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REPORT ON THE FEASIBILITY OF PROVIDING INSTREAM FLOW IN THE LARAMIE RIVER INSTREAM FLOW SEGMENT NO. 1

June 1991

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June 1991

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LARAMIE RIVER INSTREAM FLOW
TABLE OF CONTENTS

LIST OF APPENDICES

LARAMIE RIVER INSTREAM FLOW
TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

Report on the Feasibility of
Providing Instream Flow in the Laramie River
Instream Flow Segment No. 1
Temporary Filing No. 27 6/30

Wyoming Water Development Commission
June 1991

I SUMMARY

The Wyoming Water Development Commission (WWDC) is required by W.S. 41-3-1004 (a) to determine the feasibility of providing various amounts of unappropriated direct flow of water for instream uses within stream segments requested by the Wyoming Game and Fish Department (WGFD). For the Laramie River, WWDC contracted with Western Water Consultants, Inc. (WWC) of Laramie, Wyoming to prepare the technical study. The WGFD has requested a direct flow water right for purposes of providing instream flow for fisheries in a segment of the Laramie River upstream of Woods Landing. The amounts of flow requested by season are: 50 cubic feet per second (cfs) during the months of October through March; 100 cfs during the months April, May and June; and 50 cfs during the months of July, August and September. The segment is called the Laramie River - Instream Flow Segment Number 1 and is defined by an upstream point located at the south boundary line of the west half of the northwest quarter of Section 26, Township 13 North, Range 77 West and a downstream point located at the east boundary of the south half of the northeast quarter of the southeast quarter of Section 10, Township 13 North, Range 77 West, all in Albany County, Wyoming. The segment has a stream length of approximately 3.94 miles and the location is shown on Figure 1.

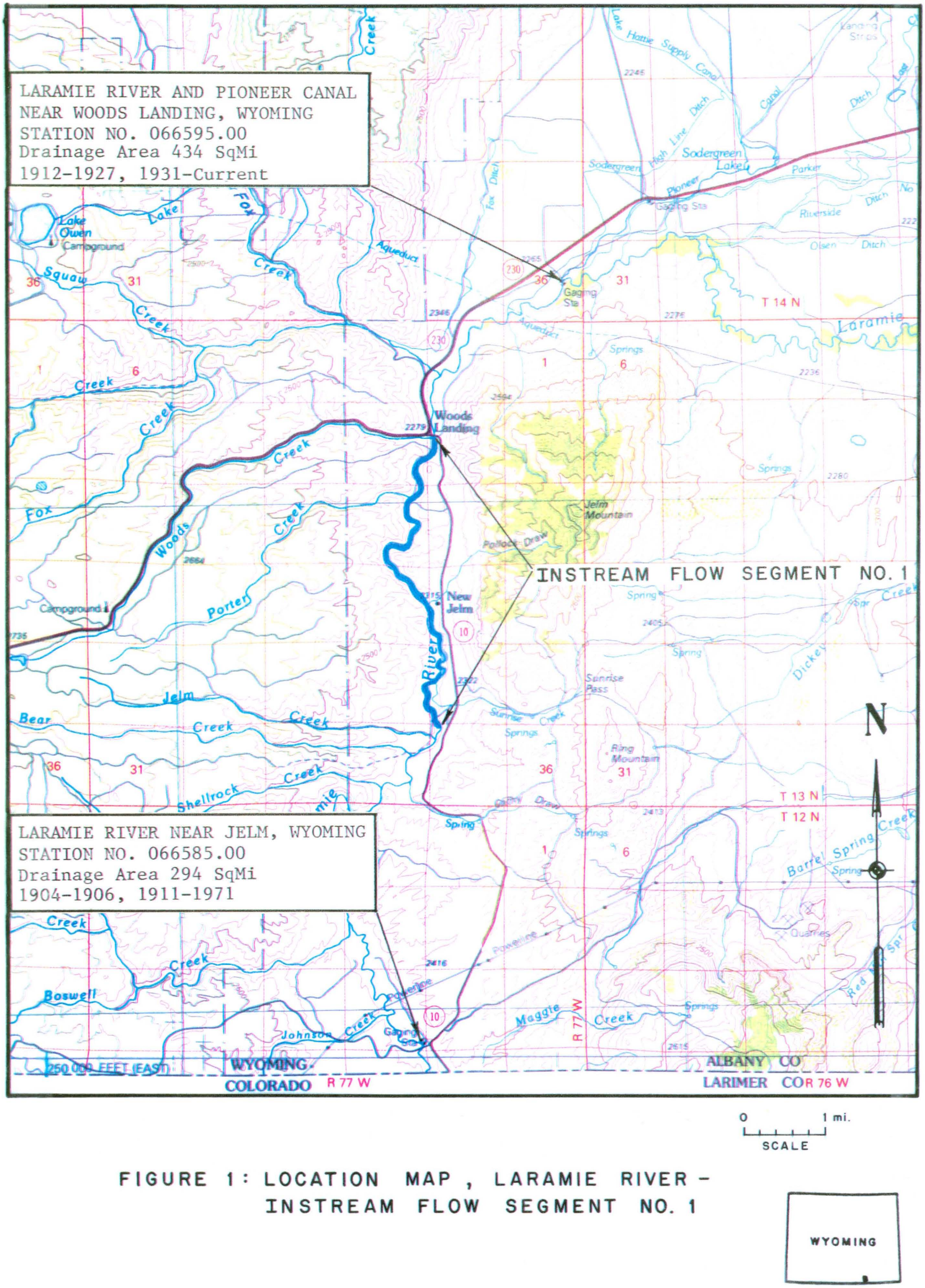


FIGURE 1: LOCATION MAP, LARAMIE RIVER - INSTREAM FLOW SEGMENT NO. 1

Mean monthly flow, dry year flow, and a daily flow exceedence analyses were conducted for the Laramie River at the lower end of the proposed Instream Flow Segment No. 1. The mean monthly flow analysis shows that on the average, the flow of 50 cfs requested for the period of October through March is not available in its entirety during the months of December through March. The requested flows of 100 cfs for the months of April, May and June and of 50 cfs for the month of July, August and September are available during average years. During extremely dry years the requested flows are available only during the spring runoff months of April, May and June.

A daily flow duration analysis was conducted for each of the three periods throughout the year. The flow of 50 cfs requested for the months of October through March is available only about 26% of the time, the requested flow of 100 cfs for the months of April, May and June is available 80% of the time, and the flow of 50 cfs requested for the months of July, August and September is available 70% of the time. WGFD considers that if the requested flows are available at least 50% of the time during the period of July through September, their criteria are satisfied. The WGFD has not developed exceedence criteria for other times of the year but has stated that during these periods the flow should equal natural flows up to the requested amounts.

II WATER RIGHTS

Water rights and permits for diversion at points located upstream of the downstream end of the instream flow segment have been tabulated. Table 1 lists the Wyoming water rights and Table 2 lists the Colorado water rights. Both direct flow and storage rights are

TABLE 1

WYOMING WATER RIGHTS
From the Laramie River and Tributaries
Upstream of the Downstream End of
Instream Flow Segment No. 1

Permit Number	Proof Number	Facility	Source	Priority Date Mo	Day	Yr	Amount CFS	Use*	Adj./ Unadj.	Diversion Location Sec.	Twn.	Rng.	**
DIRECT FLOW													
Terr-29	4509	Smith No. 2 Ditch	Laramie River	5		1885	0.43	1	Adj.	34	13	77	A
Terr-29	4508	Smith No. 1 Ditch	Laramie River	5		1885	1.00	1	Adj.	34	13	77	A
Terr	4675	Bear Gulch Ditch	Bear Gulch			1889	1.14	1	Adj.	33	13	77	A
Terr-46	4536	Heidrich Ditch	Laramie River	9		1889	0.83	1	Adj.	26	13	77	IN
1027	5990	Bench Placer Mining	Bear Gulch	7	23	1895	1	9	Canc.	34	13	77	A
3347	17448	Porter Mill Race & Ditch	Laramie River	8	07	1901	0.50	1	Adj.	15	13	77	IN
5041	5995	Johnson Creek Ditch	Johnson Creek	8	03	1902	0.57	1	Adj.	16	12	77	A
5040	5997	Beaver Creek Ditch	Boswell Creek	9	03	1902	0.57	1	Adj.	9	12	77	A
5454	5987	Mattie Ditch	Jelm or Spring Creek	5	7	1903	0.01	1,3	Adj.	34	13	77	A
6825	9419	C.D.	Johnson Creek	8	31	1905	2.18	1	Adj.	16	12	77	A
1413E	9420	Enl. Johnson Creek Ditch	Johnson Creek	8	31	1905	1.31	1	Adj.	16	12	77	A
7871	17456	Crystal Ditch	Spring	7	9	1907	0.06	1,3	Adj.	30	13	76	IN
7969	9414	Champion Ditch	Spring	9	23	1907	0.68	1,3	Adj.	23	13	77	IN
15095	20369	Jelm Ditch	Jelm or Spring Creek	3	17	1917	0.27	1,2,3	Adj.	34	13	77	A
15094	20368	Mansfield Ditch	Bear Gulch	3	17	1917	1.55	1,2,3	Adj.	34	13	77	A
19036	23504	Jelm Mtn. Lookout Pipe Line	Jelm Spring	12	2	1938	0.01	2	Adj.	13	13	77	IN
19641	22926	Gramm Summer Home Pipeline	Gramm Spring	7	03	1941	0.03	2,3	Adj.	2	12	78	A
23478	29891	Potter Pipeline	Potter Spring	7	16	1970	0.04	3	Adj.	4	12	78	A
23670	30110	Hatcher Spring and Pipe Line	Hatcher Spring	6	10	1971	0.06	2	Adj.	23	13	77	IN
23672	30514	Maggie Creek Spring	Maggie Creek Spring	9	2	1971	0.06	3	Adj.	17	12	76	A
23932	30663	Hansel Spring Pipeline	Hansel Spring	10	6	1972	0.06	2	Adj.	22	13	77	IN
TF 27 6/30	-----	Laramie River - Ins. Flow Seg. 1	Laramie River	12	15	1989	50,100	Instream Flow	Unadj.	10	13	77	
RESERVOIRS													
5035R	22971	Maggie Creek No. One Res.	Maggie Creek	9	1	1938	0.85 AF	2,3	Adj.	18	12	76	
5036R	22972	Maggie Creek No. Two Res.	Maggie Creek	9	1	1938	0.90 AF	2,3	Adj.	17	12	76	
7184SR	30550	Enl. Maggie Creek No. 1 St. Res.	Maggie Creek	10	4	1971	2.33 AF	3	Adj.	18	12	76	
7475R	30852	Homan Reservoir	Boswell Creek	9	28	1972	5.20AF	3,10,11	Adj.	21	12	78	

* Use Description
1=Irrigation, based on 1 cfs/70 acres
2=Domestic
3=Stock
4=Highway Department
5=Power
6=Reservoir Conveyance
7=BLM Water Use
8=Municipal Use
9=Mining
10=Flood Control
11=Fish

** A-Indicates diversion is above upper end of proposed Instream Flow Segment #1

IN-Indicates diversion is within proposed Instream Flow Segme

TABLE 2

COLORADO WATER RIGHTS
From the Laramie River and Tributaries
Upstream of the Downstream End of
Instream Flow Segment No. 1

Permit Number	Proof Number	Facility	Source	Priority Date Mo	Day	Yr	Amount CFS*	Use**	Adj./ Unadj.	Diversion Location Sec.	Twn.	Rng.
DIRECT FLOW												
519		Mansfield Ditch 2	Laramie River	6	1	1880	19.84	1	Adj.	1	11	77
512		Hills Ditch	Laramie River	7	1	1880	11	1	Adj.	33	11	76
520		Warren Ditch	Laramie River	3	25	1881	6.67	1	Adj.	26	12	77
566		Hance Ditch	Grace Ck	3	31	1881	19.44	1	Adj.	2	11	77
568		Stuck Ck Ditch	Stuck Ck	4	1	1881	16.12	1	Adj.	22	12	77
549		Jim Creek Ditch	Jim Creek	7	10	1881	9	1	Adj.	36	11	76
572		Bliler Boswell Ditch	Laramie River	4	1	1882	9.39	1	Adj.	23	12	77
572		Bliler Boswell Ditch	Laramie River	4	1	1882	16.43	1	Adj.	35	12	77
518		Mansfield Ditch	Laramie River	4	20	1882	11.61	1	Adj.	12	11	77
514		Yelton Ditch	Laramie River	7	1	1882	30.14	1	Adj.	29	11	76
509		Martin Ditch No 1	Laramie River	4	20	1883	15.5	1	Adj.	14	10	76
559		La Garde Ditch	La Garde Ck	6	10	1883	10.33	1	Adj.	20	11	76
551		Ward Ditch No 1	Jimmy Ck	6	15	1883	4.25	1	Adj.	27	11	76
550		Ward Ditch No. 2	Jimmy Ck	7	1	1883	9.48	1	Adj.	26	11	76
553		Jimmy Creek Ditch	Jimmy Ck	6	1	1884	5.52 (S)	1	Adj.	7	11	76
513		Smiths Brown Ditch	Laramie River	6	10	1884	16.63	1	Adj.	33	11	76
554		Trollope Ck. Ditch	Trollope Creek	6	15	1884	6.89	1	Adj.	23	11	76
541		Homestead Ditch	Mc Intyre Ck	7	10	1884	9	1	Adj.	6	10	76
552		Ollie Ditch	Jimmy Ck	7	1	1886	3.45 (S)	1	Adj.	27	11	76
510		Martin Ditch No 2	Laramie River	4	30	1887	14.5	1	Adj.	10	10	76
511		Upper Hills Ditch	Laramie River	5	1	1887	10.0 (S)	1	Adj.	34	11	76
565		Grace Creek Ditch	Grace Ck	4	1	1888	3.07	1	Adj.	14	11	77
524		Brown Ditch	Nun Ck	5	31	1890	10	1	Adj.	36	10	76
542		Lamb Ditch	Mc Intyre Ck	6	1	1890	3.88	1	Adj.	5	10	76
515		Jimmy Creek Ditch	Laramie River	5	1	1891	5.52 (AP)	1	Adj.	20	11	76
522		Laramie River Ditch	West Branch Lar. R.	8	7	1891	400	1	Adj.	14	8	76
539		Comet Ditch	Mc Intyre Ck	12	7	1892	7.4	1	Adj.	17	10	76
534		Forrester Ditch	Brown Ck	5	15	1893	7	1	Adj.	25	10	76
557		Pache Ditch	La Garde Ck	5	25	1893	18.14	1	Adj.	31	11	76
505		Link Ditch #1	Laramie River	6	1	1894	14.22	1	Adj.	11	9	76
535		Lone Tree Ditch	Lone Tree Ck	10	24	1894	25	1	Adj.	11	10	76
546		Stuart Ditch	Stuart Ck	4	15	1896	7.2 (S)	1	Adj.	6	10	76
554		Trollope Ck. Ditch Enl.	Trollope Creek	5	29	1896	10.86	1	Adj.	23	11	76
567		Slough Creek Ditch	Slough Ck	5	30	1896	4.11	1	Adj.	2	11	77
559		La Garde Ditch Enl	La Garde Ck	6	1	1896	4.87 (S)	1	Adj.	20	11	76
553		Jimmy Ck. Ditch Enl	Jimmy Ck.	6	2	1896	9.48 (S,AP)	1	Adj.	17	11	76
515		Jimmy Creek Ditch Enl	Laramie River	6	2	1896	9.48 (S)	1	Adj.	20	11	76
527		Link Ditch #2 Enl	Link Creek	6	15	1896	3.4 (S)	1	Adj.	2	9	76
527		Link Ditch #2	Laramie River	6	15	1896	2.0	1	Adj.	2	9	76
558		La Garde Ditch No 1	La Garde Ck	6	16	1896	15.4 (S)	1	Adj.	30	11	76

TABLE 2 (continued)

COLORADO WATER RIGHTS

From the Laramie River and Tributaries Upstream of the Downstream End of Instream Flow Segment No. 1

