WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Little Popo Agie Instream Flow Report

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INTRODUCTION

Instream flow studies were done on a segment of the Little Popo Agie river south of Lander, Wyoming in 1981 (Figure 1). Results were used for determining instream flows which would maintain or improve the existing fishery in a section of the Little Popo Agie river. Results apply to the stream segment extending upstream from the north boundary of the NE1/4, SW1/4 of Section 34, T32N, R99W, to the south boundary of the E1/2, NE1/4 of Section 4, T31N, R99W. This stream section is 1.4 miles long.

The Little Popo Agie 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 primarily for wild Rainbow trout (Oncorhynchus gardneri) but some hatchery fish are stocked to supplement natural recruitment which is sometimes limited. Hatchery fish are normally planted during June and July, but plants have been made as early as May and as late as August. Other salmonid species present are brown trout (Salmo trutta) and mountain whitefish (Prosopium wiliamsoni). This section of the Little Popo Agie River provides significant recreational fishing opportunities and is accessible through a WGFD public fishing easement. For these reasons, this stream reach is considered a critical segment.

The WGFD management goal for the Little Popo Agie River is to maintain or improve the existing rainbow 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 for trout survival, 2) maintain physical habitat for rainbow trout spawning, 3) maintain physical habitat for juvenile rainbow trout stocked by the WGFD, and 4) maintain the existing quality of adult trout habitat during late summer.

METHODS

Data for these studies were collected from a site located approximately 1.5 miles upstream from Highway 28 in Section 4, Range 99 West, Township 31 North (Figure 1). These studies were conducted between June and August 1981 within a 380 foot long study site that contained trout habitat typical of that found throughout the

