The Montana Department of Natural Resources and Conservation

Upper Missouri Water Availability Analysis

December, 1997

Introduction

The Montana Power Company (MPC) and the United States Bureau of Reclamation (USBR) have claimed large direct flow water rights for hydropower production at their Missouri River mainstem facilities. These claimed water rights are still pending final adjudication by the Montana Water Court. The issue being analyzed in this report is whether unappropriated water is available for new consumptive uses and the pending provisional water use permit applications in the upper Missouri River Basin and if so, in what months and in what amounts. In this report, the Montana Department of Natural Resources and Conservation (DNRC) compared Missouri River flows at the various dams to the flow rates that the USBR and MPC have claimed for hydropower production at their Missouri River mainstem facilities.

DNRC only addressed the effects of MPC's and USBR's claimed hydropower water rights on the availability of unappropriated surface water flows in the upper Missouri River Basin. DNRC did not examine groundwater use and availability in the upper basin, the availability of stored USBR contract water from Canyon Ferry Reservoir, nor the effects that these pending water rights applications could have on other senior water right users in the upper Missouri River Basin.

USBR and MPC Hydropower Water Right Claims

USBR and MPC have claimed pre-1973 water rights for a variety of beneficial uses for their Missouri mainstem dams with priority dates ranging from 1898 at Canyon Ferry Dam to 1955 at Cochrane Dam. DNRC focused its analysis only on the flow rates claimed by MPC and USBR for hydroelectric generation at their mainstem hydropower facilities. These claimed hydropower water rights are based upon maximum generator or turbine capacities and are an indication of the actual river flows that have been diverted through the turbines to generate hydroelectricity. These claimed hydropower water rights, including priority dates, are summarized in Table 1. The flow rates are in cubic feet per second (cfs). One cfs is equal to 40 miner's inches.

MPC also has water right claims for storing water within Hebgen Reservoir on the Madison River near Yellowstone Park. The storage capacity of this reservoir is about 386,000 acre-feet. No hydroelectricity is produced at Hebgen Dam. Instead, MPC stores water in Hebgen Reservoir during the spring, and then releases it later in the year after natural flows have dropped, allowing for increased power production at its downstream dams on the Madison and Missouri rivers. However,

Hebgen stored water is not separated from the rest of the river flows used in this water availability analysis.

Table 1. Summary of MPC and USBR claimed hydropower water rights for Missouri River water at their mainstem hydropower facilities.

Dam	Owner	Claimed Right	Claimed Priority Date
Canyon Ferry	USBR	6,390 cfs	10/31/1898
Holter	MPC	7,100 cfs	04/30/1918
Hauser	MPC	4,740 cfs	06/23/1905
Black Eagle	MPC	3,300 cfs	06/01/1892
Rainbow	MPC	3,500 cfs	09/16/1908
Cochrane	MPC	10,000 cfs	06/16/1955
Ryan	MPC	5,900 cfs	08/31/1915
Morony	MPC	8,280 cfs	12/20/1928

Methodology

Comparison of Missouri River Flows to Hydropower Claims

DNRC's Missouri River Water Availability Model was used to compute the river flows presented in this report. This model was developed for the upper Missouri Water Reservation process in order to assist the Board of Natural Resources and Conservation in deciding if unappropriated water was available for water reservation applications (see Mont Code Ann. 85-2-316). The model uses historical flow data from the past to predict the future. It simulates flows in the Missouri River system for a 59-year period using streamflow, irrigation, and reservoir data from 1928 to 1986. It can model the system as if reservoirs such as Canyon Ferry were in place for the entire 59 years, or the model can be run to simulate streamflows as if the reservoirs were not there. In the model, DNRC assumes a consistent (1986) level of irrigation development for the 59-year period. This means that the upper basin is modeled with historic flows adjusted as if the 1986 level of irrigation development had occurred over the entire 1928-1986 period.

River flows were calculated using the model (based on the 1986 level of irrigation development) and are tabulated in Table 2 as monthly percentile exceedence flows in cfs for each of the Missouri River mainstem hydropower facilities. For the Great Fall facilities, river flows are presented for Black Eagle, the uppermost dam, and Morony, the lowermost dam. Percentile exceedence flows are

TABLE 2. Modeled Streamflows in cfs for upper Missouri River stations (1928-1986 base period).

