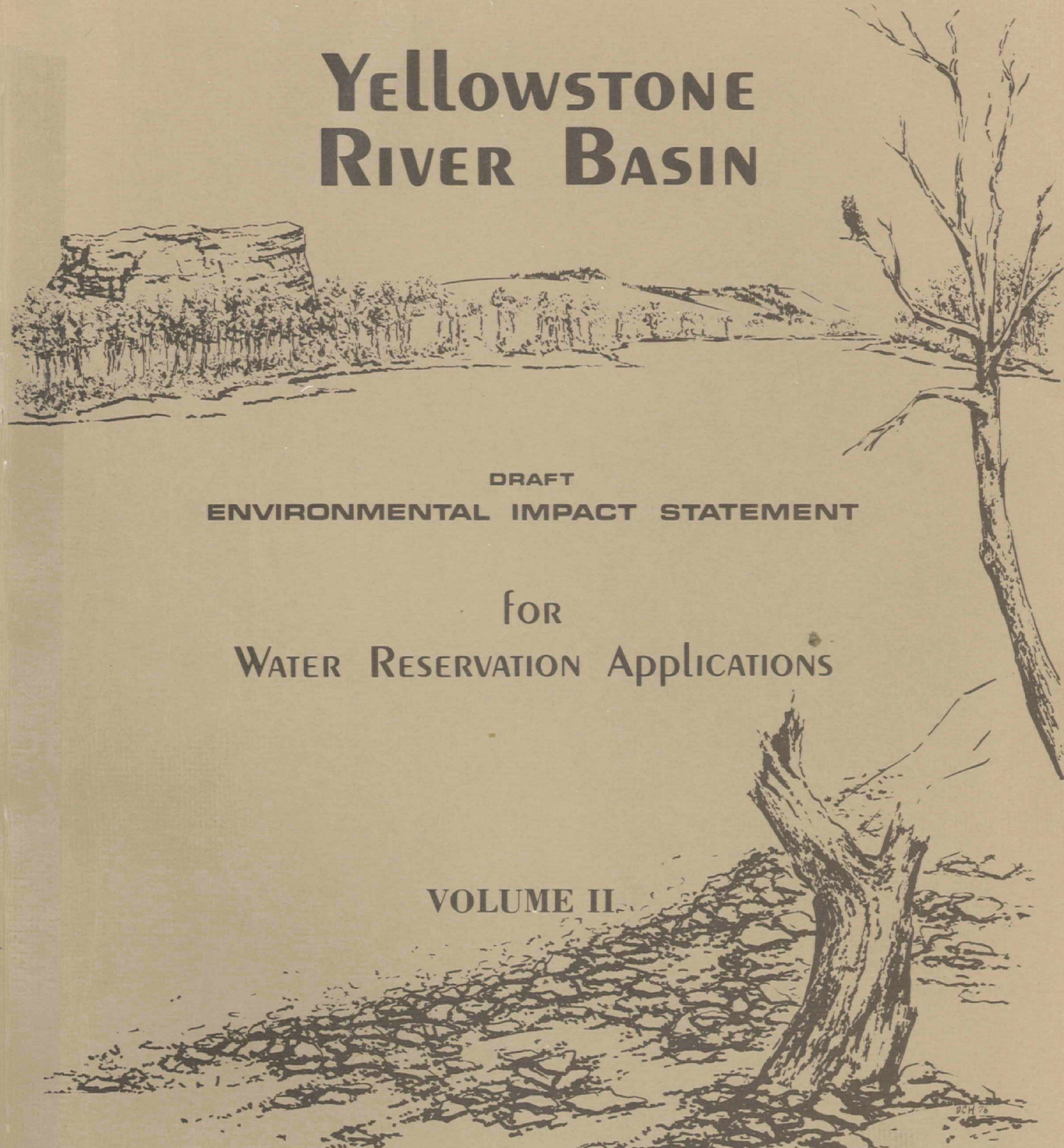
Yellowstone River Basin



DRAFT

ENVIRONMENTAL IMPACT STATEMENT

for

Water Reservation Applications

VOLUME II

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**

WATER RESOURCES DIVISION

DECEMBER 1976

VOLUME II

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ENVIRONMENTAL IMPACT STATEMENT

FOR

WATER RESERVATION APPLICATIONS

IN THE

YELLOWSTONE RIVER BASIN

December 1976

Water Resources Division
MONTANA DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
32 S. Ewing
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INTRODUCTION

Under the Montana Water Use Act (Section 89-865 et seq., R.C.M. 1947), the Board may approve, deny, or modify requests for reservations of unappropriated water for existing and future beneficial use. The Board may, if it chooses, allocate all of the unused and unappropriated waters of the Yellowstone Basin. The Board may allocate water to instream uses, such as maintenance of aquatic habitats and water quality, or consumptive uses, such as irrigation, industrial, and domestic. However, in many cases there is an inadequate supply of water to satisfy competing applicants. Thus, a number of complex issues arises.

For each of the 30 reservation applications, there are a number of conceivable alternatives. Any attempt to formulate and compare the impacts of all possible alternatives would quickly lead to an incomprehensible array of duplicative information. Therefore, the approach taken here is to formulate a set of general alternatives, representing the range of options available with as much detail as possible; the impacts of these alternatives are then presented.

It should be emphasized that the alternatives presented in this section are not the only alternatives available. Because of the large range of options, the Board has great flexibility in choosing the final combination of reservations.

STATEMENT OF ALTERNATIVES

The alternatives considered here are based on the four major uses to which the water would be put: irrigation, domestic consumption, energy conversion (thermal electric generation, coal gasification), and instream flows. In addition, a "no action" situation is considered.

THE NO ACTION ALTERNATIVE

The No Action Alternative would occur if the Board either denies all reservation requests or does not act on requests before the Yellowstone's unused waters are appropriated. The No Action Alternative attempts to answer the question: "What will happen without water reservations in the Yellowstone Basin?"

In accordance with the Montana Water Use Act, appropriation of water by permit would proceed. Water would continue to be used for irrigation, energy conversion, domestic consumption, and instream values. Based on past and current trends, as well as estimates of possible future demands for agricultural products, energy, and recreational opportunities, it is projected that this alternative would result in a mix of (1) an intermediate level of irrigation development, and (2) a high level of energy development.

THE IRRIGATION EMPHASIS ALTERNATIVE

Agriculture is the mainstay of Montana's economy and may continue to be so. In order to protect and expand this important economic sector, it may be desirable to secure a water supply for increased future irrigation.

Irrigation development does not depend exclusively on an adequate water supply. It also depends on the availability of irrigable lands, financial feasibility, markets, and less quantifiable factors such as farmer preference and peer influence. In order to consider the range of possible irrigation futures, taking into account this diversity of influences, a set of irrigation development levels--low, intermediate, and high--has been projected.

A variation on this alternative would be the granting and implementing of all noncompetive, consumptive-use reservation requests. The multipurpose requests in the Tongue and Powder rivers are not included in this variation, because these requests do not specify the amounts of water to be diverted and consumed, and because some of the same water would be diverted and consumed if granted and implemented under the irrigation requests. Except for a small (in most cases) amount of municipal water, consumption would be by irrigated agriculture. This cumulative-consumptive-applications situation is nearly the same as the Irrigation Emphasis Alternative.

THE ENERGY EMPHASIS ALTERNATIVE

It is assumed here that the Energy Emphasis Alternative would be essentially the same as the No Action Alternative.

The "energy crisis," coupled with the presence in Montana of over 50 billion tons of strippable coal, has resulted in widespread public concern over the future of water resource development and conservation in eastern Montana. Though agriculture is, and probably will always be, the major water use in the Yellowstone Basin, it was concern about energy that led to the Yellowstone Moratorium in 1974. However, if it becomes the policy of the State of Montana to maximize the level of energy development, irrigated agriculture would continue to be important and probably would continue to expand.

THE INSTREAM FLOW EMPHASIS ALTERNATIVE

An integral characteristic of Montana is its high quality natural environment. It is believed by many that this high quality environment must be protected and preserved, and that environmental quality and economic viability can be achieved jointly.

This alternative assumes that instream values would be protected at their present level; water diversion and depletion, over and above existing uses, would be made only after enough water was maintained in the streams to prevent degradation of fish and wildlife habitats and water quality. This alternative reflects a combination of the applications filed by the Fish and Game Commission and the Department of Health and Environmental Sciences.

OTHER ALTERNATIVES

The Yellowstone Basin sometimes has a limited water supply. That is, water is often not available at the time or place it is needed. Therefore, for certain uses, storage and conveyance facilities would need to be constructed. It is conceivable that water may be provided for instream or consumptive uses from other than the customary surface sources. This alternative considers some of those other sources, including ground water and Missouri River water conveyed by aqueduct.

FORMULATION OF ALTERNATIVES

The No Action Irrigation Emphasis and Energy Emphasis alternatives each assume various levels of irrigation and energy development. Following is an explanation of the rationale behind these projected development levels, the methodologies used to generate them, and the quantities of land and water resources required under each.

LEVELS OF ENERGY DEVELOPMENT

At present, relatively minor amounts of Yellowstone Basin water are diverted for use in oil, coal, and gas production, and not all water diverted is actually consumed. Up to 173 million gallons per day may be diverted for the cooling of thermal electric plants, generating 1,030 megawatts of electricity. In addition, Colstrip Units 3 and 4, certified by the Board but not yet constructed, will each have a nameplate generation capacity of 700 megawatts and will each consume 10,700 af/y. The on-line dates projected for these plants by the applicant companies are 1980 for Unit 3 and 1981 for Unit 4. Most of the water diverted for the Colstrip units will be lost into the atmosphere during the cooling process. The other generating plants in the state consume less water because they utilize once-through cooling, a process that consumes very little water; the small, natural-gas fired plant in Glendive consumes even less.

Future energy development in the Yellowstone Basin will be affected by many factors, among them:

1) the availability of water for energy conversion processes,
2) the capacity of the rail system for coal export,
3) coal severance taxes,
4) the technology and economics of eastern coal desulfurization,
5) mined land reclamation requirements,
6) federal energy policy,
7) international politics,
8) federal and state legislation on slurry pipelines,
9) national growth in energy consumption, and
10) state policy on the allocation of water to various beneficial uses.

These factors interact in a complex way, and are largely unpredictable. Projections of future demand for eastern Montana coal are therefore extremely difficult. The approach taken here in projecting energy development levels reflects an attempt to define the upper limit of coal development, based on various assumptions regarding the effects of factors tending to constrain that development.

Projections and scenarios from other studies and programs, such as the Northern Great Plains Resources Program (NGPRP), were used as a starting point. These levels were then modified by incorporating more recent information, including the Montana University Coal Demand Study (Montana University Coal Demand Study Team 1976). Generally, the effects of these changes were 1) to reduce the number of gasification plants included in the NGPRP's coal development profiles, and 2) to emphasize thermal electric generating plants.

For coal production, the high level of development was based essentially on the NGPRP high projection, while the low level represented existing coal delivery contracts and known plans for new mines. The intermediate level is evenly spaced between the high and low.

Mine and conversion plant sites were projected on the basis of locations of coal reserves, current mining, coal leases, and applications for industrial water.

In 1975, over 22 million tons of coal were mined in the state, up from 14 million in 1974, 11 million in 1973, and 1 million in 1969. By 1980, even with no new contracts, Montana's annual coal production will exceed 40 million tons. Coal reserves (see Map I-2), estimated at over 50 billion economically strippable tons (Montana Energy Advisory Council 1976), pose no serious constraint to the levels of development projected by the Yellowstone Impact Study (Table IV-1), which range from 186.7 to 462.8 million tons stripped in the basin annually by the year 2000.

The Yellowstone Impact Study projections for coal conversion are shown in Table IV-2. The related water requirements, based on unit water requirements for coal mining and conversion processes shown in Table IV-3, are illustrated in Table IV-4.

LEVELS OF MUNICIPAL WATER USE

In 1970, 81 percent of the Yellowstone Basin's 168,300 people were served by municipal systems which used 32,900 af/y of surface and ground water. That depletion is not significant compared to the 1.9 million af/y currently consumed by irrigated agriculture in the basin.

The basin's municipal water use depletion projected to the year 2000 ranges from the low development level of 5,880 af/y in increased depletion (with a population increase of 56,858) to a high development level of 10,620 af/y (with a population increase of 94,150). Even the latter figure is not significant compared to the projected depletion increases for irrigation or coal development.

See Appendix for data on 1970 municipal water use in the Yellowstone Basin, population simulations based on the levels of energy development, and the projected increases in municipal depletions for the year 2000, by subbasin.

TABLE IV-1

THE PROJECTED USE OF COAL MINED BY THE YEAR 2000 IN THE YELLOWSTONE BASIN
(MILLIONS OF TONS PER YEAR)

Subbasin[a]	Electric Generation	Gasification	Syncrude	Fertilizer	Export[b] Rail	Export[b] Slurry	Export[b] Total	Total
LOW LEVEL OF DEVELOPMENT								
Bighorn	0	0	0	0	17.1	0	17.1	17.1
Mid-Yellowstone	6.0	7.6	0	0	59.9	0	59.9	73.5
Tongue	2.0	0	0	0	77.0	0	77.0	79.0
Powder	0	0	0	0	17.1	0	17.1	17.1
Lower Yellowstone	0	0	0	0	0	0	0	0
Total	8.0	7.6	0	0	171.1	0	171.1	186.7
INTERMEDIATE LEVEL OF DEVELOPMENT								
Bighorn	0	0	0	0	23.4	5.9	29.3	29.3
Mid-Yellowstone	12.0	7.6	0	0	82.1	20.5	102.6	122.2
Tongue	8.0	0	0	0	105.6	26.4	132.0	140.0
Powder	4.0	0	0	0	23.4	5.9	29.3	33.3
Lower Yellowstone	0	0	0	0	0	0	0	0
Total	24.0	7.6	0	0	234.5	58.7	293.2	324.8
HIGH LEVEL OF DEVELOPMENT								
Bighorn	4.0	0	0	0	22.1	14.8	36.9	40.9
Mid-Yellowstone	12.0	15.2	18.0	0	77.3	51.6	128.9	174.1
Tongue	12.0	7.6	18.0	0	99.5	66.3	165.8	203.4
Powder	4.0	0	0	0	22.1	14.8	36.9	40.9
Lower Yellowstone	0	0	0	3.5	0	0	0	3.5
Total	32.0	22.8	36.0	3.5	221.0	147.5	368.5	462.8

[a] The four subbasins not shown (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, and Kinsey Area) do not include economically strippable coal deposits.

[b] It is assumed that, at the intermediate level of development, 20% of coal exports will be by slurry pipeline, and at the high level of development, 40%.

TABLE IV-2

THE INCREASE IN COAL CONVERSION IN THE YELLOWSTONE BASIN BY THE YEAR 2000

Subbasin[a]	Electric Generation (mw)	SNG (mmcf/d)	Syncrude (b/d)	Fertilizer (t/d)
LOW LEVEL OF DEVELOPMENT				
Bighorn	0	0	0	0
Mid-Yellowstone	1,500	250	0	0
Tongue	500	0	0	0
Powder	0	0	0	0
Lower Yellowstone	0	0	0	0
Total	2,000	250	0	0
INTERMEDIATE LEVEL OF DEVELOPMENT				
Bighorn	0	0	0	0
Mid-Yellowstone	3,000	250	0	0
Tongue	2,000	0	0	0
Powder	1,000	0	0	0
Lower Yellowstone	0	0	0	0
Total	6,000	250	0	0
HIGH LEVEL OF DEVELOPMENT				
Bighorn	1,000	0	0	0
Mid-Yellowstone	3,000	500	100,000	0
Tongue	3,000	250	100,000	0
Powder	1,000	0	0	0
Lower Yellowstone	0	0	0	2,300
Total	8,000	750	200,000	2,300

[a] The four subbasins not listed (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, and Kinsey Area) are not expected to include sites for coal conversion facilities.

TABLE IV-3

WATER AND COAL REQUIREMENTS FOR COAL PROCESSES

Process	Water	Coal
Thermal electric generation	15,000 af/y/1,000 mw	4 mmt/1,000 mw
Gasification	9,000 af/y/250 mmcf/d	7.6 mmt/250 mmcf/d
Syncrude	29,000 af/y/100,000 b/d	18 mmt/100,000 b/d
Fertilizer	13,000 af/y/2,300 t/d	3.5 mmt/2,300 t/d
Slurry	750 af/mmt	
Strip Mining	50 af/mmt	

TABLE IV-4

THE INCREASE IN WATER DEPLETION FOR ENERGY BY THE YEAR 2000
BY SUBBASIN (af/y)

Subbasin*	INCREASE IN DEPLETION (af/y) Elec. Generation	Gasification	Syncrude	Fertilizer	Export	Strip Mining	Total
LOW LEVEL OF DEVELOPMENT							
Bighorn	0	0	0	0	0	860	860
Mid-Yellowstone	22,500	9,000	0	0	0	3,680	35,180
Tongue	7,500	0	0	0	0	3,950	11,450
Powder	0	0	0	0	0	860	860
Lower Yellowstone	0	0	0	0	0	0	0
Total	30,000	9,000				9,350	48,350
INTERMEDIATE LEVEL OF DEVELOPMENT							
Bighorn	0	0	0	0	4,420	1,470	5,890
Mid-Yellowstone	45,000	9,000	0	0	15,380	6,110	75,490
Tongue	30,000	0	0	0	9,900	7,000	46,900
Powder	15,000	0	0	0	2,210	1,670	18,880
Lower Yellowstone	0	0	0	0	0	0	0
Total	90,000	9,000			31,910	16,250	147,160
HIGH LEVEL OF DEVELOPMENT							
Bighorn	15,000	0	0	0	11,100	2,050	28,150
Mid-Yellowstone	45,000	18,000	29,000	0	38,700	8,710	139,410
Tongue	45,000	9,000	29,000	0	24,860	10,170	118,030
Powder	15,000	0	0	0	11,100	2,050	28,150
Lower Yellowstone	0	0	0	13,000	0	0	13,000
Total	120,000	27,000	58,000	13,000	80,210	22,980	326,740

* The four subbasins not shown (Upper Yellowstone, Billings Area, Clarks Fork Yellowstone, and Kinsey Area) are not expected to experience water depletion associated with coal development.

LEVELS OF IRRIGATION DEVELOPMENT

Rainfall during the growing season, particularly in the eastern portion of the basin, rarely exceeds 10 inches. Since water requirements for most irrigated crops normally exceed 20 inches over the growing season, irrigation of many crops is necessary.

Irrigated agriculture in the Yellowstone Basin has been increasing since 1971 (Montana DNRC 1975b). Much of this expansion can be attributed to the introduction of sprinkler irrigation systems. Approximately two-thirds of all irrigation systems recently installed are sprinkler systems (Montana DNRC 1975b), with pump lifts varying from a few feet to 450 feet above the Yellowstone River.

As a part of the Yellowstone Impact Study, DNRC is determining the feasibility of delivering water to irrigable lands in the Yellowstone Basin and projecting what development may occur over the next 25 years. Only the Yellowstone River and its four main tributaries are considered as water sources in this study.

DNRC's reconnaissance land classification survey was used to identify the irrigable land in the basin. A preliminary economic evaluation, conducted to set upper limits of pumping feasibility, limited the area of consideration to land no more than three miles from the river and no more than 450 feet above the water source. The total area considered was thus reduced from the 2.2 million irrigable acres listed in the land classification survey to 448,000 acres. These lands were categorized according to lift (50-foot increments) and pipeline length (half-mile increments).

For each parcel of land, the costs of delivering an adequate supply of irrigation water were calculated. Irrigation costs were separated into water delivery cost and application cost. Annual costs of delivering water to the farm gate were developed for each lift and length category. Basic data were provided by the U.S. Bureau of Reclamation, and a computer program was used to select the most efficient pump and pipe size for each category, based on both initial and annual operation costs.

Water application costs were developed from information provided by the Cooperative Extension Service (1969). The costs of a center-pivot sprinkler system were used, since this type was employed on about two-thirds of all new irrigation systems installed since 1973 (Montana DNRC 1975b).

Costs for both the water delivery system and the application system include both initial costs and annual operation costs. The initial cost of all pumps, pipe, houses, electrical equipment, and installation was converted to an annual cost using a capital recovery factor at 10 percent interest with a 10-year loan period, terms slightly better than the prevalent rate and loan period at the time the study was begun. This amortized cost was then added to the annual operation costs (labor, maintenance, repairs, and electricity) and divided by the irrigated acres to determine total irrigation costs per acre per year.

Also calculated for each parcel of land was the per-acre capacity to pay all irrigation costs. Separate farm budgets were prepared for each subbasin to reflect local farming practices. All crops produced in each area were placed into four categories, and an average cropping pattern developed to represent historical patterns. Sugar beets were used to represent all high-value cash crops such as beets or dry beans. Barley represented the grains; alfalfa represented all hay crops; and corn silage represented all silage crops (including ensiled hay or beet tops).

The farm budgets assess costs and profits associated with crop production, plus generalized farm costs such as investment, maintenance, and repair of buildings and fences. Since the budgets include all costs associated with a farm enterprise, including adequate payments to the farmer for his labor, management, and investment, all remaining profit may be used to pay irrigation costs. This profit margin was then compared to the total irrigation costs for each lift and length category. Maximum pumping lifts and distances were identified for each subbasin, and the approximate total acreage feasible to irrigate was determined.

Of the 448,000 acres studied, 237,000 were determined to be financially feasible for irrigation. These lands, along with those now receiving full or partial irrigation, are listed in Table IV-5 and shown on Map IV-1. Table IV-6 shows the feasibly irrigable acreage in each subbasin by lift and pipeline length, and Table IV-7 shows the same acreage by subbasin and county.

Three levels of development were projected to allow for such factors as farmer preference and peer influence: the lowest includes one-third; the intermediate, two-thirds; and the highest, all of the feasibly irrigable acreage. These constant-interval levels permit interpolation of results to other possible situations.

The number of acres financially feasible for new irrigation at each development level was converted to a projected water consumption level by applying a water depletion rate of two acre-feet per acre, a rate derived from average consumption requirements for basin crops, with allowances for factors such as evaporation and leakage from distribution systems. Table IV-8 shows the increased irrigated acreage and associated water consumption for the low, medium, and high levels of development in each subbasin. In order to analyze the effects of these levels of irrigation development on Yellowstone Basin streams, it was assumed that the irrigation diversion rate would be three acre-feet per acre. Thus, one acre-foot per acre would later be returned to the streams.

Following, for each of the alternatives introduced above, is a detailed description of each alternative and a discussion of the environmental and economic impacts, both primary and secondary, which would likely result if the alternative was realized.

TABLE IV-5

YELLOWSTONE DRAINAGE BASIN IRRIGATED AND IRRIGABLE LANDS

County	Irrigated Lands Full	Partial	Total	Irrigable lands	Lands feasible[a] to irrigate
Big Horn	70,243		70,243	309,676	15,222
Carbon	97,159	1,800	98,959	70,509	2,160
Carter		2,185	2,185	12,108	b
Custer	34,617	11,046	45,663	88,272	43,795
Dawson	19,840	0	19,840	416,902	18,355
Fallon		2,433	2,433	48,399	b
Gallatin	4,000		4,000	4,180	b
Garfield		80	80	0	b
McCone				498	b
Meagher	25		25	121	b
Musselshell	102		102	674	b
Park	68,434	141	68,575	98,249	21,664
Powder River	5,476	27,816	33,292	394,486	46,853
Prairie	12,341	717	13,058	77,895	11,789
Richland	40,157		40,157	113,057	10,421
Rosebud	33,125	3,126	36,251	126,507	21,135
Stillwater	34,592	270	34,862	18,930	10,204
Sweetgrass	56,250		56,250	88,805	6,208
Treasure	22,241	885	23,126	82,504	9,591
Wibaux		107	107	18,489	663
Yellowstone	99,514	50	99,564	232,126	19,412
Basin total	598,116	50,656	648,772	2,202,387	237,472

[a]Criteria for feasibility are explained elsewhere in this report.
[b]Because only the Yellowstone mainstem and its major tributaries were considered as sources of irrigation water in the feasibility study discussed in this report, no lands in these counties were considered economically feasible to irrigate.

TABLE IV-6

FEASIBLY IRRIGABLE ACREAGE BY LIFT AND PIPELINE LENGTH, HIGH LEVEL OF DEVELOPMENT

Pipeline length (mi)	Lift (ft) 0-50	50-100	100-150	150-200	200-250	250-300	Total
UPPER YELLOWSTONE SUBBASIN							
0 - .5	38,076	0	0	0	0	0	38,076
CLARKS FORK SUBBASIN							
0 - .5	2,160	0	0	0	0	0	2,160
BILLINGS AREA SUBBASIN							
0 - .5	3,308	3,324	329	2,147	0	222	9,330
.5 - 1.0	347	71	8,084	1,305	0	0	9,807
1.0 - 1.5	110	0	0	0	0	0	110
1.5 - 2.0	0	165	0	0	0	0	165
Total	3,765	3,560	8,413	3,452	0	222	19,412
BIGHORN SUBBASIN							
0 - .5	4,478	0	1,309	0	0	0	5,787
.5 - 1.0	1,608	3,451	0	0	0	0	5,059
1.0 - 1.5	0	2,191	0	0	0	0	2,191
Total	6,086	5,642	1,309	0	0	0	13,037
MID-YELLOWSTONE SUBBASIN							
0 - .5	16,000	1,691	0	0	0	0	17,691
.5 - 1.0	3,180	4,358	0	0	0	0	7,538
Total	19,180	6,049	0	0	0	0	25,229
TONGUE SUBBASIN							
0 - .5	21,947	0	0	0	0	0	21,947
KINSEY AREA SUBBASIN							
0 - .5	3,248	0	0	1,180	0	0	4,428
.5 - 1.0	0	0	0	0	0	0	0
1.0 - 1.5	308	0	0	0	0	0	308
Total	3,556	0	0	1,180	0	0	4,736
POWDER RIVER SUBBASIN							
0 - .5	74,224	0	0	0	0	0	74,224
.5 - 1.0	981	0	0	0	0	0	981
Total	75,205	0	0	0	0	0	75,205

TABLE IV-6, continued

Pipeline length (mi)	Lift (ft)						Total
	0-50	50-100	100-150	150-200	200-250	250-300	
			LOWER YELLOWSTONE SUBBASIN				
0 - .5	23,677	1,804	1,775	0	0	0	27,256
.5 - 1.0	1,813	4,992	100	0	0	0	6,905
1.0 - 1.5	0	2,599	0	0	0	0	2,599
1.5 - 2.0	0	805	0	0	0	0	805
2.0 - 2.5	0	105	0	0	0	0	105
Total	25,490	10,305	1,875	0	0	0	37,670
			BASIN SUMMARY				
0 - .5	187,118	6,819	3,413	3,327	0	222	200,899
.5 - 1.0	7,929	12,872	8,184	1,305	0	0	30,290
1.0 - 1.5	418	4,790	0	0	0	0	5,208
1.5 - 2.0	0	970	0	0	0	0	970
2.0 - 2.5	0	105	0	0	0	0	105
Total	195,465	25,556	11,597	4,632	0	222	237,472

NOTE: This table should not be considered an exhaustive listing of all feasibly irrigable acreage in the Yellowstone Basin; it includes only the acreage identified as feasibly irrigable according to the geographic and economic constraints explained elsewhere in this report.

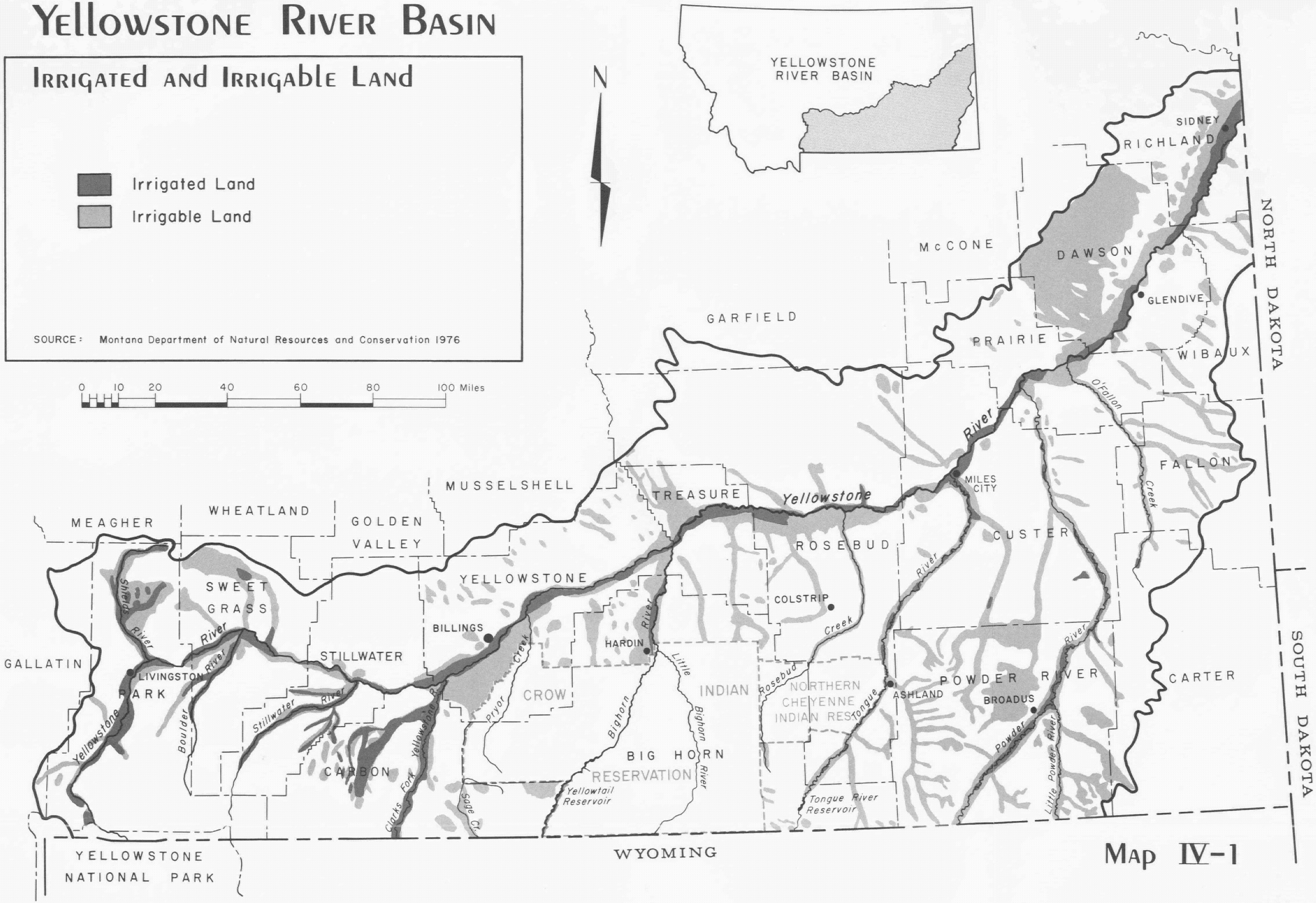
TABLE IV-7

FEASIBLY IRRIGABLE ACREAGE BY COUNTY AND SUBBASIN BY 2000, HIGH LEVEL OF DEVELOPMENT

County	Upper Yellowstone	Clarks Fork	Billings Area	Big Horn	Mid Yellowstone	Tongue River	Kinsey Area	Powder River	Lower Yellowstone	County Totals
Park	21,664									21,664
Sweet Grass	6,208									6,208
Stillwater	10,204									10,204
Carbon		2,160								2,160
Yellow-stone			19,412							19,412
Big Horn				13,037		2,185				15,222
Treasure					9,591					9,591
Rosebud					11,408	9,727				21,135
Powder River								46,853		46,853
Custer					4,230	10,035	3,092	26,438		43,795
Prairie							1,644	1,914	8,231	11,789
Dawson									18,355	18,355
Richland									10,421	10,421
Wibaux									633	633
Basin Totals	38,076	2,160	19,412	13,037	25,229	21,947	4,736	75,205	37,670	237,472

NOTE: The number of irrigable acres for the low and intermediate development levels are one-third and two-thirds, respectively, of the numbers given here. This table should not be considered an exhaustive listing of all feasibly irrigable acreage in the Yellowstone Basin; it includes only the acreage identified as feasibly irrigable according to the geographic and economic constraints explained elsewhere in this report.

Yellowstone River Basin



Map IV-1

TABLE IV-8

THE INCREASE IN WATER DEPLETION FOR IRRIGATED AGRICULTURE BY 2000
BY SUBBASIN

Subbasin	Increase in acreage	Increase in diversion (af/y)	Increase in depletion (af/y)
Low level of development			
Upper Yellowstone	12,690	38,070	25,380
Clarks Fork	720	2,160	1,440
Billings area	6,470	19,410	12,940
Bighorn	4,350	13,050	8,700
Mid-Yellowstone	8,410	25,230	16,820
Tongue	7,320	21,960	14,640
Kinsey area	1,580	4,740	3,160
Powder	25,070	75,210	50,140
Lower Yellowstone	12,560	37,680	25,120
Total	79,170	237,510	158,340
Intermediate level of development			
Upper Yellowstone	25,390	76,170	50,780
Clarks Fork	1,440	4,320	2,880
Billings area	12,940	38,820	25,880
Bighorn	8,690	26,070	17,380
Mid-Yellowstone	16,820	50,460	33,640
Tongue	14,630	43,890	29,260
Kinsey area	3,160	9,480	6,320
Powder	50,140	150,420	100,280
Lower Yellowstone	25,100	75,300	50,200
Total	158,310	474,930	316,620
High level of development			
Upper Yellowstone	38,080	114,240	76,160
Clarks Fork	2,160	6,480	4,320
Billings area	19,410	58,230	38,820
Bighorn	13,040	39,120	26,080
Mid-Yellowstone	25,230	75,690	50,460
Tongue	21,950	65,850	43,900
Kinsey area	4,740	14,220	9,480
Powder	75,200	225,600	150,400
Lower Yellowstone	37,670	113,010	75,340
Total	237,480	712,440	474,960

THE NO ACTION ALTERNATIVE

The Board of Natural Resources and Conservation may approve, deny, or modify requests for reservation of water. If the Board either denies the reservation requests or takes action too late to exercise the preference options encouraged by the Yellowstone Moratorium, the result would be quite similar.

Water would continue to be appropriated and used consistent with the provisions of the Montana Water Use Act. Irrigated agriculture would probably continue to expand, at least in the near future. Decisions to develop specific projects would be based on market conditions for agricultural products and irrigation equipment. The availability of a dependable water supply would be determined on a project-by-project basis, as it would for projects with reserved water. All factors considered, it is expected that the intermediate level of irrigation development is the appropriate projection for this No Action Alternative.

Currently pending because of the Yellowstone Moratorium are several applications for large industrial diversions. The quantities of water involved in these applications, shown in Table V-1, are large; indeed, in the Tongue and Powder subbasins, more water has been applied for than could be made available. It is unlikely that these applications would be implemented in their entirety even where a potential water supply exists. For the purposes of the No Action Alternative, then, it was assumed that the high level of energy development, believed to be the upper limit based on the many factors which constrain coal development, is the appropriate projection.

Population growth is more a function of industrial than agricultural growth. Therefore, the high level of municipal growth is also the appropriate projection.

Table IV-9, following, shows the demands for consumptive water use under the No Action Alternative based on the needs for the intermediate level of irrigation development and the high levels of energy and municipal development. Note that, for irrigation, the diversion requirement would be 50 percent more than the depletion. Later discussion will point out the inability of the Tongue and Powder subbasins to meet these demands.

TABLE IV-9

THE INCREASE IN WATER DEPLETION DEMAND
FOR THE NO ACTION ALTERNATIVE
BY THE YEAR 2000

	Increase in Depletion (af/y)			
Subbasin	Irrigation	Energy	Municipal	Total
Upper Yellowstone	50,780	0	0	50,780
Clarks Fork	2,880	0	0	2,880
Billings Area	25,880	0	3,900	29,780
Bighorn	17,380	28,150	480	46,010
Mid-Yellowstone	33,640	139,410	3,840	176,890
Tongue[a]	29,260	118,030	780	148,070
Kinsey Area	6,320	0	0	6,320
Powder[a]	100,280	28,150	1,140	129,570
Lower Yellowstone	50,200	13,000	480	63,680
TOTAL	316,620	326,740	10,620	653,980[a]

[a]The water supply in the Tongue and Powder subbasins is insufficient to meet the demands; consequently, the basinwide depletion would be reduced to about 612,000 af/y.

Under the No Action Alternative, little provision is made for instream flows. In the Upper Yellowstone Subbasin, instream flows would presumably be protected by the earlier filing of the Department of Fish and Game on the "blue ribbon" reach of the Yellowstone mainstem. In the Tongue Subbasin, the Department's analysis assumed the provision of minimum flows of 45 cfs (2700 af/month) during March, April, and May and 15 cfs (900 af/month) the rest of the year, because of the especially diverse and productive fishery. These minimum flows are not intended to minimize impacts on the fishery, but rather to prevent its total destruction.

In other tributaries and in the Yellowstone mainstem, no special provisions were made, as a part of the No Action Alternative, for instream flows.

IMPACTS -- NO ACTION ALTERNATIVE

The No Action Alternative demands the diversion of 812,290 af/y and the consumption of 653,980 af/y of water throughout Montana's portion of the Yellowstone Basin. The impacts of such diversion and depletion are discussed below, first considering the effects which might result throughout the basin, then those which would be unique to each subbasin.

GENERALIZED IMPACTS -- NO ACTION ALTERNATIVE

PRIMARY IMPACTS

Although this alternative would place heavy water demands on the system, the supply would generally be adequate. Water availability problems would occur in the Tongue and Powder rivers and the lower Yellowstone mainstem.

Water quality would remain near its current high level in the upper basin. However, the natural degradation of the lower basin waters, particularly in the Tongue and Powder subbasins, would be amplified. Irrigation return flows would be of poor quality (saline), but would be adequately diluted by the larger streams such as the Yellowstone mainstem.

With the major exception of the Powder River, changes in channel morphology in most subbasins would not be noticeable. Some localized sedimentation and erosion would occur, but most could be mitigated by proper land management practices and diversion designs. In many cases conversion of overgrazed rangeland or dry cropland to irrigated cropland would reduce erosion and sedimentation by improving the vegetation cover.

Aquatic ecosystems would suffer varying impacts, ranging from minor on the upper basin mainstem to severe in some small tributaries, as well as in the Tongue and Powder subbasins.

Under present conditions, most primary productivity in the Yellowstone mainstem is by two groups of algae: 1) diatoms, of which there are probably 300 to 400 species, and 2) green algae of the genus *Cladophora*. Because the diatoms are such a diverse group, it is likely that any adverse effects to one species as a result of altered streamflows would be offset by benefits to another species.

Cladophora however, is extremely sensitive to streamflow fluctuations. Cladophora thrives onstable flows such as those below dams and sewage outfalls. In such situations, it is often a nuisance, as in the case below the Yellowtail afterbay dam where its abundance interferes with fishing. Further stabilization of flows anywhere in the basin would tend to favor Cladophora,perhaps to the point of nuisance.

Under unstable flow conditions, *Cladophora* does not do well. Presently, *Cladophora* in the Yellowstone mainstem is held in check, but at a point of high productivity, by the fluctuating flow regime. An increase in the fluctuation of streamflows, as would be the case where low flows were diverted and depleted and peak flows were not attenuated by storage, would result in a decrease in the productivity of Cladophora and, thus, the river.

Riparian ecosystems would be affected less than the aquatic ecosystems; in fact, increasing numbers of migratory waterfowl could be attracted to the new irrigated fields.

SECONDARY IMPACTS

Under this alternative, water would generally be available for consumptive uses, such as irrigation, municipal-domestic, and industrial.

Perhaps most significant to potential irrigators is that, even though a future irrigation water supply would not be secured by reservation, neither would it be precluded by instream reservations. Irrigation could expand where profitable with water supplies, if available, acquired by permit. In Part III of this EIS, beginning on page 154, the future benefits from irrigation are estimated. Irrigating the 158,310 acres envisioned under the No Action Alternative (which assumes the intermediate level of irrigation development) would have effects similar to those of irrigating the 162,500 acres considered in that discussion.

The No Action Alternative could benefit future industrial expansion. The granting of reservations could make water less available to industry, either constraining development or necessitating increased expenditures for developing and treating alternative water supplies.

Much of the time water would also be available in most subbasins for instream uses. However, in some upper Yellowstone tributaries, in the lower Yellowstone, and especially in the Tongue, the impact of the No Action Alternative on instream values could be most serious. These values, for example, fish and wildlife habitat, water quality, recreation, and aesthetics, would be unprotected and vulnerable to degradation resulting from industrial and agricultural depletions.

The dollar value of these losses would be substantial, but impossible to determine because contemporary methods of analysis are inadequate and because it is not known with certainty how much degradation will take place in the future.

UPPER YELLOWSTONE, CLARKS FORK YELLOWSTONE, BILLINGS AREA, AND BIGHORN SUBBASINS -- IMPACTS OF THE NO ACTION ALTERNATIVE

With the exception of a relatively small amount of coal mining in the Bighorn subbasin, which would be served by the already regulated Bighorn River, no energy development is projected for these subbasins; therefore, the No Action Alternative would be nearly the same as the intermediate level of irrigation development. For irrigated lands supplied by the Yellowstone mainstem as well as the Bighorn River, the water supply would be adequate. The resulting environmental impacts, both primary and secondary, would be minor.

