PROPOSED WATER MANAGEMENT PLAN

FOR ALAMO LAKE AND

THE BILL WILLIAMS RIVER

Final Report and Recommendations of the Bill Williams River Corridor Technical Committee

ARIZONA GAME AND FISH DEPARTMENT
ARIZONA STATE PARKS DEPARTMENT
U.S. BUREAU OF LAND MANAGEMENT
U.S. BUREAU OF RECLAMATION
U.S. ARMY CORPS OF ENGINEERS
U.S. FISH AND WILDLIFE SERVICE

Submitted to the Bill Williams River Corridor Steering Committee

FINAL REPORT - VOLUME I

November 1994

THE STATE OF ARIZONA

GAME & FISH DEPARTMENT

2221 West Greenway Road, Phoenix, Arizona 85023-4399 (602) 942-3000

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Fife Symington

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November 30, 1994

Dear Steering Committee members:

The Bill Williams River Corridor Technical Committee is pleased to present its Final Report and Recommendations on a Proposed Water Management Plan for Alamo Lake and the Bill Williams River. We have endeavored to fullfil your charge to us to carry out a coordinated interagency planning effort to develop and recommend an effective water management plan for Bill Williams River Corridor resources.

The Technical Committee provided a forum for agencies to reach shared agreement regarding water management for Alamo Lake and the Bill Williams River. While this report is neither an action nor a decision document, the proposed 1125 foot plan represents a consensus multi-agency position. The 1125 foot target elevation water management alternative was selected by the Technical Committee as the plan which optimizes collective values and benefits for riparian, fisheries, wildlife, and recreation resources while meeting reservoir operation requirements. The Technical Committee hopes this report will meet with your approval as an interagency recommendation to the Corps of Engineers for the reoperation of Alamo Dam and the reallocation of water conservation storage for the purpose of threatened and endangered species, fish and wildlife, downstream riparian habitat, and recreational benefits.

This study illustrates that alternative operational plans for Alamo Dam can enhance benefits associated with the reservoir and downstream resources. The proposed plan results in no projected substantive loss of benefits to Alamo Dam project purposes which include flood control, water conservation and supply, hydropower generation, and recreation.

The 15 Technical Committee meetings conducted over the past three years were well attended by individuals representing all agencies. Their participation was invaluable and is reflected in this document.

Ours was a complex and difficult task. However, serving as coordinator of this Technical Committee and principal author of this report has been a pleasure due to the caliber and commitment of its members and the supporting personnel. Their efforts deserve special recognition and thanks.

Sincerely,

Eric Swanson

Eric Swanson
Technical Committee Coordinator

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EXECUTIVE SUMMARY

In 1991, at the direction of the Steering Committee, the Arizona Game and Fish Department, Arizona State Parks, Bureau of Land Management, Fish and Wildlife Service, and the Corps of Engineers formed the Bill Williams River Corridor Technical Committee. The purpose of the Technical Committee was to cooperatively develop a revised water management operations proposal for Alamo Lake and the Bill Williams River. The Bureau of Reclamation joined the Technical Committee a year later as did the Arizona Department of Water Resources which served only in an advisory capacity. The agencies recognized that water resource management is the inextricable link that serves to protect the important and significant water-dependent uses and values within the Bill Williams River corridor. While water availability, either in the form of lake storage or stream flow, is the driving force behind all agency resource goals, it was also an issue of controversy among the resource agencies.

The goal of the Technical Committee is to carry out a coordinated interagency planning effort to develop an effective water management plan for Bill Williams River corridor resources and, by doing so, to resolve perceived agency water management conflicts. The Technical Committee was guided by a Steering Committee-approved process that called for the selection of a reservoir operation plan that best meets collective agency resource objectives. In meeting these objectives, riparian, fisheries, wildlife, and recreational resource values and benefits are to be optimized while meeting Alamo Dam project purposes for flood control, water conservation and supply, and recreation.

Subcommittees were established to develop independent water management prescriptions for Alamo Lake and the Bill Williams River for each of five categories: riparian, fisheries, wildlife (including threatened and endangered species), recreation, and reservoir operations. The prescriptions were blended to create alternative operation plans for Alamo Dam that balanced all resource objectives. Streamflow requirements for riparian habitat, as recommended by the Riparian Subcommittee, were the key to establishing the reservoir release pattern for alternative operation plans. Based on each Subcommittee's recommendations, evaluation criteria were developed for each resource category to determine how well the alternative plans maximized benefits to resources in Alamo Lake and the Bill Williams River.

The principal water management evaluation tool used in the Technical Committee study was the Corps of Engineers' HEC-5 computer program. This program simulated river flow and reservoir system operation on a continuous basis using observed flow records from 1929-93 as input. Using the HEC-5 program, a range of operational alternatives were simulated to identify performance in meeting optimal resource evaluation criteria. Each alternative sought to operate the lake between a minimum 1100 foot elevation and a target lake elevation ranging from 1115 to 1171.3 feet (top of Water Conservation Pool). These target elevations determined the point at which Alamo Dam releases would be changed from base flows (25-50 cfs) to high release "flushing" flows (1,000-7,000 cfs). The operational alternatives were compared to the original authorized operations at 1070 feet (General Design Memorandum or GDM) and current operations, which attempt to retain the lake at the 1100 foot minimum elevation.

When compared to the current (1100 foot) operations, a significant improvement in nearly all evaluation criteria categories was realized for each of the alternatives considered. By consensus, the 1125 foot target elevation water management alternative was selected by the Technical Committee as the plan which optimizes resource objectives within operational constraints and objectives of Alamo Dam. While the 1125 foot plan is the preferred alternative of the Technical Committee, the 1120, 1123, and 1127 foot plans performed similarly in nearly all resource categories evaluated. The 1125 foot plan provides 80,000 acre-feet of lake storage above the 1100 foot minimum lake level that represents current operations. This large-volume storage is available for riparian, fish, wildlife, and recreational benefits. While this proposal is referred to as the 1125 foot plan, attention should be focused on resource benefits realized from a revised Alamo Dam operational scheme, not on the target 1125 foot lake elevation itself.

The preferred 1125 foot target elevation proposal provides sufficient water storage for downstream flows, while keeping lake elevations $\geq$ 1100 feet for a majority of the time. When reservoir pool levels are below the target elevation, reduced reservoir releases are made to maintain seasonal base flows ranging from 25-50 cfs throughout the Bill Williams River corridor at levels beneficial to riparian habitat. For reservoir pool levels above the 1125 foot elevation, a rapid transition is made to high releases (1,000-7,000 cfs) that mimic natural pre-dam flood flows to the extent practicable. These operations maintain relatively stable lake elevations suitable for fisheries and recreational resource objectives. Additional benefits to riparian, wildlife, and water conservation resources can be realized with reduced or diminished pumping activities at Planet Ranch. Additional enhancements to riparian, fisheries, and recreation resources also occur when outlet tunnel inspection and maintenance activities are conducted so that reservoir drawdowns are not required as frequently, or at all.

Benefits of the recommended 1125 foot reoperation plan are substantial for flood control, recreation, fisheries, riparian habitat, wildlife and threatened and endangered species categories. For flood control, lake elevations are predicted never to reach the flood control pool elevation of 1171.3 feet. The recommended plan maintains higher lake elevations over a greater period of time, which translates into greater utilization of the existing boat ramps and recreational facilities at Alamo Lake. For fisheries, lake elevations are held more consistently between 1110 and 1125 feet, and the incidence of harmful lake fluctuations during the spawning season are reduced more than 50%. Riparian resources will greatly benefit from significant increases in base flow amounts and duration for all seasons. Recommended flushing flow releases will provide benefits similar to a natural flooding event and eliminate mortality of riparian vegetation due to extended inundation. For wildlife, dramatic improvement is achieved in keeping the lake above 1100 feet and restoring riparian communities downstream. Bald eagles will benefit from an improved fish forage base and the restoration of cottonwood and willow habitats for nesting and perching activities. While the recommended plan will increase inundation frequency of historically used nest sites in the upper lake, the significance of the inundation may be less than previously believed since bald eagles used alternative sites away from lake disturbances in 1993 and 1994. A less than 10% reduction in mean annual water delivered to Lake Havasu (5,561 acre-feet) is realized due to evaporation losses caused by retaining more water in the Water Conservation Pool of Alamo Lake over time.

Implementation of the proposed water management plan for Alamo Dam and the Bill Williams River will require numerous steps and the resolution of various issues. The Technical Committee recommends a public involvement process begin after Steering Committee approval of a final water management plan proposal. Public involvement would be preceded by briefings with state, regional, and local political entities and downstream landowners. Meetings should be held to advise the public of the interagency process to date, the proposed Alamo Dam operation changes and probable implementation strategies. Any operational changes to Alamo Dam will require formal documentation by the Corps which will necessitate full public disclosure and National Environmental Policy Act compliance. Thus, a more formal public involvement process will occur prior to any changes in Alamo Dam operations.

Water rights and water conservation are significant issues to resolve. At present there are four water right applications for Alamo Lake storage and Bill Williams River instream flows. It may be necessary to modify or withdraw these applications so that a single (or joint) entity may pursue water rights that secure the recommended lake storage and base flows under this proposal. Various studies have demonstrated that a considerable amount of unappropriated public water is available for beneficial use from the Bill Williams River system.

There are specific institutional and procedural implications if the recommended operational changes are considered reoperation or reallocation. It is the opinion of the Corps that they cannot formally reoperate Alamo Dam until the State of Arizona agrees to change the allocation of the Water Conservation Pool to threatened and endangered species, fish and wildlife, downstream riparian habitat, and recreation purposes. The Corps anticipates five sequential administrative steps for reallocation: 1) preparation of an Initial Appraisal Report, 2) preparation of a Reconnaissance Study Report, 3) preparation of a Feasibility Report, 4) approval of Feasibility Report by Corps Office of Chief of Engineers and Secretary of Army, and 5) Congressional reallocation approval. Following Congressional reallocation of Alamo storage, the final step for formal reoperation is to revise the Water Control Manual for Alamo Dam. It is estimated that these steps may take from 3-5 years. These steps may be reduced or expedited by specific Congressional actions in the future. During the interim period, the Technical Committee recommends the Corps exercise operational flexibility, as legally allowed, under the current Manual to operate Alamo Dam in a manner approximating the proposed 1125 foot target plan.

While this 1125 foot target elevation proposal will best optimize the various resource objectives evaluated, it is important to recognize that reoperation of Alamo Dam itself may not be sufficient to fully achieve all resource potentials. Management and monitoring of environmental and recreational resources by agencies will continue to be a critical component in the overall optimization of resources associated with Alamo Lake and the Bill Williams River.

Technical Committee Recommendations

- Approve the proposed 1125 foot plan as the water management alternative which best meets optimal resource objectives within operational constraints and objectives of Alamo Dam.

- Following Steering Committee approval of a final water management plan proposal, a public involvement process should begin with the following elements: 1) briefings with state, regional, and local political entities and downstream landowners, 2) press release, and 3) if necessary, informational open house public meetings.

- The Steering Committee should aggressively pursue implementation of the proposed water management plan. This may include, but not be limited to, coordination with the Corps in development of a Feasibility Report and a revised Water Control Manual, and pursuit of congressional sponsorship of legislation that would expedite the reallocation and reoperation of Alamo Lake.

- Agencies should continue the cooperative, interagency framework of the Technical Committee to actively pursue resolution of the numerous remaining issues.

- A single (or joint) entity should obtain water rights that secure the recommended lake storage and base flows under this proposed plan.

- Agencies should continue to emphasize management and monitoring activities that enhance resource benefits associated with Alamo Lake and the Bill Williams River.

- While reallocation and reoperation procedures are being implemented, the Corps should exercise operational flexibility, as legally allowed, to operate Alamo Dam in a manner approximating the proposed 1125 foot target plan. The Technical Committee could be used as a forum for collaborative input to the Corps on "interim" lake level management and Alamo Dam release prescriptions.

I. INTRODUCTION

A. PURPOSE AND NEED

In the mid to late 1980's, the Arizona Game and Fish Department (AGFD), Arizona State Parks (ASP), Bureau of Land Management (BLM), and U.S. Fish and Wildlife Service (USFWS) were working independently on a range of efforts to change Alamo Dam operations and/or secure water rights to achieve their resource agency goals. Many of these goals revolved around the availability and management of water in Alamo Reservoir and along the Bill Williams River downstream (Figure 1). Although agency perspectives regarding management of the Bill Williams River and Alamo Dam and Reservoir were perceived as conflicting, most agencies had similar or overlapping resource management objectives for Alamo Lake and the Bill Williams River. [NOTE: Alamo Lake and Alamo Reservoir are used interchangeably in this report.] It became evident that by working together cooperatively, agencies could best achieve meaningful and lasting improvements to Alamo Dam operations that would serve multiple resource purposes.

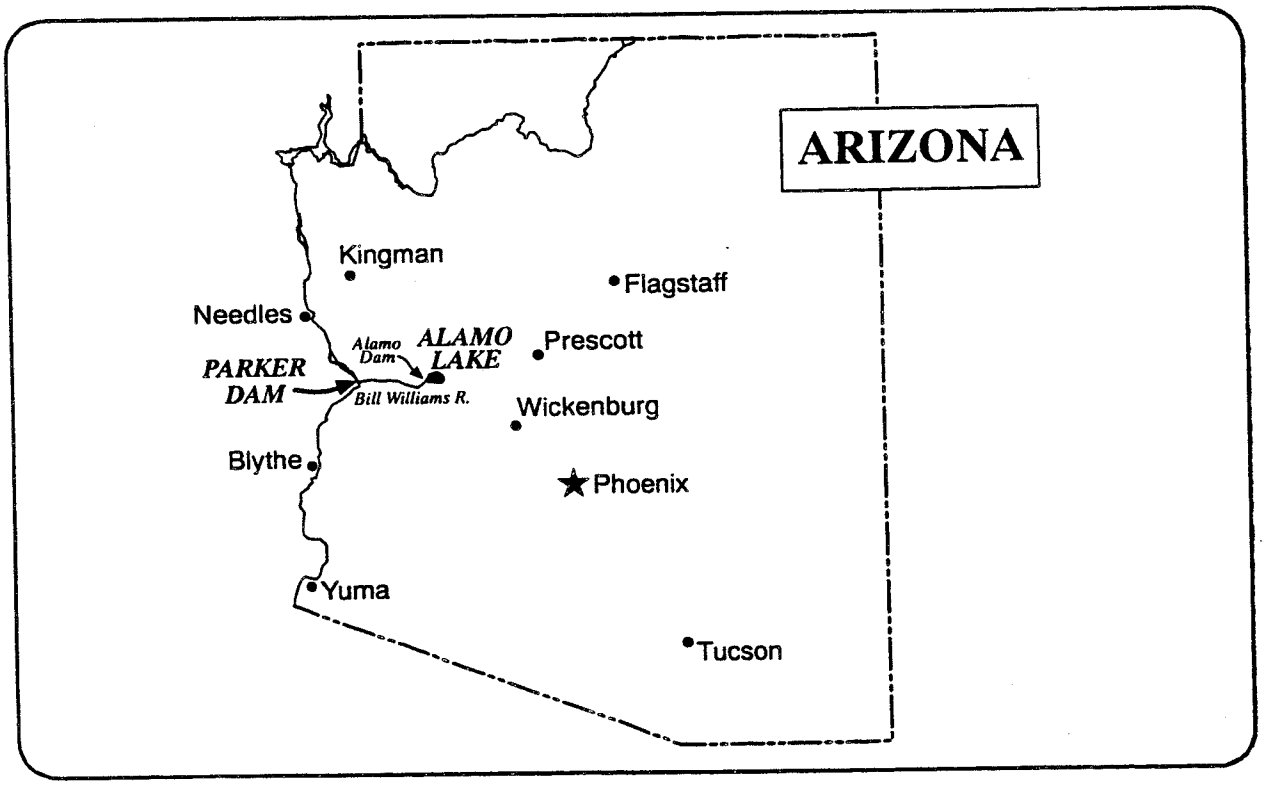


Figure 1. Bill Williams River corridor site location map.

Agency and public concerns have been expressed that lake elevation targets were impacting recreational use, and downstream releases resulting from the operations of Alamo Dam were degrading the aquatic ecosystem of the Bill Williams River. There was disagreement among

agencies over how the Army Corps of Engineers (Corps) was managing the water conservation pool at Alamo Lake, since conditions had changed from the dam's completion in 1968. Key concerns revolved around two nesting pairs of bald eagles at Alamo Lake, drawdown of lake levels for maintenance and inspection of the dam outlet works, increased demand for water-based recreation (especially fishing), water rights in the lake and downstream, and significant losses of riparian vegetation along the Bill Williams River. Riparian losses were attributed to a combination of low flow regimes affecting recruitment and extended inundation during flood flow releases resulting in mortality to mature trees.

