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Colorado River Storage Project Constraints and Operation of Glen Canyon Dam

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This report outlines the legal and operational constraints and criteria that define the operation and management of Glen Canyon Dam, the key regulatory feature on the Colorado River. It describes the overall management of the Colorado River system, the Colorado River Storage Project Act, and the distribution of hydroelectric power by the Western Area Power Administration. Also described are: history of operation of Glen Canyon Dam (pre- and post-construction, 1922 to present); determination of annual, monthly, and hourly release volumes; Glen Canyon Dam uprate and rewind program, Colorado River Storage Project power marketing; and future operational constraints.

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COLORADO RIVER STORAGE PROJECT CONSTRAINTS AND THE OPERATION OF GLEN CANYON DAM, ARIZONA

The release of water from Glen Canyon Dam to Glen and Grand Canyons is controlled by a combination of physical, legal, and system boundaries and interpretations. The information presented in this report outlines the major parameters that are considered in the determination of the actual releases that occur at Glen Canyon Dam.

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INTRODUCTION

The Colorado River winds over 1,400 miles through seven western states and northern Mexico and collects water from over 244,000 square miles. It is the primary source of water for the basin. The economic health, recreational opportunities, and growth potential of many communities in the Colorado River Basin are directly related to the management of the river.

Glen Canyon Dam is the key water regulatory feature on the Colorado River. The objective of this report is to outline the constraints and criteria that define the operation and management of Glen Canyon Dam and to describe the operation of the dam as related to the management of the Colorado River system, The Colorado River Storage Project (CRSP) Act, the Western Area Power Administration (WAPA) power and transmission system, and the consultation process with the Colorado River Basin states. The Department of the Interior, with its Secretary, has the responsibility in the Colorado River system to ensure that each state receives its defined allocation. The actions of the Department of the Interior are set within the defined legal, river system, and physical constraints of the Colorado River basin.

The information presented in this report provides background on the operation and management of Glen Canyon Dam. This report is not presented as an in-depth description of all the legal and political balanacing that defines the operation of the dam. RAther, it outlines the operational framework and boundaries that are taken into account in the

determination of the managment of Glen Canyon Dam and consequently the releases into the Glen and Grand Canyons.

GLEN CANYON DAM MANAGMENT FRAMEWORK

The scarcity and unpredictable nature of water in the Colorado River Basin have resulted in a long history of competition for the limited water resources. Over the past 100 years, uses of the Colorado River have increased exponentially and demands on it have accelerated.

Today, over two million acres of agricultural land are irrigated in the Colorado River basin. Reservoir storage capacity totals over 61.5 million acre-feet (maf) and can provide over 3,330,000 kilowatts of electrical capacity. Given the importance of the Colorado River and the demands made upon it, it has been necessary to physically and legally control use of the river. The legal control has been defined through a number of Congressional acts, court decisions, treaties, and compacts known collectively as the "Law of the River" (Nathanson 1978).

Wise management of the Colorado River Basin was argued for by John Wesley Powell (1962) as early as 1878. His arguments were largely ignored. E.C. LaRue (1916) followed Powell's philosophy and identified the necessity for a comprehensive water supply study of the entire Colorado River Basin. During the early 1920s, the seven Colorado River Basin states (Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming) realized that control of the Colorado River required a coordinated approach. The need to control storage and available water supplies led to the negotiation of the 1922 Colorado River Compact (Compact) (Olson 1962). This first interstate water compact was intended to balance the expanding demands of the Lower Basin states and the need to preserve adequate water for future use in the less-developed Upper Basin states.

The Compact officially divides the Colorado River Basin into the Upper and Lower Basins. The dividing point, or Compact Point, was established at Lees Ferry, Arizona. The Compact apportions, in perpetuity, 7.5 maf of Colorado River water annually to each basin. In addition, the Lower Basin was given the right to increase its apportionment by as much as 1.0 maf in any given year. The Compact required Upper Basin delivery

of 75.0 maf for any period of ten consecutive years to the Lower Basin.