Lands could also be irrigated using waters of the Shields River, Sweet Grass Creek, Rock Creek, and the Clarks Fork Yellowstone. Discussions of the water supply and environmental implications of these situations are presented in Part III of this document; see the sections on the Park, Sweet Grass, and Carbon conservation district applications (pages 134, 138, and 140).

MID-YELLOWSTONE SUBBASIN -- IMPACTS OF THE NO ACTION ALTERNATIVE

Under the No Action Alternative, the Mid-Yellowstone Subbasin would undergo large-scale energy development, as well as extensive new irrigation. It is assumed that all water would be supplied from the Yellowstone mainstem.

Because of anticipated upstream depletions, which would amount to over 300,000 af/y, the effects of the No Action Alternative would begin to be felt within this subbasin. Although changes in streamflow, water quality, and aquatic habitat would be small (but noticeable) under average flow conditions, these effects during low flow months of low flow years would be significant. August and September flows would be especially vulnerable. See the section, following, on the Lower Yellowstone Subbasin for a discussion of the impacts which would begin to be noticed in this subbasin.

TONGUE SUBBASIN -- IMPACTS OF THE NO ACTION ALTERNATIVE

PRIMARY IMPACTS

The No Action Alternative in the Tongue Subbasin predicts an increased diversion of 162,700 af/y and increased depletion of 148,000 af/y from the Tongue River. At the present time, most of the firm annual yield of Tongue River Reservoir--40,000 af/y--is already commited to existing uses. Any significant further development would require additional storage.

The construction of High Tongue Dam about nine miles downstream from the existing structure would create an active storage capacity of up to 450,000 af. The firm annual yield available to Montana would be from 112,000 to 134,000 af/y, depending on the amount of water depleted in Wyoming and on the location of Montana points of diversion. This range in firm annual yield is still significantly less than the projected demand under the No Action Alternative.

During simulation of this alternative, using the State Water Planning Model, it was assumed that instream flows of 45 cfs (2,700 af/month) during March, April, and May and 15 cfs (900 af/month) the rest of the year would be provided from an active reservoir storage capacity of 320,000 af. This would further reduce the water available for consumptive use; even so, it would not alleviate the severe impact on the fishery. In the simulation, priority was given to the energy industry because it presumably would be able to outbid irrigators for the water.

Streamflow Alterations

Figure IV-1 shows the effect of the No Action Alternative on the monthly outflows of the Tongue Subbasin. The 90th percentile low flows would be the same as the instream flow provisions outlined above. Median flows would be modestly reduced from December through June. The median July flow would be reduced by nearly half. From August through November, median flows would be approximately the same as the 90th percentile low flows (instream flow guarantees).

Channel Form

Despite these significant flow reductions in certain months, the river channel would probably change very little, for it has already undergone a major change due to the construction of the existing dam. Because of reduced flows, however, vegetation would tend to encroach on the channel.

Water Quality

TDS concentrations in the Tongue River already exceed 500 mg/l two-thirds of the year, and average over 700 mg/l during December and January. Salinity would increase appreciably under the No Action Alternative. TDS levels would average over 1,000 mg/l at least half of the time; for 90th percentile low flows, TDS concentrations would exceed 1,000 mg/l in all but high flow months, and would be on the order of 1,300-1,400 mg/l half of the time.

Reduced streamflows would decrease the sediment transport capacity of the river. However, sediment available for transport would also be reduced. The bed of the river is presently armored with large particles not subject to erosion. Finer, erodible particles in the banks would not be accessible to the reduced flows, especially after vegetation encroaches farther into the channel.

Although no exact analysis is available, it is clear that summer water temperatures would increase and that diurnal fluctuations would reduce dissolved oxygen concentrations to levels dangerously low for aquatic life.

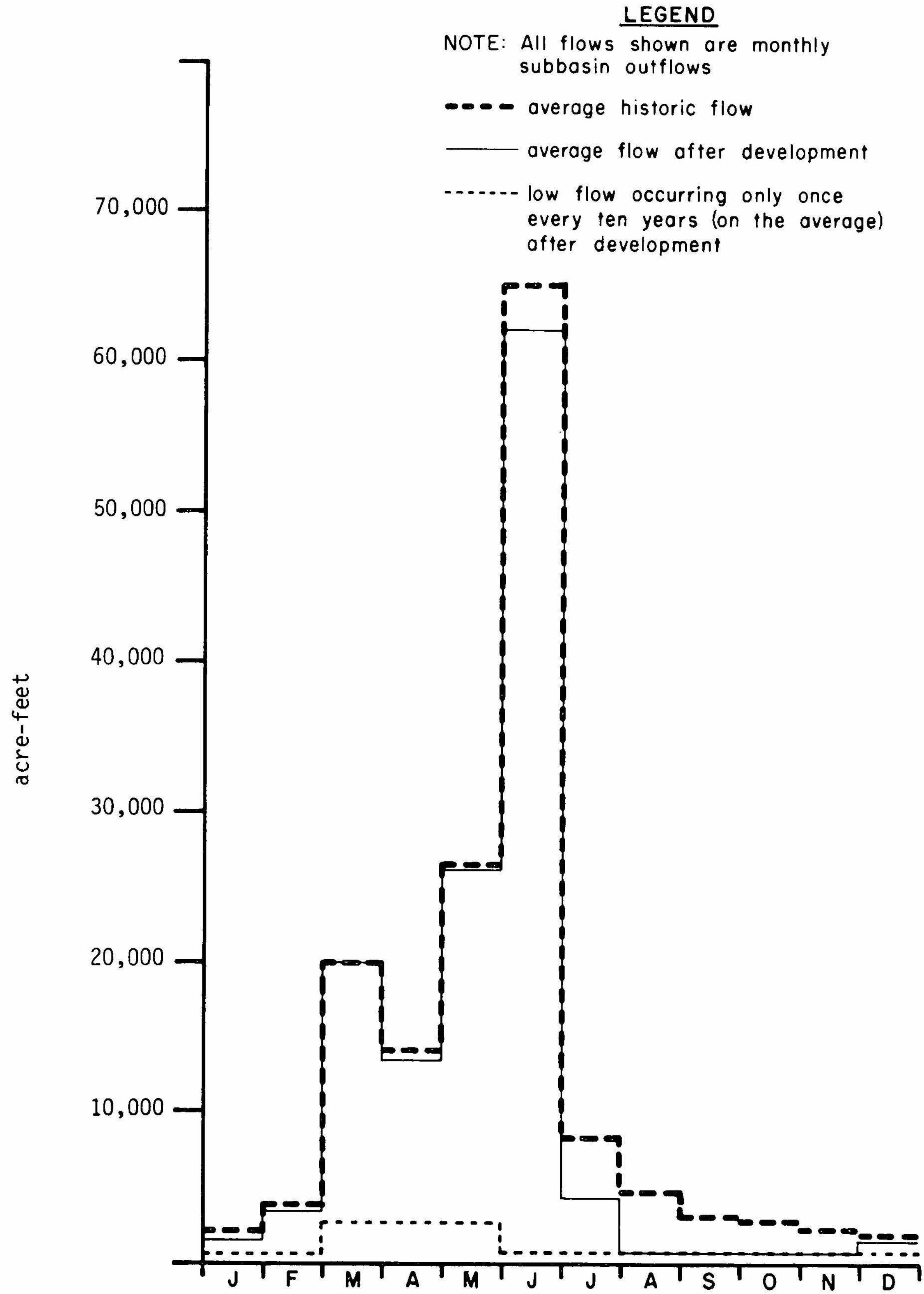


FIGURE IV-1. Tongue River Subbasin Monthly Outflows for the No Action Alternative

Ecosystems

Virtually all aquatic organisms would suffer severe impacts from the flow and water quality changes which would result under the No Action Alternative.

The species composition of periphyton and macroinvertebrate communities would change, reflecting the competitive advantage of those tolerating high salinities and temperatures as well as fluctuating concentrations of dissolved oxygen.

The instream flows under this alternative would be far less than those needed for spawning, rearing, and wintering of the current fishery. Species composition would change, with the virtual elimination of such migratory species as sauger and shovelnose sturgeon. Channel catfish, smallmouth bass, and non-game fish would also probably not be able to tolerate the poor water quality. The fish population level would be substantially reduced because of the loss of suitable habitat.

The present lack of islands in the Tongue River limits the nesting ability of Canada geese. Flow reductions such as those which would result under the No Action Alternative would increase predators' access to goose nests, decreasing (or eliminating) the already low goose population. At present, more ducks than geese can be found along the Tongue, but major flow reductions would severely reduce the habitat available to ducks as well. Inundation of the existing reservoir by the High Tongue Dam would destroy the cormorant rookery there.

Major impacts to beaver have already occurred with the construction of Tongue River Dam and the subsequent loss of river islands and backwater areas. Encroachment of vegetation on the river channel would increase the food supply for beavers until vegetation approached the expected cottonwood climax, when food supply would be reduced. Lower flows in winter could also result in freezing of beaver caches and muskrat feedbeds, exposing these animals to both predation and thermal stress.

SECONDARY IMPACTS

Under the No Action Alternative, enough water would be available to meet the demands projected under the high level of energy development.

Irrigation expansion would be constrained, however, by the limited water supply and the probable inability of irrigators to pay for the necessary increased storage. Irrigation expansion, if it were to occur, would require a financially subsidized water supply. There would be a far less than adequate supply for instream uses of water. In fact, as described above, a significantly modified ecosystem--with a different animal species composition and a different vegetation structure--would evolve.

The existing semi-natural, semi-pastoral valley would become more industrialized and urbanized. Land use patterns, historically reflecting agriculture and wildlife, would be partially converted to include strip mines, energy conversion plants, pipelines, transmission lines, and buildings.

Recreation opportunities would diminish markedly due to fish and wildlife habitat destruction, alteration of aesthetics, and increased human population.

KINSEY AREA SUBBASIN -- IMPACTS OF THE NO ACTION ALTERNATIVE

This small subbasin would, under the No Action Alternative, have no energy development and little increased irrigation. Flows in the Yellowstone mainstem differ from those in the Mid-Yellowstone Subbasin immediately upriver mostly because of flows entering from the Tongue River. Under the No Action Alternative, the flows from the Tongue would be severely reduced; however, because they are quite small relative to those of the Yellowstone mainstem, the effects would be small.

For impacts, refer to the Mid-Yellowstone Subbasin, above, and the Lower Yellowstone Subbasin, below.

POWDER SUBBASIN -- IMPACTS OF THE NO ACTION ALTERNATIVE

The No Action Alternative in the Powder Subbasin predicts the diversion of 179,710 af/y and the depletion of 129,570 af/y by the year 2000. Irrigation would deplete 100,280 af/y and the energy industry 28,150 af/y.

Because of extreme streamflow fluctuations and the lack of water storage, the Powder can presently sustain no significant additional development. Extensive development such as that envisioned under this alternative would require the construction of proposed Moorhead Dam and Reservoir.

It is estimated that sedimentation would reduce the active storage of Moorhead Reservoir from over 1,000,000 af to 275,000 af in about 75 years. The firm annual yield, as simulated by the State Water Planning Model, would be 124,000 af/y. This yield would be entirely consumed under this alternative, since it is less than the projected demand.

Figure IV-2 shows the changes in monthly subbasin outflows, assuming the construction of Moorhead Dam, which would result under this alternative. For a general discussion of the environmental impacts, see the discussion on the Irrigation Emphasis Alternative below. Although the timing of demand might be different, either alternative would eventually require the entire firm annual yield of the reservoir.

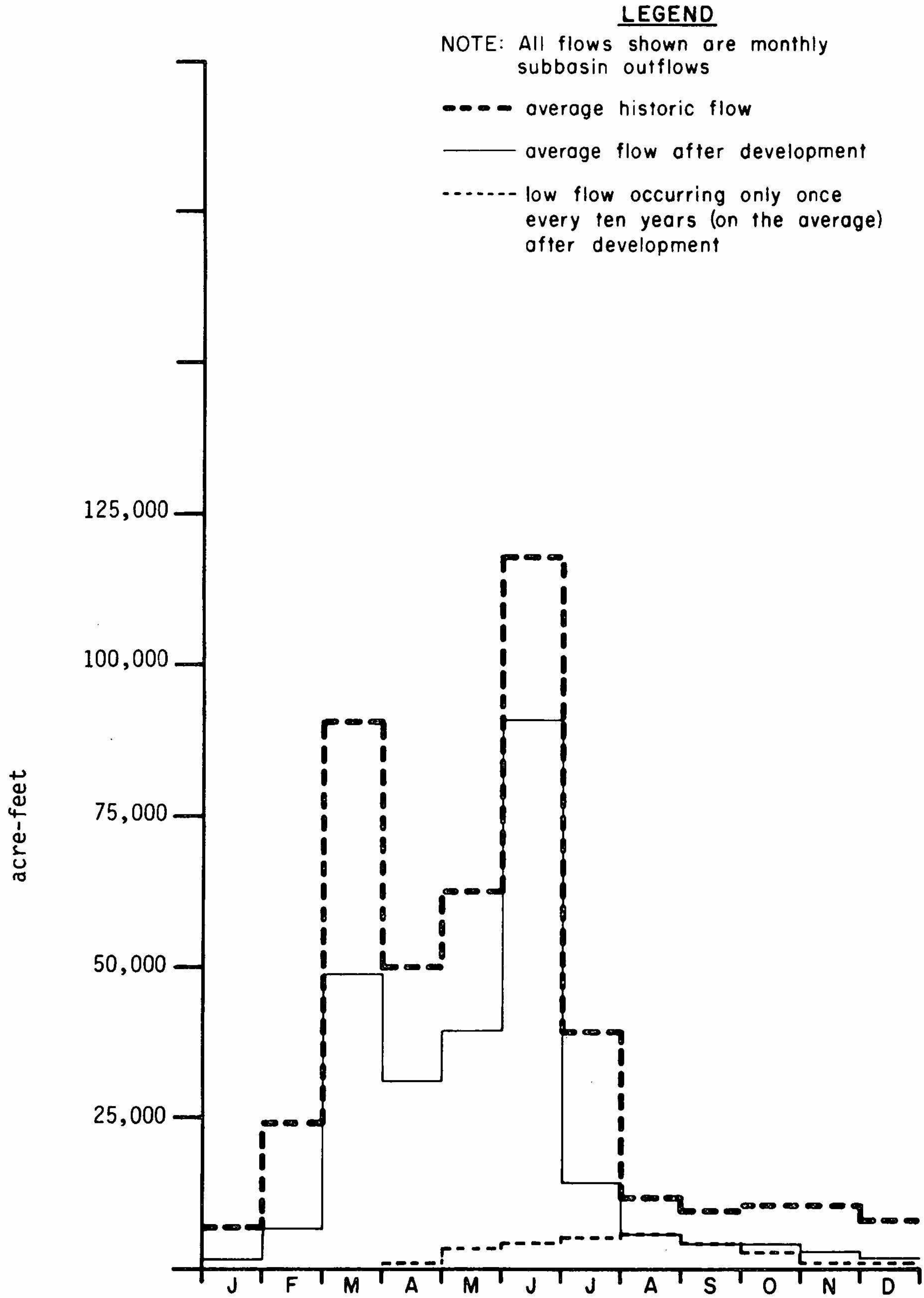


FIGURE IV-2. Powder River Subbasin Monthly Outflows for the No Action Alternative

LOWER YELLOWSTONE SUBBASIN -- IMPACTS OF THE NO ACTION ALTERNATIVE

Under the No Action Alternative, this subbasin would experience minor energy development (13,000 af/y depleted) and extensive additional irrigation development (75,300 af/y diverted and 50,200 af/y depleted).

More importantly, this subbasin would feel the effect of all of the upstream developments. Basinwide, about 750,000 af/y would be diverted and about 612,000 af/y depleted under the No Action Alternative. These figures reflect the inability of the Tongue and Powder subbasins to supply the demand resulting under this alternative.

Figure IV-3 shows the effect on the monthly outflows of the Lower Yellowstone Subbasin under the No Action Alternative. The only additional storage assumed was that of the proposed High Tongue and Moorhead dams.

PRIMARY IMPACTS

Streamflow Alterations

Throughout the year, the median flows would be reduced by less than five percent. Even the 90th percentile low flows would be reduced by less than five percent from October through July. But the 90th percentile low August and September flows would be reduced by 12 percent and 7 percent, respectively. Low flows during this time of year are particularly damaging to the aquatic ecosystem.

Channel Form

The dominant discharge in the spring would not be reduced enough to result in a perceptible change in the morphology of the stream channel.

Water Quality

Although the historical average annual TDS concentration is 419 mg/l, that average is somewhat distorted by the cleaner high flows in June and July. In eight months of the year, the historical average TDS concentration has exceeded 500 mg/l, the recommended upper limit for drinking water. For the 90th percentile low flows, TDS levels have exceeded 600 mg/l for the eight months from September through April. Consequently, TDS concentrations in the Yellowstone mainstem must be considered high in this subbasin.

Under the No Action Alternative, those TDS concentrations would increase significantly. TDS levels at median flows would exceed 600 mg/l eight months of the year. For 90th percentile low flows, TDS values would exceed 700 mg/l in those eight months and would exceed 1,000 mg/l in August.

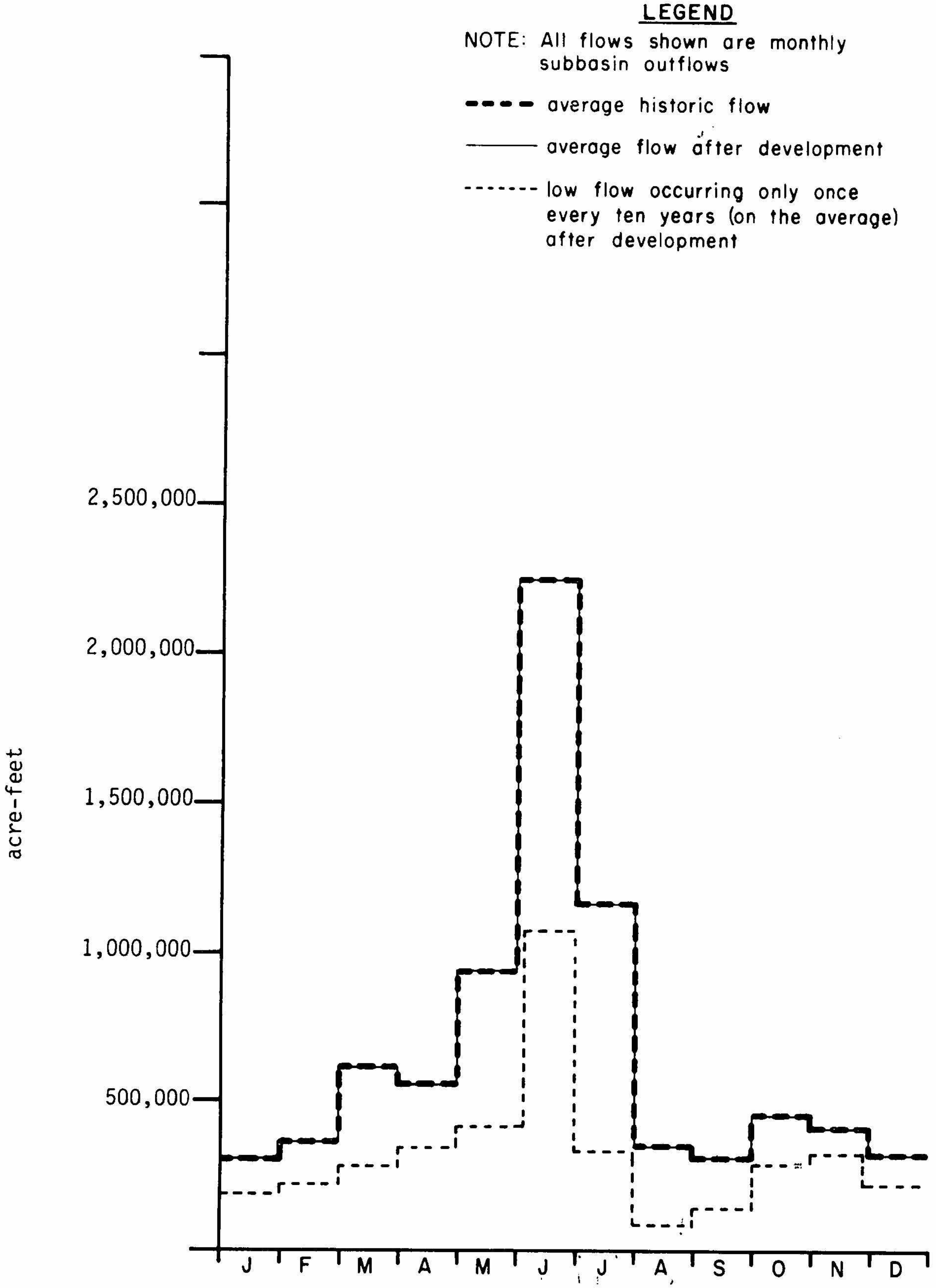


FIGURE IV-3. Lower Yellowstone River Subbasin Monthly Outflows for the No Action Alternative

At 90th percentile low flows, the summer water temperatures would increase by about 1° C (less than 2° F) under the No Action Alternative.

Sediment transport capacity would be reduced, due to the reduced flows, but the river would still be able to carry the sediment load. If Moorhead Dam were constructed, as assumed under this alternative, the Powder River sediment load would be greatly reduced. At present, the Powder contributes about half of the Yellowstone's sediment load.

Ecosystems

At median flows, the effects under this alternative would be small. At 90th percentile low flows, however, serious stresses would be felt by the aquatic ecosystem.

Under this alternative, the median and 90th percentile low flows in the month of August would be about 310,000 af/month and 96,000 af/month respectively, equivalent to steady flows of about 5,030 cfs and 1,560 cfs. A flow of 7,000 cfs is needed for maximum productivity of aquatic insects. Under the No Action Alternative, then, food production for insect-feeding fish such as the shovelnose sturgeon would be curtailed.

Water temperature is strongly correlated with air temperature. During hot weather, the river temperature may now exceed 80° F, approaching a stress level for many of the fish species. The 2° F increase expected under this alternative, although not large in itself, could be serious under these conditions.

The impact on aquatic systems would also depend on whether they were able to recover from an extremely low flow year, which would require normal flows the following year. Recovery from more than one successive low flow year would be slow.

Increased irrigation may make the area more attractive to migratory geese and ducks. Reduced flows would probably have little effect on the availability of nesting sites or on nesting success.

The impact on beavers and other riparian furbearers would be minimal.

SECONDARY IMPACTS

Under the No Action Alternative, adequate water would be available to satisfy the demands of agricultural, industrial, and municipal users.

Water quality would be a problem for municipal and domestic use, and for some industrial processes. Either additional treatment would be needed or alternate sources of supply, such as ground water, would have to be developed.

Recreational use of the river would suffer during low flow times; boating and water skiing would be curtailed, though access to the river may be slightly improved where flooding of unimproved roads is now a problem.

THE IRRIGATION EMPHASIS ALTERNATIVE

Agriculture has been, and may continue to be, the foundation of Montana's economy. Indeed, in the Yellowstone Basin, irrigated agriculture is by far the largest water user. At present, about 1.9 mmaf/y are consumed in the irrigation of 648,000 acres in the Montana portion of the basin. Including Wyoming, the basin-wide irrigation depletions are approximately 3.5 mmaf/y. It is extremely unlikely that any other activity, including even the most ambitious energy development programs, would ever approach water use of that order of magnitude, by the year 2000.

Agriculture is more than an economic activity in the Yellowstone Basin. It is a lifestyle that emphasizes independence, self-sufficiency, and a close relationship with the soil and water.

Preservation of this economic sector and way of life may become an explicit policy of the State of Montana. One way to contribute to that preservation would be to reserve water for future irrigation expansion.

In Part III of this EIS, the effects of the individual conservation district applications for reservation of irrigation water were discussed. Here, three distinct levels of irrigation development will be considered as alternatives. The derivation of these levels, based on the availability of irrigable lands and on farm budgets, was presented earlier in Part IV. Table IV-8 on page 239 shows the expected increases in irrigated acreage and water diversions and depletions by the year 2000, by subbasin.

As shown in Table IV-10, the sum of all irrigation applications is about 320,000 acres, substantially larger than that of the projected high level of irrigation development (237,480 acres). The expected basin-wide diversion of 816,420 af/y for all irrigation requests is somewhat greater than the 712,500 af/y diversion that would be needed assuming the high level of irrigation development for this alternative. However, the Park, Sweet Grass, and Carbon conservation districts applied for water to irrigate lands in the Shields River, Sweet Grass Creek, and Rock Creek drainages respectively, but the Yellowstone Impact Study considered only the Yellowstone mainstem and the Clarks Fork Yellowstone, Bighorn, Tongue, and Powder rivers as water sources. The impacts identified in this part of the EIS are applicable only to the latter streams.

IMPACTS-IRRIGATION EMPHASIS ALTERNATIVE

Following are discussions of the impacts of the three levels of irrigation development projected for the year 2000. Generalized, basin-wide impacts are presented first, followed by specific subbasin sections. Where only the high level of development and intermediate levels of development would result in similar impacts of proportionately less magnitude.

GENERALIZED IMPACTS--IRRIGATION EMPHASIS ALTERNATIVE

Impacts to the Yellowstone mainstem as a result of the depletions associated with the projected levels of the Irrigation Emphasis Alternative vary from

TABLE IV-10

COMPARISON OF WATER RESERVATION APPLICATIONS FOR IRRIGATION USE AND IRRIGATION EMPHASIS ALTERNATIVE

	RESERVATION REQUESTS		IRRIGATION EMPHASIS ALTERNATIVE (HIGH LEVEL OF DEVELOPMENT)	
Subbasin	Acres	Increase In Depletion (af/y)	Acres	Increase In Depletion (af/y)
UPPER YELLOWSTONE				
Park CD[a]	36,570	70,315		
Sweetgrass CD	18,510	35,940		
Stillwater CD	5,177	10,307		
Carbon CD	630	1,260		
DSL[b]	4,354	8,708		
Total	65,241	126,530	38,080	76,160
CLARKS FORK YELLOWSTONE				
Carbon CD	20,385	37,062		
DSL	897	1,794		
Total	21,282	38,856	2,160	4,320
BILLINGS AREA				
Yellowstone CD	26,785	53,130		
Huntley ID[c]	4,000	8,000		
DSL	2,185	4,370		
Total	28,970[f]	57,500[f]	19,410	38,820
BIGHORN				
Big Horn CD	9,175	17,030		
DSL	500	1,000		
Total	9,675	18,030	13,040	26,080
MID-YELLOWSTONE				
Treasure CD	7,645	16,063		
DSL	3,031	6,062		
Rosebud CD	34,525	73,088		
North Custer CD[d]	2,070	4,061		
Total	47,271	99,284	25,230	50,460
TONGUE RIVER				
Rosebud CD	2,835	5,422		
Big Horn CD	470	909		
North Custer CD[d]	4,605	9,093		
DSL	330	660		
Total	8,240	16,075	21,950	43,900
KINSEY AREA				
North Custer CD[d]	4,140	8,124		
Prairie County CD[e]	5,162	9,520		
DSL	416	832		
Total	9,718	18,476	4,740	9,480

TABLE IV-10 - continued

Subbasin	RESERVATION REQUESTS		IRRIGATION EMPHASIS ALTERNATIVE (HIGH LEVEL OF DEVELOPMENT)	
	Acres	Increase In Depletion (af/y)	Acres	Increase In Depletion (af/y)
POWDER RIVER				
Powder River CD	25,245	51,450		
North Custer CD[d]	26,150	53,290		
DSL	2,107	4,214		
Total	53,502	108,954	75,200	150,400
LOWER YELLOWSTONE				
Prairie County CD[e]	15,484	28,565		
Dawson County CD	17,897	35,152		
Richland County CD	21,710	38,565		
Buffalo Rapids ID	41,306	82,612		
DSL	3,657	7,314		
Total	75,284[f]	142,668[f]	37,670	75,340
YELLOWSTONE BASIN TOTAL	319,183[g]	626,373	237,480	474,960

[a]CD is the acronym for conservation district.

[b]DSL is the acronym for Department of State Lands.

[c]ID is the acronym for Irrigation District.

[d]The North Custer CD application is for lands in the Mid-Yellowstone, Tongue, Kinsey Area, and Powder subbasins.

[e]The Prairie County CD application identifies lands in the Kinsey Area and Lower Yellowstone subbasins.

[f]Duplication of lands between irrigation districts and conservation districts is eliminated in totals.

[g]Does not include lands designated for water spreading.

virtually no impact in the Upper Yellowstone Subbasin, gradually worsen as the river progresses downstream, and reach significant levels in some years in the Mid-Yellowstone, Kinsey Area, and Lower Yellowstone subbasins. Principal impacts in these lower subbasins would be reduced water supply, increased TDS concentrations, and stress on the ecosystem. These impacts will affect such water uses as irrigation and instream flows for fish and wildlife.

The Tongue and Powder rivers will show significant impacts at the projected levels of depletion. These impacts will be severe for all primary impact categories and water uses examined.

The application of large additional amounts of irrigation water to the land may augment near-surface aquifers. In general, shallow alluvial aquifers will not be affected by flow reductions associated with the high projected level of irrigation development.

PRIMARY IMPACTS -- IRRIGATION EMPHASIS ALTERNATIVE

Streamflow Alterations

Although there are some significant exceptions, the Yellowstone mainstem and its tributaries have an adequate water supply to provide the depletion amounts identified, even under the high projected level of future irrigation development, with little or no impact on the environment and without additional storage. The mainstem from the Billings Area Subbasin downstream would, about one year in ten, experience fall flows low enough to cause environmental stress.

The exceptions to this pattern would be in the Tongue and Powder subbasins, where, as explained below, water supply problems would exist even with additional storage. Remember that the smaller tributaries were not considered as water sources when the projections of the various levels of irrigation were developed.

Channel Form

The channel formation processes are expected to be affected little or not at all by the projected depletions in the mainstem and most tributaries. The form of the Tongue River channel has already undergone change from a braided to a single channel following construction of Tongue River Dam; further impoundment on that river should have little effect. There would be a great deal of change in the form of the Powder River channel, however, if that now-unimpounded stream were dammed.

Water Quality

The potential for water quality degradation exists in the middle and lower basin, becoming greater as the river progresses downstream.

For the high level of development, salinity would not be a problem in the upstream subbasins (including the Clarks Fork Yellowstone and Bighorn), even though irrigation return flows will be high in salts, because the streamflows will be adequate to dilute the saline return flows. In subbasins farther down the mainstem, the build-up of salts will result in occasional salinity problems in low-flow months if the high projected level of irrigation development is implemented.

In the Tongue and Powder subbasins, salinity is a problem which will be aggravated by any irrigation development beyond present levels. Depletion for irrigation even at the low projected level would result in significant impacts from increased salinity in both of these subbasins.

Increased water temperature should be a problem nowhere along the mainstem, even at the high projected level of development. In the Tongue and Powder subbasins, flows will be substantially reduced, resulting in significant water temperature increases.

The conversion of rangeland to cultivated, irrigated fields may tend to increase erosion and sedimentation, especially if soils are not carefully managed. However, where overgrazed rangelands or dry croplands are converted to irrigated fields, erosion and sedimentation could be reduced due to improved vegetation cover.

The Yellowstone mainstem would have more than adequate capacity to transport modest increases in sediment load. The Bighorn and Tongue rivers will not become major sources of sediment to the mainstem because of the effect of reservoirs on those rivers. The sediment contribution of the Powder, now the main source of sediment to the mainstem, would actually be decreased because dam construction is necessary to provide additional water supply.

Ecosystems

Any new cultivated lands in the basin could serve as feeding areas for migratory waterfowl; increasing numbers of both geese and ducks would probably stop to feed along the rivers during Central Flyway migration.

Stabilizing streamflow through new storage, or increasing streamflow fluctuations through such actions as diversion during low flow periods, would affect green algae of the genus Cladophora, as discussed on page 242 in connection with the No Action Alternative.

SECONDARY IMPACTS--IRRIGATION EMPHASIS ALTERNATIVE

Agricultural Water Use

As shown in Table IV-8, total water depletions for irrigation throughout the basin would be 158,340 af/y by the year 2000 for the low level of development, 316,620 af/y for the intermediate, and 474,960 af/y for the high; diversion requirements would be 50% higher than those figures. Water availability would be a problem only in the Tongue and Powder rivers, where storage would be necessary to make enough water available. On the Powder, only 55% of the high irrigation development projections can be satisfied even with storage. At the high level of development, TDS concentrations in three mainstem subbasins (Mid-Yellowstone, Kinsey Area, and Lower Yellowstone) would be high enough during low-flow months during some years to require careful application of water to avoid salt accumulation in the root zone. In the Tongue and Powder subbasins, TDS concentrations would be high enough even at the low and intermediate development levels to make using that water for irrigation unwise. Note, however, that provision of even modest instream flows would tend to mitigate the salinity problem.

The comparatively small use of water for agricultural purposes other than irrigation would not be affected. Reduced streamflows may lower water levels to the point that existing diversion structures, particularly the smaller gravity diversions, would not function. Large diversions usually have small dams to maintain heads, and pump intakes are usually low enough to operate even when flows are low.

Information in the conservation district applications may be used to estimate the effect of expanded irrigation on personal income in the basin. According to the applications, if all anticipated irrigation (about 290,000 acres) was developed, annual payment capacity would exceed annual irrigation costs by about $18,775,000. This sum can be considered to be the net annual income increase to farmers, before taxes. If that expanded irrigation had been developed in 1972, it would have accounted for about 2.6% of the basin's total personal income of $721,522,000.

Comparison between the estimated increases from irrigation expansion and 1972 data for total personal income differ widely by county. In nine of the thirteen counties, the 1972 total personal income would have been increased by five percent or less. In Yellowstone County, which accounts for half of the basin's total personal income, the increase would have been only 0.4% because of the large non-farm population. In Prairie and Powder River counties, the increase would have been 32 and 25%, respectively, because the populations of these counties are mostly rural.

All estimates of increases in total personal income are probably overstated because (1) the cost estimates excluded land acquisition costs, legal fees, and conservation district overhead, and (2) the relative importance of agriculture is declining in the basin due to the increase in the manufacturing, energy, and service industries.

On-farm employment benefits from irrigation expansion will probably be insignificant. Agriculture is noted for technological innovations which increase productivity and reduce labor requirements; this trend is evident in the Yellowstone Basin. During the 1950's, a lack of employment opportunities led to an outmigration of working-age people. During this period the output of agricultural products was increasing. While the new irrigation may create enough jobs to counterbalance the employment decline due to technical progress, it will not add enough additional workers to reverse the prevailing trend.

The major employment benefits would be in the services and the industrial sectors which supply farm inputs and consumer goods for the increased expenditures of the farmers. These benefits will be concentrated in the regional centers that sell goods and services to farmers.

From 1960 to 1970 all towns in the basin except Billings suffered declines in population. Increases in employment outside the Billings regional trading center may help to stem these declines in the other trading centers such as Miles City, Glendive, and Sidney. This is an important social benefit because migration from these towns to Billings requires additional investments in schools, roads, and other public services, while these facilities remain underutilized in the declining towns.

In Part III, beginning on p. 193 , is a discussion of future benefits to irrigated agriculture which might be foregone if instream flow reservations are granted.

Municipal and Domestic Water Use

It is assumed that there would be no significant population increase accompanying the projected increase in irrigated acreage. Therefore, about the same quantity of water would be used for municipal and domestic purposes. In the Tongue and Powder subbasins, where TDS concentrations will frequently exceed 500 mg/l (the suggested upper limit for drinking water), users of river water may be forced to find another water source. No municipalities use this water at present.

Industrial Water Use

No specific level of energy or industrial development is projected in this alternative, although, even if irrigation reservations are granted, there will still be water available in some areas of the basin to accommodate increased energy and industrial development. That some will occur is virtually certain. Adoption by the Board of the Irrigation Emphasis Alternative could direct energy development to basins where adequate water supplies remain available for appropriation. If it is assumed that energy development will take place in subbasins where strippable coal reserves lie, the adoption of this alternative could theoretically encourage energy development in the Bighorn, Mid-Yellowstone, and Lower Yellowstone subbasins. In actuality, energy development could proceed even in the Tongue and Powder subbasins if this alternative were adopted, because energy companies could elect to store spills from the dams during flood flows for year-round use or use one or more of the alternate water sources considered later in Part IV.

Depending on the specific use, some industrial water must be treated. For example, cooling water may be of low quality, but water used in boilers must be highly treated. In the Powder and Tongue subbasins, where TDS concentrations would be extremely high, energy companies could find treatment of water more expensive than usual.

Recreation and Aesthetics

Recreational and aesthetic experiences are closely related to streamflows. In subbasins where streamflows would not significantly change (for example, the Bighorn), recreation and aesthetics would not be much affected. In others, such as the Tongue and Powder subbasins, both recreation and aesthetics would change significantly.

UPPER YELLOWSTONE SUBBASIN -- IMPACTS OF THE IRRIGATION EMPHASIS ALTERNATIVE

The Yellowstone mainstem in this subbasin has an adequate water supply for the high level of projected irrigation development without storage, and without causing serious environmental impacts. Remember, only the Yellowstone mainstem is considered here. See Part III (p. 153) for the impacts of irrigation in the tributaries.

CLARKS FORK YELLOWSTONE SUBBASIN -- IMPACTS OF THE IRRIGATION EMPHASIS ALTERNATIVE

The high level of irrigation development would deplete only 4,320 af/y in the Clarks Fork Yellowstone subbasin. Even without storage, this small depletion would have almost no effect on the environment.

Historically, the Clarks Fork Yellowstone has been a major sediment producer. An extensive increase in cultivation and irrigation, especially if accompanied by improper soil management, could increase the Clarks Forks' sediment contribution to the mainstem and the chance of sedimentation problems in downstream basins. Irrigation of only 2,160 acres, as projected in the high development level of this alternative, should not create major sedimentation problems; however, the Carbon Conservation District has proposed in its reservation application the irrigation of 17,075 new acres along the Clarks Fork Yellowstone, and the Department of State Lands has proposed an additional 857 acres (See Part III, p.140).

The construction of dams on the Clarks Fork Yellowstone in Wyoming has been proposed. Such dams would result in major changes in the river's channel form, similar to those that occurred in the channel of the Bighorn River following the construction of the Yellowtail Dam (Montana DNRC 1976). However, reduction of peak flows would reduce the sediment load in the lower subbasin.

BILLINGS AREA SUBBASIN -- IMPACTS OF THE IRRIGATION EMPHASIS ALTERNATIVE

At the high projected level of development, the impacts of reduced flows would begin to materialize in this subbasin, which would experience the cumulative effect of depletions in the Upper Yellowstone and Clarks Fork Yellowstone subbasins. The high level would deplete 119,280 afy in and above this subbasin.

Figure IV-4, a hydrograph of monthly outflows from this subbasin at historical and future, high irrigation conditions, shows that water availability would not generally be a problem in the Billings Area Subbasin. It would not be necessary to provide additional water by impounding the Yellowstone mainstem, which is now free flowing. However, Figure IV-4 does show that, one year in ten, there would be very low flows in August and September.

The Billings Area Subbasin is in the transition zone between the salmonid cold-water fishery of the headwaters and the non salmonid warm-water fishery of the plains. As such, it may be considered marginal habitat for trout and whitefish. The streamflow reductions shown in Figure IV-4, especially those 90th percentile August and September low flows, may stress the ecosystem to the point that the transition zone would shift upstream. A popular recreational fishery near a large urban center could be lost.