In 1990, the Corps completed a Section 216 Reconnaissance Study for Alamo Lake that reevaluated reservoir operations for the purposes of water supply diversion to the Central Arizona Project, and water conservation, recreation, and environmental enhancement. The Arizona Department of Water Resources (ADWR) was the local sponsor for the study. Conclusions of this study were that the Corps could exercise existing authority to reallocate storage and reregulate the reservoir for the aforementioned purposes. The Corps recommended that all issues, problems, and opportunities identified in the Reconnaissance Study be evaluated in a Federally-funded Water Control Study--the goal of which is to establish the optimum storage allocation and operation schedule for all Alamo Lake project purposes. Shortly thereafter, ADWR issued a letter that provisionally agreed to the findings of the Reconnaissance Study. As the State's water management agency, ADWR requested that a coordinated effort be initiated among the affected agencies to resolve conflicts and seek common ground in the management and operation of water resources along the Bill Williams River.

In the spring of 1990, AGFD initiated dialogue among ASP, BLM, and USFWS regarding development of a coordinated, interagency planning effort focused on the management of water resources in Alamo Lake and the Bill Williams River. The agencies recognized that by working cooperatively, merging common interests, and negotiating conflicts, a comprehensive water management agreement could be achieved that would best optimize all agency management goals. In August 1990 a coordination meeting of upper level management from these four agencies and the Corps was held to establish an interagency planning team with instructions to develop a comprehensive water resource management plan for the Bill Williams River corridor. The area of concern was identified as the Bill Williams River at the Santa Maria and Big Sandy confluence, continuing downstream to include Alamo Lake, the Bill Williams River below Alamo, and the Bill Williams River National Wildlife Refuge (Refuge)(Figure 2). It was recognized that water resource management is the inextricable link that serves to protect the important and significant water-dependent uses and values within the Bill Williams River corridor. Water availability, either in the form of lake storage or stream flow, is the driving force behind all agency goals. Two interagency committees were established (Steering and Technical) to develop a corridor modeling approach for the Bill Williams River and Alamo Lake.

The agencies recognized that resolution of water level management issues at Alamo Lake, in conjunction with resource management issues involving the aquatic ecosystem of the Bill Williams River, would not be a simple process. Hydrological, biological, and recreational components of the Bill Williams River corridor must be thoroughly analyzed, and optimum resource management criteria developed. These components must be accommodated within the framework of a water

management plan that balances water level operations at Alamo Lake with downstream surface and groundwater needs in the Bill Williams River.

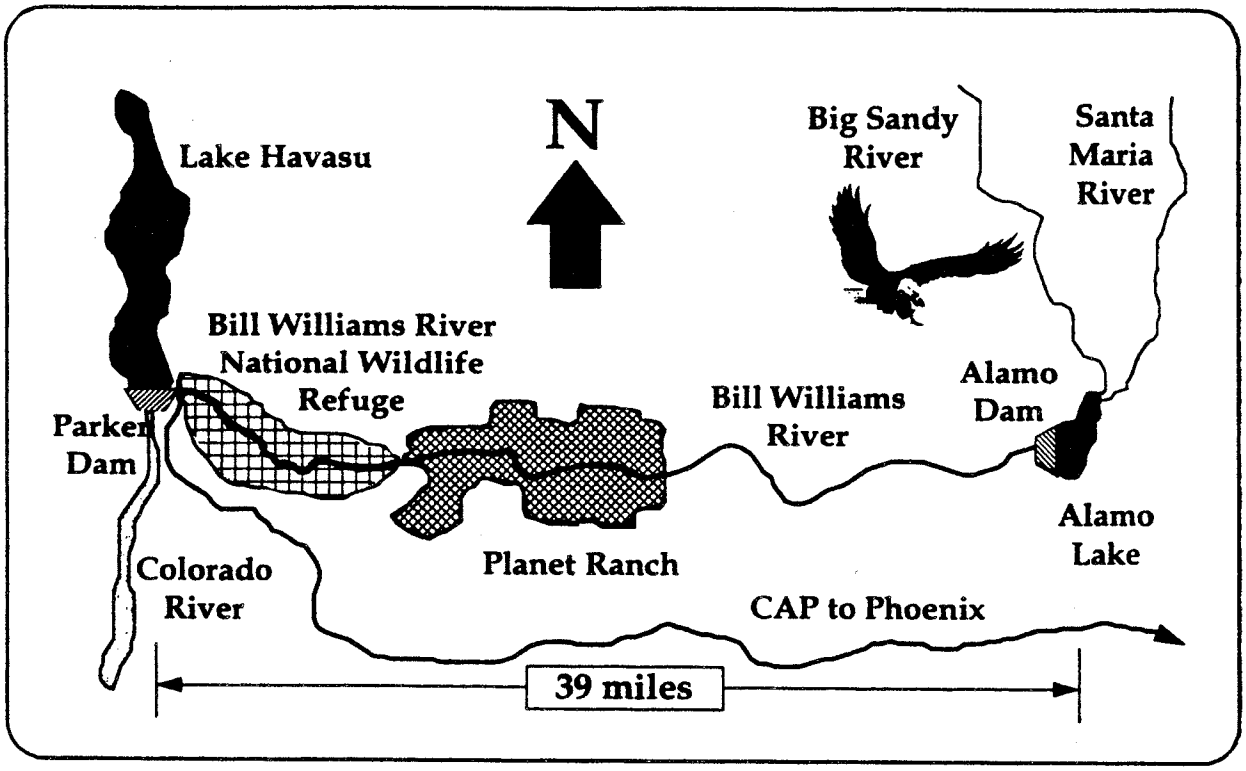


Figure 2. Bill Williams River corridor features site location map.

B. TECHNICAL COMMITTEE

The interagency planning team conceived by the five agencies became the Bill Williams River Corridor Technical Committee (Technical Committee). The Technical Committee was tasked with addressing a range of resource, recreation, and management issues, concerns, and opportunities related to Alamo Lake and the Bill Williams River. Figure 3 shows the primary resource categories of concern and how they are all tied to the operation of Alamo Dam. Alamo Dam operations, which affect threatened and endangered species, warmwater sportfisheries, water-based recreation, riparian habitat, and wildlife, is the one factor over which public agencies already have institutional control.

The goal of the Technical Committee is to carry out a coordinated interagency planning effort to develop an effective water management plan for Bill Williams River corridor resources.

The scope of the Technical Committee efforts were intentionally centered on water-dependent resources at Alamo Lake and the Bill Williams River corridor (flood plain). The Technical Committee did not address land management issues such as grazing or special protection designations (e.g. Wilderness Areas, Wild and Scenic Rivers), land acquisitions such as Planet Ranch, nor did it extend to the Big Sandy, Santa Maria, or adjacent watersheds.

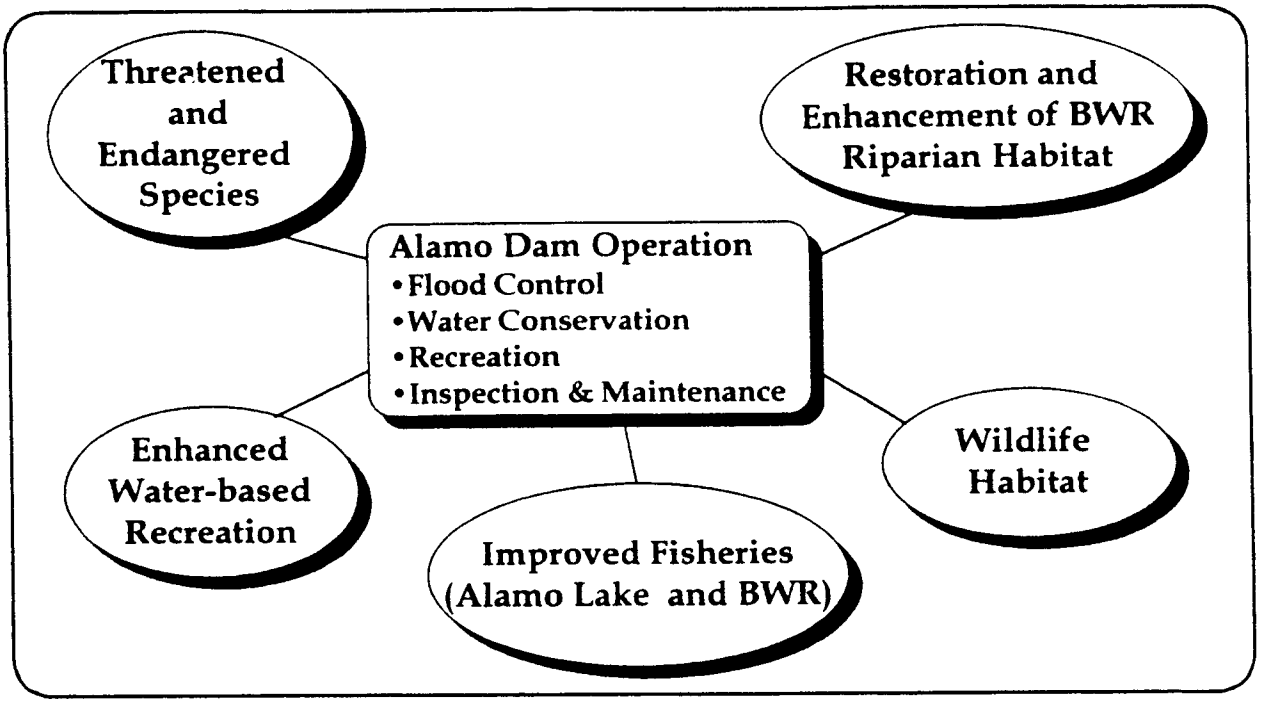


Figure 3. Resource issues, concerns, and opportunities related to Alamo Dam operations.

The Technical Committee was guided by a Steering Committee-approved 13 step process. All agencies expressed commitment to this decision-making process, which then served to focus and direct the efforts of the Technical Committee. Key steps in the process as followed by the Technical Committee are identified in Table 1. Finally, implementation steps to facilitate establishment of revised operation criteria for Alamo Dam are discussed in Chapter VI.

Table 1. Summarization of Bill Williams River Corridor Technical Committee Process.

- Each agency recognizes the importance of other agency objectives and commits to seek out potential management alternatives that would enhance the achievement of other agency objectives.
- Assemble a committee of representatives from each agency.
- Identify each agency's resource goals and objectives.
- Formulate independent water management prescriptions that optimize values and benefits for riparian, fisheries, wildlife, and recreation resources, while meeting reservoir operation requirements.
- Develop alternative reservoir operation plans that best meet collective resource goals.
- Analyze/evaluate alternative reservoir operation plans.
- Select the reservoir operation plan that best meets all agency resource objectives.
- Submit the recommended operation plan.

After a year of meetings, the Technical Committee was expanded to include the Bureau of Reclamation (USBR) and ADWR (Table 2). Appendix A lists agency personnel serving as Technical Committee members and those that participated in meetings.

Table 2. Agencies participating on the Bill Williams River Corridor Technical Committee.

- ARIZONA GAME AND FISH DEPARTMENT
- ARIZONA STATE PARKS DEPARTMENT
- ARIZONA DEPARTMENT OF WATER RESOURCES*
- U.S. BUREAU OF LAND MANAGEMENT
- U.S. BUREAU OF RECLAMATION
- U.S. ARMY CORPS OF ENGINEERS
- U.S. FISH AND WILDLIFE SERVICE

* ADWR participation is in an advisory role rather than as an advocate.

The ADWR, due to their responsibilities in State water rights and management, provided the following description of their role on the Technical Committee:

> "Participation by the Arizona Department of Water Resources (Department) in the Bill Williams River Interagency Planning Committee constitutes confirmation that it is the policy of the Department to assist in coordinating the planning activities of all governmental agencies related to the Bill Williams River to the extent the Department may do so in accordance with its responsibilities and authority under the law. It is not intended that the Department's participation on the committee shall be determinative of any decision to be made by the Department in any adjudicatory or rule-making proceeding. The Department's role, therefore, is primarily advisory to the Technical Committee."

C. STUDY AREA LOCATION

Alamo Lake is located on the Bill Williams River, 39 miles upstream from its confluence with the Colorado River in Lake Havasu (Figure 2). The lake is on the border of La Paz and Mohave Counties, Arizona. Paved access is from the town of Wenden, on U.S. Highway 60, approximately 36 miles south of the lake.

The Alamo Lake recreation area includes 22,856 acres of Corps-withdrawn lands of which approximately 16,400 acres represent the lake area for a probable maximum flood event. Fish and wildlife management responsibilities for the entire area have been turned over to the AGFD under a license agreement. Of the total 22,856 acres, 17,963 acres are specifically managed as the Alamo Wildlife Area by the AGFD, while recreation management of the remaining 4,893 acres is the responsibility of ASP under a separate lease agreement with the Corps.

Alamo Lake supports a productive warmwater fishery characterized by the popular largemouth bass. A quality fishery, coupled with other water-based recreational opportunities, supports substantial recreation use at the lake. Recreation facilities provided at Alamo Lake are operated by ASP and include an administration and service building, including offices for ASP and Corps staff. Other facilities include a 160-acre use area, trailer campsites with hookups, campsites, picnic areas with ramadas, swimming area, three boat launching facilities, and associated parking areas.

Alamo Lake is fed by two main tributaries, the Big Sandy and Santa Maria Rivers. These rivers merge to form the Bill Williams River, approximately 8 miles upstream of Alamo Dam. The Bill Williams River continues below Alamo Dam and flows westerly into the Colorado River immediately above Parker Dam.

The Bill Williams River riparian corridor contains the last extensive native woodland riparian habitat along the lower Colorado River. Riparian vegetation and the open surface waters of the Bill Williams River are the principle components of this unique desert habitat, supporting an abundance and diversity of wildlife, including fish. Flows in the river have been regulated by Alamo Dam since its completion in 1968. River flows in the lower 15 miles are also affected by water uses at Planet Ranch.

There are two BLM Wilderness Areas along the Bill Williams River, the Rawhide (2,700 acres) immediately below Alamo Dam and the Swansea (1,900 acres) immediately above Planet Ranch. The majority of landownership along the Bill Williams River is federal (BLM and USFWS), however a small number of private parcels occur along the 39 mile reach. The most notable private landowner is the City of Scottsdale, who purchased the 8,389 acre Planet Ranch in 1984 for its water rights. The Bill Williams River National Wildlife Refuge (Refuge) was established in 1941 and covers 6,105 acres along the lower 9 miles of the river. The Refuge was established following Parker Dam construction as mitigation for loss of riparian habitat along the mainstem lower Colorado River, and as a breeding ground and refuge for migratory birds and other resident wildlife.

D. ALAMO DAM AND RESERVOIR

1. PROJECT HISTORY

Alamo Dam was constructed as a multipurpose project under authorization of the Flood Control Act of December 22, 1944 (Public Law 534, 78th Congress, 2nd Session). The initial planning for Alamo Dam is contained in a January 15, 1941, report by the District Engineer, Los Angeles District. The report recommended a flood control dam be constructed at the Alamo site on the Bill Williams River. The report also recommended that the features of the dam and reservoir have the capability to meet water conservation and power developments, as well as changes in flood control requirements.

After formal authorization, the Corps conducted various hydrologic, topographic, and geologic studies from 1946 through 1963. The Corps entered into an agreement with the USBR for the

latter to assess water conservation and hydropower potential of the project. In a November 1961 report, the USBR (acting under agreement with the Corps) concluded that there was water conservation potential, but no feasible hydropower potential.

The original design concept was a concrete arch dam with an overflow spillway located in the center of the structure. However, following a restudy in the early 1960's, the final design consisted of an earthfill dam with a detached spillway in the right abutment. (Reference Design Memorandum No. 3, dated April 1964.) Construction of the dam and appurtenant works was started in March 1965 and completed in July 1968. Alamo Lake operations are directed according to a revised 1973 Reservoir Regulation (Water Control) Manual.

2. PROJECT PURPOSES

The various authorized purposes for which the project is operated (flood control, water conservation and supply, and recreation) are described below. Figure 4 shows current reservoir storage allocations for these purposes, along with release criteria.