Permit Number	Proof Number	Facility	Source	Priority Date Mo	Priority Date Day	Priority Date Yr	Amount CFS*	Use**	Adj./ Unadj.	Diversion Location Sec.	Diversion Location Twn.	Diversion Location Rng.
564		Detro Ditch No 1	Forrester Creek	6	17	1896	5.0 (S)	1	Adj.	7	11	76
506		Parker Ditch	Laramie River	10	10	1896	14.1 (S)	1	Adj.	26	10	76
583		Sand Creek D. Sys	Columbine Ck	6	15	1899	288.0 (S)	1	Adj.	27	11	77
565		Grace Creek D. 1 Enl	Grace Ck	4	28	1900	6.3 (S)	1	Adj.	14	11	77
524		Brown Ditch	Porter Creek	9	10	1900	15.9 (S)	1	Adj.	24	9	76
531		Davy Ditch	Deadman Ck	9	15	1900	20.0 (S)	1	Adj.	36	10	76
533		Cabin Ditch	Stubb Ck	9	16	1900	7.94 (S)	1	Adj.	35	10	76
536		Glendevey Ditch	Mc Intyre Ck	7	1	1901	2.0 (S)	1,2	Adj.	29	10	76
543		Talmage Ditch No 2	Jinks Ck	7	2	1901	3.0 (S)	1,2	Adj.	28	10	76
523		Brinker Creek D.	Brinker Creek	7	10	1901	8.0 (S)	1	Adj.	24	9	76
562		Homestead D. No 1	Big Jenkins Ck	10	22	1901	5.0 (S)	1	Adj.	25	11	77
561		Homestead D. No 2	Little Jenkins Ck	10	23	1901	8.0 (S)	1	Adj.	25	11	77
518		Mansfield Ditch Enl	Laramie River	4	1	1902	4.0 (S)	1	Adj.	12	11	77
519		Mansfield Ditch 2 Enl	Laramie River	4	15	1902	1.9 (S)	1	Adj.	1	11	77
542		Lamb Ditch Enl	Mc Intyre Ck	5	28	1902	15.0 (S)	1	Adj.	5	10	76
574		Forrester Ck. D. No. 2	Forrester Creek	5	30	1902	4.0 (S)	1	Adj.	7	11	76
537		Talmage Ditch No 1	Mc Intyre Ck	5	31	1902	8.0 (S)	1	Adj.	29	10	76
528		Nun Creek Ditch	Nun Creek	7	8	1902	5.0 (S)	1	Adj.	18	9	75
502		Long Park Ditch	Laramie River	7	10	1902	10.0 (S)	1	Adj.	25	9	76
544		Pine Creek Ditch	Pine Ck	8	20	1902	4.0 (S)	1	Adj.	20	10	76
500		Rawah Lower Sup D	Rawah Creek	8	25	1902	275.0 (S)	1	Adj.	14	9	76
576		Lar. R. Tunnel of Lar. Sys	Laramie River	8	25	1902	300.0 (S)	1	Adj.	7	8	75
582		Rawah D of Lar R Sys	Rawah Creek	8	25	1902	225.0 (S)	1	Adj.	32	9	76
581		Mc Intyre D. of Lar R Sys	Mc Intyre Ck	8	25	1902	40.0 (S)	1	Adj.	31	9	76
560		Nellie Ditch	Mc Guire Ck	9	10	1903	15.3 (S)	1	Adj.	2	10	77
507		Timothy Ditch	Laramie River	7	5	1904	34.36 (S)	1	Adj.	23	10	76
580		Mansfield Ditch No 3	Laramie River	9	1	1904	29.4 (S)	1	Adj.	1	11	77
556		Schnitger Ditch Enl	La Garde Ck	5	29	1906	8.0 (S)	1	Adj.	30	11	76
548		British Ck Ditch No 2	British Ck	7	1	1906	12.0 (S)	1	Adj.	6	10	76
565		Grace Creek D. 2 Enl	Grace Ck	4	1	1907	10.0 (S)	1	Adj.	14	11	77
538		Mc Intyre Ditch	Mc Intyre Ck	7	21	1908	7.0 (S)	1	Adj.	20	10	76
510		Martin D. 2 2nd Enl Ext	Laramie River	5	25	1910	6.0 (S)	1	Adj.	10	10	76
544		Pine Creek Ditch Ext.	Pine Ck	7	8	1911	1.75 (S)	1	Adj.	20	10	76
532		Stubb Creek D.	Stubb Ck	7	28	1911	5.0 (S)	1	Adj.	35	10	76
579		Grant Ditch	Roaring Ck	6	30	1912	10.0 (S)	1	Adj.	7	10	76
540		Stuart Ditch No. 2	Mc Intyre Ck	5	24	1913	29.4 (C,S)	1	Adj.	9	10	76
584		Wright Ditch No 2	Laramie River	7	3	1916	15.0 (S)	1	Adj.	14	10	76
526		Comet Ditch Enl	Spring Ck	7	1	1923	2.6 (S)	1,2	Adj.	17	10	76
556		Schnitger Ditch Enl.	La Garde Ck	4	20	1940	9.0 (S)	1	Adj.	30	11	76
2401		Stuck Ck. Min Flow	Stuck Ck	7	11	1978	1.0 (S)	11	Adj.	35	11	78
2101		Johnson Ck Min Flow	Johnson Ck	7	11	1978	2.0 (S)	11	Adj.	20	12	77

TABLE 2 (continued)

COLORADO WATER RIGHTS

From the Laramie River and Tributaries Upstream of the Downstream End of Instream Flow Segment No. 1

Permit Number	Proof Number	Facility	Source	Priority Date Mo	Day	Yr	Amount CFS*	Use**	Adj./ Unadj.	Diversion Location Sec.	Twn.	Rng.
RESERVOIRS												
4004		Johnson Res	Grace Ck	6	7	1897	149.0 AF (S)	1	Adj.	2	11	77
4001		Link Lake No 11	Mc Intyre Ck	8	25	1902	1148.0 AF(S,C	1	Adj.	31	9	76
3998		Link Lake #4	Rawah Creek	8	25	1902	592.0 AF (S)	1	Adj.	32	9	76
4002		Link Lake No 10	Mc Intyre Ck	8	25	1902	425.0 AF (S,C	1	Adj.	31	9	76
3390		Link Lake No 1	Rawah Creek	8	25	1902	1050.0 AF (S)	1	Adj.	7	8	76
3993		Link Lake No 3	Rawah Creek	8	25	1902	525.0 AF (S)	1	Adj.	5	8	76
3392		Link Lake No 2	Rawah Creek	8	25	1902	1400.0 AF (S)	1	Adj.	5	8	76
3991		Link Lake No 9	Rawah Creek	8	25	1902	2000.0 AF (S)	1	Adj.	6	8	76
3995		Link Lake #5	Rawah Creek	8	25	1902	700.0 AF (S)	1	Adj.	5	8	76
3997		Link Lake #12	Rawah Creek	8	25	1902	138.0 AF (S)	1	Adj.	4	8	76
3994		Link Lake #7	Rawah Creek	8	25	1902	440.0 AF (S)	1	Adj.	5	8	76
3996		Link Lake #8	Rawah Creek	8	25	1902	574.0 AF (S)	1	Adj.	4	8	76
3999		Link Lake #6	Rawah Creek	8	25	1902	314.0 AF (S)	1	Adj.	32	9	76
4000		Link Lake #13	Rawah Creek	8	25	1902	597.0 AF (S)	1	Adj.	29	9	76
4003		Link Lake #14	Spring Creek	8	25	1902	597.0 AF (S)	1	Adj.	29	9	76
4006		Laramie River Res	Laramie River	8	6	1908	44536 AF (S,C	1	Adj.	35	10	76
4004		Johnson Res Enl	Grace Ck	6	1	1940	Not Stated (S)	1	Adj.	2	11	77

* NOTE:
C - Conditional
S - Supplemental
AP- Alternate Point of Diversion
CA- Conditional Made Absolute

** USE DESCRIPTION:
1=Irrigation
2=Domestic
3=Stock
4=Highway Department
5=Power
6=Reservoir Conveyance
7=BLM Water Use
8=Municipal Use
9=Mining
10=Flood Control
11=Fish

listed in each table. The listings of both Wyoming and Colorado water rights were obtained from the respective State Engineer's Offices in January 1991.

There is a U.S. Supreme Court Decree governing diversions of water in Colorado for use both within the basin and by out-of-basin diversions. A 1957 stipulation to the Decree limits the trans-mountain diversions to 19,875 acre-feet per year and limits in-basin diversions to 29,500 acre-feet per year. The decree also identifies which lands can be irrigated within the Laramie River Basin in Colorado. The basis of the stipulation is that there is significant return flow to the Laramie River from the meadowlands in Colorado diversions which are useable in Wyoming.

III STREAMFLOW RECORDS

Two United States Geological Survey (USGS) streamflow gaging stations were used to estimate flow at the downstream end of the proposed instream flow segment. The locations of these gages are shown on Figure 1. These gaging stations are:

1. Laramie River near Jelm, Wyoming; Station Number 066585.00; 1904-1906, 1911-1971.

2. Laramie River and Pioneer Canal Near Woods, Wyoming; Station Number 066595.00; 1912-1923, 1931-Current.

A third gaging station did exist for a few years at a site closer to the instream flow segment but the records are of little use due to their short length and lack of overlap with other stations. That station is:

3. Laramie River at Woods Landing, Wyoming; Station Number 066595.00; 1897-1900, 1911-1912.

Station number 066595 (Pioneer) is approximately 3 miles downstream from the downstream end of the instream flow segment. Station number 066585 (Jelm) is approximately 6 miles upstream from the upstream end of the instream flow segment. The mean monthly flows in c.f.s. for Station number 066585 (Jelm) and Station number 066595 (Pioneer) are presented in Tables 3 and 4, respectively.

IV HYDROLOGY

A hydrologic analysis was conducted to estimate the flows at the downstream end of the proposed instream flow segment. The analysis developed a linear relationship between the flows at the stations upstream and downstream of the instream flow segment. From that relationship, the flow at the downstream end of the instream flow section was estimated by assuming that the per square mile flow contribution between the two gages was uniform.

Station number 066585, (Jelm), is very close to the Wyoming-Colorado state line. Records at this station reflect all of the Colorado diversions and the Wyoming diversions on Maggie Creek which joins the Laramie River in Colorado. Diversion and storage rights on Maggie Creek are very small and not significant to this analysis. Records of the Laramie River at station number 066595, (Pioneer), reflect all Wyoming diversions upstream of, within, and downstream of the proposed instream flow segment to the Pioneer Canal. The records for the station include diversions by the Pioneer Canal, the first large diversion from the Laramie River in Wyoming. Figure 2 is a schematic diagram of the Laramie River from the Colorado State Line to the Pioneer Canal showing the relative locations of gaging stations, tributaries, diversions, and the proposed instream flow segment.

TABLE 3

LARAMIE RIVER NEAR JELM, WYOMING
Station No. 066585.00
Average Monthly Flows (cfs)

YEAR	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL(AF)
1904										271.71	101.00	45.90	
1905	44.61	40.00	35.00	30.00	25.00	22.00	50.17	458.23	1158.83	212.35	97.84	39.60	133406
1906				35.00	30.00								
1907													
1908													
1909													
1910													
1911				35.00	30.00	40.00	120.00	565.06	791.77	222.55	71.39	43.07	
1912	68.06	62.33	45.00	40.00	45.00	45.00	60.00	488.45	1245.23	543.00	119.81	81.73	171794
1913	83.29	55.30	35.00	40.00	35.00	50.00	175.57	516.32	440.63	134.77	55.26	51.97	101232
1914	71.39	55.87	45.00	40.00	40.00	50.00	114.97	956.94	1335.23	234.29	107.74	37.27	186617
1915	71.61	45.00	28.00	22.00	28.00	30.00	120.03	303.90	477.17	128.61	73.13	63.43	83956
1916	68.77	50.10	45.00	48.00	48.00	65.00	111.83	528.06	761.50	154.45	97.65	82.37	124762
1917	90.00	80.00	65.00	52.00	50.00	40.00	100.13	470.39	2002.40	876.45	171.71	81.03	246028
1918	44.48	40.00	35.00	35.00	35.00	45.00	87.13	581.13	1170.13	242.42	90.68	61.03	148788
1919	50.00	45.00	45.00	45.00	45.00	50.00	120.07	425.23	281.97	91.77	54.90	37.77	78194
1920	42.61	35.00	30.00	30.00	25.00	30.00	50.00	590.00	1392.70	284.19	147.74	75.90	164874
1921	59.68	30.00	40.00	40.00	40.00	50.00	84.90	583.55	1414.07	316.52	122.68	62.43	171465
1922	49.03	38.00	35.00	30.00	30.00	50.00	80.03	334.74	499.43	121.13	68.58	37.03	82945
1923	31.26	28.00	25.00	25.00	25.00	35.00	75.00	450.00	1480.00	395.97	101.35	64.90	164842
1924	76.90	75.93	48.00	45.00	40.00	50.00	160.07	515.16	988.57	189.10	64.65	60.00	139537
1925	75.10	60.00	50.00	40.00	35.00	45.00	70.20	339.06	397.03	151.87	118.39	95.27	89369
1926	105.00	85.10	70.00	65.00	50.00	75.00	167.40	842.55	830.07	292.90	96.65	57.30	165731
1927	65.03	50.27	35.00	30.00	40.00	60.00	73.77	516.06	648.93	213.58	104.13	61.70	114839
1928	75.55	55.00	45.00	40.00	40.00	50.00	88.97	844.19	879.53	296.55	86.03	50.67	154596
1929	56.97	49.70	40.00	35.00	35.00	45.00	120.07	425.13	1262.00	338.71	110.74	97.07	157573
1930	66.35	40.00	25.00	15.00	15.00	20.00	192.27	416.29	449.37	120.10	135.90	61.23	94143
1931	77.55	46.57	32.00	30.00	35.00	39.55	171.03	304.39	383.97	66.52	42.45	33.33	76151
1932	54.26	47.20	35.00	30.00	30.00	40.00	92.60	594.71	723.70	157.71	56.74	32.17	114567
1933	44.65	48.07	25.65	23.13	22.68	35.42	121.07	256.61	1089.53	146.45	52.06	49.70	115019
1934	44.23	32.03	27.42	31.10	37.29	41.52	107.60	231.68	51.33	17.90	29.52	21.93	40770
1935	34.13	27.63	23.61	25.52	28.89	32.74	44.73	176.26	1030.83	183.71	56.97	40.53	102430
1936	48.71	64.80	36.97	34.77	39.45	37.58	192.17	585.10	401.03	99.58	66.90	43.77	99957
1937	50.77	55.73	28.32	23.74	25.36	38.29	111.97	433.39	406.50	135.61	50.32	36.10	84482
1938	48.42	39.23	29.32	29.26	39.21	65.77	99.83	614.84	1019.77	197.62	55.65	78.70	139817
1939	58.29	44.13	30.52	26.19	28.21	45.65	98.87	476.39	318.53	45.61	31.68	32.03	74858
1940	38.58	36.57	24.16	23.45	23.86	33.06	57.90	335.32	482.73	212.90	63.45	50.43	83663
1941	61.06	40.63	37.23	32.39	29.43	39.71	60.33	378.77	478.47	210.84	88.52	68.93	92388
1942	81.55	56.77	36.55	20.81	22.00	26.23	100.97	460.84	934.30	127.61	46.29	32.53	117320
1943	54.45	48.53	38.26	28.03	31.93	41.16	172.70	466.81	838.63	128.00	60.52	34.34	117134
1944	40.90	41.10	30.74	20.77	20.48	24.74	67.27	302.65	489.00	146.45	63.13	28.67	77129

TABLE 3 (continued)

LARAMIE RIVER NEAR JELM, WYOMING
Station No. 066585.00
Average Monthly Flows (cfs)