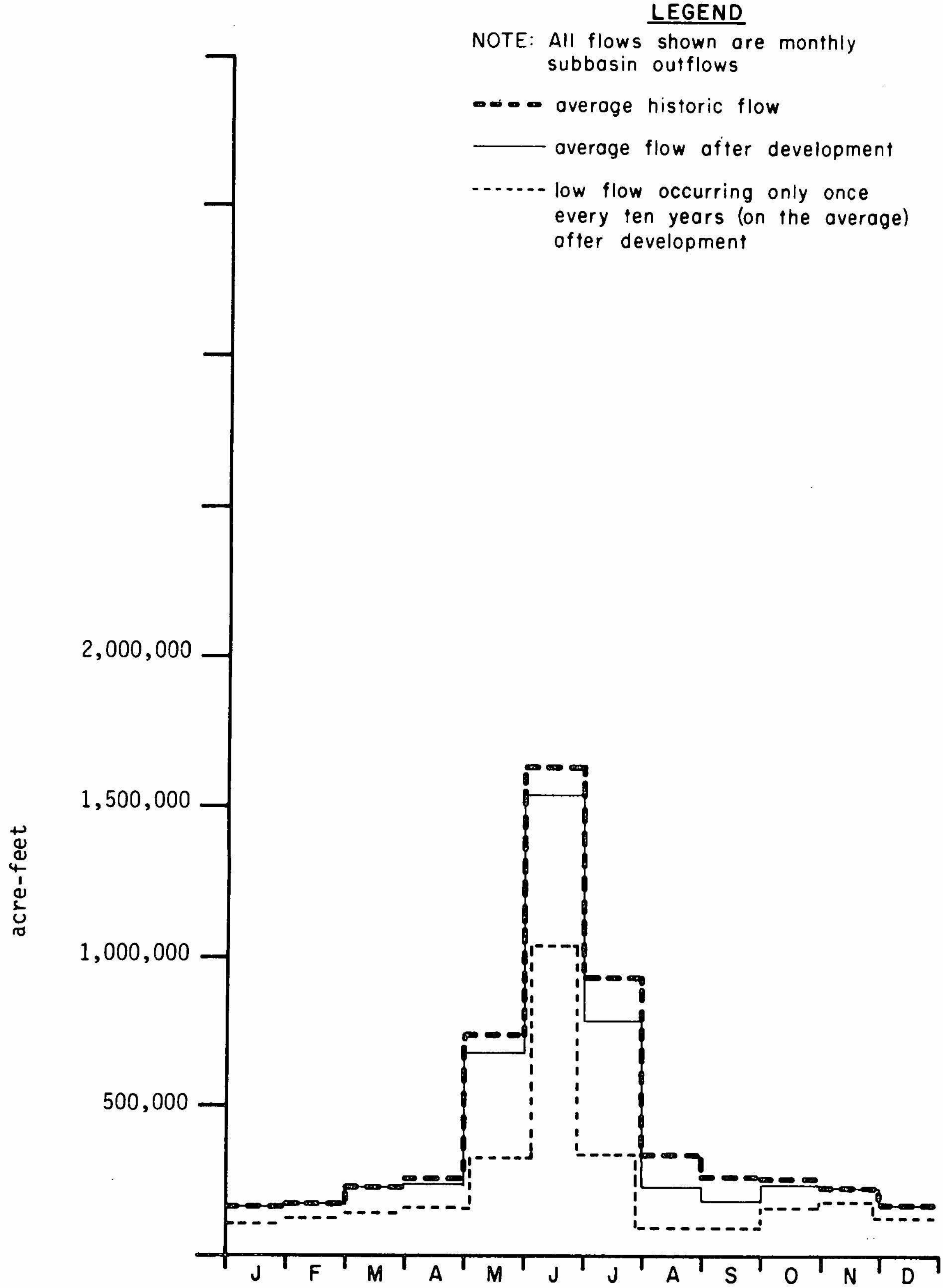


FIGURE IV-4. Billings Area Subbasin Monthly Outflows for the High Irrigated Emphasis Alternative

BIGHORN SUBBASIN -- IMPACTS OF THE IRRIGATION EMPHASIS ALTERNATIVE

The Bighorn River is heavily regulated by Buffalo Bill, Boysen, and Yellowtail dams, which have already effected major environmental changes in the river. Implementation of the high level of irrigation development would cause few further changes. With Yellowtail Dam, the water supply is more than adequate to allow the 26,080 af/y depletion projected in the high level of irrigation development.

MID-YELLOWSTONE SUBBASIN -- IMPACTS OF THE IRRIGATION EMPHASIS ALTERNATIVE

The depletion projected for this subbasin at the high development level is 50,460 af/y, and the cumulative effects of depletions in the Upper Yellowstone, Clarks Fork Yellowstone, Billings Area, and Bighorn River subbasins would also be felt.

PRIMARY IMPACTS

Streamflow Alterations

Although the Yellowstone mainstem is unimpounded, the Mid-Yellowstone subbasin reflects the influence of the Bighorn River, which is heavily controlled.

Figure IV-5 shows the average monthly outflows of the Mid-Yellowstone subbasin under the high level of irrigation development. Although no storage was included in the simulation, water availability would not generally be a problem. Exceptions might occur in August and September, when flows are seriously low about one year in ten.

Channel Form

Reduced flows would decrease the sediment transport capacity of the river. The present sediment transport capacity is considerably in excess of the sediment load, but at the projected levels of irrigation development localized sedimentation problems may be expected in backwaters and behind diversion structures.

Water Quality

At this time, average TDS concentrations in the Mid-Yellowstone mainstem are moderate, except for December and January when values exceed 500 mg/l. One year in ten, January TDS concentrations exceed 700 mg/l.

Table IV-11 shows the increases in TDS concentrations which may be expected from implementation of the high level of irrigation development. For median flows, the average annual TDS concentration would increase from 352 to 379 mg/l. However, the increases would be substantial during August and September.

For 90th percentile low flows, the annual TDS concentrations would likewise increase only slightly. However, during August, the TDS concentration could approach 1,000 mg/l, a 60% increase over the historical value. Lesser but substantial increases would be experienced in July and September.

TABLE IV-11

MONTHLY OUTFLOWS AND TOTAL DISSOLVED SOLIDS,
MID-YELLOWSTONE SUBBASIN, HIGH LEVEL OF IRRIGATION DEVELOPMENT

	50% (MEDIAN FLOW)				90TH PERCENTILE LOW FLOW			
	Historical		Simulated		Historical		Simulated	
Month	Flow (af)	TDS (mg/l)	Flow (af)	TDS (mg/l)	Flow (af)	TDS (mg/l)	Flow (af)	TDS (mg/l)
Jan	301,526	583	296,885	593	199,194	731	194,862	748
Feb	301,438	583	301,972	585	230,446	675	225,516	688
Mar	471,878	457	488,033	451	298,629	586	294,401	596
Apr	477,479	454	462,443	466	334,211	552	322,563	568
May	1,079,204	291	947,413	315	523,115	432	398,723	508
Jun	2,234,590	196	2,076,815	206	1,280,809	265	1,123,140	293
Jul	1,240,724	270	980,011	312	547,511	421	364,882	561
Aug	458,038	465	227,748	684	275,029	613	104,374	997
Sep	428,158	482	303,135	584	252,952	642	149,556	867
Oct	484,960	450	459,919	472	340,670	546	321,480	575
Nov	414,095	491	410,016	499	322,048	563	333,949	562
Dec	348,555	539	337,278	553	221,141	691	217,384	708
Annual	8,240,640	352	7,291,668	379	4,825,755	478	4,050,830	532

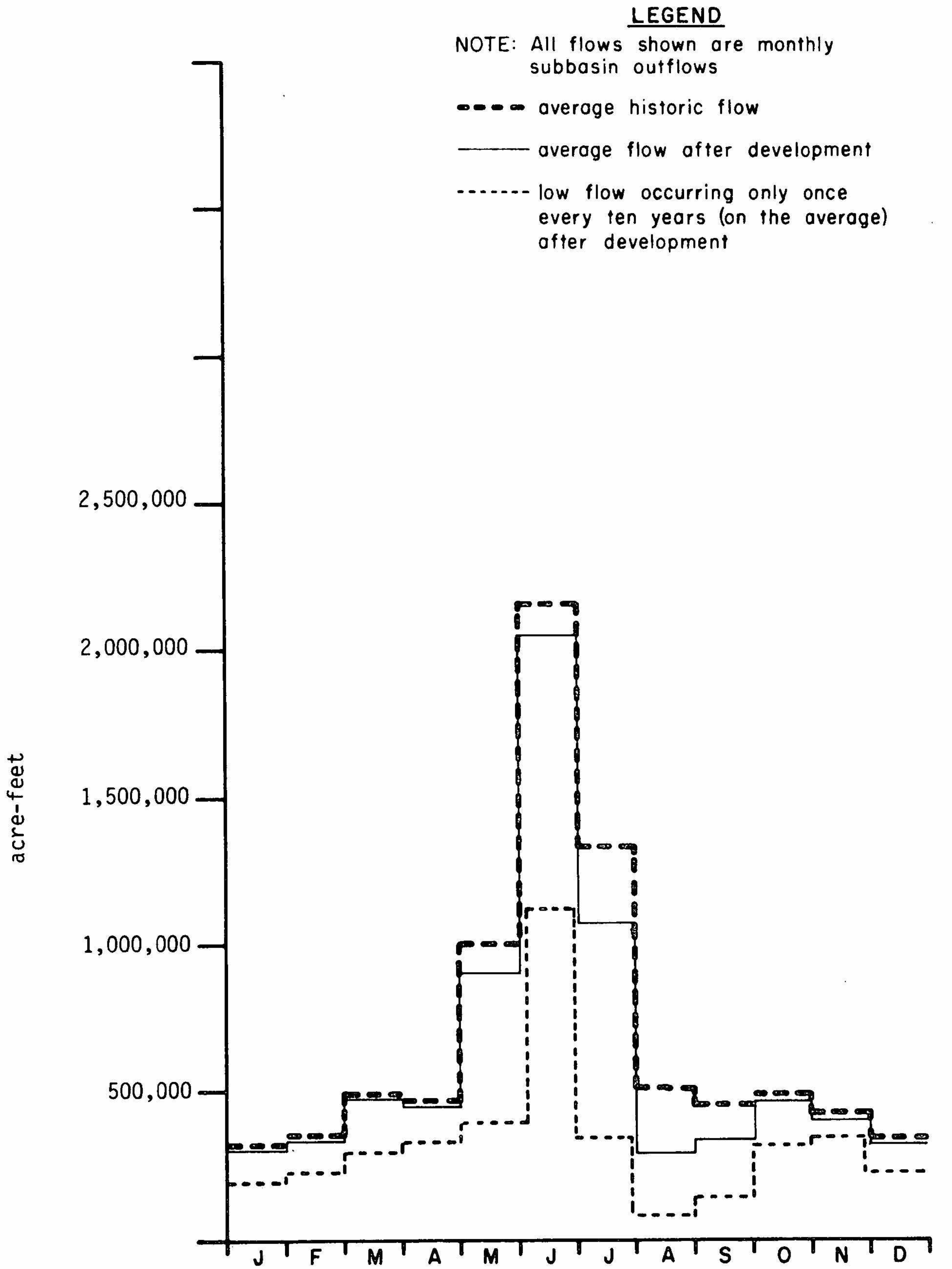


FIGURE IV-5. Mid-Yellowstone River Subbasin Monthly Outflows for the High Irrigation Emphasis Alternative

Ecosystems

If the high level of irrigation development were implemented, streamflows during August and September would be reduced and TDS concentrations increased to the point that the aquatic ecosystem would be placed under stress. It is unlikely that a long term or irreversible degradation would occur, unless several low flow years happened in succession.

The cumulative effects of upstream depletions would be more noticeable than those in the Billings Area Subbasin, just upstream, but less than for the Lower Yellowstone Subbasin.

SECONDARY IMPACTS

Under the conditions of the high level of irrigation development, water would be available, without storage, to all consumptive users.

Recreation and aesthetics would not be significantly affected.

TONGUE SUBBASIN -- IMPACTS OF THE IRRIGATION EMPHASIS ALTERNATIVE

The projected high level of development for this subbasin involves the irrigation of 21,950 acres depleting 43,900 af/y; the intermediate level, 14,630 acres depleting 29,260 af/y; the low level, 7,320 acres depleting 14,640 af/y.

The Tongue River is controlled by the Tongue River Dam, located about 10 miles north of Wyoming. Constructed in 1939, the dam has an active storage of about 69,000 af and a firm annual yield of 40,000 af. However, because all of this storage is already in use, any future water-dependent development in the basin would require additional storage.

PRIMARY IMPACTS

Streamflow Alterations

The effect of the low projected level of development on the outflows from the Tongue River is shown in Figure IV-6. The low level of development requires raising the existing dam and increasing active storage to 125,000 af. One year in ten, flows would be seriously low during the summer and fall.

Figure IV-7 shows the intermediate level of development. High Tongue Dam, nine miles downstream from the existing dam, would have an active capacity of 320,000 af and would provide a firm annual yield of 134,000 af, enough to satisfy the diversion and depletion requirements associated with the intermediate level of development. However, even with the High Tongue Dam, one year in ten flows would be seriously low; in fact, flows would be near zero in February, November, and December.

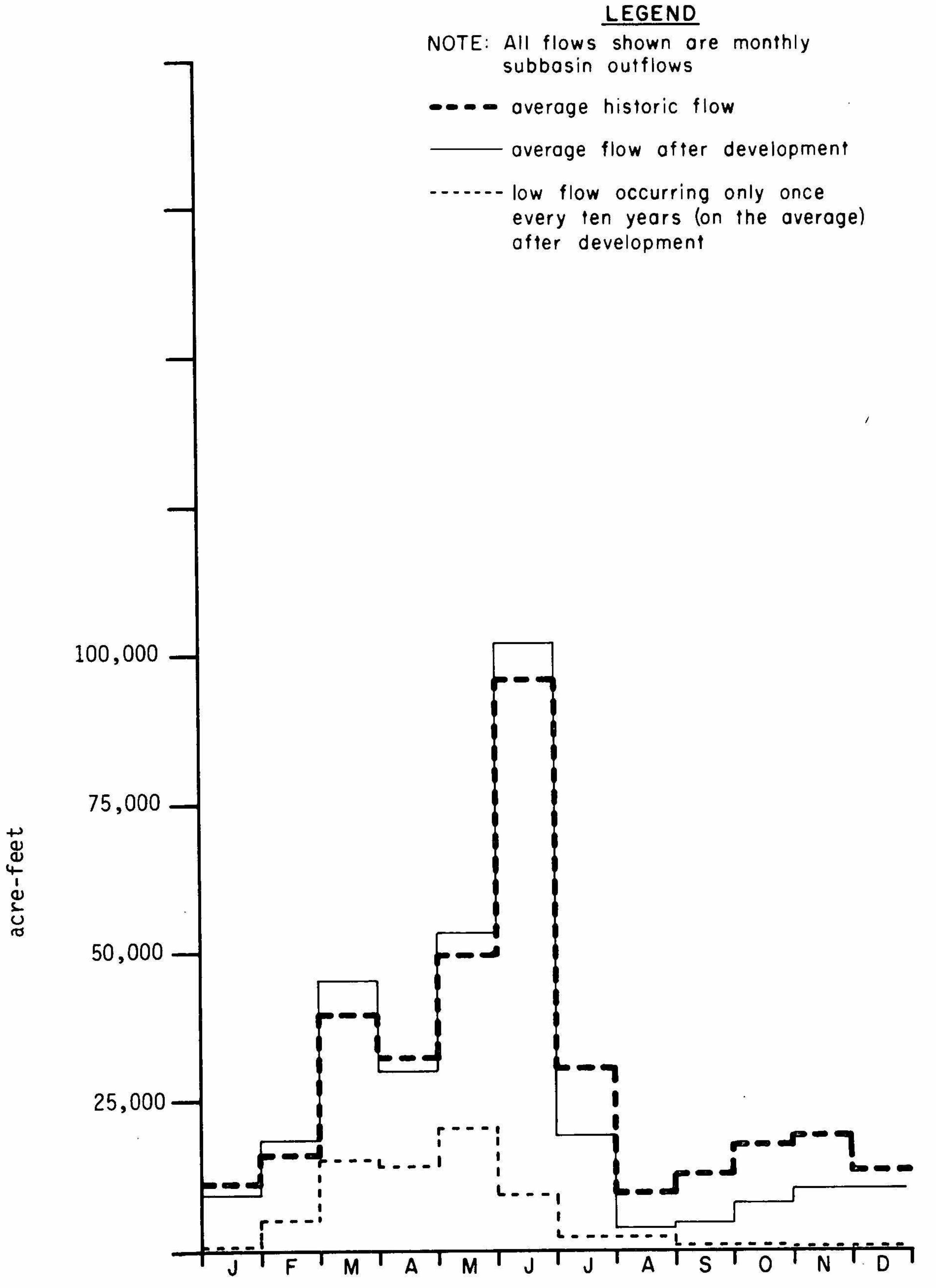


FIGURE IV-6. Tongue River Subbasin Monthly Outflows for the Low Irrigation Emphasis Alternative

Note: Modified flows exceed the historic flows in certain months because the rules of operation assumed for the new dam differ from the mode of operation for the existing dam.

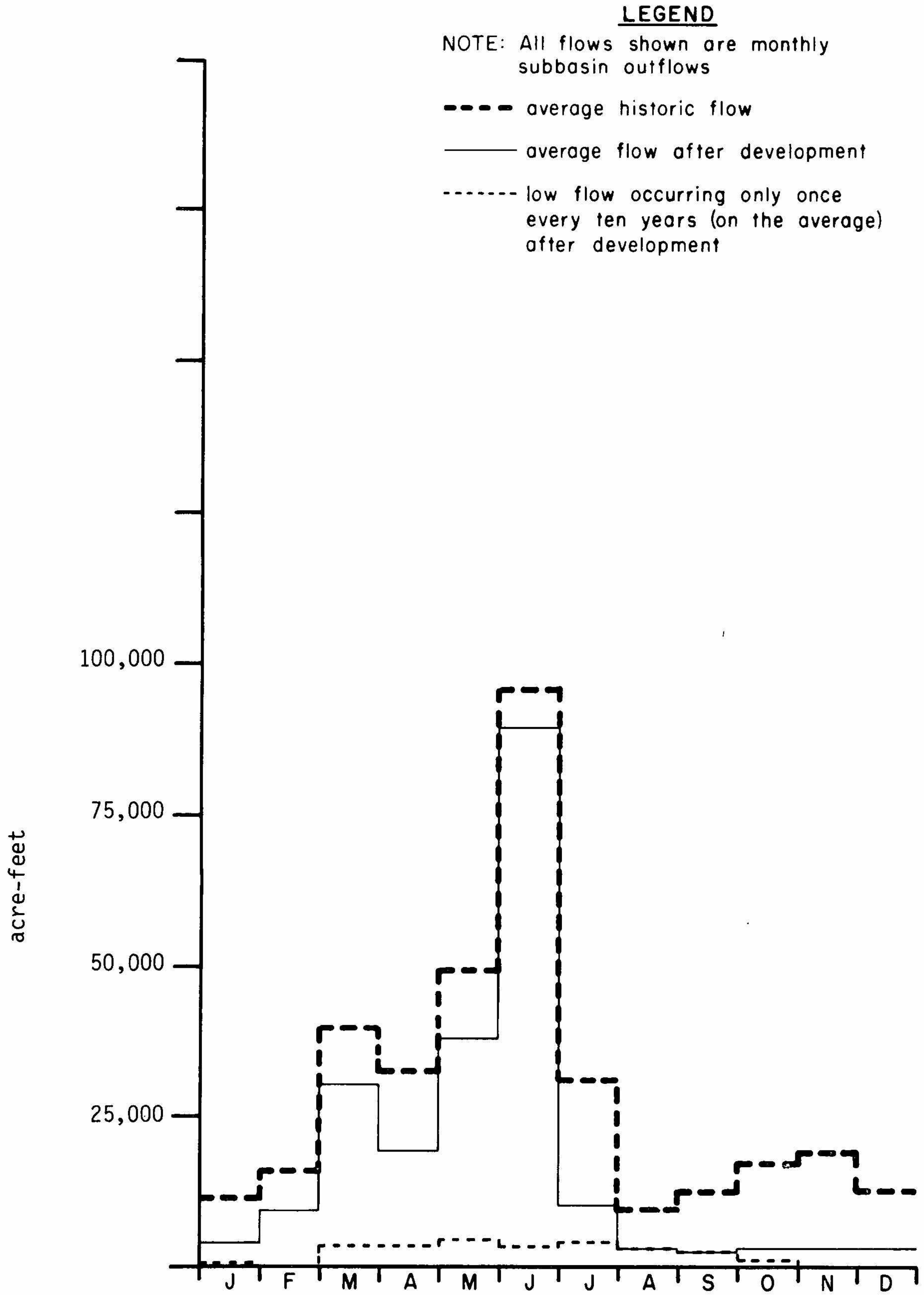


FIGURE IV-7. Tongue River Subbasin Monthly Outflows for the Intermediate Irrigation Emphasis Alternative

The high level of irrigation development, shown in Figure IV-8, also assumes the High Tongue dam with a 320,000 af active storage reservoir. After meeting the irrigation demand and providing instream flows of five cfs during March, April, and May 15 cfs the remainder of the year, some water would still be available for additional development. The 90th percentile low flows under this high development assumption are somewhat higher during the summer and fall than under the intermediate level of development because of the guaranteed instream flows.

Channel Form

The Tongue River presently contributes a relatively small proportion of the sediment load in the Yellowstone mainstem, because the Tongue River Dam traps sediments and releases relatively clean water in all but peak runoff periods. Although reduced flows in the river would reduce the ability of the river to transport sediment, further irrigation development in the subbasin is not expected to appreciably alter the present condition. The riverbed downstream from the dam is armored from previous downcutting. The principal sources of sediment in the Tongue River will continue to be the tributaries below the dam.

Water Quality

Salinity

Salinity is presently high in the Tongue River, with an average historical TDS level of 454 mg/l. The recommended limit for drinking water (500 mg) is exceeded over half of the time.

Projections of salinity were made, using the State Water Planning Model. Dilution effects of reservoirs were considered, using the active storage capacity of the reservoir assumed for each resource development level. A salt pickup of one-half ton per acre per year for returned irrigation water was also assumed. Predicted increases in salt concentrations for the 50th percentile (median) and 90th-percentile (low) flows are shown in Tables IV-12, IV-13, and IV-14.

As shown in Table IV-12, irrigation development at the low level would increase average annual TDS concentrations at median flows from a historical 454 mg/l to 460 mg/l, a small increase. Major increases, however, would occur in the low-flow months of August, September, and October, when monthly TDS concentrations would exceed 1,100 mg/l.

As shown in Table IV-13, for the intermediate level of irrigation development, median flow TDS concentrations in the Tongue River would increase to 538 mg/l. For the low flow months, TDS values would exceed 1,000 mg/l. TDS levels, one year in ten, would increase to annual value of 1,243 mg/l, and, for several low flow months, would exceed 1,400 mg/l.

TDS concentrations for the high level of irrigation development shown in Table IV-14, would be comparable to those of the intermediate level of

TABLE IV-12

MONTHLY OUTFLOWS AND TOTAL DISSOLVED SOLIDS,
TONGUE SUBBASIN, LOW LEVEL OF IRRIGATION DEVELOPMENT

Month	50TH-PERCENTILE FLOW				90TH-PERCENTILE LOW FLOW			
	Historical		Simulated		Historical		Simulated	
	Discharge (af)	TDS mg/l	Discharge (af)	TDS mg/l	Discharge (af)	TDS mg/l	Discharge (af)	TDS mg/l
Jan	10,266	700	10,809	716	8,114	740	1,120	1,110
Feb	11,882	596	12,878	597	6,385	670	5,296	723
Mar	28,278	480	30,142	482	13,524	548	15,005	557
Apr	24,569	570	24,819	583	8,923	665	13,198	657
May	43,154	459	48,560	465	12,479	563	21,019	567
Jun	82,096	291	104,813	283	13,564	440	9,861	604
Jul	25,204	368	14,939	506	3,135	604	2,215	1,357
Aug	7,746	509	2,215	1,212	1,107	765	2,215	1,373
Sep	11,541	501	1,630	1,108	1,190	800	1,630	1,229
Oct	14,569	540	1,485	1,152	2,152	762	1,485	1,274
Nov	17,490	590	9,496	720	5,533	760	1,265	1,364
Dec	12,356	703	11,172	799	6,332	820	1,190	1,360
Annual	289,151	454	272,958	460	82,438	623	75,499	705

TABLE IV-13

MONTHLY OUTFLOWS AND TOTAL DISSOLVED SOLIDS,
TONGUE SUBBASIN, INTERMEDIATE LEVEL OF IRRIGATION DEVELOPMENT

Month	50TH-PERCENTILE FLOW				90TH-PERCENTILE LOW FLOW			
	Historical		Simulated		Historical		Simulated	
	Discharge (af)	TDS mg/l	Discharge (af)	TDS mg/l	Discharge (af)	TDS mg/l	Discharge (af)	TDS mg/l
Jan	10,266	200	1,340	1,158	8,114	740	1,340	1,390
Feb	11,882	596	1,190	945	6,385	670	1,190	1,444
Mar	28,278	480	14,452	581	13,524	548	3,140	1,432
Apr	24,569	570	13,478	668	8,923	665	3,290	1,208
May	43,154	459	30,429	534	12,479	563	4,310	1,021
Jun	82,096	291	73,934	333	13,564	440	2,960	858
Jul	25,204	509	3,530	1,343	3,135	604	3,530	938
Aug	7,746	501	3,530	1,367	1,107	765	3,530	1,057
Sep	11,541	540	2,360	1,261	1,190	800	2,360	1,413
Oct	14,549	590	2,070	1,304	2,152	762	2,070	1,473
Nov	17,490	703	1,630	1,375	5,533	760	1,630	1,481
Dec	12,356	700	1,480	1,372	6,332	820	1,480	1,355
Annual	289,151	454	149,423	538	82,438	623	30,830	1,243

TABLE IV-14

MONTHLY OUTFLOWS AND TOTAL DISSOLVED SOLIDS,
TONGUE SUBBASIN, HIGH LEVEL OF IRRIGATION DEVELOPMENT

Month	50TH-PERCENTILE FLOW				90TH-PERCENTILE LOW FLOW			
	Historical		Simulated		Historical		Simulated	
	Discharge (af)	TDS mg/l	Discharge (af)	TDS mg/l	Discharge (af)	TDS mg/l	Discharge (af)	TDS mg/l
Jan	10,266	700	1,560	1,184	8,114	740	1,560	1,238
Feb	11,882	596	1,335	1,014	6,385	670	1,335	1,065
Mar	28,278	480	6,754	715	13,524	548	3,360	895
Apr	24,569	570	8,323	763	8,923	665	3,570	988
May	43,154	459	22,871	605	12,479	563	5,115	1,105
Jun	82,096	291	71,229	350	13,564	440	3,990	1,406
Jul	25,204	368	4,845	1,347	3,135	604	4,845	1,450
Aug	7,746	509	4,845	1,351	1,107	265	4,845	1,455
Sep	11,541	501	3,046	1,281	1,190	800	3,046	1,373
Oct	14,569	540	2,690	1,294	2,152	762	2,690	1,377
Nov	17,490	590	1,995	1,369	5,533	760	1,995	1,439
Dec	12,356	703	1,770	1,368	6,332	820	1,770	1,432
Annual	289,151	454	131,263	600	82,438	623	38,121	1,273

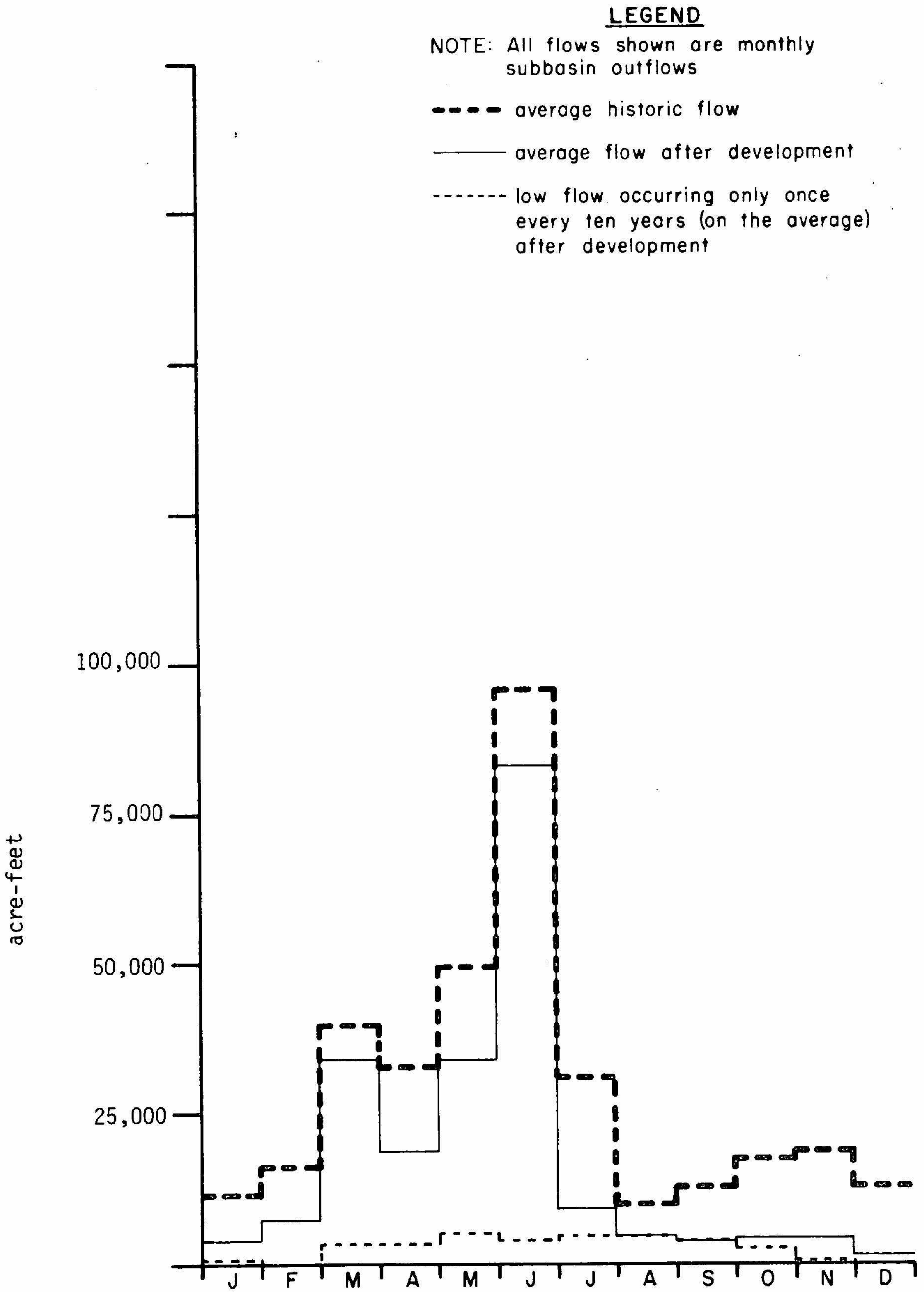


FIGURE IV-8. Tongue River Subbasin Monthly Outflows for the High Irrigation Emphasis Alternative development. Had small instream flows not been included in the simulations of the high development level, TDS concentrations would have increased further.

In summary, the Tongue River near Miles City would experience substantial increases in salinity under all levels of development. In actuality, irrigation expansion in the Tongue subbasin, with or without water reservations, may be limited by these salinity increases.

Dissolved Oxygen

No quantitative analysis has been done, but it is likely that the dewatering that would result under all levels of irrigation development projected would result in extreme diurnal dissolved oxygen deficits.

Ecosystems

Fishery

A productive and diverse warm-water fishery exists in the Tongue River because there are adequate flows for migration, spawning, rearing, and winter survival. Water depth and velocity are key hydrological factors during these life stages; temperature and water quality are also important.

Winter months are critical low-flow periods because dewatering accelerates freeze-up of riffles, depleting oxygen levels. Many warm-water species migrate and spawn in the spring; during this period, adequate flows are necessary to ensure passage, spawning, and rearing. Spring peak flows, which scour the channel and cleanse silt from gravel interstices are also necessary for food production.

The reduced instream flows and resulting water quality degradation would both seriously affect the fishery. TDS values in excess of 700 mg/l begin to stress the osmotic regulation of freshwater organisms. Excessive salinity is avoided by fish, especially migratory species able to choose a tributary for spawning. Excessive salinity in the summer would tend to discourage channel catfish from entering the Tongue River, and from May to mid-July the shovelnose sturgeon run would be affected. In March and April, sauger spawning would be affected by high TDS concentrations. Even if fish chose to enter these saline waters, reproduction may be less successful, because eggs and fry cannot metabolize in saline waters as well as adult fish can.

These high salinities may adversely affect the fisheries in both the Tongue River and the mainstem Yellowstone. Although it is clear that the Tongue River is an important spawning area, its relative importance in maintaining high fish populations in the Yellowstone mainstem is presently not known.

The intermediate and high levels of irrigation development would require construction of the High Tongue dam, about nine miles downstream from the present structure. Although the enlarged reservoir would provide an expanded flat-water fishery habitat, perhaps the finest reach of stream fishery in the Tongue Subbasin would be inundated. The brown trout fishery below the new dam would be shorter and less successful, since it would not enjoy the high-gradient, canyon-shaded stream which now exists.

If dewatering results in extreme diurnal dissolved oxygen deficits, which is likely, the species composition of the fishery would shift toward a predominance of such species as channel catfish and carp, which are more tolerant of reduced dissolved oxygen levels.

Following are brief, but more detailed discussions of the effects of the three specific levels of irrigation development on the fishery of the Tongue River.

Low Level of Irrigation Development. One year in ten, August flows would be critically low. The reduced flows, and associated reductions in water velocity, depth, and wetted perimeter, would eliminate channel catfish spawning. September flows would be inadequate for catfish rearing five years out of six. Rearing flows would be inadequate three out of four Octobers and every other November on the average.

Sauger spawning would be minimal because of low March flows half of the time and low April flows seven years out of ten. May and June flows would be adequate.

Seven years out of ten, July flows would be so low that water temperature increases would be detrimental to the hatching of shovelnose sturgeon eggs.

Intermediate Level of Irrigation Development. The impacts of this level of development would be similar to those of the low level, but would occur more frequently.

Fall flows would be inadequate for channel catfish spawning and rearing nine years out of ten.

Adequate over-wintering flows would be available to all species only one year in four or five.

High Level of Irrigation Development. The fishery impacts resulting from this level of development would not be much more severe than those experienced under the low and intermediate levels, because of the provision of instream flows. The channel catfish, sauger, and shovelnose sturgeon populations would be virtually eliminated. Rough fish such as carp and carpsucker would be less affected because of their ability to tolerate adverse conditions.

Furbearing Mammals

Furbearing mammals could be affected by reduced flow in the Tongue. If minimum flows are not maintained, winter flow reductions could cause freezing of beaver caches and muskrat feedbeds. Entrances to beaver lodges and bank dens may become either exposed or frozen, possibly resulting in increased predation or starvation.

SECONDARY IMPACTS

Agricultural Water Use

Under all of the levels of development considered, TDS concentrations would increase to the point that, without careful crop selection and water management, irrigation would be limited.

Lower water levels may reduce the effectiveness of existing headgates. The major diversions, however, would not be affected by low flows because of their dams.

Municipal and Domestic Water Use

At present, no municipalities use surface water from the Tongue River. Many domestic users do, however, and these users would be adversely affected by the increases in salinity which would result from any of the levels of irrigation development considered here.

Industrial Water Use

At any of the levels of irrigation development, water could be made available for industrial use. Increased salinity would increase treatment costs for some uses.

Recreation and Aesthetics

Sport fishing, a popular recreational activity along the Tongue River, would be severly impacted if reduced flows or water quality harm the existing fishery. Reduced flows, especially during summer months, would also have an effect on those recreationists attracted to flowing water for its intrinsic aesthetic value. A lesser quantity of water could diminish the perceived quality of the aesthetic experience.

The Tongue River canyon, immediately below the existing dam, would be inundated by implementation of either the intermediate or the high level of irrigation development. Lost would be a valuable, scenic resource, popular now for fishing, boating, and sight-seeing.

KINSEY AREA SUBBASIN--IMPACTS OF THE IRRIGATION EMPHASIS ALTERNATIVE

Although the high level of irrigation development predicts a depletion of only 9,480 af/y in the Kinsey Area Subbasin, the cumulative effects of withdrawals above this area would also be felt. A hydrograph of the outflows from the subbasin (Figure IV-9) illustrates this depletion. Because the existing conditions and expected flow changes are nearly the same as for the Lower Yellowstone Subbasin, the impacts in the two subbasins would be nearly identical. Refer to the discussion of impacts on the Lower Yellowstone Subbasin beginning on page 284 .

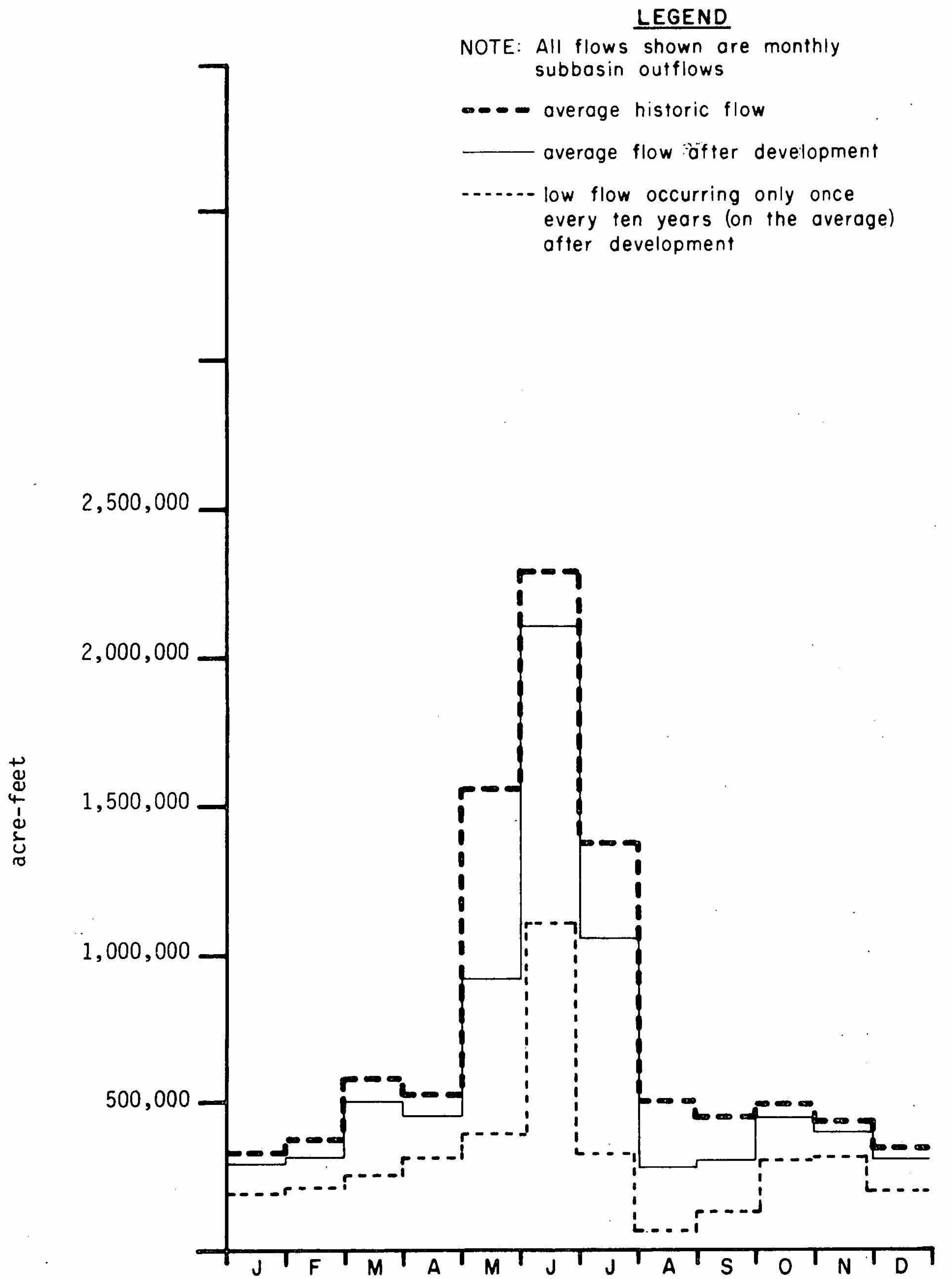


FIGURE IV-9. Kinsey Area Subbasin Monthly Outflows for the High Irrigation Emphasis Alternative

POWDER SUBBASIN--IMPACTS OF THE IRRIGATION EMPHASIS ALTERNATIVE

The projected high level of irrigation development for this subbasin predicts the additional irrigation of 75,200 acres and the depletion of 150,400 af/y.

With the exception of stock ponds, there is almost no storage in the Powder Subbasin. Because of the extreme variability of streamflows, the basin cannot provide a dependable water supply for further water development unless storage is provided.

One way to achieve additional storage would be to construct Moorhead Dam (see page 248). The State Water Planning Model simulation of the Powder Subbasin, which assumes an active storage at Moorhead of 275,000 af, shows a firm annual yield of 124,000 af.

PRIMARY IMPACTS

Streamflow Alterations

Figure IV-10 shows average monthly outflows from the Powder Subbasin, as well as the effect of the low level of irrigation development of those flows. This level of development predicts irrigation of 25,070 additional acres and depletion of 50,140 af/y. In this simulation, no instream flows were provided. As may be seen, flows would often be seriously low at the 90th percentile level during all months except May.

Even with Moorhead Dam, the demands of the high level of irrigation development cannot be met in the Powder. Figure IV-11, for example, shows the monthly hydrograph for supplying 55 percent of the high irrigation development. Instream flows would often be minimal.

Channel Form

The Powder River is a braided stream, exhibiting few islands, but numerous lateral and midchannel gravel bars. This form is a product of the bed and bank materials, the dominant (approximately bankfull) flows, and the suspended sediment load.

Any level of development considered here would require the construction of Moorhead Dam. The result would be downcutting of the channel which would retard the processes of lateral and midchannel gravel bar evolution. The channel would tend to degrade, with vegetation encroaching on the banks.