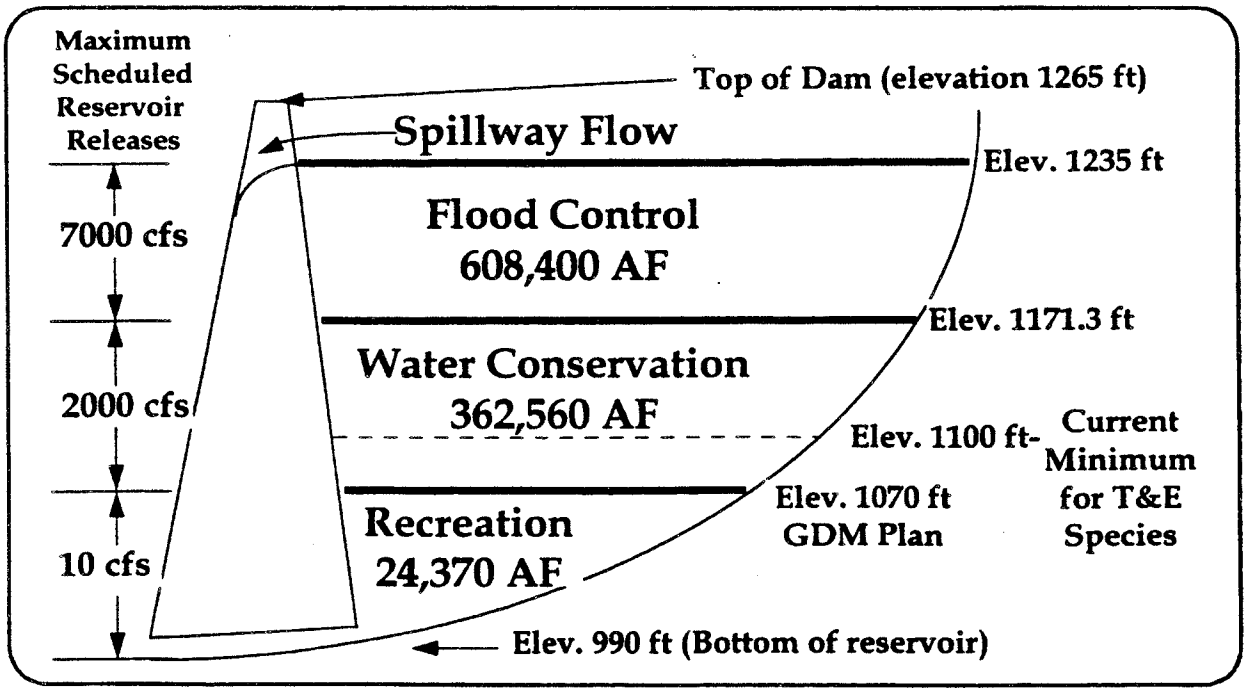


Figure 4. Alamo Dam storage allocations and current operation.

a. Flood Control

The dam was authorized to provide flood control for lower Colorado River communities downstream from Parker Dam (Lake Havasu), and to provide flood protection along the Bill Williams River corridor. At the time of the project's proposal, the Bill Williams River was the last major unregulated tributary to the lower Colorado below Hoover Dam. Alamo Dam was deemed necessary because the dams on the lower Colorado River, below

the Bill Williams River confluence, were not authorized for flood control. Alamo Dam flood control operation is accomplished by reducing flood flows on the Bill Williams River to a maximum reservoir release of 7,000 cubic feet per second (cfs), or less. Selection of 7,000 cfs is based on two factors: 1) the capacity of the Bill Williams River channel to carry this discharge without significant damage, and 2) the non-damaging Colorado River channel capacity below Parker Dam was about 25,000 cfs. In conjunction with the USBR dams on the Colorado River, Alamo Dam is operated to reduce lower Colorado River flood flows to non-damaging levels.

b. Water Conservation and Supply

To date, the Corps has not contracted with a water supply user for supply and conservation storage. In the past, the Corps has requested the State to act as a cooperator in the project, however, the State has been unable and unwilling to assume the financial responsibilities associated with such an arrangement. The conservation pool has been used for only short-term storage of water, which has been released to Lake Havasu. Potential local users of the water conservation pool have recently applied to the ADWR for rights to the unallocated water (see Chapter VI, Remaining Issues). Reservoir releases to satisfy water rights of downstream users presently consist of matching inflow up to a maximum of 10 cfs. These base flow releases (averaging 7,240 acre feet per annum) are necessary to provide sufficient flow in the downstream river system to meet water right withdrawals.

Prior to reaching Lake Havasu, the entire Bill Williams River water supply is considered solely as Arizona's entitlement. Once Bill Williams River flows reach the Colorado River, they are allocated in a manner consistent with the "Law of the River" including the U.S. Supreme Court Decree in Arizona v. California of March 1964. The decree provided that the first 7.5 million acre-feet available in the Colorado River main stem each year for consumptive use by Arizona, California and Nevada be apportioned as follows: 2.8 million acre-feet for Arizona; 4.4 million acre-feet for California; 300,000 acre-feet for Nevada. If more than 7.5 million acre-feet were available in a given year, California and Arizona are each apportioned 50 percent of the surplus, and the United States has the right to contract with Nevada for up to 4 percent of the surplus. This 4 percent is to come out of Arizona's surplus share.

c. Recreation

For Alamo Lake, a recreation pool was established immediately below the water conservation pool. The recreation pool is maintained, inasmuch as possible, by limiting releases to 10 cfs whenever the reservoir water surface elevation is within the pool. The AGFD currently holds water rights in the recreation pool for 25,000 acre-feet which, when using the Corps 1993 revised area-capacity tables, provides approximately 1,172 surface acres at a lake elevation of 1070.5 feet. These non-consumptive rights are for fish, wildlife, and recreational purposes and comprise a minimum recreational pool within the reservoir. Recreational facilities at Alamo Lake consist of boat launching ramps, campgrounds, and appurtenant structures. All facilities are operated and maintained by

ASP. Alamo Lake is one of the few water bodies in western-central Arizona, and as such is highly important for water-based recreation.

3. CURRENT ISSUES AND CONCERNS

Since 1978, the entire Colorado River basin has experienced several years of above-normal runoff. For the years 1983 through 1986, the natural flow at Lee's Ferry averaged over 22 million acre-feet per year, or about 150% of the 1906-1990 average. Runoff on the Bill Williams River system in 1980 totalled 503,800 acre-feet or 477 percent of the normal annual volume for the same period of record. To alleviate future flooding concerns on the lower Colorado River, a multi-agency meeting was convened in March 1980 to discuss what appropriate measures should be taken with respect to the Bill Williams River. A decision was made whereby the Corps would gradually lower the elevation in Alamo Reservoir to 1110 feet, and maintain that elevation as long as conditions warranted. The 1110 foot elevation was chosen because, at the time, it was determined to be an optimal value for flood control, water supply, and recreational interests. Because above-normal runoff in the Colorado river system continued into the mid-1980's, the reservoir water surface elevation was maintained at or near 1110 feet longer than originally anticipated. While making the Alamo Lake area an even more popular and valuable recreation resource, the higher lake elevations created a number of public and agency expectations which gave rise to issues and concerns surrounding the operation of Alamo Dam. These issues are summarized in the following paragraphs.

a. Lake Recreation

Arizona State Parks replaced boat launch ramps and other recreational facilities inundated by the higher lake elevation. Boat launch ramps and other recreation facilities constructed by ASP were designed for usage at water surface elevations above 1100 feet. The new facilities, coupled with the higher lake elevation, increased annual recreational usage because of greater lake surface area. Arizona State Parks has planned further expansion of the recreational facilities around the lake on the assumption that a minimum 1105-1110 foot lake elevation will be maintained.

b. Lake Fishery

The AGFD has established a successful and highly popular largemouth bass fishery at Alamo Lake. Largemouth bass spawning success can be negatively impacted by fluctuating lake levels during the spawning season. Recruitment of warmwater fish corresponds to available habitat and prey abundance which are affected by water surface elevation changes and lake inflows. In response to increased angling pressure and the associated impacts on fish populations, the AGFD enacted special "slot length" regulations on largemouth bass in 1989 to preserve and manage the quality bass fishery.

c. Bald Eagles

In the early 1980's a pair of Southern Bald Eagles, a Federally listed endangered species, was discovered nesting in a partially inundated tree within the upper reaches of Alamo

Lake. Subsequently, another pair was discovered nesting on a bluff in the canyon wall downstream from the dam. The use of the lake by the eagles for foraging prompted the USFWS to request that the lake elevation remain within the range of 1100-1135 feet for the preservation of the eagles. In a March 25, 1988, letter to the Corps, the USFWS requested that Alamo Lake not be drawn down below elevation 1100 feet. This request was made to ensure sufficient lake surface foraging area for the eagles living in the two nests. The request was in accordance with the National Environmental Policy Act (P.L. 91-190, 91st Congress, 1st Session) and the Endangered Species Act (P.L. 93-205, 93rd Congress, 1st Session). The 1135 foot maximum lake elevation was requested to prevent inundation of the reservoir nest. Lake operations since 1988 have attempted to comply with an 1100 foot minimum lake elevation--this essentially represents current conditions.

d. Riparian Habitat

Historic accounts of Bill Williams River flows estimate that the maximum peak flood flow past Planet Ranch was in excess of 200,000 cfs and occurred in 1891. Other pre-Alamo Dam flood events with peak flows past Planet Ranch of 100,000 cfs or more occurred in 1884, 1905, 1906, 1906, 1910, 1916, and 1927. Since construction of Alamo Dam in 1968, the highest peak flow (i.e., inflow to Alamo Reservoir) was 104,667 cfs in February 1993. Other peak flows in excess of 60,000 cfs occurred in 1978 (twice), 1980, 1983, and 1991. In the absence of Alamo Dam, these peak flows would have resulted in peaks of similar magnitude at Planet Ranch. However, since the completion of Alamo Dam, Bill Williams River flows past Planet Ranch have been limited to a maximum 7,000 cfs.

Unregulated flooding events have a beneficial flushing effect on the downstream riparian community and also tend to provide massive, almost instantaneous recharge to the alluvial aquifer system. A significant portion of the cottonwood tree stands along the Bill Williams River have been destroyed as a result of the pattern of past Alamo Dam releases. By 1978, 10 years after Alamo Dam completion, Ohmart (1978) estimated that riparian areas had decreased in extent by 70% over historic levels. The construction of Alamo Dam has resulted in greatly altered flow magnitude, duration, frequency, and timing in the Bill Williams River. Riparian communities are adversely affected by the lack of base flows, sustained inundation of their root zones during high flow events, lack of sediment, and general alteration of a natural flow regime.

Because riparian vegetation has diminished since the completion of Alamo Dam, various resource agencies have sought to modify release patterns from Alamo Dam to help restore the riparian area. Recommended releases have included requests that call for higher peaks (up to the 7,000 cfs authorized maximum), mimic natural pre-dam spring and summer (monsoon) flood events, avoid inundation mortality of mature trees, and provide adequate base flows that sustain downstream riparian habitat all the way to Lake Havasu.

e. Outlet Tunnel Inspection and Maintenance

Corps regulations prescribe that every five years a complete inspection and engineering evaluation of the condition of the dam be performed. Inspections in 1986 indicated that

the emergency and service gates were leaking and in need of repair. To inspect and/or maintain the gates, the outlet tunnel must be dewatered requiring lowering of Alamo Lake water levels. An Environmental Assessment, Alamo Lake Gate Rehabilitation Project, was prepared in September 1989 that determined that reservoir drawdown impacts associated with dewatering the outlet tunnel were insignificant. Reservoir drawdowns for the purposes of outlet tunnel inspections have never occurred at Alamo Lake due to: 1) already low lake levels, 2) high lake levels that prevented installation of the bulkhead, and 3) rehabilitation of the bulkhead and gates in 1991.

The outlet tunnel dewatering process is accomplished by: 1) closing all service gates; 2) placing a bulkhead gate over the outlet tunnel intake structure; and 3) opening one of the service gates. When the bulkhead gate is in place the reservoir water surface elevation cannot exceed 1110 feet. If the elevation exceeds 1110 feet, the hydrostatic pressure exerted against the bulkhead gate could cause failure of the bulkhead gate and/or intake structure concrete. During an extended maintenance period, sufficient reservoir storage space below elevation 1110 feet is necessary to prevent a flood from raising the pool above 1110 feet before the bulkhead can be removed (Appendix H). In recent years, a lake target elevation of 1100 feet has been identified to provide this safety "buffer". The scheduled period of reservoir drawdown for inspections is from June through November. In summary, approximately every five years an inspection of the outlet tunnel must be made that requires Alamo Lake elevations below 1110 feet--for high water years, this may require a reservoir drawdown.

f. Hydraulic Limitations of Dam Outlet Works

Operational criteria for the three pairs of outlet gates restrict the gate setting to 80 percent of the maximum 8.5 feet opening, or 6.8 feet. As a result of this restriction, the minimum elevation within the water conservation pool at which 7,000 cfs can be released (due to hydraulic head requirements) is 1148.4 feet. Minimum releases from the outlet gates are in the range of 150-180 cfs depending on lake elevation.

The outlet works also include a butterfly valve for discharging low flows from 1-105 cfs. The butterfly valve has a computed discharge capacity at maximum opening of 88-105 cfs, depending on reservoir pool elevation.

E. PREVIOUS STUDIES

A variety of studies, planning and operation documents, environmental assessments, and management plans and reports on the Bill Williams River and Alamo Lake have been prepared over the past 30 years. A listing of selected titles is included in the Bibliography (Chapter VII).

II. IDENTIFIED RESOURCE GOALS

As part of the original Technical Committee 13-Step Process, goal statements were requested from AGFD, ASP, BLM, USFWS, and the Corps. Input was also received from USBR and ADWR when they joined the Technical Committee. Table 3 is a consolidated list of resource goals identified by each agency during the process. Appendix C includes the specific goal statements identified by each agency. While the original verbiage in identified goal statements varied, many elements were common across agencies.

Table 3. Consolidated list of agency resource goals for the Bill Williams River corridor.

- Restore, maintain, and enhance Bill Williams River Corridor ecosystem with emphasis on riparian and wetland habitats.
- Enhance fish and wildlife habitat, including habitat for endangered and threatened species.
- Provide habitat for migratory birds.
- Preserve the wilderness character of designated wilderness areas.
- Provide for high quality wildlife-oriented recreational opportunities.
- Enhance recreational opportunities at Alamo Lake.
- Maintain and enhance the quality of recreational and warmwater fishery at Alamo Lake.

Goals identified by the Corps (Appendix C) include some unique to that agency which relate to administration of the dam project, but also indicate the commitment of the Corps to this coordinated, interagency process. These Corps goals include:

1. Develop a recommended reservoir water control plan which best meets the coordinated objectives of the Technical Committee, consistent with project authorized purposes, applicable post-construction authorities, and Corps water control guidance.
2. Seek Corps approval to implement the recommended plan.
3. Prepare an updated water control manual.

The matrix in Table 4 summarizes the commonality of elements in goal statements from the involved agencies. This commonality of broad spectrum interest in various resource groups assisted in blending resource prescriptions in the development of a water management plan.

Table 4. Matrix of agency resource or management concerns.

BWRCTC Member Agencies	Riparian Habitat	Wildlife Habitat	Endan-gered Species	Fishery	Recreat-ion	Water Conser-vation	Flood Control
AZ Game & Fish	X	X	X	X	X		
AZ State Parks				X	X		
AZ Dept Water Res *						X	X
Bureau of Land Mgmt	X	X	X	X	X		
Bureau Reclamation	X	X	X			X	X
Corps of Engineers	X	X	X	X	X	X	X
US Fish & Wildlife	X	X	X	X	X		

* ADWR participated in the Technical Committee in an advisory role rather than an advocacy role.

III. FORMULATION OF ALTERNATIVE RESERVOIR OPERATION PLANS

The resource goals identified by the Technical Committee were grouped into one of the following five categories: riparian, fisheries, wildlife (including threatened and endangered species), recreation, and reservoir operations. The next step in the process was to model water management prescriptions to achieve each goal independent of others. To develop each of these prescriptions required additional technical support. The Technical Committee decided on a formulation/evaluation process that could be best carried out by forming five Technical Subcommittees based on the following resource categories:

- RIPARIAN
- FISHERIES
- WILDLIFE
- RECREATION
- RESERVOIR OPERATIONS

The Technical Subcommittees developed water operation recommendations that optimized benefits to their respective resource goals. Final reports from the five subcommittees are found in Appendices D-H, Volume II. The Technical Subcommittees provided recommendations for optimum Alamo Lake elevation(s) and optimum downstream flow regime by month.

A. SYNOPSIS/HIGHLIGHTS OF SUBCOMMITTEE REPORTS

1. RIPARIAN (full report in Appendix D, Volume II)

The Bill Williams River riparian corridor contains the last extensive native riparian woodland habitat along the lower Colorado River. However, much of the native riparian community has been lost or severely degraded since construction of Alamo Dam in 1969. Dam operations have impacted the corridor with restricted flows (10 cfs) of sediment-poor water during much of the year, combined with occasional moderately high flows (2,000-3,000 cfs) for extended periods (>60 days) for flood control. This altered water regime has severely stressed existing native vegetation, prevented natural recruitment of cottonwoods, and allowed native vegetation to be extensively replaced by non-native salt cedar. A properly functioning riparian ecosystem could be restored by implementing a flow regime that mimics the pattern of historic (pre-dam) flows.

The Riparian Subcommittee focused on restoring riparian resources downstream from Alamo Dam and maintaining the cottonwood gallery forest at the upper end of Alamo Lake (Santa Maria River arm). The primary objectives for riparian resources in the Bill Williams River corridor are:

1. to maintain both area (acreage) and structural diversity of existing vegetation stands dominated by native riparian species, particularly cottonwood/willow stands; and
2. to expand coverage and diversity of native riparian stands through natural recruitment.

The following recommendations assume that cottonwood and willow are key indicator species for riparian systems, such that healthy cottonwood-willow stands indicate a properly functioning riparian system.

a. Alamo Lake

The Subcommittee recommended maintaining Alamo Lake levels within the water conservation pool (1100-1171.3 feet). To maintain the cottonwood stands at the upper end of Alamo Lake in the Santa Maria River arm, lake levels should not exceed 1200 feet. This upper limit would prevent salt cedar from encroaching on cottonwood stands at this site and from interfering with the natural recruitment of these cottonwoods. Alamo Lake should be operated at an elevation ≥ 1115 feet to retain sufficient water volume in the lake for future minimum base flows, as recommended below, for downstream riparian resources.

b. Bill Williams River

Priorities for using water to benefit riparian resources below Alamo Dam are:

1. Base flows, to stabilize and maintain existing riparian stands;
2. Spring flushing flows, to promote seed bed establishment, germination, and recruitment of key riparian species; and
3. Monsoon (Fall) flushing flows, to recharge the aquifer and promote additional riparian species.