YEAR	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL(AF)
1945	43.19	31.07	28.32	26.48	30.07	30.74	59.60	427.13	619.93	296.13	187.29	71.07	112086
1946	58.32	55.93	41.16	32.03	30.82	44.03	179.67	394.03	588.03	209.58	93.81	54.90	107665
1947	57.61	46.87	40.39	20.00	20.93	28.13	85.13	604.74	783.63	340.03	130.74	81.33	135602
1948	78.23	67.30	55.00	42.00	36.00	39.00	98.97	592.87	431.40	126.77	80.48	32.70	101950
1949	39.29	34.97	30.68	28.74	31.50	42.61	114.63	513.23	962.97	157.74	70.26	46.30	124973
1950	55.06	43.67	30.48	24.23	29.93	31.16	73.90	285.39	605.39	150.87	71.10	68.97	88625
1951	47.45	38.73	34.10	27.48	27.68	34.52	88.30	626.39	978.27	204.55	127.71	60.90	138702
1952	66.23	42.20	30.29	32.48	32.79	44.06	133.70	696.35	981.83	144.94	56.84	33.67	138645
1953	33.42	31.20	28.90	31.71	28.11	35.97	56.77	190.23	361.23	74.06	103.90	32.13	60835
1954	34.23	38.87	35.48	33.29	25.21	29.06	84.47	240.32	107.57	48.13	30.90	21.47	44174
1955	53.77	38.40	33.10	23.84	23.79	26.06	49.63	214.35	271.50	125.84	118.06	34.90	61378
1956	37.48	46.67	35.13	35.16	31.34	37.32	86.03	645.29	585.63	126.42	103.61	32.50	109224
1957	25.71	37.17	29.68	25.48	32.18	38.16	64.67	352.58	1571.67	643.52	103.42	56.93	179681
1958	65.48	51.33	40.03	36.45	32.46	31.52	58.90	635.77	510.60	75.42	58.84	37.90	99015
1959	42.71	38.07	30.45	29.87	29.93	31.48	59.20	336.61	745.43	113.19	84.55	55.67	96246
1960	80.58	58.57	34.39	19.42	15.10	19.48	128.03	361.42	584.00	141.42	101.55	52.07	96444
1961	45.19	39.03	24.58	17.48	14.14	20.87	49.27	411.68	838.70	125.26	73.90	124.60	107568
1962	156.03	103.13	53.55	41.71	61.50	56.16	270.50	763.55	804.23	333.10	71.45	42.80	166778
1963	53.61	36.37	30.77	19.97	26.18	35.94	69.90	352.52	196.97	50.48	101.87	64.50	63005
1964	37.35	38.70	24.16	17.68	16.79	16.61	54.97	406.74	449.50	191.65	125.45	60.03	87257
1965	42.77	39.53	33.48	27.29	24.50	27.06	79.87	368.35	1116.13	241.45	105.06	113.40	133614
1966	122.87	75.57	63.90	41.32	32.18	60.00	75.57	306.84	177.33	52.35	47.55	34.23	66093
1967	46.58	37.03	32.06	27.23	28.96	51.19	58.17	302.97	782.20	351.77	60.71	54.53	110705
1968	53.81	41.90	32.65	37.61	38.17	41.65	69.37	214.26	1047.17	163.84	110.61	70.67	115571
1969	59.61	45.80	40.74	35.32	31.93	38.77	120.03	575.29	468.90	125.03	76.39	53.47	101209
1970	66.13	58.93	35.16	25.87	31.93	42.23	96.70	643.87	1072.73	201.77	79.94	58.00	145664
1971	70.74	56.03	35.74	34.87	31.43	47.13	113.20	443.42	1397.53	227.26	82.32	66.23	156805
MEAN	59.13	47.91	36.41	31.61	31.67	39.83	100.01	462.49	767.67	202.41	86.04	54.73	115736
STD DEV	21.95	14.41	9.85	8.98	8.74	11.69	44.09	165.27	399.96	140.32	32.37	21.05	38479
# RECORD	61	61	61	63	63	62	62	62	62	63	63	63	61
MIN	25.71	27.63	23.61	15.00	14.14	16.61	44.73	176.26	51.33	17.90	29.52	21.47	40770
MAX	156.03	103.13	70.00	65.00	61.50	75.00	270.50	956.94	2002.40	876.45	187.29	124.60	246028

TABLE 4

LARAMIE RIVER AND PIONEER CANAL NEAR WOODS, WY.
Station No. 066595.00
Average Monthly Flow (cfs)

YEAR	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL(AF)
1912							649.74	649.74	1577.20	558.84	127.68	80.13	
1913	103.52	69.90	37.58	43.06	42.61	53.58	213.40	622.65	446.27	111.35	50.58	50.80	160855
1914	43.19	59.83	51.77	46.16	47.04	54.58	130.23	992.58	1022.07	152.97	41.32	18.57	91843
1915	70.19	50.17	30.23	24.77	32.64	35.42	137.67	331.87	539.67	140.26	64.45	63.30	146424
1916	65.10	49.47	46.48	51.61	52.86	69.26	148.70	690.71	801.07	224.42	125.26	95.13	279923
1917	104.87	85.30	68.90	57.35	52.61	43.26	124.90	618.19	2334.73	896.84	184.97	70.03	
1918							105.83	841.45	1390.97	243.81	78.00	72.70	
1919	52.71						129.80	459.65	291.20	75.94	57.52	38.40	
1920								985.45	1580.17	327.71	138.19	78.03	
1921	55.45	72.70	64.00			69.10	92.77	890.17	1591.43	314.81	151.81	55.57	
1922	61.97	51.50	26.71	19.00	19.00	49.52	130.87	489.97	656.67	113.45	64.23	34.97	103779
1923	14.65	26.33					79.50	524.42	1727.20	542.10	136.32	80.80	
1924													
1925													
1926													
1927								772.45	762.97	251.26	77.55	70.37	
1928													
1929													
1930													
1931													
1932								874.61	836.50	184.13	65.74	29.73	
1933	44.00	40.93	35.00	35.00	38.00	55.00	93.47	395.32	1270.83	160.71	52.68	45.87	136276
1934	36.84	32.00	30.00	34.00	40.00	50.10	139.90	287.32	62.93	20.13	26.07	14.76	46862
1935	33.77	23.55					64.43	307.39	1220.67	204.19	60.13	38.30	
1936	42.49	55.56						793.30	458.20	107.59	85.80	48.45	
1937	38.99	65.13				41.00	136.30	579.13	495.07	156.75	53.83	34.60	
1938	47.38	50.60				75.25	151.97	898.71	1202.93	214.74	67.53	111.73	
1939	67.61	73.00					160.63	561.35	314.65	52.72	40.58	30.58	
1940	36.79	37.90				70.04	86.65	402.71	471.70	219.10	59.92	50.33	
1941	63.19	50.55					88.33	487.35	467.50	209.23	86.43	42.46	
1942	75.24	84.64					176.82	639.81	1106.73	152.20	48.13	33.34	
1943	52.90	57.00					272.77	543.10	869.07	139.97	54.79	32.33	
1944	39.06						75.56	386.26	511.47	157.47	67.51	27.36	
1945	46.03	44.13					147.40	681.03	738.00	319.39	201.26	67.43	
1946	57.93	73.84					240.03	466.84	610.10	216.97	92.31	52.31	
1947	45.06						128.78	802.74	930.43	391.97	142.61	75.98	
1948	76.11						194.88	815.09	487.00	135.77	80.68	27.67	
1949	51.40							743.19	1127.50	201.72	65.96	49.50	
1950	67.16						108.57	457.98	738.47	166.99	72.79	73.55	
1951	51.71	44.90	43.13	36.19	36.96	43.13	119.90	854.74	1051.47	212.39	122.94	57.60	161736
1952	79.74	50.40	41.03	42.26	41.41	51.84	197.10	920.55	1027.93	157.68	55.55	31.00	163045
1953	33.74	42.60	40.13	44.06	40.07	52.48	78.57	233.29	376.53	74.00	101.13	28.77	69144
1954	34.58	43.93	38.54	31.39	31.21	40.26	123.20	287.81	116.90	50.52	24.84	17.37	50894

TABLE 4 (continued)

LARAMIE RIVER AND PIONEER CANAL NEAR WOODS, WY.
Station No. 066595.00
Average Monthly Flow (cfs)

YEAR	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL(AF)
1955	49.45	38.43	35.42	24.90	24.64	29.39	67.00	241.63	281.63	133.94	127.06	35.53	65960
1956	36.81	43.07	41.26	37.74	34.55	50.32	108.13	786.23	680.87	129.03	100.32	32.73	126107
1957	35.26	44.03	34.35	28.35	37.04	47.77	83.40	554.19	2052.00	725.84	125.29	63.97	230920
1958	80.23	63.37	54.45	46.19	43.07	43.13	87.90	843.39	539.60	83.84	62.74	46.10	120889
1959	50.74	42.97	32.58	32.06	32.21	35.97	97.40	485.39	787.30	123.77	85.16	58.00	112439
1960	91.29	64.60	55.13	44.39	38.86	42.26	192.27	443.81	620.63	143.55	97.84	48.93	113823
1961	40.26	33.20	28.26	24.32	27.32	43.10	76.37	537.52	933.70	137.06	78.10	128.27	125867
1962	160.39	94.90	58.19	53.65	74.50	70.00	355.47	1057.45	781.47	310.35	75.10	45.50	189907
1963	59.06	51.13	41.77	34.68	43.21	48.42	98.97	404.61	233.70	60.00	89.87	61.70	74313
1964	35.81	38.53	33.45	28.48	25.93	27.74	93.33	503.42	460.23	181.48	115.94	56.60	97049
1965	42.10	45.43	38.35	45.81	47.50	50.00	135.20	554.35	1236.07	273.32	115.90	126.23	163305
1966	133.35	87.13	77.39	57.13	43.71	84.94	120.23	343.06	190.20	58.26	46.45	29.17	77046
1967	49.19	37.77	32.61	29.23	40.64	61.48	82.33	328.48	804.83	340.42	63.35	60.07	116501
1968	52.45	48.67	38.26	46.77	43.83	52.90	89.27	342.90	1164.40	182.52	119.65	75.73	135892
1969	69.35	49.43	50.19	39.13	34.61	40.16	163.07	609.58	461.37	127.84	73.94	54.37	107369
1970	74.90	69.17	49.42	39.84	48.57	50.61	101.67	866.71	1162.67	239.81	83.10	60.57	172003
1971	81.52	67.47	39.58	36.58	36.57	59.58	158.43	706.68	1441.43	240.45	81.23	73.57	182212
1972	67.48	46.60	39.48	38.87	42.07	78.84	88.23	382.06	809.57	91.87	84.65	67.60	110799
1973							108.77	839.16	1124.73	348.81	114.87	81.90	
1974							157.84	938.16	830.47	154.87	65.32	65.83	
1975							92.97	308.84	804.50	363.71	89.84	59.90	
1976							106.63	400.39	465.00	162.97	138.61	59.17	
1977							114.37	299.13	237.90	67.26	48.81	33.30	
1978							112.37	548.03	1161.83	202.26	66.55	54.53	
1979							154.07	722.65	1152.83	222.84	88.45	48.10	
1980							143.00	782.90	1040.73	140.65	44.06	33.57	
1981							112.20	233.58	341.40	101.42	43.71	36.57	
1982							69.27	405.45	1086.70	477.77	136.90	123.60	
1983							89.13	504.81	2441.00	1019.48	194.10	78.63	
1984							129.47	1130.74	1207.10	418.00	156.23	116.53	
1985							184.47	828.97	673.17	140.97	49.77	53.33	
1986							272.77	917.52	1719.60	346.16	90.32	88.90	
1987							161.17	407.16	185.70	65.97	39.23	33.73	
1988							155.00	651.00	808.00	99.80	43.10	34.20	
1989							161.00	241.00	188.00	55.30	41.30	45.50	
MEAN	59.25	53.53	43.02	38.43	39.77	52.07	140.18	597.74	863.73	222.98	85.97	56.36	128730
STD DEV	26.04	16.44	11.97	9.73	10.13	13.55	82.55	230.19	503.32	180.00	39.23	25.48	51547
# RECORD	49	43	31	30	30	34	66	71	71	71	71	71	29
MIN	14.65	23.55	26.71	19.00	19.00	27.74	64.43	233.29	62.93	20.13	24.84	14.76	46862
MAX	160.39	94.90	77.39	57.35	74.50	84.94	649.74	1130.74	2441.00	1019.48	201.26	128.27	279923

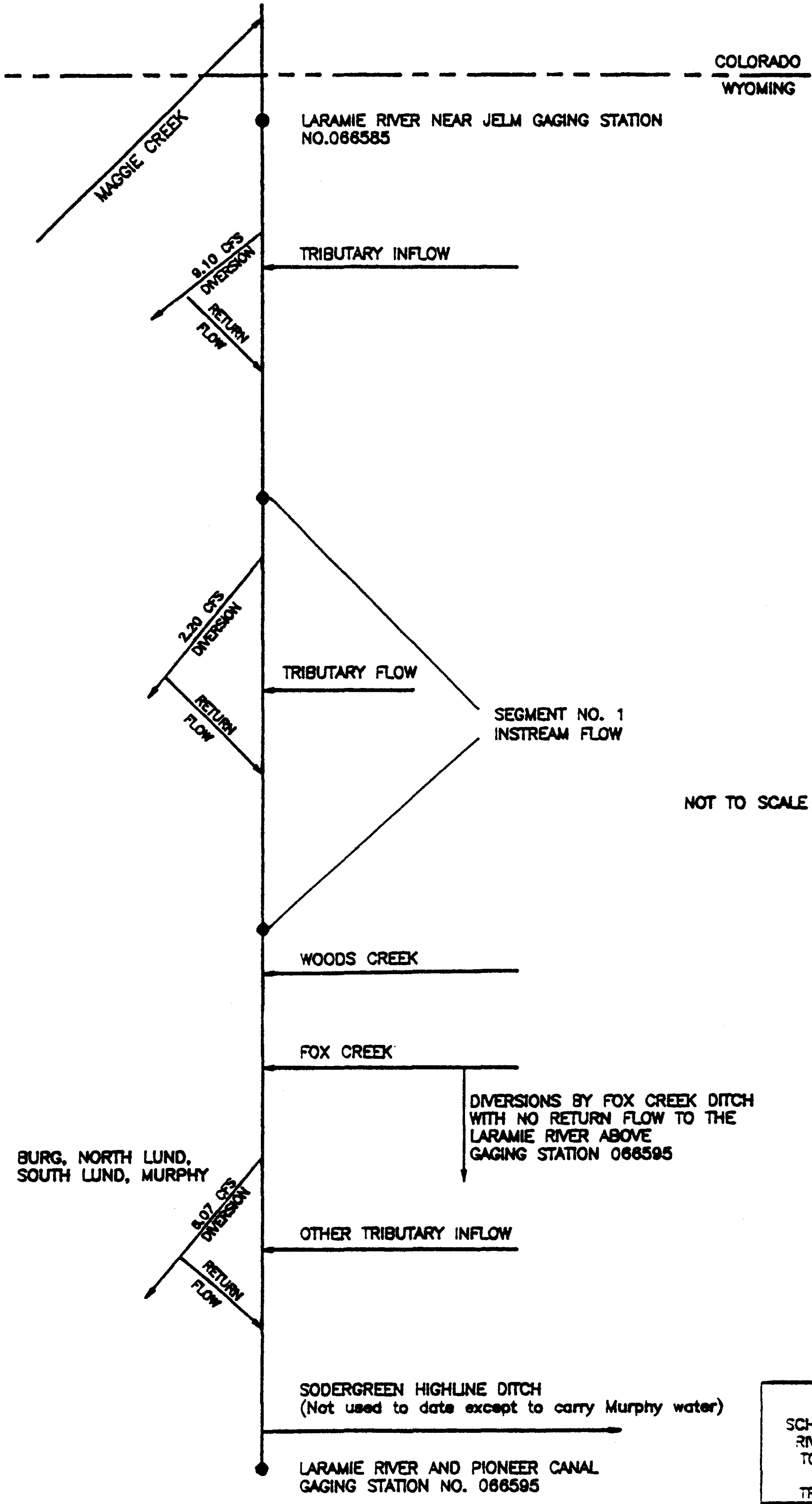


FIGURE 2

SCHEMATIC DIAGRAM OF LARAMIE RIVER BELOW THE STATE LINE TO PIONEER CANAL SHOWING RELATIVE LOCATIONS OF TRIBUTARIES AND DIVERSIONS

Western Water Consultants, Inc.

Adjudicated water rights on the Laramie River and tributaries between the gaging station at Jelm (006585) and the upstream end of the instream flow segment (those indicated with an "A" in Table 1) total 9.10 cfs based on 1 cfs per 70 acres. Water rights within the proposed instream flow segment (those indicated by "in" in Table 1) total 2.20 cfs at 1 cfs per 70 acres. The water rights listed in Table 1 are for the irrigation of lands very close to the Laramie River or tributary streams from which the water is diverted. Since the lands being irrigated are on the permeable alluvium adjacent to the Laramie River or its tributaries much of the return flow occurs during the month in which the water was diverted. The return flow is that portion of the diversion amount which is not consumed for beneficial or non-beneficial purposes. Between the downstream end of the instream flow segment and the station at Pioneer Canal (066595) there are four ditches with water rights totaling 6.07 cfs at 1 cfs per 70 acres. Major tributaries in this latter reach are Woods Creek and Fox Creek. Neither of these creeks are gaged. There are no diversions from Woods Creek but diversions by the Fox Creek Ditch, which has the first priority on Fox Creek, essentially dry up the creek during the irrigation season. Since the irrigated land is not adjacent to the creek, there is little or no return flow to Fox Creek or to the Laramie River above the Pioneer Canal gage. The Sodergreen High Line Ditch has a large water right from the Laramie River in this section, however this ditch has not been utilized except to carry the Murphy appropriation during the period of record analyzed and the amount of that right is not included in the 6.07 cfs mentioned above.