The Compact was the first step to legally define the Colorado River rights of the seven basin states, but it was by no means the last. Additional laws, treaties, and court decisions continue to refine the interpretation and allocation of Colorado River water. The composite of all of these actions define the "Law of the River." The primary actions are listed in Table 1 and are more fully discussed in Weatherford and Brown (1986) and Nathanson (1978).

Table 1. Primary Colorado River laws and interpretations.

Colorado River Compact (signed)	November 24, 1922
California Limitations Act	March 4, 1929
Boulder Canyon Project Act (45 Stat. 1057) (signed)	June 25, 1929
Arizona v. California	1931, 1934, 1936
Mexican Water Treaty (Treaty Series 994)	November 8, 1945
Upper Colorado River Basin Compact	October 11, 1948
Colorado River Storage Project Act (70 Stat. 105)	April 11, 1956
Arizona v. California (373, U.S. 564, 565 [1963])	March 9, 1964
Colorado River Basin Project Act (P.L. 90-537)	September 30, 1968
Colorado River Basin Salinity Control Act (Minute No. 242)	August 30, 1973

While all of the define laws, treaties, and legal interpretations impact the allocation of the Colorado River, the CRSP Act specifically allowed for the construction of Glen Canyon Dam.

Colorado River Storage Project Act. The CRSP Act (70 Stat. 105) passed on April 11, 1956, provides for the comprehensive development of the water resources of the Upper Colorado River Basin and long-term regulatory storage of Colorado River water to meet the commitments of the Colorado River Compact (Upper Colorado River Commission 1987).

Originally, the CRSP plan included ten dams and reservoirs within the Upper Colorado River Basin. Six

dams were finally authorized for construction (Meyers 1967).

The primary objectives of the storage projects were to regulate the flow of the Colorado River, to store water for beneficial consumptive use, to provide reclamation of arid and semiarid land, to provide control of floods, and as an incidental basis to generate hydroelectric power (U.S. Department of the Interior 1954). The revenues generated by the project would be used to repay the cost of construction and operation and maintenance requirements.

The hydroelectric powerplants and transmission lines authorized by the CRSP Act are directed to operate in conjunction with other Federal powerplants and to produce the greatest practicable amount of power. The revenues collected from the generated power are to repay the initial government investment of the CRSP dams and provide support for other Bureau of Reclamation (BOR) participating projects.

Construction of Glen Canyon Dam began in 1956 and was completed in 1963. The structure impounds Lake Powell, a 27 maf reservoir with Glen Canyon Dam being the key regulatory element controlling water releases to the Lower Basin.

LEGAL OPERATING CRITERIA OF GLEN CANYON DAM

The operation of Glen Canyon Dam is controlled by the physical parameters of reservoir size, annual runoff, discharge capacity, the legal and institutuional constraints specified by Federal laws, an interstate compact, an international treaty, and Supreme Court decisions.

The legal mandates that are important to the management of the Colorado River and Glen Canyon Dam are listed in Table 1. Specific legislative accords that direct actual dam operation include the Filling and Operating Criteria for Glen Canyon Dam. The **Filling Criteria** for Lake Powell had three main objectives: (1) to provide sufficient water to meet downstream requirements, (2) to make a fair allowance for any deficiency in energy generation at Hoover Dam due to the impoundment of water behind Glen Canyon Dam, and (3) to bring the storage capacity in Lake Powell to elevation 3,490 feet at the earliest feasible time. Elevation 3,490 feet is the minimum elevation necessary to initiate power generation. Specific managment principles were

establsihed to assist in the achievement of these objectives. The Filling Criteria were approved in April 1962 by Secretary of the Interior Stewart Udall and were terminated in June 1980 when Lake Powell reached the full reservoir elevation of 3700 feet.

The **Operating Criteria** for Glen Canyon Dam were adopted in 1968 as part of the Colorado River Basin Project Act (Section 602(b) of P.L. 90-537) to cover the coordinated long-range operations of facilities of the CRSP, Parker-Davis Project, Boulder Canyon Project, and the participating CRSP projects.