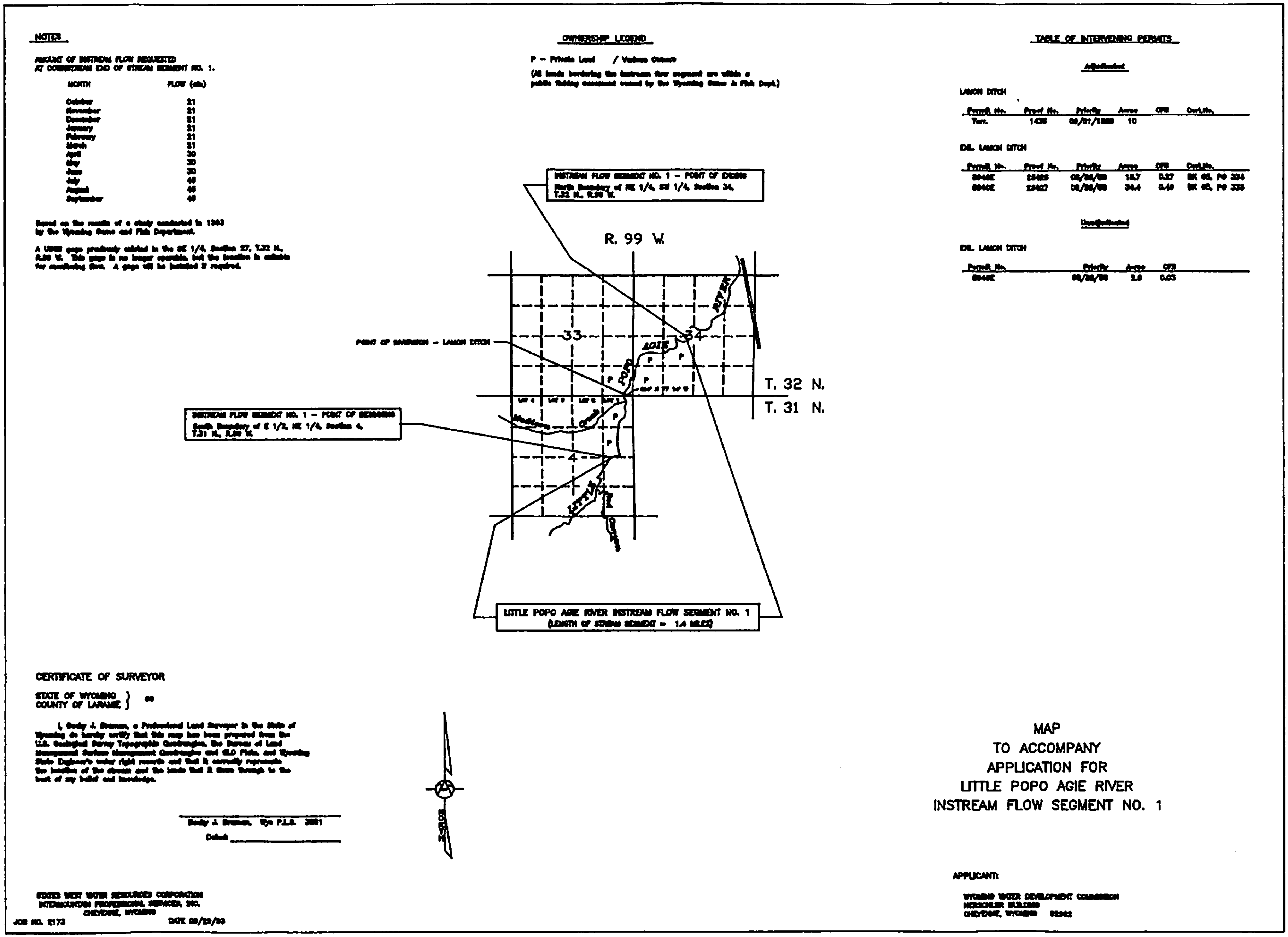

Figure 1. Little Popo Agie instream flow reach.

candidate section of the Little Popo Agie 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 Little Popo Agie River during 1981.

Date	Discharge Cubic Feet Per Second (cfs)
06-23-81	137
07-13-81	61
08-04-81	32

Three techniques were used to examine relationships between streamflows and trout habitat quantity and quality; the 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 research of 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). Data from three riffles were included in this analysis.

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]	50

1 - At average daily flow of 80 cfs
2 - Compared to wetted perimeter at bankfull conditions of 520 cfs.

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 analyzed with the PHABSIM subroutine AVPERM.

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). Depth, velocity and substrate data were collected from eight transects in accordance with guidelines given by Bovee and Milhous (1978).

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. (1984). Weighted Usable Area estimates for spawning and juvenile rainbow trout were generated with these calibration techniques and HSI curves from Raleigh et al. (1984). Weighted Usable Area simulations for these life stages were made for flows ranging from 10 to 200 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 as if associated habitat features were 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 10 to 200 cfs.

United States Geological Survey data from a gage (#062330) on the Little Popo Agie River were used to illustrate average streamflow conditions (Table 3). This stream gage, located at the Highway 28 crossing about 1.5 miles below the study site, was operated continuously between 1947 and 1971. These hydrograph data were used to help asses the effects of existing and hypothetical flow conditions.

Table 3. Monthly mean flow for the Little Popo Agie River near Lander, Wyoming for the years 1947-1971.

Month	Average Monthly Flow
October	35
November	30
December	26
January	23
February	24
March	25
April	43
May	190
June	341
July	135
August	53
September	41

RESULTS AND DISCUSSION

Habitat Retention

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 at flows of 21, 12, and 12 cfs, 2 of 3 defined hydraulic criteria are met at the three riffles from which data were collected (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 criteria, the maintenance flow for this segment of the Little Popo Agie River is 21 cfs.

Table 4. Results from IFG-1 modeling at the Little Popo Agie study site.