To estimate streamflows at the downstream end of the proposed Instream Flow Segment, several standard estimating procedures were considered. These include estimates of streamflow based on precipitation or snow course data, estimates using geographic regressions such as Lowhman's Method (1988) and unit runoff estimates. It was concluded that the most logical method was to use recorded or estimated values of runoff to compute unit runoff for the area between the two gaging stations above and below the instream flow segment. There are no large inflows or large current uses in the reach of the Laramie River from the state line to the gaging station at the Pioneer Canal, thus the difference between the flows at the two stations divided by the 140 square mile drainage area between them provides an estimate of the yield per square mile within the reach. This average yield for the entire reach multiplied by the 49 square miles of area between the downstream end of the instream flow segment and the Pioneer Canal was subtracted from the recorded flow of the Laramie River at Pioneer Canal to define the estimated flow at the downstream end of the instream flow segment. The average yield was determined by regressing the monthly flows for each period for the two stations thus compensating for minor measurement errors and variations in precipitation and runoff events.

Using the average yield for the entire reach between gaging stations is a conservative assumption since the terrain is less mountainous for the drainage area below the downstream end of the instream flow segment than above it. Therefore the yield per square mile should be higher for the reach above and within the instream flow segment than below it. Using the assumption of uniform yield per square mile for the reach below the instream flow segment results in a conservative, or lower estimate of flow, for the downstream end of the instream flow segment.

There are several years of concurrent records for the Laramie River at the Jelm and Pioneer Canal gages. However, the Jelm gage was discontinued in 1971 and it was felt that, if possible, estimates of yield and also estimates of flow at the instream flow segment for the more recent years 1971-1989 would have more meaning for personal remembrance when considering the feasibility of instream flows. Therefore, the use of regression techniques to estimate the flows at the downstream end of the instream flow segment was selected.

For each of the three instream flow periods; October 1 - March 31, April 1 - June 30, and July 1 - September 30; the mean monthly flow rates for the two stations were correlated using linear regression procedures. The regression lines were forced through zero which lowers the least squares best fit but more accurately reflects the lower flows which are very important in this analysis. Results of the linear regressions with the Pioneer station as the independent variable (X) and the near Jelm station as the dependent variable (Y) are:

October - March (1951 - 1971)

No. of Observations	126
Equation: Jelm = 0.843 (Pioneer) . .	Y = 0.843X
Correlation Coefficient (R) . . .	0.936
Coefficient of Determination (R^2) . .	0.877

April - June (1950 - 1971)

No. of Observations	66
Equation: Jelm = 0.846 (Pioneer) . .	Y = 0.846X
Correlation Coefficient (R) . . .	0.982
Coefficient of Determination (R^2) . .	0.965

July - September (1932 - 1971)

No. of Observations	120
Equation: Jelm = 0.929 (Pioneer) . .	Y = 0.929X
Correlation Coefficient (R) . . .	0.992
Coefficient of Determination (R^2) . .	0.985

As can be seen, these regressions have relatively high correlation coefficients indicating a strong linear relationship between the records from the two gaging stations. Plots of the regressions for the three periods are shown on Figure 3, 4 and 5.

The drainage areas used in the analysis are:

Station No. 066585 (Jelm)	294 square miles
Instream Flow Segment (Downstream End) . .	385 square miles
Station No. 066595 (Pioneer)	434 square miles
Between Gaging Stations	140 square miles
Between Instream Flow Segment and Pioneer Gage .	49 square miles

Based on the regression equations and the drainage areas, the adjustment of the relationship between the stations at Jelm and Pioneer Canal to the instream flow segment yields the following equations which were used to estimate the flows in Table 5.

October - March

Instream Flow Segment = 0.945 (Pioneer)

April - June

Instream Flow Segment = 0.946 (Pioneer)

July - September

Instream Flow Segment = 0.975 (Pioneer)

Using these equations and the recorded flows of the Laramie River at the Pioneer Canal gaging station, the estimated flows at the downstream end of the proposed instream flow segment were computed. These estimates are presented in Table 5.

FIGURE 3: MONTHLY FLOWS OF LARAMIE RIVER AT PIONEER CANAL / JELM FOR PERIOD OCTOBER - MARCH (1951 - 1971)

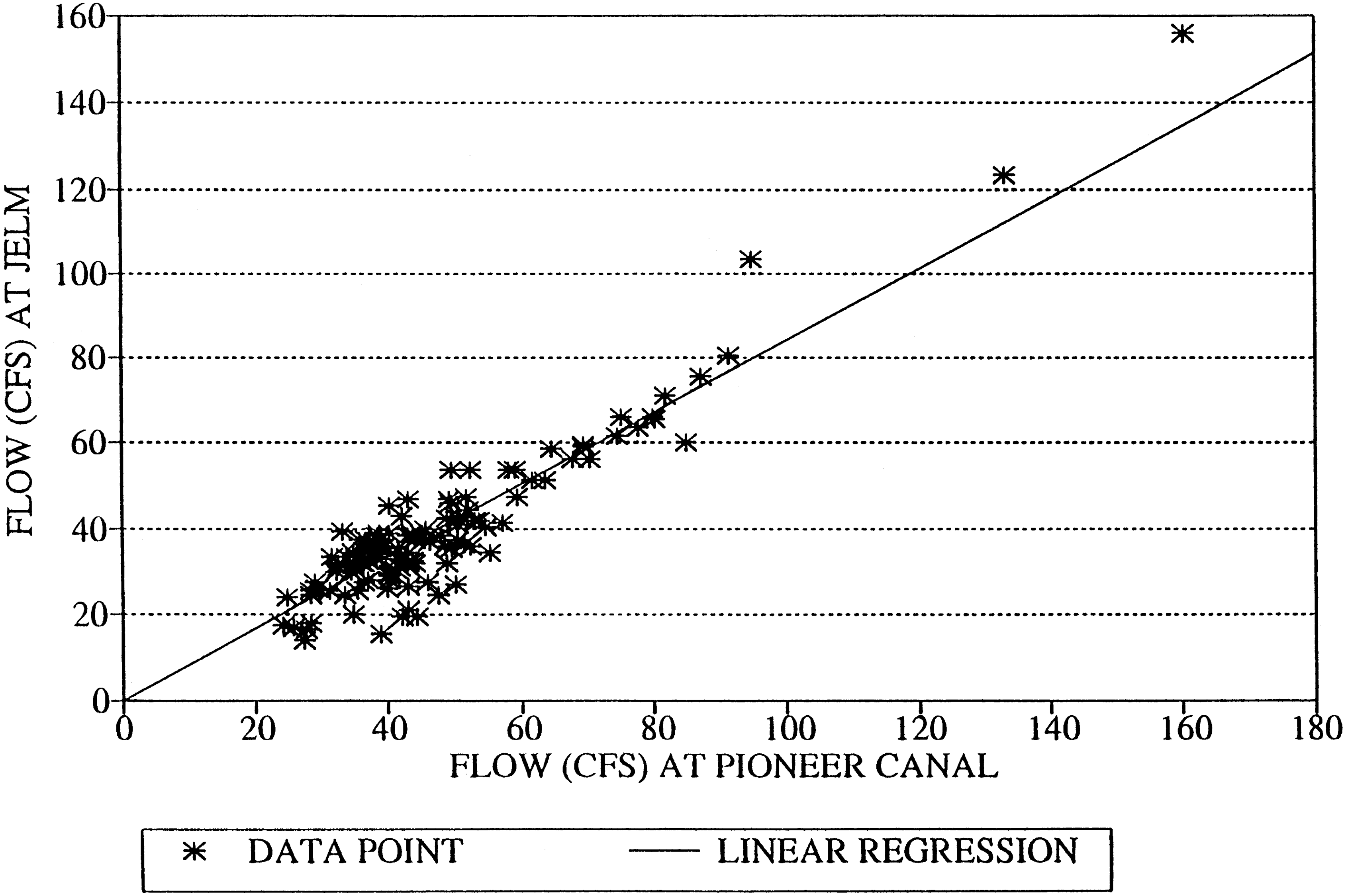


FIGURE 4: MONTHLY FLOWS OF LARAMIE RIVER AT PIONEER CANAL / JELM FOR PERIOD APRIL - JUNE (1950 - 1971)

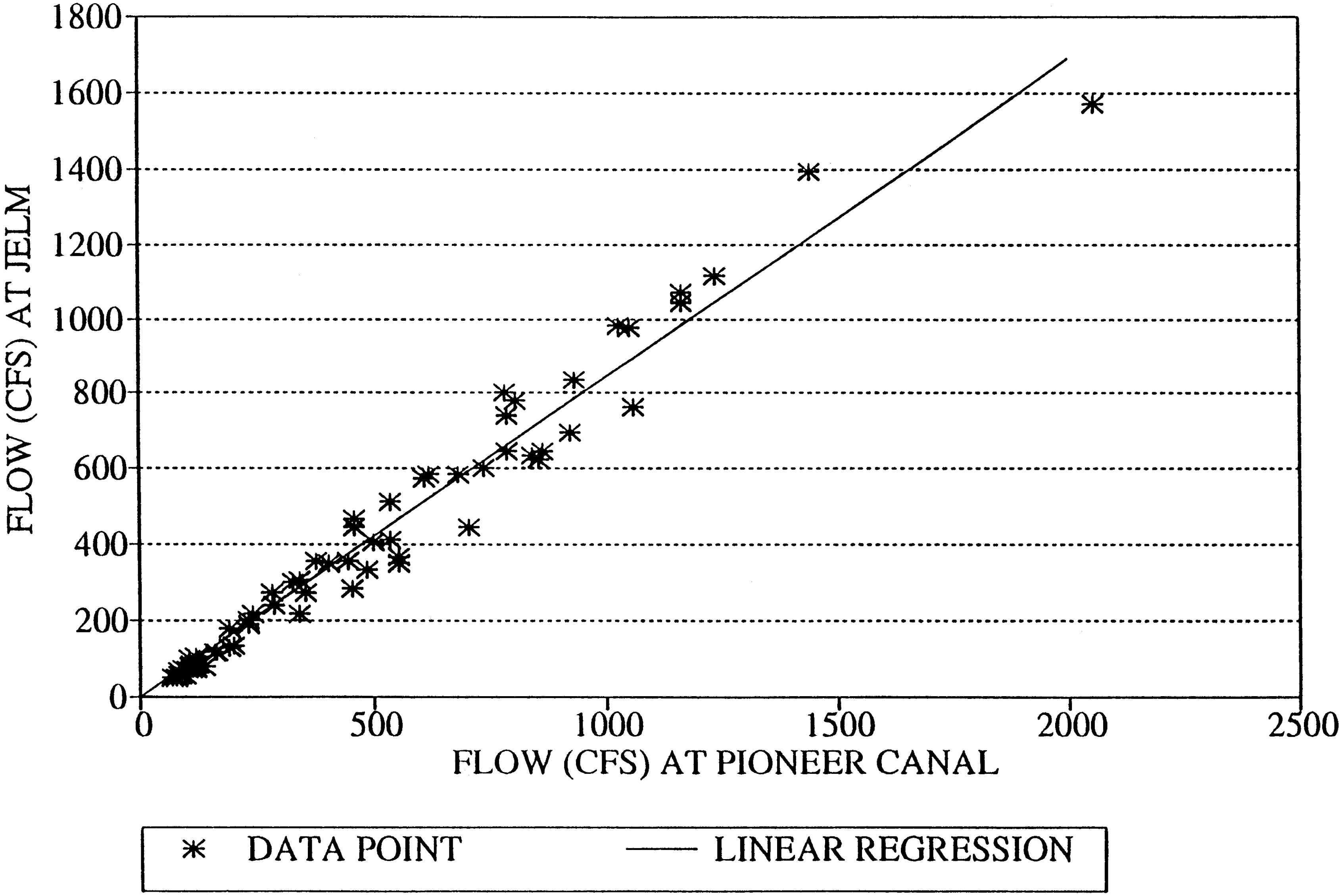


FIGURE 5: MONTHLY FLOWS OF LARAMIE RIVER AT PIONEER CANAL / JELM FOR PERIOD JULY-SEPTEMBER (1932 - 1971)

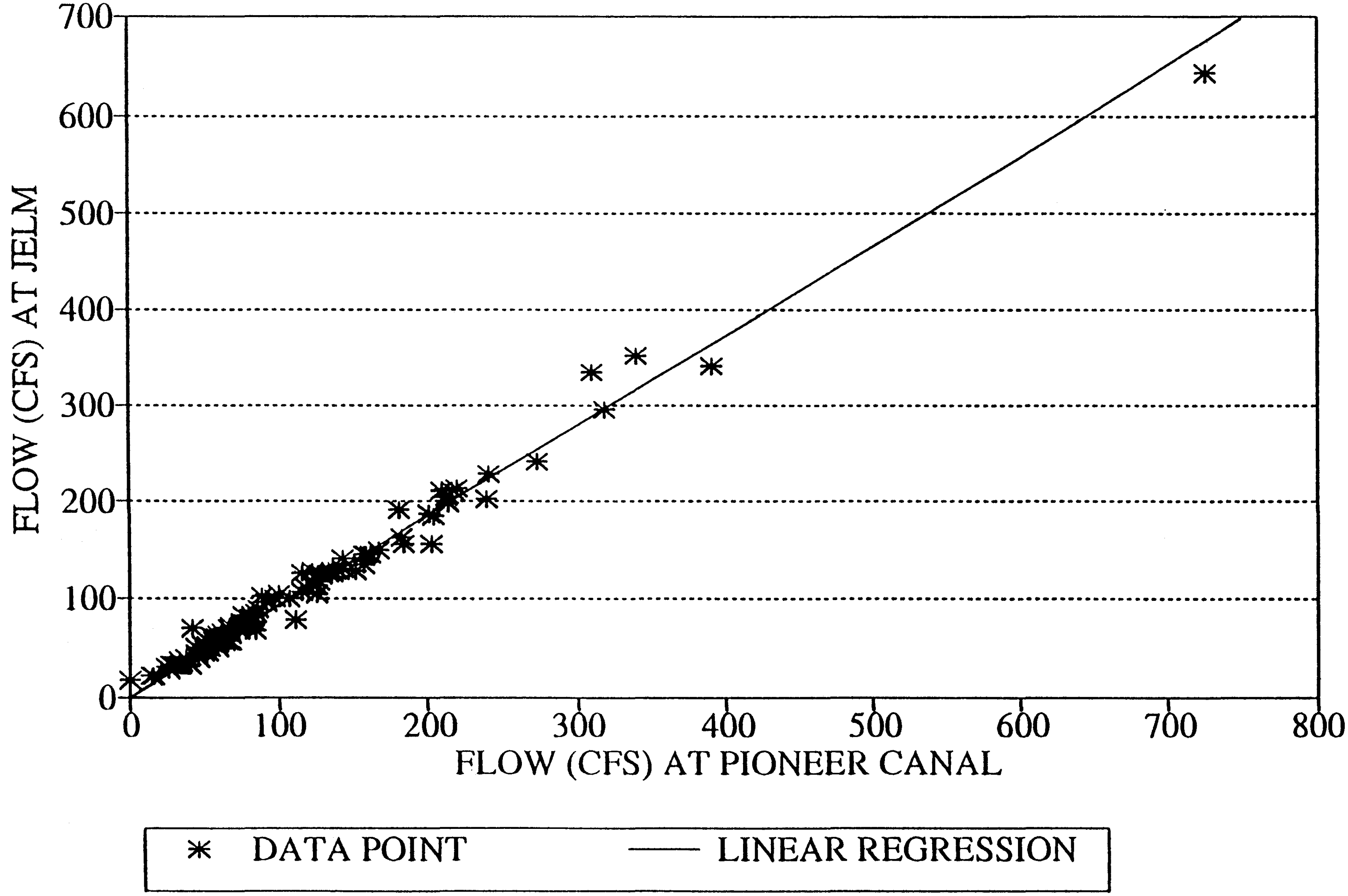


TABLE 5

LARAMIE RIVER: GENERATED FLOWS AT DOWNSTREAM END OF INSTREAM FLOW SEGMENT NO. 1

Average Monthly Flows (cfs)

