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Reservoir Release Patterns for Hydropower Operations at the Aspinall Unit on the Gunnison River, Colorado

**Environmental Assessment Division
Argonne National Laboratory**

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Reservoir Release Patterns for Hydropower Operations at the Aspinall Unit on the Gunnison River, Colorado

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May 1995

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Western Area Power Administration

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FOREWORD

This report is one of a series of technical memorandums prepared to support an environmental impact statement (EIS) on power marketing prepared by Argonne National Laboratory for the U.S. Department of Energy's Western Area Power Administration (Western). Western markets electricity produced at hydroelectric facilities operated by the Bureau of Reclamation. The facilities are known collectively as the Salt Lake City Area Integrated Projects (SLCA/IP) and include dams equipped for power generation on the Colorado, Green, Gunnison, and Rio Grande rivers and on Plateau Creek in the states of Arizona, Colorado, New Mexico, Utah, and Wyoming.

Western proposes to establish a level of commitment (sales) of long-term firm electrical capacity and energy from the SLCA/IP hydroelectric power plants; the impacts of this proposed action are evaluated in the EIS. Of the SLCA/IP facilities, only the Glen Canyon Dam, Flaming Gorge Dam, and Aspinall Unit (which includes Blue Mesa, Morrow Point, and Crystal dams) are influenced by Western's power scheduling and transmission decisions. For this reason, the impacts of hydropower operations at these three facilities were examined in the EIS.

The technical memorandums present detailed findings of studies conducted by Argonne National Laboratory specifically for the EIS. These studies are summarized in the EIS, and the results were used to assess environmental impacts related to alternative commitment levels. Technical memorandums were prepared on a number of socioeconomic and natural resource topics. Staff members of Argonne National Laboratory's Decision and Information Sciences Division and Environmental Assessment Division prepared these technical memorandums and the EIS as part of a joint effort managed by the Environmental Assessment Division.

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RESERVOIR RELEASE PATTERNS FOR HYDROPOWER OPERATIONS AT THE ASPINALL UNIT ON THE GUNNISON RIVER, COLORADO

by

S.C.L. Yin, J.J. McCoy, and J. Sedlacek

ABSTRACT

This report presents the development of reservoir release patterns for the Aspinall Unit, which includes Blue Mesa, Morrow Point, and Crystal Reservoirs on the Gunnison River in Colorado. Release patterns were assessed for two hydropower operational scenarios — seasonally adjusted steady flows and seasonally adjusted high fluctuating flows — and three representative hydrologic years — moderate (1987), dry (1989), and wet (1983). The release patterns for the operational scenarios were developed with the aid of monthly, daily, and hourly reservoir operational models, which simulate the linked operation of the three Aspinall Unit reservoirs. Also presented are reservoir fluctuations and downstream water surface elevations corresponding to the reservoir release patterns. Both of the hydropower operational scenarios evaluated are based on the ecological research flows proposed by the U.S. Fish and Wildlife Service for the Aspinall Unit. The first operational scenario allows only seasonally adjusted steady flows (no hourly fluctuations at any dam within one day), whereas the second scenario permits high fluctuating flows from Blue Mesa and Morrow Point Reservoirs during certain times of the year. Crystal Reservoir would release a steady flow within each day under both operational scenarios.

1 INTRODUCTION

The Salt Lake City Office of the Western Area Power Administration (Western) markets electricity produced at hydroelectric facilities operated by the Bureau of Reclamation on the Upper Colorado River Basin (the subbasin of the Colorado River basin upstream of Glen Canyon Dam). The facilities are known collectively as the Salt Lake City Area Integrated Projects. Hydropower operations at three of these facilities are affected by Western power marketing activities: Glen Canyon Dam on the Colorado River, Flaming Gorge Dam on the Green River, and the Aspinall Unit on the Gunnison River (Figure 1*). This report presents the development of the Aspinall Unit release patterns and the resulting reservoir surface fluctuations and downstream water surface elevations for two hydropower

*For readability, all figures and tables are placed in sequence following Section 5 of this report.

operational scenarios — seasonally adjusted steady flows and seasonally adjusted high fluctuating flows. The results presented here were used for assessing potential impacts of the hydropower operational scenarios on ecological, cultural, recreational, and other natural resources in the vicinity of the Aspinall Unit. The results of these assessments are presented in the environmental impact statement (EIS).

2 DEVELOPMENT OF RESERVOIR RELEASE PATTERNS

The Aspinall Unit on the Gunnison River in Colorado consists of Blue Mesa Reservoir, Morrow Point Reservoir, and Crystal Reservoir in downstream order (Figure 2). On the basis of streamflow records, water years 1987, 1989, and 1983 were selected as representative moderate, dry, and wet years, respectively. (A water year begins on October 1 of the preceding calendar year and ends on September 31 of the current calendar year, e.g., water year 1987 begins on October 1, 1986, and ends on September 30, 1987.) Reservoir release patterns were developed for these three representative hydrologic years.

The two hydropower operational scenarios evaluated in this report — seasonally adjusted steady flows and seasonally adjusted high fluctuating flows — are both based on the ecological research flows proposed by the U.S. Fish and Wildlife Service for the Aspinall Unit (Harris 1992). The first scenario allows only seasonally adjusted steady flows (no hourly fluctuation within a day), whereas the second scenario permits seasonally adjusted high fluctuating flows from Blue Mesa and Morrow Point Reservoirs within the requirements of research flows. Crystal Reservoir would release only seasonally adjusted steady flows within each day under both operational scenarios.

2.1 ECOLOGICAL RESEARCH FLOWS

The monthly releases from Crystal Reservoir for the representative water years are shown in Table 1. The releases for 1987 and 1989 are the flows below Crystal Dam that were proposed for ecological research by the U.S. Fish and Wildlife Service for representative moderate and dry water years, respectively; also proposed were research flows for a wet year, 1985 (Harris 1992). Because the representative wet year for this analysis is 1983 rather than 1985, monthly research flows for 1983 were developed on the basis of the 1985 research flow pattern. The research flows below Crystal Dam are presented graphically in Figure 3. For comparison, actual historical releases from Crystal Reservoir for 1987, 1989, and 1983 are also shown in Figure 3.

Release patterns from the two upstream reservoirs — Blue Mesa and Morrow Point — were developed on the basis of the Crystal Dam research flows. The feasibility of these releases from the three reservoirs was confirmed by monthly reservoir operational models for the three representative years based on historical inflows to Blue Mesa and side inflows to Morrow Point and Crystal Reservoirs. Initial reservoir storages were also based on historical values, except for the 1987 initial storage for Blue Mesa. An initial storage of

660,000 acre-feet, lower than the historical 742,000 acre-feet, was necessary for the proposed Crystal research flows to be feasible. Operations of reservoirs upstream from Blue Mesa could be modified to provide such a lower initial storage. Tables 2, 3, and 4 show reservoir operations based on the research flows for 1987, 1989, and 1983, respectively. The reservoir surface elevations shown in the tables were computed from the storage-elevation relationships presented in Table 5.

2.2 RESERVOIR RELEASE PATTERNS

Reservoir release patterns for all three reservoirs under either of the two operational scenarios might be restricted by the operating constraints for Crystal Reservoir, which could have large surface fluctuations due to its relatively small storage capacity. The feasibility of the operational scenarios on both daily and hourly bases was assessed by developing daily and hourly reservoir operational models to simulate the linked operations of the three Aspinall Unit reservoirs. The reservoir operation was simulated by accounting daily inflows (from upstream and side inflows between two dams) and outflows (reservoir release and evaporation loss) and, subsequently, determining end-of-day reservoir storage and corresponding reservoir surface elevation. The water travel time between a dam and the head of the next downstream reservoir was ignored because of the short distances, which, even under low reservoir conditions, are less than 1 mi.

The daily operational models are illustrated in Table 6, which shows the spreadsheet setup and the first month of the numerical simulation for each reservoir operation. The hourly operational model is similar, except that the time interval is one hour. The daily operational model was validated by simulating historical reservoir operations for 1987, 1989, and 1983, using recorded daily reservoir inflows and releases and estimated evaporation losses. Calculated end-of-month water surface elevations for all three reservoirs were found to deviate generally less than 1 ft from those reported by the Bureau of Reclamation. The reservoir operational models were developed with the spreadsheet program Quattro Pro run on an IBM-compatible personal computer.