INFLOWS TO CANYON FERRY RESERVOIR

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	4,435	4,724	3,743	3,361	3,744	4,419	5,789	8,978	11,586	4,614	2,118	3,274	5,062
10th%	6,361	6,094	4,595	4,224	4,739	5,440	7,572	14,298	19,153	8,379	3,711	4,881	6,867
20th%	5,715	5,533	4,279	3,917	4,334	5,208	7,142	12,218	16,506	7,137	3,114	4,587	6,273
50th%	4,264	4,641	3,812	3,396	3,854	4,307	5,489	8,330	11,531	4,125	2,077	3,084	4,980
80th%	3,232	4,057	3,237	2,730	3,098	3,747	4,584	5,563	5,994	2,053	933	2,233	3,673
90th%	3,118	3,562	2,558	2,339	2,479	3,459	3,712	4,529	4,746	1,329	572	1,669	3,256

CANYON FERRY RESERVOIR OUTFLOWS

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	4,556	4,600	4,598	4,162	4,350	5,349	5,784	6,190	6,037	4,944	3,671	3,770	4,836
10th%	5,503	5,625	5,845	5,861	6,066	8,212	8,853	9,545	9,255	8,347	5,450	5,463	6,595
20th%	5,361	5,465	5,548	5,415	5,516	6,867	7,463	8,128	7,837	7,029	4,631	4,708	6,025
50th%	4,738	4,737	4,742	4,147	4,249	5,360	5,856	6,383	6,157	4,291	2,928	3,026	4,753
80th%	3,888	3,887	3,892	2,928	3,242	2,928	3,026	2,928	3,026	2,928	2,928	3,026	3,302
90th%	2,928	3,026	2,928	2,928	3,242	2,928	3,026	2,928	3,026	2,928	2,928	3,026	2,984

HAUSER RESERVOIR OUTFLOWS

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	4,562	4,572	4,626	4,217	4,347	5,373	5,761	6,120	5,954	4,840	3,613	3,780	4,815
10th%	5,549	5,633	5,838	5,852	6,060	8,150	8,826	9,536	9,120	8,348	5,404	5,482	6,585
20th%	5,404	5,443	5,560	5,424	5,612	6,854	7,448	8,121	7,768	6,958	4,553	4,738	5,981
50th%	4,722	4,706	4,781	4,140	4,298	5,407	5,830	6,248	6,051	4,122	2,923	3,211	4,710
80th%	3,714	3,880	3,890	2,993	3,235	3,030	3,235	3,122	3,072	2,820	2,813	2,979	3,281
90th%	3,002	2,898	3,022	2,922	3,152	2,926	3,011	2,797	2,899	2,750	2,788	2,924	2,945

HOLTER RESERVOIR OUTFLOWS

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	4,551	4,571	4,731	4,366	4,485	5,425	5,762	6,097	6,063	4,806	3,598	3,831	4,858
10th%	5,608	5,573	5,793	6,005	6,561	7,868	8,973	9,523	9,595	8,541	5,339	5,552	6,704
20th%	5,305	5,355	5,560	5,698	5,665	7,269	7,325	8,354	8,325	6,498	4,488	4,782	6,032
50th%	4,722	4,798	4,875	4,276	4,341	5,388	5,742	5,844	5,791	3,951	3,120	3,424	4,713
80th%	3,773	3,751	3,897	3,049	3,319	3,272	3,936	3,273	3,597	2,901	2,741	2,976	3,264
90th%	2,885	2,805	3,152	2,815	3,032	2,786	3,049	2,613	2,964	2,757	2,627	2,776	2,919

MISSOURI RIVER AT BLACK EAGLE DAM

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	5,639	5,436	5,336	5,027	5,342	6,600	7,534	10,383	11,086	6,574	4,506	4,647	6,511
10th%	7,084	7,169	6,851	7,081	7,534	9,944	11,243	16,070	19,053	10,965	6,829	6,982	8,915
20th%	6,668	6,581	6,344	6,618	6,826	8,818	9,422	13,233	14,003	9,528	5,902	5,937	8,274
50th%	5,840	5,471	5,512	5,129	5,198	6,828	7,483	10,079	10,285	5,926	3,847	4,076	6,167
80th%	4,427	4,323	4,579	3,672	3,767	3,932	5,262	6,686	6,647	3,535	3,223	3,536	4,880
90th%	3,710	3,456	3,496	3,227	3,261	3,637	3,912	5,907	4,881	3,095	3,010	3,281	3,895

MISSOURI RIVER AT MORONY DAM

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	5,989	5,786	5,686	5,377	5,695	6,950	7,884	10,733	11,436	6,924	4,856	4,997	6,862
10th%	7,435	7,519	7,201	7,431	7,884	10,294	11,593	16,420	19,403	11,315	7,179	7,332	9,265
20th%	7,018	6,931	6,695	6,968	7,176	9,168	9,773	13,583	14,353	9,878	6,252	6,287	8,624
50th%	6,190	5,821	5,862	5,480	5,548	7,178	7,833	10,429	10,635	6,276	4,197	4,426	6,517
80th%	4,777	4,673	4,929	4,022	4,117	4,282	5,612	7,036	6,997	3,885	3,573	3,886	5,230
90th%	4,060	3,806	3,846	3,577	3,611	3,987	4,262	6,257	5,231	3,445	3,361	3,631	4,245

streamflows that have been equaled or exceeded at a given frequency for each monthly period modeled. To understand percentile flows, please refer to Table 2 and the following example. Under the heading "INFLOWS TO CANYON FERRY RESERVOIR" go across the row labeled "50th%" to the column "AUG" or August. The value you should be reading is 2,077 cfs. In statistical terms, the 50th percentile flow is referred to as the "median" flow. This is the August 50th percentile flow for the river. What this number means is that during about half of the 59 Augusts modeled (the 59 years from 1928-1986) the average flow for the month was greater than or equal to 2,077 cfs--and during the other half, it was less than 2,077 cfs. Now go down the same column to the 80th% flow (low flow) for August. It is 933 cfs. That means that an average monthly flow of 933 cfs was exceeded or higher for 47 (80 percent) of the 59 Augusts for the period of record, and the average flow that was less than 933 cfs only occurred for the remaining 12 Augusts. Another way to explain the 80th percentile flow is that there is about a one chance-in-five that the flow during the month of August will be less than 933 cfs.