Section 602(a) of the Operating Criteria requires the Secretary of the Interior to prepare an annual report that describes the actual operations of the Colorado River reservoirs under the criteria for the preceding year and the projected operations for the current year. The Secretary is to determine if sufficient water exists in storage to meet the downstream delivery requirements. The actual amount of 602(a) storage required in Lake Powell to meet the Lower Basin states requrements has not been determined by the Secretary. If too little water is in Lake Powell storage, releases from Glen Canyon Dam will be limited to 8.23 maf. However, if excess water exists, releases greater than 8.23 maf can be made to accomplish specific goals defined in the Act. These goals include fulfilling the requirements of the Colorado River Compact as related to deliveries to the Lower Basin states and the requirements of the treaty with the country of Mexico.

The objective of the Operating Criteria was a more efficient and reasonable river management. The Operating Criteria take into consideration the great diversity among the Colorado River system users and stipulate that any plan of operation must reflect appropriate consideration of the uses of the reservoirs for all purposes including flood control, water quality control, recreation, enhancement of fish and wildlife, and other environmental factors.

The Secretary of the Interior may modify the Operating Criteria. A formal review of the Operating Criteria is made at least every five years, with participation by state representatives and others that the Secretary may deem appropriate. In addition, each year the Colorado River Basin states and the Secretary agree on an Annual Operation Plan (AOP) for the reservoirs of the Colorado River.

Operation of the Upper Basin Reservoirs. The operation

of the Upper Basin reservoirs takes into account many factors with the overall objective being to ensure an annual release of water to the Lower Basin states of 8.23 maf. Lake Powell is the primary "water bank" from which the releases are made. If the Upper Basin storage reservoirs' active storage forcast on September 30 of the current year is greater than the quantity of storage required by Section 602(a) of the Colorado River Basin Project Act, as determined by the Secretary, and if the active storage forecast for September 30 of the current year of Lake Powell is greater than the Lake Mead active storage forecast for that date, then water shall be released from Lake Powell at a rate greater than 8.23 maf.

Objectives of this additional release include: to reasonably serve beneficial domestic and agricultural needs; maintain, as nearly as practical, equal active storage in Lake Mead and Lake Powell; and avoid bypassing water.

HISTORIC OPERATION OF GLEN CANYON DAM

Management of Glen Canyon Dam has had an impact on the flow patterns of the Colorado River through the Glen and Grand Canyons. Three distinct phases of river flow can be interpreted from the flow records.

Phase I. Pre-dam, 1922-1962. The pre-dam period was characterized by frequent, natural, high flows in the late spring and early summer seasons and by low flows during the late summer, fall, and winter seasons. Mean daily flows in excess of 80,000 cubic feet per second (cfs) were common and occasionally reached the 100,000 cfs level. Flows less than 3,000 cfs were frequent during the fall and winter months. Average daily flows greater than 30,000 cfs occurred about 18 percent of the time, and flows less than 5,000 cfs occurred about 20 percent of the time. Variability in flow occurred on a seasonal basis.

Phase II. Lake Powell Filling, 1963-1980. Lake Powell began storing water in March 1963, and was filled in June 1980. The management of Lake Powell and the operation of Glen Canyon Dam was accomplished under the Filling Criteria to ensure the efficient and timely filling of Lake Powell and to minimize the impact to the downstream operation of Hoover Dam.

Little water was released for the first two years following Glen Canyon Dam closure. In 1965, Lake

Powell achieved the minimum elevation necessary for power production (3490 feet). However, the elevation of Lake Mead dropped below the minimum necessary for operation of the Hoover Powerplant. This shortage of water occurred prior to spring runoff being available to supplement water volumes necessary to meet the downstream water use requirements. Subsequently, nearly 11 maf of water was released prior to the spring runoff in 1965 from Lake Powell to restore the minimum reservoir elevation at Lake Mead. Releases from Glen Canyon Dam were targeted to achieve the 75 maf for any period of ten consecutive years as legislated by the Colorado River Compact.

The Operating Criteria were implemented prior to the termination of the Filling Criteria in order to provide a more efficient management of the Colorado River System. The range over which river flows varied during the filling period was smaller than that of the pre-dam period. Flows greater than 65,000 cfs did not exist, and flows less than 5,000 cfs occurred only 10 percent of the time. Variability in flows changed from a seasonal basis to a daily basis.

