REPORT OF THE COMMITTEE ON PROBABILITIES AND TEST STUDIES TO THE TASK FORCE ON OPERATING CRITERIA FOR THE COLORADO RIVER

United States
Department of the Interior
Bureau of Reclamation

October 30, 1969

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This group was formed to make whatever studies seemed appropriate to define the effects of several parameters which might possibly be considered for inclusion in the criteria and to test the criteria with a range of possible effects which might occur in the future.

In general, we studied the following parameters which would appear to be items which should be defined by the operating criteria:

(a) A storage reserve in the Upper Basin to assure the delivery of priority 1 and 2 water during periods of subnormal runoff.

(b) A minimum annual release at Lake Powell.

(c) A rule governing the magnitude of releases from Lake Mead.

In addition, we tested the criteria by imposing on the following items ranges of values which we believe encompass the more likely possibilities which could occur in the future:

(a) Streamflow sequences.

(b) Upper Basin depletions.

(c) Lower Basin uses and losses.

In applying these various operating criteria and estimates of future uses and water supply, we ran 146 computer studies to evaluate their potential effects on the future operation of the river. A summary of various resulting values from these studies is shown on Table 1, pages 2, 3, 4, and 5. Although most of the studies involved various combinations of the six items listed above, we also ran two unique studies at the request of members of this group. One study involved the production of firm power at Hoover and one of the studies involved the operation of the system under depletion conditions which are estimated to occur after year 2000.

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Sheet No. 1

COMPARISON OF TEST STUDIES

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AP Study No.	12	13	14	15	16	17	18	19	20	21	22
Minimum Release from Upper Basin in Million AF/year	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25
Rule curve probability in percent	98.4+	95.2	98.4	90.5	90.5	90.5	90.5	90.5	95.2	98.4	90.5
Lake Mead rule elev. above which add'l Low. Bas. use assumed	1190	1190	1190	1190	1190	1170	1190	1190	1190	1190	1190
Lake Mead rule elev. below which Low. Bas. shortage assumed	1100	1100	1100	1100	1100	1100	1070	1100	1100	1100	1100
Lake Mead demand - 1970 thru 1979 in 1000 AF/Yr.	8400	8400	8400	8400	8400	8400	8400	8400	8400	8400	8400
Lake Mead demand - 1980 and after	9500	9500	9500	9500	9500	9500	9500	9200	9200	9200	9800
Upper Basin depletion schedule	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base
Sequence No. 3 - 1916 through 1946 - Depleted Flow (103% of Average)			11,168	11,168	11,167	11,167	11,167	11,167	11,167	11,167	11,167
Upper Basin storage											
31-Year average (1970-2000)			23,765	23,623	23,553	22,947	23,553	23,983	23,933	23,983	23,055
End of study (Sept. 30, 2000)			17,419	16,195	16,195	15,045	16,195	17,785	17,785	17,793	14,483
Minimum end-of-year storage			14,404	14,401	14,399	13,074	14,399	15,260	15,260	15,260	13,364
Lake Powell storage											
31-year average (1970-2000)			18,961	18,824	18,794	18,210	18,794	19,209	19,209	19,210	18,313
End of study (Sept. 30, 2000)			14,238	13,048	13,048	11,940	13,048	14,593	14,593	14,601	11,431
Minimum end-of-year storage			11,491	11,480	11,486	10,280	11,486	12,267	12,267	12,267	10,569
Lake Mead storage											
31-year average (1970-2000)			19,276	19,413	19,401	18,739	19,401	19,947	19,947	19,949	18,787
End of study (Sept. 30, 2000)			12,279	13,441	13,441	12,335	13,441	15,210	15,210	15,226	11,505
Minimum end-of-year storage			12,279	13,441	13,441	12,181	13,441	14,715	15,210	14,715	11,505
Releases from Lake Powell			10,348	10,393	10,364	10,422	10,363	10,306	10,306	10,305	10,439
Upper Basin shortages			0	0	0	0	0	0	0	0	0
Total Hoover releases			10,403	10,403	10,320	10,432	10,320	10,177	10,177	10,177	10,475
Wasted releases from Lake Mead			1,045	1,045	1,022	1,022	1,022	1,062	1,062	1,062	983
Upper Basin energy			5,953	5,951	5,949	5,936	5,949	5,942	5,942	5,943	5,953
Lower Basin energy			5,837	5,848	5,804	5,819	5,804	5,759	5,759	5,758	5,844
Total energy			11,790	11,809	11,753	11,755	11,753	11,701	11,701	11,701	11,797
Hoover energy @ 83%			4,677	4,689	4,652	4,655	4,652	4,627	4,627	4,626	4,674
Sequence No. 6 - 1931 through 1961 - Depleted Flow (86% of Average)	9,156	9,156	9,154	9,154	9,155	9,155	9,155	9,155	9,155	9,155	9,155
Upper Basin storage											
31-year average (1970-2000)	16,586	15,205	15,542	15,170	15,178	15,178	15,185	15,892	15,892	16,242	14,450
End of study (Sept. 30, 2000)	11,951	7,267	9,187	6,808	6,807	6,807	6,729	8,604	8,604	10,343	5,532
Minimum end-of-year storage	8,899	7,267	8,099	6,808	6,807	6,807	6,729	8,604	8,604	8,717	5,532
Lake Powell storage											
31-year average (1970-2000)	13,436	12,244	12,470	12,120	12,128	12,128	12,116	12,895	12,895	13,111	11,478
End of study (Sept. 30, 2000)	9,600	5,865	7,342	5,467	5,465	5,465	5,401	7,049	7,049	8,139	4,335
Minimum end-of-year storage	7,221	5,865	6,852	5,467	5,465	5,465	5,401	6,873	6,873	6,873	4,335
Lake Mead storage											
31-year average (1970-2000)	14,288	15,107	15,007	15,173	15,176	15,176	15,084	15,972	15,971	15,772	14,480
End of study (Sept. 30, 2000)	9,107	9,787	9,464	9,838	9,844	9,844	8,300	10,810	10,810	10,085	8,968
Minimum end-of-year storage	9,107	9,787	9,464	9,838	9,844	9,844	8,300	10,810	10,810	10,085	8,968
Releases from Lake Powell	8,690	8,895	8,816	8,906	8,906	8,906	8,909	8,925	8,925	8,750	8,507
Upper Basin shortages	0	0	0	0	0	0	0	0	0	0	0
Total Hoover releases	8,759	8,910	8,902	8,974	8,916	8,916	8,974	8,774	8,774	8,739	9,030
Wasted releases from Lake Mead	0	0	0	0	0	0	0	0	0	0	0
Upper Basin energy	4,855	4,862	4,844	4,854	4,865	4,855	4,866	4,881	4,881	4,861	4,842
Lower Basin energy	4,551	4,791	4,773	4,830	4,800	4,800	4,762	4,783	4,783	4,752	4,743
Total energy	9,406	9,664	9,617	9,694	9,665	9,665	9,628	9,664	9,664	9,613	9,585
Hoover energy @ 83%	3,524	3,758	3,741	3,770	3,766	3,766	3,722	3,765	3,765	3,737	3,696
Sequence No. 8 - 1941 through 1968 - Depleted Flow (93% of Average)			9,957	9,957	9,956	9,956	9,956	9,956	9,956	9,956	9,956
Upper Basin storage											
31-year average (1970-2000)			20,938	20,447	20,433	20,036	20,253	20,956	20,966	21,302	19,994
End of study (Sept. 30, 2000)			20,041	17,651	17,637	17,532	16,437	18,799	18,083	20,295	16,986
Minimum end-of-year storage			11,574	11,342	11,330	10,509	11,323	12,483	12,483	12,453	10,089
Lake Powell storage											
31-year average (1970-2000)			16,781	16,319	16,311	16,008	16,143	16,782	16,792	17,111	15,918
End of study (Sept. 30, 2000)			16,106	13,776	14,763	13,658	12,607	14,301	14,982	16,288	13,109
Minimum end-of-year storage			8,797	8,565	8,724	8,044	8,533	9,706	9,706	9,676	7,753
Lake Mead storage											
31-year average (1970-2000)			16,768	16,926	16,914	16,524	16,692	17,485	17,492	17,239	16,391
End of study (Sept. 30, 2000)			13,764	13,810	13,795	13,592	12,626	14,915	14,995	14,817	13,153
Minimum end-of-year storage			9,929	10,093	10,080	10,047	8,784	10,657	10,657	10,318	9,578
Releases from Lake Powell			9,117	9,210	9,209	9,221	9,253	9,158	9,154	9,038	9,242
Upper Basin shortages			0	0	0	0	0	0	0	0	0
Total Hoover releases			8,976	9,063	9,004	9,032	9,095	8,897	8,891	8,847	9,075
Wasted Releases from Lake Mead			2	2	2	2	2	2	2	2	2
Upper Basin energy			5,374	5,380	5,379	5,368	5,385	5,393	5,393	5,388	5,364
Lower Basin energy			4,920	4,973	4,942	4,924	4,790	4,926	4,923	4,888	4,944
Total energy			10,294	10,353	10,321	10,302	10,175	10,319	10,315	10,276	10,308
Hoover energy @ 83%			3,879	3,923	3,899	3,887	3,837	3,896	3,892	3,867	3,892
Sequence No. 12 - 1961 through 1628 - Depleted Flow (111% of Average)			12,084	12,084	12,083	12,083	12,083	12,083	12,083	12,083	12,083
Upper Basin storage											
31-year average			24,589	24,589	24,579	24,379	24,573	24,655	24,635	24,657	24,463
End of study (Sept. 30, 2000)			27,070	27,070	27,068	26,101	27,069	27,287	27,287	27,288	26,832
Minimum end-of-year storage			10,735	10,735	10,720	10,720	10,720	10,720	10,720	10,722	10,720
Lake Powell storage											
31-year average (1970-2000)			19,406	19,406	19,336	19,242	19,395	19,453	19,453	19,460	19,300
End of study (Sept. 30, 2000)			21,127	21,127	21,125	20,216	21,125	21,344	21,344	21,345	20,839
Minimum end-of-year storage			8,214	8,214	8,201	8,201	8,201	8,201	8,201	8,203	8,201
Lake Mead storage											
31-year average (1970-2000)			20,658	20,658	20,665	20,447	20,665	20,766	20,766	20,766	20,554
End of study (Sept. 30, 2000)			21,164	21,164	21,163	20,252	21,163	21,381	21,381	21,383	20,925
Minimum end-of-year storage			16,182	16,182	16,132	16,132	16,132	16,132	16,132	16,132	16,192
Releases from Lake Powell			10,911	10,911	10,910	10,948	10,910	10,907	10,907	10,907	10,921
Upper Basin shortages			0	0	0	0	0	0	0	0	0
Total Hoover releases			10,683	10,683	10,624	10,693	10,627	10,605	10,605	10,605	10,545
Wasted releases from Lake Mead			791	791	791	791	791	841	841	842	649
Upper Basin energy			6,338	6,338	6,337	6,354	6,337	6,330	6,330	6,330	6,347
Lower Basin energy			6,095	6,095	6,081	6,092	6,083	6,055	6,055	6,055	5,970
Total energy			12,433	12,433	12,398	12,446	12,398	12,385	12,385	12,385	12,417
Hoover energy @ 83%			4,809	4,809	4,871	4,803	4,871	4,870	4,870	4,870	4,875