Water Quality

Salinity

TDS concentrations already extremely high in the waters of the Powder River, would increase significantly under any of the levels of development.

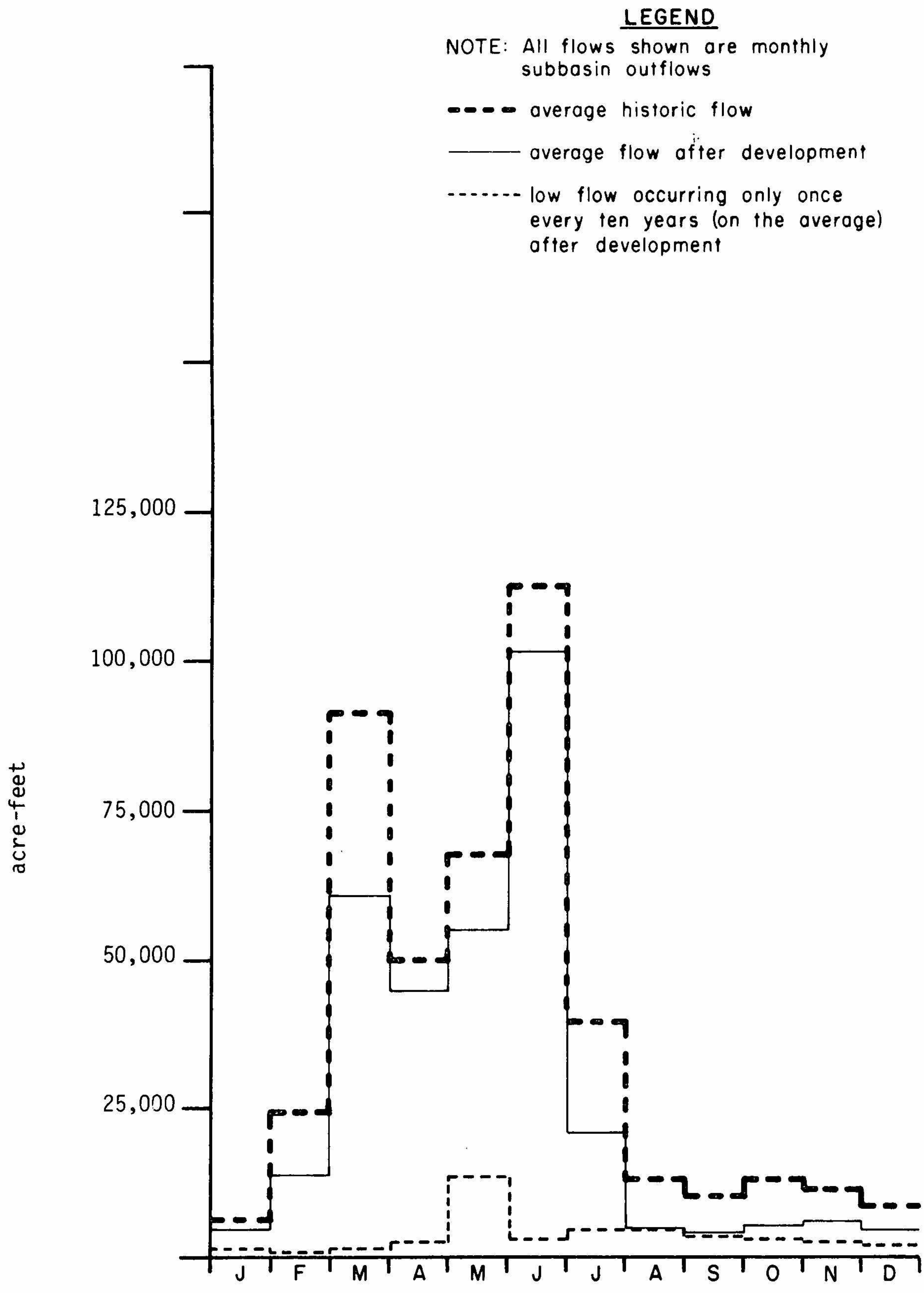


FIGURE IV-10. Powder River Subbasin Monthly Outflows for the Low Irrigation Emphasis Alternative

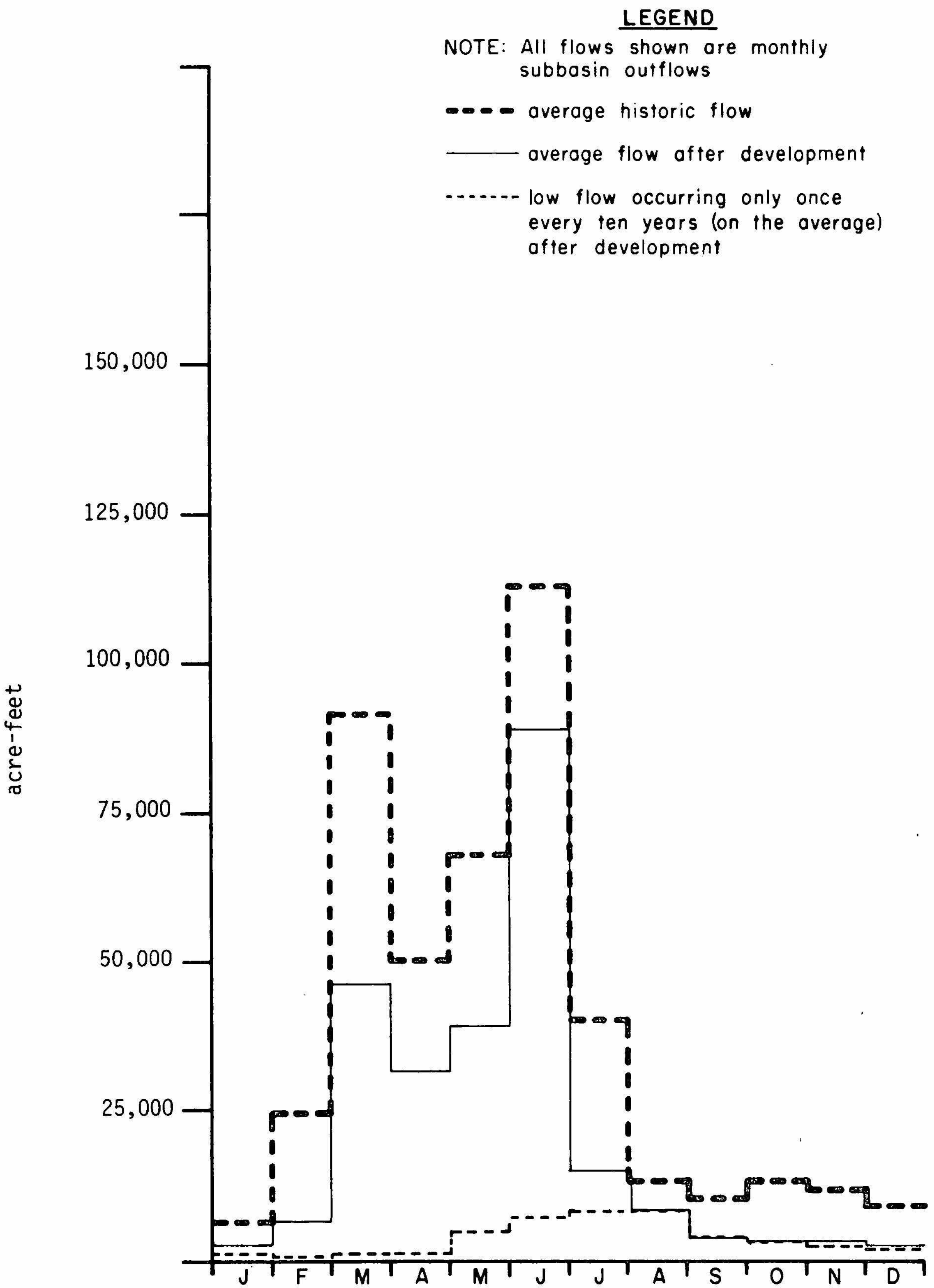


FIGURE IV-11. Powder River Subbasin Monthly Outflows for the High Irrigation Emphasis Alternative

A 1,150,000 acre-foot reservoir (the initial storage capacity of Moorhead) was assumed to simulate the possible dilution of salts. It was also conservatively assumed that the application of irrigation water would not increase salts delivered to the river by return flows. Even so, and even for the low level of development (as shown in Table IV-15), in one year out of two, on the average, total dissolved solids in the Powder River, which now average over 1,100 mg/l, would increase to over 3,000 mg/l in several low-flow months, including the irrigation season. Occasional (i.e., at the 90th percentile level) values would be even higher.

The TDS concentrations would increase even more for the intermediate and high levels of irrigation development, especially (1) if the irrigation return flows pick up additional salts from the land, and (2) as the dilution volume of the reservoir decreases due to sediment deposition.

Temperature

Though no quantitative analysis is available, it is clear that depleted flows such as those shown in Figures IV-10 and IV-11 would drastically increase temperatures, adversely affecting the aquatic ecosystems.

Sedimentation

The Powder River is the Yellowstone's major source of sediment, producing up to one-half of its sediment but only about five percent of its water. Eighty percent of this sediment is fine silt and clay particles, the source of which is in the watershed rather than the bed and banks of the stream. Should Moorhead Dam be constructed, as required for any substantial development in the Powder, most of the current sediment load at Moorhead would be deposited in the reservoir. The water emerging from the dam would attempt to regain its sediment load by degradation (downcutting) and/or widening of the channel. The slope, already in the range of five to eight feet per mile, would increase, and the bed would inevitably become armored.

The sediment load delivered to the Yellowstone mainstem would decrease because:

1) Moorhead Reservoir would trap sediment,

2) the reservoir would attenuate the high flows which carry most of the sediment,

3) diversions would decrease flows, and

4) the bed and banks are a limited source of fine sediment.

Dissolved Oxygen

No quantitative analysis is available, but it is likely that, as a result of extreme low flows, diurnal oxygen fluctuations would occasionally reduce dissolved oxygen to levels intolerable to the migratory fish.

TABLE IV-15

MONTHLY OUTFLOWS AND TOTAL DISSOLVED SOLIDS, POWDER SUBBASIN, LOW LEVEL OF IRRIGATION DEVELOPMENT

Month	50% MEDIAN FLOW				90% LOW FLOW			
	Historical		Simulated		Historical		Simulated	
	Discharge	TDS mg/l	Discharge	TDS mg/l	Discharge	TDS mg/l	Discharge	TDS mg/l
Jan	6,393	1,754	750	3,121	1,967	1,931	750	3,511
Feb	11,160	1,279	3,312	1,320	3,565	1,608	500	3,511
Mar	53,543	989	34,922	1,163	17,889	1,238	750	3,472
Apr	34,266	1,340	30,600	1,192	20,643	1,445	2,315	2,059
May	63,747	990	51,484	1,189	26,065	1,149	14,066	1,704
Jun	100,360	986	91,303	1,204	10,946	1,237	3,500	3,439
Jul	27,601	1,238	4,500	3,041	2,889	1,931	4,500	3,511
Aug	9,221	1,637	4,500	3,292	861	1,771	4,500	3,511
Sep	4,164	1,363	2,500	3,292	535	1,544	2,500	3,511
Oct	7,192	1,468	2,000	3,267	553	2,049	2,000	3,511
Nov	10,351	1,475	1,250	3,267	3,688	2,017	1,250	3,511
Dec	7,069	1,929	1,000	3,267	3,750	2,196	1,000	3,511
Annual	335,067	1,137	228,121	1,339	93,331	1,390	37,631	2,739

Ecosystems

Because of high turbidity and frequent low flows, the fishery in the Powder River is currently limited to channel catfish, non-game fish which can tolerate adverse conditions, and spawning migrants such as sauger, shovelnose sturgeon, and, possibly, paddlefish. Construction of Moorhead Dam under any of the levels of development could conceivably alleviate both turbidity and low flow extremes, resulting in a fishery similar to that which now exists in the Tongue River. However, instream flows would have to be provided. A minor cold-water trout fishery could develop for a few miles downstream of the dam. The reservoir itself could develop an important fishery with such species as white and black crappie, walleye, smallmouth bass, and northern pike.

The sturgeon chub, reportedly Montana's rarest fish, is common in the Powder River and Mizpah Creek. Reduced turbidities in Powder River, as a result of the dam, would eliminate the competitive advantage this chub has in murky waters. Mizpah Creek would be unaffected by a mainstem Powder River dam.

The increases in TDS projected in connection with low and reduced high levels of development could offset any gains from improvements in turbidity and low flow extremes. Unless TDS increases can be held to a minimum by the provision of instream flows, the spawning and recruitment of channel catfish, sauger, shovelnose sturgeon, and paddlefish would be eliminated.

Construction of Moorhead Dam would affect waterfowl both adversely and beneficially. Downcutting of the river channel would tend to eliminate islands and, therefore, nesting sites for the marginal resident Canada goose population. However, maintenance of instream flows could help protect island nesting sites from predators, and increased agricultural development would provide feeding sites for geese and ducks. An improvement in the fishery would benefit fish-eating birds such as great blue herons, white pelicans, and double-crested cormorants.

Beaver populations in the Powder Subbasin have not been studied. Informal observations indicate that more beavers occupy the river and its perennial tributaries than in the Tongue Subbasin, but fewer than in the Yellowstone mainstem. The construction of Moorhead Dam would probably tend to reduce the beaver populations to levels near those on the Bighorn and Tongue rivers. Channel processes would be retarded by the reduction and regulation of flows, and vegetation would tend to the climax stage, thus reducing the food supply for beavers.

SECONDARY IMPACTS

Agricultural Water Use

The construction of Moorhead Dam would make a great deal of water available. However, even at the low projected level of development, the quality of the water would be unacceptable for irrigation at least one year out of two. Provision of instream flows may mitigate that water quality degradation to the point that, with careful water management, irrigation water use may be expanded.

Municipal and Domestic Water Use

Powder River water would not be suitable for this use. Even now, TDS concentrations stay above the recommended upper limit for drinking water.

Industrial Water Use

Under this alternative, no water would be available for any consumptive use other than irrigation.

Recreation and Aesthetics

Water-based recreational activity in the Powder River subbasin is small due to turbid waters, the frequency of low flows, the low human population, and the proximity to the Yellowstone mainstem. Recreational potential would increase if Moorhead Dam were built. River waters would appear cleaner, due to reduced turbidity, and the fishery might improve. In addition, the reservoir would provide a warm-water sport fishery and boating opportunities.

LOWER YELLOWSTONE SUBBASIN--IMPACTS OF THE IRRIGATION EMPHASIS ALTERNATIVE

Because this subbasin is farthest downstream on the mainstem, the cumulative impacts of all mainstem and tributary development would be felt here. The high level of irrigation development would require depletion of 75,340 af/y in this subbasin; when added to the depletions in all upstream subbasins, the total depletion by the year 2000 would be 474,960 af/y.

PRIMARY IMPACTS

Streamflow Alterations

Figure IV-12 shows the effect of the high level of irrigation development on the monthly outflows from the Yellowstone Basin. Water diversions and depletions in all subbasins are included. (In the Powder Subbasin, the high level of development is reduced to reflect the available water supply.) Water supply in the Yellowstone mainstem is generally adequate, without storage, for the high level of development. An exception may occur in August and possibly September. The 90th percentile low flow in August would be less than 1,000 cfs. These low flows could be prevented by reserving instream flows or by providing offstream storage.

Channel Form

Analysis of bed and bank materials and dominant discharges indicates the sediment transport capacity of the Yellowstone, under the high level of

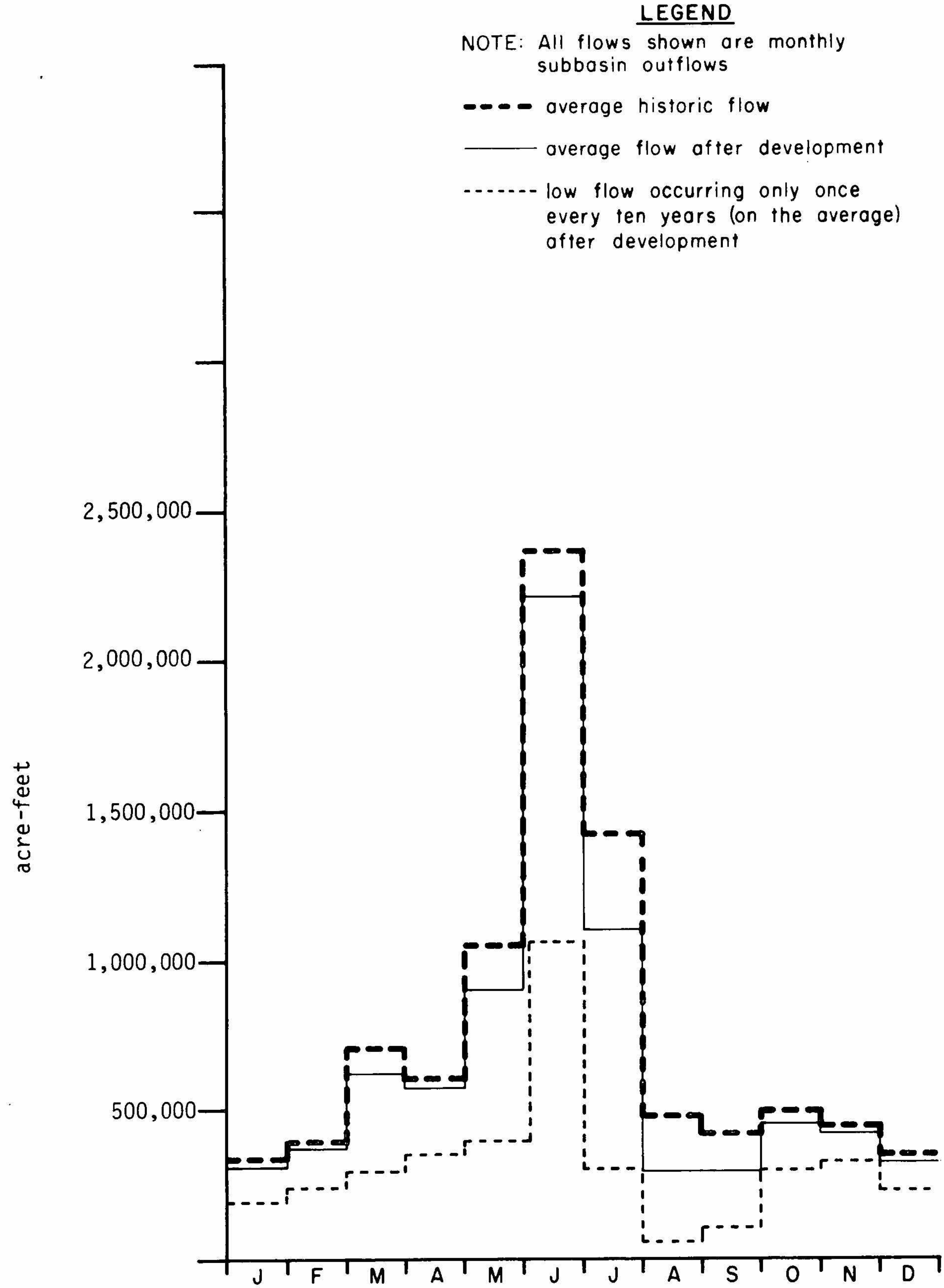


FIGURE IV-12. Lower Yellowstone River Subbasin Monthly Outflows for the High Irrigation Emphasis Alternative development, could decrease up to 30 percent. Whether this decrease would cause sedimentation and aggradation depends on the supply of sediment to the river. That supply has already been decreased by the construction of dams on the Bighorn and Tongue rivers. Moorhead Dam would decrease it even further. Therefore, the reduced sediment transport capacity would probably be adequate for the sediment supply, and aggradation would not occur.

Water Quality

TDS concentrations average less than 500 mg/l. However, December and January levels exceed 600 mg/l, and February through April and September through November levels exceed 500 mg/l. Under the high level of irrigation development, TDS concentrations would increase as shown in Table IV-16.

In performing the simulations shown in Table IV-16, it was conservatively assumed that irrigation return water would not add salt. For the 50th percentile flows, a salt pickup of one ton/acre/year would increase the TDS values less than three percent annually, and for all months except July (five percent), August (11 percent), and September (six percent). For the 90 percent values, a salt pickup of one ton/acre/year would increase TDS values less than five percent annually, and in all months except July (12 percent), August (23 percent), and September (11 percent).

The table shows that, at the high level of irrigation development, TDS concentrations in most months, at the 50 percent level, would increase only moderately. Water would usually violate the recommended upper limit for domestic consumption (500 mg/l), but possibly could be so used without adverse effects. At the 90 percent level, monthly TDS values would increase significantly in the months of July through September, approaching 900 mg/l in August. However, that concentration would occur infrequently, and only for short periods.

Ecosystems

The high level of irrigation development would have a marked effect on streamflows, especially during August and September, the most important months for growth of adult fish and rearing of young fish. Flows on the order of 1,000 cfs, which would occur about one year in ten under the high level of development, would result in a substantial reduction in food production in riffle areas. Coupled with possible increased temperatures and reduced diurnal dissolved oxygen, this would severely affect most fish, but especially such species as shovelnose sturgeon and goldeye, which are heavily dependent on insects for food. Channel catfish could probably utilize small forage fish as a food supply, rather than insects.

The principally reduced fish habitat and degraded water quality which would occur as August flows approached 1,000 cfs would affect game fish like sauger and shovelnose sturgeon more than such nongame fish as carp. The tendency would be for fish population compositions to shift toward greater proportions of the nongame fish.

TABLE IV-16

MONTHLY OUTFLOWS AND TOTAL DISSOLVED SOLIDS,
LOWER YELLOWSTONE SUBBASIN, HIGH LEVEL OF IRRIGATION DEVELOPMENT

	50% (MEDIAN)				90% (LOW FLOW)			
	Historical		Simulated		Historical		Simulated	
Month	Flow	TDS	Flow	TDS	Flow	TDS	Flow	TDS
Jan	327,344	648	308,226	670	200,095	750	196,365	772
Feb	340,096	591	326,122	604	256,410	632	245,761	647
Mar	635,385	510	593,263	528	343,573	615	292,420	657
Apr	547,605	560	511,933	572	345,280	604	358,737	617
May	1,196,647	357	971,412	405	569,424	459	400,958	533
Jun	2,321,298	281	2,132,337	284	1,217,402	242	1,064,324	261
Jul	1,244,332	298	974,208	343	532,541	335	309,444	458
Aug	446,355	452	264,510	593	237,778	542	61,528	880
Sep	431,778	537	279,310	633	218,388	622	111,365	789
Oct	489,571	549	450,539	596	338,778	639	307,736	699
Nov	441,416	578	424,565	601	340,461	644	338,862	660
Dec	360,109	631	348,206	645	243,249	671	230,268	692
Annual	8,724,936	419	7,584,631	452	4,843,379	481	3,973,088	538

These adverse effects would not be irreversible as long as low flow years did not succeed one another.

The increase in irrigated agriculture would tend to attract more migrant waterfowl for feeding. Spring flows would not be reduced enough to adversely affect goose nesting.

The impact on beaver and other riparian furbearers would be minimal.

SECONDARY IMPACTS

Under the high level of irrigation development, water would generally be available and suitable for agricultural and industrial users. Occasional high TDS concentrations would require careful irrigation water management.

Water would be unsuitable for domestic use, since TDS values would exceed 500 mg/l in all months but May, June, and July.

The adverse effects on the fishery would degrade recreational experiences. Aesthetic perceptions would change as land is converted to irrigated fields.

ENERGY EMPHASIS ALTERNATIVE

The high level of energy development presented on page 227 is believed to be the maximum, based on current understanding of the many complex constraints involved. Therefore, it is assumed that the Energy Emphasis Alternative would be the same as the projected high level of energy development.

Except in water-short areas such as the Tongue and Powder subbasins, a high level of energy development would not necessarily restrict expansion of irrigated agriculture. In this alternative, it is assumed that future irrigation would compete with the energy industry for water, rather than having a secure future supply reserved. Therefore, it is reasonable to assume that, under the Energy Emphasis Alternative, irrigation expansion would proceed to the intermediate level of development.

The Energy Emphasis Alternative thus becomes identical to the No Action Alternative, previously discussed. See that section (page240) for an assessment of the impacts.

INSTREAM FLOW EMPHASIS ALTERNATIVE

Montana is what it is, to a large degree, because of its high quality natural environment--its open spaces, its big sky, and its free-flowing streams. The Yellowstone is the epitome of a free-flowing river, being virtually unimpounded its entire 670-mile length from its headwaters in the mountains south of Yellowstone National Park to its confluence with the Missouri, just across the North Dakota state line.

A free-flowing Yellowstone River, protected from major depletions in order to preserve its diverse and productive aquatic and riparian ecosystems, would continue to enhance the quality of life for Montanans for many generations to come. This alternative considers the effects of preserving these instream values.

Even under the most consumptive of the development alternatives, most of the water would remain in the channels as instream flows. However, water quality and aquatic ecosystems would be severely affected under certain circumstances, i.e., in certain subbasins and during extremely low flow periods. The Instream Flow Emphasis Alternative would keep water in the streams when it is most needed to protect these values.

FORMULATION OF THE INSTREAM FLOW EMPHASIS ALTERNATIVE

The preservation of instream flow values is best articulated by the reservation applications of the Montana Fish and Game Commission and the Department of Health and Environmental Sciences. Those applications have been described in detail in Part III of this EIS (see pages 180 and 208), but can be briefly summarized here.

The Montana Fish and Game Commission application covers essentially the entire basin. Because it seeks to preserve the existing ecosystem, it asks the reservation of significant percentages of the average flow. In some of the smaller creeks, all flows, year around, are requested (subject to existing rights).

The Montana Department of Health and Environmental Science application identifies flow levels necessary to maintain legal water quality standards on three sections of the mainstem which include the entire river from the mouth of the Clarks Fork Yellowstone to the North Dakota state line. No tributaries are included.

Table IV-17 compares the monthly amounts requested in these two applications for the three river sections applied for in common. The third column selects the higher of the two requests, for each month, to show the maximum amount of water that might be reserved for instream flows. The total annual amount at the state line, as shown in Table IV-17, would be 9,778,050 af/y, considerably higher than the average annual flow adjusted for existing development, of 8,800,000 af/y.

Note, however, that these two applicants are not attempting to reserve more water than is available. The discrepancy between the average annual yield and the combined instream requests is probably due to calculations based on different periods of streamflow record and differences in adjusting streamflow records to reflect the current level of development.

The conservation districts which applied for reservations for future irrigation also applied for instream flow levels in order to keep the river within reach of existing diversions. However, only the North Custer Conservation District quantified its request, and that request, for 4,000 cfs, is less than the amount applied for by the Fish and Game Commission. Because North Custer Conservation District's request would apparently be satisfied by granting the amounts shown in Table IV-17, that table together with the remainder of the Fish and Game Commission application represent the maximum option for providing instream flows by granting reservation requests. The impacts are considered below.

IMPACTS--INSTREAM FLOW EMPHASIS ALTERNATIVE

GENERALIZED IMPACTS

The principal beneficial effects of this option would be the maintenance of existing instream flows and water quality. There should be no negative effect on the aquatic or terrestrial ecosystems or on recreation. Consumptive

TABLE IV-17

COMPARISON OF INSTREAM FLOW RESERVATION REQUESTS OF THE MONTANA DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES AND THE MONTANA FISH AND GAME COMMISSION (acre-feet)

Month	DHES Application	Fish and Game Application	Higher Request
Yellowstone River From the Mouth of the Clarks Fork Yellowstone to the Mouth of the Bighorn			
Jan	240,000	153,720	240,000
Feb	217,000	138,845	217,000
Mar	210,000	178,315	210,000
Apr	197,000	214,215	214,215
May	321,000	514,455	514,455
June	694,000	1,215,070	1,215,070
July	204,000	577,784	577,784
Aug	160,000	295,140	295,140
Sep	227,000	220,165	227,000
Oct	273,000	221,355	273,000
Nov	230,000	208,264	230,000
Dec	211,000	172,165	211,000
TOTAL	3,184,000	4,109,493	4,424,664
Yellowstone River From the Mouth of the Bighorn to the Mouth of the Powder			
Jan	515,000	295,200	515,000
Feb	410,000	309,745	410,000
Mar	460,000	676,500	676,500
Apr	700,000	654,500	700,000
May	469,000	773,370	773,370
June	232,000	2,272,520	2,272,520
July	129,000	856,650	856,650
Aug	300,000	430,000	430,000
Sep	450,000	416,500	450,000
Oct	450,000	430,500	450,000
Nov	440,000	416,500	440,000
Dec	460,000	344,400	460,000
TOTAL	5,015,000	7,876,385	8,434,040

TABLE IV-17 - continued

Month	DHES Application	Fish and Game Application	Higher Request
Yellowstone River From the Mouth of the Powder to the State Line			
Jan	680,000	301,350	680,000
Feb	620,000	332,270	620,000
Mar	690,000	676,500	690,000
Apr	840,000	654,500	840,000
May	450,000	832,860	832,860
June	547,000	2,427,190	2,427,190
July	126,000	937,500	937,500
Aug	370,000	430,500	430,500
Sep	530,000	416,500	530,000
Oct	600,000	430,500	600,000
Nov	600,000	416,500	600,000
Dec	590,000	350,550	590,000
TOTAL	6,643,000	8,206,720	9,778,050

users with existing valid appropriations would benefit from the maintenance of existing water quality, and all residents and recreational users would benefit from the strong influence of this option toward preservation of the existing environment and recreational resource.

The principal negative impact of this option would be the prevention of significant future resource development involving consumptive use in the basin (unless alternative water sources are used to supply that development). The general effects of this aspect are described in more detail in the discussion in Part III of the Fish and Game Commission application (page 192).

PRIMARY IMPACTS--INSTREAM FLOW EMPHASIS ALTERNATIVE

Streamflow Alterations

Granting the cumulative instream flow applications would not alter streamflows. Considered here is whether flows at the existing level of development and prior water appropriations will be adequate to supply the instream requests.

It is doubtful that there is sufficient water legally (or even, in some cases, physically) available to satisfy this alternative. The combined total request in the mainstem at the North Dakota state line is about 9.8 million af/y, one million af/y more than flows out the state, on the average. On the tributaries, as elsewhere, water rights are as yet unquantified and unadjudicated. The uncertainty of the total amounts of these rights, including Indian and federal reserved rights, in addition to uncertainty about Wyoming's Yellowstone Compact share of the four interstate tributaries, make it impossible to accurately assess how much water is now available for reservation for instream flow. Any instream flow reservation, of course, would be subject to existing rights and other legal claims and would have legal precedence only over subsequent rights and reservations.

Channel Form

The Fish and Game Commission application has requested a 24-hour dominant discharge so that the streams will be able to maintain the existing channels in their dynamic, usually braided, form. It is questionable whether a 24-hour period is long enough for a stream to perform that function. However, the dominant discharges of most streams would probably actually be maintained for a longer period of time, unless spring peaks were markedly diminished by diversions to storage.

Water Quality

Under this alternative, water quality would be maintained at the present level barring unforeseen pollution inputs to the system.

Ecosystems

Under this alternative, aquatic and terrestrial ecosystems would receive direct protection from degradation resulting from reduced flows. In addition, the terrestrial ecosystem would be indirectly protected, since there would be less water available for development that might disturb riparian and other terrestrial wildlife habitats.

SECONDARY IMPACTS--INSTREAM FLOW EMPHASIS ALTERNATIVE

For any potential future consumptive users, the important question concerns the amount of water, if any, that would be available for diversion, storage, and depletion under this alternative.

Figures IV-13 and IV-14 show the average amount of water left for development in the Billings and Mid-Yellowstone subbasins, respectively, assuming that this instream flow alternative is adopted.

Not shown is the availability of water for development during the 90th percentile (one-year-in-ten) low flows; availability of water during that time would be zero for all months. It is clear that this option would leave water available for additional consumptive use only in average or near-average flow years, and then only in some months.

Agricultural Water Use

The principal benefits of this alternative to agricultural water users are that:

1) water quality would be maintained at the current, acceptable levels for irrigation, and

2) water levels in the rivers would be maintained at their present elevations, posing no additional problems for diversion.

These benefits would be available, for the most part, to holders of existing rights; there would be insufficient water supply left beyond the instream flow reservation levels for new agricultural appropriators without the construction of expensive storage. As shown in Figures IV-13 and IV-14, there would not be water available for new appropriations through the entire irrigation season in average years even in portions of the mainstem. In the tributaries, especially the Tongue and Powder rivers, there would probably be no water available for additional development. Additional storage would increase the availability of water for consumptive use, but agricultural interests alone can seldom afford the cost of such projects.

Presented in Part III (page192) is a discussion of the cost to future irrigators precluded from developing irrigable lands by the Fish and Game Commission reservation, if granted.

Municipal and Domestic Water Use

Water for these purposes is normally diverted year-round. Even in an average year, there would be some months when no water would be available for new municipal diversions. Cities seeking larger municipal supplies would

SEE PAGE 302

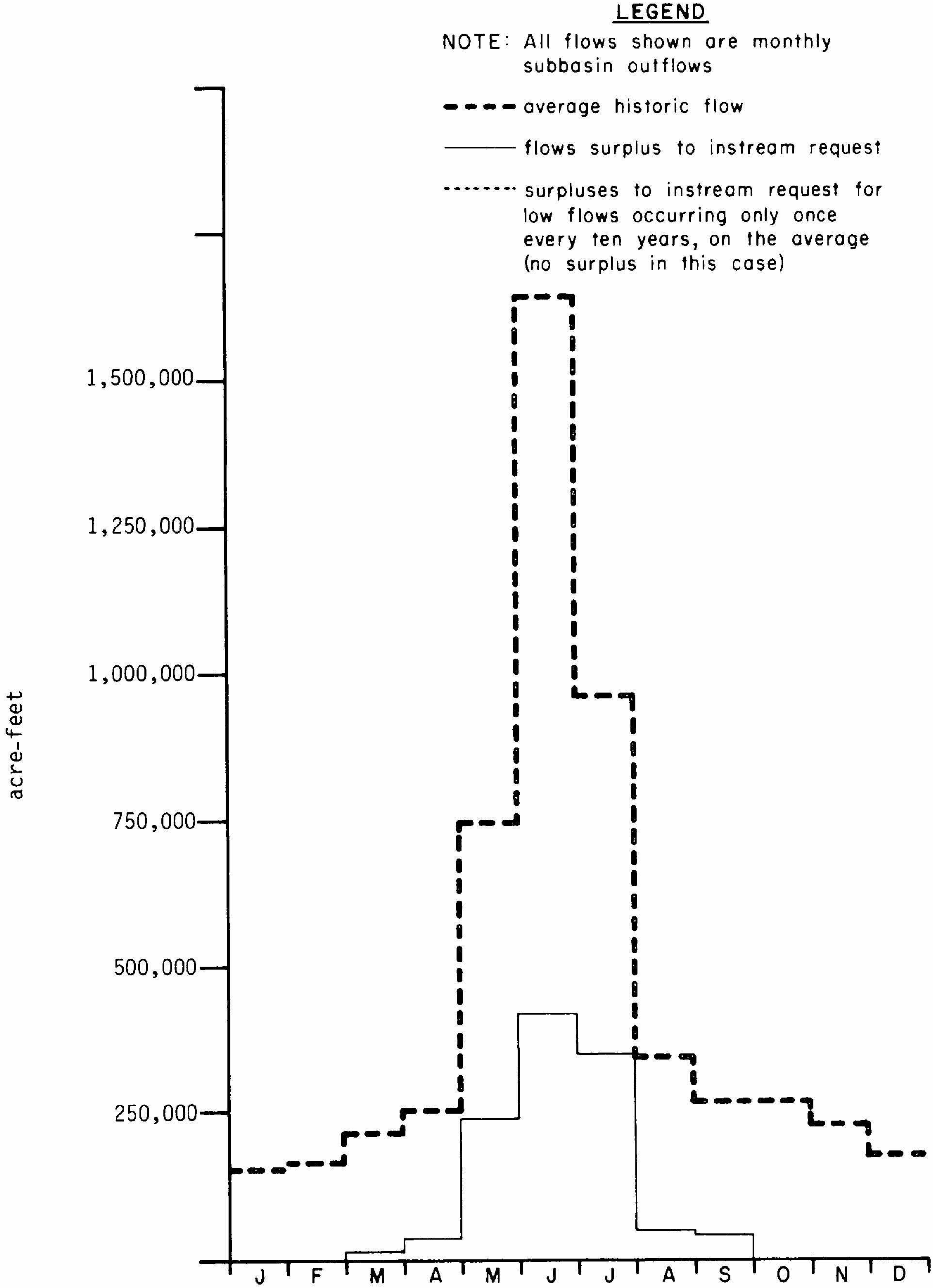


FIGURE IV-13. Billings Area Subbasin Monthly Outflows for the Department of Health and Environmental Sciences and Montana Fish and Game Commission Applications Combined

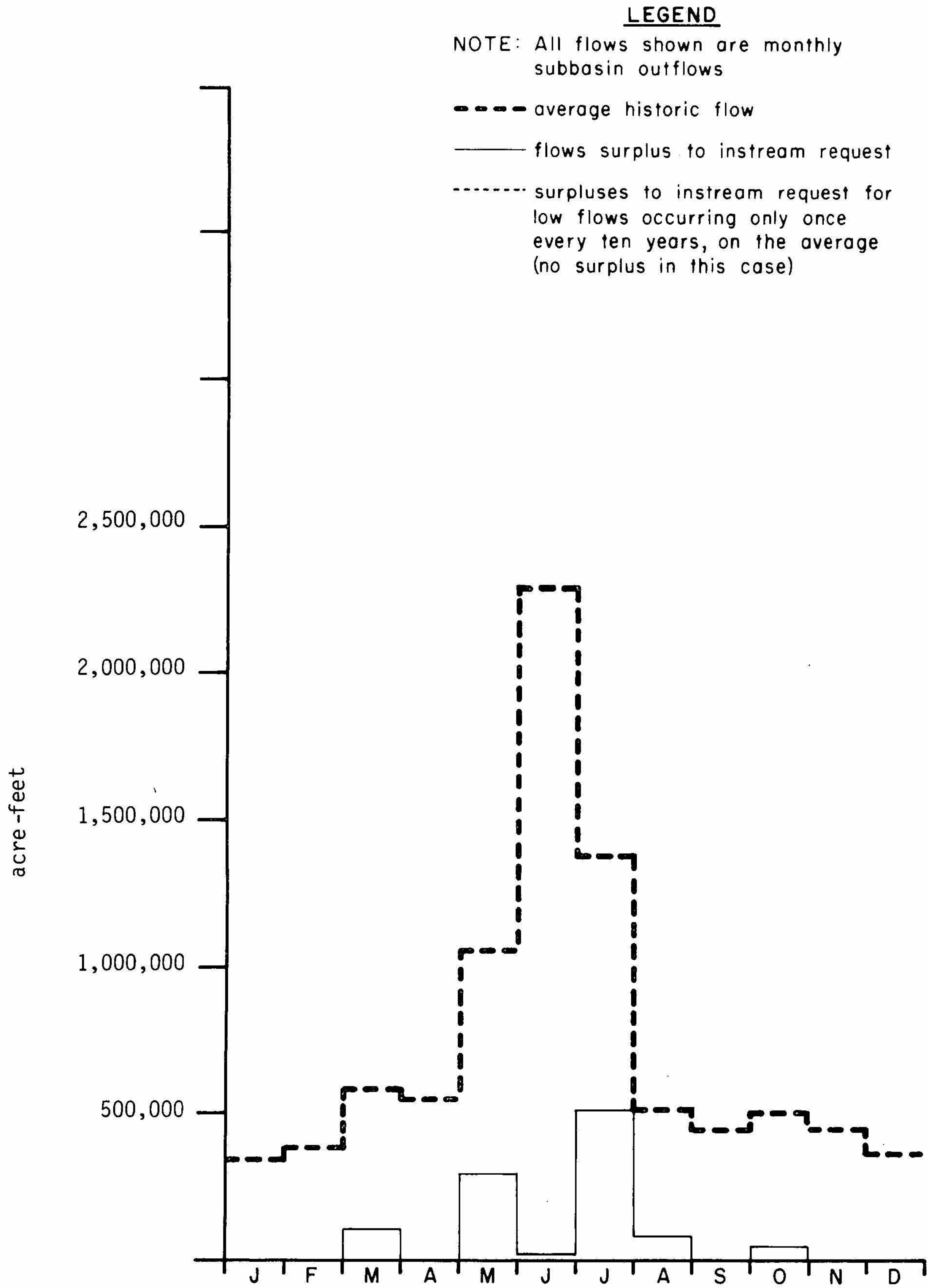


FIGURE IV-14. Mid-Yellowstone River Subbasin Monthly Outflows for the Department of Health and Environmental Sciences and Montana Fish and Game Commission Applications Combined

OTHER INSTREAM ALTERNATIVES

Under the three diversion alternatives, (No Action, Energy Emphasis, and Irrigation Emphasis), not all streamflows would be diverted. Tables IV-18, IV-19, and IV-20 present historical flows, instream flow reservation requests, and the flows which would remain instream under the three diversion alternatives at three locations.