Discharge (cfs)	Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter
	Riffle 1		
520	2.26	5.46	44.1
80	1.21	2.04	33.4
50	1.17	1.64	27.0
45	1.17	1.55	25.7
40	1.17	1.45	24.5
35	1.15	1.35	23.5
30	1.13	1.24	22.3[1]
25	1.09	1.12	21.4
21[2]	1.05	1.00[1]	20.6
20	1.04	1.98	20.4
15	0.97	1.84	19.3
10	0.91[1]	1.66	17.3
	Riffle 2		
520	0.76	7.69	56.7
80	0.74	2.97	35.8
50	0.60	2.41	34.5
45	0.57	2.31	34.2
40	0.56	2.21	32.5
35	0.56	2.09	30.2
30	0.54	1.95	38.7
28	0.52	1.89	28.4[1]
25	0.50	1.81	28.0
20	0.44	1.65	27.3
15	0.39	1.48	26.2
12[2]	0.36[1]	1.37	21.2
10	0.44	1.29[1]	17.9

Table 4. (Continued)

Discharge (cfs)	Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter
		Riffle 3	
520	1.46	6.70	54.6
80	0.87	2.65	35.5
50	0.72	2.13	33.3
45	0.69	2.04	32.8
40	0.65	1.93	32.6
35	0.60	1.83	32.4
30	0.55	1.72	32.1
25	0.50	1.62	31.8
20	0.43	1.51	31.4
15	0.35[1]	1.41	30.9
12[2]	0.32	1.36	27.3[1]
10	0.30	1.33[1]	25.4

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 21 cfs.

Streamflow data for the Little Popo Agie River show that average monthly flows during the winter are always in excess of 21 cfs (Table 3). However, instantaneous low flows during the winter may occasionally be lower than 21 cfs and the maintenance flow may not always be present in the winter every year. 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 21 cfs, in order to maintain existing survival rates of trout populations.

PHABSIM Modeling

Within the range of hydraulic simulations, physical habitat for rainbow trout spawning was maximized at 200 cfs and gradually reduced at lower flows down to about 100 cfs (Figure 2). Between 100 cfs and 30 cfs there was an increase in physical habitat and a subsequent decrease at flows below 30 cfs. About 75% of the maximum physical habitat available for spawning is preserved at a flow of 30 cfs.

