WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Deer Creek Instream Flow Report

PROJECT: IF-5589-07-8901

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INTRODUCTION

Data were collected during the 1984 field season to conduct instream flow analyses for a segment of Deer Creek located in Converse County, Wyoming. The study and this report were prepared in compliance with instream flow legislation to support a Wyoming Water Development Commission application for an instream flow water right.

In 1985, the Wyoming State Legislature authorized the Wyoming Water Development Commission (WWDC) to develop plans for a storage facility on Deer Creek to provide flood control and additional municipal water for Casper and other communities along the North Platte River. The enabling legislation also provided for minimum instream flow releases from the dam (Table 1), a minimum pool of 12,400 acre feet, public access to the reservoir and to Deer Creek below the dam, and a boat ramp (House Bill No. 333 1985). Instream flow releases from the reservoir are intended to mitigate stream habitat losses that will occur due to proposed project. When full, the reservoir will inundate approximately 7.3 miles of Deer Creek, the West Fork of Deer Creek, and Duck Creek combined. The loss of fish habitat due to inundation by the reservoir will increase the importance of the trout fishery in Deer Creek below the reservoir because of the close proximity of the stream to the towns of Casper and Douglas.

Table 1. Guaranteed instream flow releases from proposed Deer Creek Reservoir specified by 1985 Wyoming State Legislature.

Time Period	Minimum Release (cfs)
October 1 to March 31	10
April 1 to September 30	15

According to the 1986 instream flow legislation, stored waters may be released for instream flows to establish or maintain fisheries. The goal of this study was to assess the adequacy of legislatively authorized instream flow releases for maintaining a stream fishery and for mitigating project impacts. Based on this guideline, the specific objectives of this study were to determine instream flows necessary to 1) maintain hydraulic characteristics year-round that are important for survival of trout, fish passage and aquatic insect production, 2) maintain physical habitat for brown trout spawning during the fall, 3) maintain physical habitat for rainbow trout spawning during the spring, and 4) maintain adult trout production for all trout species during the late summer months.

METHODS

Study Area

Deer Creek is considered a Class 3 trout stream by the Wyoming Game and Fish Department (WGFD). Trout stream classifications throughout Wyoming range from Class 1 (highest rating) to Class 5 (lowest rating). Class 3 trout streams are generally considered important trout fisheries on a regional basis.

Deer Creek contains naturally reproducing populations of rainbow and brown trout. The stream is currently managed as a wild fishery for rainbow and brown trout; therefore no fish are stocked by the WGFD. Maintenance of wild trout fisheries is a high priority because they cost less to manage and wild trout are generally preferred over hatchery trout by most anglers. Stream fishing opportunities in this part of the state are already in short supply. As mentioned above, the trout fishery in Deer Creek below the proposed reservoir will increase in importance even more with the loss stream fishing opportunity on over 7 miles of stream at the reservoir site. Because the proposed instream flow reach passes through Federally owned land controlled by the Bureau of Land Management and private land on which permanent access has been secured for public fishing, this stream segment is readily accessible to the public. For these reasons, this segment was identified as a critical reach.

Data Collection

All of the field data used in this study were collected from a 270 foot long study site located in the southeast 1/4 of Section 35, Township 32 North, Range 77 West. This study site was located approximately 4 miles downstream from the proposed Deer Creek Dam and approximately 1 mile upstream from the VR Ditch (Figure 1). The study site contained a combination of pool and riffle habitat for trout that was representative of trout habitat features found throughout this portion of the stream. Results and recommendations were applied to a portion of the stream extending from the USGS gage in the NE 1/4 SE 1/4 of S 26, T32N, R77W upstream to the proposed Deer Creek Dam site in the SE 1/4 of S 11, T31N, R77W. This is a distance of approximately 5 stream miles.