C O M P A R I S O N   O F   T E S T   S T U D I E S

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CAP Study No.	23	24	25	26	27	28	29	30	31	32	33
Minimum Release from Upper Basin in Million AF/Year	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25
Rule curve probability in percent	95.2	98.4	95.2	90.5	98.4	98.4+	98.4	90.5	98.4	98.4	98.4
Lake Mead rule elev. above which add'l Low. Bas. use assumed	1190	1190	1190	1190	1190	1190	1190	1190	1190	1190	1190
Lake Mead rule elev. below which Low. Bas. shortage assumed	1100	1100	1100	1100	1100	1100	1100	1070	1070	1100	1100
Lake Mead demand - 1970 thru 1979 in 1000 AF/Yr.	8400	8400	8400	8400	8400	8400	Firm P.	8400	8400	8400	8400
Lake Mead demand - 1980 and after	9800	9800	9500	9500	9500	9500	Firm P.	9500	9500	9500	9500
Upper Basin depletion schedule	Base	Base	Base	Ult.	Ult.	Base	Base	Base 1/	Base 1/	Base	Rapid
Sequence No. 3 - 1916 through 1946 - Depleted Flow (103% of Average)	11,167	11,167	11,167	10,152	10,152	11,167	11,167	9,156	9,156	11,167	10,655
Upper Basin storage											
31-Year average (1970-2000)	23,055	23,416	23,553	21,329	22,636	24,559	24,575	15,153	15,529	23,695	22,771
End of study (Sept. 30, 2000)	14,483	16,798	16,195	12,804	17,379	21,310	17,680	7,006	9,439	17,417	13,810
Minimum end-of-year storage	13,364	13,672	14,399	11,490	11,730	16,135	16,074	7,006	8,855	14,404	12,019
Lake Powell storage											
31-year average (1970-2000)	18,313	18,652	18,794	17,577	18,236	19,750	19,725	12,096	12,445	18,931	18,058
End of study (Sept. 30, 2000)	11,431	13,634	13,048	10,365	14,498	18,011	14,485	5,638	7,475	14,229	10,832
Minimum end-of-year storage	10,569	10,870	11,486	9,089	9,323	13,082	13,034	5,638	7,021	11,491	9,210
Lake Mead storage											
31-year average (1970-2000)	18,787	18,457	19,401	18,111	17,734	18,534	20,281	15,028	14,735	19,264	17,985
End of study (Sept. 30, 2000)	11,505	9,840	13,441	10,539	9,706	9,988	14,840	8,360	7,455	12,278	9,756
Minimum end-of-year storage	11,505	9,840	13,441	10,539	9,706	9,988	14,840	8,360	7,455	12,278	9,756
Releases from Lake Powell	10,439	10,351	10,369	9,692	9,522	10,173	10,295	8,906	8,811	10,324	9,959
Upper Basin shortages	0	0	0	0	0	0	0	0	0	0	0
Total Hoover releases	10,475	10,454	10,320	9,604	9,474	10,268	10,171	9,071	8,916	10,320	10,078
Wasted releases from Lake Mead	983	983	1,022	448	449	1,022	1,317	0	0	1,022	926
Upper Basin energy	5,953	5,938	5,949	5,708	5,667	5,912	5,959	4,863	4,841	5,940	5,740
Lower Basin energy	5,844	5,306	5,804	5,352	5,258	5,712	5,751	4,757	4,444	5,792	5,579
Total energy	11,797	11,744	11,753	11,060	10,925	11,624	11,710	9,620	9,285	11,732	11,319
Hoover energy @ 83%	4,674	4,638	4,652	4,253	4,174	4,565	4,626	3,717	3,410	4,641	4,450
Sequence No. 6 - 1931 through 1961 - Depleted Flow (66% of Average)	9,155	9,155	9,155	8,221	8,221	9,156	9,156	9,522	9,522	9,156	8,657
Upper Basin storage											
31-year average (1970-2000)	14,547	15,031	15,220	10,588	12,356	16,586	15,374	19,512	19,763	15,529	16,990
End of study (Sept. 30, 2000)	5,981	8,432	7,005	2,765	6,871	11,951	9,233	10,641	12,137	9,439	8,795
Minimum end-of-year storage	5,981	8,432	7,005	2,765	5,814	8,955	8,855	9,111	9,634	8,855	8,515
Lake Powell storage											
31-year average (1970-2000)	11,565	12,011	12,165	8,605	10,111	13,426	12,310	15,868	16,010	12,445	13,746
End of study (Sept. 30, 2000)	4,739	6,877	5,641	3,163	6,581	9,600	7,382	7,725	8,985	7,475	6,686
Minimum end-of-year storage	4,739	6,873	5,641	3,163	5,022	7,021	7,021	7,103	7,564	7,021	6,686
Lake Mead storage											
31-year average (1970-2000)	14,456	14,139	15,166	12,076	11,086	14,288	14,230	16,896	16,783	14,954	12,307
End of study (Sept. 30, 2000)	9,056	7,658	9,801	9,102	7,364	9,107	9,427	8,233	7,699	9,468	7,380
Minimum end-of-year storage	9,056	7,658	9,801	9,102	7,084	9,107	9,427	8,233	7,699	9,468	7,380
Releases from Lake Powell	8,943	8,855	8,896	8,429	9,220	8,606	8,622	9,035	8,979	8,811	8,395
Upper Basin shortages	0	0	0	0	0	0	0	0	0	0	0
Total Hoover releases	9,010	9,051	8,910	8,386	8,277	8,759	8,877	9,029	8,994	8,840	8,486
Wasted releases from Lake Mead	0	0	0	0	0	0	93	0	0	0	0
Upper Basin energy	4,843	4,831	4,865	4,239	4,376	4,855	4,835	5,258	5,243	4,841	4,690
Lower Basin energy	4,695	4,393	4,795	4,166	3,041	4,551	4,711	4,717	4,689	4,748	3,313
Total energy	9,538	9,224	9,660	8,405	7,417	9,406	9,546	9,975	9,932	9,589	8,003
Hoover energy @ 83%	3,650	3,352	3,762	3,188	2,076	3,534	3,602	3,679	3,647	3,722	2,327
Sequence No. 8 - 1941 through 1908 - Depleted Flow (93% of Average)	9,956	9,956	9,956	8,991	8,931	9,957	9,957	9,957	9,957	9,957	9,435
Upper Basin storage											
31-year average (1970-2000)	20,061	20,069	20,461	14,760	16,347	21,059	20,902	20,139	20,794	20,794	19,853
End of study (Sept. 30, 2000)	17,146	19,560	17,678	12,720	17,716	23,932	20,019	16,420	19,998	19,998	17,331
Minimum end-of-year storage	10,089	11,289	11,330	3,537	6,061	12,036	13,171	11,457	11,531	11,531	9,245
Lake Powell storage											
31-year average (1970-2000)	15,980	16,527	16,338	12,725	14,090	16,954	16,992	16,063	16,674	16,674	15,888
End of study (Sept. 30, 2000)	13,272	15,613	13,801	11,330	15,921	19,804	15,948	12,589	16,062	16,062	13,546
Minimum end-of-year storage	7,753	8,512	8,553	3,936	5,674	9,259	10,394	8,513	8,754	8,754	7,135
Lake Mead storage											
31-year average (1970-2000)	16,365	16,005	16,894	14,306	13,523	16,483	17,029	16,622	16,226	16,682	15,435
End of study (Sept. 30, 2000)	13,315	12,294	13,335	11,346	9,215	10,655	14,865	12,606	11,491	13,809	9,762
Minimum end-of-year storage	9,566	9,461	10,082	9,353	8,904	9,918	9,954	8,765	7,616	9,904	9,461
Releases from Lake Powell	9,235	9,138	9,207	8,727	8,510	8,958	9,104	9,234	9,098	9,098	8,706
Upper Basin shortages	0	0	0	0	0	0	0	0	0	0	0
Total Hoover releases	9,064	9,012	9,001	8,513	8,380	8,873	8,859	9,079	8,992	8,899	8,687
Wasted Releases from Lake Mead	2	2	2	0	0	2	244	2	2	2	0
Upper Basin energy	5,368	5,368	5,331	4,723	4,884	5,312	5,389	5,374	5,362	5,362	5,131
Lower Basin energy	4,917	4,455	4,940	4,335	3,864	4,851	4,872	4,778	4,432	4,875	4,563
Total energy	10,285	9,823	10,321	9,059	8,748	10,163	10,261	10,152	9,794	10,237	9,694
Hoover energy @ 83%	3,866	3,411	3,696	3,345	2,936	3,821	3,845	3,726	3,359	3,849	3,555
Sequence No. 12 - 1961 through 1928 - Depleted Flow (111% of Average)	12,083	12,083	12,083	11,048	11,098	12,082	12,062	10,194	10,194	12,082	11,550
Upper Basin storage											
31-year average	24,463	24,469	24,578	22,464	22,734	24,591	24,568	17,740	18,556	24,439	24,500
End of study (Sept. 30, 2000)	26,832	26,832	27,068	26,541	26,343	27,060	27,071	22,649	22,751	27,068	28,602
Minimum end-of-year storage	10,720	10,720	10,720	11,383	11,383	10,772	10,772	11,683	11,683	10,772	10,743
Lake Powell storage											
31-year average (1970-2000)	19,300	19,305	19,396	17,960	19,165	19,335	19,411	14,112	14,083	19,333	19,346
End of study (Sept. 30, 2000)	20,889	20,839	21,125	20,721	20,719	21,116	21,127	18,233	19,279	21,124	22,659
Minimum end-of-year storage	8,201	8,201	8,201	9,141	9,177	8,254	8,254	8,916	9,012	8,254	8,225
Lake Mead storage											
31-year average (1970-2000)	20,554	20,581	20,665	16,913	18,654	20,522	20,583	15,072	14,860	20,624	19,757
End of study (Sept. 30, 2000)	20,925	20,925	21,163	20,736	20,754	21,134	21,161	18,349	19,540	21,162	17,074
Minimum end-of-year storage	16,192	16,257	16,192	14,011	13,367	15,135	15,135	9,151	7,753	15,195	15,195
Releases from Lake Powell	10,971	10,971	10,910	10,141	10,136	10,868	10,837	9,321	9,263	10,957	10,289
Upper Basin shortages	0	0	0	0	0	0	0	0	0	0	0
Total Hoover releases	10,645	10,644	11,255	9,749	9,752	10,502	10,605	8,977	8,689	10,602	10,165
Wasted releases from Lake Mead	643	651	1,314	306	312	777	1,159	0	0	777	433
Upper Basin energy	6,347	6,347	6,337	5,999	6,001	6,329	6,316	5,218	5,557	6,329	6,073
Lower Basin energy	6,070	6,071	6,061	5,502	5,476	6,048	6,011	4,884	4,251	6,047	5,775
Total energy	12,417	12,418	12,398	11,501	11,477	12,377	12,327	10,002	9,808	12,376	11,848
Hoover energy @ 83%	4,875	4,876	4,371	4,383	4,361	4,852	4,841	3,643	[illegible]	4,859	4,620

1/ Runoff. Sequence 6 is substituted for Sequence 3, 7, for 8, and 9 for 12 in these studies.

TASK FORCE ON OPERATING CRITERIA - COLORADO RIVER - P. L. 90-537 Sheet No. 3

COMPARISON OF TEST STUDIES October 29, 1969

CAP Study No.	34	35	36	37	38	39	40	41	42	43	44
Minimum release from Upper Basin in Million AF/Year	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	7.5	7.5
Rule curve probability in percent	90.5	98.4	00.0	98.4	00.0	98.4	00.0	98.4	00.0	98.4	98.4
Lake Mead rule elev. above which add'l Low. Bas. use assumed	1190	1190	1190	1190	1190	1190	1190	1190	1190	1190	1190
Lake Mead rule elev. below which Low. Bas. shortage assumed	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Lake Mead demand - 1970 thru 1979 in 1000 AF/Yr.	9500	9500	8400	8400	8400	8400	8400	8400	8400	8400	8400
Lake Mead demand - 1980 and after	9500	9500	9500	9500	9500	9200	9200	9800	9800	9500	9500
Upper Basin depletion schedule	Ult.	Ult.	Base	Base 2/	Base 2/	Base 2/	Base 2/	Base 2/	Base 2/	Rapid	Base
Sequence No. 4 - 1916 through 1946 - Depleted Flow (103% of Average)											
Upper Basin storage	10,152	10,152	11,167	10,857	10,857	10,857	10,857	10,857	10,857	10,655	11,167
31-year average (1970-2000)	21,076	21,841	23,553	18,562	18,528	18,856	18,859	18,201	18,156	24,318	23,791
End of study (Sept. 30, 2000)	12,544	16,986	16,194	28,636	28,635	28,877	28,879	28,286	28,286	21,058	16,490
Minimum end-of-year storage	11,011	11,282	14,399	6,353	6,357	6,353	6,357	6,353	6,357	15,671	15,282
Lake Powell storage											
31-year average (1970-2000)	16,955	17,648	18,794	14,596	14,564	14,834	14,837	14,318	14,273	19,540	19,005
End of study (Sept. 30, 2000)	10,075	14,116	13,040	22,905	22,905	23,040	23,042	22,725	22,726	17,774	13,327
Minimum end-of-year storage	8,627	8,898	11,486	4,599	4,601	4,599	4,601	4,599	4,601	12,660	12,307
Lake Mead storage											
31-year average (1970-2000)	17,328	16,921	19,401	16,787	16,770	17,102	17,100	16,437	16,439	17,162	19,262
End of study (Sept. 30, 2000)	10,512	9,748	13,441	22,958	22,959	23,093	23,094	22,777	22,779	6,958	13,323
Minimum end-of-year storage	10,512	9,748	13,441	10,380	10,424	10,865	10,867	10,016	10,089	6,958	12,741
Releases from Lake Powell	9,720	9,552	10,360	9,754	9,756	9,740	9,740	9,774	9,776	9,677	10,352
Upper Basin shortages	0	0	0	0	0	0	0	0	0	0	0
Total Hoover releases	9,655	9,526	10,320	9,415	9,416	9,386	9,385	9,452	9,453	9,916	10,314
Wasted releases from Lake Mead	75	76	1,022	180	175	255	255	95	91	927	1,024
Upper Basin energy	5,710	5,675	5,949	5,455	5,454	5,458	5,457	5,453	5,450	5,689	5,953
Lower Basin energy	5,341	5,248	5,804	5,156	5,157	5,162	5,162	5,156	5,157	4,909	5,786
Total energy	11,051	10,923	11,753	10,611	10,611	10,620	10,619	10,609	10,607	10,598	11,739
Hoover energy @ 83%	4,229	4,150	4,652	4,074	4,074	4,085	4,085	4,066	4,067	3,798	4,635
Sequence No. 5 - 1931 through 1961 - Depleted Flow (86% of Average)											
Upper Basin storage	8,221	8,221	9,156							8,657	9,156
31-year average (1970-2000)	10,497	12,356	15,165							15,369	16,042
End of study (Sept. 30, 2000)	2,671	6,871	7,081							8,736	9,142
Minimum end-of-year storage	2,671	5,814	7,081							8,736	9,142
Lake Powell storage											
31-year average (1970-2000)	8,518	10,111	12,108							12,252	12,887
End of study (Sept. 30, 2000)	3,069	6,531	5,705							6,891	7,471
Minimum end-of-year storage	3,069	5,022	5,705							6,891	7,471
Lake Mead storage											
31-year average (1970-2000)	10,609	9,566	15,118							12,569	14,486
End of study (Sept. 30, 2000)	9,105	7,348	9,824							6,807	9,068
Minimum end-of-year storage	9,105	7,113	9,824							6,807	9,068
Releases from Lake Powell	8,433	8,230	8,903							8,341	8,806
Upper Basin shortages	0	0	0							0	0
Total Hoover releases	8,429	8,320	8,916							8,538	8,866
Wasted releases from Lake Mead	0	0	0							1	0
Upper Basin energy	4,232	4,376	4,863							4,647	4,907
Lower Basin energy	4,103	2,913	4,796							3,768	4,670
Total energy	8,335	7,289	9,659							8,415	9,567
Hoover energy @ 83%	3,123	1,947	3,762							2,777	3,642
Sequence No. 6 - 1941 through 1908 - Depleted Flow (93% of Average)											
Upper Basin storage	8,991	8,991	9,957							9,436	9,957
31-year average (1970-2000)	12,188	15,691	20,312							20,271	20,703
End of study (Sept. 30, 2000)	12,064	17,335	17,650							22,295	18,228
Minimum end-of-year storage	1,325	5,606	11,300							11,257	12,668
Lake Powell storage											
31-year average (1970-2000)	10,474	13,481	16,226							16,273	16,607
End of study (Sept. 30, 2000)	10,675	15,551	13,773							18,312	14,349
Minimum end-of-year storage	1,725	5,295	8,523							8,480	9,811
Lake Mead storage											
31-year average (1970-2000)	12,361	11,089	16,839							14,988	16,658
End of study (Sept. 30, 2000)	10,689	8,757	13,807							6,838	14,368
Minimum end-of-year storage	9,037	8,385	10,090							6,838	9,851
Releases from Lake Powell	8,831	8,538	9,188							8,519	9,158
Upper Basin shortages	- 13	0	0							0	0
Total Hoover releases	8,705	8,516	8,986							8,611	8,942
Wasted releases from Lake Mead	0	0	2							3	2
Upper Basin energy	4,302	4,860	5,368							5,087	5,385
Lower Basin energy	4,080	3,275	4,928							3,857	4,891
Total energy	8,382	8,135	10,296							8,944	10,276
Hoover energy @ 83%	3,971	2,738	3,887							2,858	3,854
Sequence No. 12 - 1931 through 1924 - Depleted Flow (111% of Average)											
Upper Basin storage	11,088	11,088	12,082							11,530	12,082
31-year average	21,478	22,540	24,499							24,485	24,717
End of study (Sept. 30, 2000)	26,564	26,595	27,068							28,316	27,152
Minimum end-of-year storage	10,684	11,383	10,772							10,743	10,772
Lake Powell storage											
31-year average (1970-2000)	17,138	18,029	19,333							19,347	19,504
End of study (Sept. 30, 2000)	20,742	20,751	21,124							22,373	21,208
Minimum end-of-year storage	8,630	9,141	8,254							8,225	8,254
Lake Mead storage											
31-year average (1970-2000)	17,452	17,282	20,624							19,689	20,421
End of study (Sept. 30, 2000)	20,776	20,786	21,162							17,098	21,246
Minimum end-of-year storage	10,416	10,360	16,195							14,382	14,616
Releases from Lake Powell	10,163	10,138	10,887							10,296	10,878
Upper Basin shortages	0	0	0							0	0
Total Hoover releases	9,815	9,794	10,602							10,175	10,598
Wasted releases from Lake Mead	256	268	777							452	778
Upper Basin energy	5,945	6,008	6,329							6,126	6,338
Lower Basin energy	5,420	5,400	6,047							5,772	6,028
Total energy	11,365	11,408	12,376							11,898	12,366
Hoover energy @ 83%	4,294	4,278	4,859							4,616	4,841

2/ Sequence is 31-year period, 1950 through 1968 and 1906 through 1920, which contains the lowest initial 12 years of record.