In Table 3, DNRC subtracted USBR and MPC hydropower water right claims from the modeled river flows found in Table 2. MPC's and USBR's hydropower claims are compared to the available river flows in order to determine the monthly amount and frequency that unappropriated water might be available for new consumptive use appropriations and the pending provisional water use permit applications (see Table 3).

Results

Canyon Ferry Dam

In Table 3, the modeled results show that almost all the Missouri River flows can be used to generate hydroelectricity at Canyon Ferry Dam in August, September, October, November, December, January, February and March of every year. The results also suggest that no water is available in dry years (the 80th percentile or lower flows) during any month. However, water may be available for appropriation in wet years (the 20th percentile or high river flows) during the months of April and July, and available at the 50th percentile flow (median flow) in the two months of May and June. These latter results are illustrated in Figure 1. The vertical bars are the median or typical monthly Canyon Ferry Reservoir inflows and the horizonal line is the claimed water right of 6,390 cfs. Only during the months of May and June are the median river flows greater than the USBR claimed water right for hydropower production.

Holter Dam

At Holter Dam, the modeled results show even less water available for appropriation after subtracting MPC's claimed hydropower water right (see Table 3). In every year, no water appears to be available during the months of August, September, October, November, December, January, February at any flow and no water is available during the other five months at the 50th percentile

TABLE 3. Missouri River flows remaining in cfs after subtracting MPC and BUREC water right claims for hydropower.

CANYON FERRY DAM

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	0	0	0	0	0	0	0	2,588	5,196	0	0	0	0
10th%	0	0	0	0	0	0	1,182	7,908	12,763	1,989	0	0	477
20th%	0	0	0	0	0	0	752	5,828	10,116	747	0	0	0
50th%	0	0	0	0	0	0	0	1,940	5,141	0	0	0	0
80th%	0	0	0	0	0	0	0	0	0	0	0	0	0
90th%	0	0	0	0	0	0	0	0	0	0	0	0	0

HAUSER DAM

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	0	0	0	0	0	633	1,021	1,380	1,214	100	0	0	75
10th%	809	893	1,098	1,112	1,320	3,410	4,086	4,796	4,380	3,608	664	742	1,845
20th%	664	703	820	684	872	2,114	2,708	3,381	3,028	2,218	0	0	1,241
50th%	0	0	41	0	0	667	1,090	1,508	1,311	0	0	0	0
80th%	0	0	0	0	0	0	0	0	0	0	0	0	0
90th%	0	0	0	0	0	0	0	0	0	0	0	0	0

HOLTER DAM

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	0	0	0	0	0	0	0	0	0	0	0	0	0
10th%	0	0	0	0	0	768	1,873	2,423	2,495	1,441	0	0	0
20th%	0	0	0	0	0	169	225	1,254	1,225	0	0	0	0
50th%	0	0	0	0	0	0	0	0	0	0	0	0	0
80th%	0	0	0	0	0	0	0	0	0	0	0	0	0
90th%	0	0	0	0	0	0	0	0	0	0	0	0	0

BLACK EAGLE DAM

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	2,339	2,136	2,036	1,727	2,042	3,300	4,234	7,083	7,786	3,274	1,206	1,347	3,211
10th%	3,784	3,869	3,551	3,781	4,234	6,644	7,943	12,770	15,753	7,665	3,529	3,682	5,615
20th%	3,368	3,281	3,044	3,318	3,526	5,518	6,122	9,933	10,703	6,228	2,602	2,637	4,974
50th%	2,540	2,171	2,212	1,829	1,898	3,528	4,183	6,779	6,985	2,626	547	776	2,867
80th%	1,127	1,023	1,279	372	467	632	1,962	3,386	3,347	235	0	236	1,580
90th%	410	156	196	0	0	337	612	2,607	1,581	0	0	0	595

RAINBOW DAM

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	2,139	1,936	1,836	1,527	1,842	3,100	4,034	6,883	7,586	3,074	1,006	1,147	3,011
10th%	3,584	3,669	3,351	3,581	4,034	6,444	7,743	12,570	15,553	7,465	3,329	3,482	5,415
20th%	3,168	3,081	2,844	3,118	3,326	5,318	5,922	9,733	10,503	6,028	2,402	2,437	4,774
50th%	2,340	1,971	2,012	1,629	1,698	3,328	3,983	6,579	6,785	2,426	347	576	2,667
80th%	927	823	1,079	172	267	432	1,762	3,186	3,147	35	0	36	1,380
90th%	210	0	0	0	0	137	412	2,407	1,381	0	0	0	395