The optimal water regime would combine sufficient base flows with large "pulse" flows resulting from natural spring (January-May) and monsoon (August-September) storm events. This optimal recommendation would: 1) provide sufficient base flows to maintain riparian resources on the river; and 2) periodically stimulate natural recruitment of cottonwood and willow trees. The combined system is designed to increase the structural diversity and acreage of native riparian vegetation within the Bill Williams River corridor.

Base Flows: The Subcommittee established a flow regime of minimum base flows to minimally support riparian resources on the river (Table 5). This regime included dam releases of 15 cfs in October, 10 cfs in winter (November-January), and 25 cfs during the hot season (February-September). Base flows below this rate, including current dam operations of 10 cfs year-round, are considered adverse in supporting riparian resources in the Bill Williams River corridor, and would continue to degrade the riparian resources. The Subcommittee recommends these minimum base flows only in severe drought situations when lake levels are in the recreation pool (< 1070 feet).

The recommended flow regime shown in Table 5 would provide acceptable base flows to stabilize the current riparian system in the Bill Williams River. Essentially, it would allow what is existing to survive, and would permit stable and predictable conditions for any (mechanical) revegetation projects. The Subcommittee recommends these flows as acceptable base flows for operating Alamo Dam. However, if used without the following flushing flows, this regime would not support natural recruitment of native vegetation.

Table 5. Riparian Subcommittee minimum and acceptable base flow seasonal recommendations for Alamo Dam releases.

	Base Flow (average cfs/day)	
Month	Minimum	Acceptable
January	10	25
February - April	25	40
May - September	25	50
October	15	40
November - December	10	25

Flushing (Pulse) Flows: These periodic "flood" events mimic the pattern of natural flows in the Bill Williams River before the dam. Spring floods would prepare seed beds to stimulate natural cottonwood and willow regeneration. Monsoon floods would scour the channel and recharge the Planet Ranch aquifer. This semiannual pattern also provides for other natural processes adapted to these flushing flow systems, some of which may be unknown. The Corps would determine when water is considered "surplus" in Alamo Lake and in need of releasing for a flush event. This determination would be based on inflow from storm events and subsequent increases in lake elevation above a target elevation.

Spring Flushing Flows (January-May): The Subcommittee recommended large-volume releases at least once in every 5-10 years to rehabilitate the downstream riparian resources. This interval corresponds to the timing of natural cottonwood regeneration in an undammed southwestern riparian corridor.

This recommendation advocates increasing to peak flows as quickly as possible (without undo hardship on downstream users), and then gradual and extended decrease in flows (approximately three weeks). This simulates, based on pre-dam data, the pattern of these spring events in a naturally functioning desert riparian system. Varying the intensity of the these flushes over the years would lead to recruitment zones at varying levels above the base water table (optimum = 1.5-3 feet). Drawing out the decrease in flows after a flood event prevents the water table from dropping too rapidly (≥1-1.5 inch/day), which would result in higher mortality of cottonwood seedlings. It is predicted that the recommended base flows would then support the riparian system at these various recruitment zones. Table 6 provides recommendations for the determination of peak flows during natural spring storm events.

Table 6. Recommendations for spring flushing flows from Alamo Dam.

Approx. Interval (years)[a]	Volume H_2O to Flush (1,000 AF)[b]	Peak Flow (cfs)	Peak Duration[c]	Recession[d]
±3	5-30	1,000-2,000	1-7 days	500->45 cfs over 6 days
±5	30-50	3,000-4,000	5-8 days	500->45 cfs over 20 days
±7	50-75	4,000-5,000	8-10 days	"
±10	75-100	6,000-7,000[e]	10-14 days	"
>10	>100	7,000[e]	14-30 days	"

[a] "Approximate Interval" reflects the approximate yearly interval we may be able to expect these levels of flows based on U.S. Geological Survey data from the Alamo Dam gauge during 1940-1969 (pre-dam).

[b] "Volume H_2O to Flush" denotes the amount of surplus water available in Alamo Lake that the U.S. Army Corps of Engineers needs to remove from the reservoir.

[c] "Peak Duration" includes time necessary to increase flows from base flows to peak flow and return to 500 cfs at approximately 1,000-2,000 cfs per day.

[d] "Recession" refers to the back side of the peak -- that is, drawing out the decrease in flows back to base flows rather than immediately returning flows to base flows.

[e] Or maximum outlet capacity for a given lake elevation.

Monsoon Flushing Flows (August-September): The Subcommittee recommends monsoon pulses only if sufficient water is stored in Alamo reservoir to maintain base flows until the following spring storms, and possibly through the following summer (in case spring flows are extremely low). Monsoon pulses are recommended approximately every 3-6 years, based on natural storm events, but at least every 6-7 years. Monsoon storms are generally flashier, of shorter duration, and lower water volumes than spring storms. Monsoon pulse releases should occur in $\leq$7 days, with peak flows $\geq$1,000 cfs. Exact peak flows and duration of flows would be determined by the Corps, depending on the volume of water to be released. Only a short recession, if any, would be necessary for these flows. These flows could be accommodated during years when drawdowns are required for outlet tunnel inspections.

Inundation Restrictions: Cottonwoods along the Bill Williams River are susceptible to mortality from extended inundation. To prevent stress or death of cottonwoods from extremely high flows, releases $\geq$1,000 cfs should not exceed 30-60 days during the dormant season for trees (November-February) and 14-30 days during the growing season (March-October). If water must be released for >30 days during the growing season or >60 days during the dormant season to remove surplus water, a "dry-out" period of $\leq$300 cfs for $\geq$30 days should be maintained. The high release/dry-out pattern could be repeated as much as necessary until all surplus water is released.

c. Alamo Dam Maintenance

The Subcommittee recommended the 5-year drawdown for inspection and maintenance of the Alamo Dam outlet works occur from April-September, with sustained flows not exceeding 300 cfs during this time frame. Drawdown releases could be used to maintain sufficient water for the riparian vegetation during the hottest time of the year. If additional water in lake storage above 1100 feet is predicted to be available above and beyond spring-summer base flow needs, it could be used as spring flushing flows from April-May or monsoon flushing flows from August-September. Since no releases can be made while the bulkhead is in place, it is recommended that the actual maintenance begin in early November, when temperatures have dropped sufficiently to initiate dormancy in trees and water requirements are lower. It is recognized that the Corps may need flexibility to evacuate additional reservoir storage in October as lake inflows occur that raise lake elevations above 1100 feet.

d. Monitoring

The Subcommittee expressed concerns that the final flow regimes agreed upon by the Technical Committee would be "set in stone" (i.e., become permanent and inflexible), regardless of the resulting impacts to the resources at Alamo Lake and the Bill Williams River. Establishment of a long-term, repeatable monitoring system to evaluate the success of the final flow regimes in meeting the resource objectives is recommended. Monitoring should be designed to determine if minimum needs of the resources are being met and if there is additional water in the system that can be used for enhancements.

Studies should monitor several variables of the riparian system, including channel morphology, groundwater depth and discharge rates, acreage and structural diversity of riparian vegetation, and plant condition and stress in low and high water situations. If evaluations show the water regimes are not meeting the resource needs, the regimes should be modified as necessary.

2. FISHERIES (full report in Appendix E, Volume II)

Of primary interest to the Fisheries Subcommittee was the development of a water management prescription for maximizing sport fishery resources at Alamo Lake and, once release patterns were established, a possible secondary fishery in the Bill Williams River below the dam could be maintained for warmwater fish or developed for native fish.

Alamo Lake contains a variety of warmwater sport fish including largemouth bass, bluegill, channel catfish, tilapia, and carp. The primary management species is largemouth bass, which has made Alamo Lake one of the premier warmwater fishing lakes in Arizona. Fish communities in the Bill Williams River below Alamo Dam include non-native fish such as channel catfish, carp, green sunfish, and red shiner. Historic records of native fish populations in the Bill Williams River are scarce and are limited to longfin dace, roundtail chub, Sonoran sucker, and desert sucker. Recent fisheries surveys in the river have been unsuccessful in finding any native fish. Fisheries management of the Bill Williams River will emphasize maintenance of the existing warmwater fishery or establishing a native fish fishery (see comments at end of Wildlife Subcommittee report).

There were two periods of concern for the management of the lake sport fishery, the spawning season (March 15-May 31) and the growing season (May 16-September 30). Lake elevations and water level fluctuations have significant impacts on fish communities during both seasons. Lake elevations affect the availability of suitable, shallow water habitat for spawning. Rapidly rising or decreasing lake levels will adversely affect fish spawning success and recruitment, particularly for largemouth bass. In developing recommendations, the Subcommittee also considered that water management opportunities at Alamo were related to annual climatic trends (i.e., wet, normal, or drought years).

Subcommittee recommendations for lake level operations during the various water years are shown in Table 7. Assumptions and recommendations made by the Subcommittee include:

1. Fish productivity will decline if lake elevations either remain constant year-round or fluctuate frequently during spawning or growing seasons;
2. Lake level fluctuations during the spawning season should not exceed 2 inches per day (up or down);
3. Fluctuations over the growing season should not drop more than 13 feet (increases are desirable);
4. Fluctuation criteria for spawning and growing seasons should be met each year, but once every other year is acceptable;
5. If lake elevations drop to 1100 feet, releases from the dam should only be made for legally mandated water rights; and

6. If releases must be made during the spawning or growing season, they should be made as fast as possible to reduce the time that extreme fluctuations occur.

Table 7. Summary of Alamo Lake fish spawning and growing season criteria.

SPAWNING SEASON

	WET WATER YEARS	NORMAL WATER YEARS	DROUGHT WATER YEARS
Lake Elevations:	Low Zone : 1110 - 1125 ft. msl High Zone: Above 1125 ft. msl Preferred High Zone: 1190 - 1210 ft. msl	Low Zone : 1110 - 1125 ft. msl every year for best results; once every other year would be acceptable	Low Zone : 1110 - 1125 ft. msl at least once every 3 years
Season Dates:	March 15 - May 31	April 1 - May 15	April 1 - May 15
Lake Fluctuations:	Maximum of 2 inches per day (Zero fluctuation is the best)	Maximum of 2 inches per day (Zero fluctuation is the best)	Maximum of 2 inches per day (Zero fluctuation is the best)

GROWING SEASON

	WET WATER YEARS	NORMAL WATER YEARS	DROUGHT WATER YEARS
Lake Elevations:	Low Zone : 1110 - 1125 ft. msl High Zone: Above 1125 ft. msl Preferred High Zone: 1190 - 1210 ft. msl	Low Zone : 1110 - 1125 ft. msl	No Requirement
Season Dates:	June 1 - Sept. 30	May 16 - Sept. 30	No Requirement
Lake Fluctuations:	Maximum Weekly fluctuation of 9.5 in.	Maximum Weekly fluctuation of 9.5 in.	No Requirement

Lake elevation zones (low, high and preferred) were selected from the elevations where changes in lake levels would result in minimum change in surface acres of the lake that are less than 20 feet deep (optimal zone for fish reproduction and recruitment). Acreage of shallow water habitats for fish spawning and growth are maximized in the identified "preferred high zone" (1190-1210 feet). However, this zone occurs in the Alamo flood control pool and maintenance of water levels at these elevations would be in direct conflict with flood control operation requirements.

Releases below the dam should be stabilized as much as possible to benefit the existing warmwater sport fishery. However, if management directions change, as expected, towards a native fish emphasis, then releases from the dam should be patterned after natural events as closely as possible.

Lake level operational patterns recommended by the Subcommittee would promote a stable largemouth bass and catfish fisheries in the lake and result in stabilization of all other species of fish, including the forage base for bald eagles. Consistent and predictable water elevation management would also benefit the recreational component in terms of public use and facility operations and development.

3. WILDLIFE (full report in Appendix F, Volume II)

The Wildlife Subcommittee determined that all threatened and endangered species, neotropical migratory birds, other sensitive species, waterfowl, and other wildlife would best benefit from the creation and maintenance of a healthy, diverse riparian ecosystem along the Bill Williams River corridor below Alamo Dam. The Subcommittee determined that only under extreme, prolonged drought conditions would water management needs of species at Alamo Lake conflict with maintenance of a healthy riparian ecosystem downstream. The Subcommittee believes the recommendations of the Riparian Subcommittee will benefit all species within its assigned scope of concern. The Subcommittee therefore endorses the Riparian Subcommittee's flow recommendations for riparian resources. The Subcommittee determined that optimum benefits for all wildlife will be achieved if management emphasizes the habitat that makes the area special: southwestern lowland riparian habitat.

A primary concern in the past has been management of the lake level with regard to the bald eagle. The Subcommittee recommends that the minimum lake level remain at 1100 feet. This minimum level is required to maintain adequate foraging habitat for the eagles and is not to be interpreted as a target lake level. Adequate foraging can be maintained at higher lake levels, up to the point of inundation of any eagle nests which may be present (historically at approximately 1124-1138 feet). If inundation of nests occurs, the Corps should exercise their options under Sections 7 and 10 of the Endangered Species Act. The eagles are currently nesting well above any threats of inundation and there are cottonwood and willow trees available on the Big Sandy and Santa Maria Rivers above the lake for future nest sites. These areas may be superior nest sites as they are removed from human activity and the snags on the lake may fall in the near future. High water at Alamo Lake is no longer a serious concern for bald eagles, unless a future nest site is in danger of inundation. The primary concern is providing adequate foraging habitat which can be accomplished by maintaining lake levels at or above 1100 feet.

The Subcommittee recommends that following high runoff events, the water in Alamo Lake be released to create high flushing flows of short duration, mimicking the natural flood events of pre-dam conditions. High flushing flows of short duration will benefit the riparian habitat, result in recruitment of young cottonwood and willows, and will more than compensate for any immediate damage. In addition, releases from Alamo Dam should be sufficient to maintain a minimum base flow of 25-50 cfs in the lower reaches of the Refuge. This is not to be interpreted as a target flow rate, but a minimum amount to maintain the riparian habitat throughout the year. Additionally,

availability of surface flows in the Bill Williams River may provide important recovery opportunities for native fish including threatened and endangered species.

4. RECREATION (full report in Appendix G, Volume II)

The goal of the Recreation and Access Subcommittee was to identify desirable and undesirable lake elevations along with river flow requirements to optimize recreational opportunities at Alamo Lake and in the Bill Williams River corridor.

Recreational use at Alamo Lake State Park is moderate to high, depending on season, and averages approximately 39,000 visitors per year. Over 85% of the visitors come to fish, usually for largemouth bass. While some shore fishing occurs, a majority of fishing effort is done by boat. Most other activities such as camping and picnicking are done in conjunction with fishing. Consequently, recreation at Alamo Lake is highly dependent upon visitors being able to launch their watercraft in a safe and convenient manner. Alamo Lake levels need to be maintained in a manner that supports a quality fishery, allows for use of boat launching facilities, and stays below levels that would inundate campgrounds and developed ASP facilities.

Other lake-oriented recreational activities include hunting, hiking, horseback riding, photography, bird watching, and nature study. Some water skiing and personal watercraft (i.e., jet ski) activity also occurs, but on a very limited scope. The future recreational activity patterns are not likely to change drastically. Fishing will continue to be the primary activity, however, the proportion of visitors seeking other forms of recreation is expected to increase.

Opportunities exist along the river corridor for a variety of recreational activities including hunting, bird watching, backpacking, off-road vehicle use, fishing, and even rafting, kayaking and canoeing during releases of 300 to 2,000 cfs. Recreational use along the Bill Williams River is very light and is limited due to few public access routes. Most recreation activities are located immediately below Alamo Dam or in the lower few miles of the Refuge. The two BLM Wilderness areas below Alamo Dam receive light use. It should be noted that non-consumptive as well as consumptive recreation uses exist along the Bill Williams River because of water availability.

The Subcommittee recommends maintaining lake elevations in a 1115-1125 foot range (Table 8). This operational range provides the best functional use of the existing Main and Cholla boat ramps and also maximizes access and recreational opportunities at other locations around the lake. Lake elevations in the 1144-1154 foot range are undesirable due to gradient and access constraints at both boat ramps. Existing ramps are not functional when water levels fall below 1094 feet. River flow recommendations call for water release patterns that mimic a "natural" stream system to create a more attractive location for a variety of recreation uses. When possible, stream flows exceeding 300 cfs on weekends would provide sufficient flows to support needs for stream floating by canoe, kayak or rubber raft. If large volume releases are required from the lake, they should be made as fast as possible to reduce lake shoreline erosion and boat ramp maintenance needs.

Table 8. Summary of recreation-based lake and river operational criteria.