TASK FORCE ON OPERATING CRITERIA - COLORADO RIVER - P. L. 90-537 Sheet No. 4

COMPARISON OF TEST STUDIES October 23, 1969

LAP Study No.	45	46	21R	25R	29R
Minimum Release from Upper Basin in Million AF/year	7.5	7.5	8.25	8.25	8.25
Rule curve probability in percent	98.4	98.4	98.4	95.2	98.4
Lake Mead rule elev. above which add'l Low. Bas. use assumed	1190	1190	1190	1190	1190
Lake Mead rule elev. below which Low. Bas. shortage assumed	1100	1100	1100	1100	1100
Lake Mead demand - 1970 thru 1979 in 1000 AF/Yr.	8400	8400	8400	8400	FirmP
Lake Mead demand - 1980 and after	9800	9200	9200	9500	FirmP
Upper Basin depletion schedule	Rapid	Rapid	Base	Base	Base
Sequence No. 1 - 1915 through 1946 - Depleted Flow (103% of Average)	10,655	10,655	11,167	11,167	11,167
Upper Basin storage					
31-year average (1970-2000)	24,193	24,408	23,985	23,553	23,326
End of study (Sept. 30, 2000)	20,958	20,989	17,794	16,194	17,650
Minimum end-of-year storage	15,554	15,593	15,260	14,399	13,906
Lake Powell storage					
31-year average (1970-2000)	19,423	19,625	19,210	18,794	18,613
End of study (Sept. 30, 2000)	17,676	17,706	14,595	13,040	13,873
Minimum end-of-year storage	12,551	12,587	12,267	11,486	11,054
Lake Mead storage					
31-year average (1970-2000)	16,715	17,791	19,949	19,401	18,840
End of study (Sept. 30, 2000)	6,854	7,819	15,226	13,441	11,749
Minimum end-of-year storage	6,854	7,813	14,715	13,441	11,749
Releases from Lake Powell	9,683	9,677	10,305	10,369	10,345
Upper Basin shortages	0	0	0	0	0
Total Hoover releases	9,941	9,862	10,177	10,320	10,374
Wasted releases from Lake Mead	888	968	1,062	1,022	1,050
Upper Basin energy	5,688	5,690	5,943	5,949	5,942
Lower Basin energy	4,736	5,217	5,758	5,804	5,795
Total energy	10,424	10,907	11,701	11,753	11,737
Hoover energy @ 83%	3,623	4,114	4,626	4,652	4,634
Sequence No. 3 - 1921 through 1961 - Depleted Flow (86% of Average)	8,657	8,657	9,156	9,156	9,156
Upper Basin storage					
31-year average (1970-2000)	14,876	15,636	16,207	15,205	14,970
End of study (Sept. 30, 2000)	8,032	8,675	10,583	7,267	8,839
Minimum end-of-year storage	8,032	8,675	8,855	7,267	8,839
Lake Powell storage					
31-year average (1970-2000)	11,813	12,514	13,071	12,144	11,937
End of study (Sept. 30, 2000)	6,559	6,830	8,260	5,865	7,168
Minimum end-of-year storage	6,559	6,830	7,021	5,865	7,021
Lake Mead storage					
31-year average (1970-2000)	12,148	13,228	15,705	15,107	13,797
End of study (Sept. 30, 2000)	6,801	7,037	10,142	9,787	9,326
Minimum end-of-year storage	6,801	7,037	10,142	9,787	9,326
Releases from Lake Powell	8,377	8,337	8,754	8,855	8,846
Upper Basin shortages	0	0	0	0	0
Total Hoover releases	8,588	8,505	8,733	8,910	8,920
Wasted releases from Lake Mead	0	0	0	0	79
Upper Basin energy	4,637	4,663	4,856	4,863	4,822
Lower Basin energy	3,624	3,996	4,744	4,791	4,671
Total energy	8,261	8,659	9,600	9,654	9,493
Hoover energy @ 83%	2,627	3,008	3,730	3,758	3,637
Sequence No. 6 - 1941 through 1908 - Depleted Flow (93% of Average)	9,436	9,436	9,957	9,957	9,957
Upper Basin storage					
31-year average (1970-2000)	19,923	20,770	21,188	20,340	19,142
End of study (Sept. 30, 2000)	21,660	23,266	20,293	17,687	19,952
Minimum end-of-year storage	10,501	11,844	12,449	11,300	10,587
Lake Powell storage					
31-year average (1970-2000)	15,876	16,653	17,032	16,253	15,386
End of study (Sept. 30, 2000)	17,689	19,283	16,286	13,808	16,017
Minimum end-of-year storage	7,970	9,067	9,672	8,523	8,029
Lake Mead storage					
31-year average (1970-2000)	14,612	15,510	17,222	16,819	15,392
End of study (Sept. 30, 2000)	6,826	7,072	14,814	13,844	12,705
Minimum end-of-year storage	6,826	7,072	10,315	10,090	9,902
Releases from Lake Powell	8,552	8,469	9,079	9,187	9,149
Upper Basin shortages	0	0	0	0	0
Total Hoover releases	8,657	8,535	8,828	8,983	9,031
Wasted Releases from Lake Mead	1	0	2	2	231
Upper Basin energy	5,076	5,089	5,377	5,370	5,300
Lower Basin energy	3,776	4,001	4,875	4,926	4,663
Total energy	8,852	9,090	10,252	10,296	10,163
Hoover energy @ 83%	2,772	3,010	3,832	3,854	3,816
Sequence No. 12 - 1961 through 1928 - Depleted Flow (111% of Average)	11,530	11,530	12,082	12,082	12,082
Upper Basin storage					
31-year average	24,366	24,592	24,582	24,409	24,332
End of study (Sept. 30, 2000)	26,312	28,313	27,263	27,068	27,071
Minimum end-of-year storage	10,743	10,743	10,772	10,772	10,772
Lake Powell storage					
31-year average (1970-2000)	19,257	19,427	19,402	19,333	19,193
End of study (Sept. 30, 2000)	22,369	22,370	21,345	21,124	21,127
Minimum end-of-year storage	8,225	8,225	8,254	8,254	8,254
Lake Mead storage					
31-year average (1970-2000)	19,469	19,933	20,731	20,624	20,182
End of study (Sept. 30, 2000)	15,837	18,228	21,383	21,162	21,164
Minimum end-of-year storage	14,382	14,382	16,135	16,195	15,135
Releases from Lake Powell	10,298	10,294	10,879	10,837	10,891
Upper Basin shortages	0	0	0	0	0
Total Hoover releases	10,227	10,129	10,503	10,602	10,620
Wasted releases from Lake Mead	338	589	324	727	798
Upper Basin energy	6,134	6,113	6,320	6,339	6,340
Lower Basin energy	5,792	5,753	6,041	6,047	6,028
Total energy	11,926	11,866	12,361	12,375	12,368
Hoover energy @ 83%	4,626	4,608	4,857	4,859	4,836

Streamflow Sequences

We had recommended in our Denver meeting that we base the criteria and the test studies only on the 31-year period 1970 through 2000. Our test studies with the one exception previously mentioned are based on this concept.

Initially we selected for study 13 - 31-year continuous sequences or those which began with each fifth year of the 1906-1968 period starting in 1906, and continuing through 1966. For the studies, we assumed 1906 followed 1968 in the streamflow sequences. Two studies (Nos. 14 and 15) were completed with all 13 sequences, but realizing the magnitude of the number of studies which would be necessary using 13 sequences in combination with many other variations in other parameters, we reduced the flow sequences to 4 for the subsequent studies. The four selected sequences are: #3 (1916-1946), #6 (1931-1961), #8 (1941-1908), #12 (1961-1929). These are shown on the graph and provide a representative cross section of sequences which we might reasonably expect during the next 31 years. The first sequence (sequence #3) is about 103% of the 1906-1968 average with higher than average years occurring early in the sequence. The second (sequence #6) is about 86% of average and is the lowest 31-year sequence of record. The third (sequence #8) is about 93% of average or about lower quartile and contains the lowest 4 and 12-year sequences of record. The fourth is 111% of average with below average years occurring early in the sequence. Nearly all studies were run with all four sequences. However, we did run a few studies using the 1953-1920 sequence which is 101% of average and includes the most critical 4 and 12-year sequences at the beginning of the study. The

six variables previously identified and included in various computations in our studies are more fully described below:

Upper Basin Storage Reserve

We have studied five different storage rules in the Upper Basin which would remain inviolate to the extent streamflow is available subject only to the minimum allowable delivery requirement from Lake Powell. The five storage levels were those amounts required to deliver either 7 1/2 or 8 1/4 MAF annually at Lee Ferry during various critical streamflow periods of record using the following streamflow sequences to define the critical periods:

(a) No specific sequence used. No inviolate storage provided.

(b) The sixth lowest in a 63 event sequence having an estimated probability of being exceeded 90.5% of the time.

(c) The third lowest in a 63 event sequence having an estimated probability of being exceeded 95.2% of the time.

(d) The lowest in a 63 event sequences having an estimated probability of being exceeded 98.4% of the time.

(e) Storage requirement defined under (d) above to which was added the amount of storage between the dead storage level and the minimum power level in Upper Basin Reservoirs. (Identified on Table as 98.4+%).

The values of Table 2 (4 sheets) indicate the effect of these rules on various items.

TABLE 2

EFFECT OF RULE CURVE

STUDY NUMBER	36	16	25R	32	28
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25	8.25	8.25	8.25
Upper Basin Rule Curve Probability, percent	0	90.5	95.2	98.4	98.4+
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190	1190	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100	1100	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	8400	8400	8400	8400
Lake Mead demand - 1980 and after, 1000 AF/Yr.	9500	9500	9500	9500	9500
Upper Basin depletion schedule	Base	Base	Base	Base	Base
Reference to previous paragraph breakdown	(a)	(b)	(c)	(d)	(e)
equence No. 3 - 1916 through 1946					
Year 2000 Content, Lake Powell 1000 AF	13,040	13,048	13,040	14,229	18,011
Year 2000 Content, Lake Mead 1000 AF	13,441	13,441	13,441	12,278	9,988
31-year average in 1000 AF					
Additional Upper Basin Use After 1968	1,332	1,332	1,332	1,332	1,332
Lake Powell Release	10,369	10,369	10,369	10,324	10,173
Lower Basin Use (Inc. Mexico & Surplus)	9,217	9,217	9,217	9,217	9,165
Lower Basin Waste (Unusable Spill)	1,022	1,022	1,022	1,022	1,022
Lower Basin Uses Above 7 1/2 MAF	241	241	241	241	241
Lower Basin Shortage in 7 1/2 MAF (CAP)	0	0	0	0	52
31-year average in MKWH					
Upper Basin Energy	5,949	5,949	5,949	5,940	5,912
Lower Basin Energy	5,804	5,804	5,804	5,792	5,712

TABLE 2

EFFECT OF RULE CURVE

STUDY NUMBER	36	16	25R	32	28
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25	8.25	8.25	8.25
Upper Basin Rule Curve Probability, percent	0	90.5	95.2	98.4	98.4+
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190	1190	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100	1100	1100	1100
Lake Mead demand - 1970 thru 1979, 1000·AF/Yr.	8400	8400	8400	8400	8400
Lake Mead demand - 1980 and after, 1000 AF/Yr.	9500	9500	9500	9500	9500
Upper Basin depletion schedule	Base	Base	Base	Base	Base
Reference to previous paragraph breakdown	(a)	(b)	(c)	(d)	(e)
Sequence No. 6 - 1931 through 1961					
Year 2000 Content, Lake Powell 1000 AF	5,705	5,465	5,865	7,475	9,600
Year 2000 Content, Lake Mead 1000 AF	9,824	9,844	9,787	9,468	9,107
31-year average in 1000 AF					
Additional Upper Basin Use After 1968	1,298	1,299	1,298	1,298	1,298
Lake Powell Release	8,903	8,906	8,895	8,811	8,696
Lower Basin Use (Inc. Mexico & Surplus)	8,916	8,916	8,910	8,840	8,759
Lower Basin Waste (Unusable Spill)	0	0	0	0	0
Lower Basin Uses Above 7 1/2 MAF	0	0	0	0	0
Lower Basin Shortage in 7 1/2 MAF (CAP)	60	60	66	135	217
31-year average in MKWH					
Upper Basin Energy	4,863	4,865	4,863	4,841	4,855
Lower Basin Energy	4,796	4,800	4,791	4,748	4,551 1/

1/ Hoover below elevation 1083 part time from 1998-2000.