YEAR	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL(AF)
1913	97.83	66.06	35.51	40.69	40.27	50.63	201.88	589.03	422.17	108.57	49.32	49.53	105989
1914	40.81	56.54	48.92	43.62	44.45	51.58	123.20	938.98	966.88	149.15	40.29	18.11	152487
1915	66.33	47.41	28.57	23.41	30.84	33.47	130.24	313.95	510.53	136.75	62.84	61.72	87243
1916	61.52	46.75	43.92	48.77	49.95	65.45	140.67	653.41	757.81	218.81	122.13	92.75	139129
1917	99.10	80.61	65.11	54.20	49.72	40.88	118.16	584.81	2208.65	874.42	180.35	68.28	266613
1918							100.12	796.01	1315.86	237.71	76.05	70.88	
1919	49.81						122.79	434.83	275.48	74.01	56.08	37.44	
1920								932.24	1494.84	319.52	134.74	76.08	
1921	52.40	68.70	60.48			65.30	87.76	842.10	1505.49	306.94	148.01	54.18	
1922	58.56	48.67	25.24	17.96	17.96	46.80	123.80	463.51	621.21	110.61	62.62	34.10	98485
1923	13.84	24.88					75.21	496.10	1633.93	528.55	132.91	78.78	
1924													
1925													
1926													
1927								730.74	721.77	244.98	75.61	68.61	
1928													
1929													
1930													
1931													
1932								827.38	791.33	179.53	64.10	28.99	
1933	41.58	38.68	33.08	33.08	35.91	51.98	88.42	373.97	1202.21	156.69	51.36	44.72	129351
1934	34.81	30.24	28.35	32.13	37.80	47.34	132.35	271.80	59.53	19.63	25.42	14.39	44404
1935	31.91	22.25					60.95	290.79	1154.75	199.09	58.63	37.34	
1936	40.15	52.50						750.46	433.46	104.90	83.66	47.24	
1937	36.85	61.55				38.75	128.94	547.86	468.34	152.83	52.48	33.74	
1938	44.77	47.82				71.11	143.76	850.18	1137.97	209.37	65.84	108.94	
1939	63.89	68.99					151.96	531.04	297.66	51.40	39.57	29.82	
1940	34.77	35.82				66.19	81.97	380.96	446.23	213.62	58.42	49.07	
1941	59.71	47.77					83.56	461.03	442.26	204.00	84.27	41.40	
1942	71.10	79.98					167.27	605.26	1046.97	148.40	46.93	32.51	
1943	49.99	53.87					258.04	513.77	822.14	136.47	53.42	31.52	
1944	36.91						71.48	365.40	483.85	153.53	65.82	26.68	
1945	43.50	41.70					139.44	644.25	698.15	311.41	196.23	65.74	
1946	54.74	69.78					227.07	441.63	577.15	211.55	90.00	51.00	
1947	42.58						121.83	759.39	880.19	382.17	139.04	74.08	
1948	71.92						184.36	771.08	460.70	132.38	78.66	26.98	
1949	48.57							703.06	1066.62	196.68	64.31	48.26	
1950	63.47						102.71	433.25	698.59	162.82	70.97	71.71	
1951	48.87	42.43	40.76	34.20	34.93	40.76	113.43	808.58	994.69	207.08	119.87	56.16	153560
1952	75.35	47.63	38.77	39.94	39.13	48.99	186.46	870.84	972.42	153.74	54.16	30.23	154533
1953	31.88	40.26	37.92	41.64	37.87	49.59	74.33	220.69	356.20	72.15	98.60	28.05	65617
1954	32.68	41.51	36.42	29.66	29.49	38.05	116.55	272.27	110.59	49.26	24.22	16.94	48289
1955	46.73	36.32	33.47	23.53	23.28	27.77	63.38	228.58	266.42	130.59	123.88	34.64	62752
1956	34.79	40.70	38.99	35.66	32.65	47.55	102.29	743.77	644.10	125.80	97.81	31.91	119554
1957	33.32	41.61	32.46	26.79	35.00	45.14	78.90	524.26	1941.19	707.69	122.16	62.37	219948
1958	75.82	59.88	51.46	43.65	40.70	40.76	83.15	797.85	510.46	81.74	61.17	44.95	114651
1959	47.95	40.61	30.79	30.30	30.44	33.99	92.14	459.18	744.79	120.68	83.03	56.55	106775

TABLE 5 (continued)

LARAMIE RIVER: GENERATED FLOWS AT DOWNSTREAM END OF INSTREAM FLOW SEGMENT NO. 1

Average Monthly Flows (cfs)

YEAR	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL(AF)
1960	86.27	61.05	52.10	41.95	36.72	39.94	181.89	419.84	587.12	139.96	95.39	47.71	108006
1961	38.05	31.37	26.71	22.98	25.82	40.73	72.25	508.49	883.28	133.63	76.15	125.06	119763
1962	151.57	89.68	54.99	50.70	70.40	66.15	336.27	1000.35	739.27	302.59	73.22	44.36	180333
1963	55.81	48.32	39.47	32.77	40.83	45.76	93.63	382.76	221.08	58.50	87.62	60.16	70603
1964	33.84	36.41	31.61	26.91	24.50	26.21	88.29	476.24	435.38	176.94	113.04	55.19	92262
1965	39.78	42.93	36.24	43.29	44.89	47.25	127.90	524.42	1169.32	266.49	113.00	123.07	155404
1966	126.02	82.34	73.13	53.99	41.31	80.27	113.74	324.53	179.93	56.80	45.29	28.44	73060
1967	46.48	35.69	30.82	27.62	38.40	58.10	77.88	310.74	761.37	331.91	61.77	58.57	111013
1968	49.57	45.99	36.16	44.20	41.42	49.99	84.45	324.38	1101.52	177.96	116.66	73.84	129041
1969	65.54	46.71	47.43	36.98	32.71	37.95	154.26	576.66	436.46	124.64	72.09	53.01	101972
1970	70.78	65.37	46.70	37.65	45.90	47.83	96.18	819.91	1099.89	233.81	81.02	59.06	163334
1971	77.04	63.76	37.40	34.57	34.56	56.30	149.87	668.52	1363.59	234.44	79.20	71.73	173041
1972	63.77	44.04	37.31	36.73	39.76	74.50	83.47	361.43	765.85	89.57	82.53	65.91	105117
1973							102.90	793.85	1063.99	340.09	112.00	79.85	
1974							149.32	887.50	785.62	151.00	63.69	64.18	
1975							87.95	292.16	761.06	354.62	87.59	58.40	
1976							100.87	378.77	439.89	158.90	135.14	57.69	
1977							108.19	282.98	225.05	65.58	47.59	32.47	
1978							106.30	518.44	1099.09	197.20	64.89	53.17	
1979							145.75	683.63	1090.58	217.27	86.24	46.90	
1980							135.28	740.62	984.53	137.13	42.96	32.73	
1981							106.14	220.97	322.96	98.88	42.62	35.66	
1982							65.53	383.56	1028.02	465.83	133.48	120.51	
1983							84.32	477.55	2309.19	993.99	189.25	76.66	
1984							122.48	1069.68	1141.92	407.55	152.32	113.62	
1985							174.51	784.21	636.82	137.45	48.53	52.00	
1986							258.04	867.97	1626.74	337.51	88.06	86.68	
1987							152.47	385.17	175.67	64.32	38.25	32.89	
1988							146.63	615.85	764.37	97.31	42.02	33.35	
1989							152.31	227.99	177.85	53.92	40.27	44.36	
MEAN	55.77	49.58	39.49	32.64	36.30	45.81	121.96	544.16	786.90	213.04	81.91	54.06	113706
STD DEV	28.58	18.95	14.79	16.05	13.68	18.03	55.71	240.03	499.70	186.01	40.67	26.51	59249
# RECORD	55	49	37	39	36	41	71	76	76	76	76	76	36
MIN	13.84	22.25	25.24	17.96	17.96	26.21	60.95	220.69	59.53	19.63	24.22	14.39	44404
MAX	156.03	103.13	73.13	65.00	70.40	80.27	336.27	1069.68	2309.19	993.99	196.23	125.06	266613

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
REQUEST	50	50	50	50	50	50	100	100	100	50	50	50

V MEAN MONTHLY FLOW ANALYSIS

The estimated mean monthly flows at the downstream end of the instream flow segment are presented at the bottom of Table 5. These flows were calculated for all years in which flow records were available at the Pioneer gaging station. Along with the mean, the standard deviation, number of records, minimum and maximum monthly flow, and the flow requested by the WGFD are presented. Figure 6 graphically compares the mean monthly flows to the requested flows.

As can be seen, the requested flow is not available in its entirety in the average year during the months of December through March. The average shortfall ranges from about 17 cfs in January to about 4 cfs in March. The flow in November equals that which has been requested. For all other months the average flow exceeds the requested flow.

VI DRY YEAR FLOW ANALYSIS

The ranking of flow records in ascending order in presented in Table 6. The table presents the flows in acre-feet ranked by yearly flow and ranked for each instream flow period. The ability of the Laramie River to meet the requested instream flows was evaluated for dry years using two methods. First, the requested flows are compared to those available in the driest year on record determined by total annual flow. Second, the requested flows are compared to the flow during the average of the lowest three years by period. This second procedure was utilized because the lowest flow during a period may not correspond to the lowest flow by annual total.

FIGURE 6: LARAMIE RIVER
Avg Monthly & Requested Flow Comparison

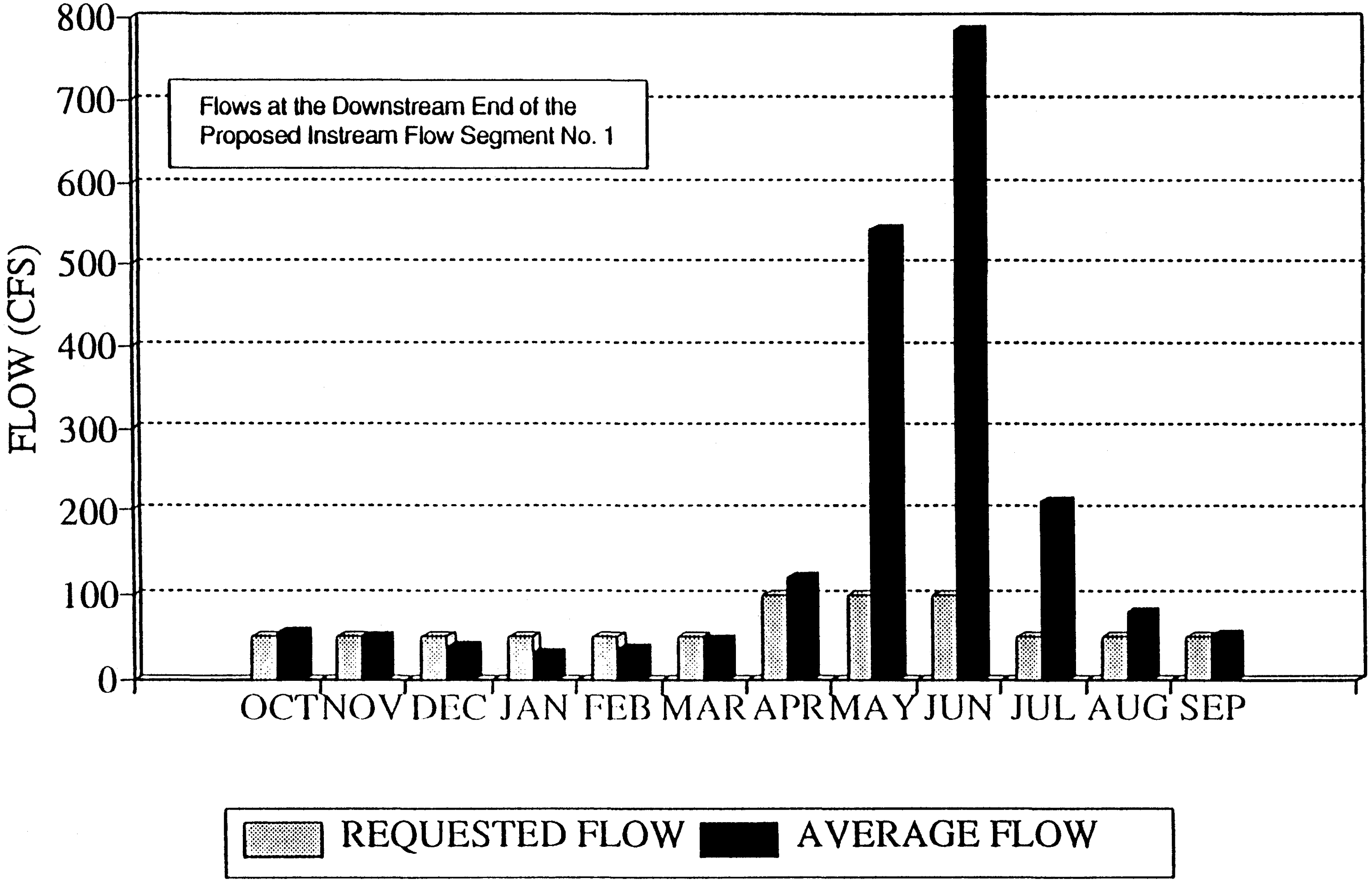


TABLE 6

RANKING OF FLOWS IN ASCENDING ORDER
Downstream End Of Instream Flow Segment
Total Flow (Acre-Feet)

OCTOBER-MARC		APRIL-JUNE		JULY-SEPTEMBER		COMPLETE YEAR	
YEAR	Acre-Feet	YEAR	Acre-Feet	YEAR	Acre-Feet	YEAR	Acre-Feet
1964	10819	1934	28131	1934	3604	1934	44404
1961	11200	1954	30257	1954	5511	1954	48289
1955	11540	1989	33664	1939	7348	1955	62752
1954	12520	1955	33680	1966	7936	1953	65617
1934	12669	1977	37230	1987	8253	1963	70603
1957	12888	1966	37430	1989	8439	1966	73060
1959	12901	1981	39121	1977	8861	1915	87243
1922	13028	1953	39188	1919	10192	1964	92262
1915	13867	1963	42262	1988	10534	1922	98485
1956	13888	1987	43210	1981	10809	1969	101972
1933	14116	1919	50436	1958	11430	1972	105117
1967	14281	1940	54855	1953	12028	1913	105989
1953	14400	1976	55468	1963	12510	1959	106775
1951	14584	1944	55513	1922	12624	1960	108006
1965	15289	1915	57433	1913	12656	1967	111013
1963	15831	1939	59407	1914	12681	1958	114651
1968	16100	1941	59637	1980	13001	1956	119554
1969	16149	1964	60444	1943	13508	1961	119763
1914	17205	1975	68485	1942	13916	1968	129041
1952	17493	1967	69047	1936	14333	1933	129351
1972	17883	1937	69228	1972	14472	1916	139129
1971	18338	1969	70609	1948	14479	1914	152487
1958	18840	1960	71575	1952	14534	1951	153560
1970	18918	1972	72762	1985	14536	1952	154533
1916	19063	1922	72833	1937	14595	1965	155404
1960	19215	1913	73352	1944	14998	1970	163334
1913	19981	1950	74321	1969	15214	1971	173041
1917	23501	1946	75010	1933	15441	1962	180333
1966	27694	1959	78036	1956	15518	1957	219948
1962	29132	1958	84381	1959	15838	1917	266613
		1948	85796	1915	15943		
		1961	88125	1932	16635		
		1982	88656	1974	17021		
		1945	89455	1960	17216		
		1956	90148	1955	17532		
		1935	90221	1935	18026		
		1968	90517	1950	18644		

TABLE 6 (continued)

RANKING OF FLOWS IN ASCENDING ORDER
Downstream End Of Instream Flow Segment
Total Flow (Acre-Feet)

