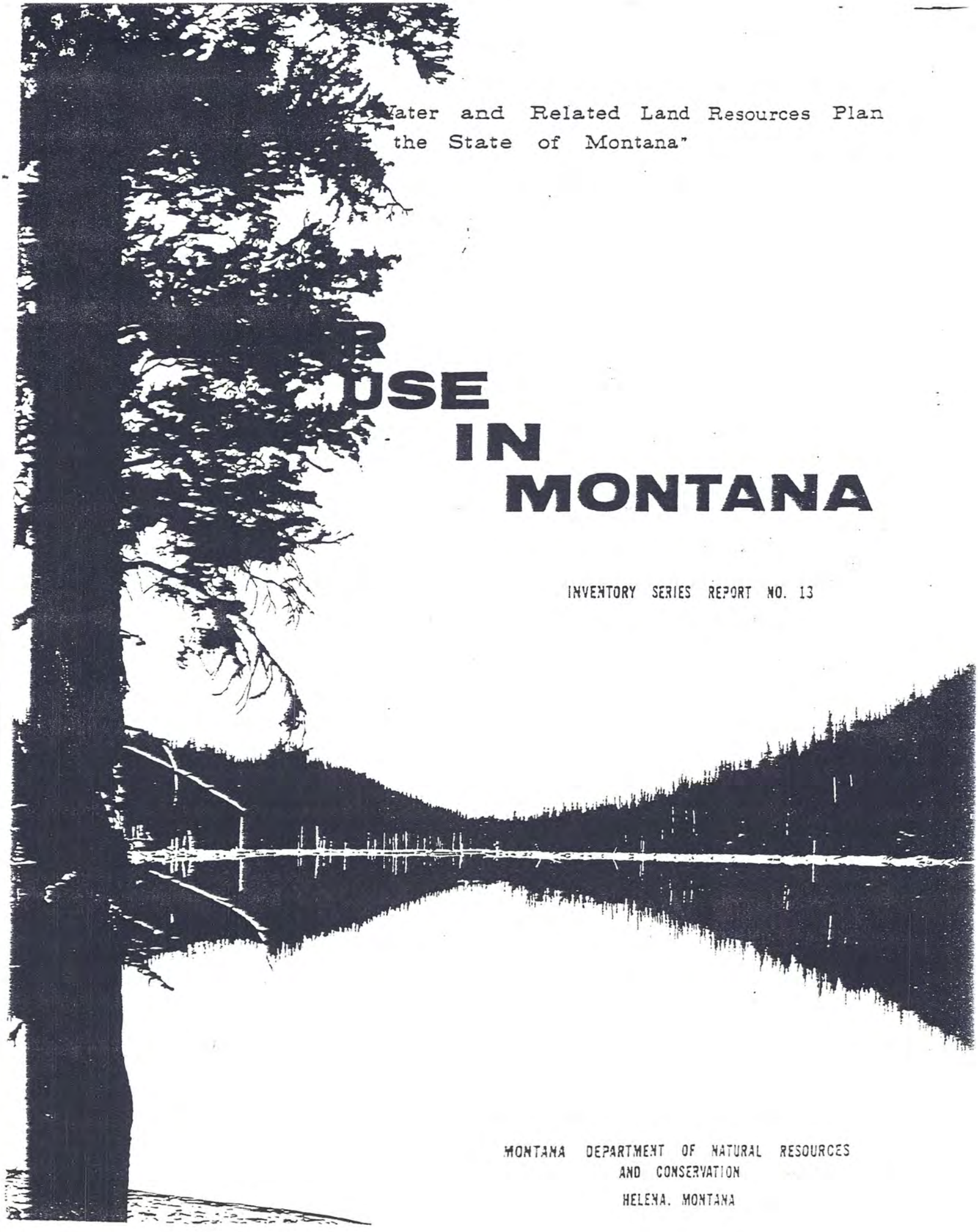
Aquatic Materials



Water and Related Land Resources Plan
the State of Montana"

R
USE
IN
MONTANA

INVENTORY SERIES REPORT NO. 13

MONTANA DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
HELENA, MONTANA

PREFACE

Perhaps the most valuable natural resource a region can possess is an ample supply of clean, fresh water. Montana, being a headwaters state, is so favored. Her water supply is in most cases adequate and, except in a few troubled areas, still reasonably unpolluted. Keeping it so under the pressures of an increasing population and a growing industrial development presents a challenging opportunity as well as an important responsibility to all Montanans.

An adequate evaluation of Montana's water resources requires both knowledge of the water available and periodic assessment of water usage. The use of water usually reduces the quantity and frequently degrades the quality of the remaining supply.

This report presents an estimate of current water use in Montana, including populations served, acreages irrigated, and water use rates.

The Department of Natural Resources and Conservation acknowledges the contributions of the following individuals:

David Ricks	—	Author	Gary Wolf	—	Illustrations
Carole Massman	—	Editor	Don Howard	—	Artwork
Don Breiby	—	Layout	George Cawlfield and Glenn Smith	—	Irrigation Information
Dan Nelson	—	Cover Design			

Appreciation is also extended to Donald Coffin and Kathleen Wilke of the Water Resources Division of the U.S. Geological Survey for technical assistance provided.

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STATE OF MONTANA

Department of Natural Resources and Conservation

Water Resources Division

Helena, Montana

"A Comprehensive Water and Related Land Resources Plan for the State of Montana"

WATER USE IN MONTANA

Inventory Series Report No. 13

April 1975

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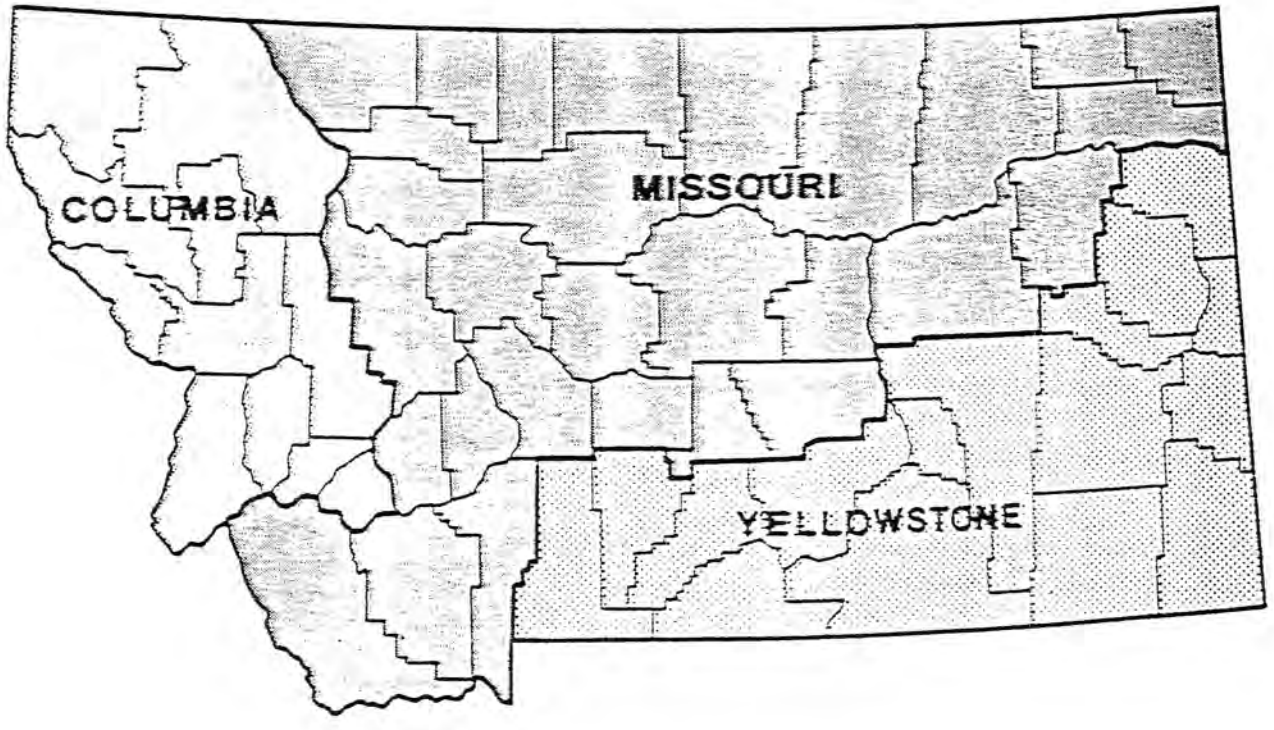
INTRODUCTION

Information on water use in Montana prior to 1970 is found in only a few publications of federal agencies and in the county water resources (irrigation) surveys of the former State Engineer's Office, State Water Conservation Board, and Montana Water Resources Board. While communities have the best opportunity to record water use, in most instances they have no means of measuring the water delivered from their systems. Similarly, it is difficult to estimate the use of water for rural, agricultural, and industrial purposes because no measurement exists.

This report was prepared in an attempt to present recent water use information, estimating both consumptive and nonconsumptive and withdrawal and instream uses that are capable of being measured, but in most cases are not. Quantities of water used were counted in the inventory as the amounts withdrawn, thereby including wastage and loss. If the same water was withdrawn, used, and discharged several times, the water was counted each time it was withdrawn. Figures of water withdrawals are arranged to show location of use, nature of use, and source of supply. Evaporation from stream channels, transpiration from non-irrigated vegetation, and consumption by wildlife are not included.

The data were tabulated both by county and by major river basin. River basin tabulations were accomplished by grouping entire counties to approximately conform with the various drainage basin boundaries. Map 1 (below) illustrates the three major basins in Montana.

MAJOR RIVER BASINS IN MONTANA
(APPROXIMATED ALONG COUNTY LINES)



Map 1

All figures within this report are in million gallons per day (mgd) or, where appropriate, in acre-feet per year (afy). The following water equivalency table can be used in converting one unit of water measurement to another.

TABLE 1 WATER EQUIVALENTS

1 cubic foot . . . . . 7.48 gallons	62.4 lbs. of water
1 acre-foot . . . . . 43,560 cubic feet	325,900 gallons
1 cubic foot per second (cfs)	448.8 gallons per minute
1 cfs = 40 Mont. statutory miner's inches	
1 cfs	646,272 gallons per day
For 24 hours	1.983 acre-feet
For 30 days	59.5 acre-feet
For 1 year	724 acre-feet
1 million gallons	3.07 acre-feet
1 million gallons per day (mgd)	1,122 acre-feet per year
1,000 gallons per minute (gpm)	2.23 cfs
1,000 gpm	4.42 acre-feet per day

An acre-foot covers one acre of land to a depth of one foot.