The releases from Crystal Reservoir, including hourly release fluctuations, are sometimes limited to enhance the stability of the reservoir side-slope. In wet seasons (April through July), the reservoir surface elevation is not allowed to change by more than 0.5 ft in any 24-hour period if the elevation is lower than 6,748 ft. If the elevation is at or above 6,748 ft, the elevation is not allowed to change by more than 4 ft in any 24-hour period and by not more than 6 ft in any 48-hour period. In dry seasons (August through March), the reservoir surface elevation is not allowed to change by more than 0.5 ft in any 24-hour period if the elevation is lower than 6,733 ft. If the elevation is at least 6,733 ft, the elevation is not allowed to change by more than 10 ft in any 24-hour period or by more than 15 ft in any 48-hour period. The data presented in the last four columns of Table 6 (Crystal Reservoir) were used to check the compliance of operations with these constraints.

2.2.1 Seasonally Adjusted Steady Flows

Under the seasonally adjusted steady flow scenario, the reservoirs would have steady releases, i.e., no hourly fluctuations. The daily operational model was used to simulate the seasonally adjusted steady flow scenario on the basis of the recorded inflow to the reservoir farthest upstream (Blue Mesa) and side inflows to Morrow Point and Crystal Reservoirs. Releases from each reservoir were initially assumed to be steady flows equal to the monthly releases shown in Tables 2 through 4. Steady releases from all three reservoirs were feasible for 1987 and 1989 without violating restrictions on short-term water surface fluctuation for Crystal Reservoir. However, shifting the daily releases from Crystal Reservoir, but maintaining the average monthly releases, was necessary for April through July 1983; the adjusted daily flows are listed in Table 7.

2.2.2 Seasonally Adjusted High Fluctuating Flows

The seasonally adjusted high fluctuating flow scenario can be considered a variation of the seasonally adjusted steady flow scenario. Daily reservoir release volumes would be the same for both scenarios, but hourly fluctuations within the day would be maximized under the seasonally adjusted high fluctuating flow scenario.

The hourly operational model was used to test the feasibility of fluctuating hourly flows for the seasonally adjusted high fluctuating flow scenario. This model is an extension of the daily operational model and reproduces its end-of-day reservoir storages and elevations. Results from the hourly operational model indicate that releases from Blue Mesa could fluctuate up to 100% of the power plant capacity (3,700 cfs) on any day except for those months in which minimum releases greater than zero would be required because of the large total volumes to be released. Morrow Point releases could fluctuate up to 100% of power plant capacity (5,300 cfs) during the dry season (August through March) and up to 25 to 40%, depending on the year and the month, during the wet season (April through July) because of more stringent constraints on the surface fluctuation of Crystal Reservoir (Table 8). Ramp up and down are assumed to occur in one hour; ramp up is assumed to start on the hour at a certain hour such that the approximate center of the on-peak period is at 4:00 p.m. If the on-peak period is greater than 15 hours (8:00 a.m. to 11:00 p.m.), a base flow is added and the maximum fluctuation is reduced so that the peak release does not exceed the power plant capacity. The resulting release patterns for Blue Mesa and Morrow Point Reservoirs are presented in Tables 9 and 10.

3 RESERVOIR SURFACE FLUCTUATIONS

End-of-month reservoir elevations and daily elevation changes within each month for a moderate hydrologic year (1987) are presented in Table 2 for the seasonally adjusted steady flow scenario. The elevation changes were calculated from the reservoir storage-elevation relationships shown in Table 5. Day-to-day elevation changes would range from

about 0 to 0.5 ft at Blue Mesa, 0 to 0.2 ft at Morrow Point, and 0 to 0.4 ft at Crystal. Similar elevation changes for dry and wet years are shown in Tables 3 and 4, respectively.

Maximum daily fluctuations in reservoir surface elevation under the seasonally adjusted high fluctuating flow scenario in the moderate water year (1987) are shown in Table 11. The fluctuations result from both the hourly reservoir release fluctuations and the monthly inflow-outflow imbalance. The maximum surface fluctuations in one day would range from 0.1 to 0.5 ft for Blue Mesa Reservoir and from 0.3 to 1.5 ft for Morrow Point Reservoir. Because of its relatively small storage capacity, Crystal Reservoir elevations would have larger daily fluctuations, ranging from 2.1 ft in June to 8.4 ft in September. The maximum daily fluctuations shown in Table 11 are based on calculation of hourly storage changes and maximum elevation fluctuations during the first day of each month, as presented in Table 12. For each month, the maximum daily fluctuations in elevations for subsequent days would be about the same as the first day.

Reservoir surface fluctuations result from both daily inflow-outflow imbalance and hourly release fluctuations. The fraction of the total surface fluctuation that could be attributed to the hourly release fluctuations range from 4 to 100% for Blue Mesa, 70 to 99% for Morrow Point, and 92 to 100% for Crystal (Table 11). The percentages of daily fluctuations resulting from the hourly fluctuations were calculated from the daily elevation changes in Table 2 and the maximum elevation changes on an hourly basis shown in Table 12.

4 WATER SURFACE ELEVATIONS BELOW MORROW POINT DAM

The water surface elevations in the Gunnison River below Morrow Point Dam were calculated for flows between 0 and 5,300 cfs, the latter being the maximum power plant release. The surface elevation at a particular location depends not only on the river flow and channel geometry in the area, but is also greatly affected by the surface elevation of Crystal Reservoir immediately downstream. The elevations were estimated from a water surface profile model for the Gunnison River with the HEC-2 computer program (U.S. Army Corps of Engineers 1982).

The HEC-2 model for the Gunnison River was developed with the best data available, including U.S. Geological Survey 7.5-minute topographic maps (elevation contour intervals of 20 to 40 ft), cross-section data for the modified channel below the dam, and the discharge-elevation relationship for the channel (Bureau of Reclamation 1971). Channel roughness coefficients required for the model were estimated to be 0.03 to 0.06 for the main channel and 0.05 to 0.07 for the overbanks; these estimates were based on field observation and values in the literature (Chow 1959; Barnes 1967). The model was calibrated by using the discharge ratings for the channel below the dam. The water surface elevation below the dam for a discharge of 2,100 cfs was reported to be 6,755.8 ft in a dam design report (Bureau of Reclamation 1971). The calibrated model calculated a water surface elevation of 6,755.5 ft for the same discharge. No other water surface elevations for discharges below 5,300 cfs were available in the design report.

The calibrated model was used to estimate water surface elevations below Morrow Point Dam for flows ranging from 100 to 5,300 cfs (Figure 4). The water surface elevation just below the dam might fluctuate by about 10 ft for dam releases ranging from 0 to 5,300 cfs. At 0.25 mi below the dam, the fluctuation in elevation would be reduced to about 5.5 ft because of the effect of Crystal Reservoir; at 0.5 mi below the dam, the elevation would be largely controlled by Crystal Reservoir. The elevations in Figure 4 were estimated by assuming a Crystal Reservoir elevation of 6,750 ft. In the moderate water year (1987), Crystal Reservoir end-of-month elevations during the growing season (May through September) could range from about 6,747 to 6,751 ft (Table 2). A lower Crystal elevation would tend to lower all water surface profiles, with lesser effects on the profiles for higher flows and lesser effects on locations farther upstream.

Changes in river surface widths due to changes in flows can be estimated by using estimated water surface elevation changes from Figure 4 and land slopes from topographic maps. Because of the limitations in data used to develop the water surface profile model for the Gunnison River, estimated changes in river elevations are believed to be more reliable than the water surface elevations.

5 CONCLUSIONS

Three reservoir operational models were developed for the simulation of linked operations of the Aspinall Unit reservoirs. The three models were used to simulate reservoir operations on monthly, daily, and hourly bases, respectively. The models provided an efficient method for developing feasible hydropower operational scenarios for the three closely related Aspinall Unit reservoirs and also provided a tool for estimating the effects of hydropower operations on reservoir surface fluctuations.

The HEC-2 water surface profile model developed for this study provided useful information on water surface elevations downstream of Morrow Point Dam. These data were used for evaluating the potential impacts of hydropower operations on natural resources.

