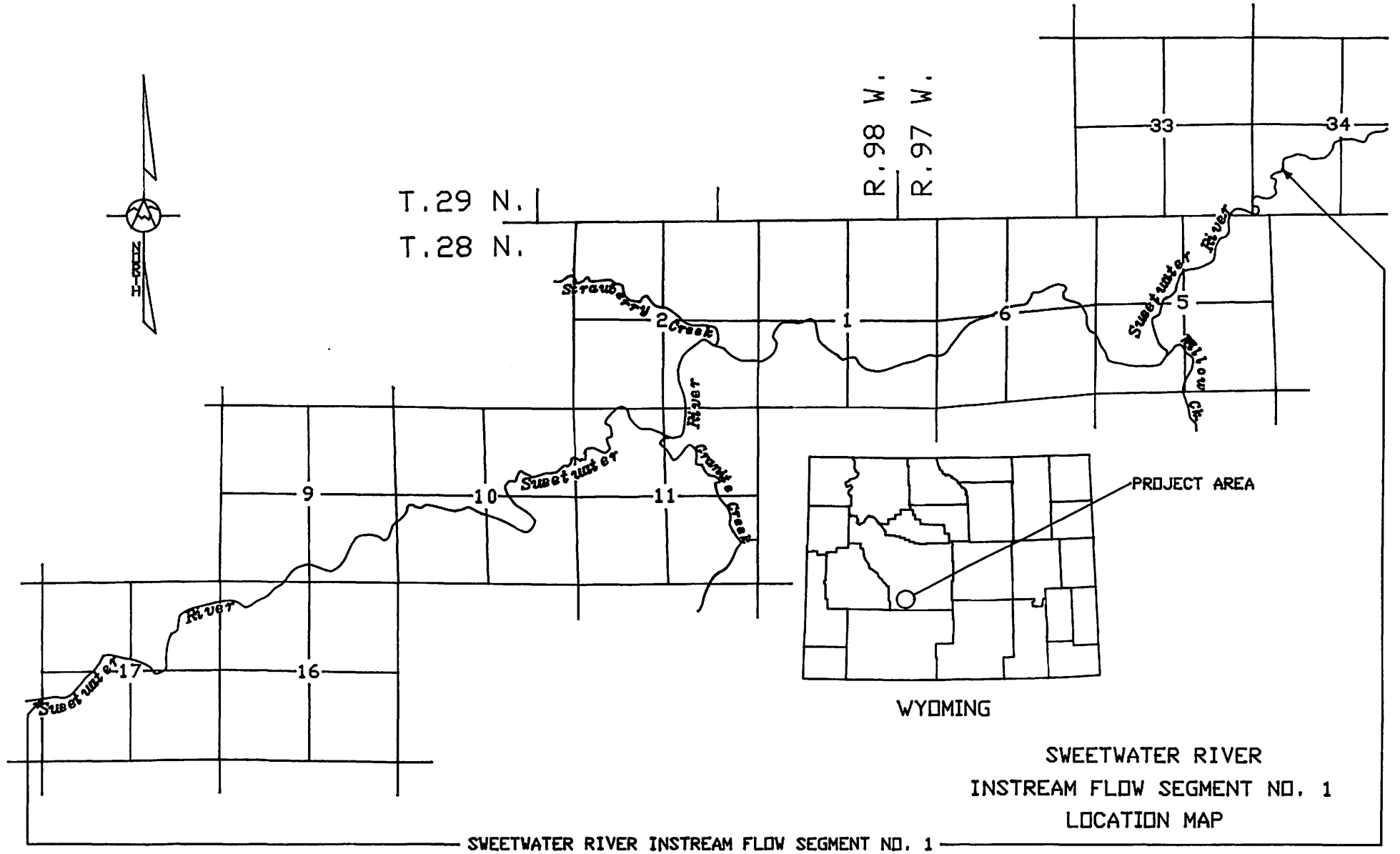
Data were collected from transects placed across two riffles within the study area and analyzed using the IFG-1 computer program (Milhous 1978). Instream flow recommendations derived from this method are applicable throughout the year except when higher instream flows are required to meet other fishery management purposes.

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]	60

1 - At average daily flow
2 - Compared to wetted perimeter at bankfull conditions

Figure 1. Location of instream flow filing reach on Sweetwater River.



A physical habitat simulation model (PHABSIM) developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) was used to examine incremental changes in the amount of physical habitat available for rainbow trout and brown trout spawning at various discharge rates. This model is generally regarded as state-of-the-art technology and is the most commonly used method in North America for quantifying changes in physical habitat with changes in discharge (Reiser et al. 1989).