WITHDRAWAL USES

Withdrawal use is any use which requires removal of water from a source of supply such as a stream or well. Withdrawal uses are grouped into six categories: irrigation, thermoelectric[1], self-supplied industry,[2] municipal and industrial, livestock, and rural domestic.

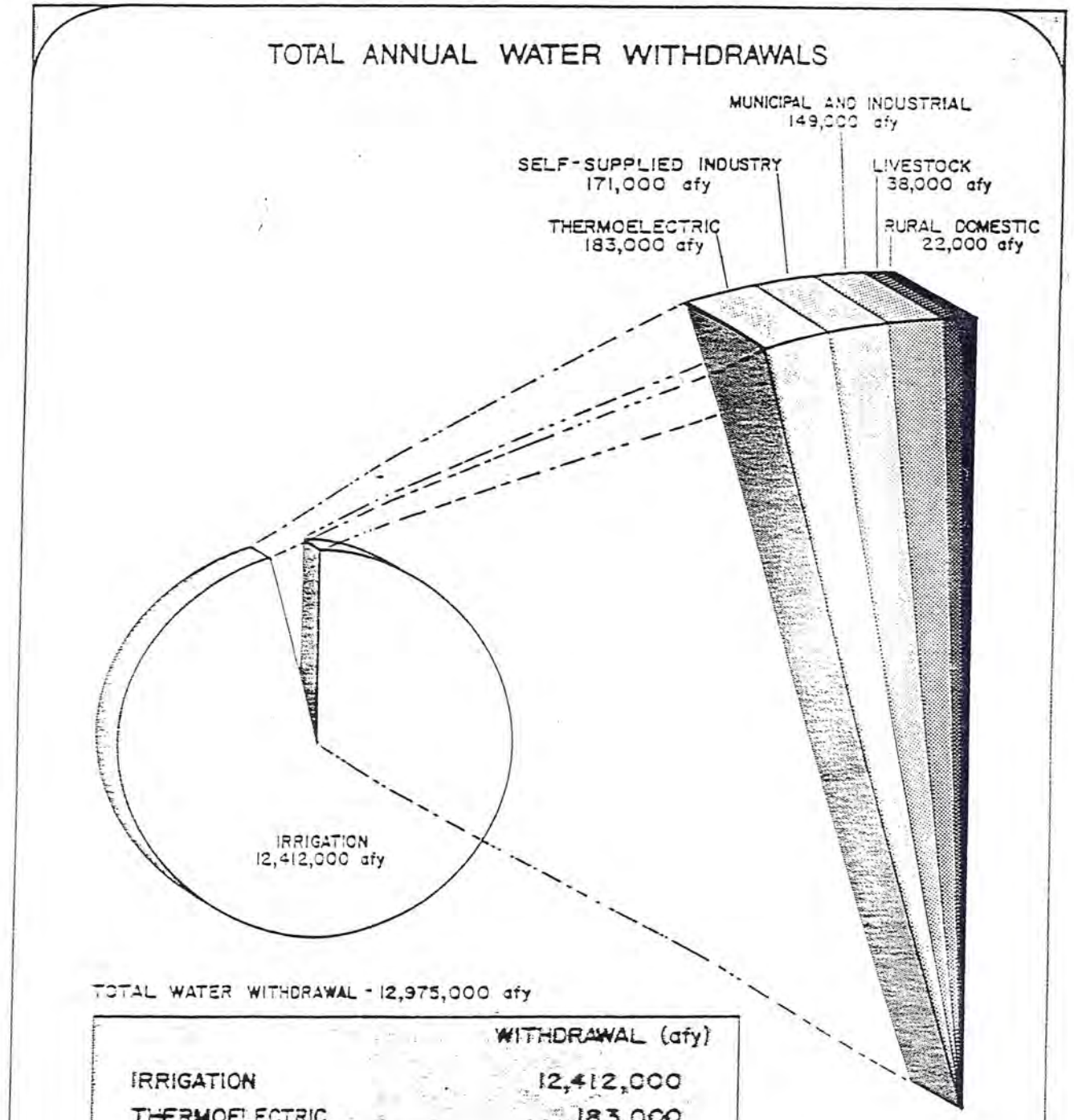
Removal of water from its source through some type of channel generally provides an opportunity for either measuring or estimating the amount of water withdrawn. However, because little or no treatment is required of most of Montana's water, and because there are usually no special waste disposal problems, little measurement is done.

Figure 1 (opposite) illustrates the estimated quantities of water withdrawn annually for the six categories of water use. Later discussions will concern source of supply, daily use, and county and river basin withdrawals.

Withdrawal use of water can be classified as either non-consumptive or consumptive. Much of the withdrawal use is non-consumptive; that is, the water is withdrawn from its source, used, and subsequently returned to the same or another source where it again becomes available for withdrawal. Consumptive use, however, precludes further use of the water because it is evaporated, incorporated into products or crops, consumed by man or animals, or otherwise removed from the immediate environment. Consumptive use is important because it represents actual depletion of the supply.

[1] Thermoelectric water is that used for cooling in the production of electric power from heat sources such as coal.

[2] Self-supplied industrial water is that which is obtained from the source by the industry as opposed to an industrial supply provided by a municipality.



TOTAL WATER WITHDRAWAL - 12,975,000 afy

	WITHDRAWAL (afy)
IRRIGATION	12,412,000
THERMOELECTRIC	183,000
SELF-SUPPLIED INDUSTRY	171,000
MUNICIPAL AND INDUSTRIAL	149,000
LIVESTOCK	38,000
RURAL DOMESTIC	22,000

Figure 1

IRRIGATION

Irrigation water is that which is applied to the land in an effort to grow crops for human or livestock consumption. Rainfall is normally not sufficient for good crop growth, and 95.7% of the water withdrawn in Montana is for irrigation.

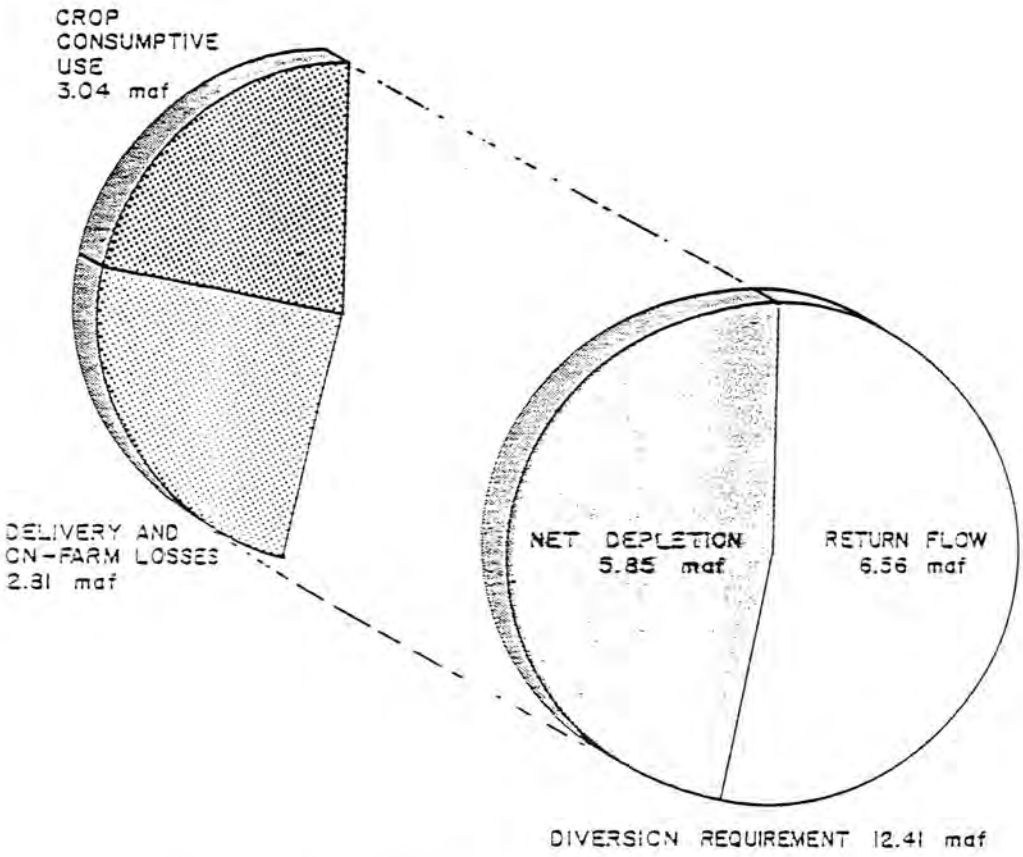
Irrigation began as early as 1842 and has increased steadily, until now over 2½ million acres are fully or partially irrigated. Although gravity ditch and lateral systems have been by far the most extensively used, sprinkler systems are becoming more and more popular, using easily portable aluminum pipe with pumps or gravity feed drawing from streams, ponds, or wells.

Total water use for irrigation amounts to 12.4 million acre-feet of water (22,165 mgd) over a six-month irrigation season each year. Surface water sources yield 99% of this water, while 1% is ground water. Figure 2 (opposite) illustrates the net depletion and return flow from irrigation water use in Montana.

Irrigation water use estimates were based on the number of acres irrigated and the consumptive use of water by crops. Average crop requirements were obtained from information supplied by the Soil Conservation Service of the U.S. Department of Agriculture. Requirements for diversion are more than double consumptive use, resulting in a return flow of 53% of the total withdrawal. Consumptive use varies with irrigation efficiency and such factors as the soil, crop, growing season, temperature, and precipitation. In the early months of April, May, and June, as well as the later months of September and October, the need for irrigation water is less than during the hot, dry months of July and August.

Total acres irrigated, diversion requirement, net depletion, and return flow by county are presented in Table 2 (Page 8), while diversions and depletions by river basin are illustrated in Figure 3 (Page 7).