Phase III. Lake Powell, Post-filling, 1981-Present. The post-filling period of Lake Powell and the operation of Glen Canyon Dam has been characterized by the preponderance of high flow releases. The 1984 inflow to Lake Powell was the highest of record and the 1983 inflow was the third highest of record. Since releases from Glen Canyon Dam in four of the last six years have been unusually high, the releases have been biased upwards.

Nevertheless, it is useful to note that only 2 percent of the mean daily flows at Lees Ferry were above 42,000 cfs and none were above 92,500 cfs. Even with the data bias, only approximately 10 percent of the flows of the period were greater than 25,000 cfs.

CURRENT OPERATION OF GLEN CANYON DAM

Flows through Glen and Grand Canyons are influenced by storage and release decisions that are made and scheduled annually, monthly, and hourly from Glen Canyon Dam. The annual decisions are in conformance with the legal mandates and Operating Criteria.

The monthly decisions are generally intermediate targets determined as necessary to systematically achieve the annual requirements. The hourly schedules

are set to meet the monthly volume targets but are primarily influenced by the power demands and minimum flow requirements. BOR sets the annual and monthly release volumes and WAPA determines the daily and hourly actual release levels.

Determination of Annual Release Volumes. Release schedules vary greatly in annual release volumes, but each adheres to the minimum release of 8.23 maf and equalization of storage between Lake Powell and Lake Mead. Annual releases greater than the minimum of 8.23 maf are permitted only if the reservoir storage in the Upper Basin reservoirs is greater than the storage required by Section 602(a) of the Colorado River Basin Project Act and if the storage in Lake Powell is greater than the storage in Lake Mead, or if runoff volumes cannot be stored in Lake Powell.

As a practical matter, the reservoir is targeted to fill each July. An informal understanding between BOR and the Upper Basin states established an annual January 1 volume target for Lake Powell storage at 22.6 maf as an intermediate target and to achieve full reservoir conditions (27 maf) by each July.

Since a full reservoir condition induces the greatest risk of flood releases, it is important to understand the basis for filling the reservoir each year. From a water conservation perspective, a full reservoir pool represents insurance against possible shortages during the drought cycles similar to those that have occurred historically. Negotiation between BOR and the Upper Colorado River Basin states are on-going to determine if a lower reservoir limit could be set that would still allow enough flexibility to meet the legal release requirements.

Since there has not been a numerical determination of actual 602(a) storage (the amount of water actually required in the Lower Colorado River Basin), a practical solution has been to keep Lake Powell full. In addition, since 1983, releases in excess of 8.23 maf annually have been allowed only under the Criteria provision of avoiding spills. Excess water is released only to the extent required by the forecast to avoid powerplant bypasses. This practice has also contributed to keeping Lake Powell full.

Determination of Monthly Release Volumes. Operational flexibility is greatest when the monthly release volumes are moderate and least when monthly release volumes are low or high. Monthly release volumes

greater than 1,200,000 acre-feet (af) require hourly and daily rates to be near maximum powerplant capacity in order to pass the monthly volume downstream. Monthly volumes between 600,000 and 1,200,000 af allow more flexibility from the power production point of view. Monthly releases less than 600,000 af do not have enough flexibility to take advantage of the entire peaking capability, maintain the minimum release rates, and conform to the monthly volume requirements. Typical 1983-1986 operations involved running the powerplant at, or near, full capacity 24 hours a day.

Fall and winter releases are managed to meet the January 1 storage target. January through March releases are managed to develop space in Lake Powell to accommodate forecasted Upper Basin runoff. April, May, and June releases are managed to accommodate the changes in inflow as they occur and to achieve a full reservoir by July 1. July through September releases are used to compensate for any missed targets and to prepare for the January 1 target of 22.6 maf of storage.

After all these considerations and monthly volumes have been satisfied, then seasonal variations in the power demand are considered. Power needs are highest during the coldest winter and hottest summer months. Therefore, higher releases are scheduled in these months whenever possible.