TABLE 2

EFFECT OF RULE CURVE

STUDY NUMBER	36	16	25R	32	28
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25	8.25	8.25	8.25
Upper Basin Rule Curve Probability, percent	0	90.5	95.2	98.4	98.4+
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190	1190	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100	1100	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	8400	8400	8400	8400
Lake Mead demand - 1980 and after, 1000 AF/Yr.	9500	9500	9500	9500	9500
Upper Basin depletion schedule	Base	Base	Base	Base	Base
Reference to previous paragraph breakdown	(a)	(b)	(c)	(d)	(e)
Sequence No. 8 - 1941 through 1908					
Year 2000 Content, Lake Powell 1000 AF	13,773	13,763	13,808	16,062	19,804
Year 2000 Content, Lake Mead 1000 AF	13,807	13,795	13,844	13,809	10,655
31-year average in 1000 AF					
Additional Upper Basin Use After 1968	1,336	1,337	1,336	1,336	1,336
Lake Powell Release	9,188	9,209	9,187	9,098	8,958
Lower Basin Use (Inc. Mexico & Surplus)	8,951	8,965	8,948	8,864	8,838
Lower Basin Waste (Unusable Spill)	2	2	2	2	2
Lower Basin Uses Above 7 1/2 MAF	71	84	71	71	71
Lower Basin Shortage in 7 1/2 MAF (CAP)	96	93	99	182	209
31-year average in MKWH					
Upper Basin Energy	5,368	5,379	5,370	5,362	5,312
Lower Basin Energy	4,928	4,942	4,926	4,875	4,851

TABLE 2

EFFECT OF RULE CURVE

STUDY NUMBER	36	16	25R	32	28
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25	8.25	8.25	8.25
Upper Basin Rule Curve Probability, percent	0	90.5	95.2	98.4	98.4+
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190	1190	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100	1100	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	8400	8400	8400	8400
Lake Mead demand - 1980 and after, 1000 AF/Yr.	9500	9500	9500	9500	9500
Upper Basin depletion schedule	Base	Base	Base	Base	Base
Reference to previous paragraph breakdown	(a)	(b)	(c)	(d)	(e)
Sequence No. 12 - 1961 through 1928					
Year 2000 Content, Lake Powell 1000 AF	21,124	21,125	21,124	21,124	21,116
Year 2000 Content, Lake Mead 1000 AF	21,162	21,163	21,162	21,162	21,154
31-year average in 1000 AF					
Additional Upper Basin Use After 1968	1,425	1,424	1,425	1,425	1,425
Lake Powell Release	10,887	10,910	10,887	10,887	10,888
Lower Basin Use (Inc. Mexico & Surplus)	9,712	9,719	9,712	9,712	9,712
Lower Basin Waste (Unusable Spill)	777	791	777	777	777
Lower Basin Uses Above 7 1/2 MAF	735	743	735	735	735
Lower Basin Shortage in 7 1/2 MAF (CAP)	0	0	0	0	0
31-year average in MKWH					
Upper Basin Energy	6,329	6,337	6,329	6,329	6,329
Lower Basin Energy	6,047	6,061	6,047	6,047	6,048

Upper Basin Depletions

In the studies Upper Basin depletions are measured at Lee Ferry and include changes in storage at water use project reservoirs.

Two different Upper Basin depletion schedules were considered. One was submitted in our initial draft of data handed out at the Denver meeting and represented the Bureau's estimate of the timing and magnitude of depletions which will occur in the Upper Basin. (Base Depletion).

The second represents the estimates of the individual Upper Basin States and the Upper Colorado River Commission. The graph (Figure 1) shows Upper Basin depletions for both estimates. (Rapid Depletion).

In addition, we have related the year-by-year depletion to the streamflow for the year by using a somewhat smaller than normal depletion in below average runoff years and a higher than normal in years of above average runoff. Our calculations and assumptions for these estimates were furnished you previously. The graphs (Figures 2, 3, 4, and 5) depict the total and normal additional year-by-year depletion and the total and additional year-by-year depletion associated with two specific sequences (Nos. 6 and 12) for both the base rate and the rapid rate of depletion.

As with differing sequences of streamflow, variations in the two Upper Basin depletions show significant ranges of values of energy production, terminal storage, and Lower Basin uses and waste as shown in Table 3 (2 Sheets).

The comparison in Table 3 shows that a more rapid rate of depletion in the Upper Basin will reduce water and power available in the Lower Basin and power in the Upper Basin.

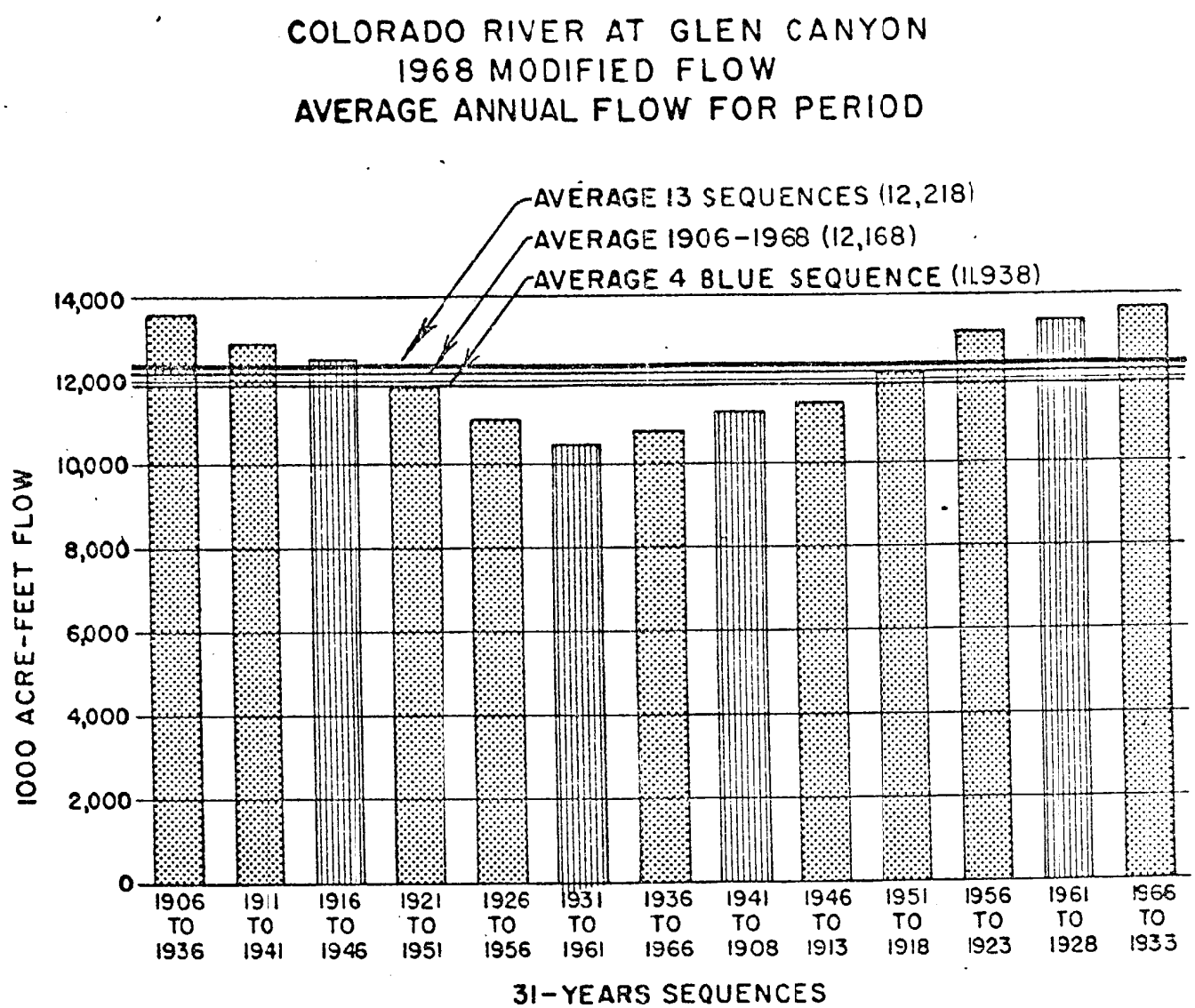
TABLE 3

EFFECT OF RATE OF INCREASE IN UPPER BASIN DEPLETIONS

STUDY NUMBER	32	33
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25
Upper Basin Rule Curve Probability, percent	98.4	98.4
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	8400
Lake Mead demand - 1980 and after, 1000 AF/Yr.	9500	9500
Upper Basin depletion schedule	Base	Rapid
Sequence No. 6 - 1931 through 1961		
Year 2000 Content, Lake Powell 1000 AF	7,475	6,686
Year 2000 Content, Lake Mead 1000 AF	9,468	7,380
31-year average in 1000 AF		
Additional Upper Basin Use After 1968	1,298	1,797
Lake Powell Release	8,811	8,305
Lower Basin Use (Inc. Mexico & Surplus)	8,840	8,486
Lower Basin Waste (Unusable Spill)	0	0
Lower Basin Uses Above 7 1/2 MAF	0	0
Lower Basin Shortage in 7 1/2 MAF (CAP)	135	490
31-year average in MKWH		
Upper Basin Energy	4,841	4,690
Lower Basin Energy	4,748	3,313 1/

1/ Hoover below elevation 1083 from 1990 - 2000.

Graph 1


COLORADO RIVER AT GLEN CANYON
1968 MODIFIED FLOW
AVERAGE ANNUAL FLOW FOR PERIOD
AVERAGE 13 SEQUENCES (12,218)
AVERAGE 1906-1968 (12,168)
AVERAGE 4 BLUE SEQUENCE (11,938)
1000 ACRE-FEET FLOW
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1906 TO 1936
1911 TO 1941
1916 TO 1946
1921 TO 1951
1926 TO 1956
1931 TO 1961
1936 TO 1966
1941 TO 1908
1946 TO 1913
1951 TO 1918
1956 TO 1923
1961 TO 1928
1966 TO 1933
31-YEARS SEQUENCES

ST. PAUL, MINNESOTA 55101 MADE IN U.S.A. CATALOG NO. 15-1006-4 Visual Products Division 3M

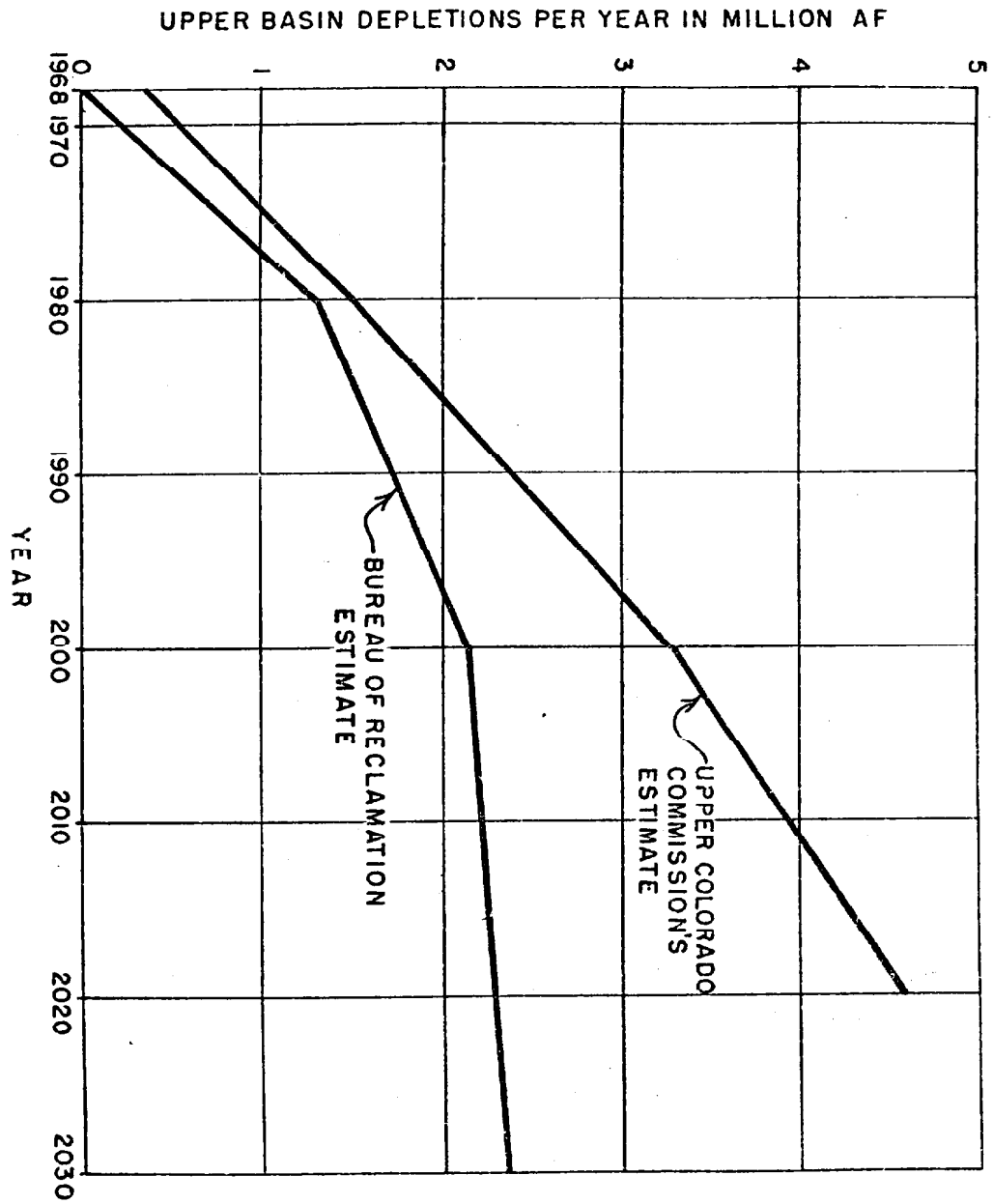


FIG. 1

UPPER BASIN DEPLETIONS

NOTES

TABLE 3

EFFECT OF RATE OF INCREASE IN UPPER BASIN DEPLETIONS

STUDY NUMBER	32	33
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25
Upper Basin Rule Curve Probability, percent	98.4	98.4
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	8400
Lake Mead demand - 1980 and after, 1000 AF/Yr.	9500	9500
Upper Basin depletion schedule	Base	Rapid
Sequence No. 12 - 1961 through 1928		
Year 2000 Content, Lake Powell 1000 AF	21,124	22,659
Year 2000 Content, Lake Mead 1000 AF	21,162	17,074
31-year average in 1000 AF		
Additional Upper Basin Use After 1968	1,425	1,977
Lake Powell Release	10,887	10,288
Lower Basin Use (Inc. Mexico & Surplus)	9,712	9,592
Lower Basin Waste (Unusable Spill)	777	483
Lower Basin Uses Above 7 1/2 MAF	735	615
Lower Basin Shortage in 7 1/2 MAF (CAP)	0	0
31-year average in MKWH		
Upper Basin Energy	6,329	6,073
Lower Basin Energy	6,047	5,775

Lower Basin Uses and Losses

After several meetings to attempt to resolve the issue of Lower Basin losses and consumptive use assignments, the States of the Lower Division on the committee recommended that we base the test studies on a normal release of 8.4 MAF at Lake Mead for 1970 - 1979 and a normal release of 9.5 MAF thereafter.