COCHRANE DAM

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	0	0	0	0	0	0	0	383	1,086	0	0	0	0
10th%	0	0	0	0	0	0	1,243	6,070	9,053	965	0	0	0
20th%	0	0	0	0	0	0	0	3,233	4,003	0	0	0	0
50th%	0	0	0	0	0	0	0	79	285	0	0	0	0
80th%	0	0	0	0	0	0	0	0	0	0	0	0	0
90th%	0	0	0	0	0	0	0	0	0	0	0	0	0

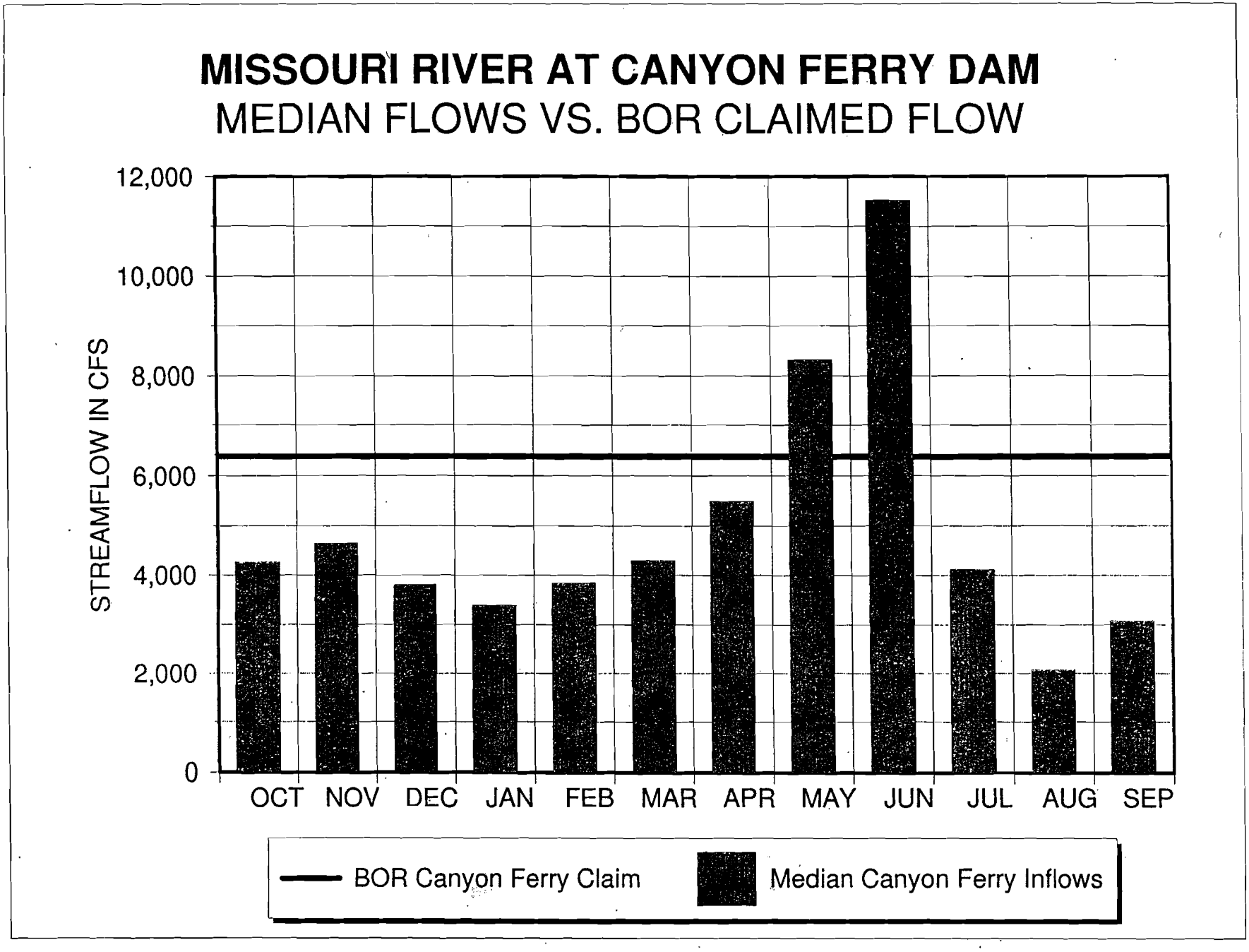
RYAN DAM

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	89	0	0	0	0	1,050	1,984	4,833	5,536	1,024	0	0	962
10th%	1,535	1,619	1,301	1,531	1,984	4,394	5,693	10,520	13,503	5,415	1,279	1,432	3,365
20th%	1,118	1,031	795	1,068	1,276	3,268	3,873	7,683	8,453	3,978	352	387	2,724
50th%	290	0	0	0	0	1,278	1,933	4,529	4,735	376	0	0	617
80th%	0	0	0	0	0	0	0	1,136	1,097	0	0	0	0
90th%	0	0	0	0	0	0	0	357	0	0	0	0	0