The remaining flows under each of the diversion alternatives represent possible alternative instream flows which could be reserved for that purpose. The Instream Flow Emphasis Alternative (discussed above) provides the most protection for instream values, while the water remaining instream under the diversion alternatives would provide lesser protection if it were reserved for that purpose. The flows remaining instream under the diversion alternatives could also be left unallocated; this approach would provide the least protection of instream values.

TABLE IV-18

COMPARISON OF HISTORICAL FLOW AND INSTREAM FLOW ALTERNATIVES

Yellowstone River Above Mouth Of Clarks Fork Yellowstone River
(acre-feet)

			Month D,J,F	M,A	M,J,JL	A,S,O,N
		Historical Flow				
Historical Flow		Mean	403,080	352,725	2,727,795	900,615
		90th Percentile [a]	289,655	235,200	1,616,135	565,675
		Instream Flow Emphasis Alternative				
Instream Flow Requests (Fish & Game Commission) [b]			304,065	247,540	1,883,675	741,220
		Other Instream Alternatives				
Streamflow remaining assuming implementation of the No Action Alternative or the Energy Emphasis Alternative		Mean	403,080	351,965	2,680,595	872,435
		90th Percentile	289,655	234,820	1,592,535	587,765
Streamflow remaining assuming implementation of the Irrigation Emphasis Alternative	HIGH	Mean	403,080	351,585	2,656,995	858,345
		90th Percentile	289,655	234,060	1,545,335	559,585
	INTERMEDIATE	Mean	403,080	351,965	2,680,595	872,435
		90th Percentile	289,655	234,440	1,568,935	573,675
	LOW	Mean	403,080	352,345	2,704,195	886,525
		90th Percentile	289,655	234,820	1,592,535	587,765

a. 90th percentile flows are those low flows occurring one year in ten (on the average).

b. No application was submitted by the Department of Health & Environmental Sciences regarding this location.

TABLE IV-19

COMPARISON OF HISTORICAL FLOW AND INSTREAM FLOW ALTERNATIVES

Tongue River At Mouth
(acre-feet)

			Month			
			D,J,F	M,A	M,J,JL	A,S,O,N
Historical Flow						
Historical Flow		Mean	40,400	71,575	175,080	56,940
		90th Percentile a.	20,830	22,450	29,180	9,930
Instream Flow Emphasis Alternative						
Instream Requests (Fish & Game Commission) b.			33,915	63,500	97,570	48,110
Other Instream Alternatives						
Streamflow remaining assuming implementation of the No Action Alternative or the Energy Emphasis Alternative		Mean	6,265	33,490	90,895	3,950
		90th Percentile	2,700	5,400	4,495	3,595
Streamflow remaining assuming implementation of the Irrigation Emphasis Alternative	High	Mean	14,110	48,685	128,150	14,735
		90th Percentile	4,665	6,930	13,950	12,575
	Intermediate	Mean	16,390	51,070	137,920	12,940
		90th Percentile	4,010	6,430	10,800	9,590
	Low	Mean	38,578	76,700	176,030	25,450
		90th Percentile	7,610	28,205	33,095	6,595

a. 90th percentile low flows are those low flows occurring on year in ten (on the average).

b. No application was submitted by the Department of Health and Environmental Sciences regarding this location.

TABLE IV - 20

COMPARISON OF HISTORICAL FLOW AND INSTREAM FLOW ALTERNATIVES

Yellowstone River at Sidney
(acre-feet)

			Month			
			D,J,F	M,A	M,J,JL	A,S,O,N
		Historical Flow				
Historical Flow		Mean	1,093,280	1,325,230	4,841,825	1,867,210
		90th Percentile[a]	699,755	688,855	2,319,370	1,135,405
		Instream Flow Emphasis Alternative				
Instream Requests[b]		Fish & Game Commission	984,170	1,331,000	4,197,550*	1,694,000
		Dept. of Health & Environmental Sciences	1,890,000*	1,530,000*	1,123,000	2,100,000*
		Other Instream Alternatives				
Streamflow remaining assuming implementation of the No Action Alternative or the Energy Emphasis Alternative		Mean	982,040	1,169,320	4,334,450	1,524,325
		90th Percentile	646,260	638,995	1,861,798	867,390
Streamflow remaining assuming implementation of the Irrigation Emphasis Alternative	High	Mean	1,008,230	1,193,675	4,236,822	1,482,340
		90th Percentile	672,395	651,160	1,774,725	819,490
	Intermediate	Mean	1,019,870	1,205,080	4,408,660	1,595,800
		90th Percentile	681,100	659,690	1,913,400	941,855
	Low	Mean	1,049,115	1,253,785	4,538,115	1,644,845
		90th Percentile	697,655	878,540	2,007,815	971,170

a. 90th percentile flows are those low flows occurring one year in ten (on the average).

b. Both requests are presented for comparative purposes; however, only the higher requests, which are marked with asterisks, comprise the Instream Flow Emphasis Alternative.

probably have to find alternative sources, such as ground-water, or expand storage facilities.

Municipal and domestic users with existing appropriations would benefit from the maintenance of existing water quality.

Industrial Water Use

Potential developers of energy would normally be better able to afford storage than agricultural users. Therefore, these users may be less severely affected than agricultural ones.

Recreation and Aesthetics

The Instream Emphasis Alternative, if implemented, would tend to maintain the status quo with respect to recreation and aesthetics. This may be considered a future benefit in that, if recreational experiences and aesthetic perceptions were degraded by industrial and agricultural development, those large and real values would be foregone.

Not to be overlooked is the "option demand" for a free-flowing, full-flowing Yellowstone River. As a unique aquatic ecosystem, the river has value to many who have no expectations of personally experiencing it.

IMPACTS BY SUBBASIN

Impacts in each individual subbasin may vary, but most are reasonably close to the generalized impacts presented above. For a more detailed discussion of the effects of instream flow reservations in each subbasin, see the impact assessments of the individual applications of the Fish and Game Commission (pages 191 to 207) and DHES (pages 208 to 211); the cumulative effect would differ only slightly.

OTHER ALTERNATIVES

The basic concern of this EIS is alternative allocations of surface waters of the Yellowstone Basin--waters which are often not available at the right place and the right time for prospective users. There are, however, a number of alternatives to this source of supply. Briefly considered here are the following alternatives:

1) ground water,
2) dry cooling for energy conversion plants,
3) aqueducts and canals from other water sources, and
4) water conservation through management.

However, assessing the environmental, social, and economic impacts of these alternatives is beyond the scope of this EIS.

GROUND WATER

Depending on the quantities involved, ground water may be considered either a substitute for or a supplement to surface supplies.

Ground-water aquifers are scattered throughout the Yellowstone Basin. Moderate to large ground-water supplies (250-1,000 gpm) are available from the alluvium and terrace deposits adjacent to rivers. Coal beds are aquifers in some portions of the basin. In other parts of the basin, adequate ground-water supplies are difficult to obtain. However, the full potential for use of ground water from these unconsolidated, near-surface sediments has not yet been attained.

Deep aquifers, of which the Madison geologic formation is the best known, lie at a depth that ranges from the surface to 8,000 feet or more. These aquifers offer the greatest water development potential in the basin, and large-yield water wells can potentially be developed in areas of significant thickness. These aquifers will produce water mostly for municipal and industrial consumption. Bedrock ground water for irrigation purposes may be limited, due to the high cost of such water and its high salinity. Estimates made by the Northern Great Plains Resource Program (1974a) indicate that the cost of obtaining Madison ground water would vary between $27 and $48 per acre-foot; if treatment is needed, costs could be higher.

Some characteristics of both the near-surface and deep aquifers are shown in Table IV-21 (adapted from NGPRP 1974a).

TABLE IV-21

CHARACTERISTICS OF NORTHERN GREAT PLAINS AQUIFERS

Aquifer	Depth (feet)	Yield (gpm)	TDS (mg/d)
Shallow	0 - 300	5 - 1,500	300 - 6,000
Madison Formation	0 - 8,000+	5 - 3,700	550 - 300,000

DRY COOLING

In coal conversion processes, water is used primarily for cooling. As shown in Table IV-22, wet cooling systems consume large amounts of water. Dry cooling techniques are the most water-conservative of the alternatives, but they are also the most expensive. However, recent studies have indicated that, if the cost of water reaches approximately $200 per acre-foot (Stroup and Townsend 1974), dry cooling techniques become economically feasible.

Though far from common, generation plants using dry cooling do exist. The Neal Simpson Station (27 mw) near Gillette, Wyoming, was the first coal-fired, electrical generation plant in the United States to use dry cooling. The Wyodak plant, now under construction at the same site and scheduled for completion early in 1977, will be the largest dry-cooled plant in the United States. It will generate 330 mw of electricity and consume from 0.2 to 1 mgd (Black Hills Power and Light Company and Pacific Power and Light Company 1973). In comparison to the 5 mgd consumed by each of Colstrip Units 1 and 2, the Wyodak plant is water-conservative.

TABLE IV-22

WATER REQUIREMENTS FOR COAL-FIRED ELECTRIC GENERATING PLANTS

Cooling System	Depletion (af/y/1,000-mw unit)
Evaporative Cooling	15,000
Pond	10,000
Once Through	3,600
Dry Cooling	2,000

SOURCE: Western States Water Council 1974

AQUEDUCTS AND CANALS

The Missouri River is ready regulated by several mainstem dams in Montana, North Dakota, and South Dakota. Conceivably, water could be delivered by pump and aqueduct from one or more of these reservoirs or from the mainstem to the Yellowstone Basin for low flow augmentation or for consumption by irrigated agriculture, industry, or municipalities.

Such water would be expensive. However, it has been estimated by the Northern Great Plains Resources Program (NGPRP 1975) that water can be delivered to Gillette, Wyoming, as cheaply from Oahe Reservoir in South Dakota as from the Yellowstone River at Miles City. Less exotic proposals involve diversions from the regulated Bighorn River. Costs are estimated to range up to $370 per acre-foot, depending on the quantities, lifts, and distances involved.

WATER MANAGEMENT

A variety of actions could be taken that could make the use of water more efficient, in effect making more water available.

IRRIGATION WATER MANAGEMENT

At present, diversions in excess of actual water needs are being made. Throughout the Yellowstone Basin, it is estimated that about six acre-feet per acre are diverted to provide a depletion of only about two acre-feet per acre. Much unused water is lost through evaporation and transpiration by non-crop vegetation. The rest finds its way into near-surface aquifers or returns to the streams.

Excess diversions are the result of irrigation systems design (e.g., often a full canal of water is diverted to maintain the head at laterals and turnouts, even when the actual water demand is low) and deterioration of old systems. Lining ditches and reconstructing headgates and turnouts could reduce waste.

Irrigation water waste has a beneficial side, however. These waters return to the streams later in the year, usually during low flow periods, thus augmenting streams that might naturally be lower if returns were not made. Downstream users have perfected rights to this water in some cases.

MUNICIPAL WATER MANAGEMENT

Municipal water use and waste could be reduced by water conservation measures and by a pricing structure to encourage economic utilization.

INDUSTRIAL WATER MANAGEMENT

Water could be conserved in the industrial sector by the use of such technologies as water recycling and dry cooling.

PART V

EFFECTS OF WATER RESERVATIONS ON PENDING WATER APPROPRIATIONS AND OTHER CONSIDERATIONS

CONTENTS

PENDING WATER RIGHT APPLICATIONS

Water reservations adopted before approval of suspended permit applications (as a result of the Yellowstone Moratorium) will have preference of water use to those permits. This is true even though the pending water applications, if eventually granted, would have an earlier priority date. Approved water reservations, then, could have a significant adverse effect on the pending appropriations listed in Table V-1. Subsequent sections define possible impacts of successful water reservation applicants on these applications.

TABLE V-1

WATER RIGHT APPLICATIONS HELD PENDING
BY YELLOWSTONE MORATORIUM

APPLICANT	SOURCE	APPROPRIATION REQUEST	MAJOR PROPOSED USE
Getty Oil Company	Yellowstone River	Offstream storage 32,000 af/y and continuous diversion up to 60,000 af/y	Industrial
Gulf Mineral Resources Company	Tongue, Powder, Yellowstone Basins	Eight alternatives including ground-water and offstream storage	Industrial
Intake Water Company	Powder River	Onstream storage 564,400 af/y	Industrial
Montana Water Storage Company	Tongue River	Offstream storage 130,000 af/y and continuous diversion up to 40,000 af/y	Industrial
Mobil Oil Company	Yellowstone River	Offstream storage 50,000 af/y or continuous diversion up to 35,000 af/y	Industrial
Utah International, Incorporated	Powder River	Offstream storage 106,730 af/y	Industrial
Water Reserve Company	Tongue River	Offstream storage 91,000 af/y and continuous diversion up to 36,200 af/y	Industrial

YELLOWSTONE RIVER

Each of the following water reservation requests could have an adverse effect on water available from the Yellowstone River to the applicants whose applications are held pending by the Yellowstone Moratorium.

Fish and Game Commission
Department of Health and Environmental Sciences

These two requests would preclude any new continuous diversion for appropriators needing a firm supply of water. The offstream water storage options in the applications, however, might be little affected, depending on the quantity of water required from offstream sites.

TONGUE RIVER

Each of the following water reservation applicants listed below could adversely affect the appropriators in the Tongue River.

Rosebud Conservation District
North Custer Conservation District
Department of Natural Resources and Conservation (DNRC)
Fish and Game Commission

These four requests could preclude any new continuous diversion for appropriators needing a firm supply of water. The offstream water storage options in these appropriations, however, might be little affected except by the DNRC request which would store large spring flows in a mainstem reservoir. However, a major proposed use of water listed in the DNRC request is industrial, implying that those demands might be met even if the water permit applicants were not successful.

POWDER RIVER

Each of the water reservation requests listed below could adversely affect water availability for the appropriators in the Powder River.

Powder River Conservation District
North Custer Conservation District
Fish and Game Commission
Department of Natural Resources and Conservation (DNRC)

These four requests could preclude any new continuous diversion for appropriators needing a firm water supply. The offstream storage options, however, might be little affected depending on the amount of water required from the reservoir. Implementation of the DNRC application would totally curtail Intake Water Company's application, since mutually exclusive storage sites are involved. However, a major proposed use of water listed in both the DNRC and Intake applications is for industrial use, implying that ,regardless of which appropriations were successful ,that demand might be satisfied.

Even if all of the industrial water right applications were negated by water reservations, it might still be possible for energy conversion to occur in Montana. Air cooling is an option for conversion plants that requires very little water (see page 304). Energy-industrial companies could build aqueducts transferring water from large reservoirs to the place of use (see page 305). Deep aquifer resources represent a potentially large source of water that may be within the economic limitations of energy-industrial companies (see page 304). However, each of these options are possibly more expensive than direct and continuous diversions from a surface water source. If large water reservations in the Yellowstone River Basin were approved, energy-industrial companies may have to resort to more expensive water supply alternatives or locate outside the basin. However, in their water permit applications, industrial interests have included plans for development that demonstrate their willingness to invest heavily in water storage, diversion, and conveyance facilities. Because water costs are normally such a small percentage of total coal mining and conversion costs, costs of alternative water sources will probably not significantly alter plant siting.

SEQUENCE OF WATER RESERVATION ADOPTION

The sequence in which the Board approves water reservations (if any) is extremely important. If surplus water is totally allocated through water reservations, on an average or low flow basis, then the first reservation adopted may have a firm water supply, while the subsequent ones approved may not. This would occur because the first one approved would have a senior priority date. This is particularly critical in conflicts between consumptive and instream users. If instream reservations have an earlier priority, then consumptive users will bear shortages in low flow periods, and vice versa. Alternatively, if both are approved at the same time and have the same priority, then consumptive and instream users will share shortages in times of low streamflow.

CLAIMS OF DOWNSTREAM USERS

Water users in downstream states and the Federal government undoubtedly will claim water rights to some part of the flow of the Yellowstone River across the Montana-North Dakota border, should reservations be approved that ultimately may consume most of the now unappropriated waters of the Yellowstone. Although the quantity of those rights is presently unknown, they do exist. Therefore, it is probably not possible in a legal sense to approve reservations which will drastically deplete the Yellowstone.

Approval of instream uses, such as the applications by the Departments of Fish and Game and Health and Environmental Sciences, obviously would not create a downstream right problem, since the water would not be consumed. However, more downstream water rights could be perfected in the future which depend on a minimum instream flow from the Yellowstone, and therefore possibly depend on the instream reservations in Montana. This could have the effect in the future of precluding Montana from later diverting the water reserved for instream uses. On the other hand, approval of instream reservations may also have the effect of prohibiting the diversion of Yellowstone water from Montana to points outside Montana since an instream reservation is a water right in Montana like all other water rights. This effect will of course depend on the amount of the instream reservation and the proposed out-of-state diversion.

It should be noted that under 33 U.S.C.A. Sec.710-1(b), part of the Federal Flood Control Act of 1944, the use for navigation of waters arising in states lying wholly or partly west of the ninety-eighth meridian by the U.S. Army Corps of Engineers in connection with the operation and maintenance of Federal flood control projects "shall be only such use as does not conflict with any beneficial consumptive uses, present or future, in states lying wholly or partly west of the ninety-eighth meridian, of such waters for domestic, municipal, stock water, irrigation, mining, or industrial purposes." (Emphasis added.) This provision, known as the O'Mahoney-Miliken Amendment, appears to allow future consumptive uses of water in those states west of the ninety-eighth meridian (which includes Montana), even though those uses may interfere with navigation.

EFFECTS OF WATER RESERVATIONS ON EXISTING RIGHTS

As is true with all water rights, water reservations cannot adversely affect senior water rights; that is, water rights existing at the time of Board approval of the water reservations. Several of the water reservations, if implemented as indicated in the application, might adversely affect existing rights. Implementation of conservation district applications in the Shields River and Sweet Grass Creek, for example, would have to be carefully monitored to ensure senior rights were protected. Adjudication of these streams, under the 1973 Water Use Act, would have to be completed, and water masters employed before complete protection of those rights could be assured.

One purpose of the water reservation hearings to be held under the Water Use Act is to receive information regarding the effect of water reservations on existing water rights. However, it is beyond the scope of this EIS to examine those effects in detail.

PART VI

RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

CONTENTS

In this section, the short-term costs and benefits of the proposals are compared to long-term effects on maintenance and enhancement of environmental productivity. Only generalized effects are considered; more detailed discussion of the implications can be found in the sections dealing with individual applications and possible alternative actions.

AGRICULTURAL PRODUCTIVITY

The granting of instream flow requests could severely limit full service irrigation expansion. The denial of all reservation requests would allow continued increases in irrigation under water use permits; however, other users may move first to secure the use of unappropriated waters by permit. This is particularly true in basins where water shortages are apparent, where coal reserves are located, and/or where expensive storage facilities will be needed.

The highest benefit to agricultural productivity and food production would result from granting the requests of conservation districts, irrigation districts, and the Montana Department of State Lands, which have applied for the reservation of water to irrigate nearly 360,000 acres of presently non-irrigated lands. Although other users could obtain the use of reserved water through temporary permits, the approval of such reservations would ensure that enough water is available to allow the greatest possible eventual increase in irrigation.

Local economies have traditionally relied upon agriculture, and the lifestyles of area residents are well-adapted to an agricultural society. Therefore, an increase in irrigation activity would benefit the economy while posing little or no social disruption to local citizens. Renewable resources including water and soil would be utilized.

Costs would be involved in providing water for irrigation, including investments in storage facilities and water delivery systems. Energy requirements and transmission costs would be incurred, and labor costs would be increased. However, individual irrigation projects would be undertaken only if the benefits to the investors exceed the costs.

Significant irrigation expansion in the Tongue and Powder river subbasins would require the cost of providing additional, major water storage facilities on these rivers. These structures would be too expensive to justify for irrigation purposes alone.

Other economic opportunity costs would be incurred through the reluctance of other possible water users to invest in facilities dependent upon temporary use of water reserved for another purpose.

WATER FOR MUNICIPAL USE

Communities with reserved water gain the benefit of securing a future water supply. A municipal water reservation could reduce the future cost of obtaining water, particularly if possible alternative sources (such as ground water) are expensive to develop and/or treat. The establishment of a water reservation might be a minor factor in encouraging the location of businesses or industries within a city or town served by an adequate water supply. Conversely, water availability or quality problems may limit or impede community growth.

WATER FOR ENERGY

If a water reservation is made for multiple purposes including industrial use, or if all reservations are denied, then water will be more readily available for energy development.

Energy conversion plants require large quantities of water, particularly if they do not utilize the more expensive dry cooling systems. In certain subbasins, notably the Powder and Tongue rivers, insufficient water is available to provide for both energy development and a high level of irrigation development. Energy development would contribute economic and employment benefits to the areas involved and would require the utilization of coal, a non-renewable resource.

Energy development would have an enormous impact on social and cultural systems, especially if conversion plants are constructed, as sparsely populated, agrarian areas become transformed into populated, industrial centers. Negative impacts to the natural environment, some of which may be extensive and long-term, would also result.

ENVIRONMENTAL QUALITY

Water remaining in the stream provides a public benefit by providing natural flow regimes to maintain amenity values like ecosystem productivity, water quality, wildlife habitat, and recreation.

Water in the basin also provides an economic benefit to individuals wishing to divert and privately use it in a beneficial manner.

In seeking individual benefits, people tend to be less concerned with public benefits, the loss of which affects them less directly. Consequently, the public aspect of the resource is often ignored, overused,or degraded.

The public benefits provided by the waters of the Yellowstone Basin could become incrementally diminished by numerous individual appropriations unless dewatering is prevented. Instream flow reservations provide at present the only mechanism for preventing this dewatering problem. The difficulty in the case of instream flows is trying to determine the optimal quantity of water to leave in the river, i.e., the marginal amount at which the public benefit begins to outweigh the private gain. Because environmental conditions are influenced by thresholds or limits, the public value of diminishing amounts of water for instream uses increases rapidly as limits are approached. If natural instream flows are allowed to diminish to these limits, environmental productivity will decrease as water quality lessens, habitat is lost, biological diversity diminishes, water temperatures increase, and natural flow regimes are altered.

PART VII

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

CONTENTS

This section discusses water, land, air, energy, and other resources which could be irreversibly or irretrievably committed by proposed water reservations. Water reservation decisions may be a significant factor in shaping the future economic and environmental character of the Yellowstone Basin. Major activities in irrigation or energy development depend, at least partially, on the outcome of these decisions. Once these activities are in motion, they are unlikely to be reversed in the near future; consequently, they direct commitment of several resources.

WATER

Water is a renewable resource providing continuous benefits to society. Unappropriated surface water is the primary environmental resource being committed at this time.

Water reservations would be reviewed periodically and could be modified or revoked if the purpose of the reservation is not being met. Consequently, water allocation patterns may be changed over time to meet changing needs. Furthermore, the irrigation, municipal, and multiple use reservations are based on future plans or expectations for water use that may not come about or may change in the future. Therefore, water reservation decisions cannot be considered absolutely irreversible or irretrievable.

Instream reservation applications, however, are intended to provide minimum flows for the protection of existing rights and aquatic life. Such reservations are less likely to be altered; therefore, commitments of unappropriated waters to instream uses may be less reversible and retrievable.

LAND

Water reserved for municipal purposes will probably not perceptibly promote industrial or suburban land uses around the applicant municipalities. However, the other types of reservation requests could substantially influence the irreversible commitment of the land resource. Water reserved for irrigation, for instance, may help provide for the conversion of rangeland and dry cropland to irrigated cropland; water reserved for multiple uses, including energy, might be a factor in the conversion of agricultural land to such uses as mines, plant sites, roads, pipelines, and urban development.

Conversely, the greater the quantity of water that is reserved for instream flows, the smaller the amount of land that can receive irrigation water. Similarly, the reservation of water for instream flows may inhibit energy-related land use changes, unless alternative sources of water are developed or water-conservative technologies utilized.

Any water storage reservoirs would flood certain lands, thereby precluding other surface use options and possibly irreversibly committing mineral resources such as coal.

AIR

Air quality could be temporarily degraded during the construction of irrigation facilities and more severely affected through the operation of energy or industrial plants over the lives of the facilities. However, such commitments are not irreversible.

ENERGY AND MATERIALS

An irretrievable commitment of energy and materials could indirectly result from the granting of applications for other than instream flow purposes, or from the denying of reservation requests.

Energy and materials are required in the construction of either irrigation or energy facilities. For instance, irrigation requires some pumping of irrigation water, and it has been estimated that implementing the current applications would involve the subsequent total consumption of about 150 megawatts of electrical energy for that purpose. Water for energy may help commit Montana's coal reserve to development, an irreversible commitment of a non-renewable resource. The instream flow applications would reduce the quantity of water readily available for energy development, perhaps slowing the rate of energy development while extending the duration of use of the basin's coal reserves.

AQUATIC COMMUNITIES

The aquatic communities are provided the greatest protection under the instream flow applications. Implementing other reservation requests would reduce the instream flow, diminishing the productivity of aquatic communities.

OTHER

Wildlife, recreation, aesthetics, and water quality are all attributes of the present river system that are given the most protection under the instream flow alternative and would be diminished to varying degrees if adequate instream flows are not provided. An approval of instream flow reservations would be a commitment to all of these resource values.

PART VIII

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In addition, substantial contributions to impact statement preparation were made by many cartographers and typists.

GLOSSARY

GLOSSARY

Acre-foot (af) - a unit commonly used for measuring a volume of water; the volume required to cover 1 acre to the depth of 1 foot, and equal to 43,560 cubic feet or 325,851 gallons.

Active storage - the volume of water that can be stored in a reservoir between the maximum pool elevations and the level of the lowest outlet structure.

Algae - primitive plants, usually one-celled and often aquatic.

Alluvial terrace - flat, generally horizontal, land surface composed of recent, water deposited, unconsolidated sediments.

Alluvium - soil material, such as sand, silt, or clay, that has been deposited by water.

Alpine - referring to the biogeographic zone above timberline.

Ambient air quality - surrounding air quality.

Anticline - a configuration of folded, stratified rocks which dip in two directions from a crest.

Aquifer - a permeable material through which water moves.

Arable land - land suitable for the production of crops.

Artesian water - ground water under sufficient pressure to rise above the water-bearing formation.

Average annual flow - the mean volume of water passing a given point during a one year period.

Bedload - sediments that move along a stream bed.

Benthic - referring to the bottom of streams or lakes.

Bentonite - a clay mineral formed from decomposition of volcanic ash, with great ability to absorb water with consequent swelling.

Biochemical oxygen demand (BOD) - the quantity of oxygen utilized in the biochemical oxidation of organic matter in a specified time and at a specified temperature.

Biomass - mass of life forms, often applied to one or more species in a particular area.

Biotic - relating to life.

Blue Ribbon Trout Stream - as defined by the Montana Department of Fish and Game, trout streams that have national significance.

Braided - in reference to streams, having diverging and converging channels separated by islands and bars.

Calibration - in reference to the State Water Planning Model, adjusting so that the characteristics and behavior of the actual basin or subbasin may be reproduced.

Clay - rock or mineral particles with a volume less than an equivalent sphere with a diameter of 0.004 mm.

Clay-loam soil - a fine to moderately fine textured soil.

Climax state - for an ecosystem, the condition of being capable of perpetuation under the prevailing climatic and soil conditions.

Cobbles - rocks, approximately ¼ - 1 inch in diameter.

Coliform - bacteria found in human and animal feces, indicative of organic pollution.

Consolidated sediment - a well-cemented sediment.

Cosmopolitan organisms - an organism distributed widely throughout the world.

Cubic feet per second - a rate of discharge (flow). One cubic foot per second is equal to the discharge of a stream having a cross section area of 1 square foot and flowing at an average velocity of 1 foot per second.

Deciduous - having leaves which are lost seasonally.

Depleted flow - natural flow adjusted to account for consumptive use.

Diatoms - algae with walls of silicates.

Dissolved oxygen - molecular oxygen in solution.

Dome - anticlinal fold which dips in all directions from a central area.

Dominant - referring to species, the the one having the most influence in an ecosystem.

Dominant discharge - the flood flow, occurring on the average about two out of three years, which transports the most sediment.

Duration curve - a curve that shows the percentage of time that specified discharges, lasting for a certain length of time, are equalled or exceeded.

Ecosystem - a life community and its physical environment.

Eightieth (80th) percentile low flow - that low flow which is equalled or exceeded in 8 of every 10 years, on the average.

Electrofishing - catching of fish by stunning them with electrical current.

Escarpment - a long inland cliff or steep slope, formed by erosion or faulting.

Eutrophic - rich in nutrients.

Fold - a bend in rock strata.

Formation - a rock body, useful for mapping or description.

Fry - referring to a period in a fish's life immediately after hatching.

Furbearers - mammals trapped for their fur, e.g. beaver, muskrat.

Gasification - conversion of coal to substitute natural gas.

Genus - a group of related species.

Geomorphology - the study of the land forms of the earth.

Habitat - the sum total of environmental conditions of a specific place occupied by an organism, population, or community.

Hybrid - cross between parents of different taxa or genotypes.

Hydrograph - a graph showing, for a given point on a stream, the discharge, stage, velocity, or other property with respect to time.

Hydrostatic bond - the molecular bond between water and soil particles.

Igneous rocks - rocks that have solidified from the molten state, e.g. granite, basalt, lava.

Intermittent stream - a stream course that carries water only part of the time.

Intrusion - a body of igneous rock that invades older rock.

Invertebrates - animals without backbones, e.g. clams, snails, shrimp, insects.

Isohyet - a line on a map connecting points of equal rainfall.

Lignite - low grade coal, common in eastern Montana and western North Dakota; typical heat value is on the order of 6000 Btu per pound, compared with 9000 Btu per pound for the sub-bituminous coals.

Molt - shedding of hair, feathers, or outer skin.

Morphology - a study of form and structure.

Ninetieth (90th) percentile low flow - that low flow which is equalled or exceeded 90% of the time.

Non-Consumptive Use - use which does not require the removal of water from the source of supply; examples would be fish and wildlife and recreation.

Non-point pollution - pollution from a widespread area, as opposed to pollution that occurs from an identifiable site.

Orographic precipitation - precipitation caused by the uplift of air masses over mountains.

Outcrop - an exposure of bedrock or strata through the soil.

Payment capacity - the money available to a water user from crops and livestock income for payment of all irrigation costs after other obligations have been deducted.

Per capita income - total personal income divided by total population.

pH - the negative logarithm of the hydrogen ion activity (or concentration); a measurement that reflects the balance between acids and alkalines (bases).

Physiography - the study of the origin and evolution of land forms.

Plankton - free-floating aquatic, generally microscopic, life forms.

Pleistocene ice age - a time span when much of the Northern hemisphere was covered by ice, some 25,000 - 1,000,000 years ago.

Present value - the present value of an investment is the discounted sum of the net benefits (total benefits minus total costs) for each year the investment produces benefits or costs. Net benefits are discounted by an interest rate because an alternative investment would at least have the interest rate.

Quaternary - a recent geologic time span, approximately the last 1,000,000 years.

Recruitment - additions of individuals to a population.

Regression analysis - a statistical method of predicting the value of dependent variables from given values of independent variables.

Riffle - a shallow rapid in a stream.

Riparian - pertaining to the banks of streams or lakes.

Riprap - material placed on a stream bank and bed for protection from stream or wave action; can consist of broken rock or other materials such as car bodies or trees.

Salmonid - a member of the salmon family, e.g. whitefish, trout.

Savannah - an area of widely spaced trees with a dense lower layer of herbs.

Sedimentary rocks - rocks, usually layered, laid down by water or air processes, e.g. limestone, sandstone.

Sessile - attached, not free to move about.

Silt - rock or mineral particles, 0.002 - 0.02 mm in diameter.

Simulation - in modeling, reproduction of the behavior of a real or hypothetical prototype.

Spawning - laying of eggs; especially applied to aquatic animals such as fish.

Specific conductivity - a measure of the electrical current which will flow through water, indicative of the concentration of dissolved ions.

Standard deviation - a measurement showing the differences of values from the arithmetic average.

Stratigraphy - the study of layered rocks, or the sequence of rock layers.

Structural basin - an elliptical or roughly circular structure in which rock strata are inclined downward to a point.

Substrata - foundation; base on which an organism growns.

Syncline - downfolding of rock layers toward a trough.

Temperature inversion - a situation where air aloft is warmer than air near the surface.

Total suspended particulates (TSP) - the mass of particles in air that can be removed by filtration.

Turbidity - a measure of the scattering of light by suspended particles

Unconsolidated sediment - uncemented sediment, e.g. loose sand.

ABBREVIATIONS AND ACRONYMS

ACRONYMS AND ABBREVIATIONS

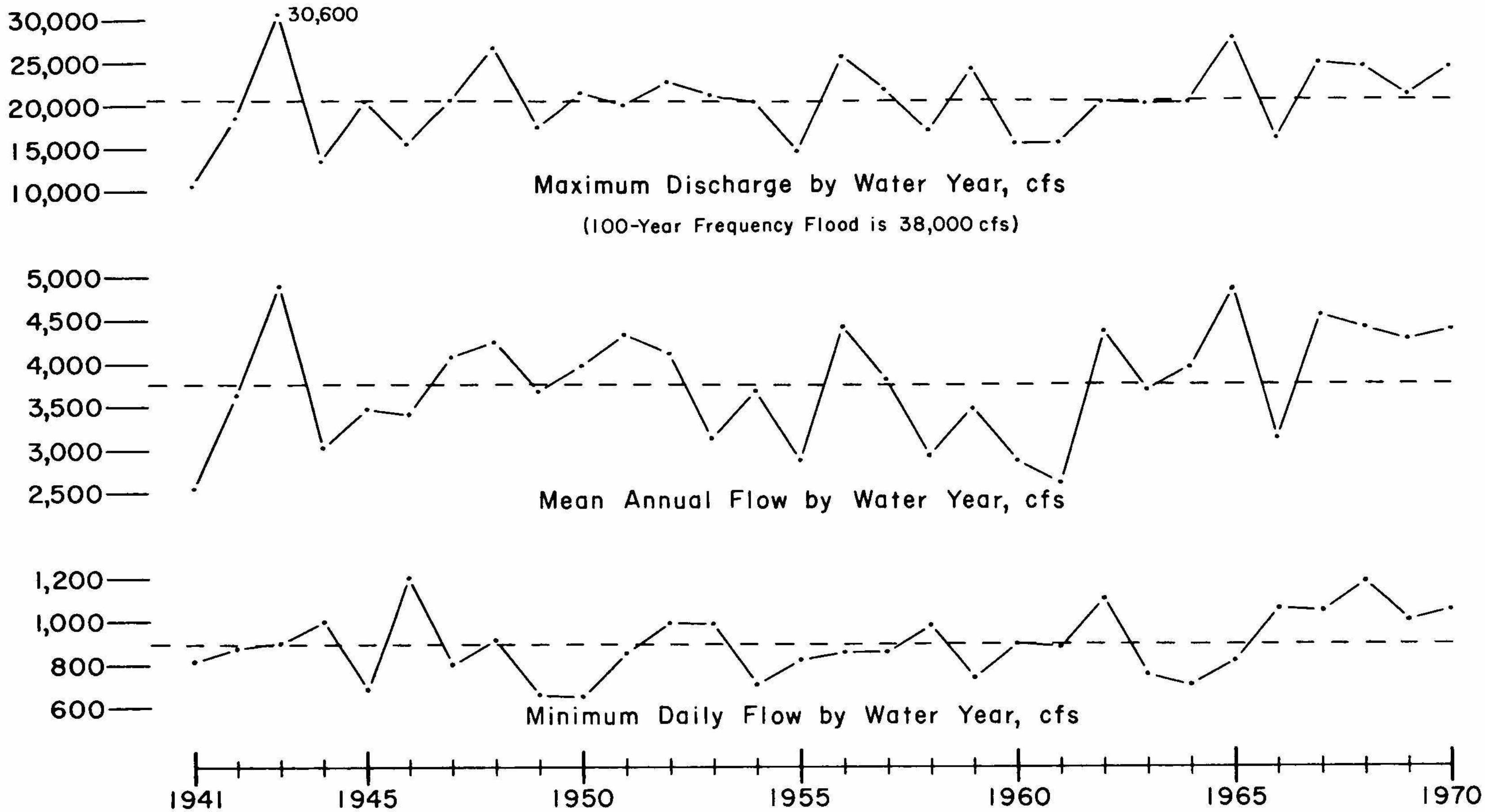
af	acre-feet
Board	Board of Natural Resources and Conservation
BOD	bio-chemical oxygen demand
BCE	before current era
C	Centigrade
CD	conservation district
cfs	cubic feet per second
cm	centimeter
CO	carbon monoxide
DHES	Montana Department of Health and Environmental Sciences
DNRC	Montana Department of Natural Resources and Conservation
DO	dissolved oxygen
EIS	environmental impact statement
F	Fahrenheit
FG	Montana Department of Fish and Game
gpm	gallons per minute
HC	total hydrocarbons
JTU	Jackson turbidity units
MEPA	Montana Environmental Policy Act
mgd	million gallons per day
mg/1	milligrams per liter
ug/m^3	micrograms per cubic meter
mmaf	million acre feet
mmaf/y	million acre feet per year
mw	megawatt
NGPRP	Northern Great Plains Resource Program

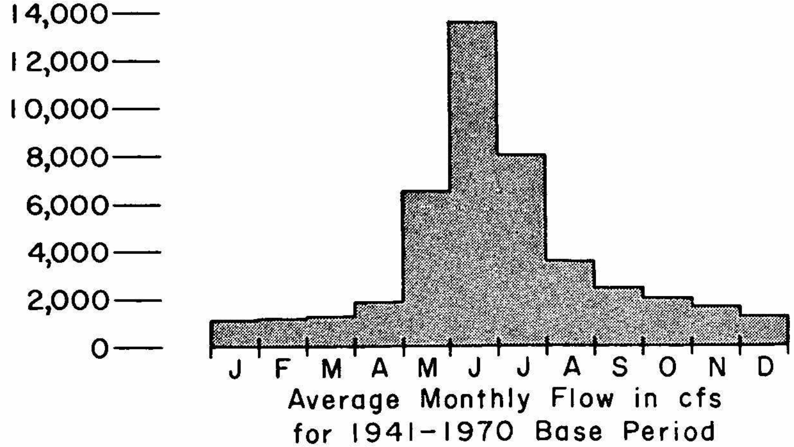
NO_x	oxides of nitrogen
SMSA	Standard Metropolitan Statistical Area
TDS	total dissolved solids
TF	total fluorides
TSP	total suspended particulates
TSS	total suspended solids
USGS	United States Geological Service

APPENDIX

CONTENTS

WATER SUPPLY DATA





YELLOWSTONE RIVER NEAR LIVINGSTON

YELLOWSTONE RIVER BASIN

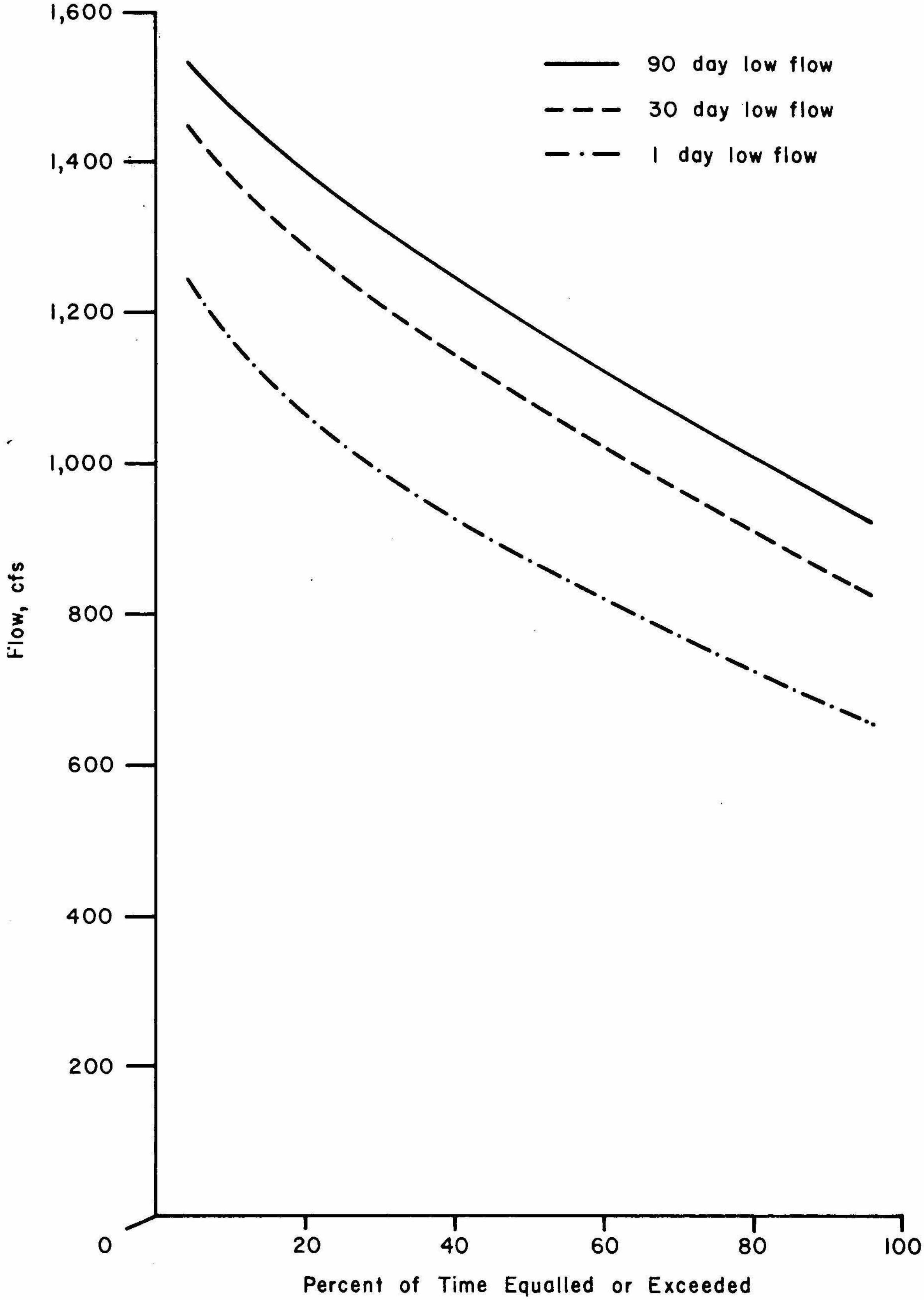
U.S.G.S. Station No. 06192500

Drainage Area 3551 sq. mi.