Since 9.5 MAF normal release after 1975 was not acceptable to all concerned, it was suggested that the normal release after 1979 be broadened to include three possibilities: 9.2, 9.5, and 9.8 MAF. The studies shown in Table 4 reflect these three conditions.

Minimum Release from Lake Powell

Two different minimum releases at Lee Ferry have been used in the studies - 7 1/2 MAF and 8 1/4 MAF. A comparison of several parameters for comparable studies using the two releases and two rates of Upper Basin depletion are shown in Table 5.

Level of Lake Mead above Which Additional Lower Basin Use is Assumed

A comparison of the results of studies 16 and 17 shown in Table 6 for sequences 6 and 12 indicates the magnitude of the change in the various parameters that would be associated with lowering the Lake Mead level from elevation 1190 to 1170 at which water deliveries for Lower Basin uses above 7.5 MAF would be made.

Level of Lake Mead below Which Shortages in Arizona Diversions are Assumed

Similarly, a comparison of the results of studies 16 and 18 shown in Table 7 for sequences 6 and 8 indicates the magnitude of changes that would be associated with lowering the Lake Mead level from elevation 1100 to 1070 at which water deliveries to Arizona would be reduced below 2.8 MAF.

TABLE 4

EFFECT OF RELEASES FROM LAKE MEAD

STUDY NUMBER	24	32	21R
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25	8.25
Upper Basin Rule Curve Probability, percent	98.4	98.4	98.4
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100	1100
Lake Mead demand - 1970 thru 1979; 1000 AF/Yr.	8400	8400	8400
Lake Mead demand - 1980 and after	9800	9500	9200
Upper Basin depletion schedule	Base	Base	Base
Sequence No. 6 - 1931 through 1961			
Year 2000 Content, Lake Powell 1000 AF	6,877	7,475	8,260
Year 2000 Content, Lake Mead 1000 AF	7,658	9,468	10,142
31-year average in 1000 AF			
Additional Upper Basin Use After 1968	1,299	1,298	1,298
Lake Powell Release	8,855	8,811	8,754
Lower Basin Use (Inc. Mexico & Surplus)	9,051	8,840	8.733
Lower Basin Waste (Unusable Spill)	0	0	0
Lower Basin Uses Above 7 1/2 MAF	0	0	0
Lower Basin Shortage in 7 1/2 MAF (CAP)	129	135	40
31-year average in MKWH			
Upper Basin Energy	4,831	4,841	4,856
Lower Basin Energy	4,393 1/	4,748	4,744

1/ Hoover below elevation 1083 from 1997 - 2000.

TABLE 4

EFFECT OF RELEASES FROM LAKE MEAD

STUDY NUMBER	22	16	19
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25	8.25
Upper Basin Rule Curve Probability, percent	90.5	90.5	90.5
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	8400	8400
Lake Mead demand - 1980 and after, 1000 AF/Yr.	9800	9500	9200
Upper Basin depletion schedule	Base	Base	Base
Reference to previous paragraph breakdown			
Sequence No. 6 - 1931 through 1961			
Year 2000 Content, Lake Powell 1000 AF	4,335	5,467	7,049
Year 2000 Content, Lake Mead 1000 AF	8,968	9,844	10,810
31-year average in 1000 AF			
Additional Upper Basin Use After 1968	1,299	1,299	1,299
Lake Powell Release	8,967	8,906	8,826
Lower Basin Use (Inc. Mexico & Surplus)	9,030	8,916	8,774
Lower Basin Waste (Unusable Spill)	0	0	0
Lower Basin Uses Above 7 1/2 MAF	0	0	0
Lower Basin Shortage in 7 1/2 MAF (CAP)	150	60	0
31-year average in MKWH			
Upper Basin Energy	4,842	4,865	4,881
Lower Basin Energy	4,743	4,800	4,783

TABLE 5

EFFECT OF MINIMUM RELEASE TO LOWER BASIN

STUDY NUMBER	44	43	32	33
Minimum Release from Upper Basin Mil.AF/Yr.	7.5	7.5	8.25	8.25
Upper Basin Rule Curve Probability, percent	98.4	98.4	98.4	98.4
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	8400	8400	8400
Lake Mead demand - 1980 and after, 1000 AF/Yr.	9500	9500	9500	9500
Upper Basin depletion schedule	Base	Rapid	Base	Rapid
Sequence No. 3 - 1916 through 1946				
Year 2000 Content, Lake Powell 1000 AF	13,327	17,774	14,229	10,832
Year 2000 Content, Lake Mead 1000 AF	13,323	6,958	12,278	9,756
31-year average in 1000 AF				
Additional Upper Basin Use After 1968	1,332	1,844	1,332	1,844
Lake Powell Release	10,352	9,677	10,324	9,959
Lower Basin Use (Inc. Mexico & Surplus)	9,212	8,910	9,217	9,072
Lower Basin Waste (Unusable Spill)	1,024	927	1,022	926
Lower Basin Uses Above 7 1/2 MAF	235	239	241	232
Lower Basin Shortage in 7 1/2 MAF (CAP)	0	305	0	136
31-year average in MKWH				
Upper Basin Energy	5,953	5,689	5,940	5,740
Lower Basin Energy	5,786	4,909 1/	5,792	5,579

1/ Hoover below elevation 1083 from 1996 - 2000.

TABLE 5

EFFECT OF MINIMUM RELEASE TO LOWER BASIN

STUDY NUMBER	44	43	32	33
Minimum Release from Upper Basin Mil.AF/Yr.	7.5	7.5	8.25	8.25
Upper Basin Rule Curve Probability, percent	98.4	98.4	98.4	98.4
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	8400	8400	8400
Lake Mead demand - 1980 and after, 1000 AF/Yr.	9500	9500	9500	9500
Upper Basin depletion schedule	Base	Rapid	Base	Rapid
Sequence No. 6 - 1931 through 1961				
Year 2000 Content, Lake Powell 1000 AF	7,471	6,891	7,475	6,686
Year 2000 Content, Lake Mead 1000 AF	9,068	6,807	9,468	7.380
31-year average in 1000 AF				
Additional Upper Basin Use After 1968	1,298	1,797	1,298	1,797
Lake Powell Release	8,806	8,341	8,811	8,305
Lower Basin Use (Inc. Mexico & Surplus)	8,866	8,538	8,840	8,486
Lower Basin Waste (Unusable Spill)	0	1	0	0
Lower Basin Uses Above 7 1/2 MAF	0	0	0	0
Lower Basin Shortage in 7 1/2 MAF (CAP)	109	438	135	490
31-year average in MKWH				
Upper Basin Energy	4,897	4,647	4,841	4,690
Lower Basin Energy	4,670	3,768 1/	4,748	3,313 2/

1/ Hoover below elevation 1083 from 1993 - 2000.
2/ Hoover below elevation 1083 from 1990 - 2000.

TABLE 6

EFFECT OF LEVEL ABOVE WHICH ADDITIONAL LOWER BASIN USE IS ASSUMED

STUDY NUMBER	16	17
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25
Upper Basin Rule Curve Probability, percent	90.5	90.5
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1170
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	8400
Lake Mead demand - 1980 and after, 1000 AF/Yr.	9500	9500
Upper Basin depletion schedule	Base	Base
Sequence No. 6		
Year 2000 Content, Lake Powell 1000 AF	5,465	5,465
Year 2000 Content, Lake Mead 1000 AF	9,844	9,844
31-year average in 1000 AF		
Additional Upper Basin Use After 1968	1,299	1,299
Lake Powell Release	8,906	8,906
Lower Basin Use (Inc. Mexico & Surplus)	8,916	8,916
Lower Basin Waste (Unusable Spill)	0	0
Lower Basin Uses Above 7 1/2 MAF	0	0
Lower Basin Shortage in 7 1/2 MAF (CAP)	60	60
31-year average in MKWH		
Upper Basin Energy	4,865	4,865
Lower Basin Energy	4,800	4,800
31-year average in MW-Yr.		
Upper Basin Capability	1,264	1,264
Lower Basin Capability	1,595	1,593

TABLE 6

EFFECT OF LEVEL ABOVE WHICH ADDITIONAL LOWER BASIN USE IS ASSUMED

STUDY NUMBER	16	17
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25
Upper Basin Rule Curve Probability, percent	90.5	90.5
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1170
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	8400
Lake Mead demand - 1980 and after, 1000 AF/Yr.	9500	9500
Upper Basin depletion schedule	Base	Base
Sequence No. 12		
Year 2000 Content, Lake Powell 1000 AF	21,125	20,216
Year 2000 Content, Lake Mead 1000 AF	21,163	20,252
31-year average in 1000 AF		
Additional Upper Basin Use After 1968	1,424	1,424
Lake Powell Release	10,910	10,948
Lower Basin Use (Inc. Mexico & Surplus)	9,719	9,857
Lower Basin Waste (Unusable Spill)	791	738
Lower Basin Uses Above 7 1/2 MAF	743	880
Lower Basin Shortage in 7 1/2 MAF (CAP)	0	0
31-year average in MKWH		
Upper Basin Energy	6,337	6,364
Lower Basin Energy	6,061	6,092
31-year average in MW-Yr.		
Upper Basin Capability	1,344	1,344
Lower Basin Capability	1,626	1,626

TABLE 7

EFFECT OF LEVEL OF LAKE MEAD BELOW WHICH SHORTAGE IN ARIZONA DIVERSIONS ARE ASSUMED

STUDY NUMBER	16	18
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25
Upper Basin Rule Curve Probability, percent	90.5	90.5
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1070
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	8400
Lake Mead demand - 1980 and after	9500	9500
Upper Basin depletion schedule	Base	Base

1/ Hoover below elevation 1083 during 1997.

Sequence No. 8 - 1941 through 1908		
Year 2000 Content, Lake Powell 1000 AF	13,763	12,607
Year 2000 Content, Lake Mead 1000 AF	13,795	12,626
31-year average in 1000 AF		
Additional Upper Basin Use After 1968	1,337	1,337
Lake Powell Release	9,209	9,253
Lower Basin Use (Inc. Mexico & Surplus)	8,965	9,058
Lower Basin Waste (Unusable Spill)	2	2
Lower Basin Uses Above 7 1/2 MAF	84	84
Lower Basin Shortage in 7 1/2 MAF (CAP)	93	3
31-year average in MKWH		
Upper Basin Energy	5,379	5,385
Lower Basin Energy	4,942	4,790 1/
31-year average in MW-Yr.		
Upper Basin Capability	1,333	1,329
Lower Basin Capability	1,568	1,447

TABLE 8

EFFECT OF GENERATING FIRM ENERGY AT HOOVER

STUDY NUMBER	32	29R
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25
Upper Basin Rule Curve Probability, percent	98.4	98.4
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	Firm Power 1/
Lake Mead demand - 1980 and after	9500	Firm Power 1/
Upper Basin depletion schedule	Base	Base
Sequence No. 6 - 1931 through 1961		
Year 2000 Content, Lake Powell 1000 AF	7,475	7,168
Year 2000 Content, Lake Mead 1000 AF	9,468	9,326
31-year average in 1000 AF		
Additional Upper Basin Use After 1968	1,298	1,298
Lake Powell Release	8,811	8,846
Lower Basin Use (Inc. Mexico & Surplus)	8,840	8,832
Lower Basin Waste (Unusable Spill)	0	79
Lower Basin Uses Above 7 1/2 MAF	0	33
Lower Basin Shortage in 7 1/2 MAF (CAP)	135	177
31-year average in MKWH		
Upper Basin Energy	4,841	4,822
Lower Basin Energy	4,748	4,671

1/ Firm Power through 1987 at 83% efficiency.

TABLE 8

EFFECT OF GENERATING FIRM ENERGY AT HOOVER

STUDY NUMBER	32	29R
Minimum Release from Upper Basin Mil.AF/Yr.	8.25	8.25
Upper Basin Rule Curve Probability, percent	98.4	98.4
Lake Mead rule elev. above which additional Lower Basin use assumed	1190	1190
Lake Mead rule elev. below which Lower Basin shortage assumed	1100	1100
Lake Mead demand - 1970 thru 1979, 1000 AF/Yr.	8400	Firm Power 1/
Lake Mead demand - 1980 and after	9500	Firm Power 1/
Upper Basin depletion schedule	Base	Base
Sequence No. 8 - 1941 through 1908		
Year 2000 Content, Lake Powell 1000 AF	16,062	16,017
Year 2000 Content, Lake Mead 1000 AF	13,809	12,705
31-year average in 1000 AF		
Additional Upper Basin Use After 1968	1,336	1,336
Lake Powell Release	9,098	9,149
Lower Basin Use (Inc. Mexico & Surplus)	8,864	8,766
Lower Basin Waste (Unusable Spill)	2	231
Lower Basin Uses Above 7 1/2 MAF	71	48
Lower Basin Shortage in 7 1/2 MAF (CAP)	182	258
31-year average in MKWH		
Upper Basin Energy	5,362	5,300
Lower Basin Energy	4,875	4,863

1/ Firm power through 1987 at 83% efficiency.

Firm Energy Generation at Hoover Powerplant

A comparison of studies similar except for power production at Lake Mead is shown on Table 8. Study 29R shows the results of generating firm energy at Hoover from 1970 through 1987 and is compared to the base study 32.

Sequences Containing the Lowest Streamflows during the early years

Although the 1931-1961 sequence is the lowest in terms of total runoff for the entire period of all the possible sequences, the 1953-1920 sequence contains less total runoff in the early years. Since this might indicate a problem in maintaining power production at Glen Canyon during the next few years, we ran one study with the following parameters to check this possibility. A comparison with the Base Study (#32) is shown on Table 9.

may results

Table 9

Values for 31-year period (1970-2000)	Study 32	Study 37
Minimum level Lake Powell - 1000 AF	5,582	4,017
Minimum level Lake Mead - 1000 AF	9,291	9,990
Average Energy, Upper Basin (MKWH)	4,841	5,455
Average Energy, Lower Basin (MKWH)	4,748	5,156
Average Release, Lake Powell - 1000 AF	8,811	9,754
Average Release, Lake Mead - 1000 AF	8,840	9,415
31-Year Average 1968 Modified Flow at Glen Canyon	10,454	12,263

Studies to Reflect Depletion Conditions after Year 2000

At the request of Mr. Holburt, we ran four studies with four streamflow sequences each for the year 2001 to 2031 period to demonstrate the effect of the criteria after year 2000. One of these studies (Number 34) using sequence 8 indicated an Upper Basin shortage of 426,000 acre-feet in the

twenty-sixth year of the study. This was the only Upper Basin shortage imposed by the criteria found in all of the 146 studies that were made.