MORONY DAM

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN
AVERAGE	0	0	0	0	0	0	0	2,453	3,156	0	0	0	0
10th%	0	0	0	0	0	2,014	3,313	8,140	11,123	3,035	0	0	985
20th%	0	0	0	0	0	888	1,493	5,303	6,073	1,598	0	0	344
50th%	0	0	0	0	0	0	0	2,149	2,355	0	0	0	0
80th%	0	0	0	0	0	0	0	0	0	0	0	0	0
90th%	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 1. Comparison of median Canyon Ferry Reservoir inflows to flow claimed by USBR for hydropower production at the dam.



flow (median flow or in half the years) during the period of record (1928-86). Water, however, is available at the 20th percentile flow during the months of March, April, May and June (when the monthly river inflows are high) and at the 10th percentile flow (very high flow) during July. Figure 2 illustrates the results for median or typical monthly river inflows. Please note again that the median monthly inflows to Holter Dam never exceed the claimed water right of MPC at Holter dam. It appears that in at least half the years, there is no water available for new appropriations during any month.

Cochrane and Morony Dam--Near Great Falls, Mt.

MPC has claimed its largest flow rate (10,000 cfs) for hydropower production at Cochrane Dam. Upstream of this dam, river flows greater than the claimed amount generally occur in only four months: during very wet Aprils (10th percentile flow or at least one year in ten), during average and above average months in May and June (50th percentile flow or at least 5 years in ten), and during very wet months of July (10th percentile flow or at least one year in ten). Flows above the claimed rate occur rarely during the other eight months from August through March.

The results for Morony Dam are similar to Cochrane Dam, but not as restrictive. MPC's claimed hydropower water right of 8,280 cfs is exceeded in median months of May and June (50th percentile flow or at least 5 years in ten), and during March, April, and July of wet years (20th percentile flow or at least 2 years in ten).

Refer to Figures 3 and 4 for a comparison of median monthly inflows to the MPC's hydropower claims for Cochrane and Morony dams. At Cochrane dam, the median monthly inflows exceed slightly MPC's claimed hydropower water rights in the months of May and June (Figure 3). At Morony dam, the median monthly inflows exceed MPC's hydropower water right by approximately 2,200 cfs in both months of May and June (Figure 4).

Effects of Canyon Ferry Reservoir Storage

The results in Table 3 are not adjusted to account for the effects of water stored and released from Canyon Ferry Reservoir. Water is typically stored in Canyon Ferry reservoir during spring runoff (April-June), and released later in the season. The effects of Canyon Ferry operations on Missouri River flows are most noticeable during dry years. In Figure 5, the modeled dry-year streamflows near Great Falls are compared with and without the effects of Canyon Ferry Reservoir storage. This Figure shows that during late summer, water releases from Canyon Ferry reservoir have provided more river flows than would have occurred naturally. These released river flows have allowed MPC to generates about 4.3 percent more hydroelectricity than it would have produced without Canyon Ferry Reservoir[1].

[1] Missouri River Basin: Draft Environmental Impact Statement for Water Reservation Applications above Fort Peck Dam. MT DNRC, June 1991.

Figure 2. Comparison of median flows at Holter Dam to flow claimed by MPC for hydropower production at the dam.