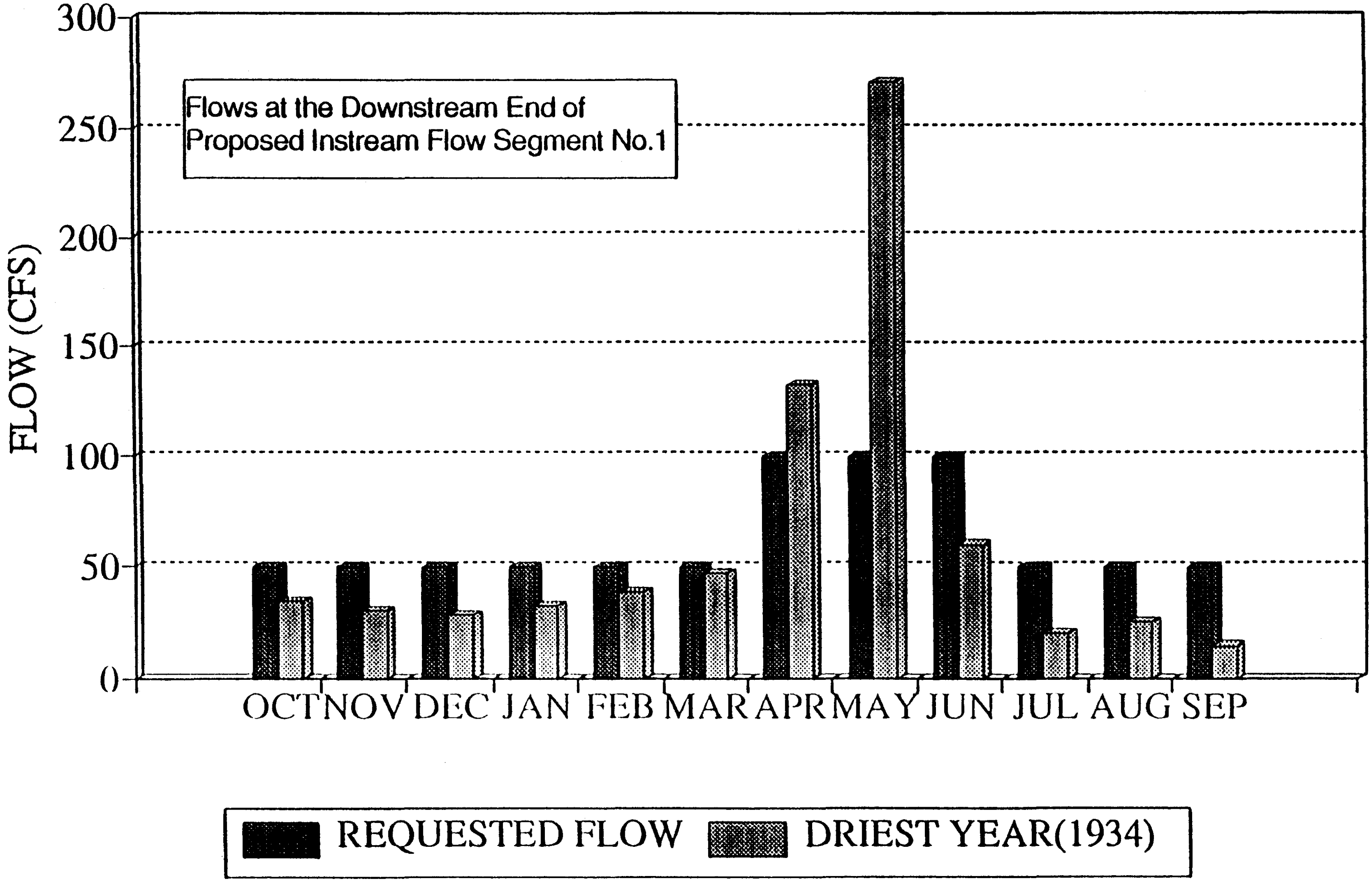
OCTOBER-MARC		APRIL-JUNE		JULY-SEPTEMBER		COMPLETE YEAR	
YEAR	Acre-Feet	YEAR	Acre-Feet	YEAR	Acre-Feet	YEAR	Acre-Feet
		1988	92076	1949	18888		
		1916	93641	1978	19256		
		1943	95867	1940	19629		
		1985	96498	1941	20104		
		1933	99794	1961	20438		
		1978	103605	1964	21000		
		1947	106319	1976	21359		
		1965	109437	1979	21375		
		1942	109470	1946	21499		
		1974	110205	1968	22424		
		1980	112174	1970	22829		
		1979	115603	1951	23319		
		1951	115657	1938	23490		
		1973	118248	1918	23501		
		1970	121587	1971	23539		
		1952	122506	1927	23781		
		1914	122601	1962	25691		
		1962	125510	1916	26425		
		1938	128546	1967	27685		
		1971	131165	1975	30608		
		1923	132207	1965	30678		
		1918	133203	1921	31012		
		1984	141011	1986	31323		
		1921	146586	1920	32342		
		1957	152442	1973	32486		
		1986	165524	1945	34867		
		1983	171789	1947	36328		
		1917	174416	1984	41110		
				1982	43995		
				1923	45253		
				1957	54619		
				1917	68697		
				1983	77094		

The driest year on record for the Laramie River is 1934. A comparison of the recorded monthly flows for 1934 versus the flows requested by the WGFD is presented in Table 7. Shortage occurred in all months except April and May. A bar graph comparing 1934 monthly flows to the requested flows is presented on Figure 7.

Table 7
Comparison of Monthly Flows During Driest Year on Record (1934) and Requested Flow

Month	1934 Mean Monthly Flow (cfs)	Requested Flow (cfs)	Shortfall (cfs)		Volume of Shortfall (AF)
Oct.	34.8	50	15.2		935
Nov.	30.2	50	19.8		1,178
Dec.	28.4	50	21.6		1,328
Jan.	32.1	50	17.9		1,101
Feb.	37.8	50	12.2		678
Mar.	47.3	50	2.7		166
Apr.	132.4	100	---		----
May	271.8	100	---		----
June	59.5	100	40.5		2,410
July	19.6	50	30.4		1,869
Aug.	25.4	50	24.6		1,513
Sept.	14.4	50	35.6		2,118
				TOTAL	13,296
				TOTAL (June-Sept.)	7,910

FIGURE 7: LARAMIE RIVER
Driest Year & Requested Flow Comparison



Using the average of the three lowest years for each instream flow period allows the use of more records which may be complete for the period but not the entire year. In addition, the average of the three lowest years is often considered more representative of drought conditions than would be the most extreme dry year recorded.

October - March	1964, 1961, 1955
April - June	1934, 1954, 1989
July - September	1934, 1954, 1939

Averaging the monthly flows for the three driest years by period yields the information shown in Table 8. This analysis shows that there are shortfalls for the requested flows for all months except April, May and June. Figure 8 is a bar graph relating the three lowest year average, by period, to the requested flow. The shortfall for the year is 10,500 acre-feet versus 13,200 acre-feet for 1934, the driest year on record.

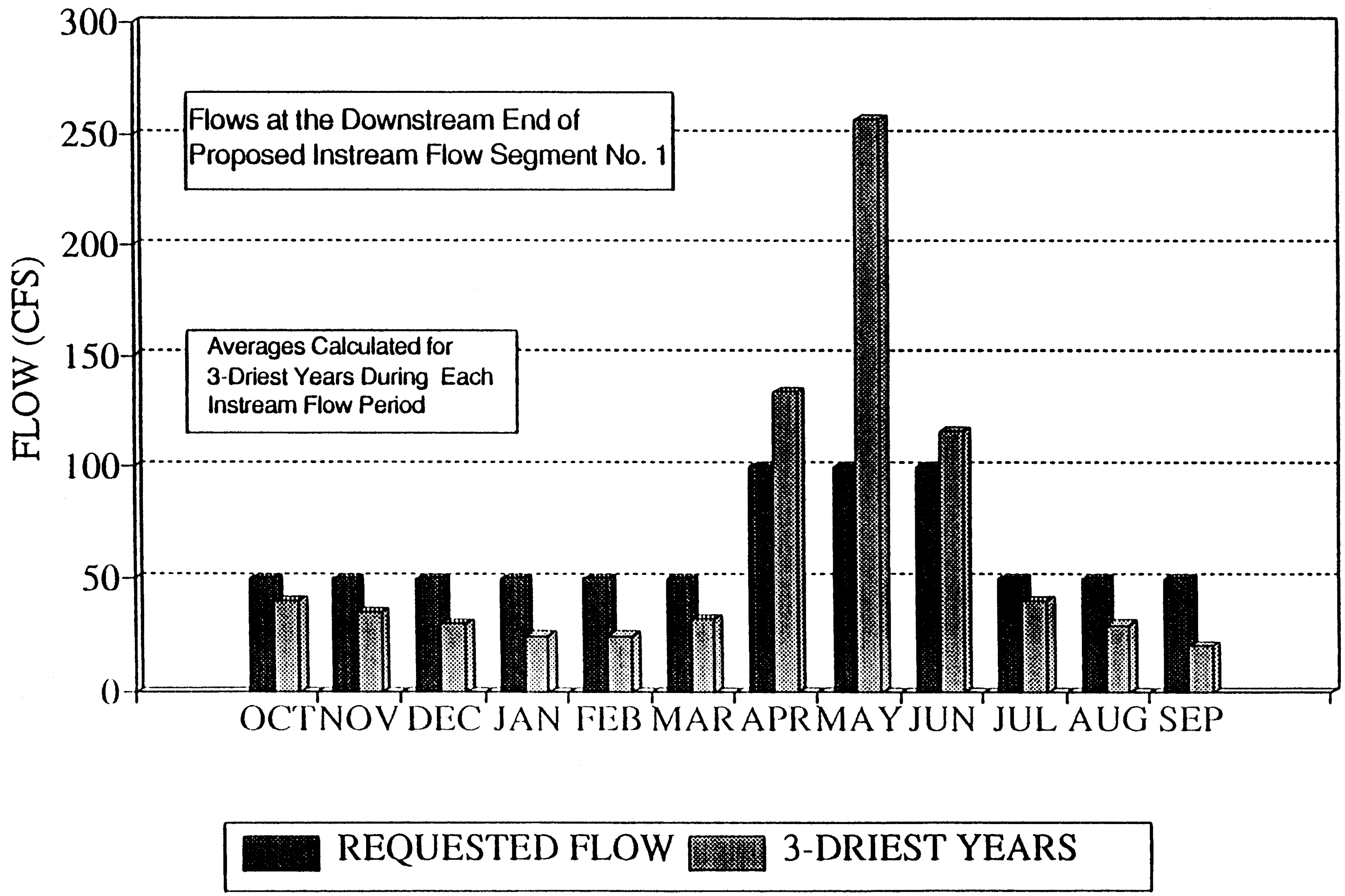
Table 8

Comparison of Monthly Flows During the Average of 3 Driest Years by Period and Requested Flows

Month	3-Year Mean Monthly Flow (cfs)	Requested Flow (cfs)	Average Shortfall (cfs)	Average Volume Shortfall (AF)
Oct.	39.5	50	10.5	646
Nov.	34.7	50	15.3	910
Dec.	30.6	50	19.4	1,193
Jan.	24.5	50	25.5	1,568
Feb.	24.5	50	25.5	1,416
Mar.	31.6	50	18.4	1,131
Apr.	133.7	100	---	-----
May	257.4	100	---	-----
June	116.0	100	---	-----
July	40.1	50	9.9	609
Aug.	29.7	50	20.3	1,248
Sept.	20.4	50	29.6	1,761
			TOTAL	10,482
			TOTAL (July-Sept.)	3,618

FIGURE 8: LARAMIE RIVER

3-Driest Yr Avg & Request Comparison



VII RESERVOIR OPERATION STUDY

Since the estimated historic flows of the Laramie River at the downstream end of the proposed Instream Flow Segment No. 1 are not always sufficient to meet the requested flows, a cursory study of whether storage could provide water to fulfill the requested flows was conducted. A reservoir could be physically constructed on the Laramie River or on Boswell Creek above the proposed instream flow segment for the purpose of meeting the WGFD requested flows at all times. However, before water could be stored in such a reservoir, downstream storage rights would have to be filled, or negotiated agreements to store water out of priority would have to be arranged. Because of these institutional constraints to a new storage facility, such a proposal would have to be studied in considerable detail.

The Upper Laramie River Basin has experienced water shortages during the late portions of the irrigation season for over 100 years. Numerous reservoirs have been proposed to help alleviate this problem but none has been constructed and presently there are no reservoirs upstream of the instream flow segment which would be capable of regulating flows. An analysis of alternatives for alleviating water problems in the upper basin is being pursued at this time by the Wyoming Water Development Commission. If a reservoir were proposed to meet instream flow requests that reservoir should be integrated with the other water uses in the basin. Such an analysis is beyond the scope of this report.

For a simplistic approach to determine if storage would be possible, a balance of flows at the instream flow segment was performed. Two scenarios were examined; first provide additional water to meet the instream flow request for the entire year and second provide water to meet the request only for the period of July to September. The WGFD has stated that if natural winter flows are not sufficient to satisfy the requested flow, it is their intent that the request would be only to maintain natural flows. They do not believe storage is critical to supplement occasional shortages in natural streamflow during the winter period. However, the computations are presented for purposes of enlightenment.

Table 9
Summary of Annual Flow Shortages and Excesses
Laramie River at Proposed Instream Flow Segment

	Average Year (AF)	Lowest Year (AF)	Lowest 3-Years by Period (AF)
Shortfall for Entire Year	2,152	13,296	10,482
Shortfall for July - September	0	7,910	3,618
Excess Flow	86,306	12,492	12,635

As can be seen, the amount of storage necessary to satisfy the instream flow request for April through September depends on the criterion used. The flow in the river, if regulated by a reservoir with about 10,000 acre-feet of capacity, could meet the instream flow request for July through September even in the driest year on record. The July through September request can be supplied during an average year so on the average no storage is required.

VIII DAILY FLOW EXCEEDENCE ANALYSIS

The Wyoming Game and Fish Department considers that an instream flow request is "feasible" if during the period of July 1 through September 30 the requested flow is available 50% of the time. The WGFD has not developed exceedence criteria for other times of the year; however, they have stated that instream flows at all times of year other than July through September should equal natural flows up to the recommended amounts. Therefore, a daily flow duration analysis was conducted, and for completeness, the analysis was done for all three instream flow periods. Daily flow-duration data were obtained by periods from the Wyoming Water Research Center WRD System for both the Jelm and Pioneer gaging stations on the Laramie River. The flows at the Pioneer gaging station were then adjusted for gains and areal reduction to create duration curves for the downstream end of the instream flow segment. The duration curves for the end of the instream flow segment and the two gaging stations are plotted together to show the similarities of the shapes and verify the validity of the curve generated for the instream flow segment. The curves for all three periods are presented in Figures 9, 10 and 11.

The WGFD requested flow, their exceedence criteria and actual exceedence data are summarized below:

Table 10
Daily Flow Exceedence Summary

Period	Requested Instream Flow (cfs)	WG&F Exceedence Criteria % Time	Exceedence During Period of Record % Time
October - March	50	N/A	26%
April - June	100	N/A	80%
July - September	50	50%	70%