Period of Record 1897-1905; 1928-1932

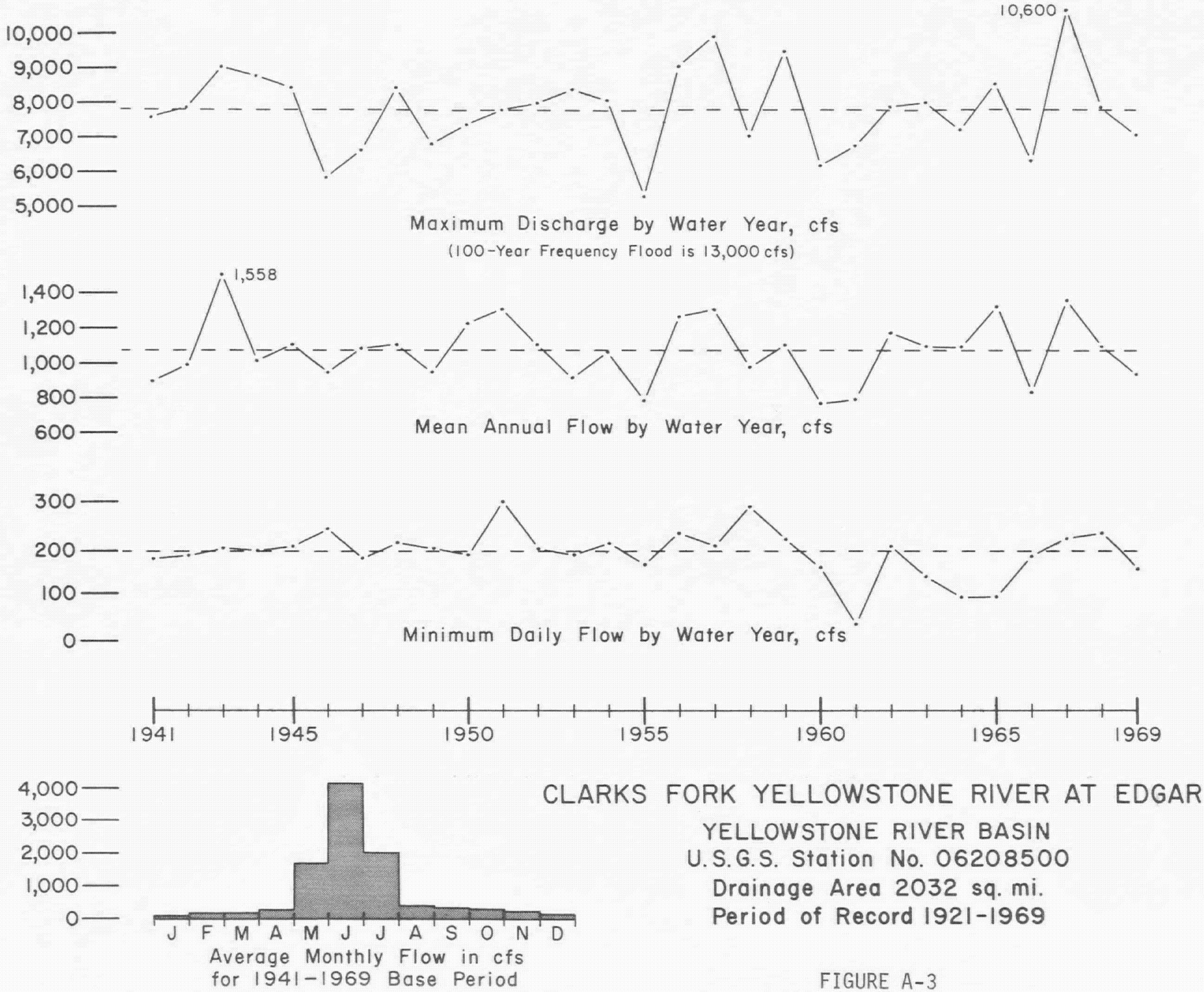
1937-1970

FIGURE A-1



LOW-FLOW DURATION CURVES
YELLOWSTONE RIVER NEAR LIVINGSTON
Period of Record 1897—1973

FIGURE A-2



CLARKS FORK YELLOWSTONE RIVER AT EDGAR

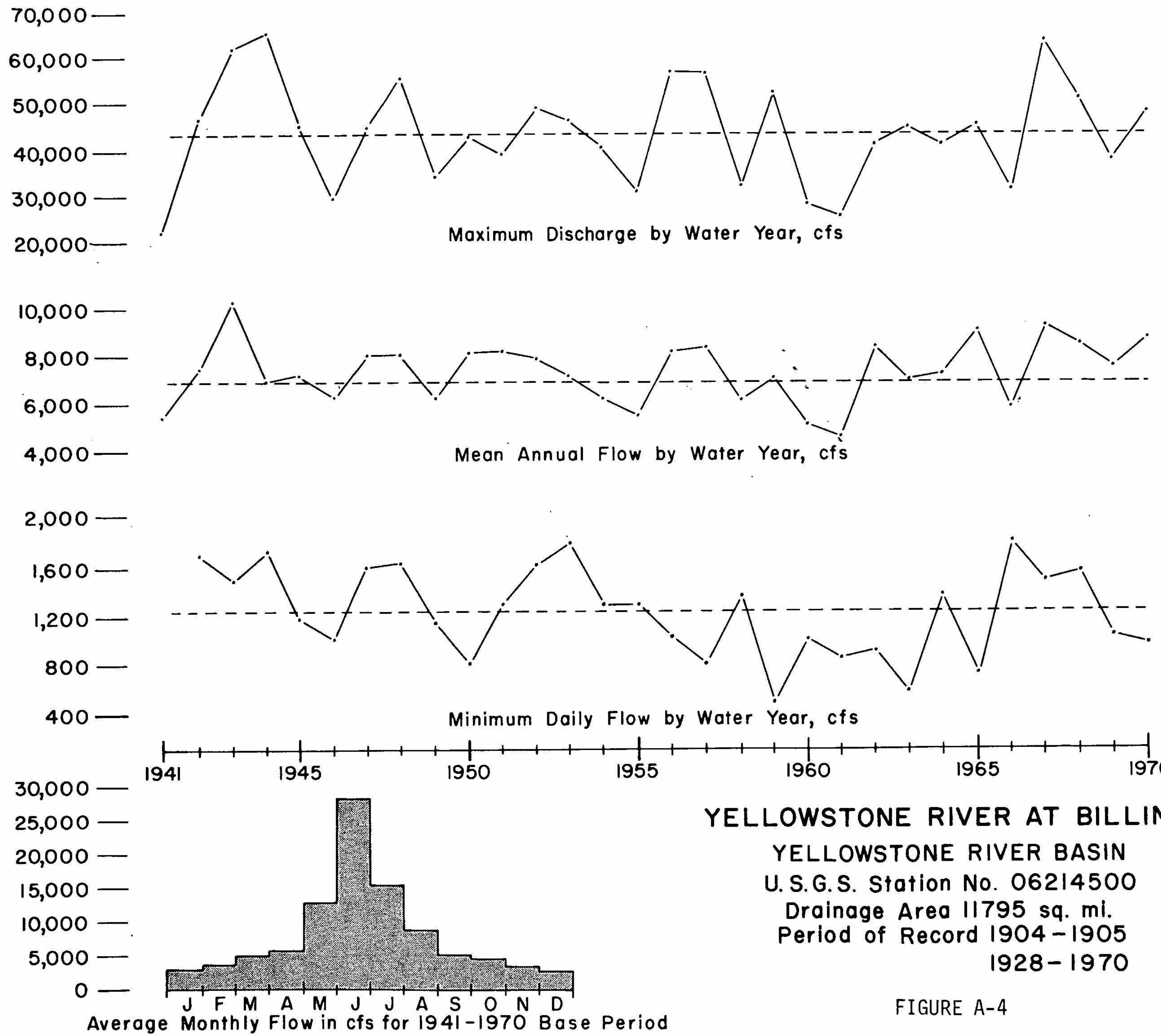
YELLOWSTONE RIVER BASIN

U.S.G.S. Station No. 06208500

Drainage Area 2032 sq. mi.

Period of Record 1921-1969

FIGURE A-3



YELLOWSTONE RIVER AT BILLINGS

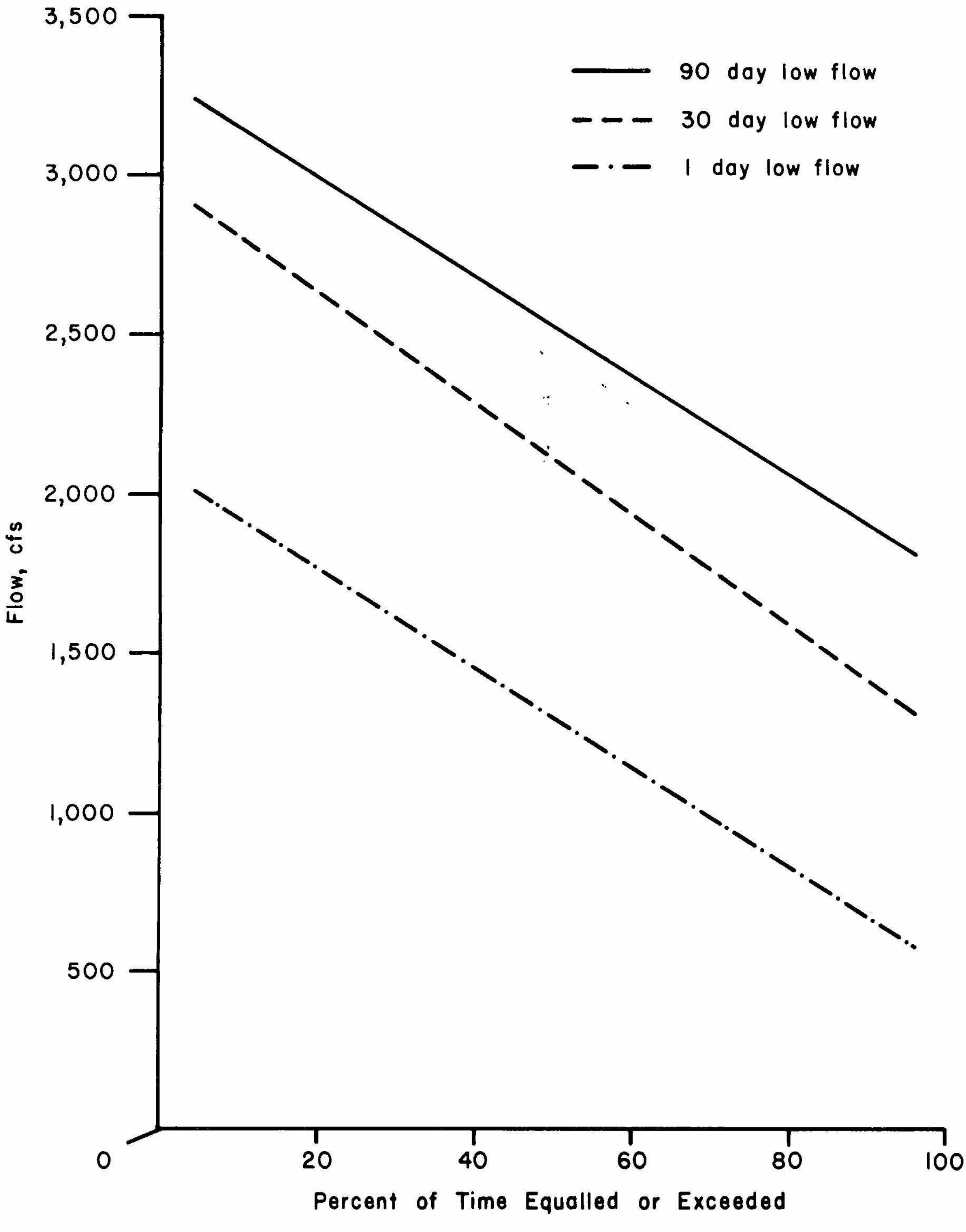
YELLOWSTONE RIVER BASIN

U.S.G.S. Station No. 06214500

Drainage Area 11795 sq. mi.

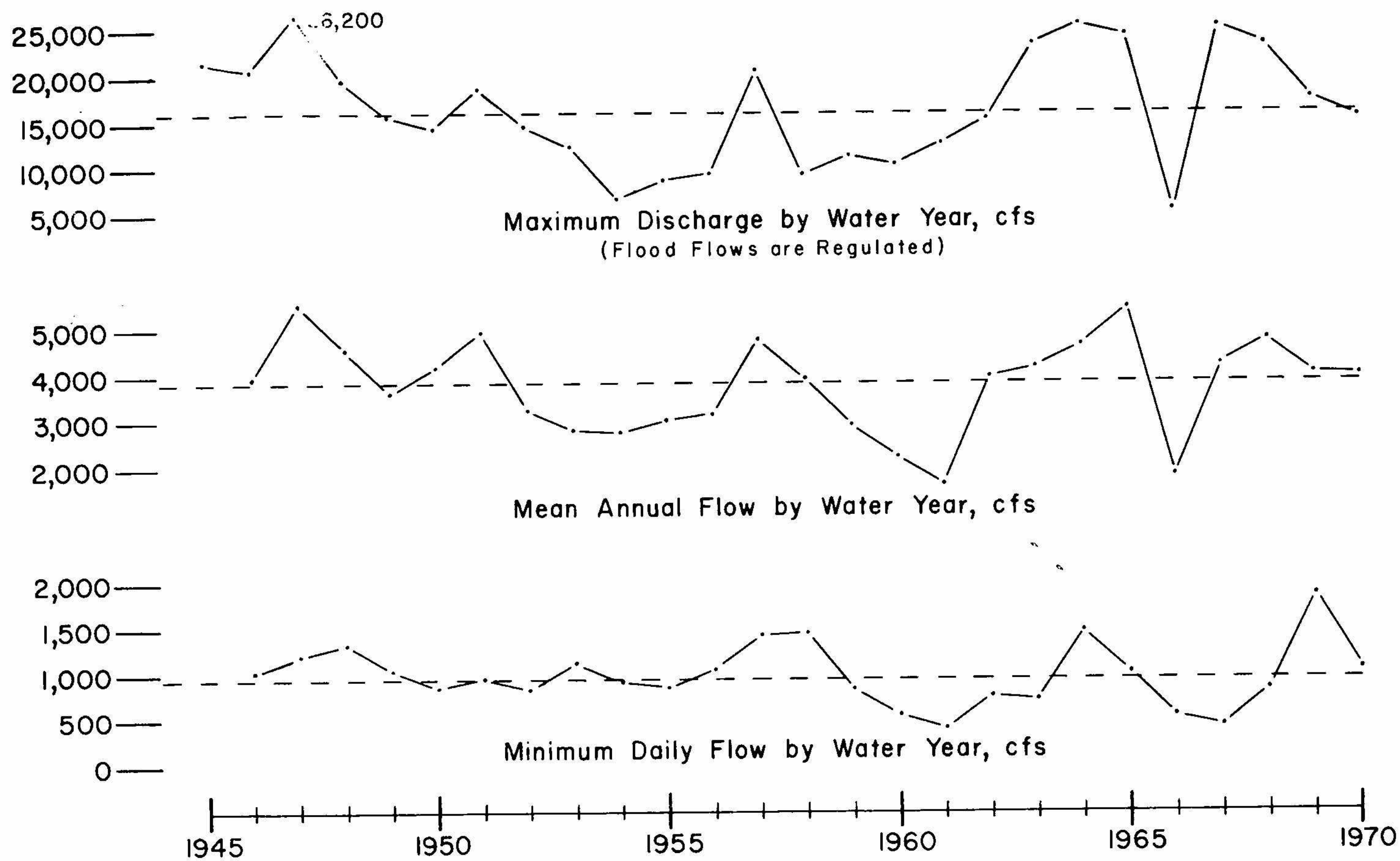
Period of Record 1904-1905
1928-1970

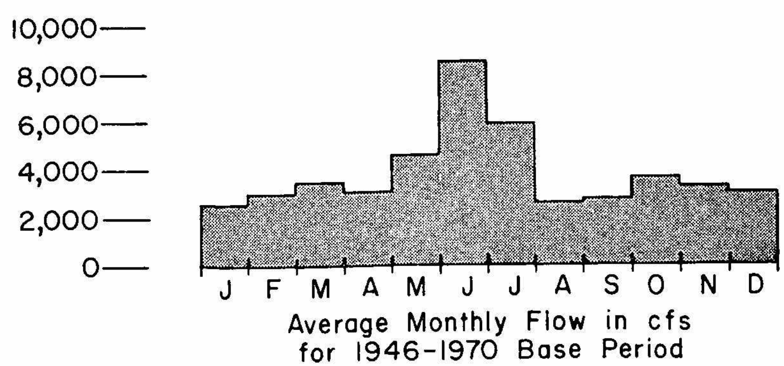
FIGURE A-4



LOW-FLOW DURATION CURVES
YELLOWSTONE RIVER AT BILLINGS
Period of Record 1930-1973

FIGURE A-5

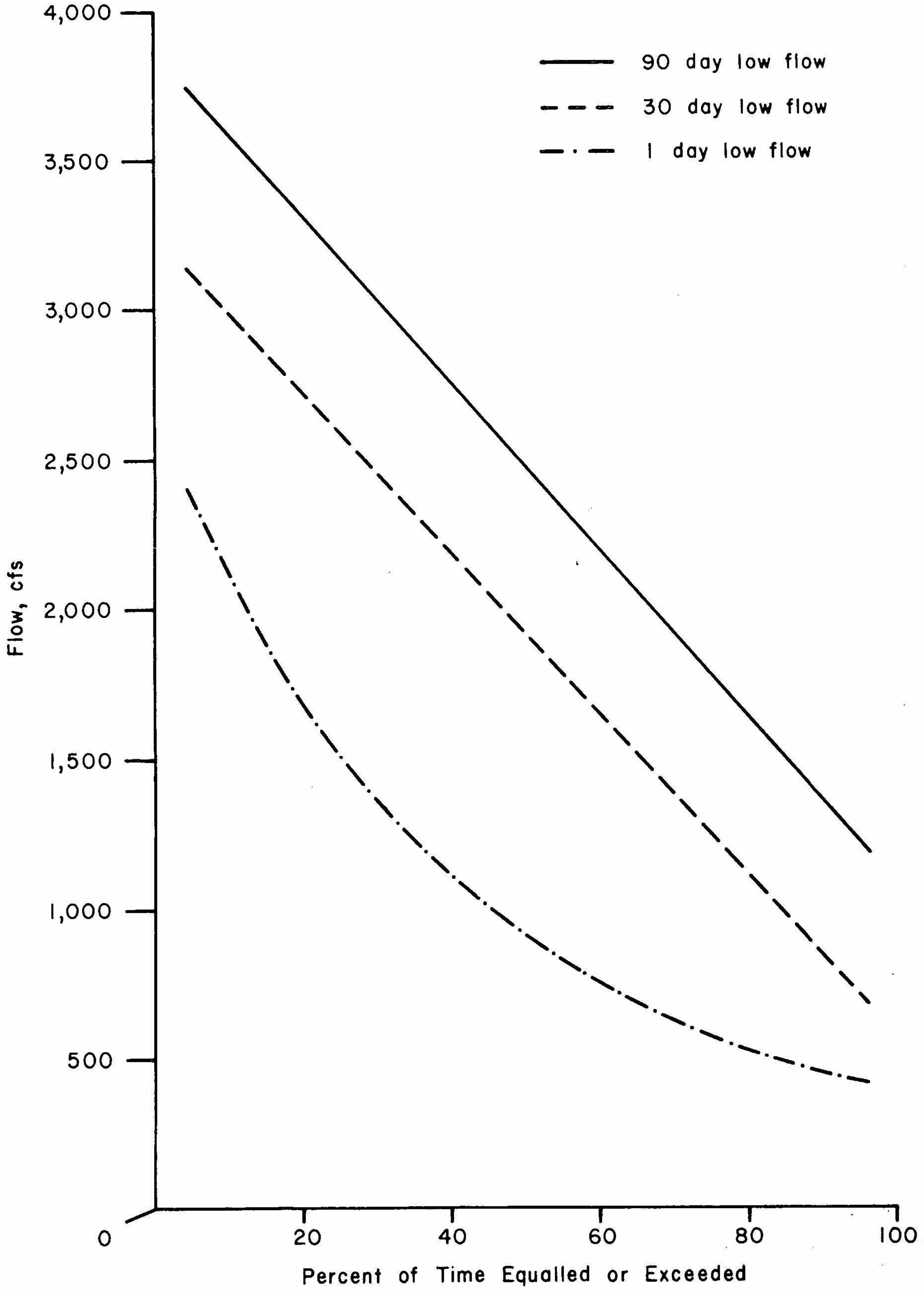




BIGHORN RIVER AT BIGHORN

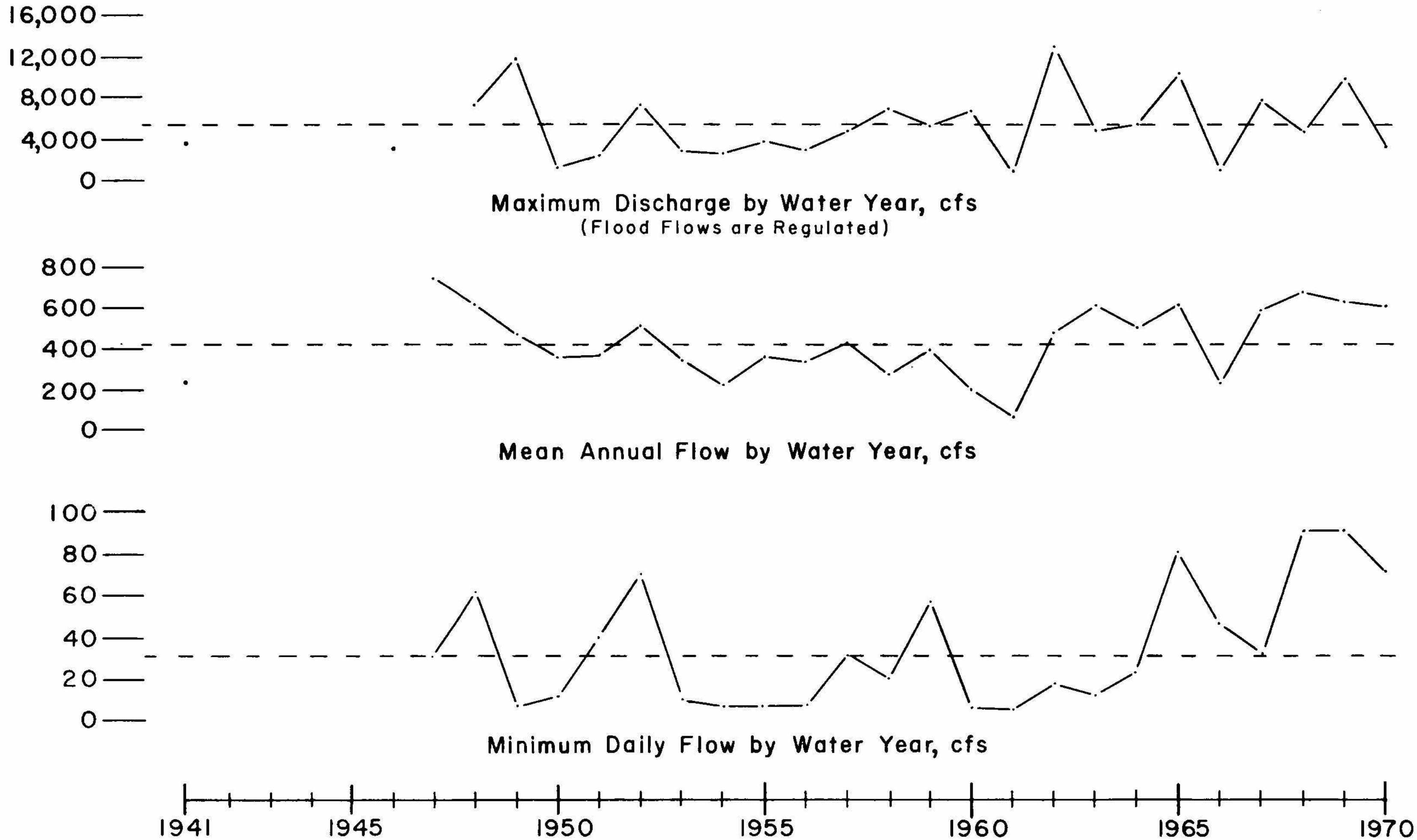
YELLOWSTONE RIVER BASIN
U. S. G. S. Station No. 06294700
Drainage Area 22885 sq. mi.
Period of Record 1945—1970

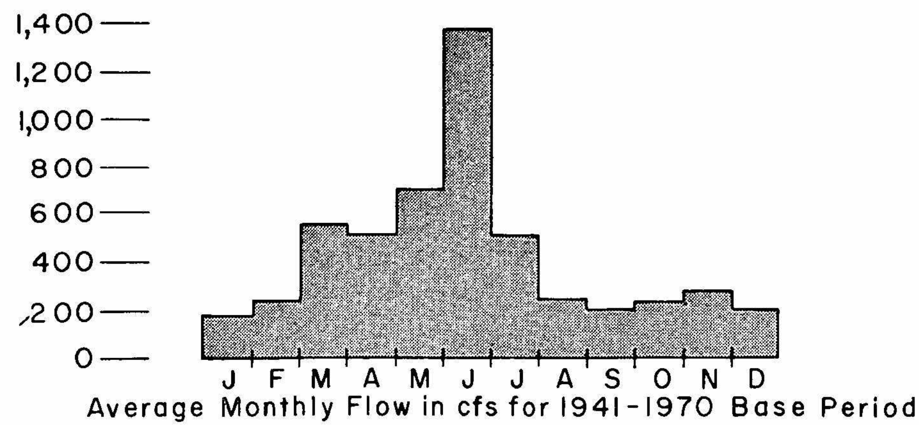
FIGURE A-6



LOW-FLOW DURATION CURVES
BIGHORN RIVER AT BIGHORN
Period of Record 1962-1973
(Post Yellowtail Reservoir Construction)

FIGURE A-7

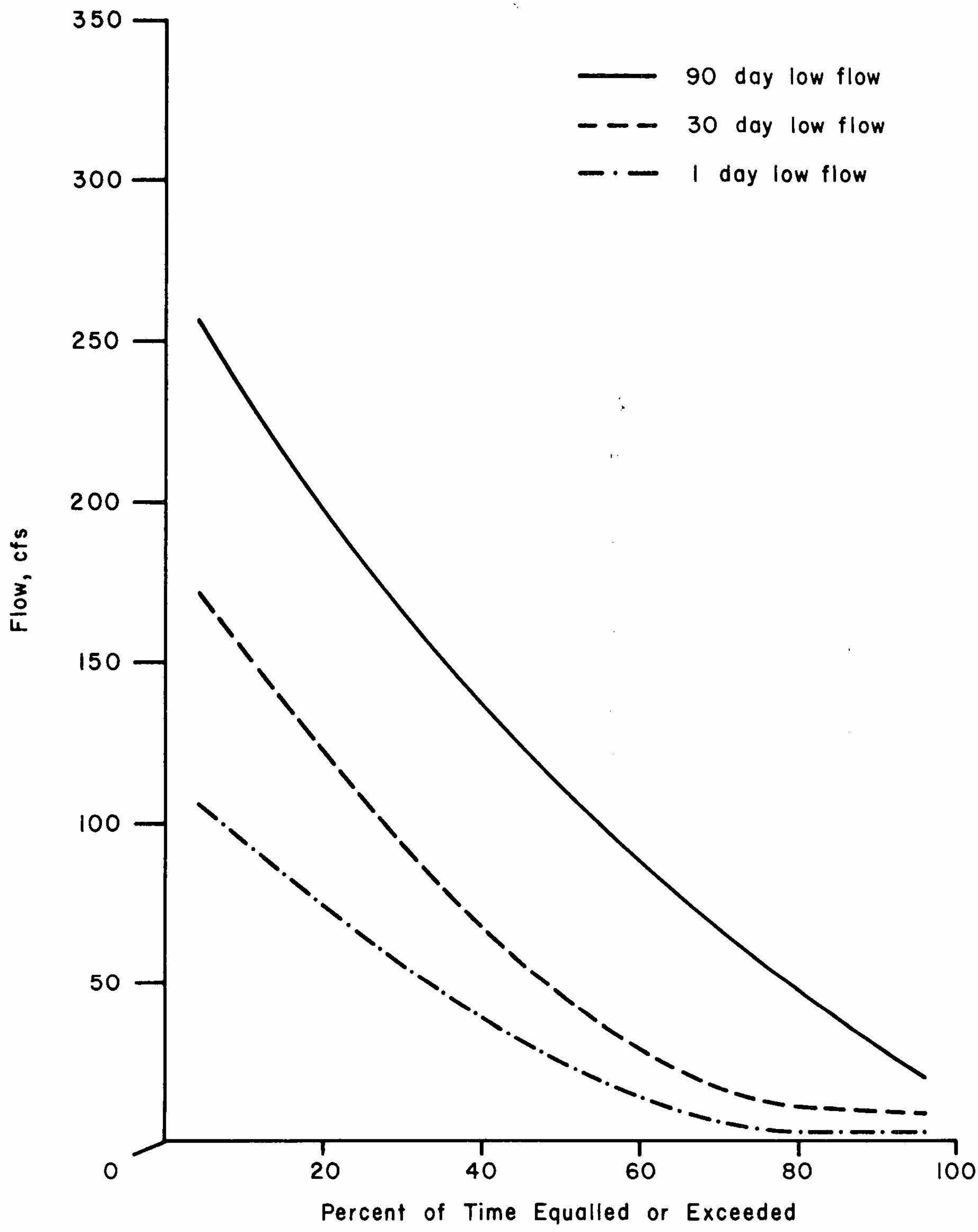




TONGUE RIVER AT MILES CITY

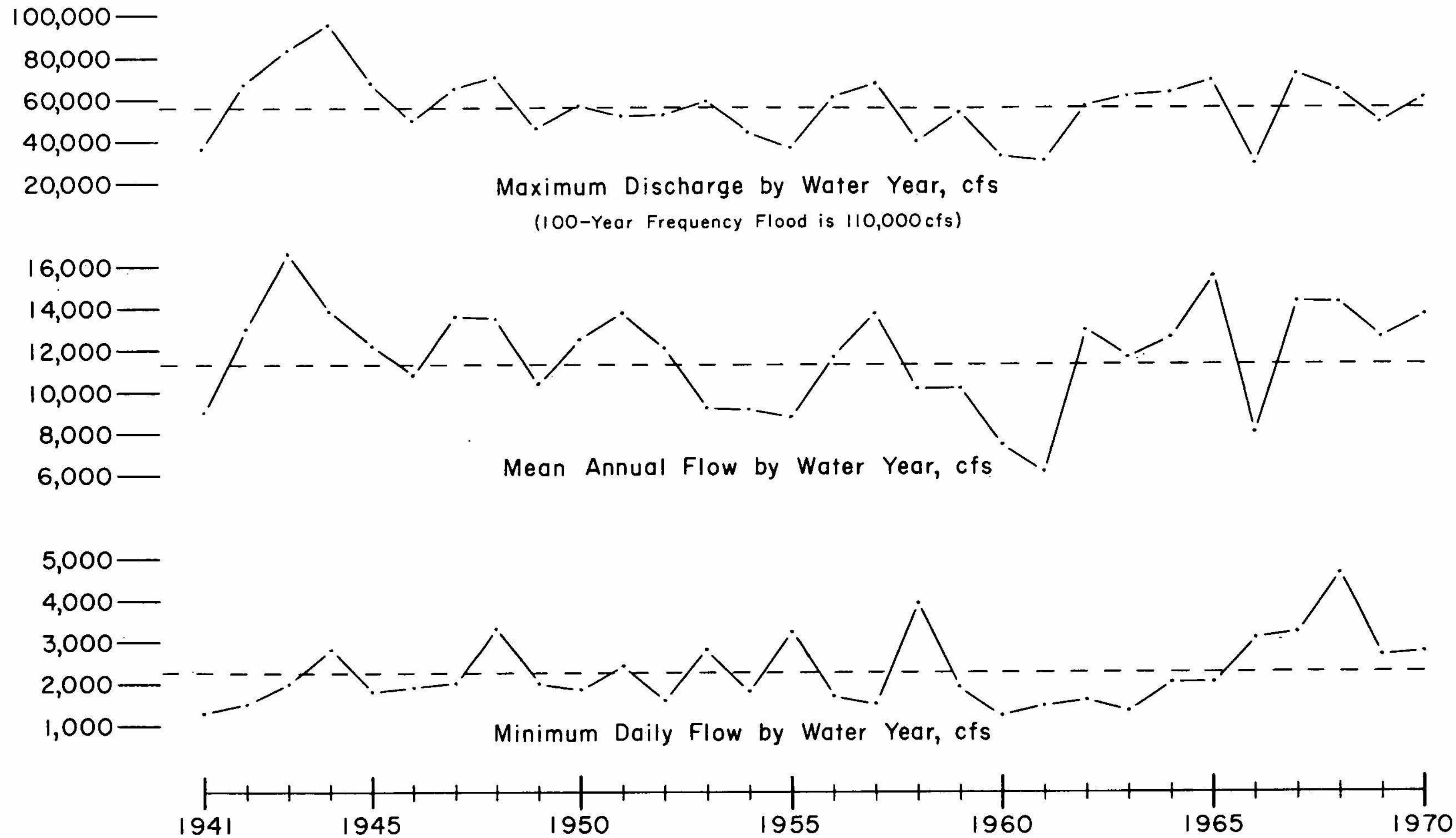
YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06308500
Drainage Area 5,379 sq.mi.
Period of Record 1938-1942
1946-1970

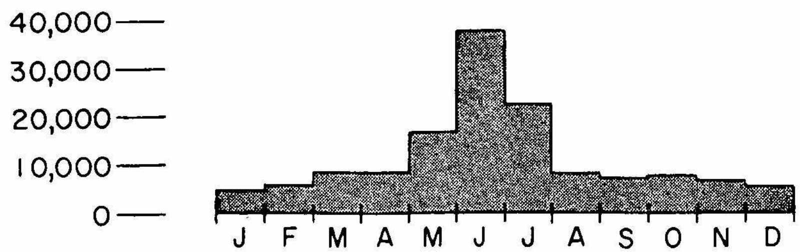
FIGURE A-8



LOW-FLOW DURATION CURVES
TONGUE RIVER AT MILES CITY
Period of Record 1939-1973

FIGURE A-9





Average Monthly Flow in cfs
for 1941-1970 Base Period

YELLOWSTONE RIVER AT MILES CITY

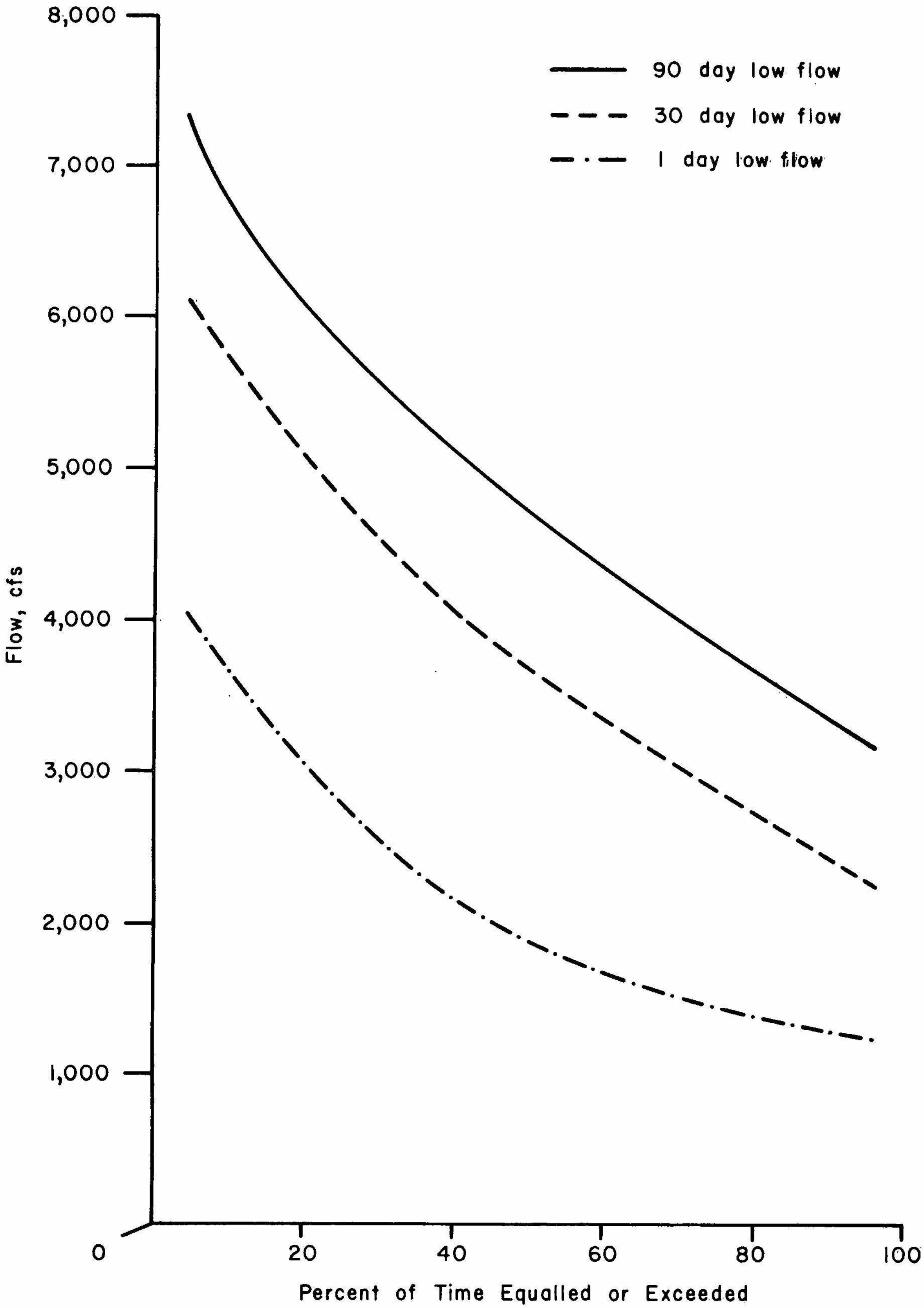
YELLOWSTONE RIVER BASIN

U.S.G.S. Station No. 06309000

Drainage Area 48253 sq. mi.