Determination of Hourly Release Volumes. Hourly releases from Glen Canyon Dam are generally set to achieve programmed monthly release volumes, to maintain established minimum rates, and to follow the pattern of energy demand. The physical limitations of the powerplant and the minimum flow requirements define the boundaries of the power releases.

The agreed upon minimum flow requirements are: 3,000 cfs from Easter Sunday to Labor Day with a daily on-peak (8:00 am to 11:00 pm) average of 8,000 cfs; and 1,000 cfs from Labor Day to Easter Sunday (U.S. Bureau of Reclamation 1988).

The following guidelines are followed, to the extent possible, within the higher priority operation constraints in producing hydroelectric power: (1) bypasses of powerplants are minimized, and to the extent possible, eliminated; (2) water releases are maximized during the peak energy demand periods, generally Monday through Saturday between 7:00 am and 11:00 pm; (3) water releases are maximized during

months of peak energy demand and minimized during low demand months; and (4) sufficient reservoir storage is maintained to assure efficient use of the generator units.

Demand for power may change the rate at which water is released; however, this demand is not supposed to alter the releases required to satisfy other project purposes. Emergencies may cause severe departures from expected schedules, but these emergencies are usually of short duration and their effect on release volumes can be mitigated rapidly.

Glen Canyon Dam Uprate and Rewind Program. In 1975, an inspection of Glen Canyon Dam generators revealed that the original generator windings were reaching the end of their service life and that a "rewinding" of the eight generators was necessary to maintain efficient operation.

A decision to "uprate" the generators at Glen Canyon Dam was made to reduce power generation constraints and to provide for more efficient use of the other power system components.

Because uprating is not a normal maintenance function, compliance with the National Environmental Policy Act (NEPA) was required. An environmental assessment, completed in 1982, resulted in a Finding of No Significant Impact (UC-FONSI 83-1) (U.S. Bureau of Reclamation 1982). The uprating of the eight generators at Glen Canyon Dam began in 1983. Before uprating, the maximum release ranged from 27,500 to 31,500 cfs, depending on lake elevation. The elevation of the reservoir determines the head, or pressure, on the turbines which drive the generators. After generator uprating was completed in 1987, the maximum releases are now able to range from 32,200 to 33,100 cfs. However, releases are limited to 31,500 cfs until the completion of the Glen Canyon Environmental Studies.

Risk of Flood Releases. The ideal operating plan would enable the reservoir to fill each year without risking flood-level releases. Unfortunately, forecasted inflows have a large degree of uncertainty and variability which amplified the risks of either flood releases or not filling the reservoir.
Flood releases occur under two conditions: (1) from an extreme runoff which could not have been contained even with full powerplant discharges starting January 1, or (2) from unanticipated late-season increases in

the inflow which exceed the available storage and release capability.

One of the key criteria for the operation of Glen Canyon Dam is to avoid releases which bypass the powerplant. Therefore, under high inflow conditions, releases are held at or near 31,500 cfs until greater releases are necessary. Due to forecast uncertainties, the decision to exceed 31,500 cfs is often delayed in the hope that actual inflow will be less than that forecasted. If the forecast is correct or even underestimates inflow, this delay necessitates releasing larger flows than would have been required had flood releases been started earlier.

COLORADO RIVER STORAGE PROJECT POWER MARKETING

In 1961, BOR initiated the development of a plan to market the hydroelectric power from the CRSP. Two components of the hydroelectric power were marketed: energy and capacity. Energy is the electrical work produced from a power generating unit of a period of time. Capacity is the load (or potential energy) for which a generator is rated. A public participation process assessed the interest in the power and developed long-term firm (will be always provided) power contracts for the future energy to be produced by the CRSP powerplants, including the yet to be completed Glen Canyon Dam.

The marketing criteria utilized in the formulation of the initial power contracts took into account the following items: (1) the source of power, (2) how much power would be available and when, (3) who would be eligible to participate and receive the power, and (4) how the power was to be delivered and where, and (5) the provisions and restrictions contained in the firm power contracts.