IRRIGATION WATER USE



DIVERSION REQUIREMENT	12.41 maf
RETURN FLOW	6.56 maf
NET DEPLETION	5.85 maf
CROP CONSUMPTIVE USE	3.04 maf
DELIVERY & ON-FARM LOSSES (Evaporation, Evapotranspiration, & Deep Percolation)	2.81 maf

Figure 2

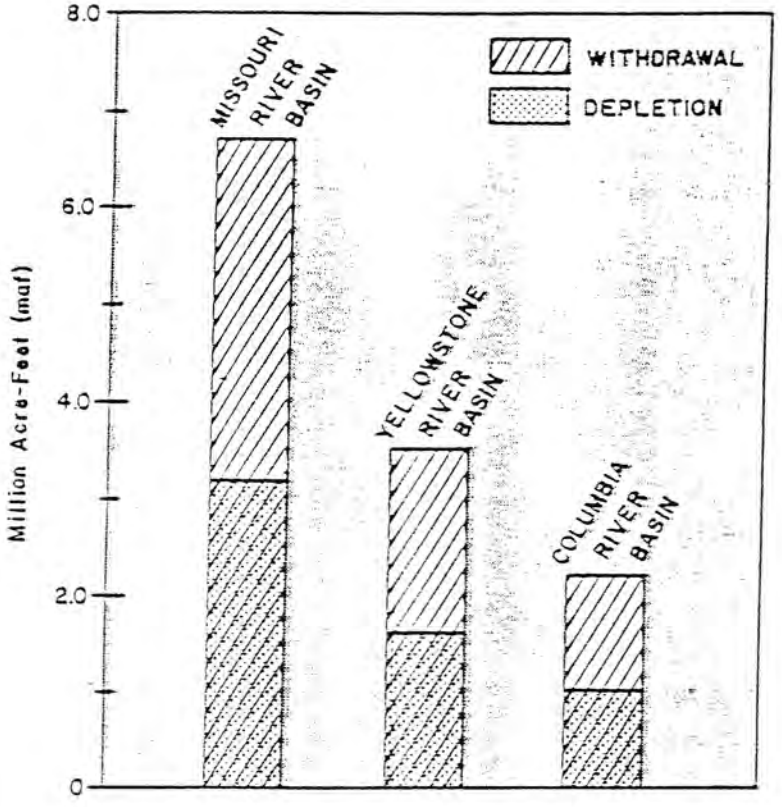
TABLE 2 WATER USE FOR IRRIGATION (BY COUNTY)

County	Acres Full Service	Acres Partial Service[1]	Acres Full Equivalent	Diversion Requirement (Acre-Feet/Year)	Net Depletion[2] (Acre-Feet/Year)	Return Flow (Acre-Feet/Year)
Beaverhead	268,895		268,895	1,087,130	512,582	574,548
Big Horn	65,569		65,569	394,334	185,929	208,405
Blaine	53,838	11,147	64,411	385,759	181,885	203,874
Broadwater	42,642		42,642	226,604	106,844	119,760
Carbon	96,362		96,362	559,719	263,907	295,812
Carter	700	43,443	22,421	140,756	66,366	74,390
Cascade	45,978		45,978	251,991	118,814	133,177
Choteau	13,011		13,011	77,241	36,419	40,822
Custer	22,745	14,597	30,043	202,277	95,374	106,903
Daniels	1,050	1,852	1,976	12,584	5,933	6,651
Dawson	16,722	3,714	18,579	118,347	55,801	62,546
Deer Lodge (c)	12,332	375	13,010	62,927	29,670	33,257
Deer Lodge (m)	8,469	142	8,540	22,064	10,496	11,568
Fallon	300	2,577	1,588	9,959	4,696	5,263
Fergus	20,274	773	20,660	80,286	37,855	42,431
Flathead	27,725		27,725	117,690	55,491	62,199
Gallatin	131,309	1,034	131,826	642,571	302,972	339,599
Garfield	1,100	8,435	5,317	40,661	18,682	21,979
Glacier	25,397		25,397	95,213	44,893	50,320
Golden Valley	2,583	2,464	3,910	27,934	13,171	14,763
Granite	36,693		36,693	145,556	68,629	76,927
Hill	9,328		9,328	61,559	29,025	32,534
Jefferson	26,280		26,280	127,416	60,077	67,339
Judith Basin	18,362		18,362	86,086	40,589	45,497
Lake	111,208		111,208	640,351	301,925	338,426
Lewis and Clark (c)	1,899		1,899	6,694	3,156	3,538
Lewis and Clark (m)	36,326		36,326	183,441	86,492	96,949
Liberty	9,500	2,947	4,923	29,576	13,940	15,636
Lincoln	7,370		7,370	44,143	20,813	23,330
Madison	125,525	3,190	125,120	632,580	298,261	334,319
McCone	5,933	4,519	8,192	44,457	20,961	23,496
Meagher	44,424	3,151	45,999	211,719	99,825	111,894
Mineral	1,736		1,736	10,681	5,036	5,645
Missoula	34,847		34,847	205,534	96,909	108,625
Musselshell	5,752	2,177	6,840	47,101	22,208	24,893
Park	88,522	415	88,729	374,359	176,510	197,849
Petroleum	11,353	2,945	13,325	83,849	39,535	44,314
Phillips	51,503	36,637	69,321	436,816	205,959	230,857
Pondera	124,618		124,618	363,886	171,572	192,314
Powder River	10,741	22,445	21,963	131,327	62,016	69,512
Powell	88,262		88,262	249,776	117,769	132,007
Prairie	10,158	3,769	12,042	71,267	33,598	37,669
Ravalli	104,569		104,569	584,473	275,579	308,894
Richland	39,836	1,919	40,795	223,306	105,299	118,017
Roosevelt	13,676	4,346	15,849	94,853	44,723	50,130
Rosebud	22,338	5,038	24,857	156,649	74,803	83,846
Sanders	29,147		29,147	178,180	84,012	94,168
Sheridan		4,191	2,095	10,833	5,108	5,725
Silver Bow (c)	1,765	664	2,097	10,327	4,869	5,458
Silver Bow (m)	2144	433	4,360	24,086	11,356	12,730
Stillwater	84,721		84,721	217,110	102,367	114,743
Sweet Grass	66,383	661	66,658	340,527	160,558	179,969
Teton	141,014		141,014	619,730	292,203	327,527
Toole	8,078	4,365	5,510	25,976	12,248	13,728
Treasure	19,340	1,891	20,285	131,160	61,861	69,329
Valley	82,757	17,339	91,426	348,534	164,334	184,200
Wheatland	29,290	7,337	32,948	162,534	71,920	80,614
Wibaux	141	150	216	1,200	566	634
Yellowstone	95,655		95,655	549,029	258,867	290,162
STATE TOTAL	2,314,785	220,362	2,424,966	12,411,938	5,851,827	6,560,111

c = Columbia Basin
m = Missouri Basin

[1] Acres partial service are those which receive less than the full water requirement.
[2] Crop requirement, delivery loss, evaporation.

IRRIGATION WATER USE BY RIVER BASIN
APRIL - OCTOBER



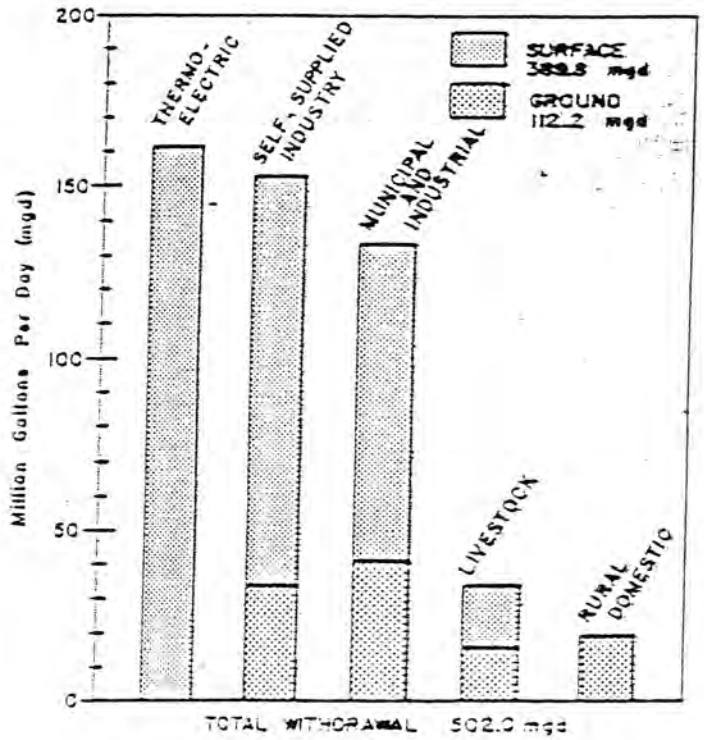
	WITHDRAWAL (maf)	DEPLETION (maf)
MISSOURI RIVER BASIN	6.71	3.16
YELLOWSTONE RIVER BASIN	3.49	1.65
COLUMBIA RIVER BASIN	2.21	1.04

Figure 3

OTHER WITHDRAWAL USES

The five remaining uses of water account for 502 mgd, or 4.3% of the total water withdrawn for use in Montana. Only 125.5 mgd (25% of the water withdrawn) is consumed, and only 93 mgd (18.5%) is ground water. Figure 4 (below) illustrates total water withdrawals for uses other than irrigation by source

WITHDRAWALS BY SOURCE (USES OTHER THAN IRRIGATION)



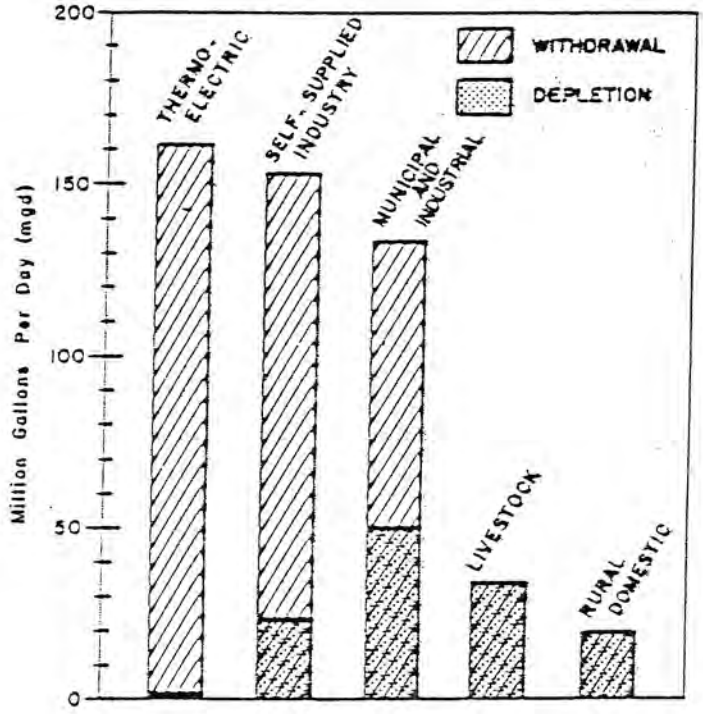
	GROUND (mgd)	SURFACE (mgd)	TOTAL WITHDRAWAL (mgd)
THERMOELECTRIC	0.0	163.0	163.0
SELF-SUPPLIED INDUSTRY	33.9	118.8	152.7
MUNICIPAL AND INDUSTRIAL	41.9	91.2	133.1
LIVESTOCK	16.8	16.8	33.6
RURAL DOMESTIC	19.6	0.0	19.6

Figure 4

of supply, while Figure 5 (below) illustrates the depletions of these same withdrawals.