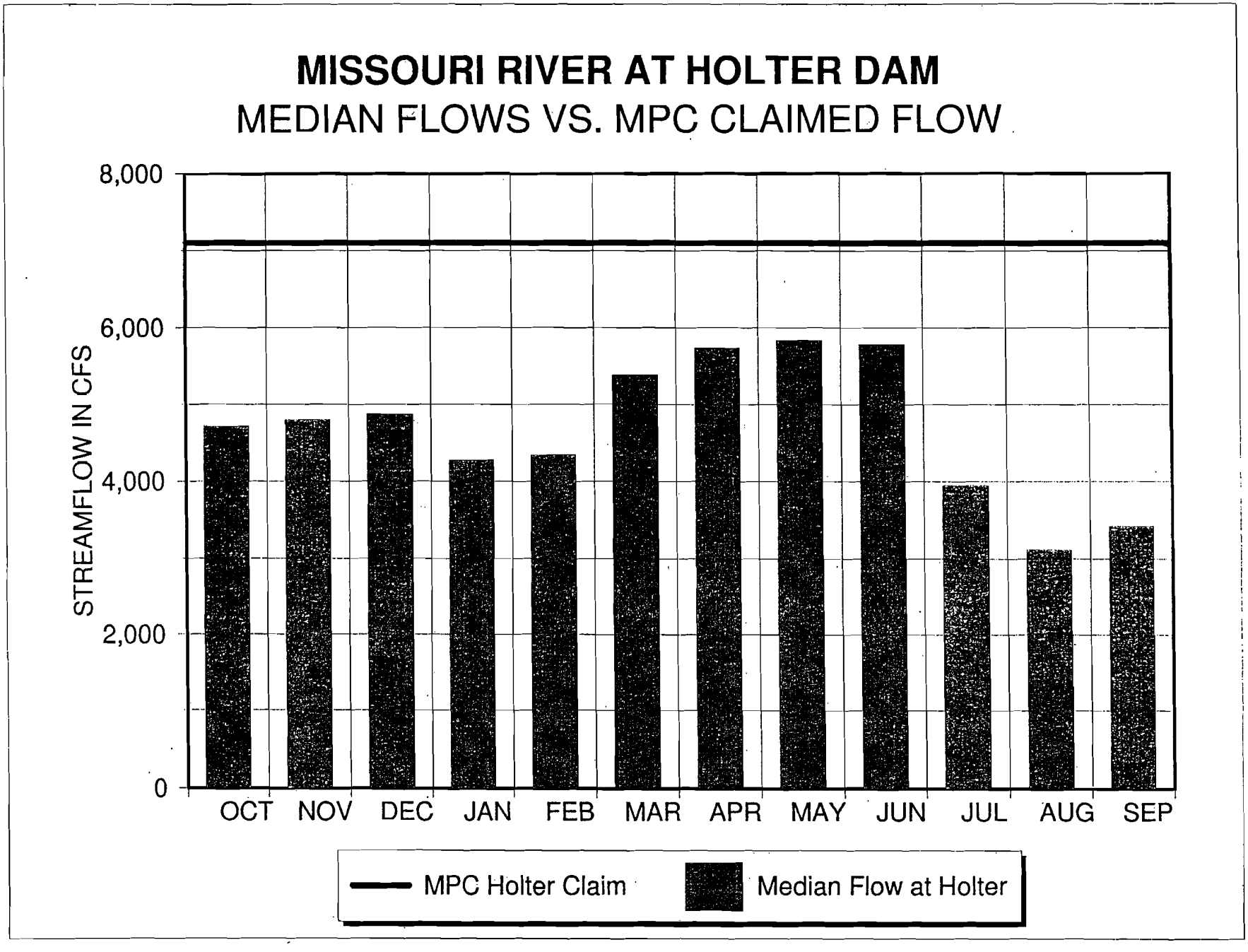


Figure 3. Comparison of median flows at Cochrane Dam to flow claimed by MPC for hydropower production at the dam.