FIGURE 1 Locations of Flaming Gorge Dam, Glen Canyon Dam, and the Aspinall Unit

FIGURE 2 Locations of Blue Mesa, Morrow Point, and Crystal Reservoirs on the Gunnison River, Colorado

FIGURE 3 Research and Historical Releases at Crystal Reservoir

FIGURE 4 Water Surface Elevations below Morrow Point Dam (Crystal Reservoir elevation at 6,750 ft)

TABLE 1 Monthly Releases from Crystal Reservoir for Moderate, Dry, and Wet Years

Month	Daily Release (cfs)		
	Moderate Year	Dry Year	Wet Year
Oct	1,920	960	1,600
Nov	1,430	303	1,600
Dec	1,280	293	1,600
Jan	683	293	1,600
Feb	702	306	1,600
Mar	748	293	1,600
Apr	2,250	1,190	3,500
May	3,580	1,330	3,500
Jun	3,830	1,410	4,600
Jul	2,640	1,420	2,500
Aug	1,920	1,460	1,650
Sep	1,920	1,400	1,650
Annual	1,910	891	2,250

TABLE 2 Reservoir Operations for the Seasonally Adjusted Steady Flow Scenario at the Aspinall Unit during a Moderate Year

Reservoir/ Month	Inflow		Side Inflow (cfs)	Release			Evaporation (cfs)	Ending Storage (acre-feet)	Ending Elevation (ft)	Elevation Change	
	acre-feet	cfs		Power (cfs)	Other (cfs)	Total (cfs)				ft	ft/d
Blue Mesa ^a											
Oct	62,539	1,017	0	1,570	0	1,570	8.8	625,462	7,495.61	-4.25	-0.14
Nov	51,278	862	0	1,200	0	1,200	4.2	605,086	7,493.05	-2.56	-0.09
Dec	30,550	497	0	1,050	0	1,050	2.5	570,920	7,488.69	-4.37	-0.14
Jan	27,811	452	0	500	0	500	2.0	567,864	7,488.29	-0.40	-0.01
Feb	28,728	517	0	510	0	510	2.6	568,124	7,488.33	0.03	0.00
Mar	55,524	903	0	500	0	500	4.9	592,603	7,491.47	3.14	0.10
Apr	125,807	2,114	0	1,600	0	1,600	7.8	622,739	7,495.27	3.80	0.13
May	271,476	4,415	0	2,370	0	2,370	14.6	747,592	7,510.23	14.96	0.48
Jun	255,805	4,299	0	3,050	0	3,050	22.8	820,553	7,518.42	8.19	0.27
Jul	97,192	1,581	0	2,350	0	2,350	24.6	771,736	7,512.98	-5.43	-0.18
Aug	64,634	1,051	0	1,750	0	1,750	18.6	727,623	7,507.91	-5.07	-0.16
Sep	44,320	745	0	1,750	0	1,750	15.2	666,907	7,500.70	-7.21	-0.24
Morrow Point ^b											
Oct	96,535	1,570	94	1,700	0	1,700	0.0	112,632	7,154.30	-2.75	-0.09
Nov	71,405	1,200	61	1,280	0	1,280	0.0	111,489	7,152.86	-1.44	-0.05
Dec	64,562	1,050	69	1,100	0	1,100	0.0	112,627	7,154.29	1.44	0.05
Jan	30,744	500	61	570	0	570	0.0	112,061	7,153.58	-0.71	-0.02
Feb	28,324	510	82	580	0	580	0.0	112,744	7,154.44	0.86	0.03
Mar	30,744	500	98	650	0	650	0.0	109,528	7,150.36	-4.08	-0.13
Apr	95,207	1,600	373	1,970	0	1,970	0.0	109,707	7,150.59	0.23	0.01
May	145,726	2,370	534	2,890	0	2,890	2.1	110,439	7,151.52	0.94	0.03
Jun	181,488	3,050	311	3,325	0	3,325	14.3	111,730	7,153.16	1.64	0.05
Jul	144,496	2,350	74	2,480	0	2,480	13.6	107,420	7,147.63	-5.53	-0.18
Aug	107,603	1,750	58	1,770	0	1,770	1.4	109,688	7,150.56	2.93	0.09
Sep	104,132	1,750	44	1,820	0	1,820	0.0	108,124	7,148.55	-2.02	-0.07

TABLE 2 (Cont.)

Reservoir/ Month	Inflow		Side Inflow (cfs)	Release			Evaporation (cfs)	Ending Storage (acre-feet)	Ending Elevation (ft)	Elevation Change	
	acre-feet	cfs		Power (cfs)	Other (cfs)	Total (cfs)				ft	ft/d
Crystal ^c											
Oct	104,529	1,700	210	1,763	156	1,919	0.0	15,276	6,747.04	-1.96	-0.06
Nov	76,165	1,280	135	1,429	0	1,429	0.0	14,443	6,744.02	-3.02	-0.10
Dec	67,636	1,100	152	1,285	0	1,285	0.0	12,413	6,736.29	-7.73	-0.25
Jan	35,048	570	135	683	0	683	0.0	13,766	6,741.50	5.21	0.17
Feb	32,212	580	123	702	0	702	0.0	13,822	6,741.71	0.21	0.01
Mar	39,967	650	147	748	0	748	0.0	16,835	6,752.48	10.77	0.35
Apr	117,223	1,970	275	1,763	489	2,252	0.0	16,418	6,751.05	-1.43	-0.05
May	177,699	2,890	680	1,763	1,815	3,578	0.0	15,926	6,749.34	-1.71	-0.06
Jun	197,851	3,325	507	1,763	2,069	3,832	0.0	15,926	6,749.34	0.00	0.00
Jul	152,489	2,480	164	1,763	872	2,635	0.0	16,480	6,751.26	1.92	0.06
Aug	108,833	1,770	130	1,763	156	1,919	0.0	15,311	6,747.16	-4.10	-0.13
Sep	108,297	1,820	97	1,763	153	1,916	0.0	15,395	6,747.46	0.30	0.01

^a Starting conditions: storage, 660,000 acre-feet; elevation, 7,499.86 ft. Totals (acre-feet): inflow, 1,115,664; release, 1,100,965; evaporation, 7,793.

^b Starting conditions: storage, 114,833 acre-feet; elevation, 7,157.05 ft. Totals (acre-feet): inflow, 1,100,965; side inflow, 112,178; release, 1,217,950; evaporation, 1,902.

^c Starting conditions: storage, 15,829 acre-feet; elevation, 6,749.00 ft. Totals (acre-feet): inflow, 1,217,950; side inflow, 166,679; release, 1,385,063; evaporation, 0.

TABLE 3 Reservoir Operations for the Seasonally Adjusted Steady Flow Scenario at the Aspinall Unit during a Dry Year

Reservoir/ Month	Inflow		Side Inflow (cfs)	Release			Evaporation (cfs)	Ending Storage (acre-feet)	Ending Elevation (ft)	Elevation Change	
	acre-feet	cfs		Power (cfs)	Other (cfs)	Total (cfs)				ft	ft/d
Blue Mesa ^a											
Oct	30,258	492	0	650	0	650	6.4	439,014	7,470.52	-1.48	-0.05
Nov	26,684	448	0	180	0	180	3.2	454,796	7,472.82	2.30	0.08
Dec	23,654	385	0	150	0	150	2.0	469,104	7,474.88	2.05	0.07
Jan	27,006	439	0	200	0	200	2.0	483,690	7,476.94	2.06	0.07
Feb	23,941	431	0	250	0	250	2.8	493,591	7,478.32	1.38	0.05
Mar	44,848	729	0	200	0	200	6.2	525,760	7,482.73	4.40	0.14
Apr	96,499	1,622	0	760	0	760	10.8	576,394	7,489.39	6.67	0.22
May	124,997	2,033	0	900	0	900	16.0	645,068	7,498.03	8.64	0.28
Jun	123,561	2,077	0	1,150	0	1,150	21.4	698,926	7,504.53	6.50	0.22
Jul	59,496	968	0	1,300	0	1,300	22.2	677,123	7,501.93	-2.60	-0.08
Aug	56,234	915	0	1,300	0	1,300	17.2	652,366	7,498.93	-3.00	-0.10
Sep	27,920	469	0	1,300	0	1,300	13.6	602,121	7,492.68	-6.25	-0.21
Morrow Point ^b											
Oct	39,967	650	38	720	0	720	0.0	112,021	7,153.53	-2.47	-0.08
Nov	10,711	180	37	200	0	200	0.0	113,033	7,154.80	1.27	0.04
Dec	9,223	150	37	200	0	200	0.0	112,234	7,153.80	-1.01	-0.03
Jan	12,298	200	(15)	220	0	220	0.0	110,082	7,151.07	-2.73	-0.09
Feb	13,884	250	24	270	0	270	0.0	110,304	7,151.35	0.28	0.01
Mar	12,298	200	66	260	0	260	0.0	110,673	7,151.82	0.47	0.02
Apr	45,223	760	207	970	0	970	0.0	110,494	7,151.59	-0.23	-0.01
May	55,339	900	192	1,090	0	1,090	2.1	110,488	7,151.58	-0.01	0.00
Jun	68,430	1,150	102	1,225	0	1,225	14.3	111,244	7,152.55	0.96	0.03
Jul	79,934	1,300	37	1,350	0	1,350	13.8	109,596	7,150.44	-2.10	-0.07
Aug	79,934	1,300	88	1,400	0	1,400	1.4	108,772	7,149.38	-1.06	-0.03
Sep	77,355	1,300	63	1,300	0	1,300	0.0	112,521	7,154.16	4.78	0.16

TABLE 3 (Cont.)