Table 3 (Page 10) and Figure 6 (Page 11) show withdrawals for uses other than irrigation by county and by river basin, respectively.

ANNUAL WITHDRAWALS & DEPLETIONS (USES OTHER THAN IRRIGATION)



	WITHDRAWAL (mgd)	DEPLETION (mgd)
THERMOELECTRIC	163.0	0.3
SELF-SUPPLIED INDUSTRY	152.7	22.9
MUNICIPAL AND INDUSTRIAL	133.1	49.0
LIVESTOCK	33.6	33.6
RURAL DOMESTIC	19.6	19.6

Figure 5

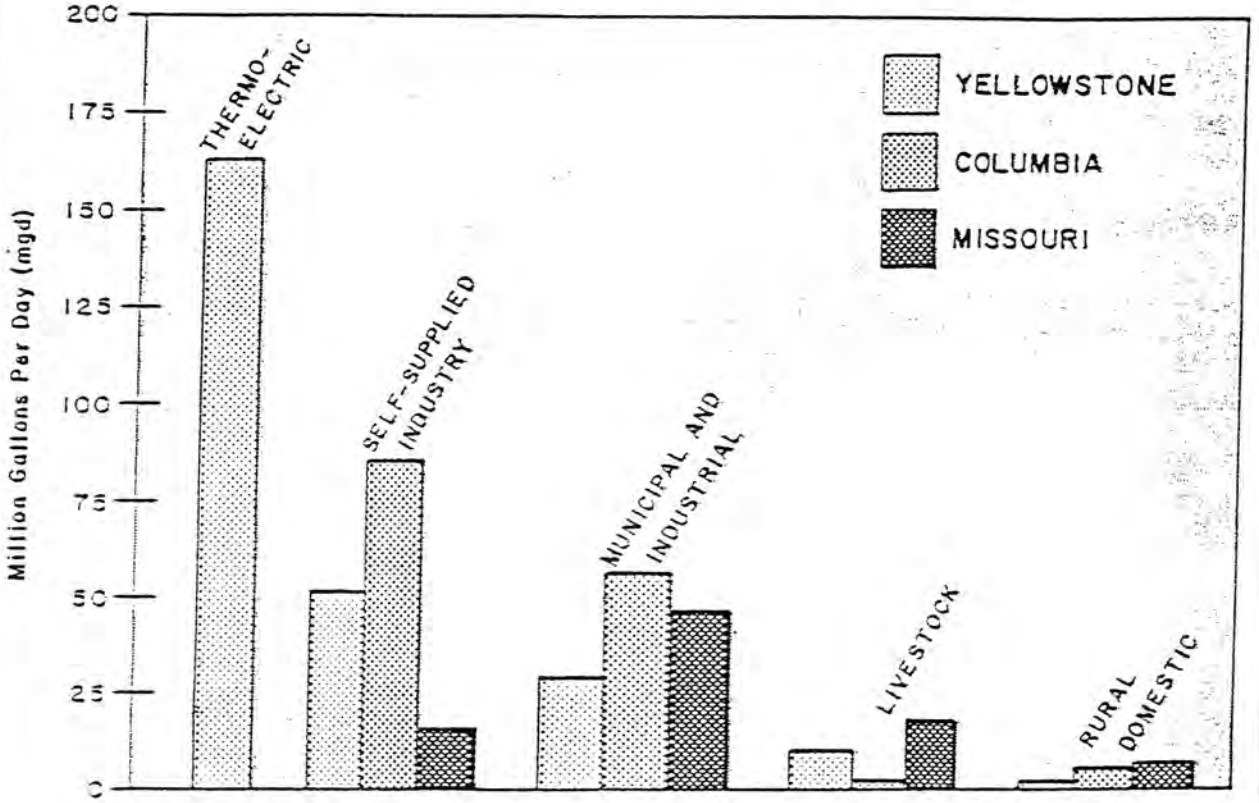
TABLE 3 WITHDRAWALS OF WATER BY COUNTY (USES OTHER THAN IRRIGATION)

(million gallons per day)

COUNTY	COMMUNITY WATER SYSTEMS G.W.[1]	S.W.[2]	TOTAL	RURAL DOMESTIC G.W.[1]	LIVE-STOCK	SELF-SUPPLIED INDUSTRY G.W.[1]	S.W.[2]	TOTAL	THERMO-ELECTRIC	TOTAL
Beaverhead	.639	.558	1.197	.329	1.750	.107		.107		3.383
Big Horn	.235	.791	1.026	.497	1.240		1.010	1.010		3.773
Blaine		.703	.703	.362	1.040	.027	.063	.090		2.195
Broadwater	.310		.310	.115	.390					.815
Carbon	.512	.679	1.191	.349	.710					2.250
Carter	.080		.080	.129	.800					1.009
Cascade	1.016	13.719	14.735	.609	.980	1.814	9.102	10.916		27.240
Choteau	.355	.674	1.029	.325	.740		.009	.009		2.103
Custer	.390	1.558	1.948	.310	.790	.436		.436		3.484
Daniels	.350		.350	.141	.260					.751
Dawson	.489	.991	1.480	.302	.620				1.0	2.402
Deer Lodge	3.768	.658	4.426	.383	.130	.008	31.900	31.908		36.847
Fallon	.516		.516	.128	.360					1.004
Fergus	2.006		2.006	.526	1.230		.072	.072		3.834
Flathead	2.846	2.447	5.293	1.962	.380	4.230	.288	4.518		12.153
Gallatin	.695	5.125	5.820	1.048	1.020	.626		.626		8.514
Garfield	.047		.047	.127	.810					.984
Glacier	.611	.741	1.352	.473	.460	.130	.019	.149		2.434
Golden Valley	.100		.100	.067	.280					.447
Granite	.059	.236	.295	.161	.370	.118	.091	.209		1.035
Hill	.964	.277	1.241	.510	.420	.041	.019	.060		2.231
Jefferson	.939	.021	.960	.166	.270	1.350		1.350		2.766
Judith Basin	.146		.146	.202	.630	.009		.009		.987
Lake	.738	1.109	1.847	.386	.820	.228		.228		3.781
Lewis and Clark	.214	8.116	8.330	.385	.660	.601	1.190	1.691		11.456
Liberty		.293	.293	.116	.190					.599
Lincoln	.117	2.313	2.430	1.183	.100	.173	2.880	3.053		6.766
Madison	.508		.508	.072	1.140	.056		.056		1.776
McCone	.095		.095	.405	.560					1.060
Meagher	.024	.666	.690	.077	.700	.040	.008	.048		1.515
Mineral	.527	.023	.550	.151	.220	.078		.078		.999
Missoula	9.308	15.243	24.551	.946	.240	18.150	.600	18.750		44.487
Musselshell	.493		.493	.131	.440					1.064
Park	.361	1.763	2.124	.318	.610	.026		.026		3.078
Petroleum	.061		.061	.040	.380					.481
Phillips	.489		.489	.264	1.160					1.913
Pondera	.210	.689	.899	.294	.420	.043		.043		1.656
Powder River	.146		.146	.176	.730		.008	.008		1.060
Powell	1.494	.477	1.971	.036	.630	.023		.029		2.664
Prairie			0	.175	.390					.565
Ravalli	1.589	.137	1.726	1.054	.680	.374		.374		3.834
Richland	1.223		1.223	.434	.710	.043	1.175	1.223	30.0	33.590
Roosevelt	.982	.181	1.163	.240	.460	.915		.915		2.778
Roseoue	.671	.333	1.004	.068	.810		.049	.049		1.931
Sanders	.300	.655	.955	.321	.270	.082		.082		1.628
Sheridan	.517		.517	.272	.350					1.139
Silver Bow	.018	12.320	12.338	.183	.080	3.000	23.100	26.100		38.701
Stillwater	.634		.634	.279	.510					1.823
Sweet Grass	.855		.855	.139	.570					1.564
Teton	.733		.733	.348	.700	.006		.006		1.787
Toole	.855		.855	.152	.230	.762		.762		2.049
Treasure	.125		.125	.070	.250					.445
Valley	.953	.760	1.713	.441	1.000	.034	.241	.275		3.429
Wheatland	.307		.307	.093	.420	.008		.008		.828
Wibaux	.060		.060	.082	.260					.402
Yellowstone	.187	16.976	17.163	.062	1.250	.482	46.970	47.452	132.0	197.927
TOTAL	41.867	91.232	133.099	19.633	33.660	33.930	118.794	152.724	163.0	502.116

[1] G.W. - Ground Water
[2] S.W. - Surface Water

WITHDRAWALS BY RIVER BASIN (USES OTHER THAN IRRIGATION)



	YELLOWSTONE (mgd)	COLUMBIA (mgd)	MISSOURI (mgd)	MONTANA (mgd)
THERMOELECTRIC	163.0	0.0	0.0	163.0
SELF-SUPPLIED INDUSTRY	50.2	85.3	17.2	152.7
MUNICIPAL AND INDUSTRIAL	29.5	56.4	47.2	133.1
LIVESTOCK	10.7	3.9	19.0	33.6
RURAL DOMESTIC	3.5	7.3	8.8	19.6

Figure 6

Thermoelectric

Thermoelectric water is that used for the cooling of power plants using heat sources such as oil, gas, coal, diesel fuel, or wood waste. Public utility thermoelectric plants, although a type of self-supplied industry, are treated as a separate water use category in this inventory. Table 4 (below) lists the eight plants in Montana, their sources of energy, and sources and amounts of water. The plants' locations are shown on Map 2 (Page 19), which also indicates the site of Colstrip Units 1 and 2, 350 megawatt coal-fired generating plants currently under construction.

182,500 afy (163 mgd) of thermoelectric water is withdrawn from surface-water sources, primarily the Yellowstone River. Of this amount, which represents 1.4% of the total state withdrawal, only 336,000 gallons per day (.2%) is consumed. When completed, Colstrip Units 1 and 2 will use an additional 16,000 afy.

The larger thermoelectric plants use small quantities of self-supplied ground water or water from a public supply for boiler feed, air conditioning, and sanitation. Most of the water is used for cooling purposes, however, and is pumped from the supplying stream, circulated through the condensers, and returned to the stream. Because very little water is evaporated or consumed in this once-through, direct-discharge system, virtually all of the water used by existing thermoelectric plants remains available to downstream water users. Ordinarily, the quality of the water discharged is affected only by an increase in temperature.