	OPTIMAL OPERATIONS	ACCEPTABLE OPERATIONS	ADVERSE OPERATIONS
Desirable Lake Elevations:	1115 - 1125 ft. msl Main & Cholla Ramps are at the optimum.	1154 - 1178 ft. msl Dirt ramp is functional 1125 - 1144 ft. msl Main ramp is functional. 1094 - 1115 ft. msl Cholla ramp is functional.	If possible, > 1094 ft. msl during high use periods. Spring [March, April, May] Fall [September, October, November]
Undesirable Elevations:	1144 - 1154 ft. msl No boat launching is available.	1144 - 1154 ft. msl No boat launching is available.	1144 - 1154 ft. msl No boat launching is available.
River Flow Requirement:	If releases are > than 300 cfs, incorporate a week-end into the release period.	If releases are > than 300 cfs, incorporate a week-end into the release period.	If releases are > than 300 cfs, incorporate a week-end into the release period.

Assumptions and recommendations made by the Subcommittee include:

1. Recreational activities, particularly fishing, boating and camping at the State Park, decrease as the lake surface and fishable shoreline decreases;
2. Recreation use of the lake increases as the quality of the fishing experience increases;
3. Extreme lake level fluctuations create a "bath tub ring" effect that degrades the visual esthetics around the lake;
4. If lake elevations drop to 1100 feet, releases from the dam should only be made for legally mandated water rights;
5. Lake levels should be kept stable when peak recreation use occurs from March-May and in October, particularly on weekends;
6. Existing ASP facilities may be a limiting factor in managing at higher lake elevations, although mitigating or replacement opportunities are possible;
7. Inundation of current developed facilities and sewage facilities will occur at lake elevations over 1200 and 1214 feet, respectively; and
8. A more predictable lake operational pattern would provide greater reliability to recreational users in terms of lake access and assist ASP in long term planning of park facilities.

5. RESERVOIR OPERATIONS (Full report in Appendix D, Volume II)

Current operating constraints and maintenance requirements of Alamo Dam are presented in Chapter I, Introduction, part D. Alamo Dam and Reservoir.

B. EVALUATION/BLENDING OF SUBCOMMITTEE REPORTS

The five water management prescriptions submitted by the Technical Subcommittees were compared to identify both common ground and conflicts. Operational recommendations for the fisheries, recreation, riparian, and wildlife resource categories were subject to project authorities and physical constraints of Alamo Reservoir operations (Figure 5). Through consensus building, the prescriptions were manipulated and blended to maximize the achievement of all resource objectives.

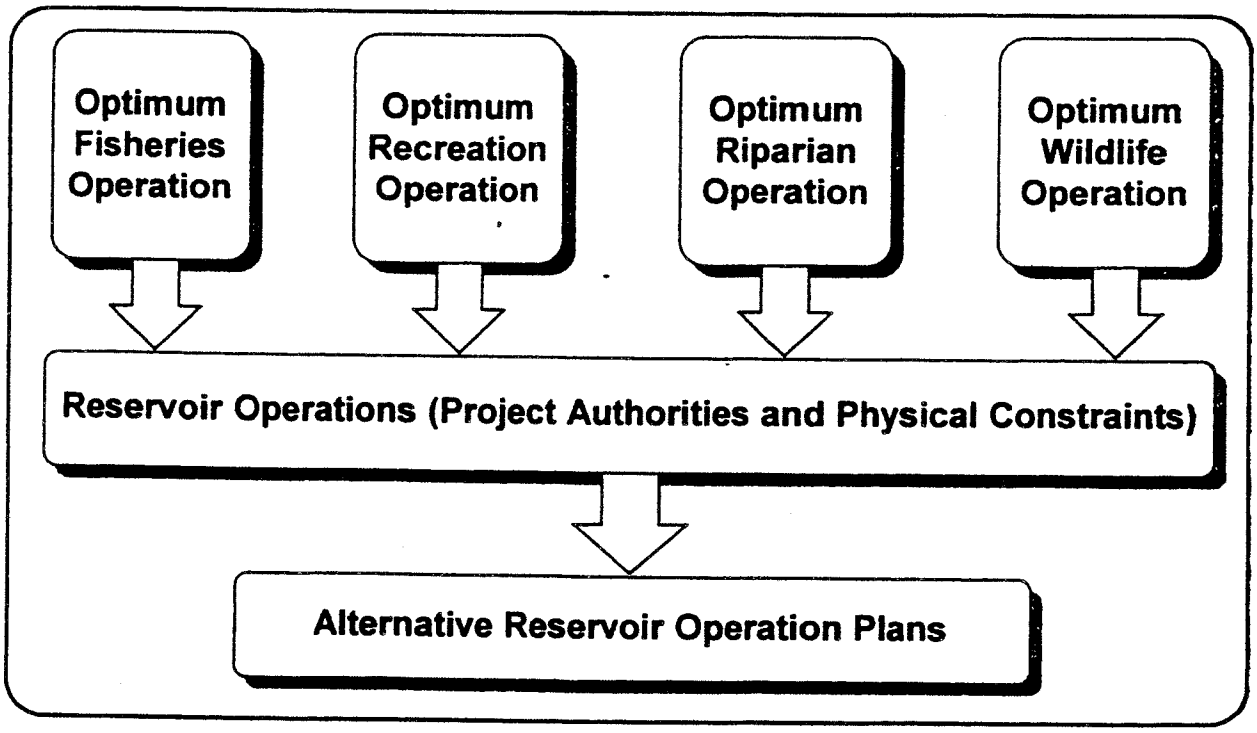


Figure 5. Generalized process to formulate water operation plan alternatives from subcommittee optimal recommendations.

Streamflow requirements for riparian habitat, as recommended by the Riparian Subcommittee, were the key to establishing the reservoir release pattern for alternative operation plans. For the Bill Williams River, wildlife resources would be optimized by meeting streamflow requirements recommended by the Riparian Subcommittee. Fisheries, Wildlife, and Recreation Subcommittees each recommended that 1100 feet be considered the minimum lake level. Lake levels above 1100 feet are desirable, but must consider risks of inundating potential bald eagle nests (historically at 1124-1138 feet). The Fisheries and Recreation Subcommittees preferred lake elevations managed

from 1110-1125 feet and when these elevations were exceeded, both Subcommittees preferred rapid evacuation of flood inflows to minimize periods of lake fluctuation. Other common features among the sub-committee recommendations aided in reaching consensus in developing alternative operational schemes. The Wildlife Subcommittee anticipated that water management conflicts between Alamo Lake and the Bill Williams River operations would only occur during drought years.

C. DEVELOPMENT OF ALTERNATIVES

The formulation of alternative plans was based on meeting and enhancing various natural resource objectives, while considering authorized project purposes and project inspection/maintenance requirements. The initial background research and analysis for these needs was accomplished by the various Technical Subcommittees. Recommendations in the subcommittee reports (Appendices D-H, Volume II) were looked at globally to formulate alternatives that best met the many objectives identified. Finally, alternative operation plans were constrained by the physical operational limitations of Alamo Dam. The alternative plans were developed around the concept of operating the Alamo Lake water surface based on a "target elevation." The target lake elevations selected for evaluation were 1115, 1120, 1123, 1125, 1127, 1130, 1140, and 1171.3 feet. The alternative plans were compared to the original authorized operations at 1070 feet (General Design Memorandum or GDM) and current operations, which attempt to maintain minimum pool elevations of 1100 feet (per USFWS 1988 request for bald eagles).

Each alternative sought to operate the lake between a minimum 1100 foot elevation and one of the target lake elevations. For this process, "target elevation" does not mean trying to hold the lake at that elevation at all times. The target elevations simply determined the point at which Alamo Dam releases would be changed from base flows (25-50 cfs) to flushing flows (1,000-7,000 cfs). The flushing flows serve to mimic natural flood events in the Bill Williams River, while also rapidly evacuating lake storage and reducing extended periods of lake fluctuation. The alternative plans selected for evaluation were intended to provide sufficient water for downstream riparian habitat flows while sustaining suitable lake elevations with minimal fluctuations for reservoir resources (wildlife, fisheries, recreation).

For reservoir pool levels below the target elevation, reduced reservoir releases are made to maintain base flows throughout the Bill Williams River corridor at levels beneficial to riparian habitat. For reservoir pool levels above the target elevation, a transition is made to high releases that mimic natural pre-dam flood flows to the extent practicable.

Release patterns for all alternatives are identified in Table 9. When the water surface rises above the target elevation, reservoir releases are increased by 1,000 cfs per foot of reservoir rise until the maximum authorized release of 7,000 cfs is reached, the outlet capacity is reached, or the water surface elevation drops back to the target elevation. When the water surface elevation is below the target elevation, releases are from 10 to 50 cfs, depending upon reservoir water surface elevation and season.

Table 9. Generalized Alamo Dam release schedule. Based on target elevations for alternative operating plans.

If current lake elevation ≤ TARGET ELEVATION then:

	Alamo Dam Releases (cfs)			
Lake Elevation (ft, msl)	Oct	Nov-Jan	Feb-Apr	May-Sept
990-1070	10	10	10	10
1070-1100	15	10	25	25
1100 to TARGET ELEV.	40	25	40	50

If current lake elevation > TARGET ELEVATION then:

Lake Elevation (ft, msl)	Alamo Dam Releases (cfs)
TARGET ELEVATION + 1 ft	1,000
TARGET ELEVATION + 2 ft	2,000
TARGET ELEVATION + 3 ft	3,000
TARGET ELEVATION + 4 ft	4,000
TARGET ELEVATION + 5 ft	5,000
TARGET ELEVATION + 6 ft	6,000
TARGET ELEVATION + 7 ft	7,000 (or outlet capacity)
Up to 1235 feet (spillway crest)	7,000
From 1235-1265 feet (top of dam)	over 7,000 (uncontrolled spillway flow)

IV. EVALUATION OF ALTERNATIVE RESERVOIR OPERATION PLANS

A. EVALUATION TOOLS: HEC-5 MODEL

The principal water management evaluation tool used in the Technical Committee study was the Corps of Engineers' HEC-5 "Simulation of Flood Control and Conservation Systems" computer program. HEC-5 simulates river flow and reservoir system operation on a continuous basis using observed flow records as input. The hydrologic model provides trends analysis and probability based on historic records, which permits prediction of possible future water management outcomes.

The following sections describe the HEC-5 program, how it was used to evaluate alternative reservoir operation plans, and the inputs to the program model used for the Technical Committee study.

1. GENERAL DESCRIPTION

The HEC-5 program is used to evaluate the operation of dams and reservoirs. The program accomplishes the task by modeling the sequential operation of a reservoir/river system over a designated time period. The time period can range from a few hours to historical periods of any length.

To completely model a reservoir/river system, HEC-5 requires the following input parameters:

Inflows: Inflows include all flows into each of the system's reservoirs and flows in the system's unregulated streams at regular time intervals (e.g., hourly, daily, or monthly); they are usually in the units of cubic feet per second (cfs).

Dam and Reservoir Characteristics: The characteristics of the dams and reservoirs include elevation/storage and elevation/area relationships, dam outlet works elevation/discharge relationships, and dam spillway elevation/discharge relationships.

Reservoir Evaporation: Monthly evaporation values, expressed in inches, for each reservoir are used by HEC-5 to compute reservoir evaporation.

Reservoir Storage Allocations: The total reservoir capacity up to dam spillway crest is apportioned within the HEC-5 program according to specific storage allocations (Figure 4). For modeling purposes, the storage allocations are normally given designations of inactive storage, buffer storage, conservation storage, and flood control storage. The allocations are the basis for HEC-5 to make specific releases from reservoirs and are used in conjunction with other operating criteria to determine release patterns for a simulation run.

Channel Characteristics: Channel characteristics include the channel carrying capacity, flow travel times in a channel, and flow routing properties of a channel.

2. PROGRAM CAPABILITIES AND LIMITATIONS

An HEC-5 program model for a dam and reservoir system can be configured for a variety of operating criteria. Scheduled releases, for instance, can be based on reservoir water surface elevation, time of year, reservoir inflow, or combinations of these parameters. Diversions can be made from the reservoirs or from points in the river channels. The magnitude of diversion flows can be based on elevations, reservoir inflows, or channel flow, and can be specified for a particular time of year. Diversions can be made to either return to the total reservoir/river system at a specific downstream location or be abstractions (withdrawals or losses) from the system. As a result of the diversion capability of HEC-5, natural flow losses to the reservoir/river system can be mimicked.

HEC-5 is a surface water modeling program, and has no internal capability to model groundwater flow. Groundwater characteristics in a river system can, at best, be approximated using the various HEC-5 input options. Groundwater basin response was simulated in the Technical

Committee HEC-5 model using groundwater data on the Bill Williams River from Harshman and Maddock (1993). However, for detailed and thorough modeling of a groundwater system, a groundwater computer program should be used.

3. MODEL INPUTS IN TECHNICAL COMMITTEE STUDY

The following sections describe the input used in the HEC-5 model of the Bill Williams River for the Technical Committee study. A schematic of the Bill Williams River system, as modelled by HEC-5, is shown in Figure 6.

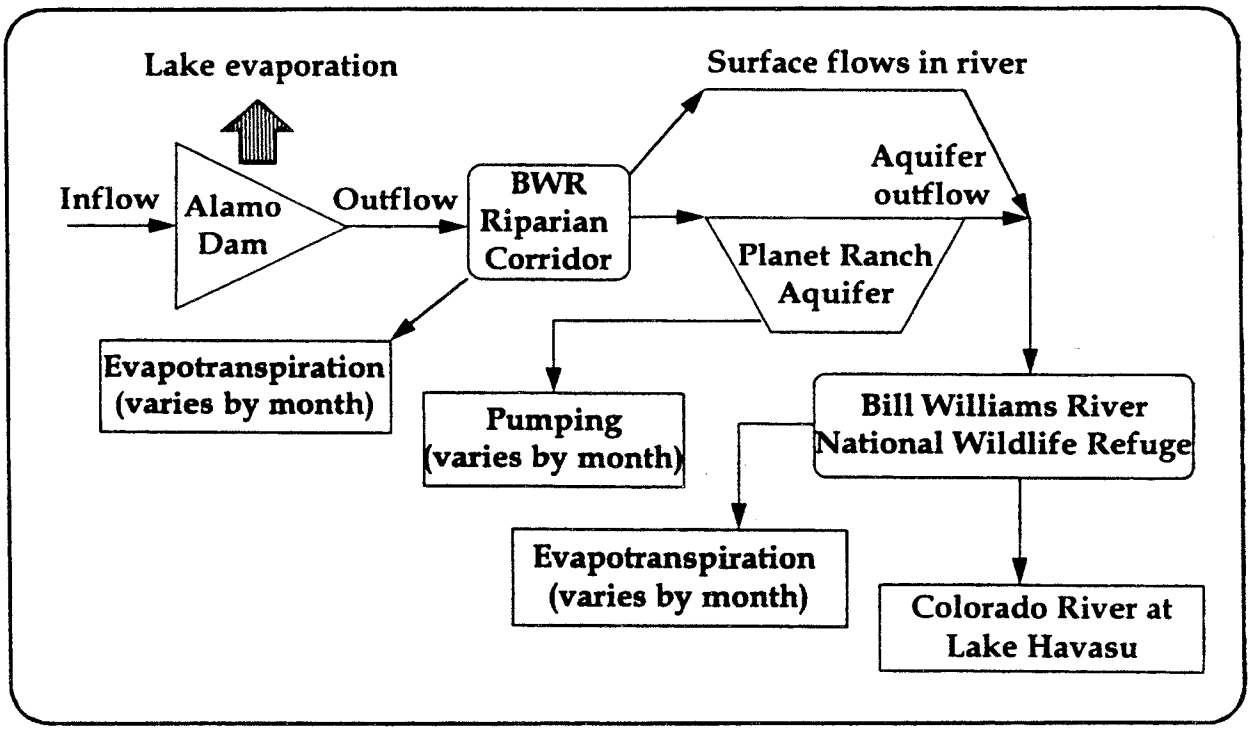


Figure 6. Hydrologic schematic of Bill Williams Reservoir and River system.

Inflow to Alamo Reservoir: Inflows to Alamo Reservoir were daily average flows in cfs for the period October 1, 1928 through December 31, 1993. This period of record was compiled from three data sources including U.S Geological Survey (USGS) stream gage data at the Alamo site (1939-68), computed flow values from the Corps daily operational records of Alamo Dam (1968-93), and flows derived from correlating measured flows at the USGS gages at the Alamo and Planet Ranch sites (1929-39). The measured flows were from the period 1940-46 when both gages were simultaneously in operation.

Monthly inflows into Alamo Reservoir for the period of record are shown in Figure 7. These inflows illustrate the pattern of inflows used by the HEC-5 model. More importantly, large fluctuations in annual precipitation create conditions where substantial amounts of water are available some years and for other years only limited amounts. For the HEC-5 model, inflow data from 1929-93 were used since they were available on a

daily basis. Hydrologic records for the Bill Williams River from 1890-1927 were available only on a monthly basis.