FIGURE 9: LARAMIE RIVER
DAILY DURATION CURVES OCT 1-MAR 31

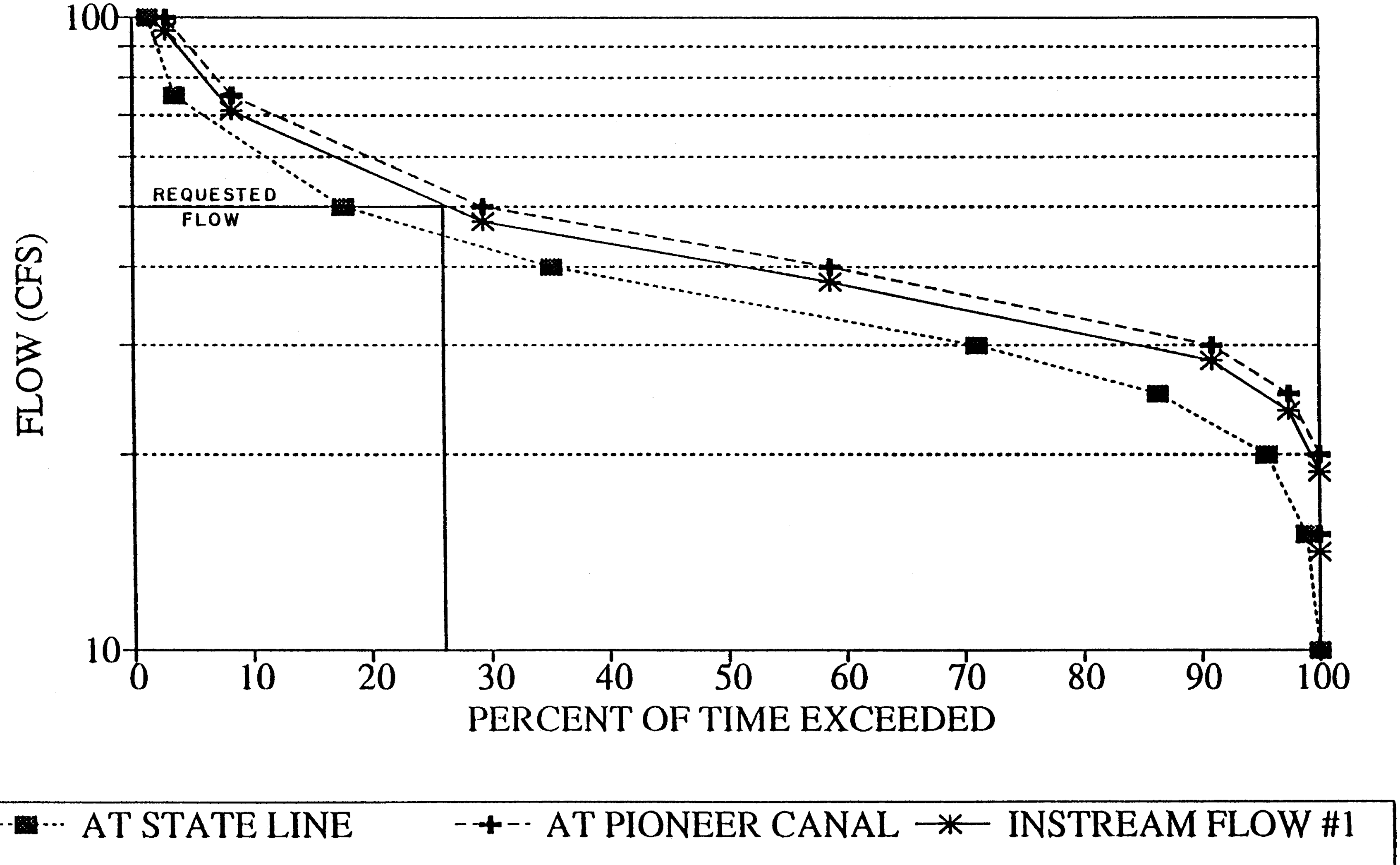


FIGURE 10: LARAMIE RIVER
DAILY DURATION CURVES APR 1-JUN 30

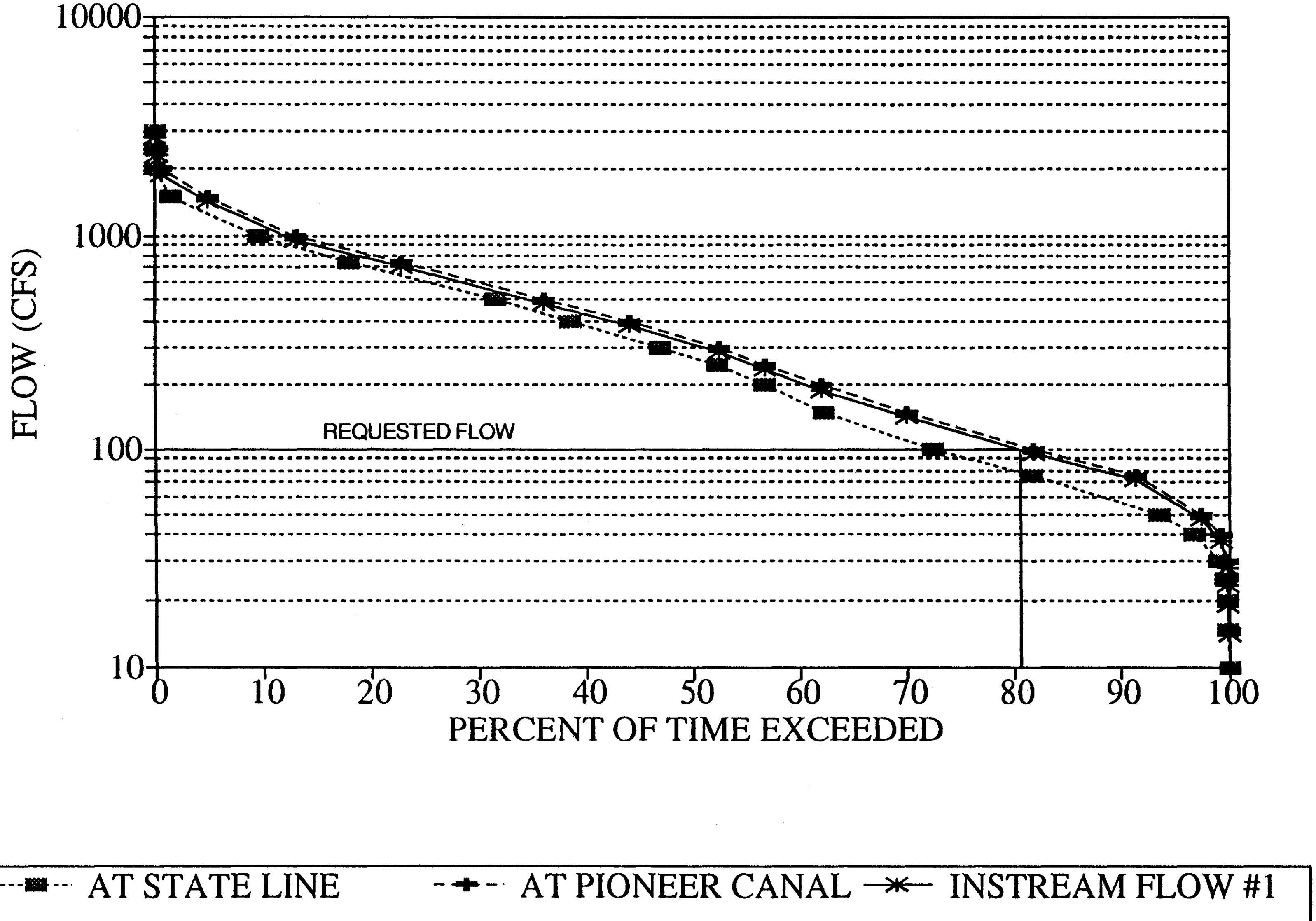
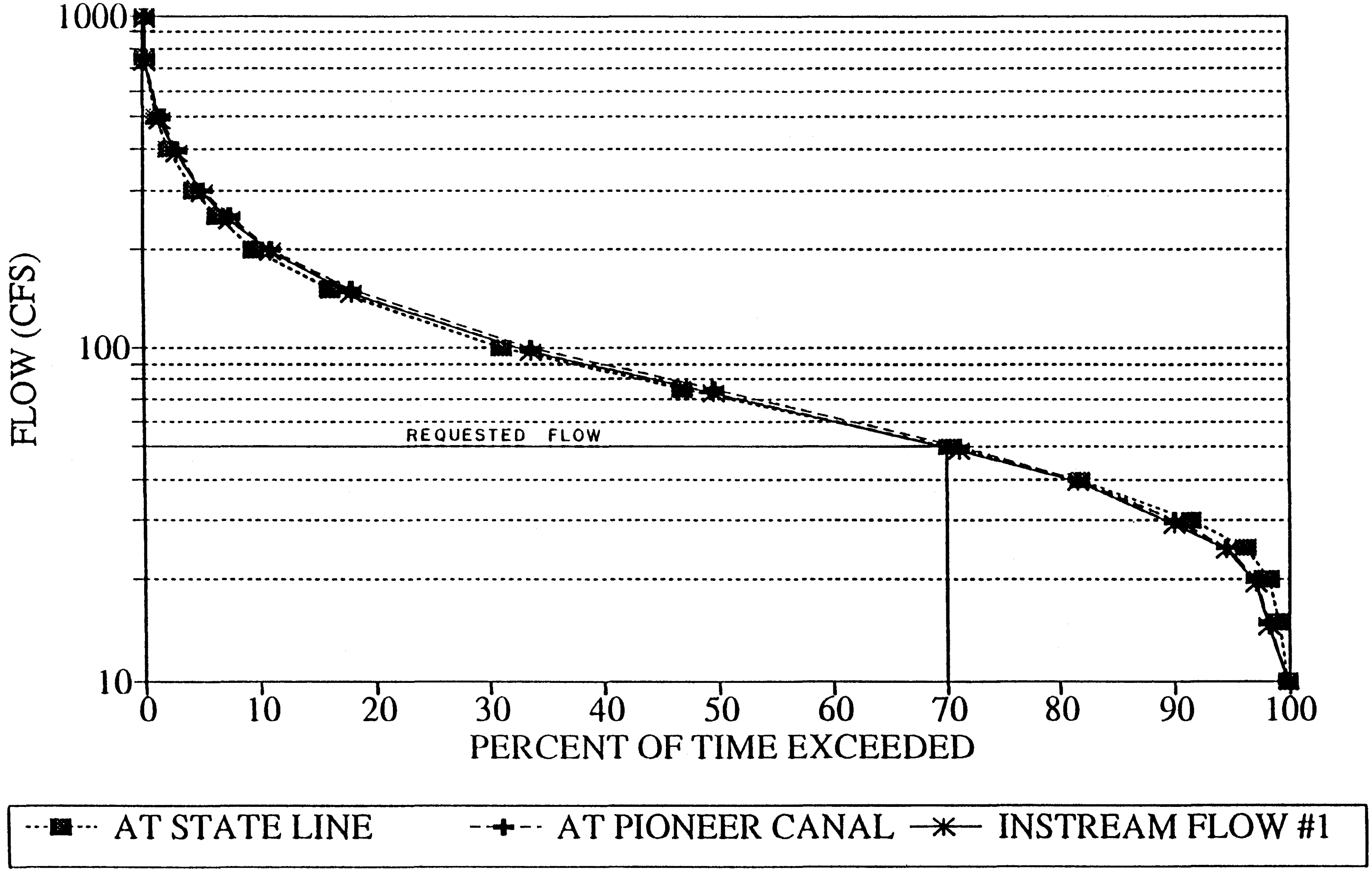


FIGURE 11: LARAMIE RIVER

DAILY DURATION CURVES JUL 1-SEP 30



This indicates that the flow of 50 cfs during the period is available 70% of the time which exceeds the WGFD exceedence criterion of 50%.

IX CONCLUSIONS

The mean monthly flow analysis indicates that on the average for the Laramie River Segment I, the WGFD instream flow request can be met by existing unappropriated direct flow except during the winter period, December through March. During extremely dry years the requested flow is only met during spring runoff, April - June. Dry year shortages could be met if storage were provided, but this is a complex issue in which other users in the basin must be considered and is not required by the exceedence criteria established by the WGFD. Their exceedence criterion of flows equalling or exceeding 50 cfs for 50% of the time during July through September can be met with existing direct flows.

APPENDIX I

WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Laramie River Instream Flow Report

PROJECT: IF-5089-07-8902

AUTHOR: Gerald F. Vogt, Jr. and Thomas C. Annear

DATE: June 1989

INTRODUCTION

Data were collected during the 1981 field season to conduct instream flow analyses for a segment of the Laramie River located near the town of Woods Landing, 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.

METHODS

Study Area

The Laramie River is considered a Class 2 stream by the Wyoming Game and Fish Department (WGFD). Stream classifications throughout Wyoming range from Class 1 (highest rating) to Class 5 (lowest rating). Class 2 streams are generally considered important trout fisheries on a statewide basis. Less than 6% of all streams in the state are Class 2 or better streams.

The Laramie River contains a naturally reproducing population of brown trout and a small population of rainbow trout. The stream is currently managed as a wild fishery for brown trout, and future emphasis will include management of wild rainbow trout. This stream segment is not currently stocked by the WGFD. The segment of the Laramie River identified as the instream flow reach passes through land owned by the WGFD and private land on which the WGFD has secured access for public fishing and is highly accessible to the public. Because this section of the Laramie River supports an important trout fishery and has public access, this segment was identified as a critical reach.

Data Collection

All of the field data used in this study were collected from a 393 foot long study site located within a WGFD public fishing area in the northeast quarter of Section 15, Township 13 North, Range 77 West. This site is located approximately 1.5

miles upstream from the town of Woods Landing (Figure 1). This 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 east boundary of the S 1/2 NE 1/4 SE 1/4 of Section 10, T13N, R77W upstream to the south boundary of W 1/2 NW 1/4 of Section 26, T13N, R77W. This is a distance of approximately 3.9 stream miles.

In accordance with the 1986 Instream Flow legislation, the goal of this study was to determine instream flows necessary to maintain or improve the existing trout fishery. The specific objectives of this study were to determine instream flows necessary to 1) maintain or improve physical habitat for rainbow trout spawning during the spring, 2) maintain or improve physical habitat for brown trout spawning during the fall, 3) maintain or improve hydraulic characteristics in the winter that are important for survival of trout, fish passage and aquatic insect production and, 4) maintain or improve adult trout production during the late summer months. Three habitat models were used to make these determinations.

Models

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. 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 1. The WUA for rainbow and brown trout was simulated for flows ranging from 10 to 400 cubic feet per second (cfs) using calibration and modeling techniques outlined in Milhous et al. (1984).

Table 1. Dates and discharges when instream flow data were collected at the Laramie River instream flow segment.

Date	Discharge (cfs)
04-13-81	52
04-30-81	194
05-13-81	103

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 three riffles within the study area were analyzed with the IFG-1 computer program (Milhous 1978). Flow data were

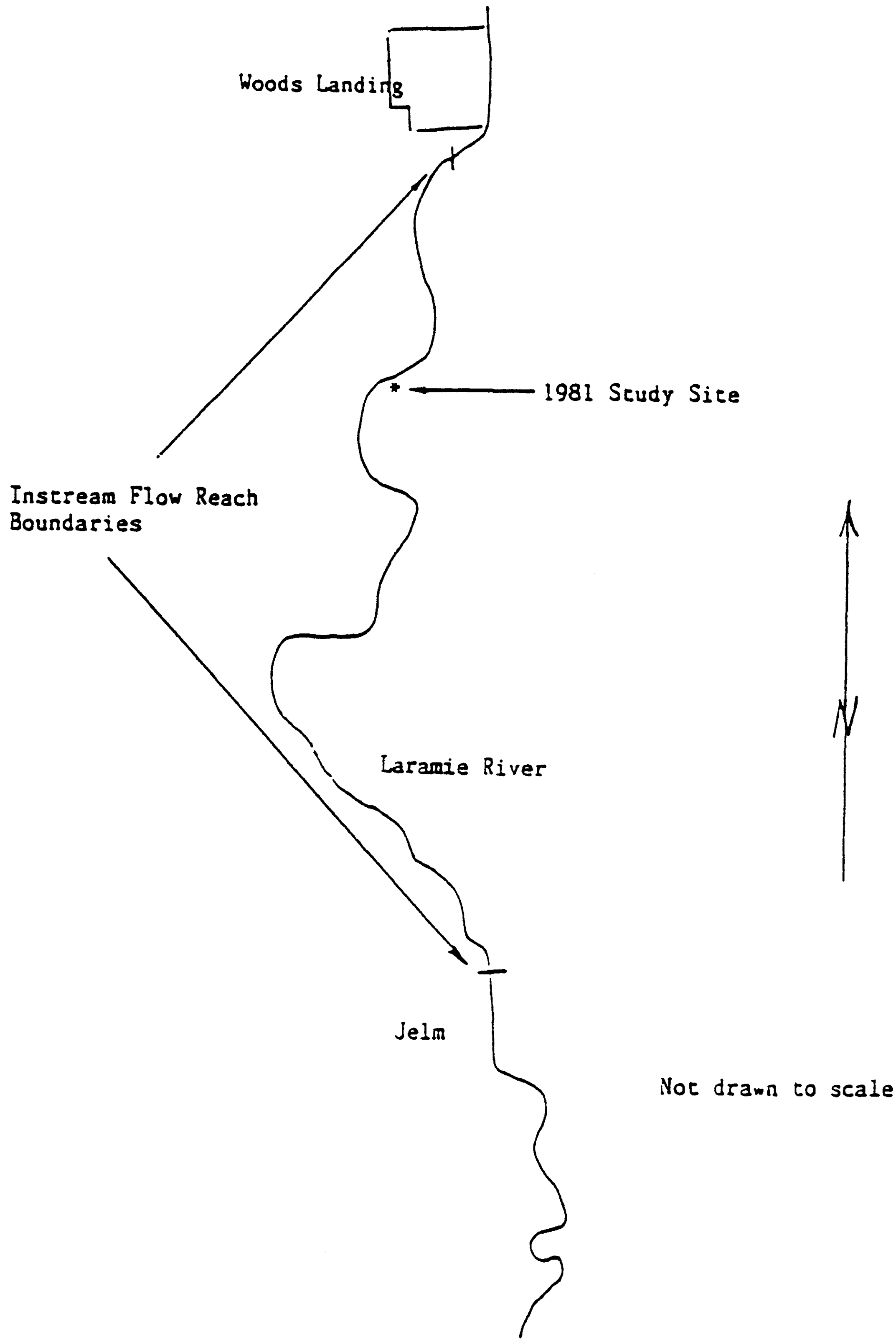


Figure 1. Location of the 1981 study site and the Instream Flow reach on the Laramie River near Woods Landing, Wyoming.

collected at three different flow levels (Table 1). The maintenance flow is identified as the discharge at which two of the three criteria in Table 2 are met for all riffles in the study area.

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/sec)	1.00
Wetted Perimeter (percent)[2]	60

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

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 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 the Laramie River 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. Habitat attributes on the Laramie River were measured on the same dates and flow levels that data were collected for the PHABSIM and Habitat Retention models (Table 1). 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 1. Other data were obtained from a U.S. Geological Survey gage located on the Laramie River immediately upstream from the Pioneer Canal for the period 1912 to 1987 (with some missing years) for determining the annual stream flow variation and critical period stream flow at the study site.