Withdrawals of Water from below Elevation 1083' at Hoover

Withdrawals of water below elevation 1083' at Hoover occur in 159 years in twenty-five study sequences. These withdrawals occurred three times using sequence 3, 11 times using sequence 6, two times using sequence 7, 8 times in sequence 8, one time in sequence 9, and no time in sequence 12.

Graphs

We have included a few graphs to illustrate some of the parameters that have been studied and included in the tables. Copies of these are attached.

FIG. 2

UPPER BASIN DEPLETION

(UPPER COLORADO RIVER COMMISSION ESTIMATE)

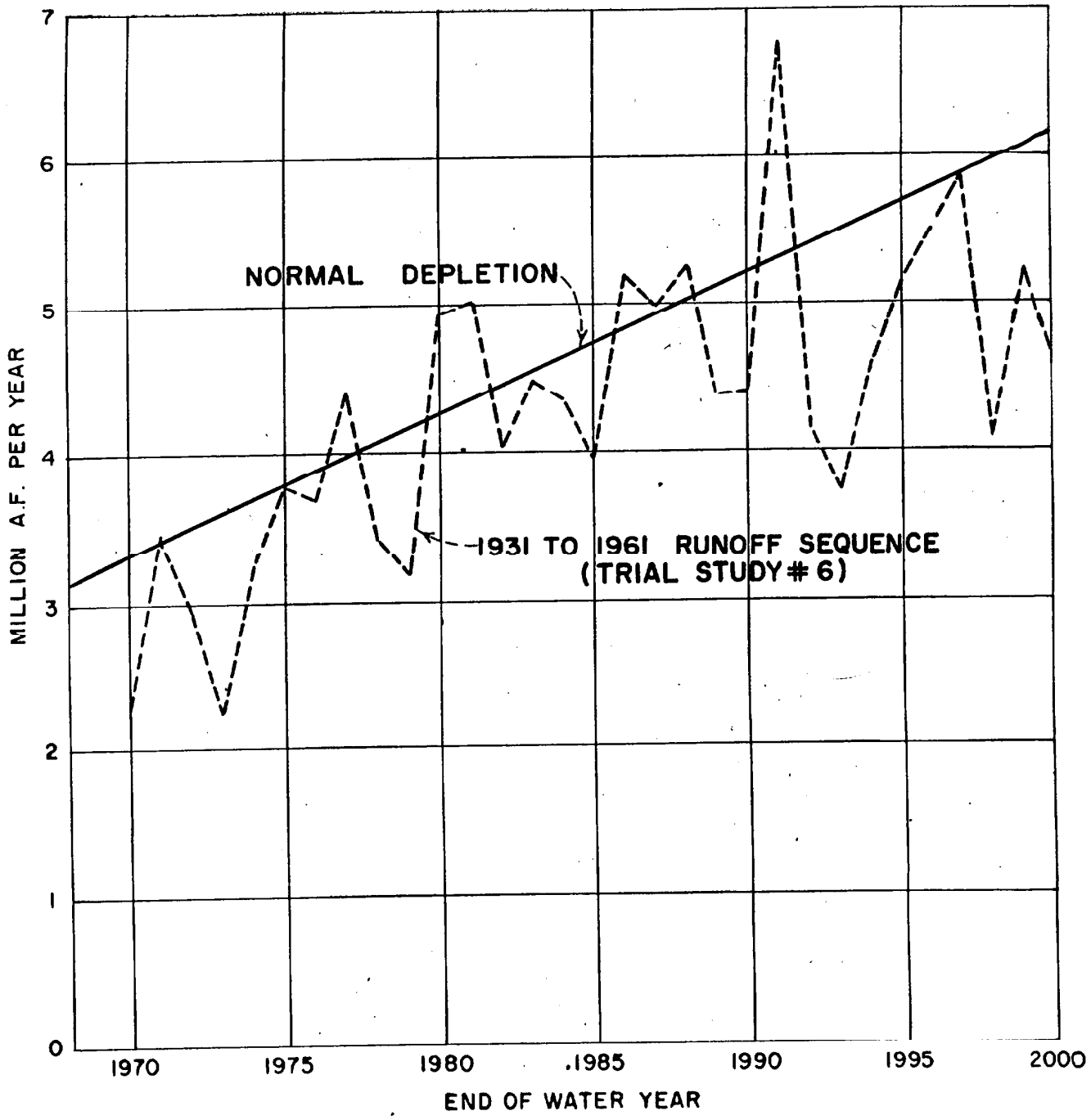


FIG. 3

UPPER BASIN DEPLETION

(UPPER COLORADO RIVER COMMISSION ESTIMATE)

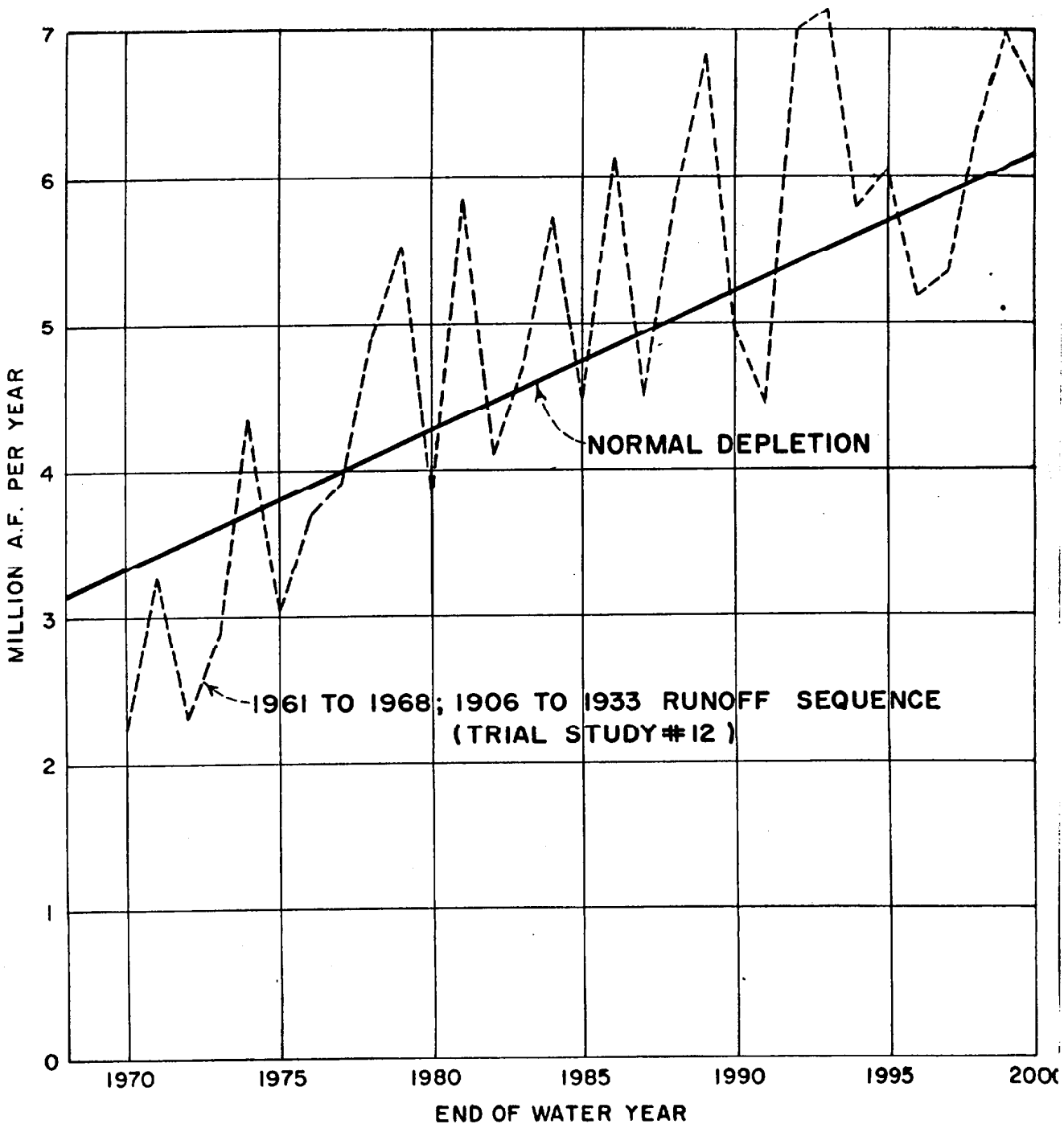


FIG. 4

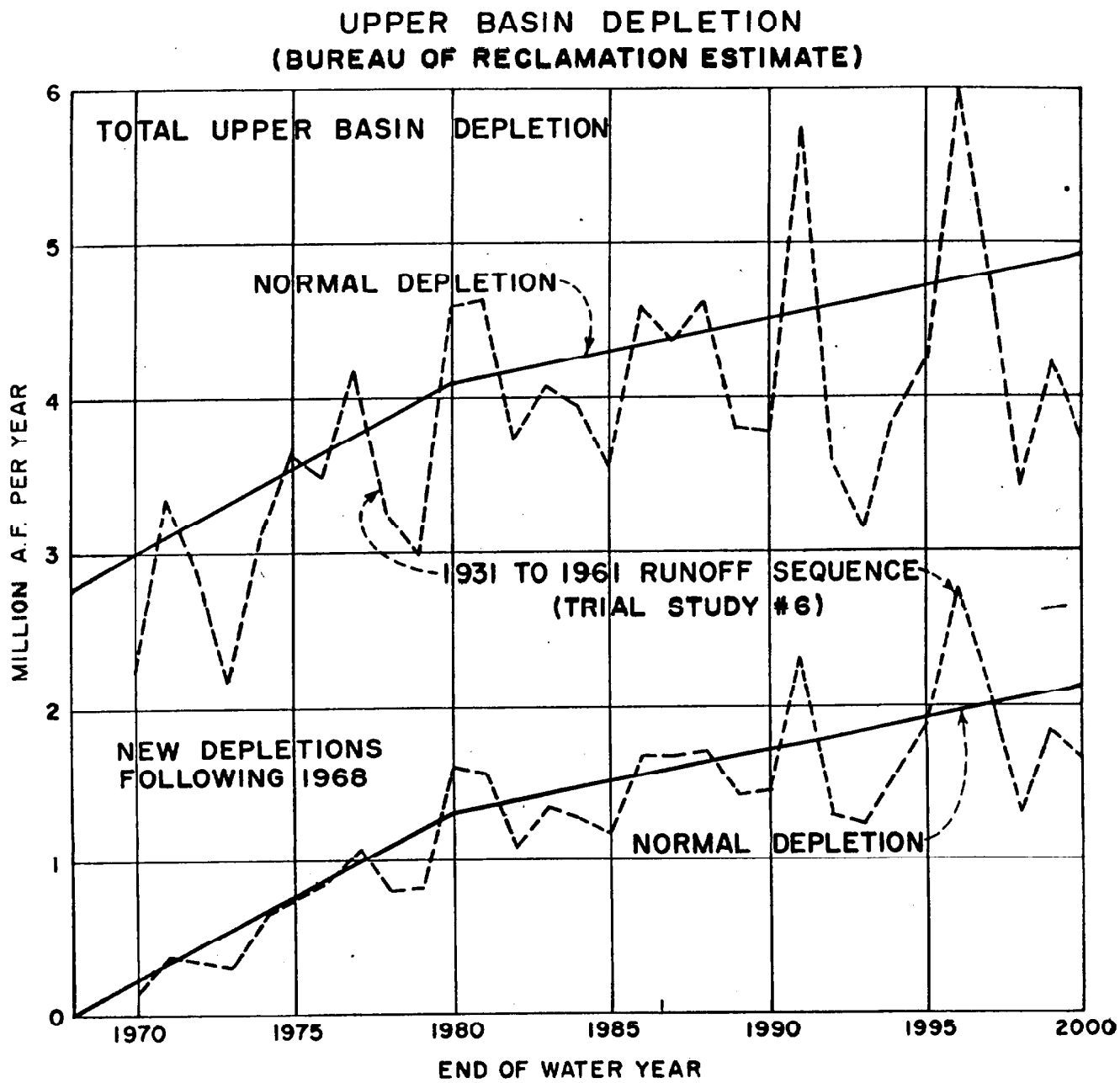
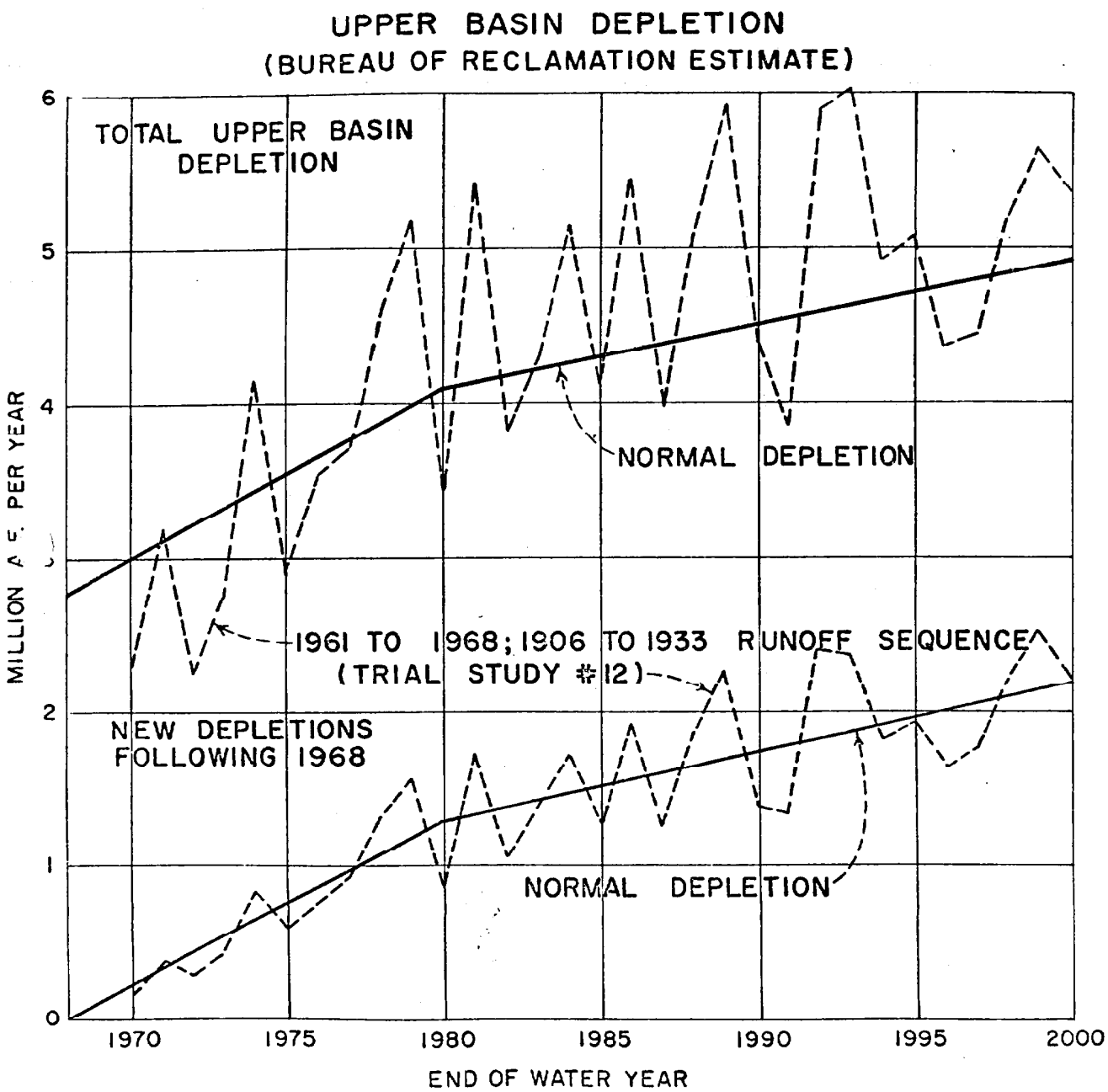