The amount of physical habitat available at a given discharge is expressed in terms of weighted usable area (WUA) and reflects the composite suitability of depth, velocity and substrate at a given flow. Depth, velocity and substrate data were collected from seven transects in accordance with guidelines given by Bovee and Milhous (1978).

Maintenance of physical habitat for rainbow trout spawning is important for ensuring adequate recruitment to the fishery in this section of the Sweetwater River. The WUA for brown trout and rainbow trout spawning was simulated for flows ranging from 20 to 500 cfs using calibration and modeling techniques outlined in Milhous (1984) and Milhous et al. (1984).

The Habitat Quality Index (HQI) developed by the Wyoming Game and Fish Department (Binns and Eiserman 1979) was used to estimate potential changes in trout production over a range of late summer flow conditions. The model incorporates seven attributes that address 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 1 pound of trout. This model was developed by the WGFD after several years of testing and model refinement. The HQI has been reliably used on many Wyoming streams to assess habitat unit gains or losses associated with projects that modify instream flow regimes.

By measuring habitat attributes at various flow events as if associated habitat features were typical of late summer flow conditions (Conder and Annear 1987), HU estimates were made for hypothetical summer flows ranging from 10 to 500 cfs. To better define the potential impact of these other late summer flow levels on trout production, some attributes were derived mathematically for flows other than those which were measured. Results of the HQI model apply to the time of year that determines trout production. For the Sweetwater River this period is from July 1 to September 30.

RESULTS AND DISCUSSION

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.

Results from the Habitat Retention Model showed that a flow of 16 cfs is necessary to maintain aquatic insect production and fish passage at riffles 1 and 2 respectively (Table 3). 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 criteria, the maintenance flow for this segment of the Sweetwater River is 16 cfs.

Table 3. Results from IFG-1 modeling at the Sweetwater River study site.

Discharge (cfs)	Average Depth (ft.)	Average Velocity (ft./sec.)	Wetted Perimeter
		Riffle 1	
1.0	0.14	1.00[1]	5.8
6.2	0.23	1.90	14.1
15.8[2]	0.23	1.47	47.2[1]
28.1	0.38	1.30	57.9
48.8	0.60[1]	1.35	59.4
55.7	0.68	1.38	59.6
82.0	0.90	1.52	60.5
102.7	1.05	1.63	61.0
204.1	1.50	2.08	66.6
345.2	1.94	2.52	71.9
530.5	2.33	2.95	78.6
		Riffle 2	
9.8	0.92[1]	0.48	22.8
16.0[2]	0.98	0.64	24.7[1]
21.4	1.06	0.79	26.2
31.7	1.07	1.00[1]	30.0
34.6	1.07	1.06	31.0
47.7	1.14	1.28	33.6
58.2	1.19	1.43	34.9
74.2	1.17	1.63	39.7
82.0	1.19	1.71	40.7
102.8	1.25	1.93	43.5
147.2	1.45	2.33	44.6
364.6	2.05	3.85	47.5
530.5	2.31	4.77	49.3

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

Natural mortality that occurs 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. For the Sweetwater River, the maintenance flow is 16 cfs.

Stream flow data are unavailable for this section of the Sweetwater River and it is possible that the discharge of 16 cfs identified by the Habitat Retention Method may not be present at times during 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 16 cfs, in order to maintain existing survival rates of trout populations.

Natural recruitment is an important mechanism for maintaining the brown trout fishery in this stream segment. Brown trout generally spawn in October and November. Their eggs incubate from December through March. Results from the PHABSIM model for spawning and incubation life stages were used to determine flows necessary to maintain or improve brown trout reproductive success during these time periods.

The brown trout spawning and incubation period coincides with the time of year when the management objective is to preserve all natural stream flows up to the maintenance flow. Results from the PHABSIM analysis show that meeting this objective with the discharge identified by the Habitat Retention Method (16 cfs) will maintain approximately 10% of the maximum physical habitat for brown trout spawning (Figure 2) for the range of flows studied. Although 16 cfs does not maximize physical habitat for spawning, this flow approximates conditions to which brown trout have adapted, and is a flow which has maintained adequate recruitment to the fishery. This flow also maintains hydraulic criteria identified by the Habitat Retention Method. Consequently, a flow of 16 cfs is recommended for the period from October 1 to March 31.