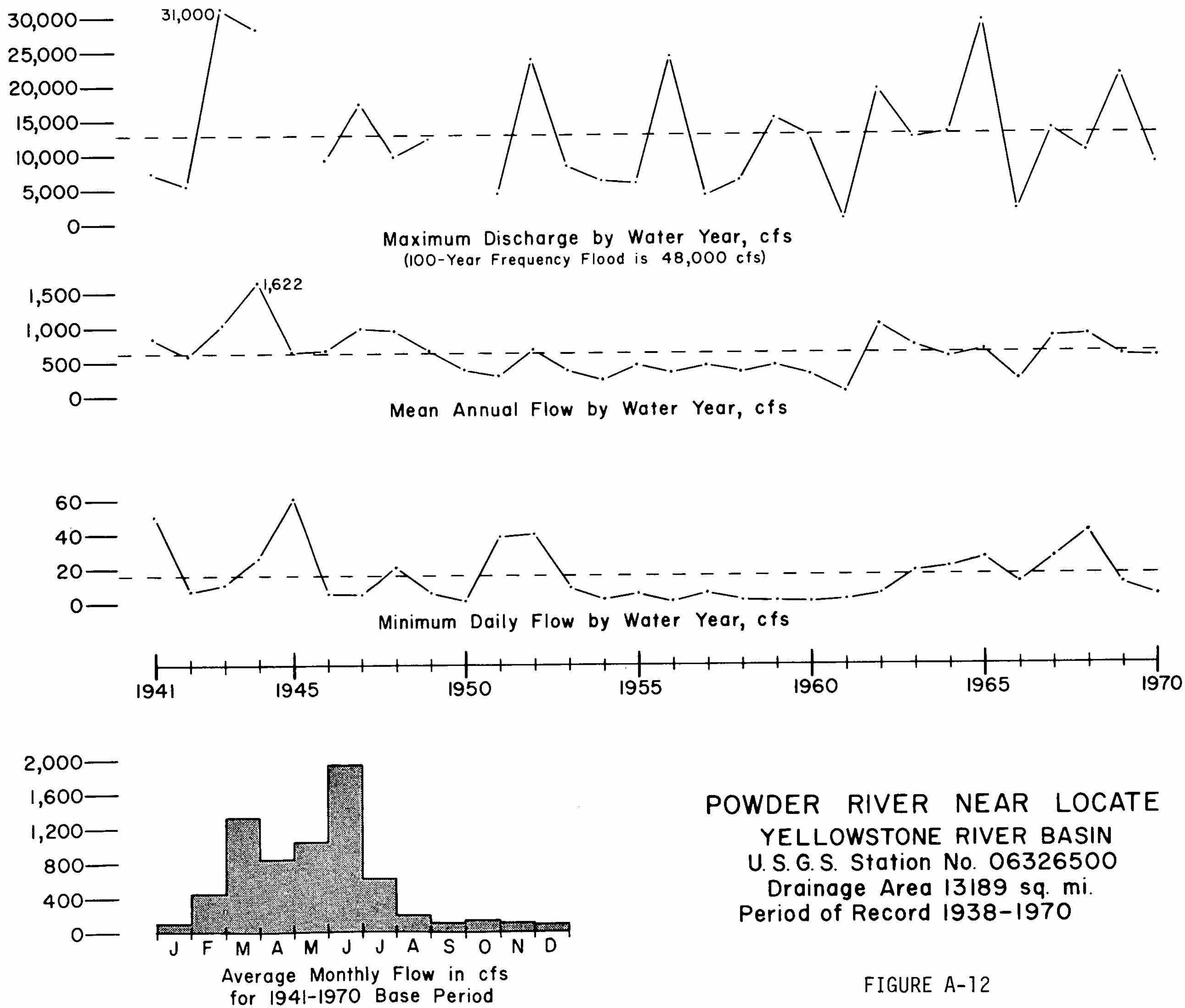
Period of Record 1922-1923
1928-1970

FIGURE A-10



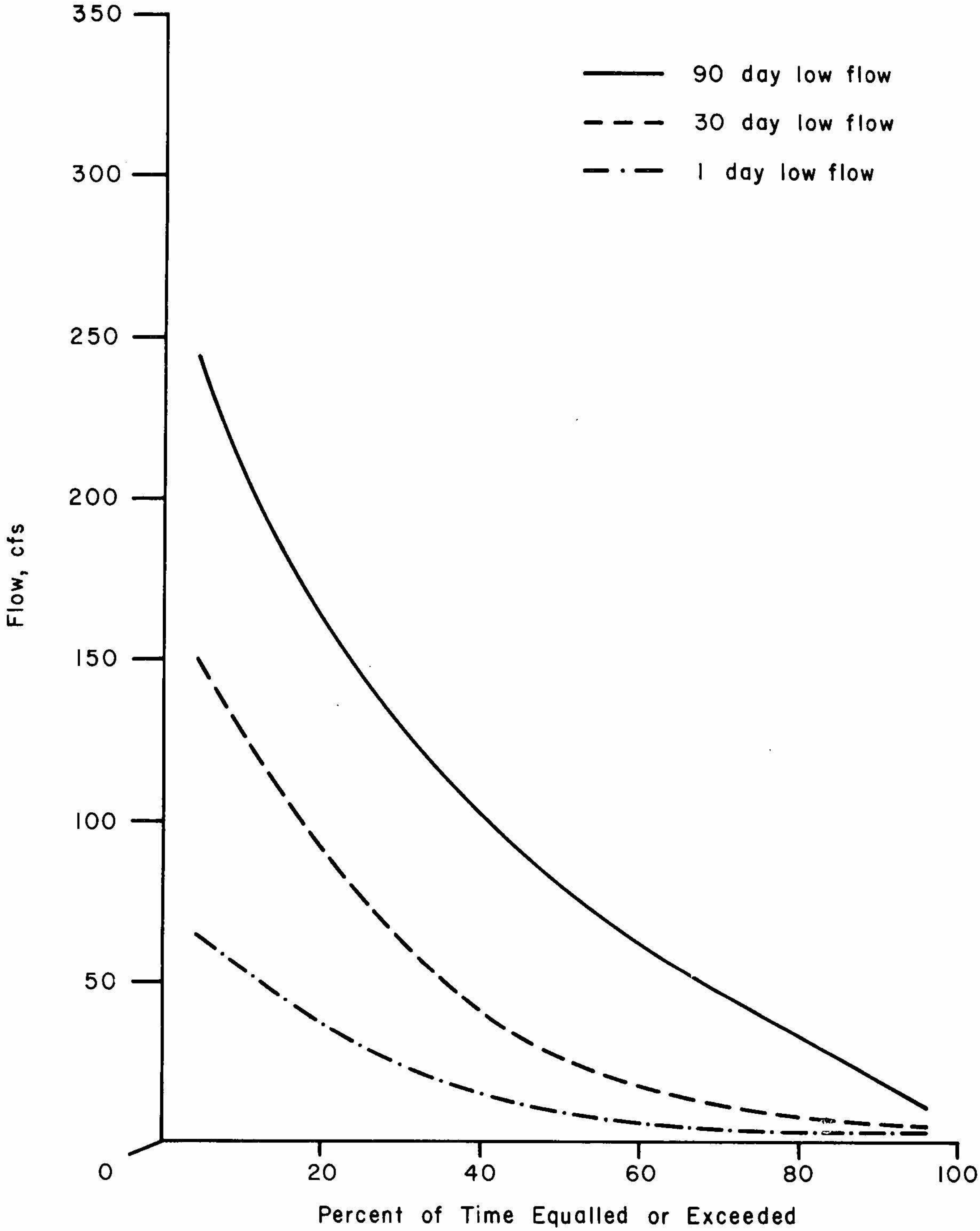
LOW-FLOW DURATION CURVES
YELLOWSTONE RIVER AT MILES CITY
Period of Record 1931-1973

FIGURE A-11



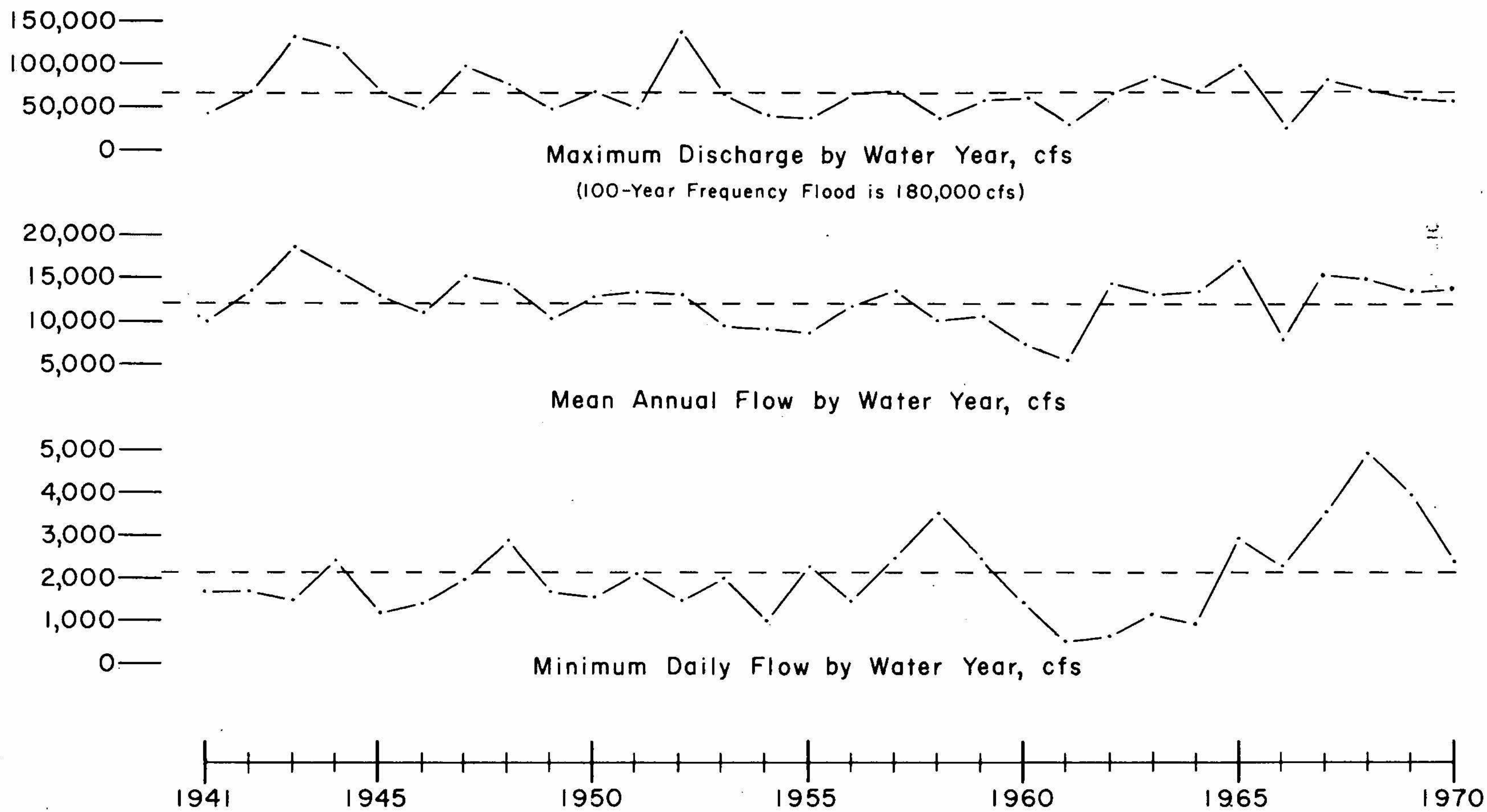
POWDER RIVER NEAR LOCATE
YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06326500
Drainage Area 13189 sq. mi.
Period of Record 1938-1970

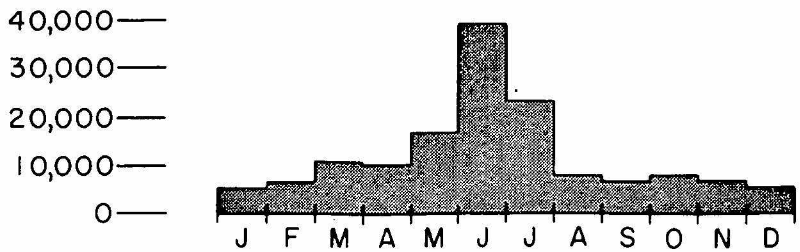
FIGURE A-12



LOW-FLOW DURATION CURVES
POWDER RIVER NEAR LOCATE
Period of Record 1939-1973

FIGURE A-13



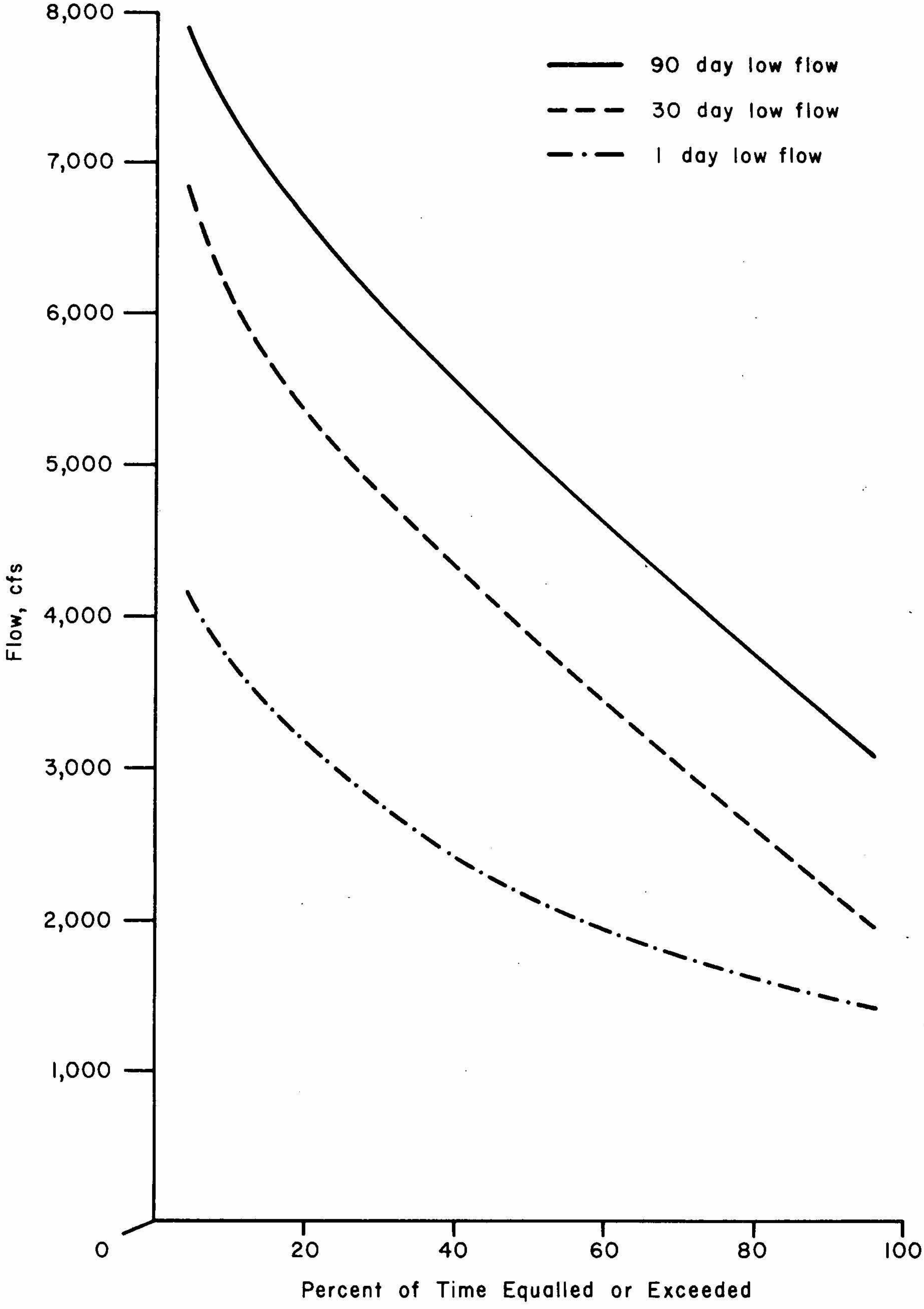


Average Monthly Flow in cfs
for 1941–1970 Base Period

YELLOWSTONE RIVER NEAR SIDNEY

YELLOWSTONE RIVER BASIN
U.S.G.S. Station No. 06329500
Drainage Area 68812 sq. mi.
Period of Record 1910–1931
1933–1970

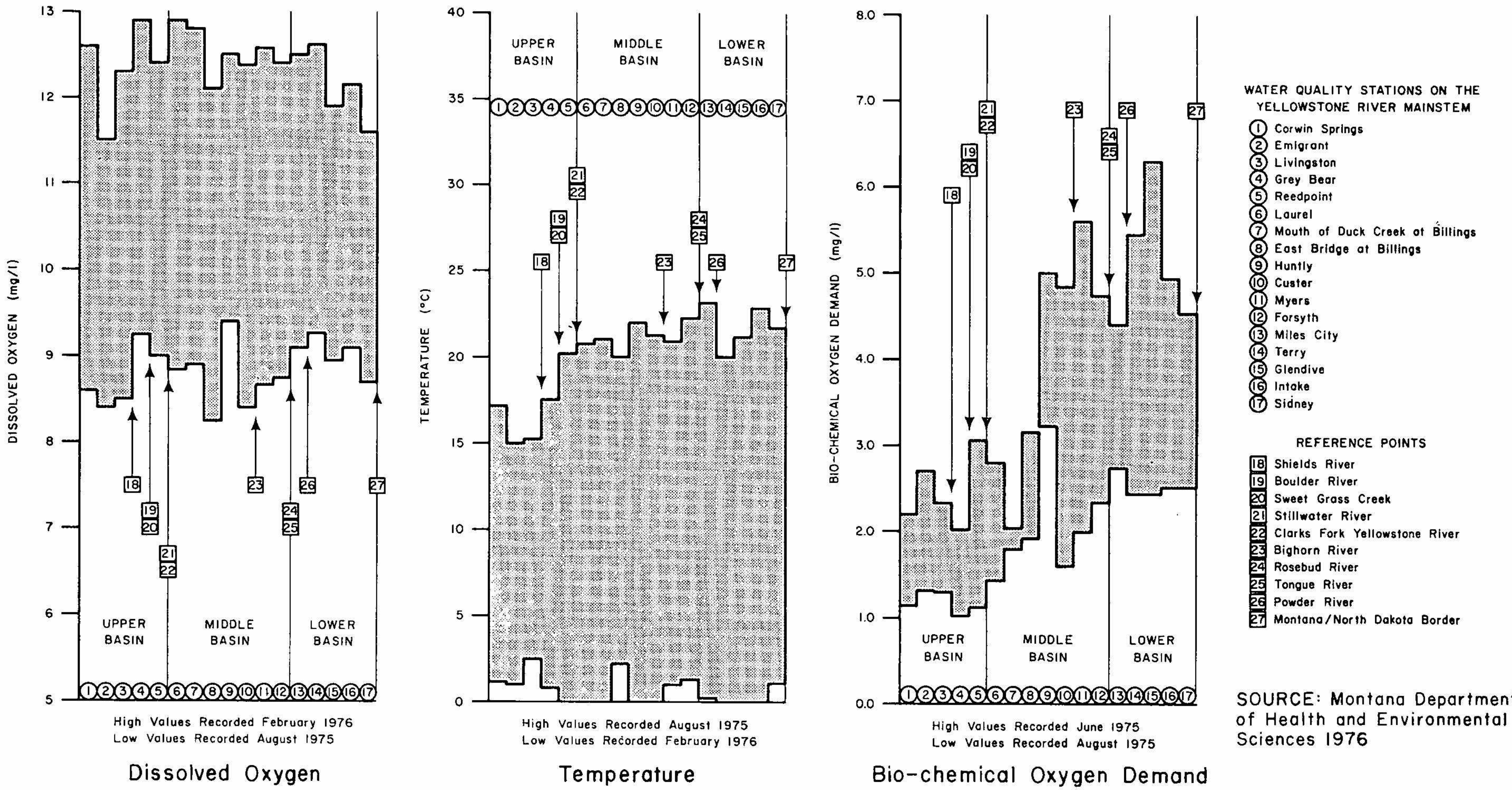
FIGURE A-14



LOW-FLOW DURATION CURVES
YELLOWSTONE RIVER NEAR SIDNEY
Period of Record 1925-1973

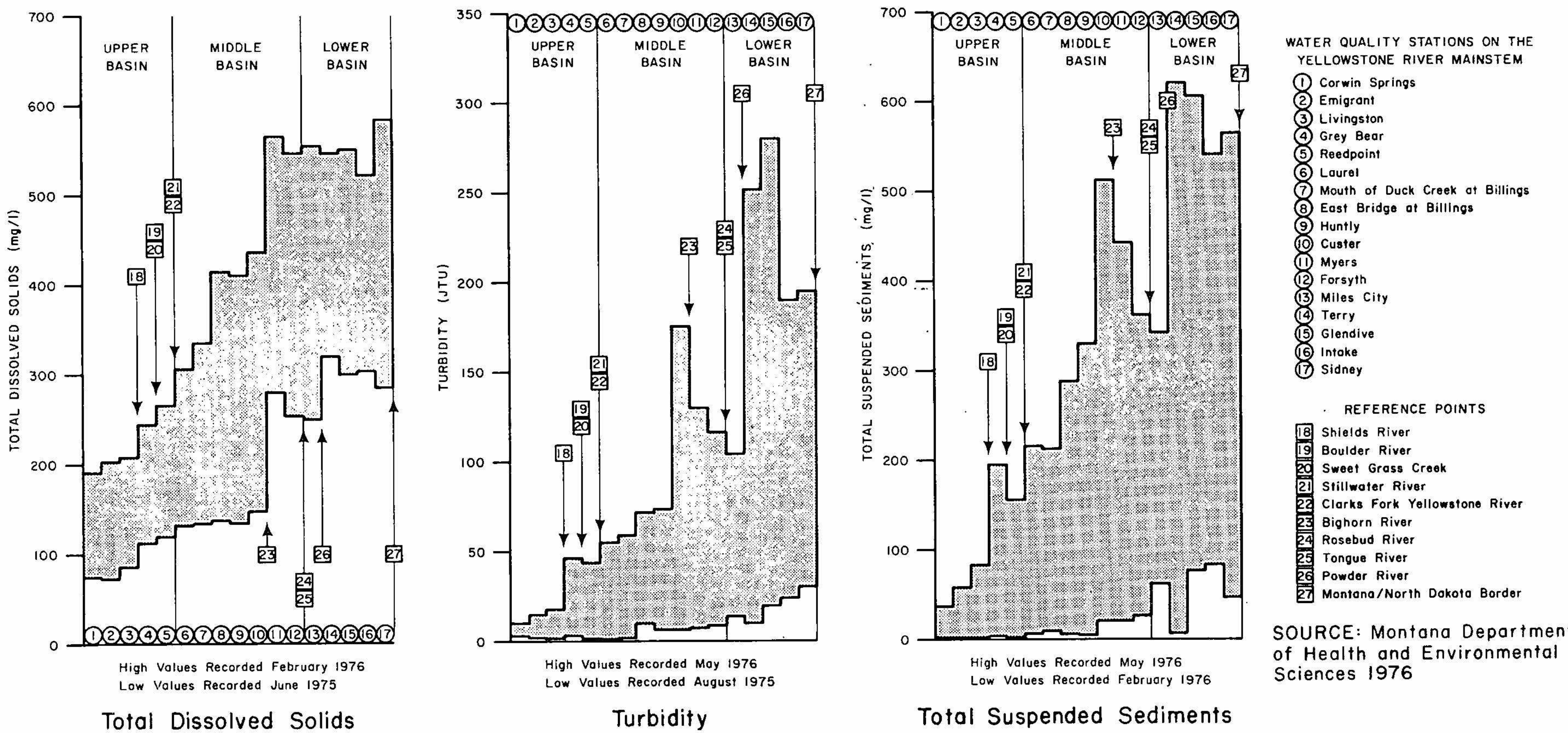
FIGURE A-15

WATER QUALITY DATA



SELECTED WATER QUALITY PARAMETERS FOR THE YELLOWSTONE RIVER

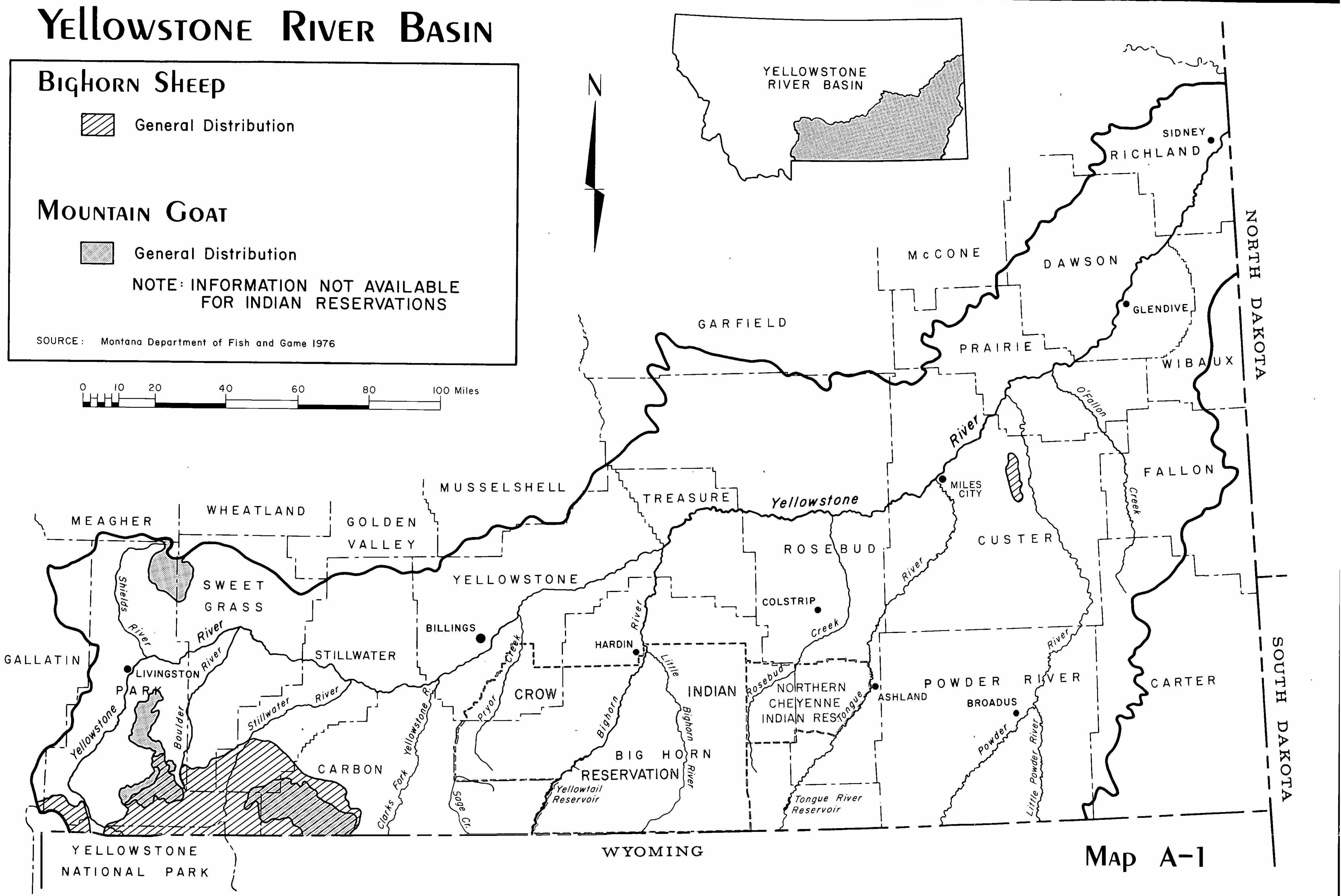
FIGURE A-16



SELECTED WATER QUALITY PARAMETERS FOR THE YELLOWSTONE RIVER

FIGURE A-17

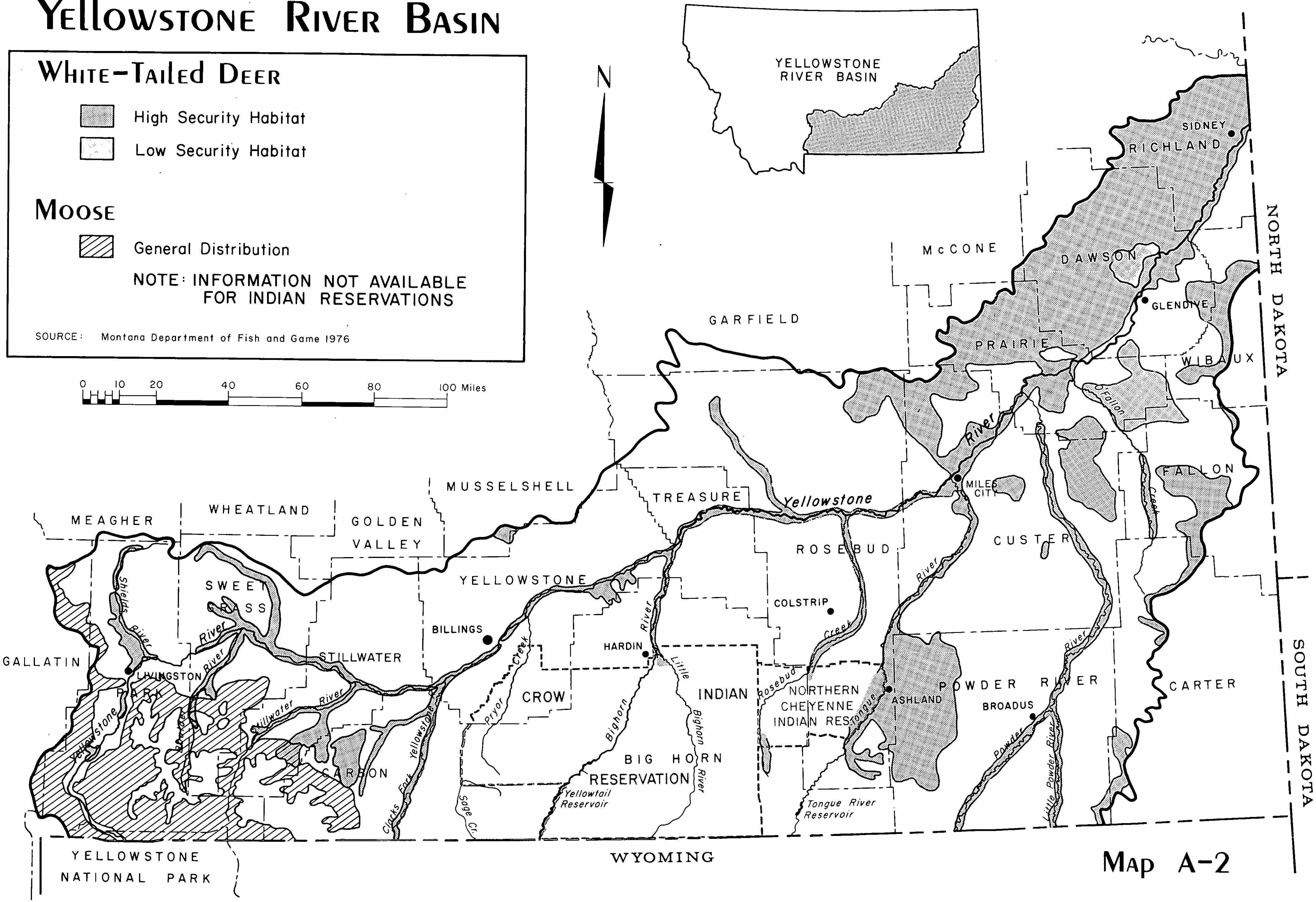
FISH AND GAME HABITAT MAPS



YELLOWSTONE RIVER BASIN
BIGHORN SHEEP
General Distribution
MOUNTAIN GOAT
General Distribution
NOTE: INFORMATION NOT AVAILABLE FOR INDIAN RESERVATIONS
SOURCE: Montana Department of Fish and Game 1976
0 10 20 40 60 80 100 Miles
N
YELLOWSTONE RIVER BASIN
SIDNEY
RICHLAND
McCONE
DAWSON
GLENDIVE
GARFIELD
PRAIRIE
WIBAUX
NORTH DAKOTA
O'Fallon
River
FALLON
MILES CITY
Creek
MUSSELSHELL
TREASURE
Yellowstone
MEAGHER
WHEATLAND
GOLDEN VALLEY
CUSTER
ROSEBUD
SWEET GRASS
YELLOWSTONE
River
Shields River
COLSTRIP
Creek
BILLINGS
River
HARDIN
River
GALLATIN
STILLWATER
LIVINGSTON
River
Creek
Little
PARK
Rosebud
NORTHERN CHEYENNE INDIAN RES
Tongue
ASHLAND
POWDER RIVER
River
CARTER
SOUTH DAKOTA
INDIAN
CROW
Pryor
Yellowstone
Boulder
Stillwater River
Yellowstone R.
Bighorn
Bighorn River
BROADUS
Powder
River
BIG HORN RESERVATION
CARBON
Clarks Fork
Sage Cr.
Yellowtail Reservoir
Tongue River Reservoir
Little Powder River
YELLOWSTONE NATIONAL PARK
WYOMING