TABLE 4 THERMOELECTRIC WATER USE

Plant	Energy Source	Water Source	Water Withdrawal
J. E. Corette - Billings	Coal	Yellowstone River	82 mgd
Frank Bird - Billings	Oil	Yellowstone River	50 mgd
Lewis & Clark - Savage	Coal	Yellowstone River	30 mgd
Glendive	Gas	Yellowstone River	1 mgd
Miles City	Gas Turbine	None	None
Baker	Gas	City Ground Water	Insignificant
Libby	Wood Waste	Libby Creek (Log Pond)	Insignificant
Libby	Diesel	Ground Water	Insignificant
			163 mgd

Self-Supplied Industry

Self-supplied industrial water refers to that which is obtained from the source of supply by industry as opposed to that provided by a municipality. In this inventory, an industry is considered to be self-supplied if any of the water it uses is obtained from its privately owned water supply facilities. Many industries also purchase additional water from public water systems, but that water will be included under the category of municipal and industrial water supply.

Industries use water for many purposes, including condenser cooling, processing, washing, conveying, air conditioning, boiler feeding, and sanitation. Not all of these uses require water of the same quality, and many industries find it advantageous to use water from different sources for different purposes. For example, a plant may use untreated surface water pumped directly from a river for condenser cooling, while using water from a well or a public supply for the more critical requirements of processing and boiler feed.

Estimates of self-supplied industrial water use compiled by the U.S. Geological Survey have been used in this report.[3] The figures do not include water supplied for the production of thermoelectric power.

Self-supplied industrial water accounts for 1.3% of the total withdrawals in the state, or 171,000 acre-feet per year (152.7 mgd). Of this amount, 22% is ground water, and 78% is surface water.

Some 23 mgd, or 15% of the amount withdrawn, is consumed.[4] Examples of consumptive use by industry are water evaporated to the atmosphere from cooling towers, water canned or bottled in foods or beverages, and water absorbed or chemically combined into a manufactured product, such as concrete.

Municipal and Industrial

Municipal and industrial water is that obtained from a public water supply, whether publicly or privately owned. In Montana, rules and regulations of the Montana Department of Health and Environmental Sciences define a public water supply as one supplying 10 users or 25 persons. Such supplies must be installed and operated under the surveillance and with the approval of that Department.

Water from public supplies is used for residential purposes and lawn watering; for sanitary purposes by commercial establishments, public institutions, and military installations; for manufacturing purposes by industrial plants; and for numerous unbilled public services such as street washing, fire fighting, and operating public buildings, parks, and swimming pools. Some water cannot be accounted for because all water systems leak to some extent.

This inventory summarizes water use data for public (municipal) water systems that in 1970 were serving 191 cities, towns, or communities in Montana. The primary source of data was a questionnaire sent to public water utilities serving 25 persons or more. Response to the questionnaire was unusually good — about 75%. Data for the smaller water systems, and for those communities not responding to the questionnaire, were obtained from estimates of water use and through supplemental information furnished by the Montana Department of Health and Environmental Sciences and the U.S. Geological Survey.

Total municipal and industrial water use in 1970 was estimated at 149,000 acre-feet per year (133.1 mgd), or 1.1% of all water withdrawn in the state (Figure 7, page 14). Surface water accounted for 68%, or 91.2 mgd, while ground water supplied 32%, or 41.9 mgd.

While public water supplies served approximately 498,000 persons, or 72% of the state's population in 1970, they also served many commercial and industrial establishments. Statewide, 38% of a community's water is used by industry, while 62% serves residential uses. While residential uses consume approximately 50% of the water used, industry consumes only 15%.

Figure 8 (page 15) illustrates populations served and the sources of supply. Not shown is the fact that, while a majority of communities in Montana use ground water, more persons are served by surface water because the larger communities all obtain their supplies from surface water sources.

Water use ranges from 42 to 1,169 gallons per capita day (gpcd), with the statewide average being 267 gpcd. Figure 9 (Page 16) presents a comparison of per capita water use in Montana.

Much of the water withdrawn for public water supplies is returned through a surface stream or an underground source from which it again becomes available to other users. It is estimated that up to 60% of the water provided by municipal systems is consumed in lawn sprinkling through the evapotranspiration process. This water is entirely lost to the atmosphere, while household water is returned to a surface or ground-water source.

Using U.S. Geological Survey estimates, 50% of total residential use, or 41.5 mgd, is consumed, plus 15% of total industrial use, or 7.5 mgd, for a total consumptive use from public water supplies in Montana of about 49 mgd.[5]

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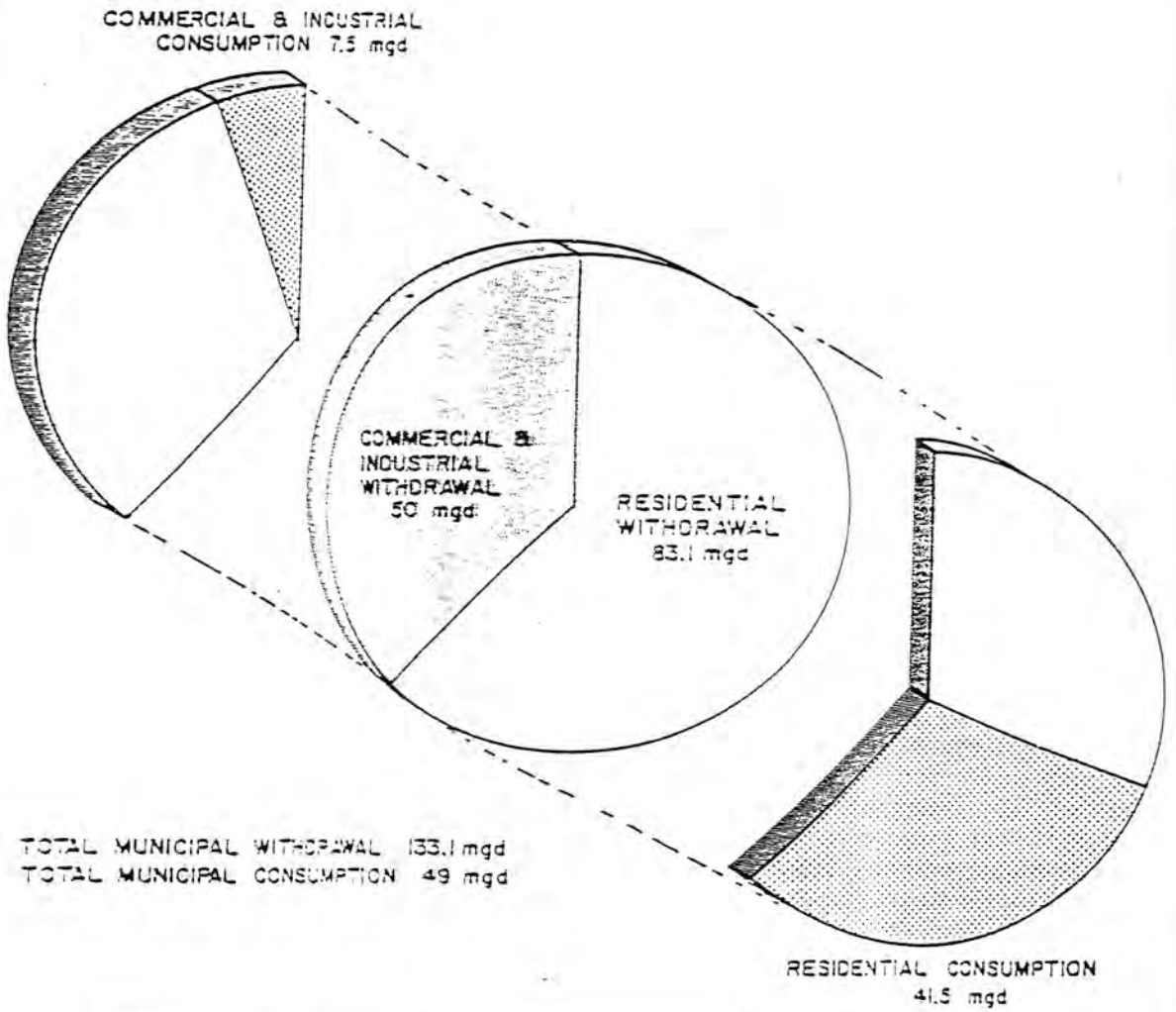
[3] Unpublished data, Water Resources Division, U.S. Geological Survey, Helena, Montana.

[4] Ibid.

[5] Ibid.

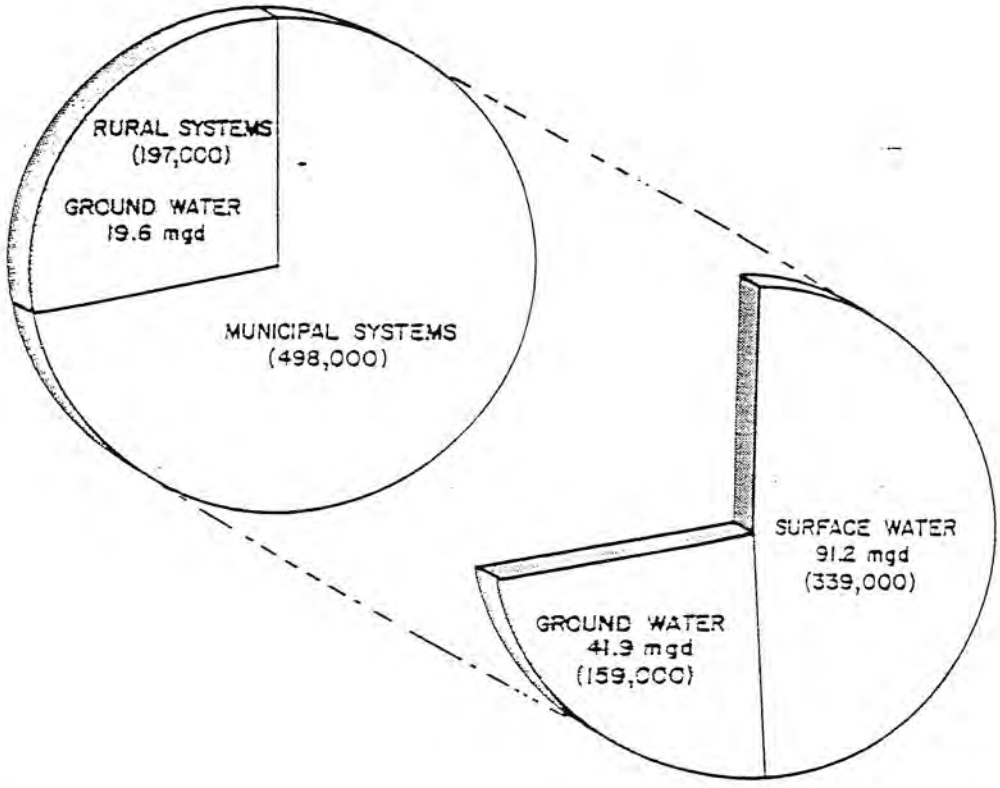
MUNICIPAL & INDUSTRIAL WATER USE AND CONSUMPTION



RESIDENTIAL WITHDRAWAL	83.1 mgd	
COMMERCIAL & INDUSTRIAL WITHDRAWAL	50.0 mgd	
TOTAL MUNICIPAL & INDUSTRIAL WITHDRAWAL		133.1 mgd
RESIDENTIAL CONSUMPTION	41.5 mgd	
COMMERCIAL & INDUSTRIAL CONSUMPTION	7.5 mgd	
TOTAL MUNICIPAL & INDUSTRIAL CONSUMPTION		49.0 mgd