UPPER BASIN DEPLETION
(BUREAU OF RECLAMATION ESTIMATE)
TOTAL UPPER BASIN DEPLETION
NORMAL DEPLETION
1931 TO 1961 RUNOFF SEQUENCE
(TRIAL STUDY #6)
NEW DEPLETIONS
FOLLOWING 1968
NORMAL DEPLETION
MILLION A.F. PER YEAR
0
1
2
3
4
5
6
1970
1975
1980
1985
1990
1995
2000
END OF WATER YEAR

FIG. 5


UPPER BASIN DEPLETION
(BUREAU OF RECLAMATION ESTIMATE)
TOTAL UPPER BASIN DEPLETION
NORMAL DEPLETION
1961 TO 1968; 1906 TO 1933 RUNOFF SEQUENCE
(TRIAL STUDY #12)
NEW DEPLETIONS FOLLOWING 1968
NORMAL DEPLETION
MILLION A.F. PER YEAR
0
1
2
4
5
6
1970
1975
1980
1985
1990
1995
2000
END OF WATER YEAR

CAP STUDY 32

98.4 % PROBABILITY RULE CURVE

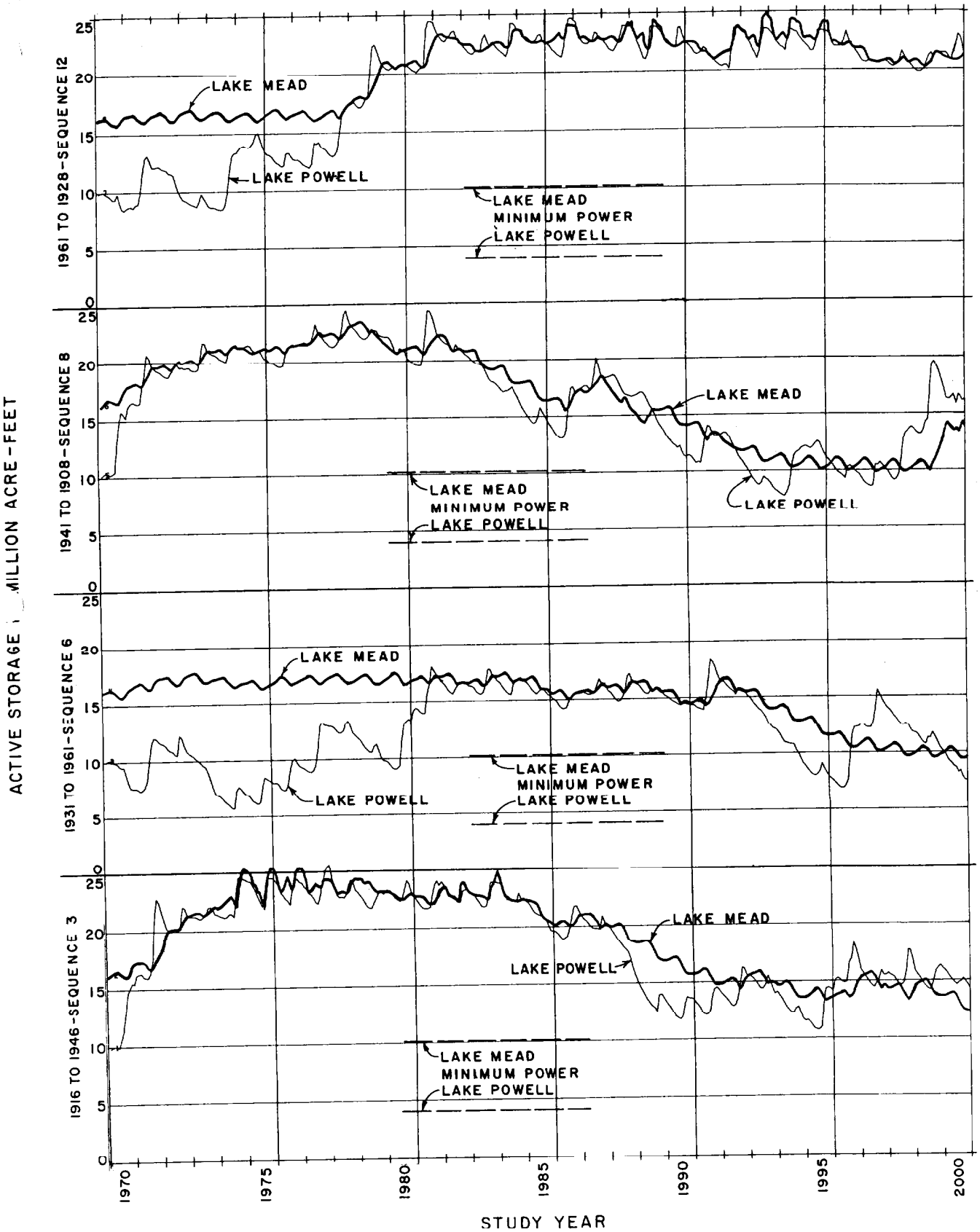
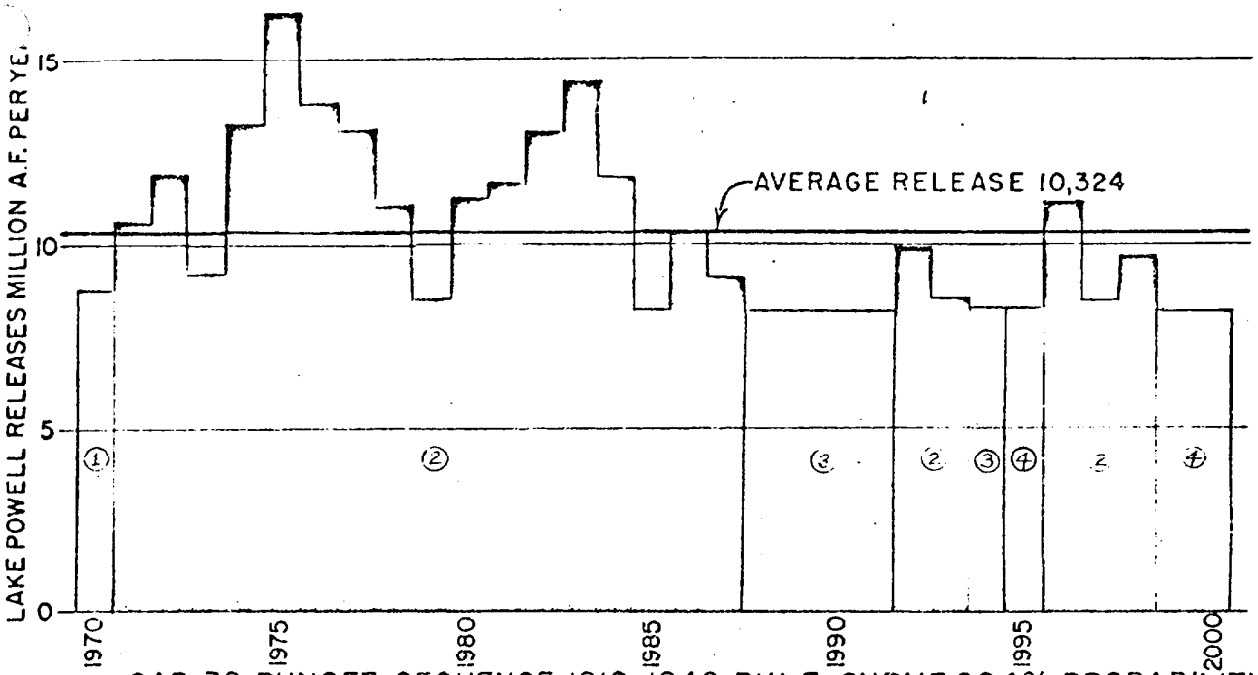
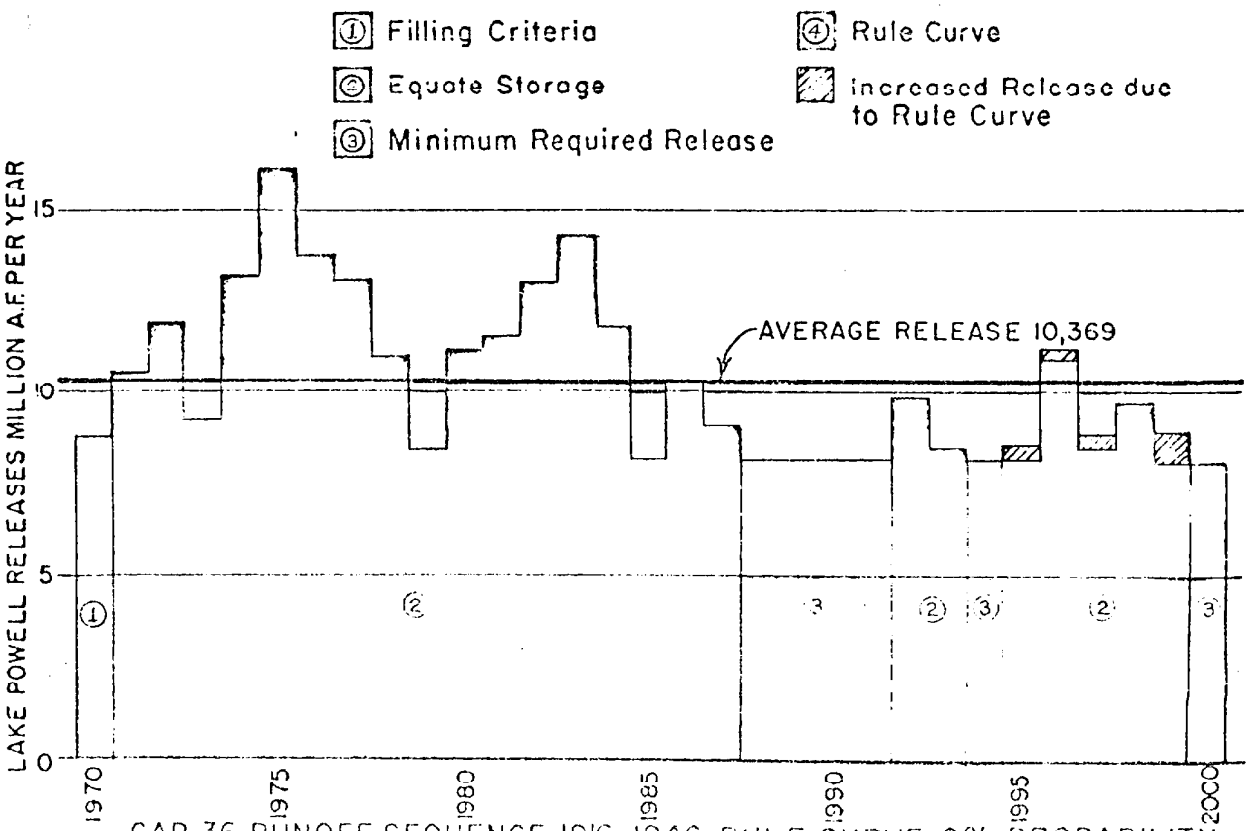