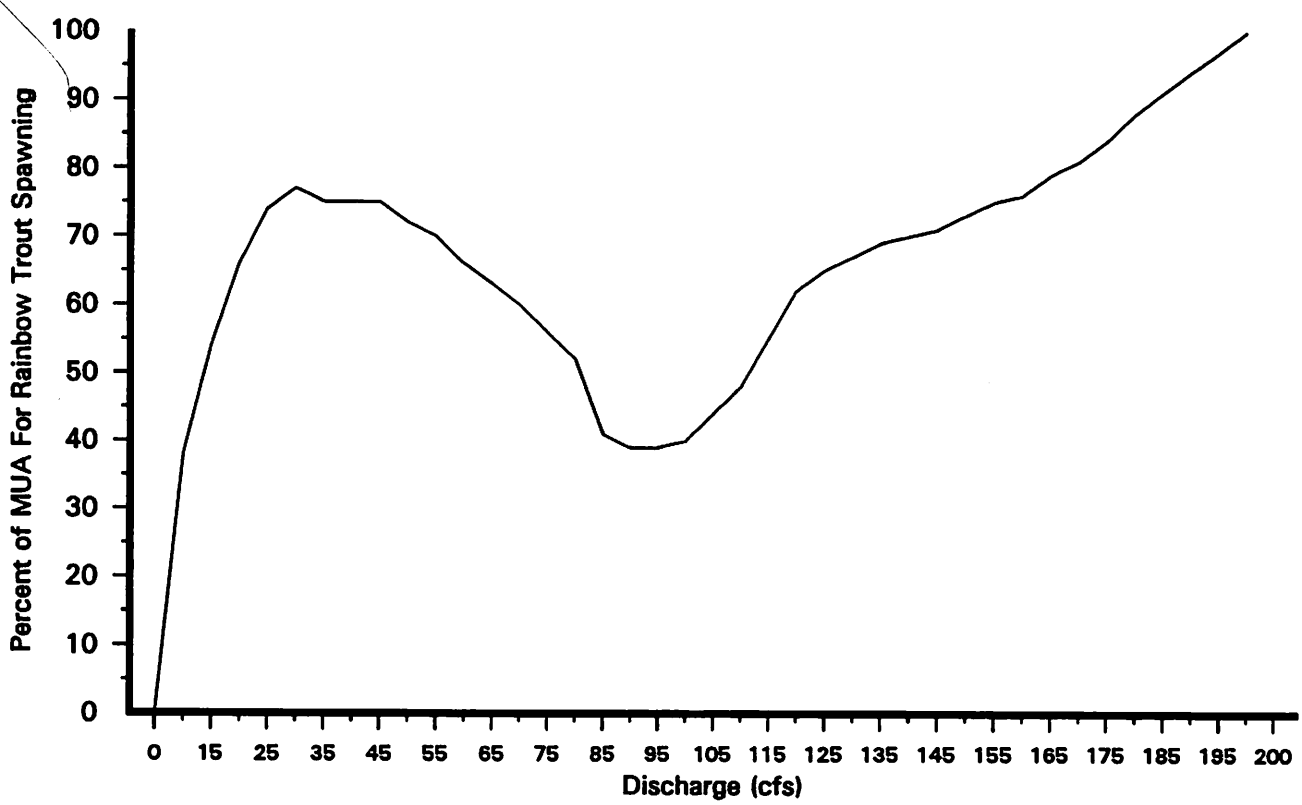

Figure 2. Percent of maximum weighted usable area (MUA) for rainbow trout spawning at the Little Popo Agie River study site as a function of discharge.

Maximum spring flows coincide with rainbow trout spawning which usually occurs from April through June. Stream gage data indicate that flows at this time often exceed the upper limit for which hydraulic simulations were possible. Although the trend for spawning suggests that suitability is maximized at these high flows, it is conceivable that higher flows may negatively affect rainbow trout spawning success in one of two ways. Eggs deposited before peak spring flows may be subject to scouring, while eggs deposited when flows are already high may eventually be dewatered as flows decline during the late spring and early summer. Because of the potential negative affects of high flows, eggs deposited at lower flows may result in better natural recruitment.

Because high spring flows may be limiting natural recruitment in this stream reach, a flow of 30 cfs is recommended for the spawning period from April 1 through June 30. A flow of 30 cfs will maintain 75% of the maximum physical habitat available for spawning over the range of flows for which data were simulated. Natural reproduction is important to successful wild fishery management but in the Little Popo Agie River, natural reproduction has been inadequate to completely support the fishery. A combination of limited reproduction and angler harvest creates a need to supplement natural fish stocks with hatchery reared fish.

Results from the PHABSIM analysis show that a flow of 35 cfs will maximize physical habitat for rainbow trout juveniles but at lower and higher flows, physical habitat is reduced (Figure 3). Because the existing fishery is supplemented by juvenile trout stocked in the spring by the WGFD it is important to maintain or improve physical habitat for juvenile rainbow trout.