Reservoir/ Month	Inflow		Side Inflow (cfs)	Release			Evaporation (cfs)	Ending Storage (acre-feet)	Ending Elevation (ft)	Elevation Change	
	acre-feet	cfs		Power (cfs)	Other (cfs)	Total (cfs)				ft	ft/d
Crystal											
Oct	44,271	720	186	960	0	960	0.0	13,657	6,741.09	-11.87	-0.38
Nov	11,901	200	98	303	0	303	0.0	13,359	6,739.96	-1.13	-0.04
Dec	12,298	200	92	293	0	293	0.0	13,298	6,739.72	-0.23	-0.01
Jan	13,527	220	73	293	0	293	0.0	13,298	6,739.72	0.00	0.00
Feb	14,995	270	46	306	0	306	0.0	13,853	6,741.83	2.10	0.08
Mar	15,987	260	99	293	0	293	0.0	17,911	6,756.08	14.25	0.46
Apr	57,719	970	224	1,193	0	1,193	0.0	17,971	6,756.27	0.20	0.01
May	67,021	1,090	244	1,334	0	1,334	0.0	17,971	6,756.27	0.00	0.00
Jun	72,893	1,225	183	1,412	0	1,412	0.0	17,733	6,755.49	-0.78	-0.03
Jul	83,008	1,350	64	1,415	0	1,415	0.0	17,671	6,755.29	-0.20	-0.01
Aug	86,083	1,400	43	1,464	0	1,464	0.0	16,380	6,750.92	-4.37	-0.14
Sep	77,355	1,300	66	1,395	0	1,395	0.0	14,654	6,744.79	-6.13	-0.20

^a Starting conditions: storage, 449,116 acre-feet; elevation, 7,472.00 ft. Totals (acre-feet): inflow, 665,098; release, 504,595; evaporation, 7,498.

^b Starting conditions: storage, 113,989 acre-feet; elevation, 7,156.00 ft. Totals (acre-feet): inflow, 504,595; side inflow, 52,909; release, 557,058; evaporation, 1,915.

^c Starting conditions: storage, 16,977 acre-feet; elevation, 6,752.96 ft. Totals (acre-feet): inflow, 557,058; side inflow, 85,783; release, 645,163; evaporation, 0.

TABLE 4 Reservoir Operations for the Seasonally Adjusted Steady Flow Scenario at the Aspinall Unit during a Wet Year

Reservoir/ Month	Inflow		Side Inflow (cfs)	Release			Evaporation (cfs)	Ending Storage (acre-feet)	Ending Elevation (ft)	Elevation Change	
	acre-feet	cfs		Power (cfs)	Other (cfs)	Total (cfs)				ft	ft/d
Blue Mesa ^a											
Oct	64,331	1,046	0	1,320	0	1,320	8.9	721,799	7,507.23	-2.02	-0.07
Nov	36,661	616	0	1,400	0	1,400	4.2	674,905	7,501.66	-5.56	-0.19
Dec	29,191	475	0	1,500	0	1,500	2.7	611,698	7,493.89	-7.78	-0.25
Jan	29,301	477	0	1,540	0	1,540	2.0	546,185	7,485.45	-8.43	-0.27
Feb	25,993	468	0	1,470	0	1,470	3.3	490,355	7,477.87	-7.58	-0.27
Mar	42,347	689	0	1,450	0	1,450	5.9	443,183	7,471.13	-6.74	-0.22
Apr	58,197	978	0	3,220	0	3,220	9.5	309,211	7,449.49	-21.65	-0.72
May	164,542	2,676	0	2,200	0	2,200	12.0	337,743	7,454.48	4.99	0.16
Jun	398,810	6,702	0	2,330	0	2,330	22.8	596,551	7,491.97	37.49	1.25
Jul	218,498	3,554	0	1,550	0	1,550	25.2	718,194	7,506.81	14.84	0.48
Aug	123,580	2,010	0	1,100	0	1,100	19.7	772,927	7,513.12	6.31	0.20
Sep	58,040	975	0	1,500	0	1,500	15.8	740,770	7,509.43	-3.68	-0.12
Morrow Point ^b											
Oct	81,164	1,320	81	1,410	0	1,410	0.0	112,214	7,153.77	-0.70	-0.02
Nov	83,306	1,400	37	1,510	0	1,510	0.0	107,870	7,148.22	-5.55	-0.19
Dec	92,231	1,500	37	1,520	0	1,520	0.0	108,915	7,149.57	1.35	0.04
Jan	94,691	1,540	35	1,520	0	1,520	0.0	112,297	7,153.88	4.31	0.14
Feb	81,640	1,470	46	1,540	0	1,540	0.0	110,964	7,152.19	-1.69	-0.06
Mar	89,157	1,450	68	1,535	0	1,535	0.0	109,919	7,150.86	-1.33	-0.04
Apr	191,603	3,220	141	3,345	0	3,345	0.0	110,871	7,152.07	1.21	0.04
May	135,273	2,200	581	2,765	0	2,765	2.1	111,725	7,153.16	1.08	0.03
Jun	138,645	2,330	855	3,180	0	3,180	14.3	111,172	7,152.45	-0.70	-0.02
Jul	95,306	1,550	298	1,840	0	1,840	13.6	110,828	7,152.02	-0.44	-0.01
Aug	67,636	1,100	152	1,300	0	1,300	1.4	107,790	7,148.12	-3.90	-0.13
Sep	89,256	1,500	60	1,510	0	1,510	0.0	110,765	7,151.94	3.82	0.13

TABLE 4 (Cont.)

Reservoir/ Month	Inflow		Side Inflow (cfs)	Release			Evaporation (cfs)	Ending Storage (acre-feet)	Ending Elevation (ft)	Elevation Change	
	acre-feet	cfs		Power (cfs)	Other (cfs)	Total (cfs)				ft	ft/d
Crystal ^c											
Oct	86,697	1,410	180	1,600	0	1,600	0.0	1,488	6,747.79	-2.17	-0.07
Nov	89,851	1,510	83	1,600	0	1,600	0.0	15,072	6,746.30	-1.49	-0.05
Dec	93,461	1,520	83	1,600	0	1,600	0.0	15,256	6,746.97	0.66	0.02
Jan	93,461	1,520	78	1,600	0	1,600	0.0	15,133	6,746.53	-0.44	-0.01
Feb	85,527	1,540	70	1,600	0	1,600	0.0	15,688	6,748.50	1.98	0.07
Mar	94,383	1,535	102	1,600	0	1,600	0.0	17,963	6,756.25	7.75	0.25
Apr	199,041	3,345	153	1,763	1,737	3,500	0.0	17,844	6,755.86	-0.39	-0.01
May	170,013	2,765	739	1,763	1,737	3,500	0.0	18,090	6,756.67	0.81	0.03
Jun	189,223	3,180	1,395	1,763	2,837	4,600	0.0	16,603	6,751.69	-4.98	-0.17
Jul	113,137	1,840	663	1,763	737	2,500	0.0	16,787	6,752.32	0.63	0.02
Aug	79,934	1,300	339	1,650	0	1,650	0.0	16,111	6,749.99	-2.33	-0.08
Sep	89,851	1,510	133	1,650	0	1,650	0.0	15,694	6,748.53	-1.46	-0.05

^a Starting conditions: storage, 739,179 acre-feet; elevation, 7,509.25 ft. Totals (acre-feet): inflow, 1,249,491; release, 1,239,907; evaporation, 7,993.

^b Starting conditions: storage, 112,767 acre-feet; elevation, 7,154.47 ft. Totals (acre-feet): inflow, 1,239,907; side inflow, 144,575; release, 1,384,581; evaporation, 1,902.

^c Starting conditions: storage, 16,103 acre-feet; elevation, 6,749.96 ft. Totals (acre-feet): inflow, 1,384,581; side inflow, 243,142; release, 1,628,131; evaporation, 0.