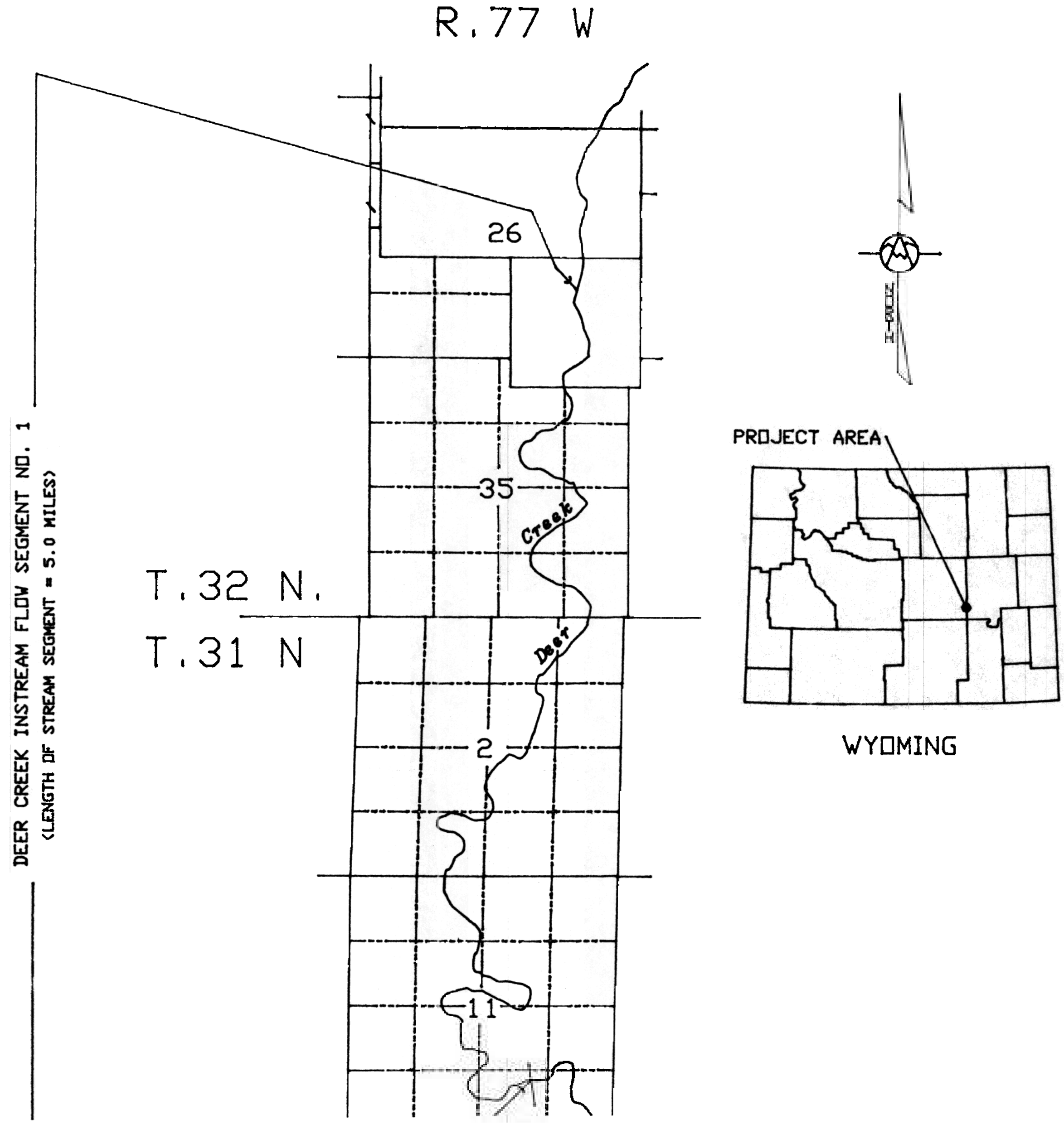

Figure 1. Location of the proposed instream flow filing reach for Deer Creek.

Models

A Habitat Retention method (Nehring 1979; Annear and Conder 1984) was used to identify a maintenance flow. A maintenance flow is defined as the lowest continuous flow that will maintain minimum hydraulic criteria at riffle areas in a stream segment. These criteria are important at all times of year to maintain passage between different habitat types for all life stages of trout. These criteria are also important for maintaining survival rates of fish and aquatic macroinvertebrates during the winter that approximate rates observed under natural stream flow conditions.

Data from single transects placed across 4 riffles within the study area were analyzed with the IFG-1 computer program (Milhous 1978). Flow data were collected at three different flow levels (Table 2). Based on extensive research of instream flow methods on Wyoming streams by Annear and Conder (1984), the maintenance flow is specifically defined as the discharge at which two of the three criteria in Table 3 are met for all riffles in the study area. Maintenance flows apply to all times of the year except when higher stream flows are required to meet other fishery management objectives.

Table 2. Dates and discharges when instream flow data were collected at the Deer Creek instream flow segment.