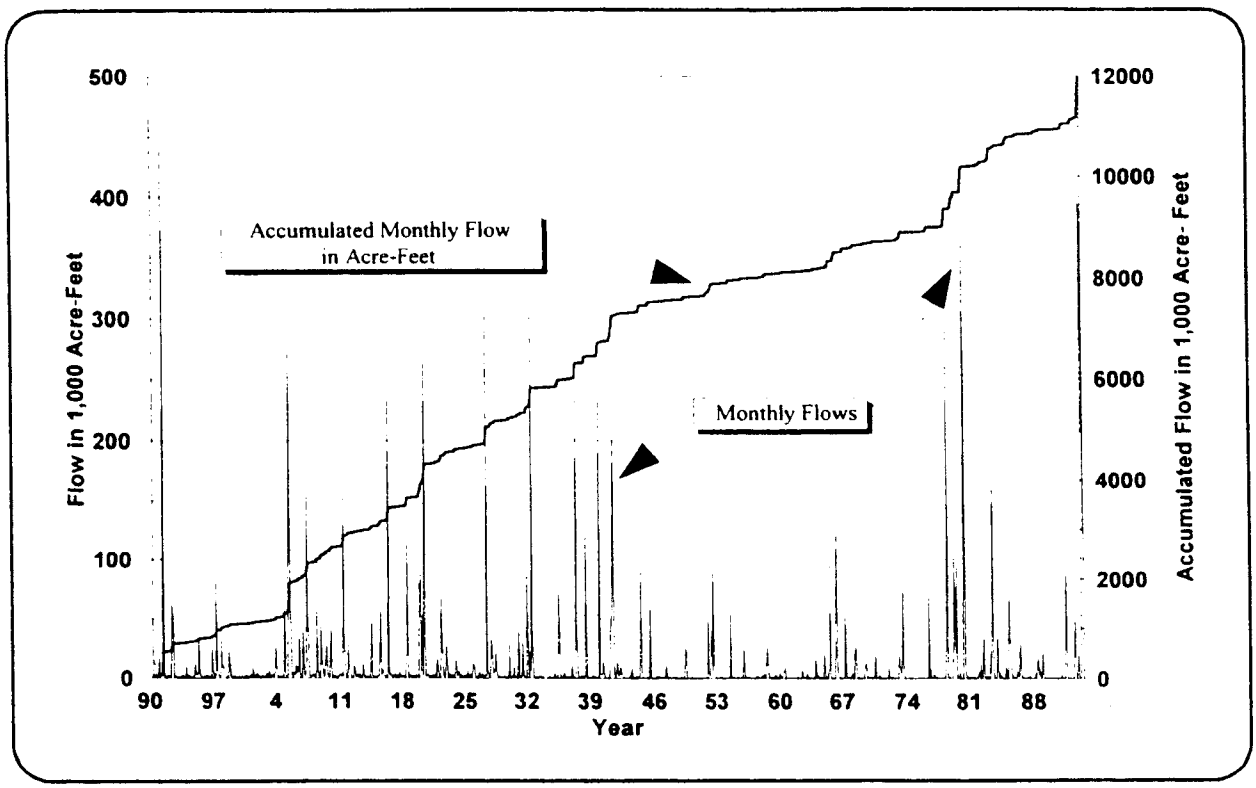


Figure 7. Alamo Dam historic monthly inflows (1890-1993).

Evaporation Losses: Mean monthly evaporation values at Alamo Reservoir were computed from pan evaporation data obtained over the period January 1976-March 1988. These monthly average evaporation values were applied to the entire 1929-1993 period of record modeled by the HEC-5 program.

Reservoir Elevation-Area/Capacity Values: The reservoir elevation-area and elevation-capacity values used in the HEC-5 model were from the Corps' June 1993 elevation-area/capacity table (Appendix H, Volume II), which is the most recent table and includes revisions for sedimentation.

Evapotranspiration Losses: Evapotranspiration (ET) losses along the Bill Williams River corridor from Alamo Dam to Planet Ranch and in the Refuge were obtained from Harshman and Maddock (1993). The report contained annual average ET values. Monthly average ET values for the river corridor and Refuge locations were estimated by applying the monthly average distribution pattern of Alamo Reservoir evaporation to the respective annual ET values.

Planet Ranch Groundwater Pumping: Monthly average pumping rates of Planet Ranch groundwater were obtained from Harshman and Maddock (1993). The pumping was treated as an abstraction from the Bill Williams River system; no irrigation return flow was assumed to enter the aquifer or the Bill Williams River.

Planet Ranch Aquifer Model: Since HEC-5 is not a groundwater modeling program, simulating the Planet Ranch aquifer's response to inflows (i.e., releases from Alamo Dam) was accomplished by considering the aquifer as a reservoir. In simulating inflows to Planet Ranch, it was assumed that a significant portion of surface flows percolated into the aquifer (Table 10).

Using known geological information, the aquifer itself was estimated to have a net holding capacity of 366,000 acre-feet. When this capacity was filled, excess percolation was assumed to flow from the aquifer in a manner similar to free flow from a dam's ungated spillway. The excess percolation was combined with the surface flows through the Planet Ranch area; this combined flow was routed to the Refuge.

Table 10. Estimated percolation of Bill Williams River surface flow into the Planet Ranch aquifer. (Correlation based on daily average surface flows recorded at both the Alamo Dam site and near Planet Ranch from 1940-46. Inflows in excess of 3,200 cfs were assumed to lose a constant 1,000 cfs to percolation. Flows in excess of those percolated were treated as surface flows through the Planet Ranch area.)

River Flows (cfs)	
Above Planet Ranch	Percolating into Planet Ranch aquifer
296	236
466	425
1,360	638
≥ 3,200	1,000

Routing of Channel Flows: Channel flows were routed from Alamo Dam to Planet Ranch, approximately 26 miles downstream, assuming a 29-hour travel time. Flows were routed from Planet Ranch to Lake Havasu (Colorado River), an 8-mile reach through the Refuge, assuming a 27-hour travel time.

4. MODEL OUTPUTS IN TECHNICAL COMMITTEE STUDY

A statistical analysis was performed on the various output parameters of the HEC-5 model. The results of these statistics for the 14 alternative plans modeled are summarized in Appendix I, Volume II. The HEC-5 model output summaries consist of information useful in evaluating the performance of the 14 alternative reservoir operating plans (Table 11).

Table 11. Codes, "target" lake elevations and descriptions of Technical Committee alternative operation plans modeled using HEC-5.

Alternative Plan Code	"Target" Lake Elevation (ft)	Description
GDM Plan	1070	General Design Memorandum. Alamo Dam operations as occurred from 1968-88. With 5 year inspection drawdown.
Current Op.	1100	Current Operations. "Target" elevation changed in response to USFWS 1988 request for bald eagle concerns. With 5 year inspection drawdown.
A1115D05	1115	Model run with 5 year inspection drawdown.
A1120D05	1120	" " " " " " "
A1123D05	1123	" " " " " " "
A1125D05	1125	" " " " " " "
A1127D05	1127	" " " " " " "
A1130D05	1130	" " " " " " "
A1140D05	1140	" " " " " " "
A1171D05	1171.3	Model run with 5 year inspection drawdown.
A1125NP5	1125	Model run with 5 year inspection drawdown and no Planet Ranch pumping.
A1125D10	1125	Model run with 10 year inspection drawdown.
A1125D15	1125	Model run with 15 year inspection drawdown.
A1125WOD	1125	Model run without inspection drawdown.

B. EVALUATION CRITERIA

The criteria for selecting the recommended alternative operation plan was based on the Technical Committee evaluation of the degree to which each plan benefitted the various resource needs, as well as the impact (positive or negative) on authorized project purposes. The needs or concerns for the resource demands of Alamo Dam and Reservoir are lake fisheries, wildlife concerns, lake recreational opportunities, riparian habitat, flood control ability and water conservation potential. Table 12 summarizes the evaluation criteria that the Subcommittees decided upon for each of the above categories. Each of the alternative plans were tested and evaluated with respect to each of the elements in Table 12 and then compared to each other to select the preferred plan.

C. EVALUATION OF ALTERNATIVES

Of the 14 alternatives considered and run through the HEC-5 model to identify performance in meeting resource evaluation criteria, two represented baseline scenarios (GDM and current

Table 12. Listing of criteria evaluated in the HEC-5 model for riparian, fisheries, wildlife, recreation, water conservation and flood control categories.

Riparian Criteria

RA1 - Percent of time streamflows at Refuge equal or exceed 18 cfs
RA2 - Percent of time WSE between 1100 - 1171.3 feet
RA3 - Percent of time Alamo Dam releases greater than or equal to 25 cfs in November through January.
RA4 - Percent of time Alamo Dam releases greater than or equal to 40 cfs in February through April and in October
RA5 - Percent of time Alamo Dam releases are greater than or equal to 50 cfs in May through September
RA6 - Total number of occurrences that Alamo Dam releases equal or exceed 1,000 cfs seven or more consecutive days in November through February
RA7 - Total number of occurrences that Alamo Dam releases equal or exceed 1,000 cfs seven or more consecutive days in March through October

Fisheries Criteria

F1 - Percent of time WSE between 1110 - 1125 feet
F2 - Percent of time in March 15-May 31 WSE fluctuates more than 2" per day
F3 - Percent of time in March 15-May 31 WSE fluctuates more than 0.5" per day
F4 - Maximum WSE drop, in feet, in June-September for the period of record (1929-93)
F5 - Average daily release during June-September
F6 - Average daily release during October-May
F7 - Percent of time streamflows at Refuge equal or exceed 25 cfs

Wildlife Criteria

W1 - Percent of time WSE at or above 1100 feet
W2 - Number of times during the year that WSE exceeds elevation 1135 feet two or more consecutive days.
W3 - Number of times from December 1-June 30 that WSE exceeds elevation 1135 feet two or more consecutive days.

Recreation Criteria

RE1 - Percent of time WSE at or above 1090 feet
RE2 - Percent of time WSE at or above 1094 feet
RE3 - Percent of time WSE at or above 1108 feet
RE4 - Percent of time WSE between 1115 - 1125 feet
RE5 - Percent of time WSE between 1144 - 1154 feet
RE6 - Percent of time outflow is between 300 and 7,000 cfs
RE7 - Percent of time in March-May WSE between 1115 -1125 feet

Water Conservation Criteria

WC1 - Average annual delivery of water to lower Colorado River (Lake Havasu)
WC2 - Average annual Alamo Reservoir evaporation in Acre Feet for period 1929-93

Flood Control Criteria

FC1 - Number of days WSE above 1171.3 feet during period of record (1929-1993)
FC2 - Maximum percent of flood control space used during period of record

Note: WSE = Water Surface Elevation of Alamo Reservoir

operations), eight represented "target" lake elevations ranging from 1115-1171.3 feet, and four were special runs.

1. ALTERNATIVES CONSIDERED

Table 13 summarizes the results of 10 of the computer simulations using the HEC-5 model and the analysis of each of the evaluation criteria noted in Table 12. Simulations were based on daily inflow values for a 65 year period of record from 1929-93. While this period of hydrologic record may not necessarily repeat itself in the future, the Technical Committee assumed that this period of record had predictive value. What is most important, however, is the comparative value in evaluating each alternative with respect to current operating conditions.

The Table 13 summary provided a means to compare the relative improvement, in terms of percent of time or actual numbers, in achieving the evaluation criteria for each alternative. Alternatives could, for example, be compared against the present situation (Current Op) or against alternatives with higher or lower "target" elevations. Note that for some evaluation criteria a lower value is better (e.g., WC2, FC1, FC1, F2).

Alternatives storing more water than the current operation (i.e., target elevation >1100 feet) performed much better in terms of meeting evaluation criteria. Flood control criteria were significantly improved for all of the alternatives evaluated, because large or maximal releases (up to 7,000 cfs) can be made much earlier than under GDM or current operation (up to 2,000 cfs in water conservation pool). When modeled using the 1929-93 period of hydrologic record, the rapid evacuation capability while in the water conservation pool means lake levels would never reach the flood control pool (1171.3 feet) for the six alternatives between 1115-1130 feet (Table 13).

The improvement between alternatives for a number of categories is relatively small. Differentiating between similar percentages may not be appropriate for most criteria since values are relatively imprecise. Some criteria are based on a narrow lake elevation range (e.g., RE4 -the percent of time the water surface elevation is between 1115' and 1125') and lake operations outside that range will have significantly lower occurrence values. Some criteria were also recognized as having greater importance than others.

Caution must be exercised in evaluating "average daily" and "percent of time" values. These values may mask seasonal and unusual event sequences which may either positively or adversely affect a particular resource. The Technical Committee made every effort to examine the HEC-5 runs on a daily, seasonal, and annual basis to better understand the reliability and limitations of the summarized values shown in Table 13.

In evaluating the eight water management alternatives with target elevations from 1115-1171.3 feet, it becomes readily apparent that each represents significant improvements in nearly all criteria categories compared to current (1100 foot) operations (Table 13).

Table 13. HEC-5 model evaluation criteria summary. Descriptions of the Alternative Operation Plans are in Table 11. WSE = Water Surface Elevation.

(GDM, Present Conditions, and Runs with 5-Year Drawdown)

Alternative Operation Plans	Minimum WSE Feet	Mean WSE Feet	Maximum WSE Feet	Recreation							Water Con.		Flood Cntl		Wildlife			Fisheries							Riparian						
				RE1	RE2	RE3	RE4	RE5	RE6	RE7	WC1	WC2	FC1	FC2	W1	W2	W3	F1	F2	F3	F4	F5	F6	F7	RA1	RA2	RA3	RA4	RA5	RA6	RA7
				%	%	%	%	%	%	%	af	af	#	%	%	#	#	%	%	%	ft	cfs	cfs	%	%	%	%	%	%	#	#
GDM Plan	1,035.9	1,068.3	1,183.3	2.8%	2.4%	1.8%	0.4%	0.3%	6.7%	0.9%	65322	5857	16	13.8%	2.1%	3	3	0.7%	13.1%	42.6%	67	48	171	24.9%	30.7%	2.1%	15.2%	22.9%	9.3%	17	26
Present Cond.	**1,080.5**	**1,098.1**	**1,185.8**	**93.5%**	**79.7%**	**3.2%**	**0.6%**	**0.2%**	**6.5%**	**1.6%**	**58735**	**13145**	**27**	**16.8%**	**36.9%**	**6**	**6**	**1.2%**	**11.5%**	**19.9%**	**36**	**37**	**161**	**21.4%**	**27.8%**	**36.8%**	**13.8%**	**20.9%**	**6.8%**	**17**	**24**
A1115D05	1,084.9	1,104.2	1,164.3	96.7%	89.1%	34.7%	2.5%	0.1%	4.2%	4.7%	55113	14807	0	0.0%	64.9%	7	7	29.8%	4.6%	27.7%	12	58	147	19.0%	43.7%	64.9%	54.2%	67.5%	54.3%	14	17
A1120D05	1,084.9	1,106.7	1,167.1	96.7%	89.5%	46.0%	26.6%	0.1%	4.4%	41.5%	54013	15501	0	0.0%	67.4%	10	10	41.3%	4.5%	29.0%	16	63	142	19.3%	46.2%	67.4%	55.2%	68.8%	59.0%	11	17
A1123D05	1,084.9	1,108.0	1,168.8	96.7%	90.1%	47.5%	30.9%	0.2%	4.5%	40.8%	53463	15844	0	0.0%	69.2%	11	11	44.0%	4.5%	26.4%	19	69	139	19.3%	49.5%	69.2%	59.6%	69.8%	60.6%	11	16
A1125D05	**1,084.9**	**1,109.0**	**1,170.0**	**96.7%**	**90.5%**	**49.0%**	**34.6%**	**0.2%**	**4.7%**	**40.6%**	**53174**	**16106**	**0**	**0.0%**	**69.5%**	**11**	**11**	**43.6%**	**4.6%**	**27.1%**	**20**	**72**	**137**	**19.0%**	**51.3%**	**69.5%**	**59.6%**	**70.3%**	**61.2%**	**12**	**16**
A1127D05	1,084.9	1,110.0	1,171.3	96.7%	90.6%	51.5%	21.2%	0.2%	4.7%	14.4%	53015	16377	0	0.0%	69.8%	13	13	29.0%	4.6%	27.6%	20	73	136	18.5%	52.8%	69.8%	59.6%	71.1%	61.6%	12	14
A1130D05	1,084.9	1,111.5	1,173.1	96.7%	90.6%	54.1%	18.4%	0.2%	4.7%	13.5%	52375	16773	3	2.0%	70.6%	17	16	27.0%	4.5%	27.5%	22	76	134	17.1%	53.8%	70.6%	61.1%	72.6%	61.8%	12	14
A1140D05	1,084.9	1,115.4	1,179.2	96.7%	90.8%	56.0%	10.2%	0.4%	5.1%	7.4%	51267	17842	7	8.8%	71.9%	25	21	15.9%	4.4%	26.0%	31	91	124	15.4%	56.0%	71.9%	61.4%	74.1%	63.9%	9	10
A1171D05	1,084.9	1,122.0	1,200.2	97.0%	90.9%	56.5%	7.8%	4.7%	6.0%	7.3%	49125	20130	362	36.3%	72.2%	28	25	13.2%	4.0%	19.3%	61	158	85	9.9%	49.8%	70.7%	61.5%	58.3%	68.7%	5	18

Notes:

Recreation
- RE1 - Percent of time WSE at or above 1090'
- RE2 - Percent of time WSE at or above 1094'
- RE3 - Percent of time WSE at or above 1108'
- RE4 - Percent of time WSE between 1115' and 1125'
- RE5 - Percent of time WSE between 1144' and 1154'
- RE6 - Percent of time Outflow is between 300 and 7,000 cfs
- RE7 - Percent of time in March thru May WSE between 1115' and 1125'

Water Con.
- WC1 - Average annual delivery of water to LCR (Lake Havasu)
- WC2 - Average Annual Evaporation in Acre Feet for period 1929-1993

Flood Control
- FC1- Number of days WSE above 1171.3 during period of record (1929-1993)
- FC2 - Maximum percent of flood control space used during period of record.