TABLE 5 Bureau of Reclamation Coefficient Tables Used to Calculate Reservoir Storages^a

Reservoir	Elevation, E_b (ft)	a	b	c
Blue Mesa	7350.	-14174.00	1668.82	12.59
	7380.	47203.00	2415.18	14.80
	7400.	101405.00	3000.20	22.13
	7420.	170210.00	2899.79	27.75
	7450.	312210.00	5572.05	29.43
	7470.	435478.00	6767.88	25.68
	7490.	501135.00	7776.96	22.50
	7510.	745605.00	8680.00	26.80
	7519.	829523.00	_b	_b
Morrow Point	6770.	0.00	0.00	0.05
	6780.	5.00	1.00	0.15
	6790.	30.00	4.00	0.20
	6800.	90.00	8.00	0.25
	6810.	195.00	13.00	0.40
	6820.	365.00	21.00	0.50
	6830.	625.00	30.70	0.63
	6850.	1490.00	56.00	0.80
	6860.	2131.07	71.39	0.55
	6880.	3781.61	93.09	0.73
	6900.	5931.25	125.13	1.23
	6920.	8911.77	175.79	0.74
	6960.	17120.46	235.21	1.28
	7038.	39833.16	402.63	1.44
Crystal	6670.	0.00	134.00	0.65
	6680.	1405.00	147.00	0.75
	6690.	2950.00	162.00	0.80
	6720.	4650.00	178.00	0.95
	6710.	6525.54	196.00	1.03
	6730.	10870.54	237.70	1.23
	6750.	16115.00	287.00	1.40
	6769.	22044.00	_b	_b

^a Reservoir storage (S_E), in acre-feet for an elevation E , can be calculated from the following equation:

$$S_E = a + b (E - E_b) + c (E - E_b)^2$$

where E_b is the next elevation in the table that is lower than E ; and a , b , and c are coefficients in the table corresponding to E_b .

^b Value missing from table provided by the Bureau of Reclamation.

Source: Bureau of Reclamation, Salt Lake City, Utah Office, April 1992; reformatted from electronic transmittal.

TABLE 6 Daily Reservoir Operations at the Aspinall Unit, October 1982

Daily Operations at Blue Mesa Reservoir							
Date	Daily Inflow (cfs)	Power Release (cfs)	Other Release (cfs)	Total Release (acre-feet)	Daily Evaporation (cfs)	Storage ^a (acre-feet)	Elevation ^a (ft)
10/1	1,344	1,320	0	2,618	12	739,203	7,509.25
10/2	1,233	1,320	0	2,618	12	739,007	7,509.23
10/3	1,353	1,320	0	2,618	12	739,047	7,509.23
10/4	1,248	1,320	0	2,618	12	738,881	7,509.22
10/5	1,285	1,320	0	2,618	11	738,789	7,509.20
10/6	1,145	1,320	0	2,618	11	738,421	7,509.16
10/7	1,223	1,320	0	2,618	11	738,207	7,509.14
10/8	1,376	1,320	0	2,618	11	738,297	7,509.15
10/9	1,244	1,320	0	2,618	10	738,127	7,509.13
10/10	1,091	1,320	0	2,618	10	737,654	7,509.07
10/11	1,335	1,320	0	2,618	10	737,663	7,509.07
10/12	1,240	1,320	0	2,618	10	737,485	7,509.05
10/13	1,172	1,320	0	2,618	9	737,174	7,509.02
10/14	1,023	1,320	0	2,618	9	736,567	7,508.95
10/15	1,209	1,320	0	2,618	9	736,329	7,508.92
10/16	1,089	1,320	0	2,618	9	735,853	7,508.86
10/17	1,290	1,320	0	2,618	8	735,778	7,508.86
10/18	1,036	1,320	0	2,618	8	735,198	7,508.79
10/19	1,047	1,320	0	2,618	8	734,640	7,508.72
10/20	892	1,320	0	2,618	8	733,776	7,508.62
10/21	1,006	1,320	0	2,618	8	733,138	7,508.55
10/22	1,016	1,320	0	2,618	8	732,520	7,508.48
10/23	901	1,320	0	2,618	7	731,674	7,508.38
10/24	742	1,320	0	2,618	7	730,513	7,508.24
10/25	789	1,320	0	2,618	7	729,446	7,508.12
10/26	701	1,320	0	2,618	7	728,205	7,507.98
10/27	630	1,320	0	2,618	7	726,823	7,507.82
10/28	727	1,320	0	2,618	7	725,632	7,507.68
10/29	723	1,320	0	2,618	7	724,435	7,507.54
10/30	584	1,320	0	2,618	6	722,963	7,507.36
10/31	740	1,320	0	2,618	6	721,800	7,507.23
Monthly total (acre-feet)	64,331						

TABLE 6 (Cont.)

Daily Operations at Morrow Point Reservoir										
Date	Inflow from Blue Mesa (cfs)	Side Inflow (cfs)	Total Inflow (cfs)	Power Release (cfs)	Other Release (cfs)	Total Release (acre-feet)	Daily Evaporation (cfs)	Storage ^b (acre-feet)	Elevation ^b (ft)	Elevation Difference (ft)
10/1	1,320	77	1,397	1,410	0	2,797	0	112,742	7,154.44	0.03
10/2	1,320	108	1,428	1,410	0	2,797	0	112,779	7,154.48	0.05
10/3	1,320	42	1,362	1,410	0	2,797	0	112,683	7,154.36	0.12
10/4	1,320	90	1,410	1,410	0	2,797	0	112,683	7,154.36	0.00
10/5	1,320	70	1,390	1,410	0	2,797	0	112,644	7,154.32	0.05
10/6	1,320	95	1,415	1,410	0	2,797	0	112,654	7,154.33	0.01
10/7	1,320	79	1,399	1,410	0	2,797	0	112,632	7,154.30	0.03
10/8	1,320	64	1,384	1,410	0	2,797	0	112,581	7,154.24	0.06
10/9	1,320	106	1,426	1,410	0	2,797	0	112,613	7,154.28	0.04
10/10	1,320	71	1,391	1,410	0	2,797	0	112,576	7,154.23	0.05
10/11	1,320	85	1,405	1,410	0	2,797	0	112,566	7,154.22	0.01
10/12	1,320	68	1,388	1,410	0	2,797	0	112,522	7,154.16	0.06
10/13	1,320	92	1,412	1,410	0	2,797	0	112,525	7,154.17	0.00
10/14	1,320	104	1,424	1,410	0	2,797	0	112,553	7,154.20	0.04
10/15	1,320	89	1,409	1,410	0	2,797	0	112,552	7,154.20	0.00
10/16	1,320	89	1,409	1,410	0	2,797	0	112,550	7,154.20	0.00
10/17	1,320	66	1,386	1,410	0	2,797	0	112,501	7,154.14	0.06
10/18	1,320	87	1,407	1,410	0	2,797	0	112,495	7,154.13	0.01
10/19	1,320	79	1,399	1,410	0	2,797	0	112,473	7,154.10	0.03
10/20	1,320	65	1,385	1,410	0	2,797	0	112,424	7,154.04	0.06
10/21	1,320	39	1,359	1,410	0	2,797	0	112,323	7,153.91	0.13
10/22	1,320	76	1,396	1,410	0	2,797	0	112,296	7,153.88	0.03
10/23	1,320	72	1,392	1,410	0	2,797	0	112,261	7,153.83	0.04
10/24	1,320	62	1,382	1,410	0	2,797	0	112,205	7,153.76	0.07
10/25	1,320	84	1,404	1,410	0	2,797	0	112,192	7,153.75	0.02
10/26	1,320	90	1,410	1,410	0	2,797	0	112,193	7,153.75	0.00
10/27	1,320	119	1,439	1,410	0	2,797	0	112,251	7,153.82	0.07
10/28	1,320	86	1,406	1,410	0	2,797	0	112,244	7,153.81	0.01
10/29	1,320	76	1,396	1,410	0	2,797	0	112,217	7,153.78	0.03
10/30	1,320	100	1,420	1,410	0	2,797	0	112,237	7,153.80	0.03
10/31	1,320	79	1,399	1,410	0	2,797	0	112,216	7,153.78	0.03
Monthly total (acre-feet)			86,143							

TABLE 6 (Cont.)