Instream flow recommendations derived from the Habitat Retention method are applicable to all times of year except when higher instream flows are required to meet other fishery management purposes.

Rainbow trout begin spawning in early April and their eggs incubate through June. Results from the PHABSIM analysis were used to identify the flows needed to maintain or improve physical habitat for the rainbow trout spawning from April 1 to June 30. Brown trout spawning begins in early October and continues into late fall. Their eggs incubate in the gravel until late March. Results from the PHABSIM analysis were also used to identify a flow from October 1 to March 31 which would maintain or improve physical habitat for brown trout spawning.

Results from the HQI model were used to identify the average flow needed to maintain or improve existing levels of trout production between July 1 and September 30.

RESULTS

Results from the Habitat Retention model showed that the hydraulic criteria in Table 2 are met at flows of 50, 37, and 35 cfs for riffles 1, 2, and 3, 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 which in this case is 50 cfs.

Table 3. Simulated hydraulic criteria for three riffles on the Laramie River. Estimated average daily flow = 177 cfs. Bank full discharge = 1145 cfs.

Riffle 1

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
2.23	5.6	92.5	1145
1.95	4.1	88.1	688
1.50	2.6	85.4	330
1.19	1.8	81.7	177
0.95	1.3	77.9	97
0.83	1.0[1]	68.8	57
0.81[1]	0.9	66.6	50[2]
0.70	0.6	55.5[1]	25
0.54	0.4	49.4	11
0.34	0.2	43.1	4

Riffle 2

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
2.26	5.9	81.6	1145
1.93	4.3	79.0	642
1.18	2.1	73.4	177
1.05	1.8	72.5	133
0.86	1.4	71.2	88
0.72[1]	1.2	69.6	60
0.60	1.1	67.3	42
0.57	1.0[1]	65.8	37[2]
0.35	0.7	49.0[1]	12
0.23	0.5	24.2	3

Riffle 3

2.61	5.2	85.6	1145
2.29	3.7	82.6	689
1.84	2.4	80.4	343
1.46	1.5	79.1	177
1.27	1.2	78.5	118
1.13	1.0[1]	78.0	89
0.98	0.8	77.5	59
0.78[1]	0.6	76.0	35[2]
0.55	0.3	69.5	13
0.19	0.1	51.4[1]	2

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

Results of the PHABSIM analysis indicate that physical habitat is maximized at 125 cfs (Figure 2). Under existing flow conditions during the month of April (average daily flow of 130 cfs), physical habitat for rainbow trout spawning is near the maximum amount available. This amount of physical habitat is also provided by stream flows of 100 cfs; however, increasingly rapid reductions in existing physical habitat for spawning occur at flows lower than 100 cfs. Though more gradual, similar reductions in physical habitat also occur at flows exceeding 130 cfs.

Gage data indicate that existing streamflows in the Laramie River often exceed 500 cfs during the months of May and June. Since the PHABSIM analysis was limited to simulations of flows up to 400 cfs, physical habitat at flows in excess of 500 could not be precisely determined. However, it appears that flows higher than 400 cfs will provide less physical habitat than is available at 100 cfs. Therefore, an instream flow of 100 cfs will improve physical habitat for rainbow trout spawning during the months of May and June. This is consistent with the objectives established in the Instream Flow Legislation.

Based on this analysis, an instream flow of 100 cfs is the minimum discharge which will maintain or improve the existing amount of physical habitat for rainbow trout spawning during the spring. Therefore, an instream flow of 100 cfs is recommended for the period April 1 to June 30.

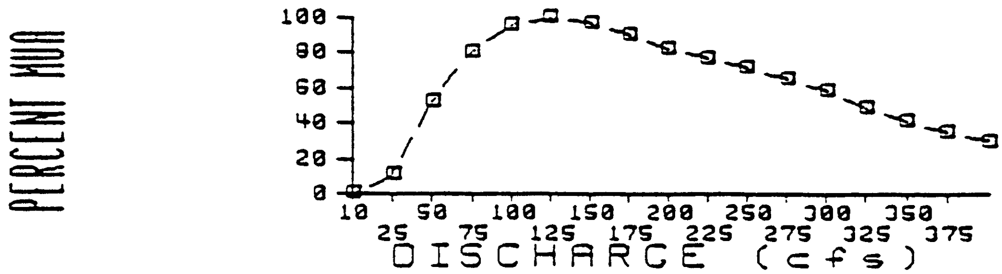


Figure 2. Percent of maximum usable area (MUA) for spawning life stage of rainbow trout.

Gage data indicate that existing mean daily flows during the fall and winter (October 1 - March 31) are approximately 50 cfs. At this discharge, PHABSIM analyses indicate that physical habitat for brown trout spawning is approximately 63% of the maximum amount available, which occurs at a discharge of 150 cfs (Figure 3). Large reductions in existing physical habitat for brown trout spawning occur at discharges below 50 cfs. The fishery maintenance flow identified by the Habitat Retention Method (50 cfs) will maintain the existing amount of physical habitat for brown trout spawning during the fall and winter, as well as meet minimum hydraulic criteria for fish passage and survival.

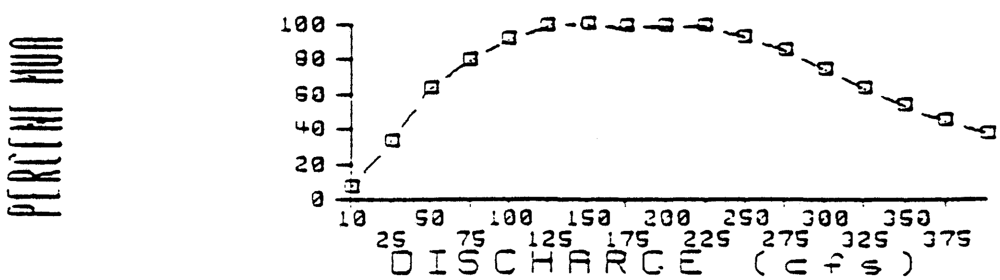


Figure 3. Percent of maximum usable area (MUA) for spawning life stage of brown trout.

Results from the HQI analyses (Figure 4) indicate that under existing average late summer conditions (approximately 75 cfs), the stream presently supports approximately 36 HUs. The current fishery management objective is to maintain or improve the existing number of HUs. A discharge of 50 cfs is the minimum flow that will accomplish this objective. At average late summer flows below 50 cfs, the model indicates that reductions in the present fishery would occur. These reductions would largely be the result of lower critical period flow and lower water velocities. Increases in stream flow above 75 cfs would increase trout HUs over present conditions.

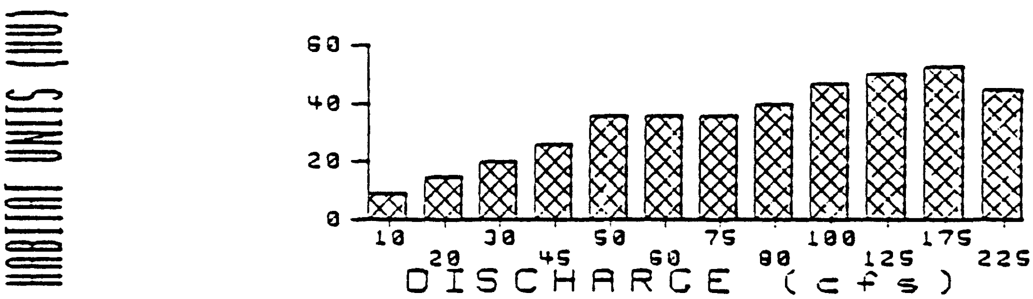


Figure 4. Number of potential trout habitat units at several average late summer flow levels in the Laramie River instream flow segment.

Based on the results from the HQI analysis, the fishery maintenance flow of 50 cfs will maintain existing levels of trout production between July 1 and September 30. 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.

CONCLUSIONS

Based on the analyses and results contained in this report, the instream flow recommendations (Table 4) apply to a 3.9 mile segment of the Laramie River extending from the east boundary of the S 1/2 NE 1/4 SE 1/4 of Section 10, T13N, R77W upstream to the south boundary of W 1/2 NW 1/4 of Section 26, T13N, R77W.

Table 4. Summary of instream flow recommendations to maintain the existing trout fishery in the Laramie River.

Time Period	Instream Flow Recommendation (cfs)
April 1 to June 30	100[1]
July 1 to September 30	50[1]
October 1 to March 31	50[2]

1 - Feasibility determined by availability at the 50% exceedence level during the specified time period

2 - To maintain existing natural stream flows

LITERATURE CITED

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.

Milhous, R. T., D. L. Wegner, and T. Waddle. 1984. User's guide to the Physical Habitat Simulation System. Instream Flow Paper 11, FWS/OBS-81/43, U.S. Fish and Wildlife Service, Fort Collins,. Colorado.

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

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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.

Form S.W. 1
Rev. 10-85

NOTE: Do not fold this form. Use typewriter or print neatly with black ink.

STATE OF WYOMING

OFFICE OF THE STATE ENGINEER

APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

THIS SECTION IS NOT TO BE FILLED IN BY APPLICANT

Filing/Priority Date

THE STATE OF WYOMING, } SS.
STATE ENGINEER'S OFFICE }

This instrument was received and filed for record on the 15th day of December, A.D. 19 89, at 2:20 o'clock P. M.

Frank J. Trelease
FRANK J. TRELEASE, for State Engineer

Recorded in Book ______ of Ditch Permits, on Page ______.

Fee Paid $ 25.00, Map Filed E

WATER DIVISION NO. 1 DISTRICT NO. 4 Temp. Filing No. 27 6/30

PERMIT NO. ______

NAME OF FACILITY Laramie River - Instream Flow Segment No. 1

1. Name(s), mailing address and phone no. of applicant(s) is/are Wyoming Water Development Commission, Herschler Building, Cheyenne, WY 82002

(If more than one applicant, designate one to act as Agent for the others)

2. Name & address of agent to receive correspondence and notices Francis Petera, Wyoming Game and Fish Department, 5400 Bishop Boulevard, Cheyenne, Wyoming; Michael Purcell, Wyoming Water Development Commission, Herschler Bldg., Cheyenne, Wyoming.

3. (a) The use to which the water is to be applied is Instream Flow

(b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item 10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is Laramie River, tributary of the North Platte River.

5. The ~~point of diversion of the proposed works is located~~ beginning Instream Flow Segment extends ~~feet distant~~ from the south boundary of the W 1/2 SW 1/4 corner of Section 26 T. 13 N., R. 77 W., and ~~is in the~~ downstream to the east bdry. of S 1/2 NE 1/4 SE 1/4 of Section 10 T. 13 N., R. 77 W.
Length of Stream approximately 3.94 miles.

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned. The land crossed by this stream segment in SE 1/4 S 15, T.13N, R.77W. and in NE 1/4 S 22, T.13N, R.77W is owned by the Wyoming Game and Fish Department. Lands crossed by this stream segment in the W 1/2 NW 1/4 S 26, T. 13N, R. 77W and in W 1/2 SW 1/4 S 23, T. 13N, R. 77W are deeded private lands from which the Wyoming Game and Fish Department has purchased permanent public fishing easements on at least one side of the river channel. Lands crossed by this stream segment in the S 1/2 NE 1/4 SE 1/4 ~~S 10, T. 13 N, R. 77 W, in the SE 1/4 SE 1/4 S 10 T. 13N, R. 77W and in the E 1/2~~ NE 1/4 S 15, T. 13N, R. 77W are deeded private lands from which the *

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is (see remarks) cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is 30 days, for completion of construction is 30 days, and to complete the application of water to the beneficial uses stated in this application is 30 days

*Wyoming Game and Fish Department has purchased a 25-year lease (expiring in 22 years) for public fishing access.

Permit No. ______ Page No. ______ (Leave Blank)

10. The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land, Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.

			NE¼				NW¼				SW¼				SE¼				
Township	Range	Sec.	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	NE¼	NW¼	SW¼	SE¼	TOTALS
13	77	26						x	x										
13	77	23										x	x						
13	77	22	x	x		x									x				
13	77	15	x	x	x	x									x		x	x	
13	77	10													x			x	

Number of acres to receive original supply ______

Number of acres to receive supplemental supply ______

Total number of acres to be irrigated ______

REMARKS

MONTHLY INSTREAM FLOW REQUESTED

Month	Flow (CFS
Oct.	50
Nov.	50
Dec.	50
Jan.	50
Feb.	50
Mar.	50
Apr.	100
May	100
June	100
July	50
Aug.	50
Sept.	50

Based on the results of a study conducted in 1981 by the Wyoming Game and Fish Department (attached), a flow right of 50 cfs is requested from October 1 to March 31 to maintain or improve existing levels of trout survival and to maintain or improve existing levels of brown trout spawning. A flow of 100 cfs is requested from April 1 to June 30 to maintain or improve existing levels of rainbow trout spawning. A flow of 50 cfs is requested from July 1 to September 30 to maintain or improve existing levels of adult trout production.

Intervening ditches - Porter Mill Race and Ditch Permit No. 3347 (Adjudicated), Jelm Reservoir Permit No. 2033 Res. (Expired), Power Canal Permit No. 10367 (Expired).

The length of stream segment is 3.94 miles.

USGS gage # 0665950, located upstream from the Pioneer canal in the SE¼ NE¼ S 36, T. 14N., R. 77W., may be appropriate for an instream flow control gage. If another gage is needed, it will be installed near the east boundary of the S ½ NE¼ SE¼ S 10, T. 13N, R. 77W.

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

[illegible signature] ______ 12/15/[illegible]
Signature of Applicant or Agent — Date

LARAMIE RIVER INSTREAM FLOW SEGMENT NO.1
(Length of river segment = 3.94 miles)
(1 Adjudicated Intervening Ditch)

Amounts of Instream Flow Requested at the downstream end of Segment No. 1

MONTH	FLOW (cfs)
Oct.	50
Nov.	50
Dec.	50
Jan.	50
Feb.	50
Mar.	50
Apr.	100
May	100
June	100
July	50
Aug.	50
Sept.	50

NOTE:
USGS gage No. 0665950 located upstream from the Pioneer Canal in the SE1/4 NE1/4 Sec. 36, T. 14 N., R. 77 W. may be appropriate for an Instream flow control gage. If another gage is needed it will be installed near the East boundary of the S1/2 NE1/4 SE1/4 Sec. 10, T. 13 N., R. 77 W.

LEGEND:

U.S. - Federal Land
P - Private Land (See Notes)
G & F - Game & Fish Land

NOTES:

P
Private land owners with no public easements

P-1
Lease agreement for public fishing, public parking and public vecicular acess. Public fishing area from midstream of the Laramie River outward and horizontally to a point (50) feet above the normal high waterline on each side of said river across the following described lands:

S1/2 NE1/4 SE1/4 Section 10, T. 13 N., R. 77 W.
SE1/4 SE1/4

E1/2 NE1/4, Section 15, T. 13 N., R. 77 W.

Public parking area as it exists
Public Vehicular Access on existing road 40 ft. in width

Granted to the State of Wyoming Game and Fish Commission by Frederick G. Hansen and Patricia L. Hansen. Recorded Sept. 24, 1986 in book 364 deeds, page 6, Albany County, Wyoming.

P-2
Quitclaim deed dated August 30, 1972 to Amos Bovee and Ethelyn Bovee, husband and wife for parcels of land Section 23, T. 13 N., R. 77 W. and Section 26, T. 13 N., R. 77 W. Reserving to the Wyoming Game and Fish Commission the perpetual right for the public to fish along and in the Laramie River as it traverses and crosses the above described lands, with the right of ingress and egress upon the stream bed of said river and lands immediately along such stream bed.

State of Wyoming)
)ss
County of Laramie)

I Jon S. Ogden, of Cheyenne, Wyoming do hereby certify that this map was made from the Woods Landing, Wyo. U.S. Geological Survey Map dated 1961 and the Jelm Mountain, Wyo. U.S. Geological Survey Map dated 1963 (7.5 min. series) the U.S. Department of the Interior, General Land Office plat for T. 13 N., R. 77 W. dated Nov. 21, 1878, and SE-27 Bureau of Land Management Surface Management Quad. dated July, 1980 (Revised) and that it correctly represents the Laramie River and the land that it flows through to the best of my knowledge and belief.

Jon S. Ogden
4/2/90

N

SCALE 1" = 1000'

MAP
TO ACCOMPANY
APPLICATION FOR
LARAMIE RIVER -
INSTREAM FLOW SEGMENT NO. 1
APPLICANT
WYOMING WATER DEVELOPMENT COMMISSION
HERSCHLER BUILDING
CHEYENNE, WYOMING 82002

Approved ______________________

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Gorden W. Fassett, State Engineer

27 6/30 (Redrawn)