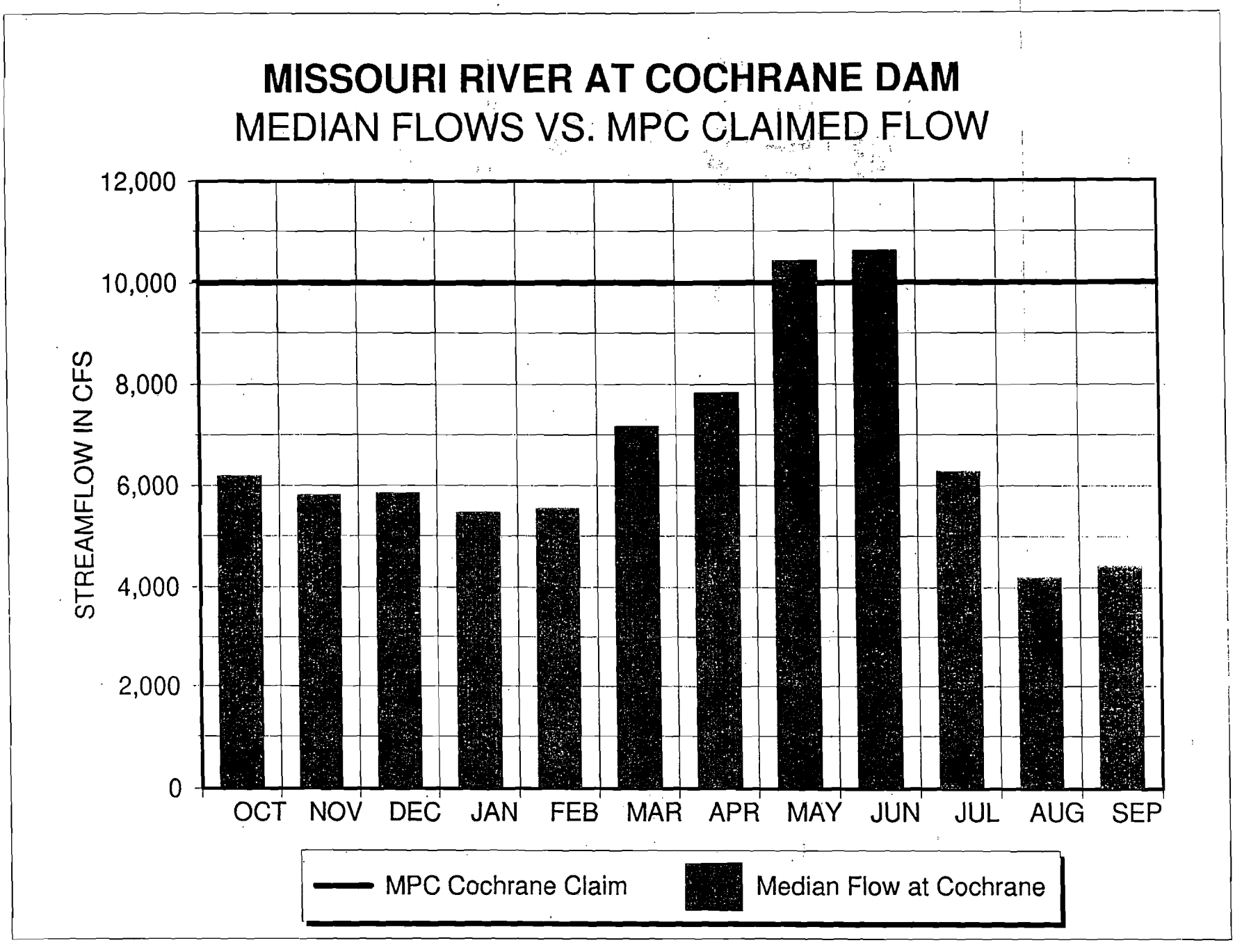


Figure 4. Comparison of median flow at Morony Dam to flow claimed by MPC for hydropower production at the dam.