Figure 7

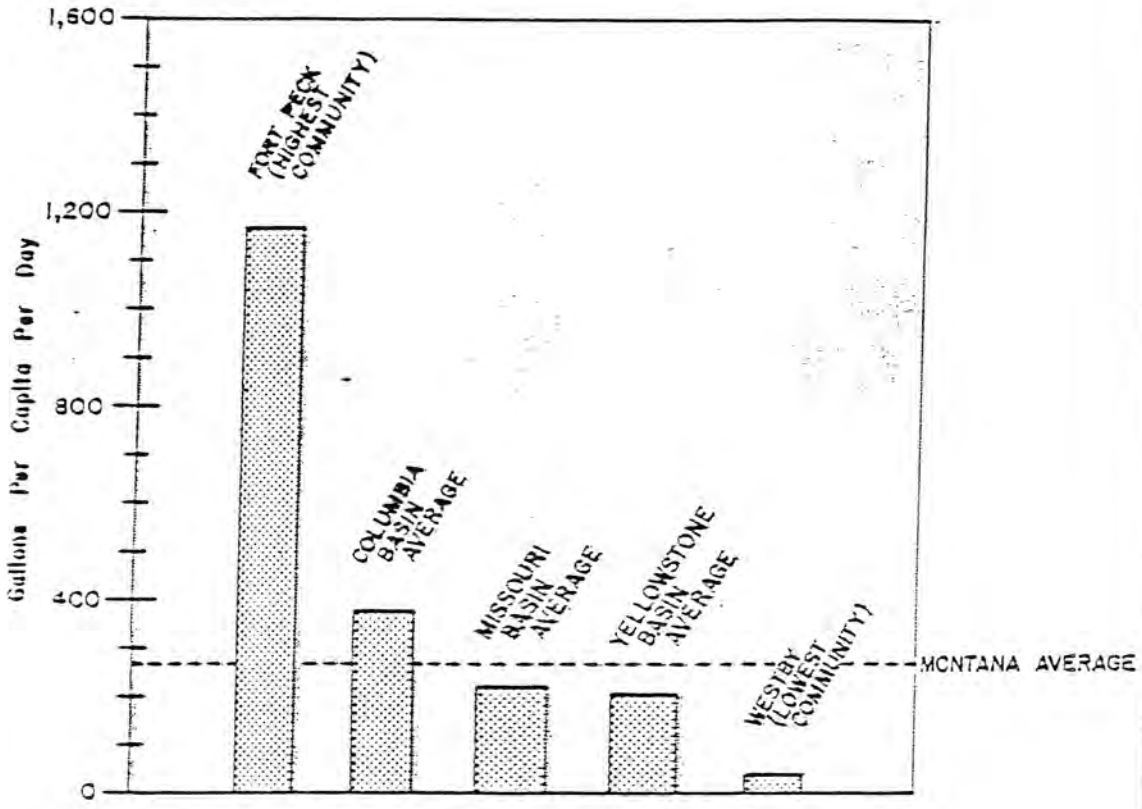
POPULATION SERVED BY SOURCE



	POPULATION SERVED	WITHDRAWAL (mgd)
MUNICIPAL SYSTEMS	498,000	133.1
SURFACE WATER	339,000	91.2
GROUND WATER	159,000	41.9
RURAL SYSTEMS	197,000	19.6
TOTAL	695,000	152.7

Figure 8

PER CAPITA MUNICIPAL WATER USE



	PER CAPITA MUNICIPAL WATER USE (Gallons Per Capita Per Day)
FORT PECK (HIGHEST COMMUNITY)[1]	1,169
COLUMBIA BASIN AVERAGE	378
MISSOURI BASIN AVERAGE	227
YELLOWSTONE BASIN AVERAGE	210
WESTBY (LOWEST COMMUNITY)[2]	42
MONTANA AVERAGE	267

1. Large usage for lawn and ground care.
2. Estimate; many residents have private water systems.

Figure 9

Livestock

Water used for livestock production was estimated by county on the basis of farm populations and the per capita water consumption of various animals. Livestock numbers as of January 1, 1970, were obtained from the Montana Crop and Livestock Reporting Service and the Montana Department of Agriculture.

Total water use is 38,000 acre-feet per year, or 33.6 mgd, all of which is considered to be consumed. Livestock water, which is estimated to come about equally from surface and ground-water sources, amounts to .3% of all water withdrawn in Montana. Water use was calculated using the following table:

TABLE 5 LIVESTOCK WATER REQUIREMENTS

Animal	Gallons per Head per Day
Milk Cows	30
Beef Cattle	10
Horses	10
Hogs	2
Sheep	1.5
Chickens	.04

Rural Domestic

Rural domestic water is that which is used by all persons not served by a public or municipal water system. The rural population of each county was taken as the total county population, less the county population served by municipal systems.

Because recent estimates of rural water consumption range from 63 gpcd[6] to 150 gpcd[7], the figure of 100 gpcd was used in this report to calculate rural water use in Montana.

The 22,000 acre-feet per year (19.6 mgd) withdrawn for rural uses comes primarily from ground-water wells or springs. Nearly all of the water withdrawn is consumed by the user or by evapotranspiration after being discharged on or immediately below the ground surface. Rural domestic water use accounts for .2% of all water withdrawn in the state.

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[6] C. Richard Murray and E. Bodette Reeves, Estimated Use of Water in the United States in 1970, U.S. Geological Survey Circular 676, Washington, D.C., 1972, p. 4.

[7] Missouri River Basin Interagency Committee, "Present and Future Needs Appendix," Comprehensive Framework Study, June 1969, p. III - 6.

INSTREAM USES

Instream uses of water are those which do not require removal of water from the source of supply. The important instream uses in Montana are hydroelectric power generation, recreation, conservation of fish and wildlife, and dilution of wastes. Several of these uses can be served simultaneously by the same water, provided the necessary water quality standards are maintained.

Unlike withdrawal uses, which can be measured if necessary, these in-channel uses of water do not easily lend themselves to quantitative measurement and, for the most part, are beyond the scope of the present inventory. They are, however, of great importance and have considerable influence on the quantity and quality of water available for withdrawal use.

HYDROELECTRIC POWER

Hydroelectric power generation is sometimes considered a withdrawal use, because the water, while not withdrawn from the stream channel, is diverted momentarily for passage through the turbines. More significantly, water stored in reservoirs is delayed in reaching downstream water users.

In 1970, water power was used to generate electricity at 21 hydroelectric plants in Montana, and one additional plant at Libby Dam was under construction (Map 2, opposite). The estimated use of water by these plants is over 80 million acre-feet per year (72,000 mgd)[3]. With the completion of the Libby Power Plant on the Kootenai River in northwestern Montana, the total use figure will be increased by approximately 7,000 mgd after 1975.

Water use by hydroelectric plants refers to the gross or total volume of water used by all plants on a stream, not to the net or absolute volume of water for the largest plant. Water discharged from each upstream plant is available to other plants downstream, so each plant in turn extracts a share of energy from the same water in its gradual descent seaward. The water of the Missouri River, for example, drives turbines of 10 generating plants whose combined water use is more than the average flow of the river.

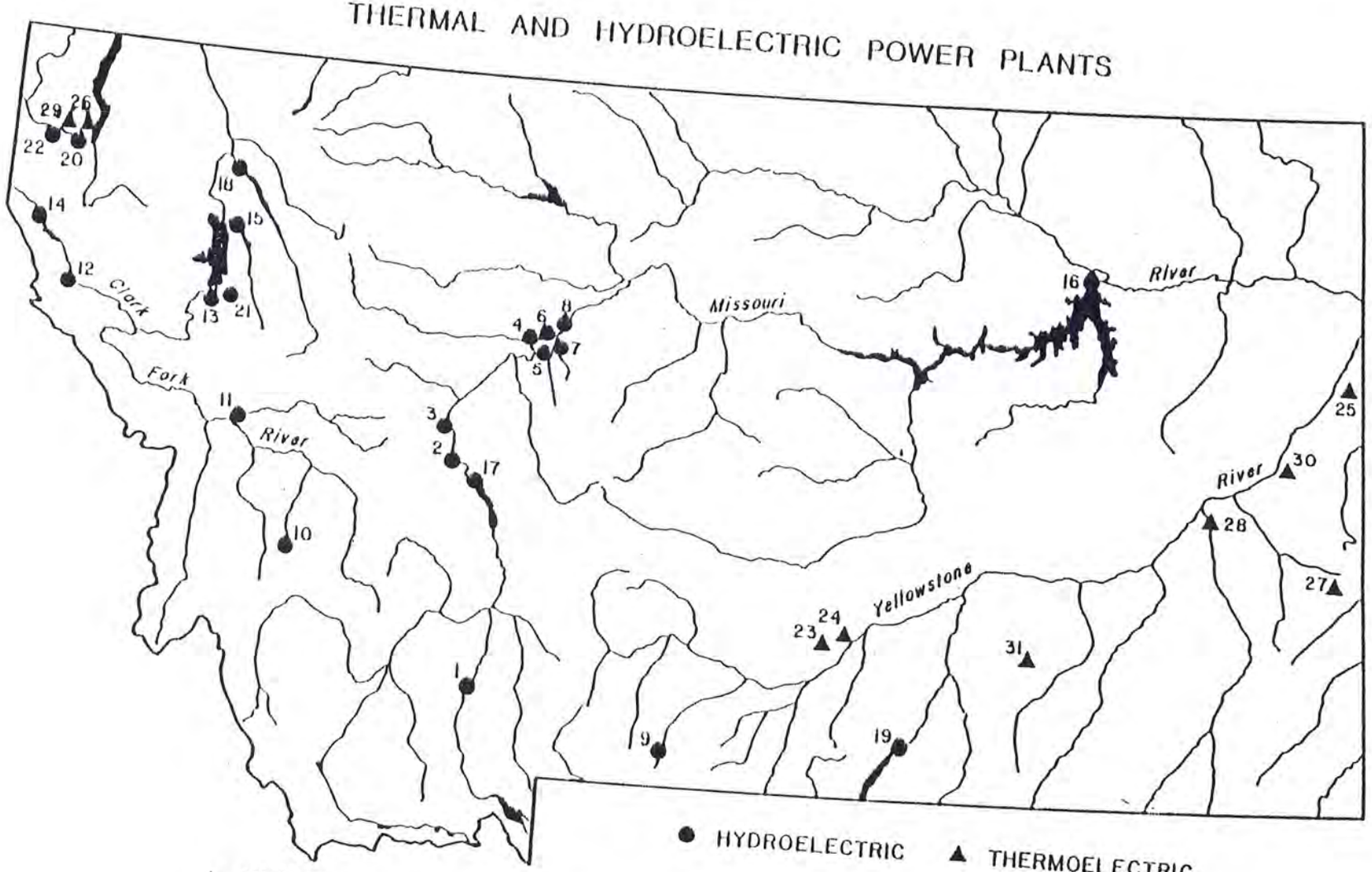
The net water requirement for hydroelectric power generation can be estimated by summing water use at only the downstream (or largest) plant on each stream, as the water reaching those plants must necessarily include that discharged by the plants upstream. On this basis, the net water requirement for hydroelectric power in Montana during 1970 was less than 25 million acre-feet, or 22,000 mgd, based on discharges below the dams shown in Table 6.