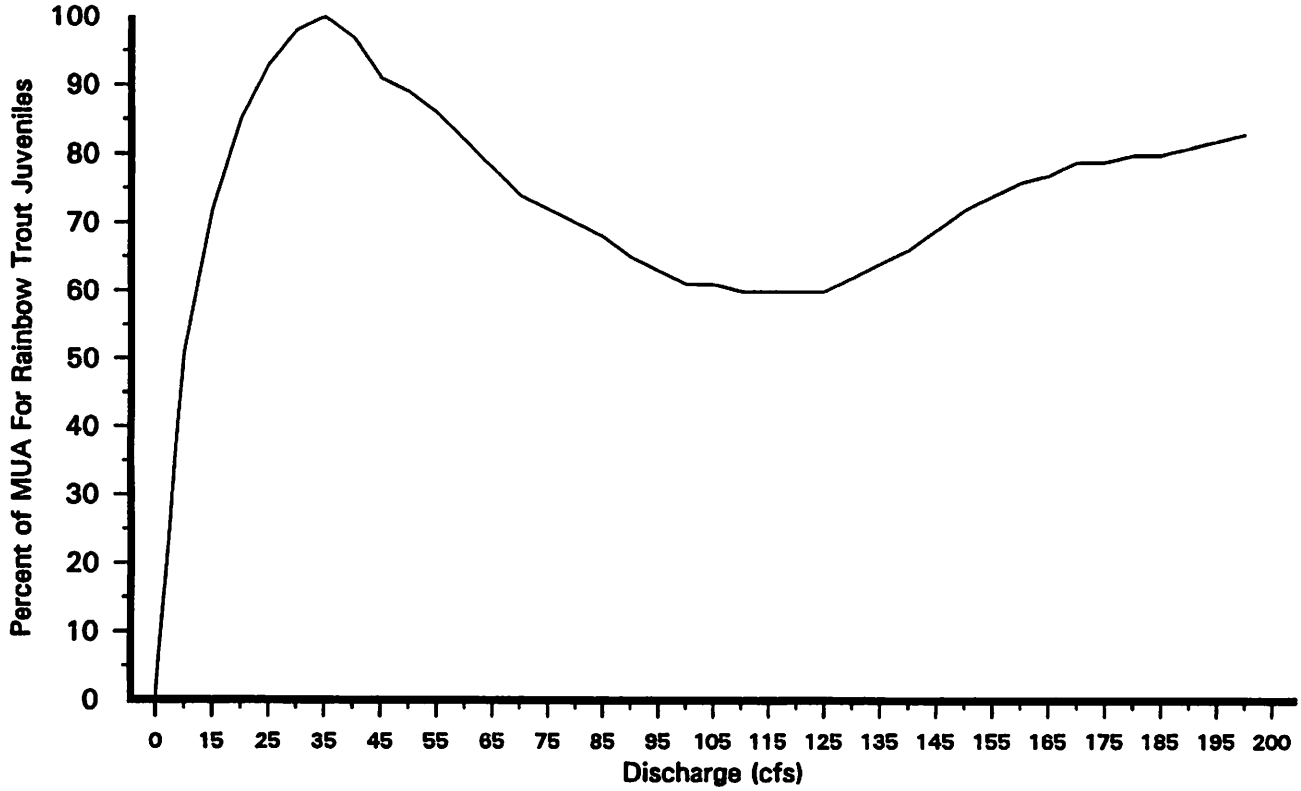

Figure 3. Percent of maximum weighted usable area (MUA) for rainbow trout juveniles as a function of discharge at the Little Popo Agie study site.

The flow recommended for spawning (30 cfs) will maintain about 95% of the physical habitat for juveniles and would maintain adequate amounts of physical habitat for juvenile trout stocked between April 1 and June 30. Under natural conditions, flows are often in excess of 30 cfs during this time period, and when this occurs, physical habitat for juvenile rainbow trout will be less than preferred.

HQI Modeling

Average late summer flows during the period that determines trout production (July 1 to September 15) are about 50 cfs. At this flow, the HQI model indicates that this segment of the Little Popo Agie River supports approximately 100 HU's per acre (Figure 4). A flow of 45 cfs is the minimum flow that will maintain or improve this existing level of habitat quality. At lower and higher flows, Habitat Units are reduced substantially from existing levels.