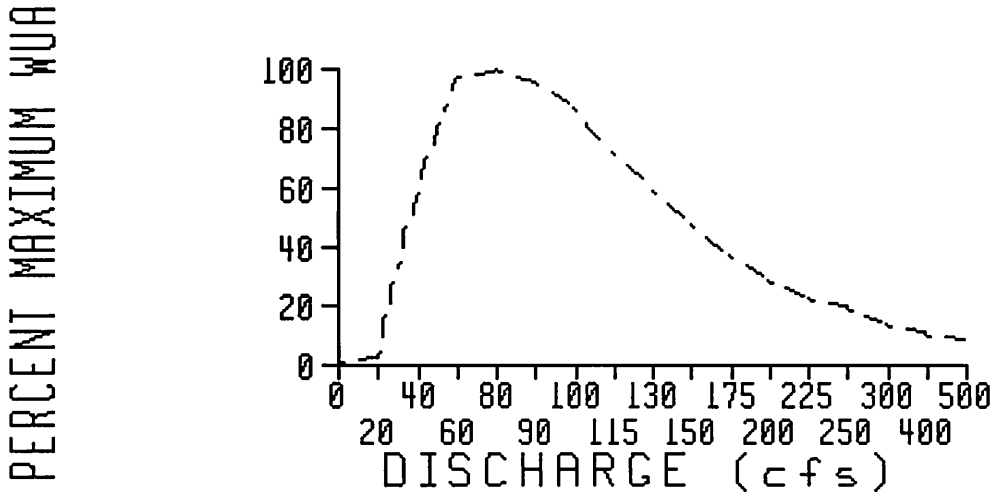


Figure 2. Percent of maximum weighted usable area (MUA) for brown trout spawning at the Sweetwater River study site as a function of discharge.

Results from the PHABSIM analysis show that a flow of 80 cfs will maximize the amount of physical habitat for rainbow trout spawning. At flows above and below 80 cfs, physical habitat is rapidly reduced (Figure 3). Under natural conditions, flows are often in excess of 80 cfs from April 1 to June 30. When this occurs, physical habitat for rainbow trout spawning will be less than the maximum. To accomplish the current fishery management objective of maintaining or improving reproductive success for rainbow trout, and at the same time, protecting the habitat features addressed by the Habitat Retention Method, a flow of 80 cfs is recommended for the period from April 1 to June 30.

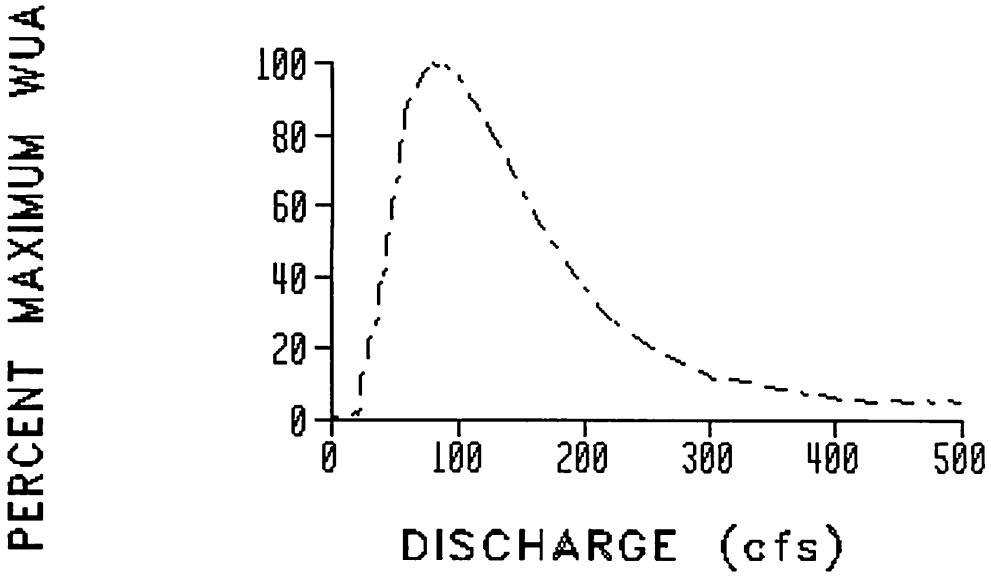


Figure 3. Percent of maximum weighted usable area (MUA) for rainbow trout spawning at the Sweetwater River study site as a function of discharge.

Results from the HQI model indicate that under existing average late summer conditions, this segment of the Sweetwater River supports approximately 56 trout habitat units per acre (Figure 4). A flow of 25 cfs is the minimum flow that will maintain this existing level of HUs. At lower flows, trout habitat units would be reduced by approximately 18% or more. Fishery management objectives for the late summer are to maintain the existing number of habitat units, and meet or exceed the hydraulic criteria addressed by the Habitat Retention Method. A flow of 25 cfs is the minimum streamflow which will accomplish these objectives for the period from July 1 through September 30.