TABLE 6 NET HYDROELECTRIC POWER GENERATION REQUIREMENTS

Plant	Stream	Discharge (acre-feet)
Fort Peck	Missouri River	6,309,000
Noxon	Clark Fork River	15,330,000
Mystic Lake	West Rosebud Creek	93,460
Yellowtail	Bighorn River	2,631,000

[3] Murray and Reeves, op. cit. p. 30.

THERMAL AND HYDROELECTRIC POWER PLANTS



1. MADISON
2. HAUSER
3. HOLTER
4. BLACK EAGLE
5. RAINBOW
6. RYAN
7. MORONY
8. COCHRANE
9. MYSTIC LAKE
10. FLINT CREEK
11. MILLTOWN
12. THOMPSON FALLS
13. KERR
14. NOXON
15. BIG FORK
16. FORT PECK
17. CANYON FERRY
18. HUNGRY HORSE
19. YELLOWTAIL
20. LIBBY
21. BIG CREEK
22. TROY
23. FRANK BIRD
24. J.E. CORETTE
25. LEWIS AND CLARK
26. LIBBY
27. BAKER
28. MILES CITY
29. LIBBY
30. GLENDIVE
31. COLSTRIP

Map 2

OTHER INSTREAM USES

Recreation users and fish and wildlife all make substantial use of Montana's instream water resources. Most Montanans and many tourists recreate on or near the state's streams, lakes, and reservoirs. Some 182,000 resident and 205,000 non-resident fishing licenses, for example, were sold in Montana in 1973.

Instream flow requirements for aquatic life are being developed and will one day help document the need for water for this use. In addition, wildlife use of water has been estimated for each type of animal, but no total statewide use has been calculated to date. Table 7 (below) illustrates wildlife water requirements for animals and habitat.

Most of these instream uses would not exist if it were not for good water quality, however, and, although they have not been adequately measured or estimated, the uses are of extreme significance both now and in the future.

Assimilation of pollution is another major use of Montana's water resource. Whether pollution is natural or man-caused, all water courses act as cleansing agents in the environment. In fact, some streams have been classified as industrial wasteways for the carrying of municipal or industrial wastes, and these waterways are unfit for most other uses.[3]

TABLE 7 WATER REQUIREMENTS FOR WILDLIFE

Deer and Anteloce	.8 - 1.5	gallons per head per day
Bighorn Sheep and Mountain Goats	1 - 3	gallons per head per day
Elk	4	gallons per head per day
Other Wildlife	1	acre-foot per 25,000 - 250,000 acres
Waterfowl Habitat	1.5 - 7	acre-feet per acre
Habitat Irrigation	1 - 2	acre-feet per acre

Source: Western U.S. Water Plan, Consumptive Water Requirements for Public Lands Administered by the Bureau of Land Management, October 1974, p. 5.

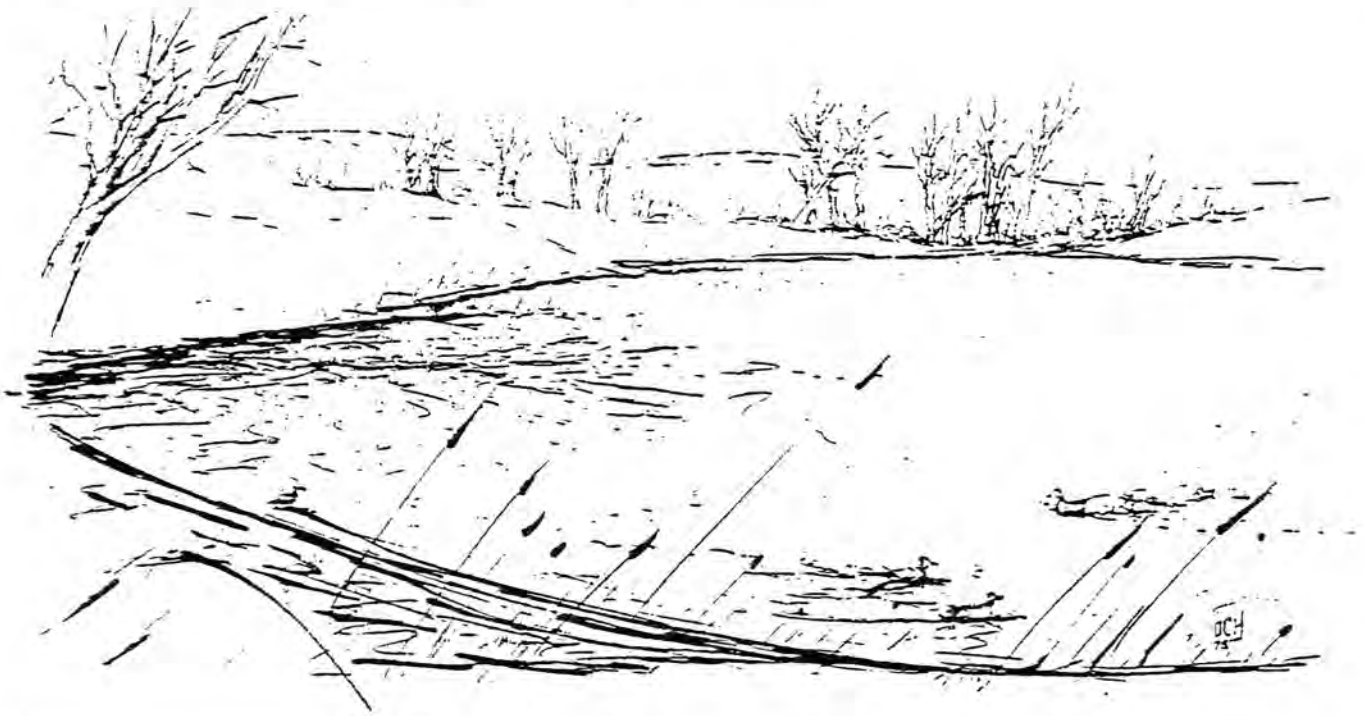
[3] Montana Department of Health and Environmental Sciences, Water Quality Standards, Helena, Montana, November 1973.

STORAGE AND EVAPORATION

Many water uses, both instream and withdrawal, are better served on a year-round basis if some facility for storing water is available to smooth the natural fluctuations in stream flow. Thus, many of the hydroelectric plants in Montana draw on storage reservoirs, and many recreational waters are man-made lakes or ponds. Likewise, many irrigation projects rely on reservoir storage to provide adequate water supplies for crop growth.

In 1968, over 240 reservoirs in Montana each stored 50 acre-feet or more water for such uses.[10] Most of these reservoirs were developed for hydroelectric power, flood control, or fish and wildlife, but many serve such withdrawal uses as irrigation and stock water as well. In addition, over 1,000 other impoundments have been constructed for the sole purpose of irrigation or stock water, and some of these are also used for recreation. The distinction between reservoirs for withdrawal use and for instream use is not important, nor in fact very clearly defined, because most water supply reservoirs also serve such uses as conservation and recreation.

The total area of these water surfaces is about 900,000 acres, or 1,400 square miles, and the total storage is 37.5 million acre-feet. Since annual evaporation from shallow water surfaces in Montana averages between 35 and 47 inches,[11] total evaporation from all reservoirs constitutes a very large quantity of water. This quantity has been estimated at over 1 million acre-feet per year (993 mgd)[12] from reservoir surfaces alone. Although much water would be conserved if evaporation from reservoirs could be entirely suppressed, not all evaporation water loss can be charged directly to the reservoirs. Some was occurring before the reservoirs were built, in the form of evaporation and transpiration from the land areas and stream surfaces later flooded.



[10] Montana Water Resources Board, **Montana Register of Dams**, Helena, Montana, October 1968.

[11] U.S. Department of Agriculture, Soil Conservation Service, **Pond Evaporation**, Technical Notes, Bozeman, Montana, February 1974.

[12] Western U.S. Water Plan, **Montana Report**, State Study Team, August 1973, p. 29.

CONCLUSION

Montana's water supply is not a fixed quantity, but depends upon the amount of precipitation and the quantity of water than can be stored by reservoirs along the state's streams. Total outflow of water from Montana averages nearly 44 million acre-feet per year, or over 39,000 mgd. Present consumptive uses of Montana's water resource, exclusive of evaporation, amount to only 6.7 million acre-feet per year, most of which occurs during the summer irrigation season. Tables 8 and 9 (below) summarize water use for the state and the three major river basins. Figure 10 (opposite) illustrates water consumption.

Irrigation uses the largest amount of water, at least during the summer season. On a yearly average, irrigation accounts for 95.7% of all water removed from the source of supply. Thermoelectric power, self-supplied industry, municipal, industrial, and rural domestic users, and livestock utilize the remaining 4.3% of water withdrawals.

Water for hydroelectric power generation constitutes the largest measurable instream use of the resource. Over 80 million acre-feet of water (72,000 mgd) flow through the 21 hydroelectric plants in Montana (exclusive of Libby Dam). Recreation, fish and wildlife, and the dilution and transportation of wastes are other important uses for instream water supplies.

Storage of water and the evaporation which occurs from water surfaces divert large quantities of water both temporarily and permanently from the available supply.

Map 3 (Page 24) illustrates total water availability and use in Montana. Total use figures indicate that Montana's available water supply is utilized more than twice before leaving the state.