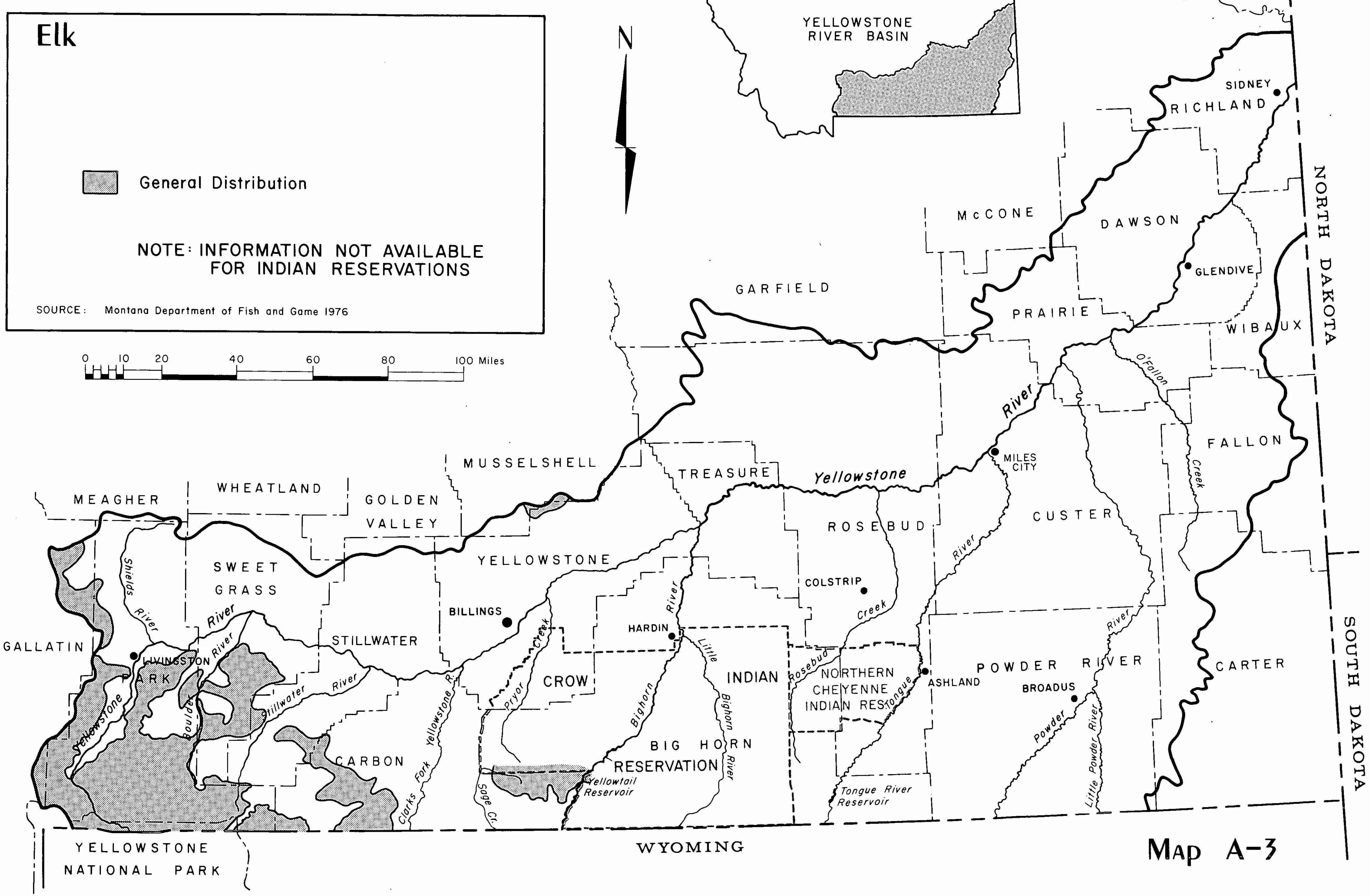
Map A-1

Yellowstone River Basin

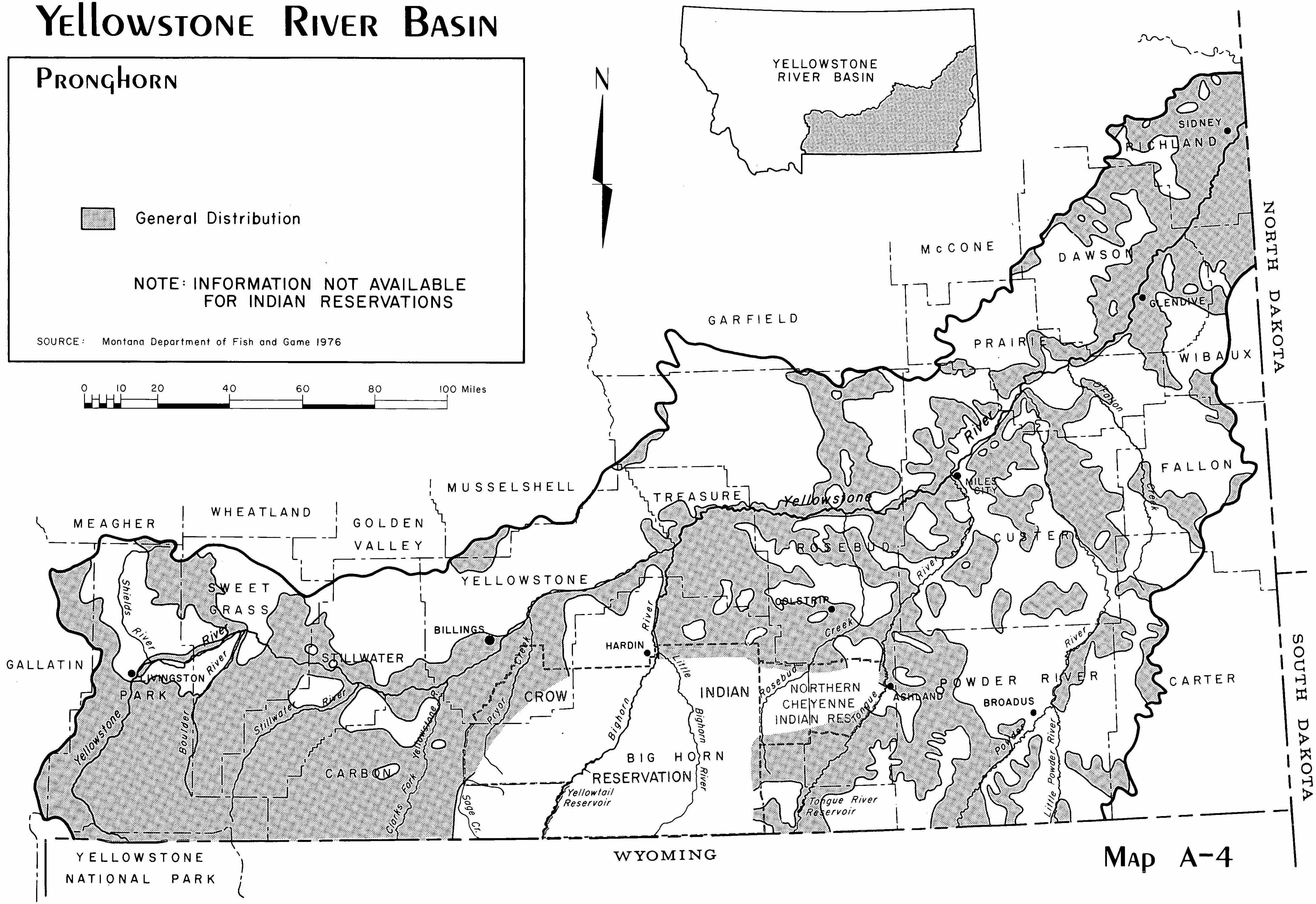


Map A-2

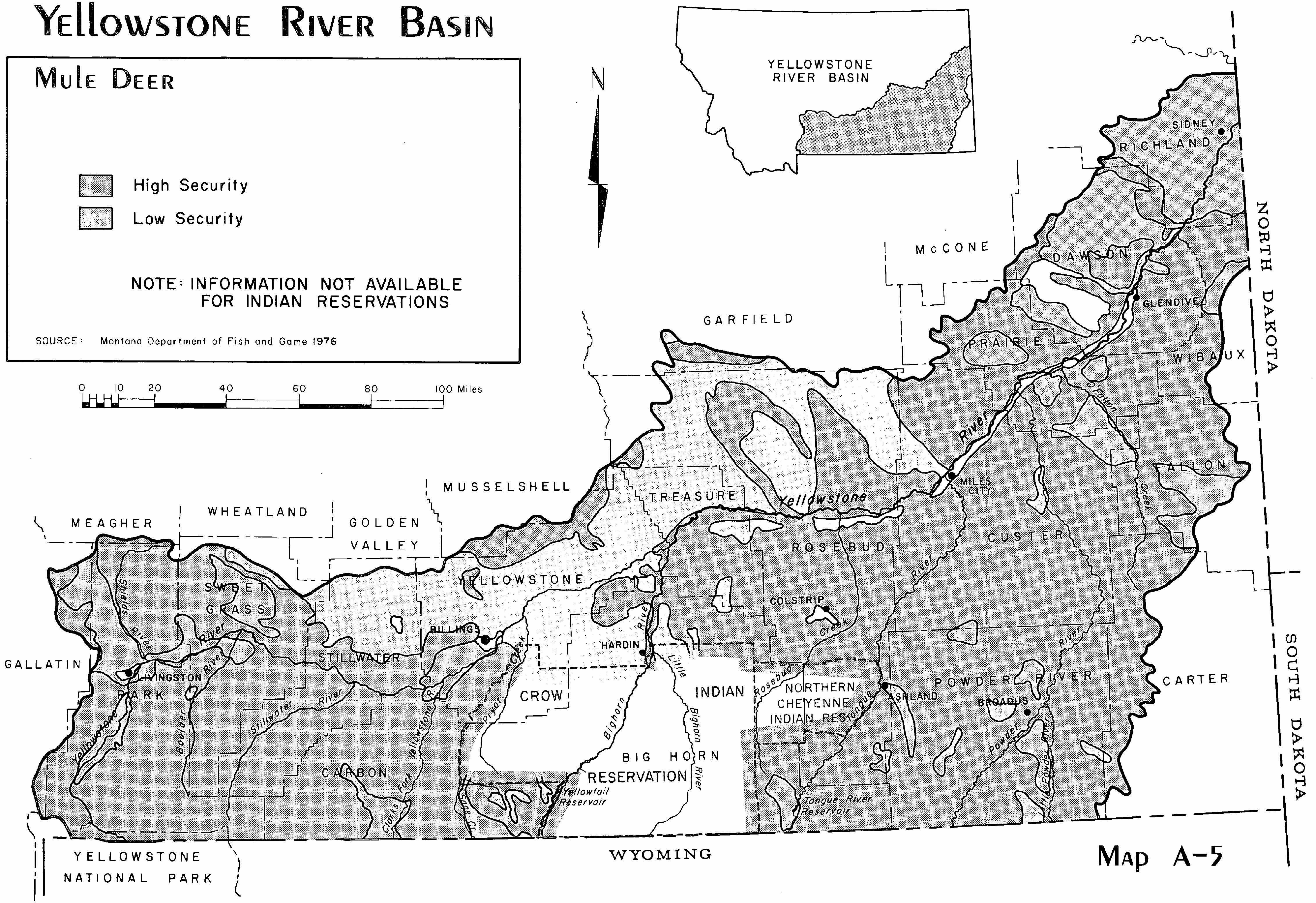
Yellowstone River Basin



Map A-3

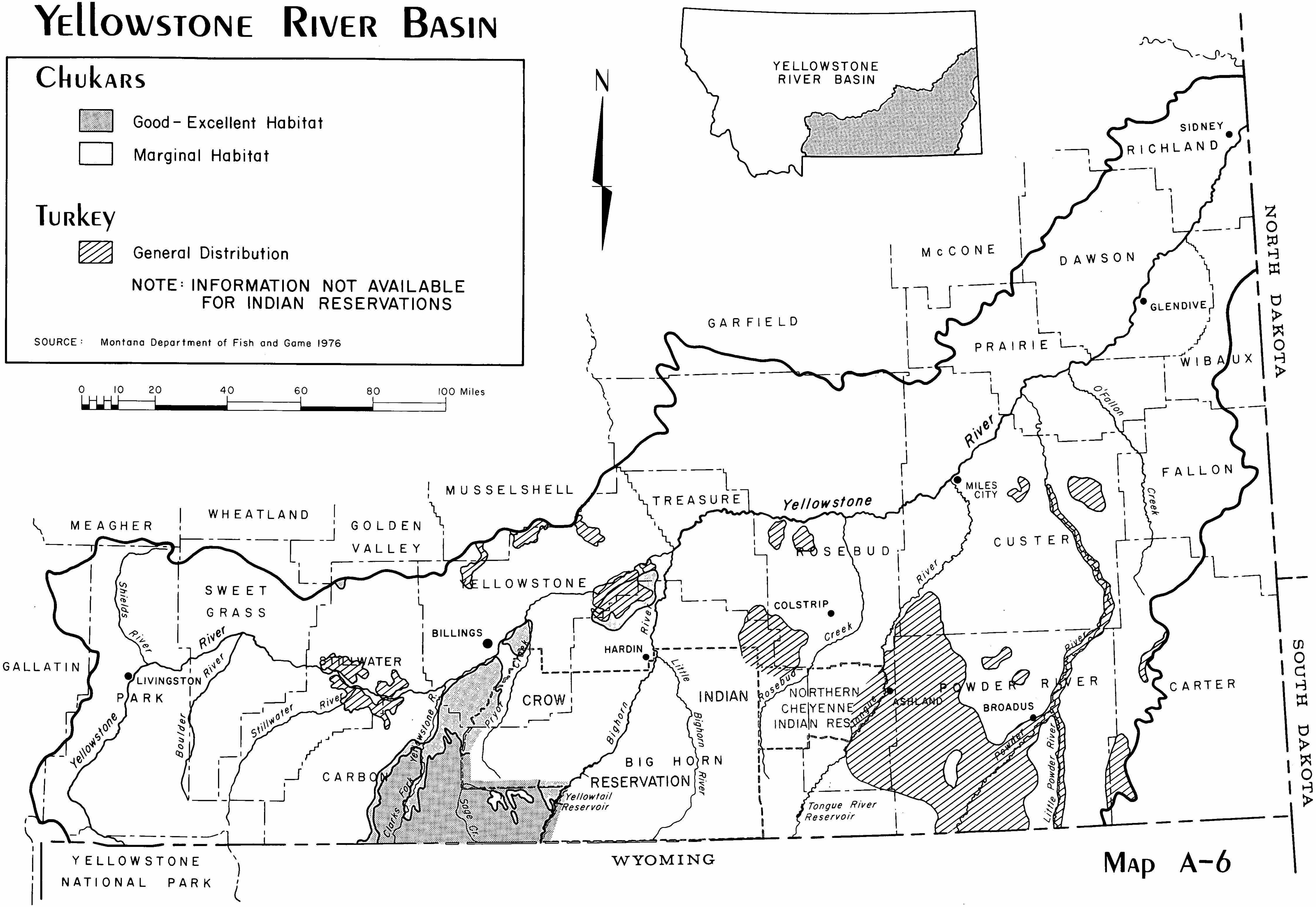

Yellowstone River Basin
Pronghorn
General Distribution
NOTE: INFORMATION NOT AVAILABLE FOR INDIAN RESERVATIONS
SOURCE: Montana Department of Fish and Game 1976
0 10 20 40 60 80 100 Miles
N
YELLOWSTONE RIVER BASIN
RICHLAND
SIDNEY
McCONE
DAWSON
GLENDIVE
GARFIELD
PRAIRIE
WIBAUX
NORTH DAKOTA
FALLON
MUSSELSHELL
TREASURE
Yellowstone
MILES CITY
River
MEAGHER
WHEATLAND
GOLDEN VALLEY
ROSEBUD
CUSTER
SWEET GRASS
YELLOWSTONE
COLSTRIP
BILLINGS
HARDIN
STILLWATER
GALLATIN
LIVINGSTON
PARK
CROW
INDIAN
NORTHERN CHEYENNE INDIAN RES
ASHLAND
POWDER RIVER
BROADUS
CARTER
SOUTH DAKOTA
CARBON
BIG HORN RESERVATION
Yellowtail Reservoir
Tongue River Reservoir
YELLOWSTONE NATIONAL PARK
WYOMING
Shields River
Boulder River
Stillwater River
Clarks Fork Yellowstone R.
Pryor Creek
Sage Cr.
Bighorn River
Little Bighorn River
Rosebud Creek
Tongue River
Powder River
Little Powder River
O'Fallon Creek
Map A-4

Yellowstone River Basin



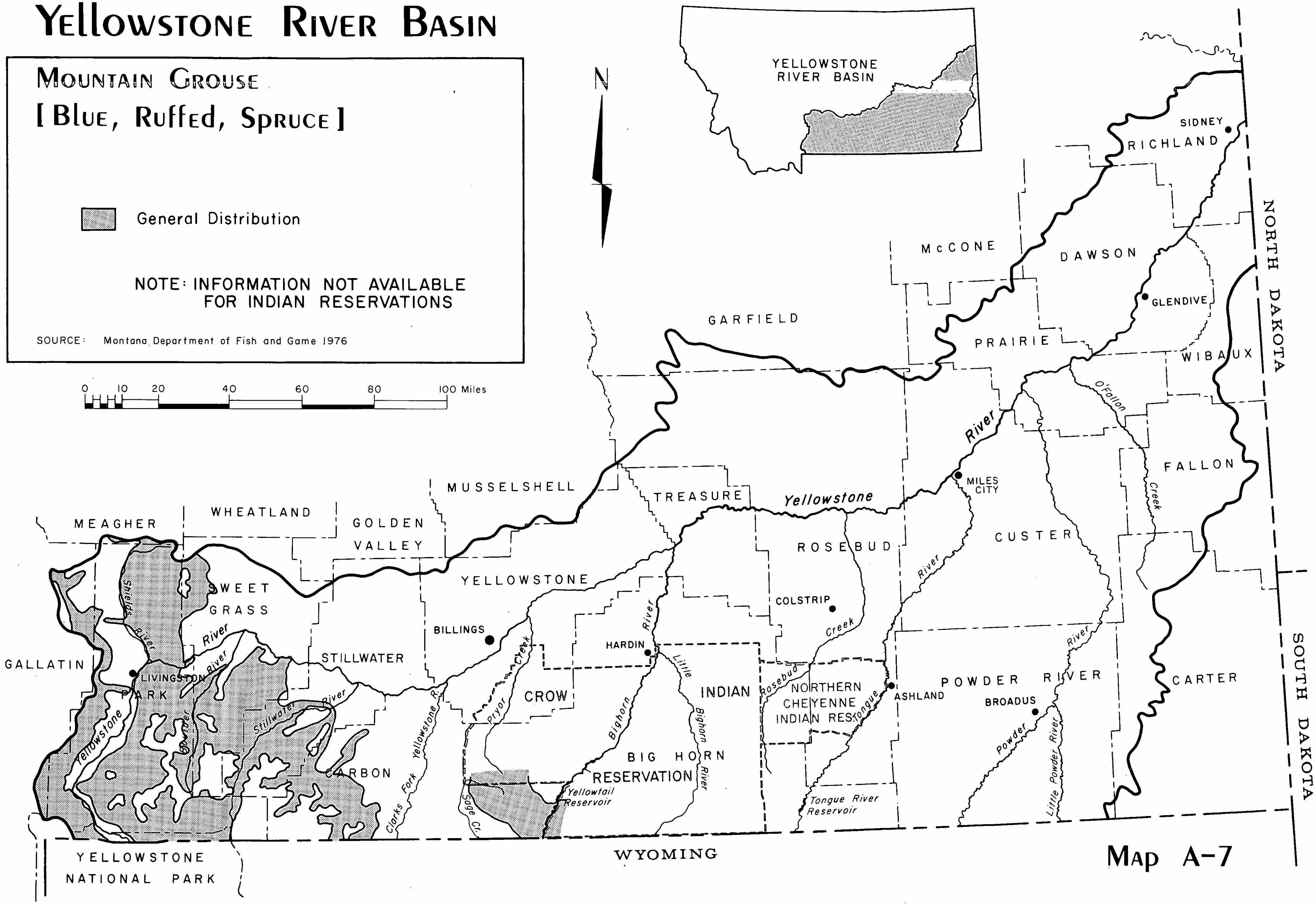
Map A-5

Yellowstone River Basin



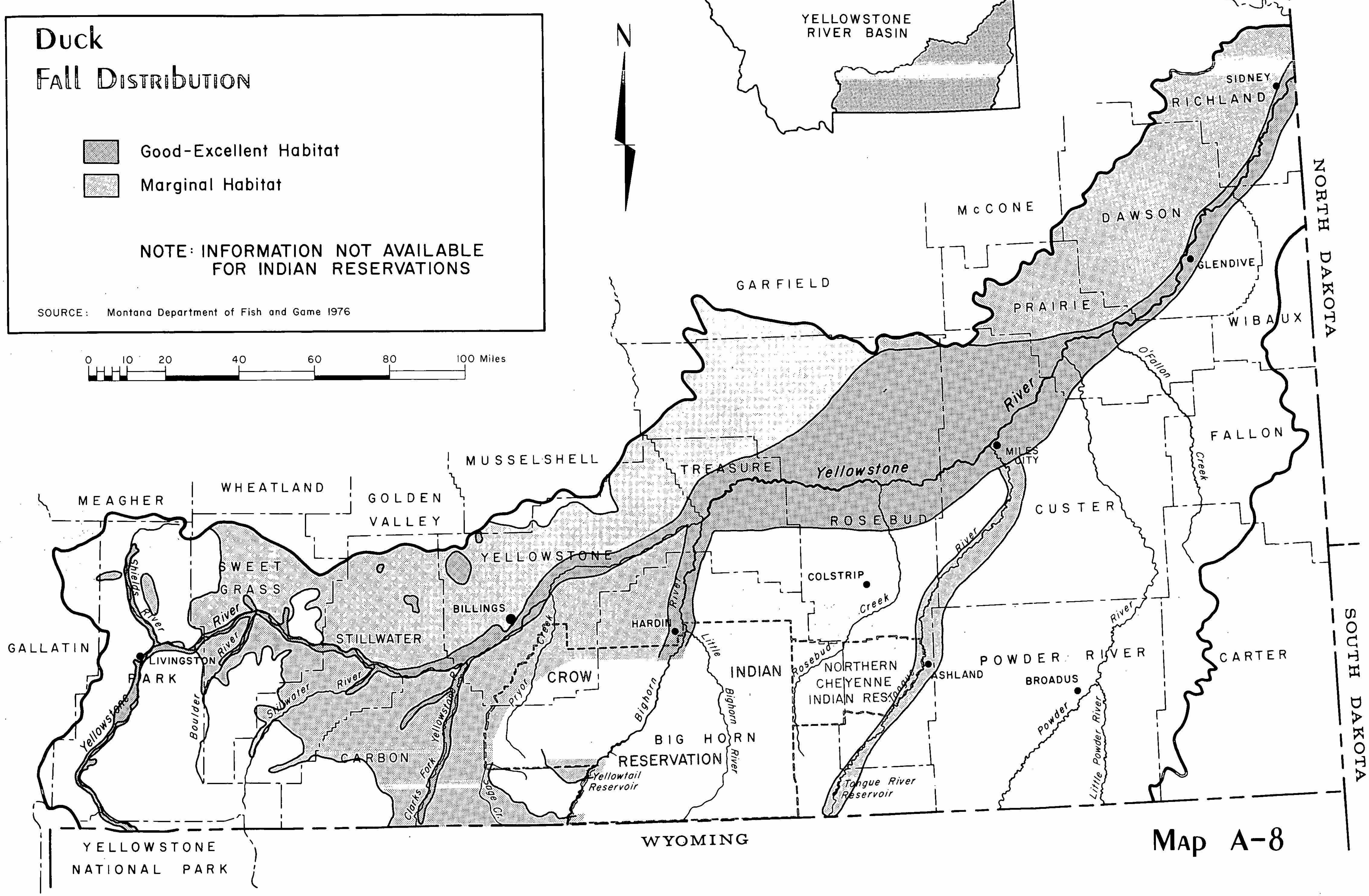
Map A-6

Yellowstone River Basin



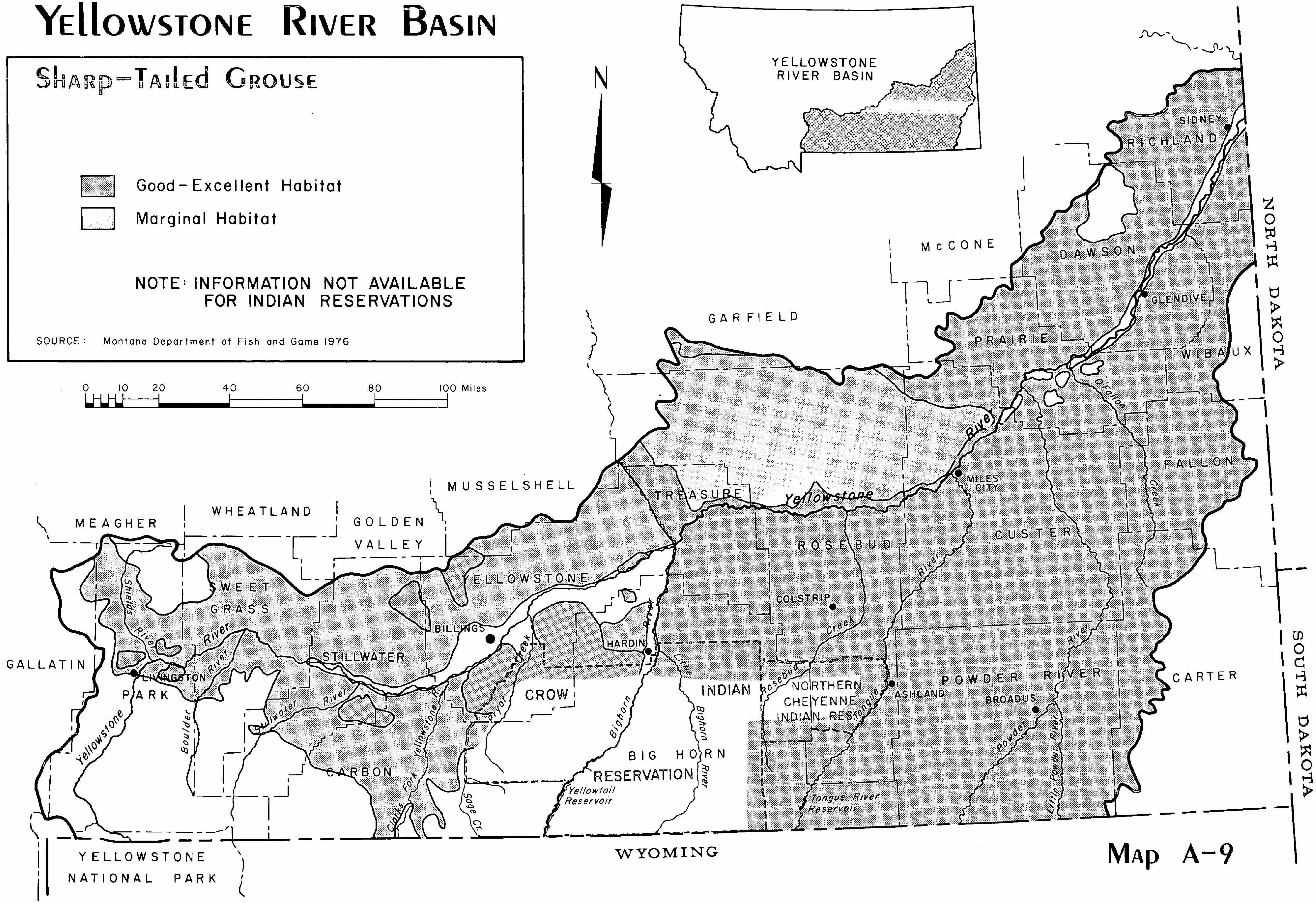
Map A-7

Yellowstone River Basin



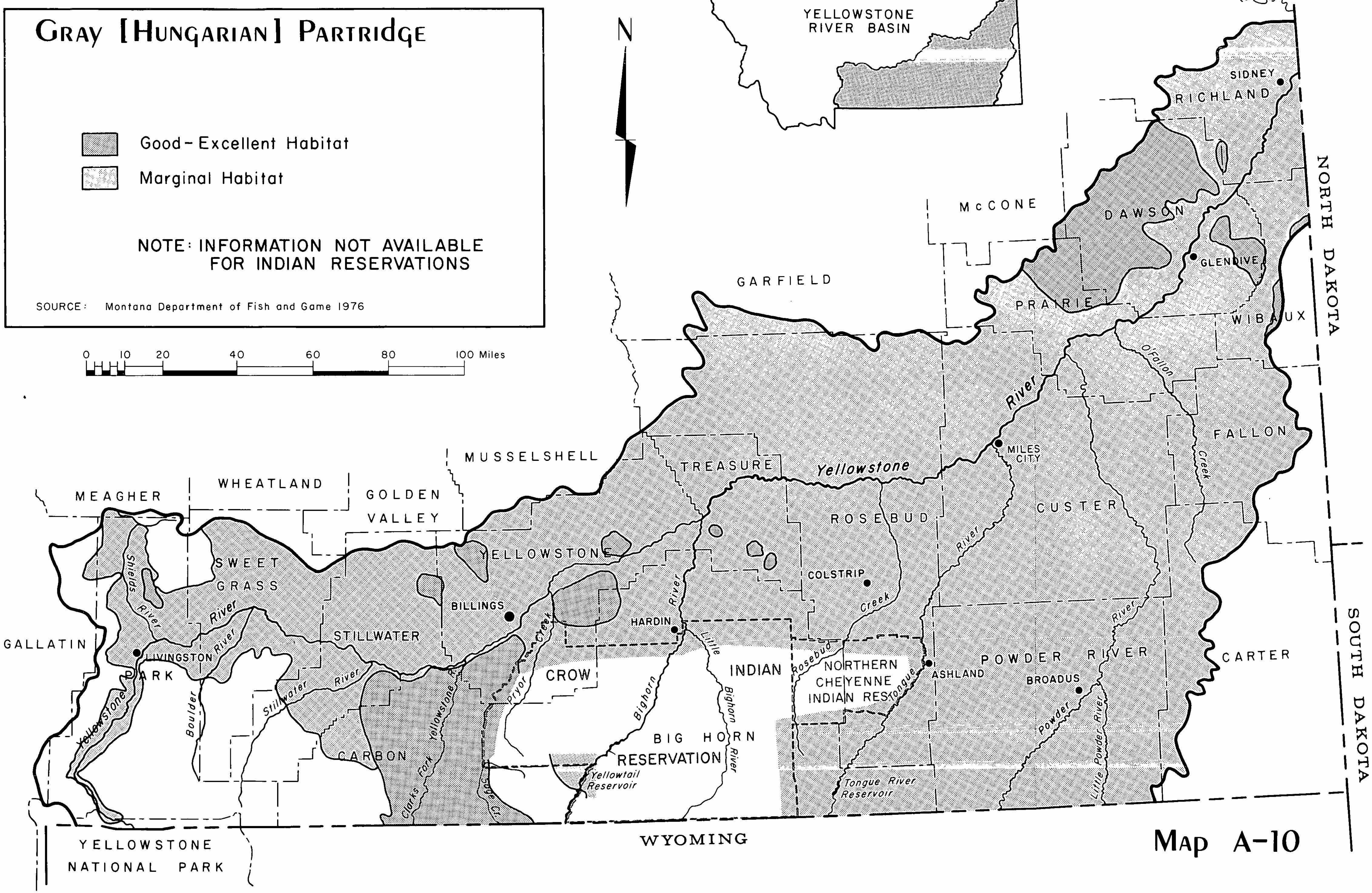
Map A-8

Yellowstone River Basin



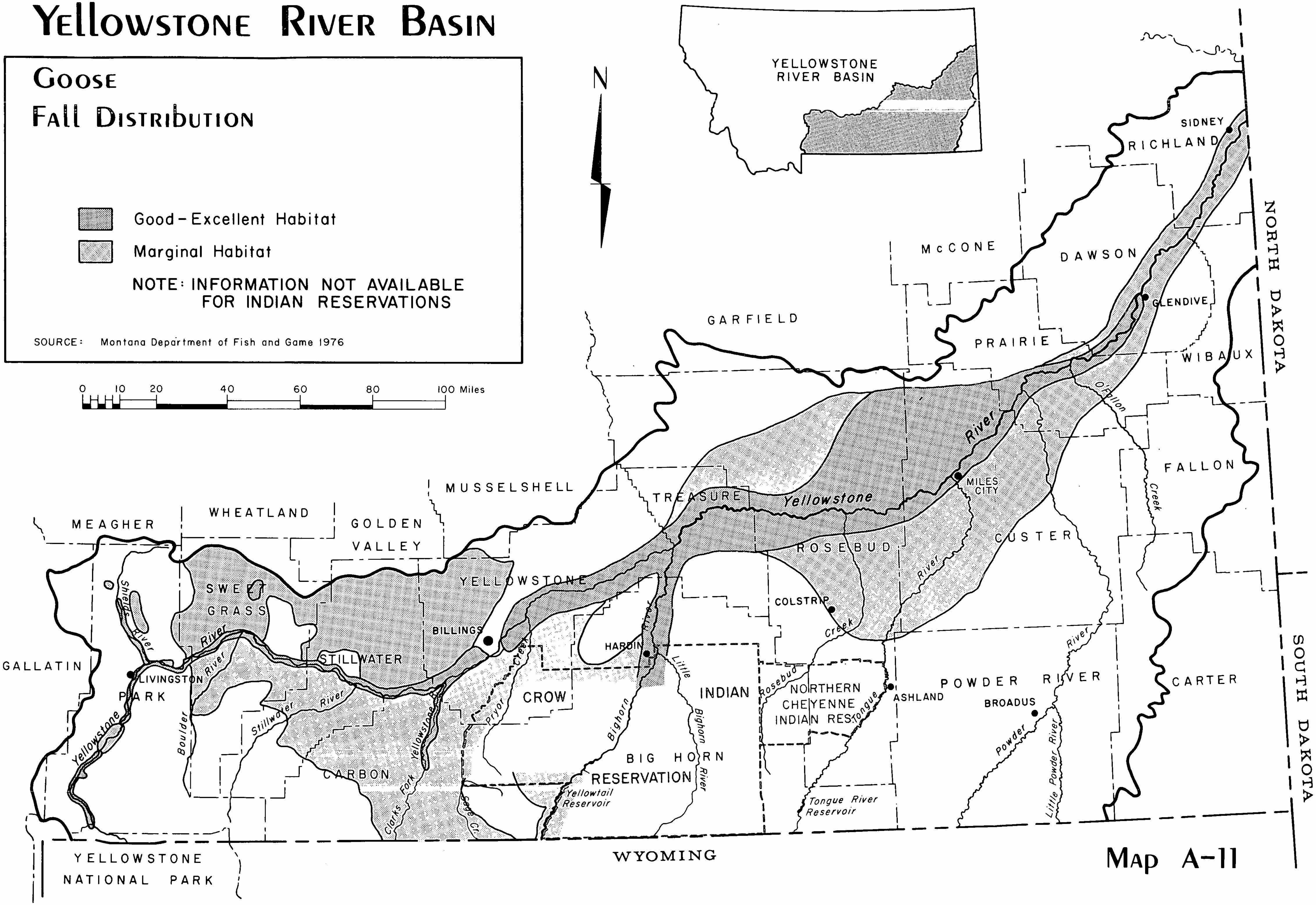
Map A-9

Yellowstone River Basin



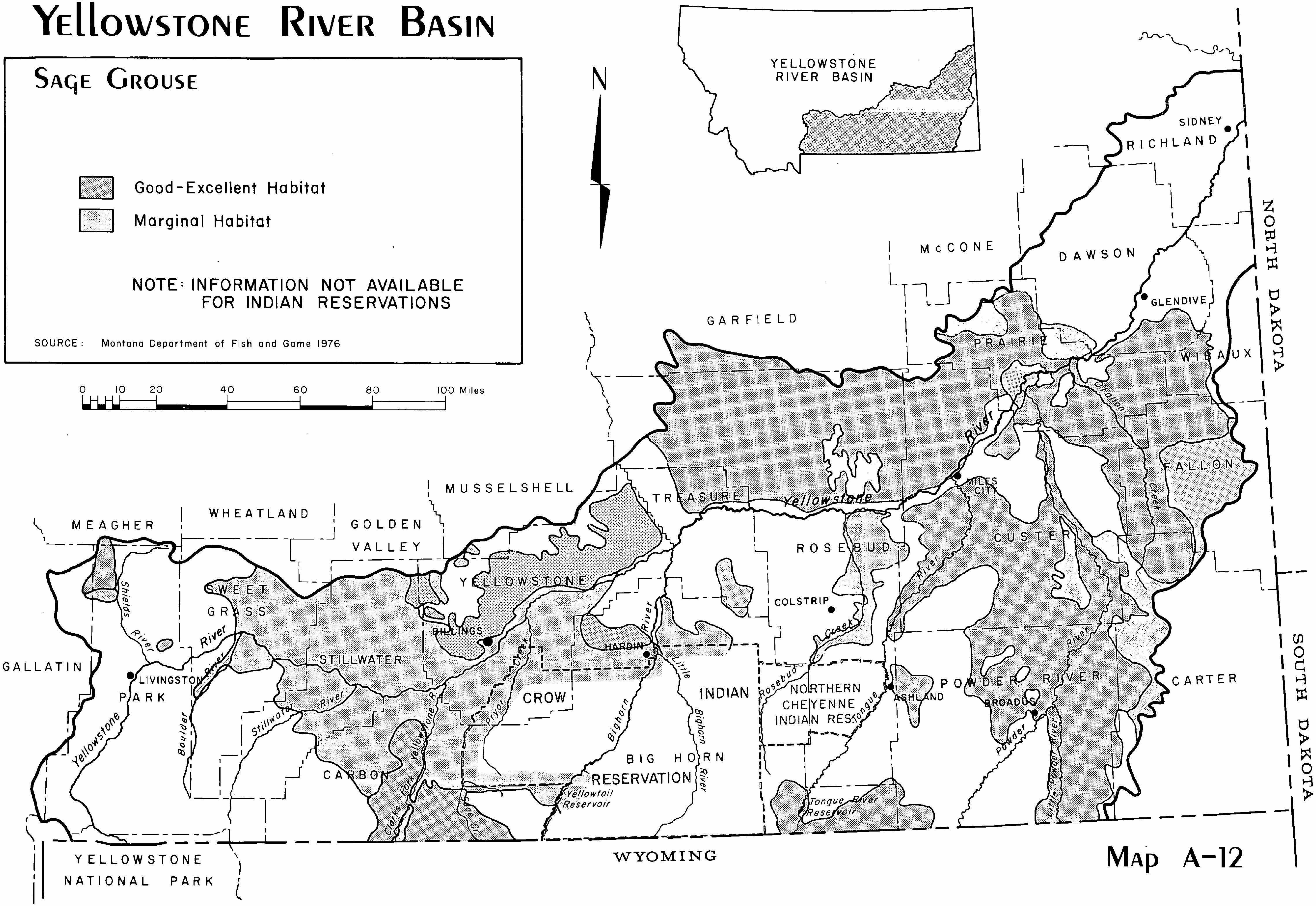
Map A-10

YELLOWSTONE RIVER BASIN

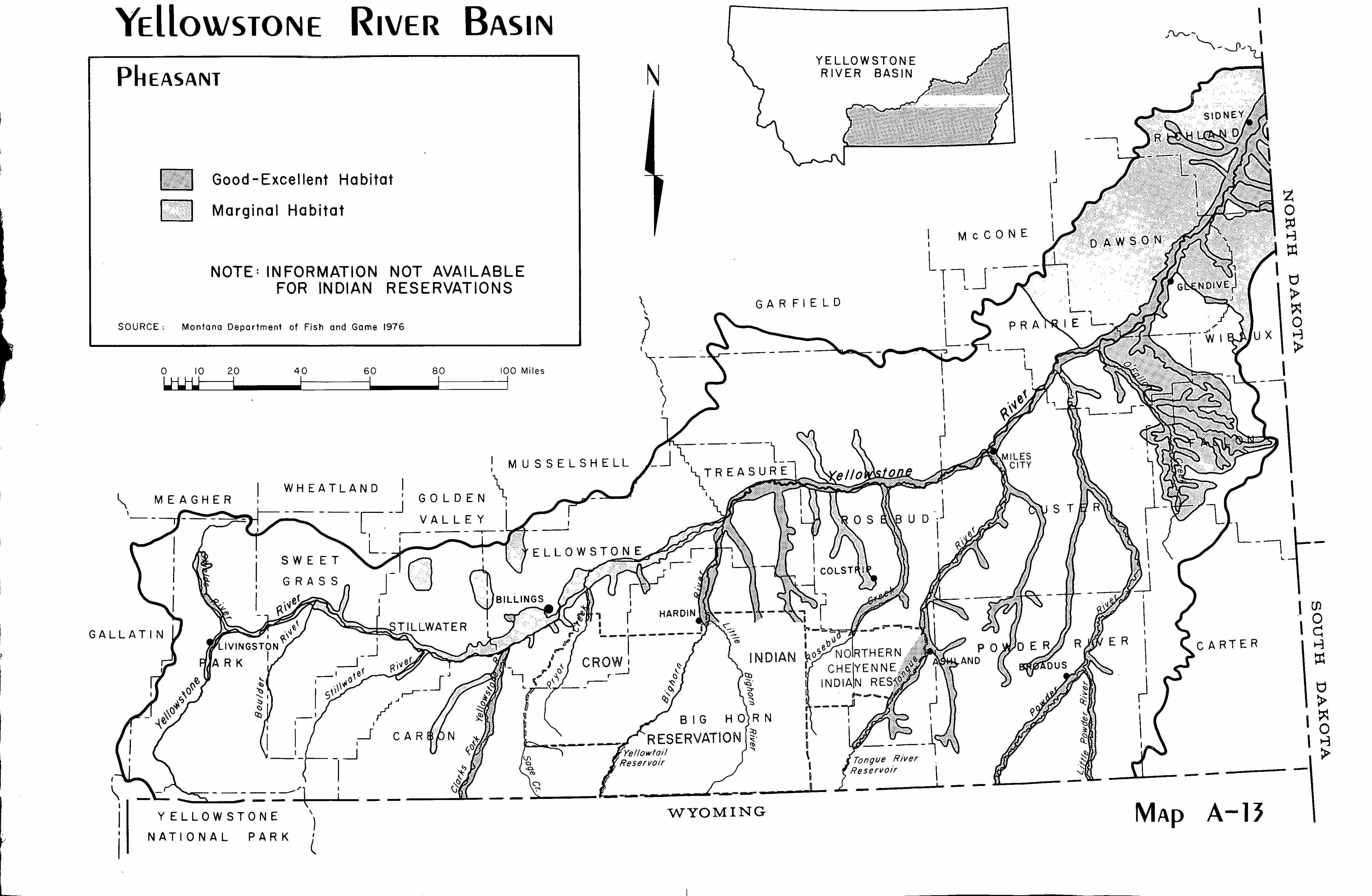


Map A-11

Yellowstone River Basin



Map A-12


Yellowstone River Basin
Pheasant
Good-Excellent Habitat
Marginal Habitat
NOTE: INFORMATION NOT AVAILABLE FOR INDIAN RESERVATIONS
SOURCE: Montana Department of Fish and Game 1976
0 10 20 40 60 80 100 Miles
N
YELLOWSTONE RIVER BASIN
SIDNEY
RICHLAND
McCONE
DAWSON
GLENDIVE
GARFIELD
PRAIRIE
WIBAUX
NORTH DAKOTA
MUSSELSHELL
TREASURE
Yellowstone
River
MILES CITY
MEAGHER
WHEATLAND
GOLDEN VALLEY
ROSEBUD
CUSTER
YELLOWSTONE
SWEET GRASS
COLSTRIP
BILLINGS
HARDIN
STILLWATER
GALLATIN
LIVINGSTON
PARK
CROW
INDIAN
NORTHERN CHEYENNE INDIAN RES
ASHLAND
POWDER RIVER
BROADUS
CARTER
SOUTH DAKOTA
CARBON
BIG HORN RESERVATION
Yellowtail Reservoir
Tongue River Reservoir
Clarks Fork Yellowstone R.
Sage Cr.
Pryor Creek
Bighorn River
Little Bighorn River
Stillwater River
Boulder River
Shields River
Rosebud Creek
Tongue
Powder River
Little Powder River
O'Fallon Creek
YELLOWSTONE NATIONAL PARK
WYOMING
Map A-13

EXISTING FILINGS

TABLE A-1

DEPARTMENT OF FISH AND GAME FILINGS ON THE DESIGNATED
BLUE RIBBON REACH OF THE YELLOWSTONE

Reach	Dates	Amount
Yellowstone Park Boundary Tom Miner Creek	Jan 1 - Dec 31	800 cfs
Tom Miner - Shields River	Apr 16 - Oct 31	2,000 cfs
	Nov 1 - Apr 15	1,200 cfs
Shields River - Boulder River	Apr 16 - Oct 31	2,000 cfs
	Nov 1 - Apr 15	1,200 cfs
Boulder River - Stillwater River	Apr 16 - Oct 31	2,200 cfs
	Nov 1 - Apr 15	1,300 cfs
Stillwater River to North-South	Apr 16 - Oct 31	2,600 cfs
Carbon-Stillwater County Line	Nov 1 - Apr 15	1,500 cfs

SOURCE: Montana Fish and Game Commission Water unpublished

TABLE A-2

MAJOR INDUSTRIAL FILINGS FOR APPROPRIATION OF YELLOWSTONE BASIN WATER

Date of Filing	Filed By	County of Application	Source	Amount	Purpose
6/8/73	Intake Water Company	Dawson	Yellowstone River	111.4 cfs (50,000 gpm) up to 80,650 af/y	to be sold, rented, and distributed for irrigation, industrial, municipal, and domestic purposes
12/22/70	Montana Power Company	Rosebud	Yellowstone River	250 cfs continuously	industrial use in a thermal-electric generating plant
4/5/73	Sherman and Stuart Hunt	Rosebud	Yellowstone River	200 cfs	irrigation, stockwater, domestic, and industrial purposes
9/6/50	Montana Power Company	Yellowstone	Yellowstone River	200 cfs	industrial use in a thermal-electric generating plant
4/5/66	Montana Power Company	Yellowstone	Yellowstone River	200 cfs	industrial use in a thermal-electric generating plant
6/29/73	Basin Electric Power Cooperative	Rosebud	Yellowstone River	50 cfs	industrial use in a thermal-electric generating plant

MUNICIPAL WATER USE DATA

TABLE A-3

MUNICIPAL WATER USE IN THE YELLOWSTONE BASIN
IN 1970

County	Number of Cities having Municipal Systems	Population Served	Water Use in mgd			Per Capita Water use, in gpcd
			Ground Water	Surface Water	Total	
Big Horn	6	5,089	.235	.791	1.026	201
Carbon	6	3,592	.512	.679	1.191	332
Custer	1	9,070	.390	1.558	1.948	215
Dawson	3	8,244	.489	.991	1.480	179
Park	6	8,017	.361	1.766	2.127	265
Powder River	2	1,099	.146	0	.146	132
Prairie	0	0	0	0	0	0
Richland	2	5,499	1.223	0	1.223	222
Rosebud	5	5,353	.671	.333	1.004	187
Stillwater	3	1,845	.634	0	.634	343
Sweet Grass	1	1,592	.855	0	.855	537
Treasure	1	373	.125	0	.125	335
Yellowstone	5	86,749	.175	16.976	17.151	198
TOTAL	38	136,522	5.816	23.094	28.910	
AVERAGE						212

TABLE A-4

YELLOWSTONE BASIN POPULATION SIMULATIONS FOR 2000

City	Population*	Population Simulations for 2000 Low Level of Development	Intermediate Level of Development	High Level of Development
Ashland	531	2,379	3,423	7,236
Billings	63,729	94,999	95,523	98,294
Birney	13	60	70	137
Broadus	799	4,138	6,096	10,692
Busby**	300	1,160	1,038	2,036
Colstrip	200	5,044	5,824	15,107
Forsyth	1,873	5,189	5,664	10,249
Glendive**	6,441	8,341	8,341	8,713
Hardin	2,733	4,783	5,458	7,094
Lame Deer**	650	1,062	1,012	1,442
Lodge Grass	860	1,090	1,215	1,462
Miles City	9,023	15,890	16,461	20,254
Sidney**	4,551	6,032	6,032	6,404

SOURCE: Prepared by the Montana Department of Community Affairs for the Yellowstone Impact Study.

*Populations given are the most recent available census or estimate. In Ashland, Birney, Busby, Colstrip and Lame Deer, the 1970 census population is given; all others are 1975 censuses or estimates.

**In Busby and Lame Deer, the projected population is less in the intermediate level of development than in the low; in Glendive and Sidney, it remains constant. The overall basin population increases from the low to the intermediate level of development, but, because the locations of coal development change, the projected population shifts from one area to another.

TABLE A-5

THE INCREASE IN WATER DEPLETION FOR MUNICIPAL USE IN 2000 BY SUBBASIN

Subbasin	Population Increase	Increase in Depletion (AF)
LOW LEVEL OF DEVELOPMENT		
Upper Yellowstone	0	0
Clarks Fork	0	0
Billings Area	31,270	3,480
Bighorn	2,050	negligible
Mid-Yellowstone	15,030	1,680
Tongue	1,788	negligible
Kinsey Area	0	0
Powder	3,339	360
Lower Yellowstone	3,381	360
Total	56,858	5,880
INTERMEDIATE LEVEL OF DEVELOPMENT		
Upper Yellowstone	0	0
Clarks Fork	0	0
Billings Area	31,804	3,540
Bighorn	2,755	300
Mid-Yellowstone	16,800	1,860
Tongue	2,900	300
Kinsey Area	0	0
Powder	5,300	600
Lower Yellowstone	3,381	360
Total	62,940	6,960
HIGH LEVEL OF DEVELOPMENT		
Upper Yellowstone	0	0
Clarks Fork	0	0
Billings Area	34,565	3,900
Bighorn	4,361	480
Mid-Yellowstone	34,494	3,840
Tongue	6,705	780
Kinsey Area	0	0
Powder	9,900	1,140
Lower Yellowstone	4,125	480
Total	94,150	10,620

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