Date	Discharge (cfs)
06-18-84	58
07-10-84	28
08-25-84	6

Table 3. Hydraulic criteria used to obtain an instream flow recommendation using the Habitat Retention method.

Category	Criteria
Average Depth (feet)	Top width[1] x 0.01
Average Velocity (feet/second)	1.00
Wetted Perimeter (percent)[2]	60

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

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 quantify incremental changes in the amount of physical habitat available for rainbow and brown trout spawning at various discharge rates. This model is generally considered to reflect state-of-the-art technology for evaluating fisheries physical habitat changes with changes in stream flows and is the most commonly used instream flow model in North America (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 at seven transects as described in Bovee and Milhous (1978). Dates and discharge rates when data were collected are given in Table 2. The WUA for rainbow and brown trout was simulated for flows ranging from 3 to 250 cubic feet per second (cfs) using calibration and modeling techniques outlined in Milhous (1984) and Milhous et al. (1984).

Because this fishery depends exclusively upon natural reproduction for continuation, it is important to maintain physical habitat for spawning for both rainbow and brown trout. Maintenance of suitable physical habitat for this life stage is a critical part of ensuring adequate recruitment to this fishery. Rainbow trout begin spawning in early April and continue through May. Their eggs incubate until June. Results from the PHABSIM analysis were used to identify the flows needed to maintain physical habitat for rainbow trout spawning from April 1 to June 30. Brown trout spawn in the fall and their eggs incubate in the gravel for the remainder of the winter. Their eggs normally hatch in mid to late March. Results from the PHABSIM analysis were therefore used to identify a flow from October 1 to March 31 which would maintain physical habitat for brown trout spawning.

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 standing crops over a range of average late summer flow conditions. 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 HU gains or losses associated with projects that modify instream flow regimes. This model incorporates seven attributes that address chemical, physical and biological components of trout habitat. Results are expressed in habitat units (HU). One HU is defined as the amount of habitat quality which will support 1 pound of trout. Analyses obtained from this method apply to the time of year that governs trout production. On Deer Creek this time period is between July 1 and September 30.

By measuring habitat attributes at various flow events as if associated habitat features were typical of average late summer flow conditions, HU estimates can be made for a range of theoretical summer flows (Conder and Annear 1987). Habitat attributes on Deer Creek were measured on the same dates and flow levels that data were collected for the PHABSIM and Habitat Retention models (Table 2). To better define the relationship of discharge and trout production, some attributes were derived mathematically or obtained from existing gage data for flows in addition to those shown in Table 2. Other data were obtained from a U.S. Geological Survey gage located on Deer Creek just upstream from the VR Ditch. These data are summarized in the Final Environmental Impact Statement for this project (U.S. Army Corps of Engineers 1987).

RESULTS/DISCUSSION

Results from the Habitat Retention model showed that the hydraulic criteria in Table 3 are met at flows of 8, 6, 4, and 6 cfs for riffles 1, 2, 3, and 4, 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 which in this case is 8 cfs.

Table 4. Simulated hydraulic criteria for four riffles on Deer Creek. Estimated average daily flow = 52 cfs. Bank full discharge = 336 cfs.

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
	Riffle 1		
1.50	4.0	59.2	336
1.45	3.4	57.2	255
1.19	2.3	55.5	137
0.97	1.5	50.4	65
0.91	1.3	48.9	52
0.84	1.1	47.8	41
0.78	1.0[1]	46.8	33
0.66	0.8	42.8	20
0.61	0.5	29.6[1]	8[2]
0.44[1]	0.2	14.9	2
	Riffle 2		
1.84	3.0	61.5	336
1.77	2.8	61.0	288
1.36	1.7	57.5	125
0.97	1.0[1]	54.7	52
0.91	0.9	51.1	39
0.86	0.8	49.0	31
0.80	0.7	46.8	24
0.65	0.4	37.9	10
0.60	0.3	30.8[1]	6[2]
0.53[1]	0.2	26.6	4
	Riffle 3		
2.40	3.6	47.0	336
1.89	2.6	44.0	210
1.48	1.8	41.6	108
1.16	1.3	37.2	52
1.06	1.1	35.6	40
1.01	1.0[1]	33.6	32
0.98	0.9	32.6	29
0.73	0.6	26.6	11
0.44	0.4	23.5[1]	4[2]
0.36[1]	0.3	17.9	2

Table 4. (continued)