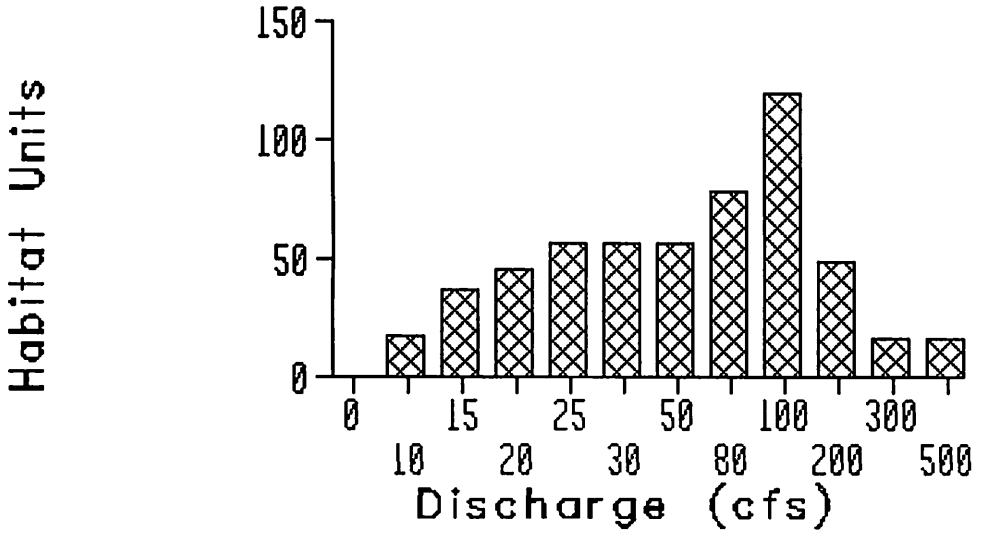


Figure 4. Adult trout habitat units (HU) as a function of discharge at the Sweetwater River study site.

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 the existing trout fishery in a section of the Sweetwater River at critical times of year. This stream section extends upstream for a distance of 10.2 miles; from Section 34, Range 97 West, Township 29 North, to the west boundary of Section 17, Range 98 West, Township 28 North. This stream section is 10.2 miles long.

Table 4. Summary of instream flow recommendations for the Sweetwater River south of Lander.

Time Period	Instream Flow Recommendation (cfs)
October 1 to March 31	16*
April 1 to June 30	80
July 1 to September 30	25

* - To maintain existing natural flows

REFERENCES

Annear, T.C. and A.L. Conder. 1984. Relative bias of several fisheries instream flow methods. North American Journal of Fisheries Management 4:531-539.

Bovee, K. and R. Milhous. 1978. Hydraulic simulation in instream flow studies: theory and technique. Instream Flow Information Paper 5. FWS/OBS 78/33. Cooperative Instream Flow Service Group, U.S. Fish and Wildlife Service. Fort Collins, Colorado.

Binns, N. and F. Eiserman. 1979. Quantification of fluvial trout habitat in Wyoming. Transactions of the American Fisheries Society 108:215-228.

Butler, R. 1979. Anchor ice, its formation and effects on aquatic life. Science in Agriculture, Vol XXVI, Number 2, Winter, 1979.

Conder, A.L. and T.C. Annear. 1987. Test of weighted usable area estimates derived from a PHABSIM model for instream flow studies on trout streams. North American Journal of Fisheries Management 7:339-350.

Kurtz, J. 1980. Fishery management investigations - a study of the upper Green River fishery, Sublette County, Wyoming (1975-1979). Completion Report. Wyoming Game and Fish Department, Fish Division, Cheyenne.

Milhous, R.T. 1984. PHABSIM technical notes. Unpublished. U.S. Fish and Wildlife Service, Fort Collins, Colorado.

_____. 1978. A computer program for the determination of average hydraulic and shape parameters of a stream cross section. Washington State Dept. of Ecology, Olympia.

_____, D.L. Wegner, and T. Waddle. 1984. User's guide to the physical habitat simulation system. Instream Flow Paper 11, FWS/OBS-81/43, Cooperative Instream Flow Service Group, U.S. Fish and Wildlife Service, Fort Collins, Colorado.

Needham, P., J. Moffett, and D. Slater. 1945. Fluctuations in wild brown trout populations in Convict Creek, California. Journal of Wildlife Management 9(1):9-25.

Nehring, R. 1979. Evaluation of instream flow methods and determination of water quantity needs for streams in the state of Colorado. Colorado Division of Wildlife, Fort Collins.

Reimers, N. 1957. Some aspects of the relation between stream foods and trout survival. California Fish and Game 43(1):43-69.

Reiser, D.W., T.A. Wesche, and C. Estes. 1989. Status of instream flow legislation and practices in North America. Fisheries 14(2):22-29.