The Department of Energy (DOE) was formed by Congress in 1977 (P.L. 95-91) and assumed the Federal power marketing responsibilites for BOR. Western Area Power Administration (WAPA) was established as an agency within DOE to market and transmit Federal power within 15 central and western states.

WAPA operates and maintains the Federal transmission lines and substations. Power is sold by WAPA to municipalities, rural electric cooperatives, public utility districts, private utilities, Federal and state agencies, irrigation districts, and other project-use

customers. It is estimated that over 15 million people can be serviced by these entities.

With the creation of WAPA and expansion of southwest regional electric needs, it was determined by WAPA that the original 1962 General Power Marketing Criteria for the CRSP hydroelectric power (promulgated by BOR) required modification. The changes were necessary to redefine the geographic market area, the availability of peaking power, and to identify additional delivery points and conditions.

A provision of the modification, completed in February 9, 1978, extended the termination date of the original power contracts to September 1989 and defined specific BOR and WAPA responsibilities. WAPA is currently in the process of developing the post-1989 marketing criteria to be used in establishing future power contracts (U.S. Department of Energy 1985).

Under a 1980 agreement between BOR and WAPA, BOR manages the reservoirs and generates hydroelectric power and WAPA markets, transmits, and regulates power delivery to the customers of the CRSP. The power generated at Glen Canyon Dam and the other CRSP powerplants is marketed by WAPA on both a long-term, firm basis through electrical sales contracts, and on a short-term basis through agreements with firm power customers or associated utilities.

Long-term Marketing. The determination of the amounts of power available for long-term marketing and the distribution of this power to utility systems is a cooperative effort between BOR and WAPA. BOR utilizes a computer model and historic hydrological data to predict available water and power resources for future time periods. The model utilizes anticipated Upper Basin water depletions, historic hydrological conditions, known reservoir storage capacity, plus known and anticipated physical resources to predict the availability of power resources. WAPA also assesses the availability of the hydroelectric resource, with consideration given to the predicted probability of occurrence of varying levels of hydroelectric resource during future periods. This assessment results in a proposed level of risk associated with a particular level of hydroelectric resource to be offered.

After the completion of the initial resource assessment, WAPA develops a formal marketing plan and establishes criteria through the public participation process. The marketing criteria provides the framework

for allocation of the available hydroelectric resources and the basis for power contracts.

Within the framework of the marketing criteria, WAPA requests applications for power needs from eligible entities; prepares allocations; and negotiates and executes formal, long-term, power contracts with preferred customers. WAPA takes power generated by BOR at the CRSP facilities and delivers it to customers at agreed to Points Of Delivery in the interconnected transmission system, commonly referred to as the Western Grid.

Customers often purchase power from the CRSP system to complement other sources of electrical generation. Large thermal powerplants (coal-fired), which utilities generally operate continuously at or near maximum output (base loaded), are the most fuel efficient, and hence the most economical to operate.

During a normal day of operation, a utility will use a mixture of electrical resources to balance its needs. Typically, a utility will increase generation early in the morning as demand increases. If demand continues to grow, utilities increase generation by bringing on line less-efficient interim units.

As electrical needs increase, additional thermal units, called "peaking units," are brought into use. These are generally oil- or gas-fired, and provide additional electrical needs for a relatively short period of time, at a substantially higher cost per unit of energy generated. The resources of the CRSP are commonly used to supplement this need for peaking power and displace the power generated by the less efficient, and more costly, peaking units. Glen Canyon Dam is classified as an "intermediate" load facility and provides both base and peaking capability.

During the nighttime hours, an excess of power is available and the cost for that power is substantially reduced. CRSP powerplants reduce generation at night to save the potential power resources for the peaking period.

The CRSP system is also commonly managed to "store" off-peak energy from thermal generating sources for use during peak load hours. This is called "shaping" and is accomplished by requiring firm power contractors to take a portion of their energy during off-peak hours. The water that would have been released during the off-peak period is stored in the reservoir, and the energy

is delivered to the customer from thermal energy sources. During the peak load hours, the water that was stored is released and the power generated sold to displace the higher priced peaking units.