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
	Riffle 4		
1.79	4.0	54.0	336
1.61	2.9	48.4	221
1.47	2.1	43.9	129
1.20	1.4	42.6	69
1.08	1.2	42.3	52
0.97	1.0[1]	42.0	40
0.81	0.8	41.6	25
0.62	0.6	41.1	14
0.41[1]	0.4	37.9	6[2]
0.32	0.3	27.0[1]	3

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

The maintenance flow is defined as a continuous flow that will maintain minimum hydraulic criteria in riffle areas within a stream segment. These criteria are important at all times of year to maintain passage between different habitat types for all life stages of trout. These criteria are also important for maintaining survival rates of fish and aquatic macroinvertebrates during the winter that approximate rates observed under natural stream flow conditions.

Low flow conditions during winter months (October through March) naturally limit the survival and growth of many trout populations. The extent of these impacts is dependent upon several factors including but not limited to snow fall, cold intensity and the duration of intense cold periods. These factors vary from year to year and affect fish populations depending on the amount of frazile ice and anchor ice formation (which can plug the gills of fish), the extent of snow bank collapse (and stream damming) and increased metabolic demands on fish (and increased stress).

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.

The 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. Protection of natural winter stream flows up to the recommended maintenance flow for each stream segment is necessary to maintain existing survival rates of trout populations. Any reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish that the stream could support. Conversely, any continuous and regular increase in winter discharge rates would be expected to increase trout survival.

Releases from the proposed reservoir will be 10 cfs from October 1 to March 31 (Table 1). This discharge would meet or exceed the maintenance flow criteria and would be consistent with the mitigation requirements for the proposed Deer Creek reservoir project. Therefore, an instream flow of 10 cfs is recommended for the period of October 1 to March 31.

Gage records indicate that existing average daily flows during the winter (October 1 - March 31) approximate 10 cfs. Therefore, a release of 10 cfs during the fall and winter will be adequate to maintain existing levels of brown trout spawning. At this discharge, PHABSIM analyses indicate that physical habitat for brown trout spawning is approximately 16% of the maximum amount available, which would occur at a discharge of 70 cfs (Figure 2). Physical habitat for brown trout spawning would be increased from pre-project conditions at all flows above 10 cfs (over the range of flows simulated). Flows lower than 10 cfs would cause a reduction in pre-project amounts of WUA. Therefore, a discharge of 10 cfs is the minimum flow that will maintain physical habitat for brown trout spawning. This discharge will also meet or exceed the hydraulic criteria addressed by the Habitat Retention Method.

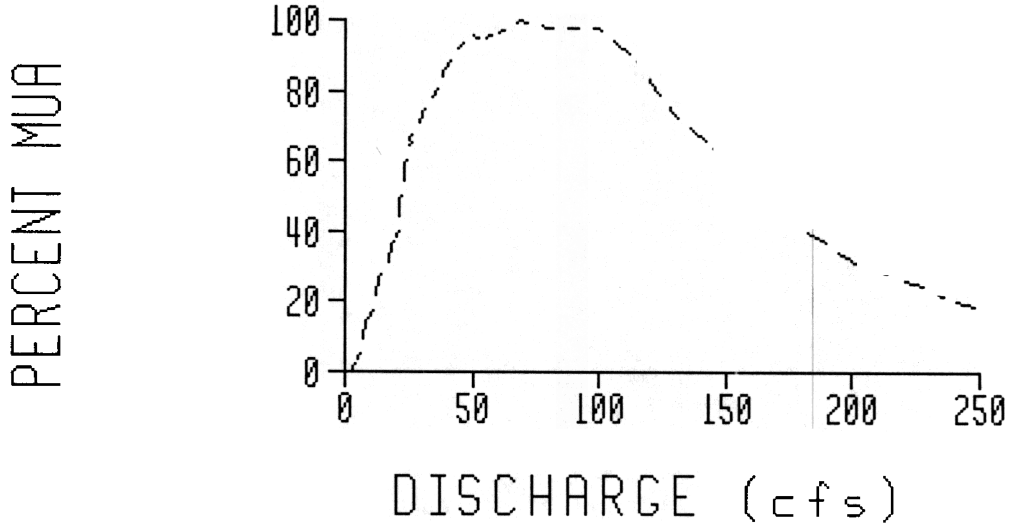

Figure 2. Percent of maximum usable area (MUA) for spawning life stage of brown trout.