Daily Operations at Crystal Reservoir													
Date	Inflow from Morrow Point (cfs)	Side Inflow (cfs)	Total Inflow (cfs)	Power Release (cfs)	Other Release (cfs)	Total Release (acre-feet)	Daily Evapo- ration (cfs)	Storage ^c (acre-feet)	Elevation ^c (ft)	Elevation Difference (ft)	Fluctuation Test (ft)		Low Eleva- tion Test (ft)
											24-hour	48-hour	
10/1	1,410	172	1,582	1,600	0	3,173	0	16,068	6,749.84	0.12	0.12	-	-0.12
10/2	1,410	241	1,651	1,600	0	3,173	0	16,169	6,750.19	0.35	0.35	0.35	0.35
10/3	1,410	93	1,503	1,600	0	3,173	0	15,977	6,749.52	0.67	0.67	0.67	-0.67
10/4	1,410	200	1,610	1,600	0	3,173	0	15,997	6,749.59	0.07	0.07	0.67	0.07
10/5	1,410	157	1,567	1,600	0	3,173	0	15,931	6,749.36	0.23	0.23	0.23	-0.23
10/6	1,410	212	1,622	1,600	0	3,173	0	15,975	6,749.51	0.15	0.15	0.23	0.15
10/7	1,410	175	1,585	1,600	0	3,173	0	15,946	6,749.41	0.10	0.10	0.15	-0.10
10/8	1,410	142	1,552	1,600	0	3,173	0	15,851	6,749.08	0.33	0.33	0.43	-0.33
10/9	1,410	237	1,647	1,600	0	3,173	0	15,944	6,749.40	0.33	0.33	0.33	0.33
10/10	1,410	159	1,569	1,600	0	3,173	0	15,882	6,749.19	0.22	0.22	0.33	-0.22
10/11	1,410	189	1,599	1,600	0	3,173	0	15,880	6,749.18	0.01	0.01	0.22	-0.01
10/12	1,410	151	1,561	1,600	0	3,173	0	15,802	6,748.91	0.27	0.27	0.28	-0.27
10/13	1,410	204	1,614	1,600	0	3,173	0	15,830	6,749.00	0.10	0.10	0.27	0.10
10/14	1,410	232	1,642	1,600	0	3,173	0	15,913	6,749.30	0.29	0.29	0.39	0.29
10/15	1,410	199	1,609	1,600	0	3,173	0	15,930	6,749.36	0.06	0.06	0.35	0.06
10/16	1,410	198	1,608	1,600	0	3,173	0	15,947	6,749.41	0.06	0.06	0.12	0.06
10/17	1,410	146	1,556	1,600	0	3,173	0	15,859	6,749.11	0.31	0.31	0.31	-0.31
10/18	1,410	193	1,603	1,600	0	3,173	0	15,866	6,749.13	0.02	0.02	0.31	0.02
10/19	1,410	176	1,586	1,600	0	3,173	0	15,838	6,749.03	0.10	0.10	0.10	-0.10
10/20	1,410	144	1,554	1,600	0	3,173	0	15,747	6,748.71	0.32	0.32	0.42	-0.32
10/21	1,410	88	1,498	1,600	0	3,173	0	15,544	6,747.99	0.72	0.72	1.04	-0.72
10/22	1,410	170	1,580	1,600	0	3,173	0	15,505	6,747.86	0.14	0.14	0.86	-0.14
10/23	1,410	161	1,571	1,600	0	3,173	0	15,447	6,747.65	0.21	0.21	0.35	-0.21
10/24	1,410	137	1,547	1,600	0	3,173	0	15,342	6,747.27	0.37	0.37	0.58	-0.37
10/25	1,410	187	1,597	1,600	0	3,173	0	15,335	6,747.25	0.02	0.02	0.40	-0.02
10/26	1,410	201	1,611	1,600	0	3,173	0	15,358	6,747.33	0.08	0.08	0.08	0.08
10/27	1,410	266	1,676	1,600	0	3,173	0	15,508	6,747.86	0.53	0.53	0.61	0.53
10/28	1,410	192	1,602	1,600	0	3,173	0	15,512	6,747.88	0.01	0.01	0.55	0.01
10/29	1,410	170	1,580	1,600	0	3,173	0	15,473	6,747.74	0.14	0.14	0.14	-0.14
10/30	1,410	223	1,633	1,600	0	3,173	0	15,537	6,747.97	0.23	0.23	0.23	0.23
10/31	1,410	177	1,587	1,600	0	3,173	0	15,511	6,747.88	0.09	0.09	0.23	-0.09
Monthly total (acre-feet)			97,785	98,377	0								

^a Initial storage = 739,179 acre-feet; initial elevation = 7,509.25.

^b Initial storage = 112,767 acre-feet; initial elevation = 7,154.47 acre-feet.

^c Initial storage = 16,103 acre-feet; initial elevation = 6,749.96.

**TABLE 7 Adjusted Daily Releases at Crystal Reservoir,
April through July 1983**

Day	Daily Release (cfs)			
	April	May	June	July
1	3,500	3,000	5,100	2,500
2	3,500	3,000	5,100	2,500
3	3,500	3,000	5,100	2,500
4	3,500	3,000	3,600	2,500
5	3,500	3,000	3,600	2,500
6	3,500	3,000	3,600	2,500
7	3,500	3,000	3,600	2,500
8	3,500	3,000	3,600	2,900
9	3,500	3,500	3,600	2,900
10	3,500	3,500	3,600	2,900
11	3,500	3,500	3,600	2,500
12	3,400	3,500	3,600	2,500
13	3,400	3,200	3,600	2,500
14	3,400	3,200	4,100	2,500
15	3,400	3,200	4,100	2,500
16	3,400	3,200	4,100	2,500
17	3,400	3,200	4,600	2,500
18	3,400	3,200	4,600	2,500
19	3,500	3,500	4,600	2,500
20	3,500	3,500	4,600	2,500
21	3,500	3,500	4,600	2,500
22	3,500	3,800	4,600	2,500
23	3,500	3,800	4,600	2,500
24	3,600	3,800	4,600	2,500
25	3,600	3,800	4,600	2,500
26	3,600	3,800	4,600	2,500
27	3,600	3,800	4,600	2,100
28	3,600	3,500	4,600	2,100
29	3,600	3,500	4,600	2,100
30	3,600	3,500	4,600	2,100
31		3,500		2,100
Average	3,500	3,500	4,600	2,500

**TABLE 8 Maximum Allowable Fluctuations
for Reservoir Releases at Morrow Point**

Month	Maximum Fluctuation as Percent of 5,300-cfs Power Plant Capacity		
	Moderate Year	Dry Year	Wet Year
April	40	40	40
May	30	40	30
June	25	40	30
July	40	40	30

TABLE 9 Daily Release Patterns for Blue Mesa Reservoir^a

Month	Release Patterns for Moderate Year				Release Patterns for Dry Year				Release Patterns for Wet Year ^c			
	Seasonally Adjusted High Fluctuating Flows			Seasonally Adjusted Steady Flows (cfs)	Seasonally Adjusted High Fluctuating Flows			Seasonally Adjusted Steady Flows (cfs)	Seasonally Adjusted High Fluctuating Flows			Seasonally Adjusted Steady Flows (cfs)
	Min. Release (cfs)	Max. Release ^b (cfs)	On-Peak Duration (hours)		Min. Release (cfs)	Max. Release ^b (cfs)	On-Peak Duration (hours)		Min. Release (cfs)	Max. Release ^b (cfs)	On-Peak Duration (hours)	
Oct	0	3,700	9	1,570	0	3,700	3	650	0	3,700	7	1,320
Nov	0	3,700	6	1,200	0	3,700	<1	180	0	3,700	8	1,400
Dec	0	3,700	5	1,050	0	3,600	<1	150	0	3,700	8	1,500
Jan	0	3,700	2	500	0	3,700	<1	200	0	3,700	8	1,540
Feb	0	3,700	2	510	0	3,700	<1	250	0	3,700	8	1,470
Mar	0	3,700	2	500	0	3,700	<1	200	0	3,700	8	1,450
Apr	0	3,700	9	1,600	0	3,700	3	760	2,260	3,700	15	3,220
May	0	3,700	14	2,370	0	3,700	4	900	0	3,700	13	2,200
Jun	1,750	3,700	15	3,050	0	3,700	6	1,150	0	3,700	14	2,330
Jul	0	3,700	14	2,350	0	3,700	7	1,300	0	3,700	9	1,550
Aug	0	3,700	10	1,750	0	3,700	7	1,300	0	3,700	6	1,100
Sep	0	3,700	10	1,750	0	3,700	7	1,300	0	3,700	8	1,500

^a The average annual releases would be 1,520 cfs for the moderate year, 1,710 cfs for the wet year, and 697 cfs for the dry year.

^b Maximum release of 3,700 cfs assumes full reservoir condition.