TABLE 8 SUMMARY OF WATER USE IN MONTANA

Use	Withdrawn		Consumed	
	(mgd)	(afy)	(mgd)	(afy)
Irrigation*	11,082.3*	12,412,000	5,367.4*	6,352,000
Thermoelectric	163.0	183,000	.3	376
Self-supplied Industry	152.7	171,000	22.9	26,000
Municipal and Industrial	133.1	149,000	49.0	56,000
Livestock	33.6	38,000	33.6	38,000
Rural Domestic	19.6	22,000	19.6	22,000
	11,584.3*	12,975,000	5,382.3*	6,993,376

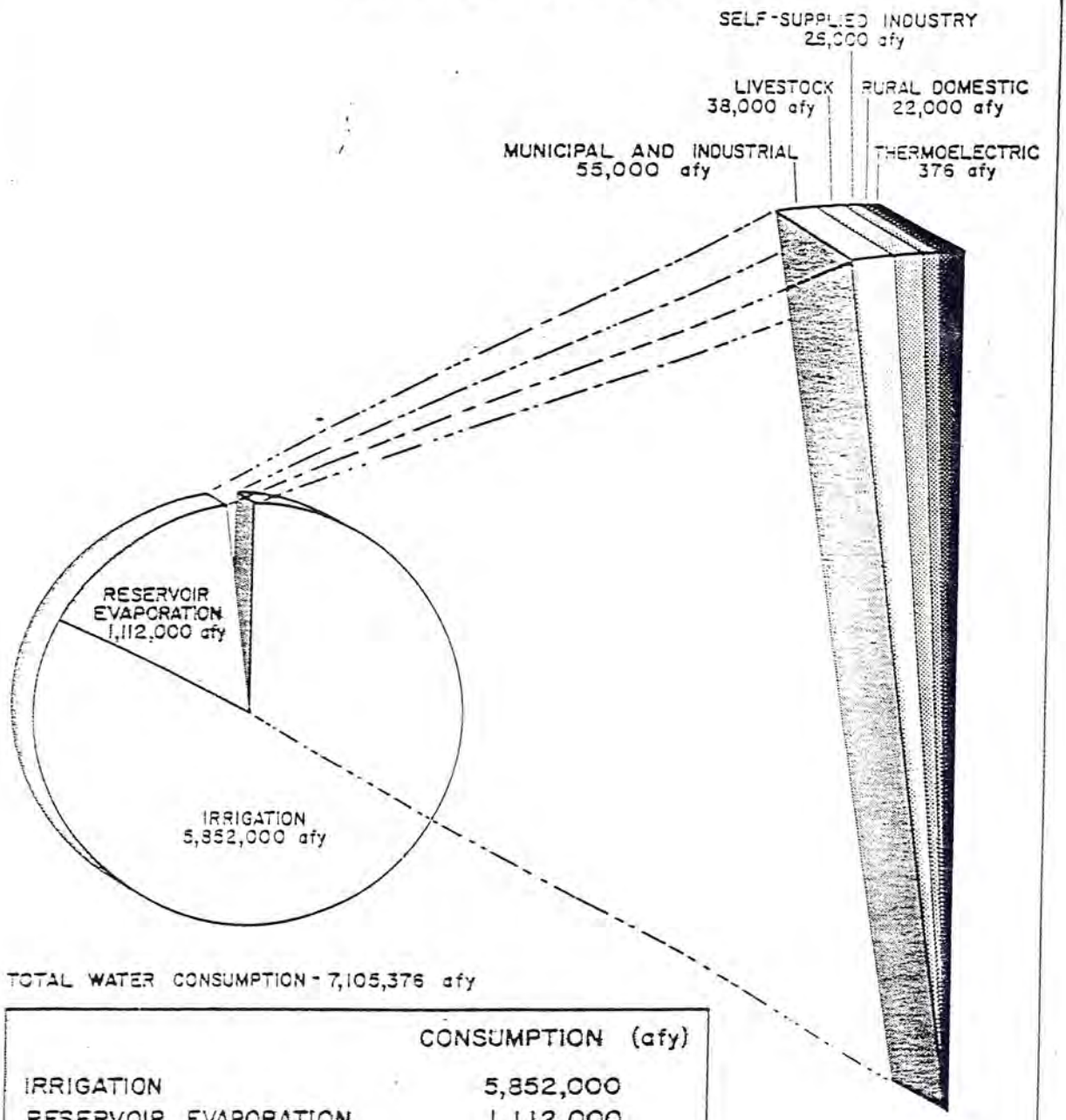
* Irrigation figures in million gallons per day are averages over a one-year period. MGD figures should be doubled to represent per day withdrawals during the six-month irrigation season.

TABLE 9 WATER WITHDRAWALS IN MONTANA BY RIVER BASIN

Use	Columbia Basin		Missouri Basin		Yellowstone Basin		Montana	
	mgd	afy	mgd	afy	mgd	afy	mgd	afy
Irrigation*	2,053.6*	2,211,000	6,071.6*	6,710,000	2,946.5*	3,491,000	11,071.7*	12,412,000
Thermoelectric	0	0	0	0	163.0	183,000	163.0	183,000
Self-supplied Industry	85.3	96,000	17.2	19,000	50.2	56,000	152.7	171,000
Municipal and Industrial	56.4	63,000	47.2	53,000	29.5	33,000	133.1	149,000
Livestock	3.9	5,000	19.0	21,000	10.7	12,000	33.6	38,000
Rural Domestic	7.3	8,000	8.3	10,000	3.5	4,000	19.6	22,000
	2,206.5*	2,383,000	6,163.3*	6,813,000	3,203.4*	3,779,000	11,573.7*	12,975,000

* Irrigation figures in million gallons per day are averages over a one-year period. MGD figures should be doubled to represent per day withdrawals during the six-month irrigation season.

WATER CONSUMPTION

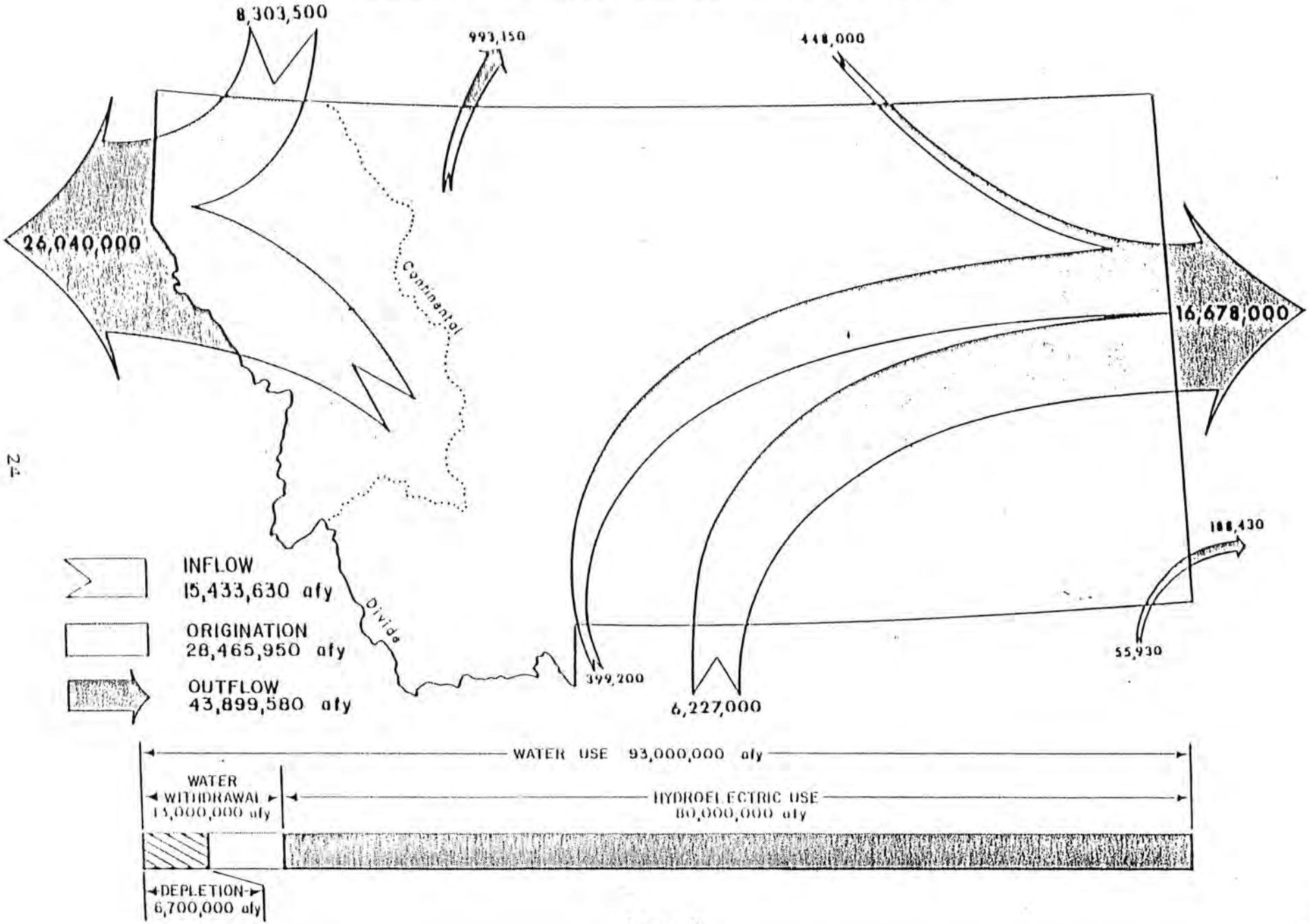


TOTAL WATER CONSUMPTION - 7,105,376 afy

	CONSUMPTION (afy)
IRRIGATION	5,852,000
RESERVOIR EVAPORATION	1,112,000
MUNICIPAL AND INDUSTRIAL	55,000
LIVESTOCK	38,000
SELF-SUPPLIED INDUSTRY	26,000
RURAL DOMESTIC	22,000
THERMOELECTRIC	376

Figure 10

SUMMARY OF WATER SUPPLY AND DEMAND



Map 3

U.S. Department of Agriculture, Soil Conservation Service. **Pond Evaporation.** Technical Notes. Bozeman, Montana. February 1974.

U.S. Department of Agriculture, Statistical Reporting Service and Montana Department of Agriculture, Agricultural Statistics. "Livestock and Poultry Inventories." **Montana Crop and Livestock Reporting Service.** Released Annually.

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Waldron, Ellis. **Municipal Facilities and Services in Montana.** Publication No. 4. Bureau of Government Research, Montana State University, Missoula, Montana, and the Montana Municipal League. 1961.

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Young, Kenneth B.; Asmus, E. Barry; and McConnen, R. J. "Estimated Industrial Water Use in Montana." **Montana Business Quarterly.** Summer 1971. pp. 23-26.

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