Rainbow trout spawning normally occurs between April 1 and June 30. Gage records indicate that average daily flows during this time approximate 165 cfs. PHABSIM analyses indicate that WUA for rainbow trout spawning at this discharge is approximately 50% of the maximum WUA available, which occurs at 70 cfs. The curve describing the relationship between discharge and WUA is bell shaped, and as a consequence, an average daily flow of 30 cfs provides as much WUA for spawning as does a flow of 165 cfs.

PHABSIM results indicate that an instream flow of 30 cfs is the minimum discharge which will maintain existing levels of physical habitat for rainbow trout spawning. This discharge will also meet or exceed the hydraulic criteria addressed by the Habitat Retention Method. Therefore an instream flow of 30 cfs is recommended for the period April 1 to June 30. According to the projected release schedule from the Deer Creek Reservoir (U.S. Army Corps of Engineers 1987) this flow will probably be exceeded during much of this period due to the anticipated reservoir releases to meet the demands of downstream users (Table 5).

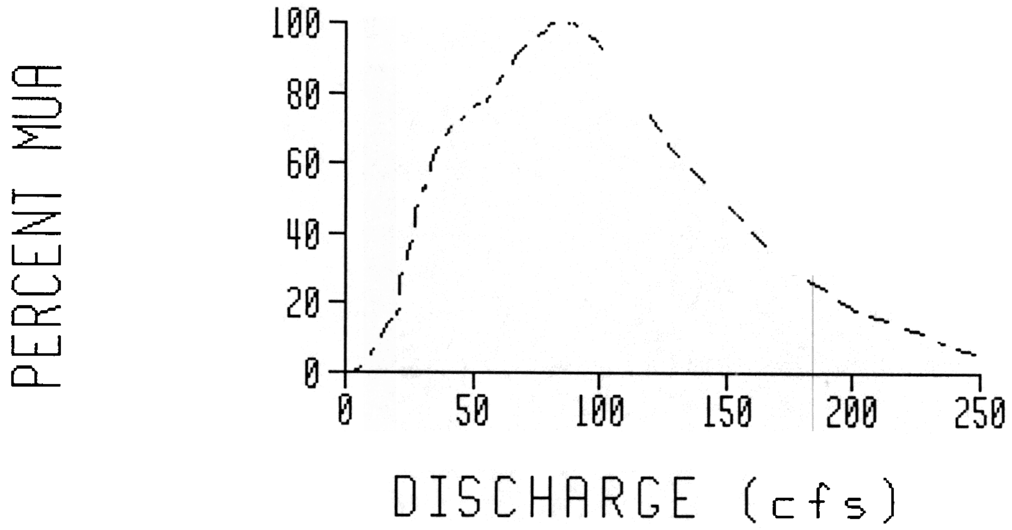

Figure 3. Percent of maximum usable area (MUA) for spawning life stage of rainbow trout.

Table 5. Projected average releases, Deer Creek Reservoir. Taken from the Final Environmental Impact Statement prepared by the U.S. Army Corps of Engineers, page 2-30.

Month	Estimated Historic Stream Flow at Glenrock (cfs)	Projected Average Monthly Releases (cfs)	
		6,400 Ac-Ft Yield	9,600 Ac-Ft Yield
October	10.1	12.2	12.0
November	11.1	11.9	11.9
December	10.7	11.7	11.7
January	10.1	11.4	11.4
February	11.4	11.7	11.7
March	24.4	20.7	15.6
April	140.5	90.9	45.7
May	311.0	231.4	230.8
June	95.8	106.5	117.8
July	14.5	51.7	69.6
August	4.9	31.1	43.3
September	5.0	22.5	30.8

Results from the HQI analyses (Figure 4) indicate that under average late summer conditions (approximately 5 cfs), Deer Creek presently supports approximately 52 HUs per acre. The analysis based on instream flow releases from the reservoir indicates that substantial HU gains could be realized in Deer Creek below the reservoir. The minimum release of 10 cfs during the winter, coupled with the storage (reduction) of peak flows in the spring will reduce annual stream flow variation in Deer Creek below the dam. More stable year-round flows resulting from reservoir operations will likely also result in better aquatic insect production. Summer water temperatures should be more suitable for trout; however this is contingent upon the use of a multi-level tower penstock to control the temperature of water released from the reservoir. The combination of these factors will likely increase trout production significantly in the instream flow reach. If optimal temperatures are not maintained, this analysis would change.