TABLE 10 Daily Release Patterns for Morrow Point Reservoir^a

Month	Release Patterns for Moderate Year				Release Patterns for Dry Year				Release Patterns for Wet Year			
	Seasonally Adjusted High Fluctuating Flows			Seasonally Adjusted Steady Flows (cfs)	Seasonally Adjusted High Fluctuating Flows			Seasonally Adjusted Steady Flows (cfs)	Seasonally Adjusted High Fluctuating Flows			Seasonally Adjusted Steady Flows (cfs)
	Min. Release (cfs)	Max. Release ^b (cfs)	On-Peak Duration (hours)		Min. Release (cfs)	Max. Release ^b (cfs)	On-Peak Duration (hours)		Min. Release (cfs)	Max. Release ^b (cfs)	On-Peak Duration (hours)	
Oct	0	5,300	6	1,700	0	5,300	2	720	0	5,300	5	1,410
Nov	0	5,300	4	1,280	0	4,800	<1	200	0	5,300	5	1,510
Dec	0	5,300	3	1,100	0	4,800	<1	200	0	5,300	5	1,520
Jan	0	5,300	1	570	0	5,270	<1	220	0	5,300	5	1,520
Feb	0	5,300	1	580	0	5,300	<1	270	0	5,300	5	1,540
Mar	0	5,300	1	650	0	5,300	<1	260	0	5,300	5	1,540
Apr	557	2,680	15	1,970	0	2,120	9	970	1,930	4,050	15	3,340
May	1,830	3,420	15	2,890	0	2,120	11	1,090	1,700	3,300	15	2,760
Jun	2,440	3,770	15	3,320	0	2,120	12	1,220	2,120	3,710	15	3,180
Jul	1,070	3,190	17	2,480	0	2,120	14	1,350	780	2,370	15	1,840
Aug	0	5,300	7	1,770	0	5,300	5	1,400	0	5,300	4	1,300
Sep	0	5,300	7	1,820	0	5,300	4	1,300	0	5,300	5	1,510

^a The annual average releases would be 1,680 cfs for the moderate year, 1,910 cfs for the wet year, and 769 cfs for the dry year.

^b Maximum release of 5,300 cfs assumes full reservoir condition.

TABLE 11 Maximum Daily Reservoir Surface Fluctuations under the Seasonally Adjusted High Fluctuating Flow Scenario during a Moderate Year

Month	Blue Mesa		Morrow Point		Crystal	
	Maximum Daily Fluctuation (ft)	% Due to Hourly Fluctuation	Maximum Daily Fluctuation (ft)	% Due to Hourly Fluctuation	Maximum Daily Fluctuation (ft)	% Due to Hourly Fluctuation
Oct	0.3	48	1.1	92	8.0	99
Nov	0.2	61	0.8	94	6.9	99
Dec	0.2	39	0.8	94	6.4	96
Jan	0.1	91	0.3	94	4.0	96
Feb	0.1	100	0.3	91	3.8	100
Mar	0.1	29	0.4	70	4.3	92
Apr	0.2	41	1.5	99	3.2	98
May	0.5	4	1.3	98	2.4	97
Jun	0.3	4	0.4	88	2.1	100
Jul	0.3	38	0.9	80	3.4	98
Aug	0.3	41	1.3	93	8.1	98
Sep	0.3	25	1.3	95	8.4	100

TABLE 12 Maximum and Minimum Reservoir Surface Elevations on the First Day of the Month under the Seasonally Adjusted High Fluctuating Flow Scenario at the Aspinall Unit during a Moderate Year

Reservoir/Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Blue Mesa												
Starting storage (acre-feet)	660,000	625,462	605,086	570,920	567,864	568,124	592,603	622,739	747,592	820,553	771,736	727,623
Inflow (cfs)	1,017	862	497	452	517	903	2,114	4,415	4,299	1,581	1,051	745
End-of-hour storage (acre-feet)												
1:00 a.m.	660,084	625,533	605,127	570,957	567,907	568,199	592,778	623,103	747,803	820,684	771,823	727,685
2:00 a.m.	660,168	625,604	605,168	570,995	567,949	568,273	592,952	623,466	748,013	820,814	771,910	727,746
3:00 a.m.	660,252	625,676	605,209	571,032	567,992	568,348	593,127	623,830	748,224	820,945	771,997	727,808
4:00 a.m.	660,336	625,747	605,250	571,069	568,035	568,423	593,302	624,194	748,435	821,076	772,083	727,869
5:00 a.m.	660,420	625,818	605,291	571,107	568,078	568,497	593,477	624,557	748,645	821,206	772,170	727,931
6:00 a.m.	660,504	625,889	605,332	571,144	568,120	568,572	593,651	624,921	748,856	821,337	772,257	727,992
7:00 a.m.	660,588	625,961	605,374	571,181	568,163	568,646	593,826	625,285	749,067	821,468	772,344	728,054
8:00 a.m.	660,672	626,032	605,415	571,219	568,206	568,721	594,001	625,343	749,116	821,293	772,431	728,116
9:00 a.m.	660,756	626,103	605,456	571,256	568,249	568,796	594,175	625,400	749,166	821,117	772,518	728,177
10:00 a.m.	660,840	626,174	605,497	571,294	568,291	568,870	594,350	625,458	749,215	820,942	772,605	728,239
11:00 a.m.	660,619	626,246	605,538	571,331	568,334	568,945	594,219	625,516	749,265	820,767	772,386	727,994
12:00 Noon	660,397	626,317	605,579	571,368	568,377	569,020	594,088	625,574	749,314	820,592	772,167	727,750
1:00 p.m.	660,175	626,082	605,314	571,406	568,419	569,094	593,957	625,632	749,364	820,417	771,948	727,506
2:00 p.m.	659,954	625,848	605,049	571,443	568,462	569,169	593,826	625,690	749,413	820,242	771,729	727,262
3:00 p.m.	659,732	625,613	604,785	571,175	568,199	568,938	593,695	625,748	749,463	820,067	771,510	727,018
4:00 p.m.	659,510	625,379	604,520	570,906	567,936	568,706	593,564	625,806	749,512	819,892	771,291	726,773
5:00 p.m.	659,288	625,144	604,255	570,638	567,673	568,475	593,433	625,864	749,562	819,716	771,072	726,529
6:00 p.m.	659,067	624,910	603,991	570,601	567,622	568,476	593,302	625,921	749,611	819,541	770,853	726,285
7:00 p.m.	658,845	624,675	603,784	570,638	567,664	568,550	593,170	625,979	749,661	819,366	770,634	726,041
8:00 p.m.	658,623	624,507	603,825	570,675	567,707	568,625	593,039	626,037	749,710	819,191	770,415	725,797
9:00 p.m.	658,651	624,578	603,866	570,713	567,750	568,699	593,098	626,095	749,760	819,016	770,196	725,552
10:00 p.m.	658,735	624,649	603,907	570,750	567,792	568,774	593,273	626,153	749,809	818,841	770,176	725,506
11:00 p.m.	658,819	624,720	603,948	570,787	567,835	568,849	593,448	626,403	749,859	818,897	770,263	725,568
12:00 Midnight	658,903	624,792	603,989	570,825	567,878	568,923	593,623	626,766	750,069	819,028	770,350	725,630
Storage (acre-feet)												
Maximum	660,840	626,317	605,579	571,443	568,462	569,169	594,350	626,766	750,069	821,468	772,605	728,239
Minimum	658,623	624,507	603,784	570,601	567,622	568,124	592,603	622,739	747,592	818,841	770,176	725,506
Elevation (ft)												
Maximum	7,499.96	7,495.72	7,493.12	7,488.76	7,488.37	7,488.46	7,491.69	7,495.77	7,510.51	7,518.52	7,513.08	7,507.98
Minimum	7,499.69	7,495.49	7,492.89	7,488.65	7,488.26	7,488.33	7,491.47	7,495.27	7,510.23	7,518.23	7,512.81	7,507.66
Difference	0.27	0.23	0.23	0.11	0.11	0.14	0.22	0.50	0.28	0.29	0.27	0.32

TABLE 12 (Cont.)