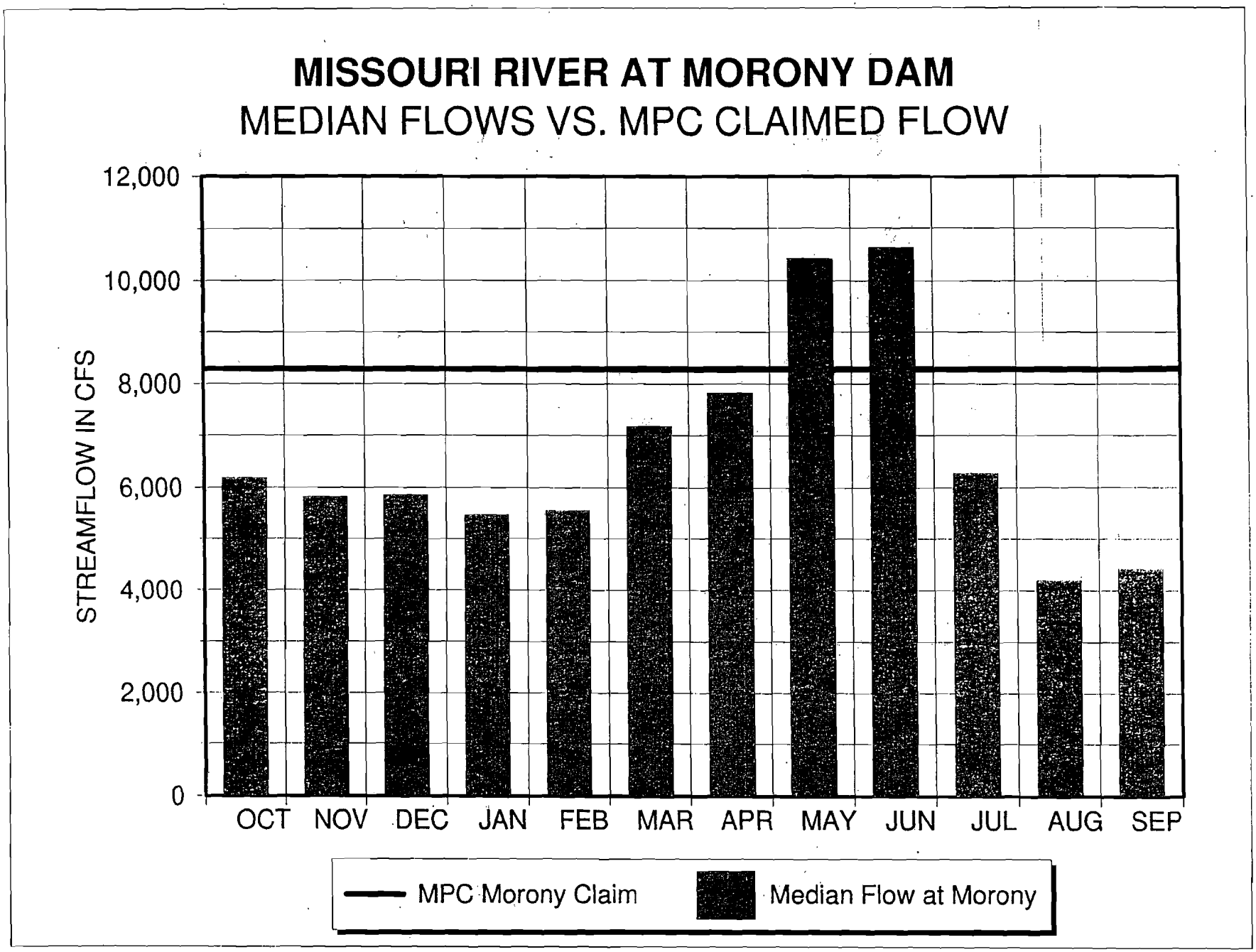
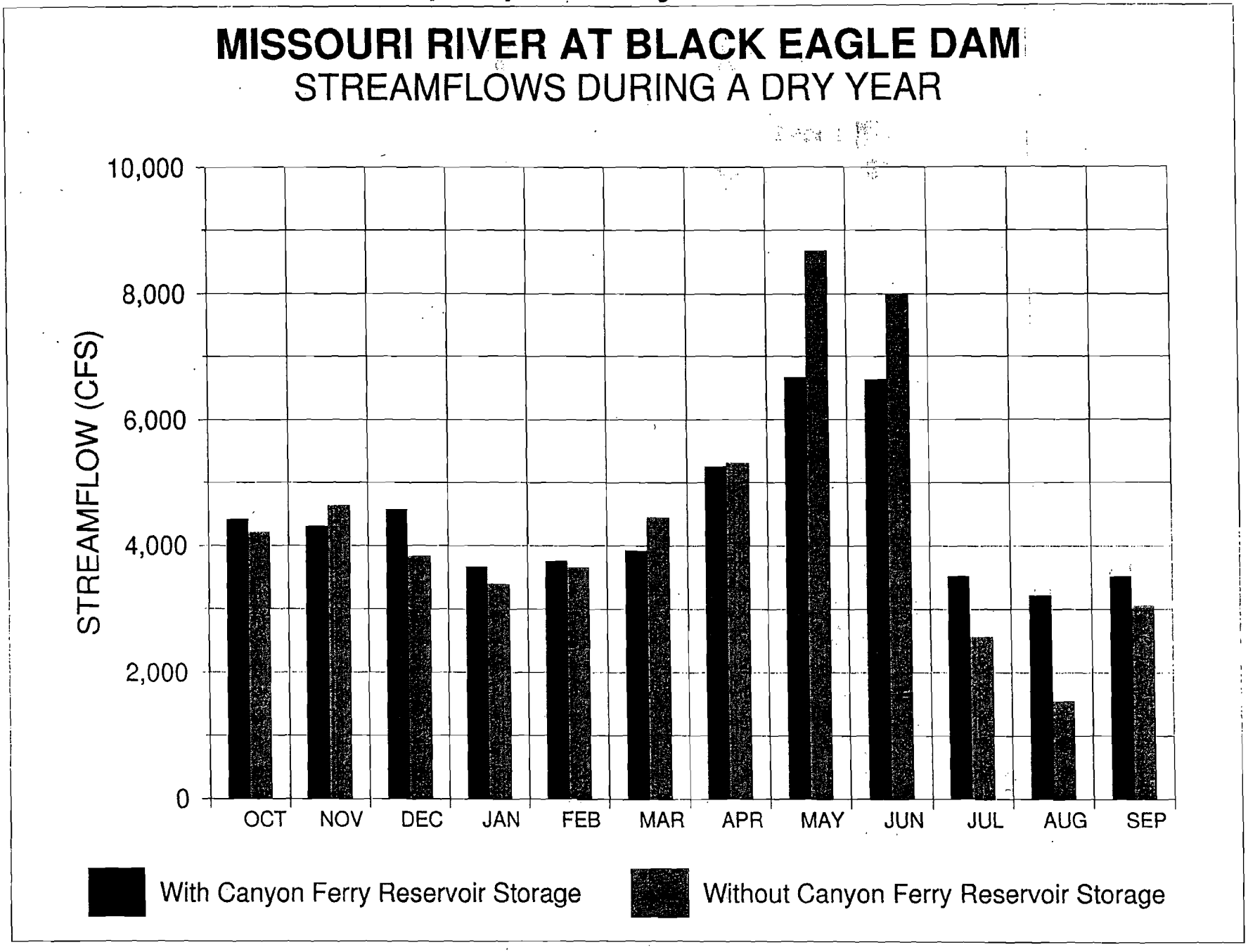


Figure 5. Comparison of modeled dry year (80th percentile) river flows near Great Falls, with and without the effects of Canyon Ferry Reservoir storage.



Summary and Conclusion

MPC's and USBR's water rights for hydropower production limit the availability of unappropriated water for new consumptive use appropriations and the pending provisional water use permit applications. Because of the magnitude of MPC's and USBR's water right claims, water for new consumptive uses such as irrigation in the upper Missouri River Basin appears to be available only in the months of April, May, June and July during the wet years (generally, the wettest two years in ten which is equivalent to the 20th percentile). Almost all the Missouri River flows in the other eight months from August through March are claimed by MPC and USBR for generating electricity at its maintain hydropower dams. Therefore, these data indicate that water for continuous full service irrigation (from April 1 to October 1) is never available in the upper Missouri Basin above Holter Dam during the months of August and September; water is not available in nine years in ten in the month of July; and is not available in at least half the years during the months of April, May, and June. Between Cochrane and Holter dams, slightly more water is available in the months of May and June (generally available in one out of every two years).