Figure 7

EFFECT OF RULE CURVE ON LAKE POWELL RELEASES



CAP 32 RUNOFF SEQUENCE 1916-1946. RULE CURVE 98.4% PROBABILITY



CAP 36 RUNOFF SEQUENCE 1916-1946. RULE CURVE 0% PROBABILITY

Figure 8

UPPER BASIN ENERGY

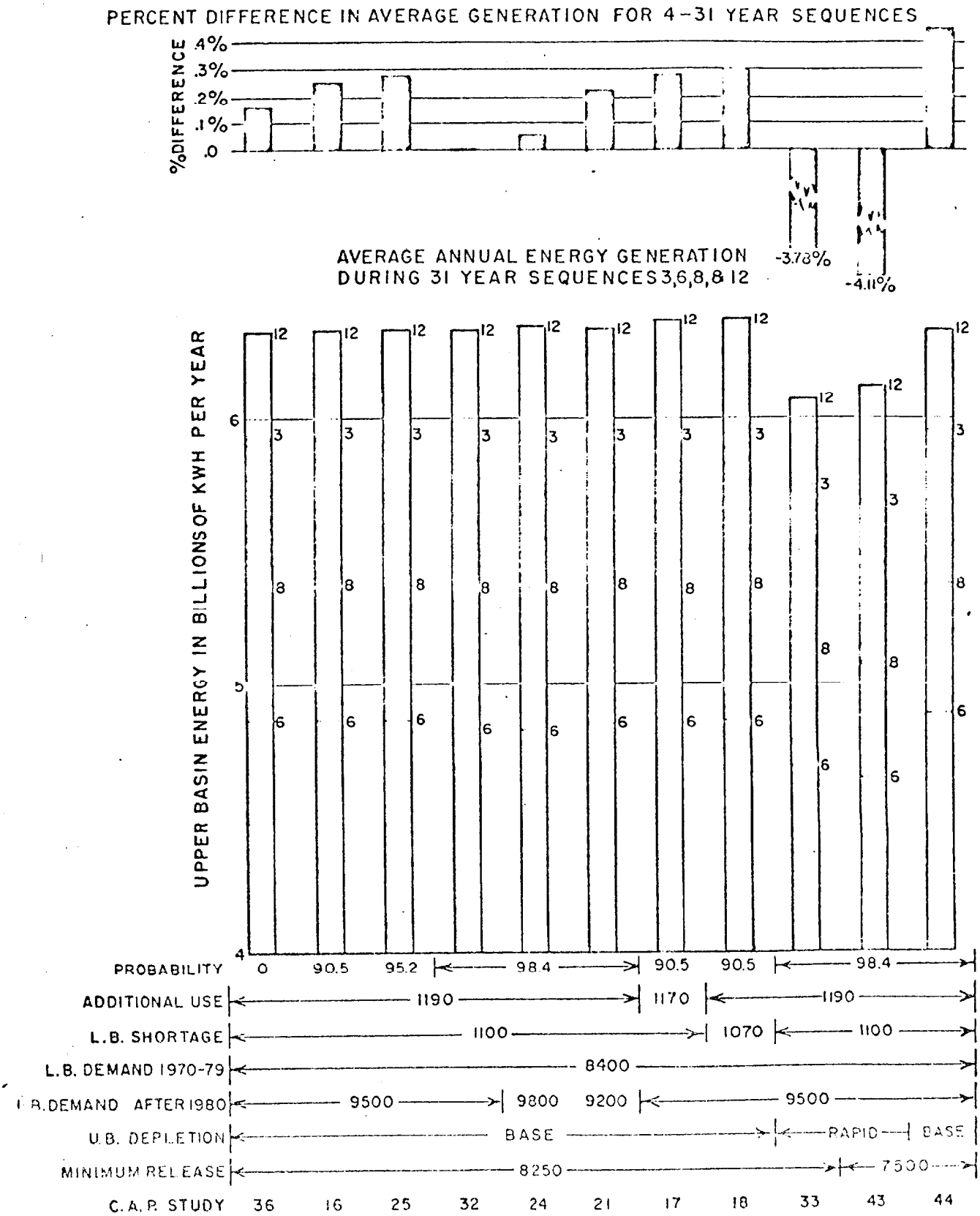


Figure 9

LOWER BASIN ENERGY

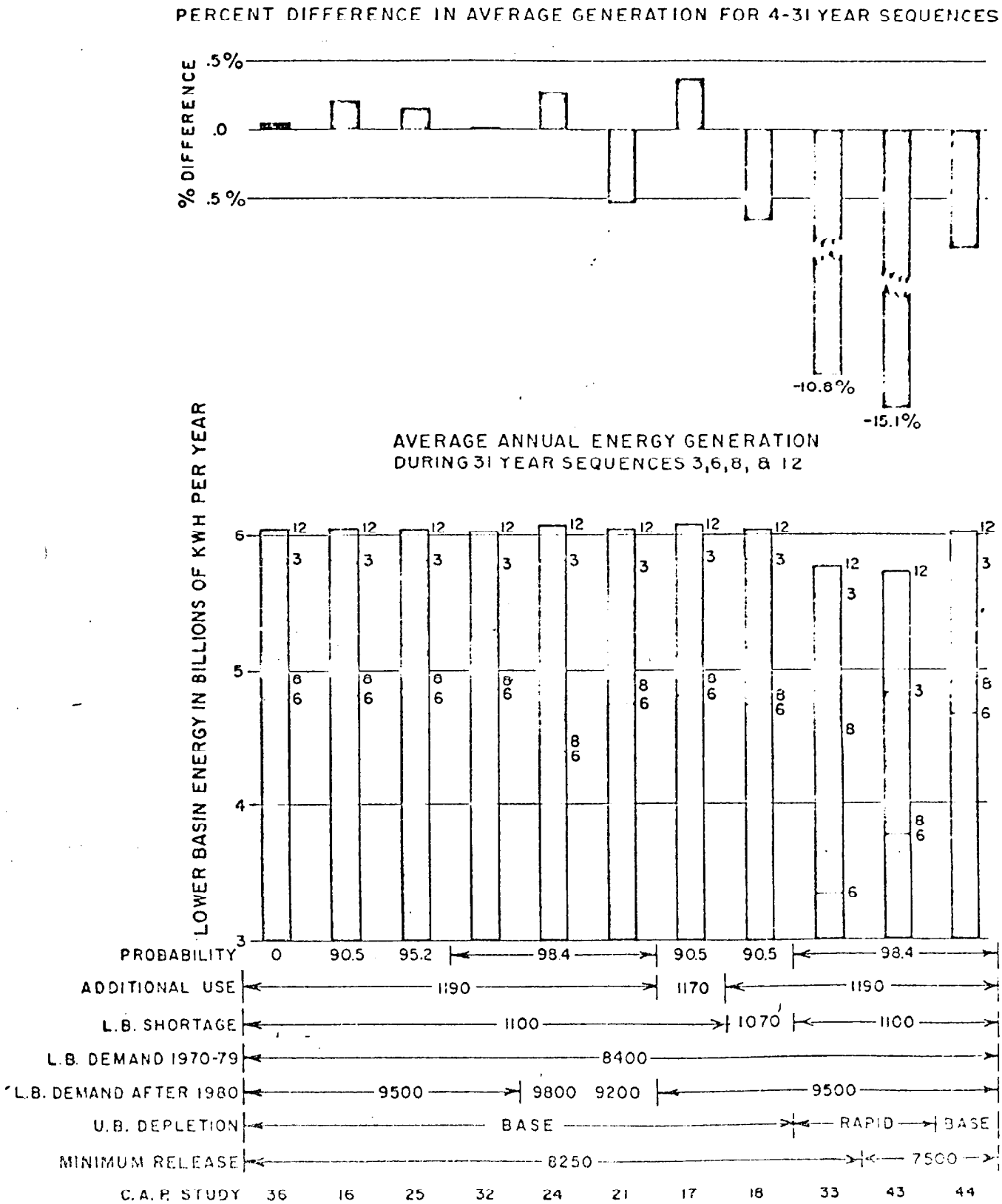
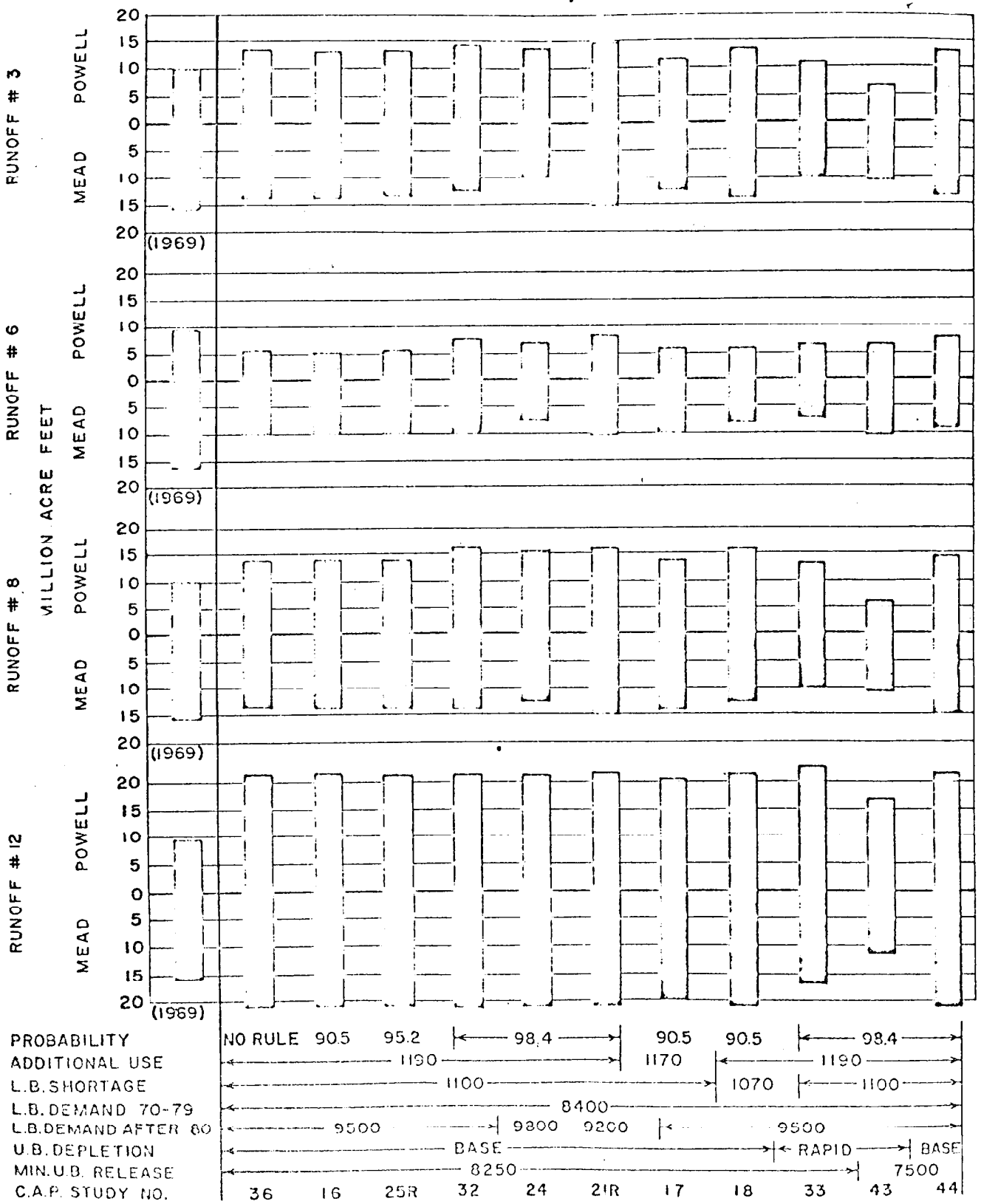
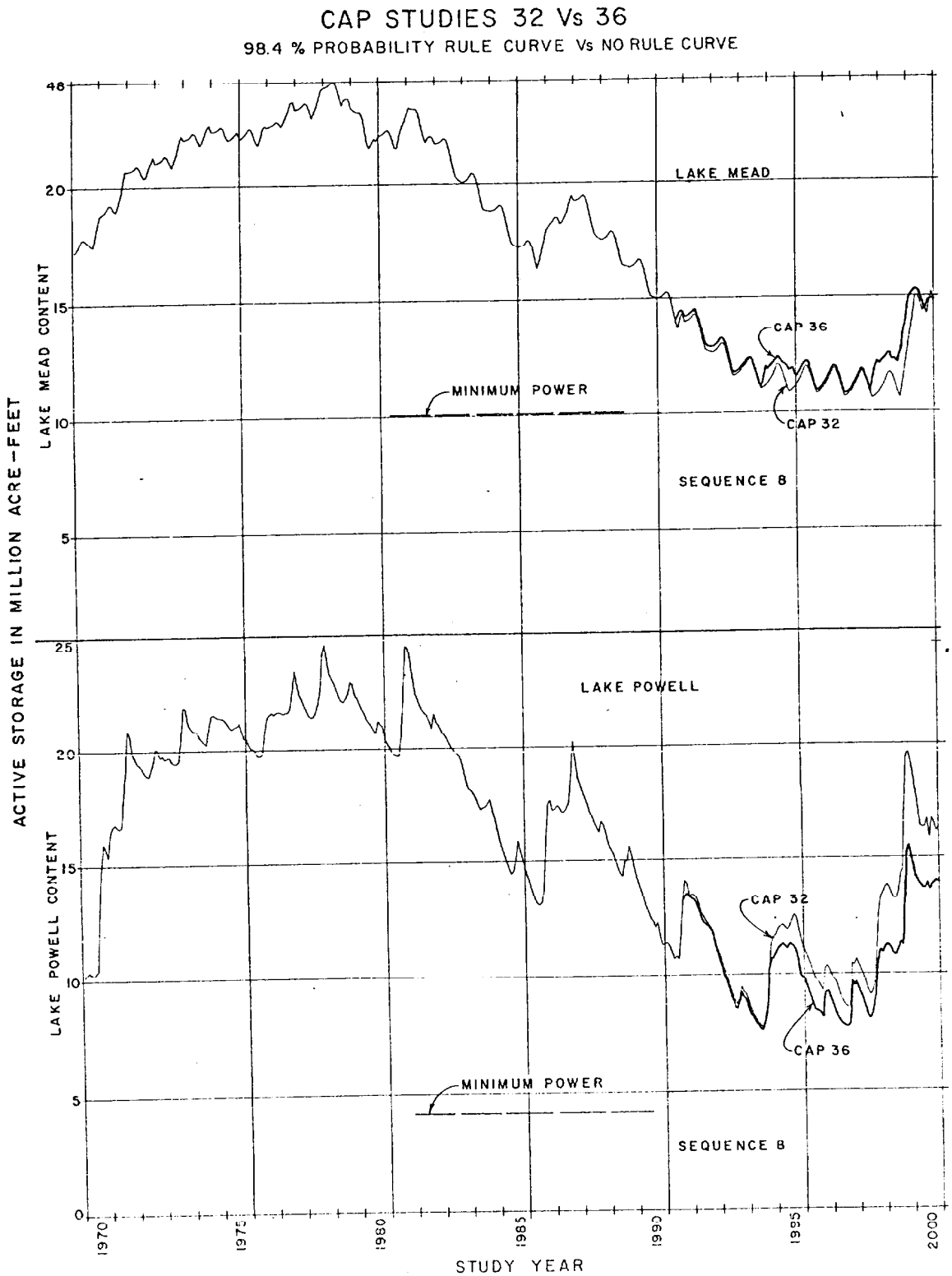


Figure 10

LAKE POWELL AND LAKE MEAD
CONTENT ON SEPTEMBER 30, YEAR 2000 (MAF)




CAP STUDIES 32 Vs 36
98.4 % PROBABILITY RULE CURVE Vs NO RULE CURVE
ACTIVE STORAGE IN MILLION ACRE-FEET
LAKE MEAD CONTENT
LAKE MEAD
CAP 36
CAP 32
MINIMUM POWER
SEQUENCE 8
LAKE POWELL CONTENT
LAKE POWELL
CAP 32
CAP 36
MINIMUM POWER
SEQUENCE 8
STUDY YEAR
1970
1975
1980
1985
1990
1995
2000