Reservoir/Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Morrow Point												
Starting storage (acre-feet)	114,833	112,632	111,489	112,627	112,061	112,744	109,528	109,707	110,439	111,730	107,420	109,688
Side inflow (cfs)	94	61	69	61	82	98	373	534	311	74	58	44
End-of-hour storage (acre-feet)												
1:00 a.m.	114,841	112,637	111,495	112,632	112,068	112,752	109,513	109,600	110,408	111,648	107,425	109,692
2:00 a.m.	114,849	112,642	111,500	112,637	112,075	112,760	109,498	109,493	110,376	111,566	107,430	109,695
3:00 a.m.	114,856	112,647	111,506	112,642	112,081	112,768	109,482	109,386	110,345	111,484	107,434	109,699
4:00 a.m.	114,864	112,652	111,512	112,647	112,088	112,776	109,467	109,279	110,313	111,402	107,439	109,703
5:00 a.m.	114,872	112,657	111,518	112,652	112,095	112,784	109,452	109,171	110,282	111,320	107,444	109,706
6:00 a.m.	114,880	112,662	111,523	112,657	112,102	112,793	109,437	109,064	110,250	111,238	107,449	109,710
7:00 a.m.	114,887	112,667	111,529	112,662	112,108	112,801	109,422	108,957	110,219	111,156	107,454	109,713
8:00 a.m.	114,895	112,672	111,535	112,667	112,115	112,809	109,231	109,025	110,239	111,204	107,458	109,717
9:00 a.m.	114,903	112,677	111,540	112,672	112,122	112,817	109,041	109,092	110,259	111,253	107,463	109,721
10:00 a.m.	114,911	112,682	111,546	112,677	112,129	112,825	108,851	109,159	110,279	111,301	107,468	109,724
11:00 a.m.	115,224	112,687	111,552	112,682	112,136	112,833	108,966	109,226	110,300	111,350	107,779	110,034
12:00 Noon	115,538	112,692	111,557	112,687	112,142	112,841	109,081	109,294	110,320	111,398	107,651	109,905
1:00 p.m.	115,413	113,003	111,869	112,693	112,149	112,849	109,197	109,361	110,340	111,447	107,524	109,777
2:00 p.m.	115,289	112,876	111,742	112,698	112,156	112,857	109,312	109,428	110,360	111,496	107,396	109,648
3:00 p.m.	115,164	112,749	111,616	112,570	112,030	112,733	109,428	109,495	110,380	111,544	107,269	109,519
4:00 p.m.	115,040	112,622	111,489	112,443	111,905	112,609	109,543	109,563	110,401	111,593	107,141	109,391
5:00 p.m.	114,915	112,495	111,363	112,499	111,943	112,510	109,658	109,630	110,421	111,641	107,014	109,262
6:00 p.m.	114,791	112,367	111,245	112,579	112,044	112,592	109,774	109,697	110,441	111,690	106,886	109,134
7:00 p.m.	114,667	112,329	111,498	112,584	112,051	112,600	109,889	109,765	110,461	111,738	106,759	109,005
8:00 p.m.	114,674	112,574	111,504	112,589	112,058	112,608	110,005	109,832	110,481	111,787	107,063	109,209
9:00 p.m.	114,738	112,579	111,510	112,594	112,064	112,617	109,930	109,899	110,502	111,835	107,374	109,518
10:00 p.m.	114,746	112,584	111,515	112,599	112,071	112,625	109,740	109,966	110,522	111,884	107,486	109,629
11:00 p.m.	114,754	112,589	111,521	112,604	112,078	112,633	109,549	109,842	110,542	111,701	107,491	109,633
12:00 Midnight	114,762	112,594	111,527	112,609	112,085	112,641	109,534	109,735	110,510	111,619	107,495	109,636
Storage (acre-feet)												
Maximum	115,538	113,003	111,869	112,698	112,156	112,857	110,005	109,966	110,542	111,884	107,779	110,034
Minimum	114,667	112,329	111,245	112,443	111,905	112,510	108,851	108,957	110,219	111,156	106,759	109,005
Elevation (ft)												
Maximum	7,157.92	7,154.77	7,153.34	7,154.38	7,153.70	7,154.58	7,150.97	7,150.92	7,151.65	7,153.36	7,148.10	7,151.00
Minimum	7,156.84	7,153.92	7,152.55	7,154.06	7,153.38	7,154.15	7,149.49	7,149.62	7,151.24	7,152.43	7,146.77	7,149.68
Difference	1.08	0.85	0.79	0.32	0.32	0.44	1.48	1.30	0.41	0.92	1.33	1.32

TABLE 12 (Cont.)

Reservoir/Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
<i>Crystal</i>												
Starting storage (acre-feet)	15,829	15,276	14,443	12,413	13,766	13,822	16,835	16,418	15,926	15,926	16,480	15,311
Side inflow (cfs)	210	135	152	135	123	147	275	680	507	164	130	97
Steady release (cfs)	1,919	1,429	1,285	683	702	748	2,252	3,578	3,832	2,635	1,919	1,916
End-of-hour storage (acre-feet)												
1:00 a.m.	15,688	15,169	14,349	12,368	13,718	13,772	16,718	16,330	15,853	15,810	16,332	15,161
2:00 a.m.	15,547	15,062	14,256	12,322	13,670	13,723	16,600	16,241	15,780	15,694	16,184	15,010
3:00 a.m.	15,405	14,955	14,162	12,277	13,622	13,673	16,483	16,153	15,707	15,578	16,036	14,860
4:00 a.m.	15,264	14,848	14,068	12,232	13,575	13,623	16,365	16,065	15,634	15,462	15,889	14,710
5:00 a.m.	15,123	14,741	13,975	12,187	13,527	13,574	16,248	15,977	15,561	15,346	15,741	14,559
6:00 a.m.	14,982	14,634	13,881	12,141	13,479	13,524	16,131	15,888	15,488	15,230	15,593	14,409
7:00 a.m.	14,840	14,527	13,788	12,096	13,431	13,474	16,013	15,800	15,415	15,114	15,445	14,259
8:00 a.m.	14,699	14,420	13,694	12,051	13,383	13,425	16,071	15,843	15,451	15,173	15,297	14,108
9:00 a.m.	14,558	14,314	13,600	12,005	13,335	13,375	16,129	15,886	15,488	15,232	15,149	13,958
10:00 a.m.	14,417	14,207	13,507	11,960	13,287	13,325	16,187	15,930	15,524	15,291	15,001	13,808
11:00 a.m.	14,275	14,100	13,413	11,915	13,240	13,276	16,245	15,973	15,561	15,350	14,854	13,657
12:00 Noon	14,134	13,993	13,319	11,870	13,192	13,226	16,302	16,016	15,597	15,409	15,144	13,945
1:00 p.m.	14,431	13,886	13,226	11,824	13,144	13,176	16,360	16,059	15,634	15,468	15,434	14,233
2:00 p.m.	14,728	14,217	13,570	11,779	13,096	13,127	16,418	16,102	15,670	15,528	15,724	14,520
3:00 p.m.	15,024	14,548	13,914	12,172	13,486	13,515	16,476	16,145	15,707	15,587	16,014	14,808
4:00 p.m.	15,321	14,879	14,259	12,564	13,876	13,903	16,534	16,188	15,743	15,646	16,304	15,096
5:00 p.m.	15,618	15,210	14,603	12,774	14,103	14,267	16,592	16,232	15,780	15,705	16,595	15,383
6:00 p.m.	15,915	15,541	14,939	12,728	14,055	14,217	16,649	16,275	15,816	15,764	16,885	15,671
7:00 p.m.	16,212	15,783	14,846	12,683	14,007	14,168	16,707	16,318	15,853	15,823	17,175	15,959
8:00 p.m.	16,376	15,676	14,762	12,638	13,959	14,118	16,765	16,361	15,889	15,882	17,034	15,914
9:00 p.m.	16,235	15,569	14,658	12,593	13,912	14,068	16,823	16,404	15,926	15,942	16,886	15,764
10:00 p.m.	16,094	15,462	14,565	12,547	13,864	14,019	16,881	16,447	15,963	16,001	16,738	15,614
11:00 p.m.	15,952	15,355	14,471	12,502	13,816	13,969	16,938	16,490	15,999	16,060	16,590	15,463
12:00 Midnight	15,811	15,248	14,378	12,457	13,768	13,919	16,821	16,402	15,926	15,944	16,442	15,313
Storage (acre-feet)												
Maximum	16,376	15,783	14,939	12,774	14,103	14,267	16,938	16,490	15,999	16,060	17,175	15,959
Minimum	14,134	13,886	13,226	11,779	13,096	13,127	16,013	15,800	15,415	15,114	14,854	13,657
Elevation (ft)												
Maximum	6,750.91	6,748.84	6,745.83	6,737.70	6,742.76	6,743.37	6,752.83	6,751.30	6,749.60	6,749.81	6,753.63	6,749.46
Minimum	6,742.88	6,741.95	6,739.45	6,733.75	6,738.95	6,739.07	6,749.65	6,748.90	6,747.53	6,746.46	6,745.52	6,741.09
Difference	8.03	6.89	6.38	3.95	3.81	4.30	3.18	2.40	2.06	3.35	8.11	8.37

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