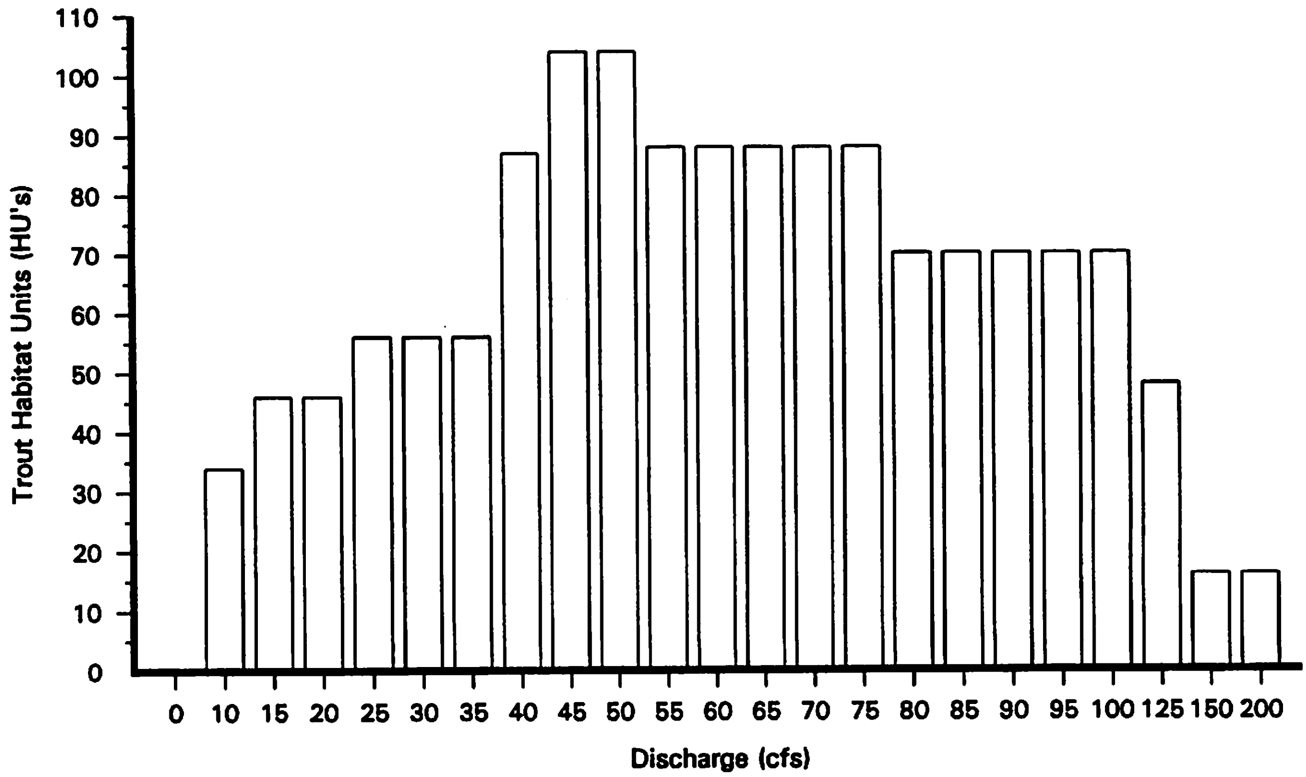

Figure 4. Adult trout habitat units (HU) as a function of discharge at the Little Popo Agie River study site.

Because a flow of 45 cfs is the minimum flow that would maintain or improve adult trout habitat quality and productive potential in this stream segment, this amount is recommended for the period from July 1 through September 30.

The streamflow recommendation based on HQI modeling (45 cfs) will also maintain in excess of 90% of the maximum physical habitat for juvenile cutthroat trout that are stocked between July 1 and September 30. Because physical habitat for juvenile rainbow trout is nearly maximized during this late summer period, and the adverse conditions associated with peak flows are past, this may be an acceptable time for stocking immature rainbow trout.

SUMMARY

The instream flow regime in Table 5 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 a section of the Little Popo Agie at critical times of year. This stream section extends for a distance of 1.4 miles; from the north boundary of the NE1/4,SW1/4 of Section 34, T32N, R99W, to the south boundary of the E1/2,NE1/4 of Section 4, T31N, R99W.

Table 5. Summary of instream flow recommendations for the Little Popo Angie River South of Lander, Wyoming.

Time Period	Instream Flow Recommendation (cfs)
October 1 to March 31	21*
April 1 to June 30	30
July 1 to September 30	45

* - To maintain existing natural flows

These flow recommendations consider only instantaneous trout habitat quality and quantity needs. They do not address the need for or role of higher flows for channel maintenance (flushing flows). Separate studies may be needed to quantify stream flows needed for this aspect of maintaining the existing fishery in the Little Popo Agie River.

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