Wildlife
- W1 - Percent of time WSE at or above 1100'
- W2 - Number of times during the year that WSE exceeds elevation 1135' two or more consecutive days.
- W3 - Number of times from 1 December through 30 June that WSE exceeds elevation 1135' two or more consecutive days.

Fisheries
- F1 - Percent of time WSE between 1110' and 1125'
- F2 - Percent of time in March thru May WSE fluctuates more than 2" per day
- F3 - Percent of time in March 15 thru May WSE fluctuates more than 0.5" per day
- F4 - Maximum WSE drop, in feet, in June thru Sept. for the period of record (1929-1993)
- F5 - Average daily release during June thru September
- F6 - Average daily release during October thru May
- F7 - Percent of time streamflows at BW Refuge equal or exceed 25 cfs

Riparian
- RA1 - Percent of time streamflows at BW Refuge equal or exceed 18 cfs
- RA2 - Percent of time WSE between 1100' and 1171.3'
- RA3 - Percent of time Alamo Releases greater than or equal to 25 cfs in November thru January.
- RA4 - Percent of time Alamo releases greater than or equal to 40 cfs in February - April & October
- RA5 - Percent of time Alamo releases are greater than or equal to 50 cfs in May thru Sept.
- RA6 - Total number of occurrences that Alamo releases equal or exceed 1,000 cfs seven or more consecutive days in Nov. thru Feb.
- RA7 - Total number of occurrences that Alamo releases equal or exceed 1,000 cfs seven or more consecutive days in March thru October

2. UNACCEPTABLE ALTERNATIVES

Alternatives found to be unacceptable in terms of meeting all resource objective criteria were the 1140 and 1171.3 foot target elevation plans. These plans performed poorly in meeting objectives for flood control, and recreation and fisheries objectives that called for maintaining lake levels in the 1110-1125 foot range (Table 13). Maintaining lake elevations in the 1140 and 1171.3 foot range greatly increases lake surface area and subsequently annual evaporation amounts, resulting in further reductions of annual water deliveries to the Colorado River. Evaluation criteria performances for these two plans and for the 1115 foot plan were considerably lower in recreation (RE3, RE4 and RE7) and fisheries (F1) resource categories than the other five plans.

3. PROPOSED ALTERNATIVE

The desired outcome of the Technical Committee is to develop a balancing of the five resource objectives within the limits of the existing water supply and Alamo Dam operational constraints. By consensus, the 1125 foot target elevation water management alternative was selected as the plan which best meets optimal resource objectives within operational constraints and objectives of Alamo Dam. The 1120, 1123, and 1127 foot plans performed similarly in nearly all other resource categories. The 1125 foot plan represented an optimal lake elevation whereby benefits were maximized most effectively. The 1125 foot plan provides 80,000 acre-feet of lake storage above the 1100 foot minimum desired lake level. This large-volume storage is available for riparian, fish, wildlife, and recreational benefits. Details of this proposed 1125 foot plan are discussed in Chapter V.

4. SPECIAL RUNS

Special runs using the HEC-5 model were made to determine changes to evaluation criteria values from: 1) no Planet Ranch pumping; 2) Alamo Dam maintenance drawdowns every 10 years and every 15 years; and 3) no Alamo Dam maintenance drawdowns (Table 14). These runs were conducted for the 1125 foot target elevation to evaluate opportunities that would further enhance benefits from this preferred alternative.

a. No Planet Ranch pumping

By eliminating Planet Ranch groundwater pumping, significant benefits can be realized in terms of average annual water delivered to the Lower Colorado River (WC1) and percent of time Bill Williams River streamflows at the Refuge exceed 18 cfs (RA1). The proposed 1125 foot target elevation alternative provides 53,174 acre-feet of water per annum to Lake Havasu with Planet Ranch pumping factored in. Without pumping, the same alternative provides 66,341 acre-feet, a 13,000 acre-foot increase in per annum water yield. In terms of water conservation, the HEC-5 model runs for the 1125 foot plan indicate that Planet Ranch pumping reduces Bill Williams River water supplies to the Lower Colorado River by up to 25% per annum.

Table 14. HEC-5 model evaluation criteria special runs for target elevation 1125 feet. Descriptions of the Alternative Operation Plans are in Table 11. WSE = Water Surface Elevation.

(GDM, Present Conditions, and A1125D05 (recommended alternative))

Alternative Operation Plans	Minimum WSE Feet	Mean WSE Feet	Maximum WSE Feet	Recreation							Water Con.		Flood Cntl		Wildlife			Fisheries							Riparian						
				RE1	RE2	RE3	RE4	RE5	RE6	RE7	WC1	WC2	FC1	FC2	W1	W2	W3	F1	F2	F3	F4	F5	F6	F7	RA1	RA2	RA3	RA4	RA5	RA6	RA7
				%	%	%	%	%	%	%	af	af	#	%	%	#	#	%	%	%	ft	cfs	cfs	%	%	%	%	%	%	#	#
GDM Plan	1,035.9	1,068.3	1,183.3	2.8%	2.4%	1.8%	0.4%	0.3%	6.7%	0.9%	65322	5857	16	13.8%	2.1%	3	3	0.7%	13.1%	42.6%	67	48	171	24.9%	30.7%	2.1%	15.2%	22.9%	9.3%	17	26
Present Cond.	**1,080.5**	**1,098.1**	**1,185.8**	**93.5%**	**79.7%**	**3.2%**	**0.6%**	**0.2%**	**6.5%**	**1.6%**	**58735**	**13145**	**27**	**16.8%**	**36.9%**	**6**	**6**	**1.2%**	**11.5%**	**19.9%**	**36**	**37**	**161**	**21.4%**	**27.8%**	**36.8%**	**13.8%**	**20.9%**	**6.8%**	**17**	**24**
A1125D05	**1,084.9**	**1,109.0**	**1,170.0**	**96.7%**	**90.5%**	**49.0%**	**34.6%**	**0.2%**	**4.7%**	**40.6%**	**53174**	**16106**	**0**	**0.0%**	**69.5%**	**11**	**11**	**43.6%**	**4.6%**	**27.1%**	**20**	**72**	**137**	**19.0%**	**51.3%**	**69.5%**	**59.6%**	**70.3%**	**61.2%**	**12**	**16**

(Special Runs)

Alternative Operation Plans	Minimum WSE Feet	Mean WSE Feet	Maximum WSE Feet	Recreation							Water Con.		Flood Cntl		Wildlife			Fisheries							Riparian						
				RE1	RE2	RE3	RE4	RE5	RE6	RE7	WC1	WC2	FC1	FC2	W1	W2	W3	F1	F2	F3	F4	F5	F6	F7	RA1	RA2	RA3	RA4	RA5	RA6	RA7
				%	%	%	%	%	%	%	af	af	#	%	%	#	#	%	%	%	ft	cfs	cfs	%	%	%	%	%	%	#	#
A1125NP5	1,084.9	1,109.0	1,170.0	96.7%	90.5%	49.0%	34.6%	0.2%	4.7%	40.6%	66341	16106	0	0.0%	69.5%	11	11	43.6%	4.6%	27.1%	20	72	137	50.3%	76.3%	69.5%	59.6%	70.3%	61.2%	12	16
A1125D10	1,085.8	1,110.7	1,170.0	97.7%	92.6%	56.8%	41.1%	0.2%	3.9%	45.1%	51915	16521	0	0.0%	74.1%	11	11	51.0%	4.6%	28.3%	20	60	141	16.6%	50.5%	74.1%	67.9%	74.7%	71.1%	14	16
A1125D15	1,084.9	1,111.1	1,170.0	96.7%	90.9%	59.4%	43.3%	0.2%	3.6%	47.1%	51910	16620	0	0.0%	73.9%	13	12	53.5%	4.6%	28.2%	20	58	141	15.9%	49.2%	73.9%	68.1%	74.6%	70.7%	15	16
A1125WOD	1,086.2	1,111.9	1,170.0	99.3%	93.6%	61.8%	44.8%	0.2%	3.2%	48.4%	51490	16804	0	0.0%	78.2%	13	12	55.5%	4.6%	30.6%	9	55	142	14.4%	49.5%	78.2%	75.6%	79.8%	78.3%	15	16

Notes:

Recreation
- RE1 - Percent of time WSE at or above 1090'
- RE2 - Percent of time WSE at or above 1094'
- RE3 - Percent of time WSE at or above 1108'
- RE4 - Percent of time WSE between 1115' and 1125'
- RE5 - Percent of time WSE between 1144' and 1154'
- RE6 - Percent of time Outflow is between 300 and 7,000 cfs
- RE7 - Percent of time in March thru May WSE between 1115' and 1125'

Water Con.
- WC1 - Average annual delivery of water to LCR (Lake Havasu)
- WC2 - Average Annual Evaporation in Acre Feet for period 1929-1993

Flood Control
- FC1- Number of days WSE above 1171.3 during period of record (1929-1993)
- FC2 - Maximum percent of flood control space used during period of record.

Wildlife
- W1 - Percent of time WSE at or above 1100'
- W2 - Number of times during the year that WSE exceeds elevation 1135' two or more consecutive days.
- W3 - Number of times from 1 December through 30 June that WSE exceeds elevation 1135' two or more consecutive days.

Fisheries
- F1 - Percent of time WSE between 1110' and 1125'
- F2 - Percent of time in March thru May WSE fluctuates more than 2" per day
- F3 - Percent of time in March 15 thru May WSE fluctuates more than 0.5" per day
- F4 - Maximum WSE drop, in feet, in June thru Sept. for the period of record (1929-1993)
- F5 - Average daily release during June thru September
- F6 - Average daily release during October thru May
- F7 - Percent of time streamflows at BW Refuge equal or exceed 25 cfs

Riparian
- RA1 - Percent of time streamflows at BW Refuge equal or exceed 18 cfs
- RA2 - Percent of time WSE between 1100' and 1171.3'
- RA3 - Percent of time Alamo Releases greater than or equal to 25 cfs in November thru January.
- RA4 - Percent of time Alamo releases greater than or equal to 40 cfs in February - April & October
- RA5 - Percent of time Alamo releases are greater than or equal to 50 cfs in May thru Sept.
- RA6 - Total number of occurrences that Alamo releases equal or exceed 1,000 cfs seven or more consecutive days in Nov. thru Feb.
- RA7 - Total number of occurrences that Alamo releases equal or exceed 1,000 cfs seven or more consecutive days in March thru October

Streamflows at the Refuge are ≥ 18 cfs for 51.3% of the time (RA1) when Planet Ranch pumping occurs (Table 14). Without pumping impacts, flows ≥ 18 cfs occur at the Refuge 76.3% of the time for the 1929-93 period of record. This represents a significant increase in maintaining instream flows at the Refuge for riparian and wildlife enhancement.

NOTE: Estimated average withdrawal of groundwater at the Planet Ranch valley is approximately 15,000 acre-feet annually, equivalent to about 20 cfs (Rivers West, 1990). The storage capacity of the aquifer underlying Planet Ranch is large and when Alamo Dam releases are < 500 cfs , hydrologic effects of this aquifer significantly reduce downstream flows to the Refuge and consequently Lake Havasu (Table 10). In the spring of 1994, the City of Scottsdale curtailed agricultural production at Planet Ranch and essentially shut down groundwater pumping from the aquifer indefinitely. Impacts of no aquifer pumping to downstream Bill Williams River flows are currently being monitored.

b. 10 and 15 year drawdown

Results from special runs based on 10 and 15 year maintenance drawdown periods (Table 14) indicate moderate improvements to most evaluation criteria. The most significant improvements (≥ 10% change) occur for recreation, fisheries, and riparian resources. Recreation and fisheries improvements are due to the reduced frequency of lake fluctuations required during drawdown periods. With longer periods between drawdowns, lake levels are kept more stable which benefits recreation access and fish spawning and recruitment. Riparian communities are benefitted by higher reliability of base flows as lake storage does not have to be evacuated down to 1100 feet as often.

Consequences of less frequent lake drawdowns are that lake elevations can be maintained near target elevations as more water is available in lake storage to carry over from year to year. This increased storage over time results in slightly higher average annual evaporation losses (WC2) and subsequent reductions (1,264 acre-feet or 2.3%) in annual water delivery to the lower Colorado River averaged over a 65 year period (WC1) for the 15 year maintenance drawdown run.

c. No drawdown

Results from runs based on no drawdowns from the 1928-93 period of record indicate high improvements (≥ 20% change) in maintaining water surface elevations above 1108' and 1100' for recreation and wildlife resources, respectively. When drawdowns are eliminated, the percent of time Alamo releases meet or exceed acceptable base flow requirements for riparian resources is improved significantly for all seasons.

It should be recognized that major structural modifications to the outlet works inlet and bulkhead would be needed to enable required inspection and maintenance activities to occur at fixed five year intervals without reservoir drawdown below elevation 1110 feet. However, if the Corps were to exercise flexibility in scheduling outlet tunnel inspection

and maintenance activities to occur over a range of, say, 3-6 years when lake elevations are already below 1110 feet, the need for reservoir drawdowns may be greatly reduced.

V. PROPOSED PLAN

A. PLAN COMPONENTS

The alternative with the 1125-foot target elevation (A1125D05) was the consensus selection of the Technical Committee as the preferred operating plan. The selected plan provided the best overall performance with respect to the evaluation criteria presented in Table 13 and Subcommittee recommendations.

1. LAKE ELEVATION

Under the proposed alternative, Alamo Lake levels would be managed for a target elevation of 1125 feet. If a storm event raises the lake above that elevation, water would be released rapidly to return the lake to 1125 feet. When the lake elevation is below 1125 feet, water would only be released to meet maintenance base flows in the Bill Williams River and to satisfy downstream water rights. Large releases would not be made for storm events until lake elevations exceeded 1125 feet.

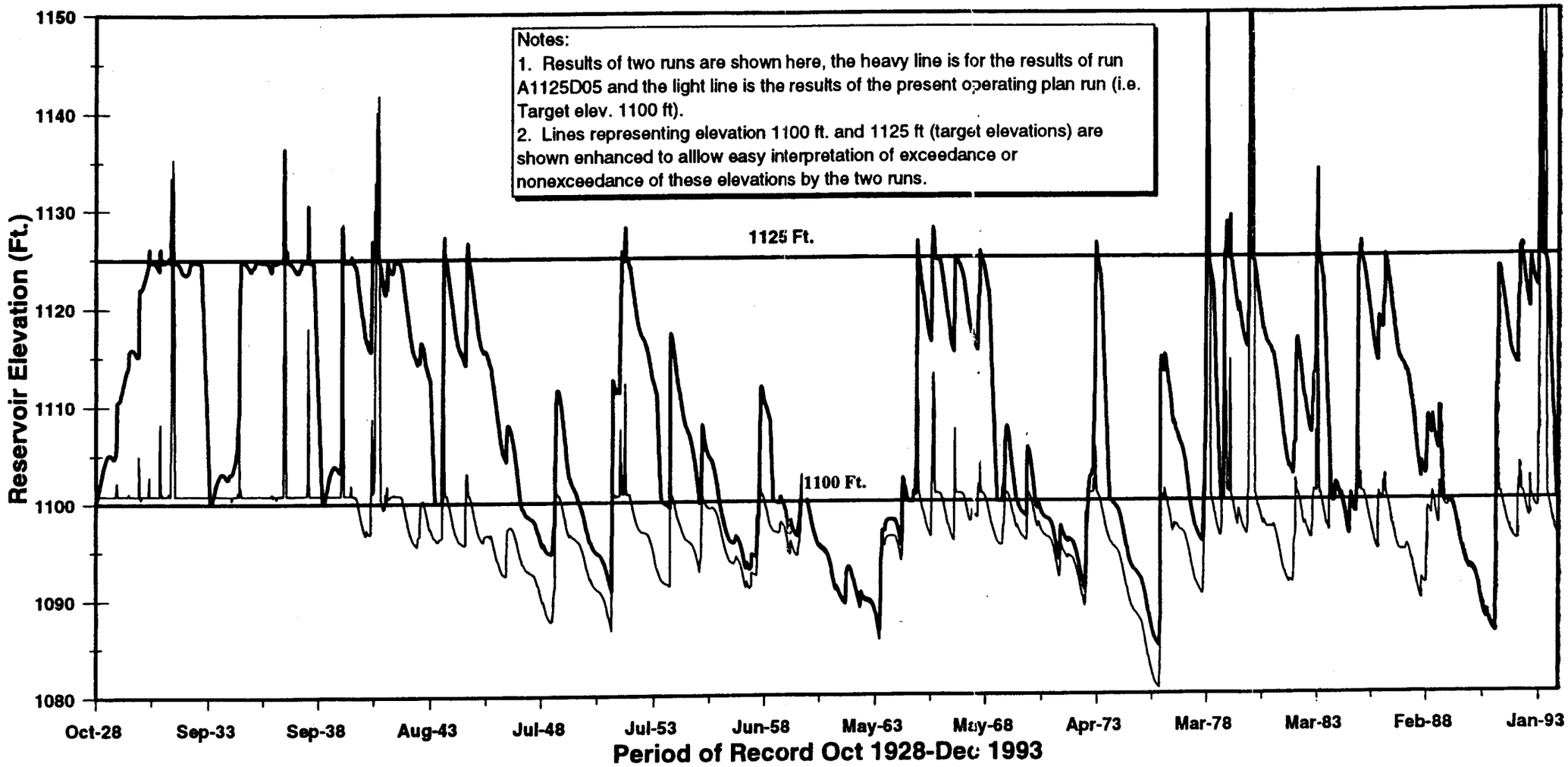
Table 15 illustrates comparative differences in Alamo Lake elevations over time for the proposed 1125 foot plan and the present 1100 foot plan. The impact of the five year inspection drawdowns (modeled to occur in years ending in a 3 and 8) on lake elevations is apparent in Table 15. For the proposed 1125 foot plan, the rate of drawdown for lake elevations in the 1100-1125 foot range is considerably less than for current operating conditions. Based on analysis of model runs for the period of hydrologic record, Alamo Lake elevations could remain below 1125 feet for long periods of time when inflow is minimal (i.e., extended drought periods). For the period of record from 1953-64, Alamo Lake elevations never exceeded 1118 feet and for nearly four consecutive years remained below 1100 feet (Table 15).