The CRSP system is also used to match minute-by-minute load changes. Hydropower efficiency is relatively high over a large range of use, while a thermal unit's efficiency changes significantly from low load to full load. The CRSP system is also used as backup generation capacity in case of unexpected system outage or emergency situations.

Short-term Marketing. When the available electrical resource is greater than the defined electrical demand (firm contracts), a portion of the resource may be identified as surplus. Surpluses may be from (1) energy resulting from generation above firm commitment; (2) excess capacity usually available since long-term capacity will be exceeded nine out of ten years; (3) excess capacity resulting from the mechanical addition or modification to generating units by BOR; (4) and in general, capacity and energy amounts offered on a long-term basis that were not committed by contract. WAPA markets surpluses on a short-term basis as a component of its overall marketing program. The surplus resources are made available to existing customers first and then to the general market.

Determination of Seasonal Surpluses. Surplus generation may be available on a month-by-month or a seasonal basis. This surplus is directly related to the runoff forecasts and resulting Glen Canyon Dam release schedule. In anticipation of high inflow to Lake Powell, BOR may determine it is necessary to increase monthly release volumes, which translates directly into increased generation available for short-term marketing. The surplus generation may be offered on a monthly or seasonal basis to long-term existing firm power customers. The rate paid for this additional energy is the firm energy rate in place at that time.

REPAYMENT OF THE COLORADO RIVER STORAGE PROJECT

Section 5 of the original CRSP Act (P.L. 84-485) established the Upper Colorado River Basin Fund. Revenues collected from the operation of the storage projects and participating projects are credited and made available for repaying the costs of operation, maintenance, and replacement of, and emergency expenditures for all CRSP projects. CRSP revenues come from

three primary sources: (1) municipal and industrial water sales, (2) power sales, and (3) irrigation water sales. In addition, revenues from specific state projects may be allocated to repay specific project features and not be generally disbursed.

CONSULTATION PROCESS

The Secretary of the Interior is responsible for the operation, management, and maintenance of all Colorado River facilities authorized by Federal law. The Secretary has been directed to comply with the applicable provision of the Colorado River Compact, the Upper Colorado River Basin Act, the Boulder Canyon Project Act, the treaty with the United Mexican States, and the legal interpretations of Arizona v. California in the storage and release of water from the reservoirs in the Colorado River Basin.

If the Secretary of the Interior fails to comply with these laws, any state of the Colorado River Basin may maintain an action in the Supreme Court of the United States to enforce the legal mandates.

The Secretary of the Interior, through BOR, annually reviews the past year's operation of the Colorado River system and the proposed operation for the up-coming year. Determination of the specific annual goals are to comply with the existing legal mandates; follow, as closely as possible, the defined operating criteria; and be done in consultation with the seven Colorado River Basin states.

SUMMARY

The operational, structural, and climatic constraints that dictate the flow of the Colorado River are complex. A sophisticated system capable of responding to political and economic conditions is required. This system, including the constraints and legal criteria influencing the movement of water through Glen Canyon Dam, will continue to evolve in response to the changing needs for water and electricity in the American Southwest. Future constraints on the operation of the Colorado River system include:

(1) The Central Arizona Project, which will allow the state of Arizona to use its full Colorado River allocation and will reduce the amount of water currently available to the state of California.

(2) Native American Reservations in the Colorado River Basin, which have a Federally reserved right to a portion of Colorado River water. As development increases, Native American water rights will become more valuable.

(3) Ranchers and farmers, who are beginning to look at their water rights as their last harvestable crop, rights that can be marketed.

(4) The proposed sale of the state of Colorado water rights to San Diego, California, which has recently brought the issue of water rights sales and transfers into the legal arena.

(5) Public concerns over the impact of CRSP operations on legally protected natural resource values in the Colorado River Basin, which continue to increase over time.

Management of the Colorado River will always be subject to the influences of politics, economics, law, and science. The complex interrelationships among these four elements form a management system that is not easily understood and is even more difficult to modify. Nevertheless, because the operation of the CRSP, particularly Glen Canyon Dam, profoundly impacts the resources of the Colorado River through Grand Canyon National Park, it is imperative to understand and explore ways that the system can be adjusted to better meet all the demands on the river.

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