The HQI analysis based on post-construction flows indicates that at the guaranteed summer flow of 15 cfs, Deer Creek could support 114 HUs per acre (Figure 4). This is an increase of approximately 62 HUs per acre over existing natural conditions (at 5 cfs). The analysis indicates that HUs are maximized at a late summer discharge of about 40 cfs, but decline rapidly at summer flows greater than 50 cfs. If summer flows are maintained at the guaranteed minimum flow of 15 cfs from July 1 to September 30, a gain of 1,327 HUs will be realized (Table 6). This is a conservative estimate of HU gains, since summer flows will likely be higher than 15 cfs (Table 5).

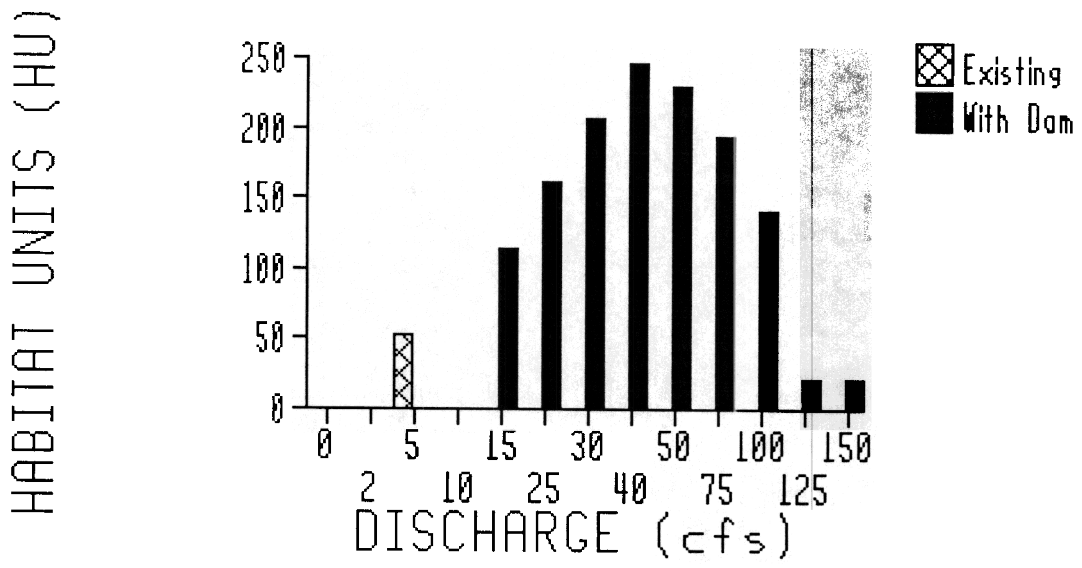

Figure 4. Number of trout habitat units under existing flow conditions and at several average late summer flow levels in the Deer Creek instream flow segment based on post-construction flow regimes.

Table 6. Total HU gains in Deer Creek below the reservoir based on a summer release of 15 cfs from July 1 to September 30.

Existing HUs/Acre	With Summer Release of 15 cfs	HU/Acre Gained	Total Acres	Total HU Gain
52	114	62	21.4	1,327

The gain of 1,327 HUs resulting from a release of 15 cfs from July 1 to September 30 would more than mitigate the 896 HUs lost due to inundation by the reservoir (WGFD 1984). In addition, this discharge will maintain minimum hydraulic criteria that allow fish passage between different habitat types and provide adequate substrate for production of aquatic insects. Therefore, an instream flow of 15 cfs is recommended for the period of July 1 to September 30.

CONCLUSIONS

Based on the analyses and results contained in this report, the instream flow recommendations in Table 7 apply to a 5 mile segment of Deer Creek extending from the USGS gage in the NE 1/4 SE 1/4 of S 26, T32N, R77W upstream to the proposed Deer Creek Dam site in the SE 1/4 of S 11, T31N, R77W.

The guaranteed flows provided by legislation are adequate to accomplish the goal of mitigating project impacts as well as maintaining the trout fishery in Deer Creek from July 1 to March 31. Additional releases totalling 30 cfs are necessary to maintain rainbow trout spawning from April 1 to June 30.

Table 7. Summary of instream flow recommendations to maintain the trout fishery in Deer Creek.

Time Period	Instream Flow Recommendation (cfs)
October 1 to March 31	10
April 1 to June 30	30
July 1 to September 30	15

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