2. PRESCRIBED RELEASES

The prescribed releases for the 1125 foot proposed alternative are presented in Table 16. Alamo Dam releases for riparian base flow requirements would range from 25 cfs from November-January and 40-50 cfs during the spring-fall period.

The most idealistic flow releases from Alamo Dam cannot recreate the historical riparian vegetation diversity, density, and distribution along the Bill Williams River due to reduced flow magnitude, frequency, duration, and timing since Alamo Dam construction. But because the recommended (optimal) base flows are probably higher than pre-dam base flows, enhancements over historic conditions may occur in terms of riparian vegetation regeneration and recruitment. It is also known that the recommended flushing flows, while lower than pre-

Table 15. Modeled Alamo Reservoir elevations for current operations and for the proposed 1125 foot plan using hydrologic data from the 1928-93 period of record.



dam, can stimulate significant cottonwood regeneration. Therefore, the overall, long-term, effect may be an enhancement of riparian communities over pre-dam conditions.

Table 16. Generalized Alamo Dam release schedule based on recommended 1125' target elevation operating plan.

If current lake elevation ≤ 1125' (target elevation) then:

	Alamo Dam Releases (cfs)			
Lake Elev. (ft)	Oct	Nov-Jan	Feb-Apr	May-Sept
990-1070	10	10	10	10
1070-1100	15	10	25	25
1100-1125	40	25	40	50

If current lake elevation > 1125' (target elevation) then:

Lake Elevation (ft, msl)	Alamo Dam Releases (cfs)
1125-1126	transition up to 1,000
1126	1,000
1127	2,000
1128	3,000
1129	4,000
1130	5,000
1131	6,000
1132	6,621 - 7,000
1148.4	7,000
Up to 1235 (spillway crest)	7,000
From 1235 to 1265 (top of dam)	over 7,000

3. RELEASE CONSIDERATIONS

Below reservoir water surface elevation 1125 feet, the release schedule provides adequate flow for downstream riparian concerns, while minimizing lake level fluctuations and maintaining a lake elevation above 1100 feet as much as possible. At 1125 feet elevation, Alamo Lake is 3,800 surface acres with 160,500 acre-feet of storage. This is 80,000 acre-feet more water storage than at 1100 feet and an additional 1,200 surface acres. Above elevation 1125 feet, the release schedule attempts to mimic the pattern of pre-dam flood events. Pre-dam flood events typically had short duration high flows followed by long recession (tapering off) which slows the rate of water table decline, allowing tree roots to follow the dropping water.

In the case of Alamo Dam, flows are limited to a maximum of 7,000 cfs as authorized for flood control release by the project authorizing document. This type of release pattern will benefit riparian resources downstream by eliminating long duration inundation of tree stands and other vegetation while serving to help regenerate riparian vegetation. Additionally, releases with higher peaks should reduce the number of occurrences when the reservoir water surface elevation exceeds 1135 feet. This will reduce the chance of a "take" of an endangered species (by inundation of a bald eagle nest) should the bald eagles return to a nest site within the reservoir. In recent years, a bald eagle tree nest site was situated at approximately elevation 1138 feet.

Approximately every five years, the reservoir water surface elevation must be drawn down to 1100 feet to permit inspection and maintenance of Alamo Dam's outlet tunnel. It is recommended that inspection of the outlet tunnel occur in October/November, when reservoir inflows will be lowest (based on historic records) and downstream release requirements for riparian communities are lowest. The drawdown procedure for the inspection/maintenance will normally begin in June, permitting reservoir evacuation over a long (6-month) time period without excessively high flows. In most cases, releases will be less than 1,000 cfs. An objective is to avoid root zone damage to the cottonwood trees caused by saturation from long term inundation (see Inundation Restrictions, Chapter III. A.1.). If a monsoon event occurs during the drawdown period, outflows would mimic inflows as much as possible so as to provide the monsoon flow effect downstream. If, during a drawdown period, no monsoon event occurs and it is deemed that such an event will benefit the riparian zones, an artificial monsoon sequence of flows can be simulated. Normally such a simulated monsoon sequence would be scheduled for early September, to mimic nature. Base flow releases after the artificial monsoon release would, most likely, be much less than prior to the monsoon release to ensure that the reservoir water surface elevation does not drop below elevation 1100 feet.

The larger spring and monsoon flushing releases would be coordinated with USBR operations on the Colorado River, similar to the present operating plan. If an excessive runoff condition occurred on the Colorado River, as happened in the early 1980's, releases from Alamo Dam would be limited to the amount the USBR can incorporate into its river operation plan. However, base flows would be maintained and if the water surface elevation of Alamo Reservoir rises into the flood control pool, releases would be increased as necessary to effect the necessary flood control operation. In a flood control operation, outflow may be as high as 7,000 cfs.

In a similar manner, base flow releases would be coordinated with the resource agencies downstream, as appropriate. If a specified seasonal release below the target elevation was deemed unnecessary to sustain downstream riparian needs, releases would be adjusted accordingly.

B. BENEFITS OF PLAN

A diagrammatic comparison of current and recommended dam operation is provided in Figure 8. Storage allocation amounts are shown as unchanged with the recommended operation plan, and Alamo Dam operations in both the recreation and flood control pools remain unchanged as well. Within the water conservation pool the recommended operation plan calls for reservoir releases

that vary with season and reservoir elevation that provide positive benefits for fish, wildlife, riparian habitat, recreation, and flood control.

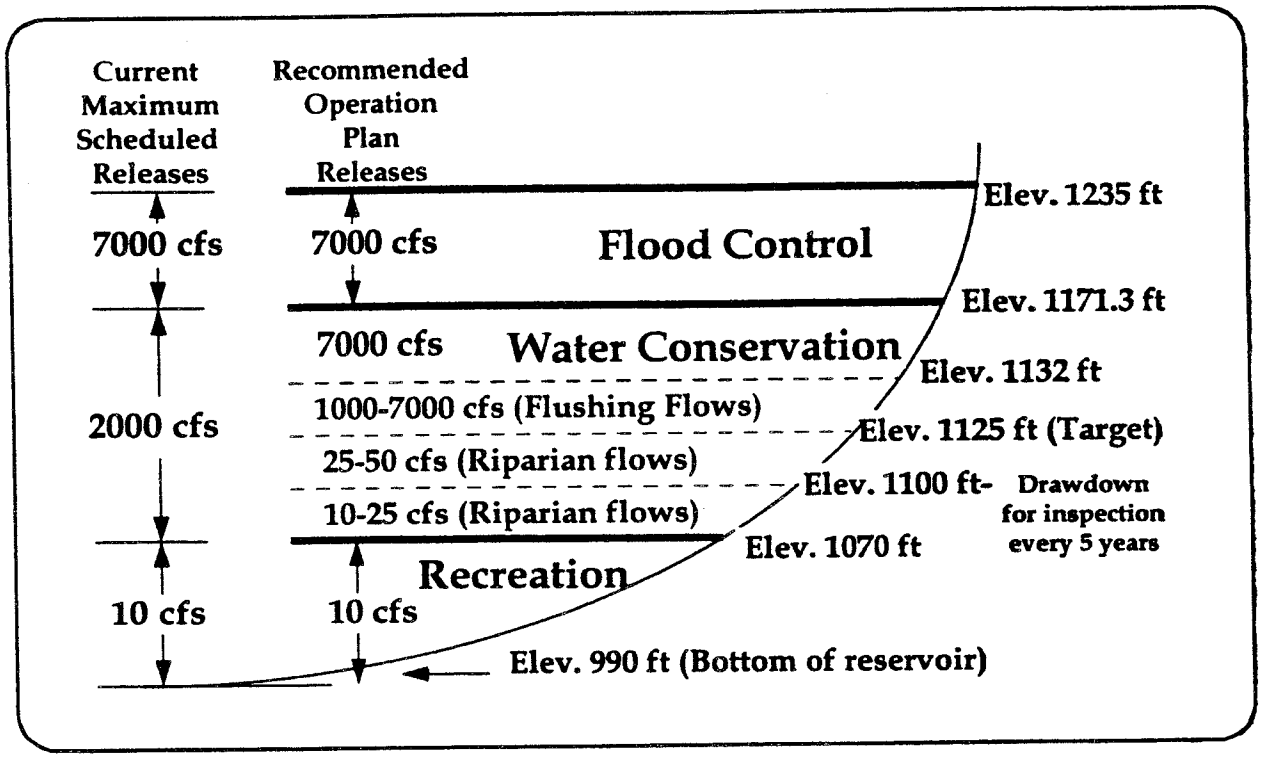


Figure 8. Comparison of current and recommended Alamo Dam operations.

In changing from current operations to the proposed 1125 foot plan, improvements in evaluation criteria occur for all categories, except water conservation (Table 13). A general summary of the effects of the proposed plan, by major resource group, is listed in Table 17.

Table 17. Summarization of effects/impacts of recommended reoperation plan.

- **Flood Control [Positive]**
- **Water Conservation [Positive and Negative]**
  - Net increase in water provided for in-stream riparian habitat
  - Net reduction in water delivery to Lower Colorado River
  - Small increase in salinity of water in Bill Williams River
- **Recreation [Positive]**
- **Fisheries [Positive]**
- **Riparian Habitat [Positive]**
- **Wildlife and Threatened & Endangered Species [Positive]**
- **Power [No Change]**

The river/reservoir simulation performed by the Technical Committee was limited to the Bill Williams River system. Therefore, predicted water deliveries in the lower Colorado River do not account for adjustments in mainstem reservoir operation to accommodate the various Alamo Dam operation alternatives. The limited scope of modeling undertaken is sufficient to identify the best overall Alamo operation plan.

Figures 9 through 14 graphically compare selected evaluation criteria between the General Design Memorandum (GDM), Current Operation, and the proposed operation with a target elevation of 1125 feet (the selected alternative). Dramatic improvements occur with the selected alternative over the current operation for flood control, recreation, fisheries, riparian and wildlife criteria.

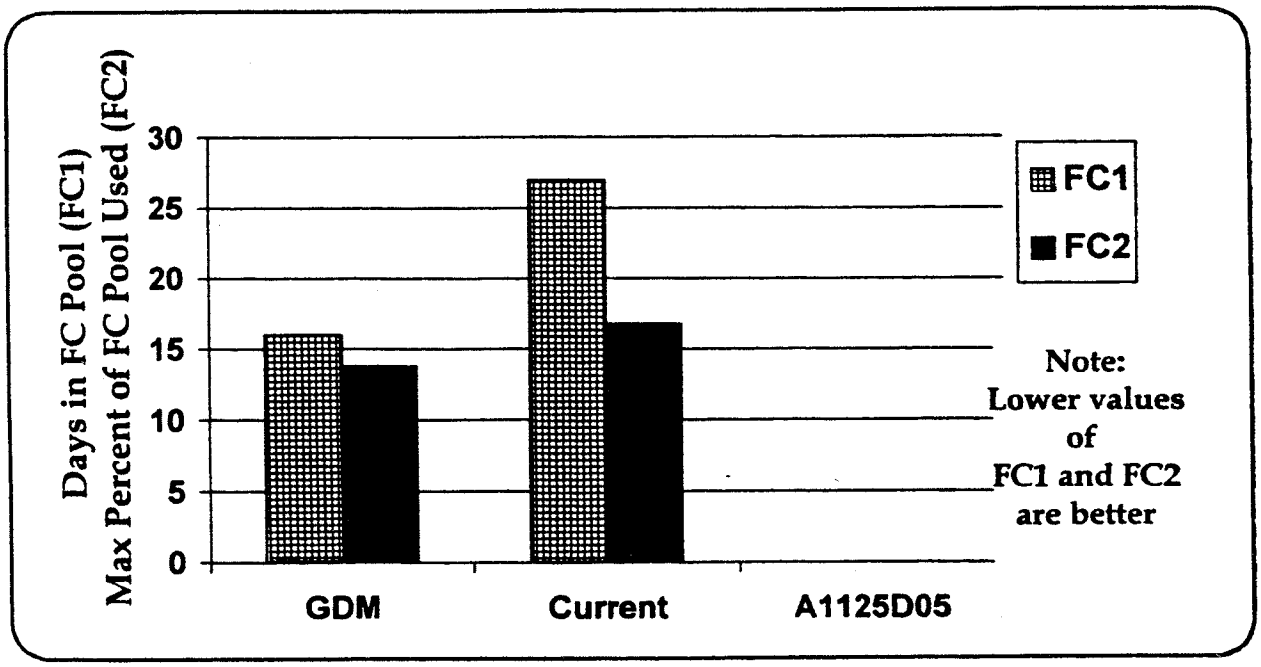


Figure 9. Comparison of success in meeting flood control goals by GDM, current operation, and recommended 1125' target. FC1 = Number of days WSE above 1171.3' during period of record; FC2 = Maximum percent of flood control space used during period of record. NOTE: values for A1125D05 for both FC1 and FC2 are zero during period of record.

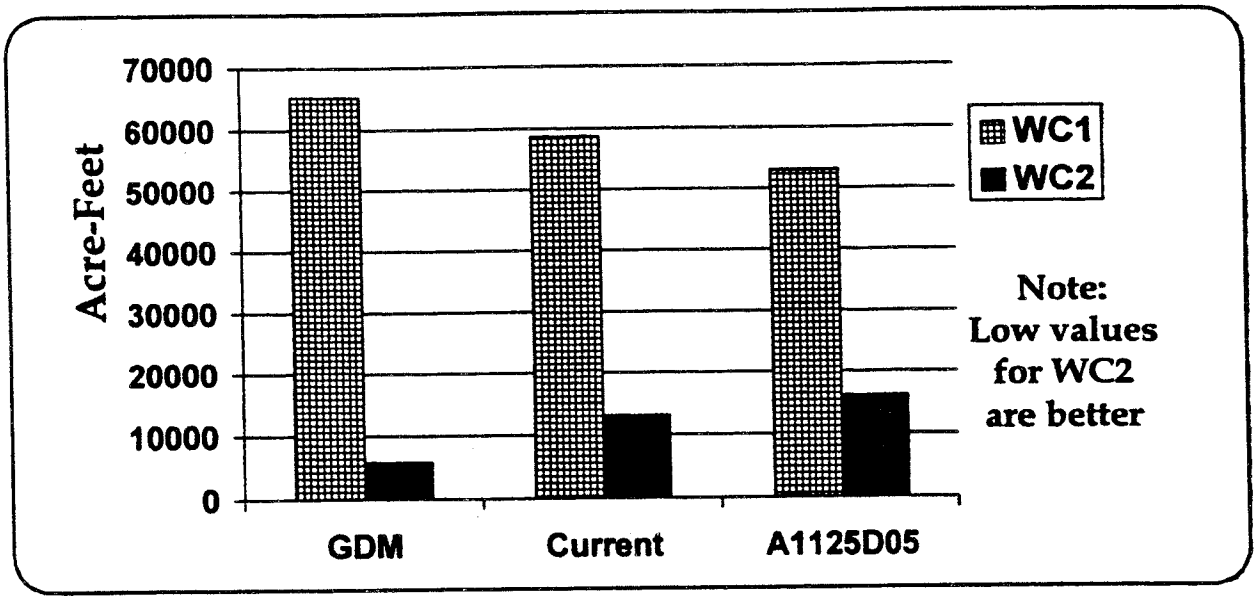


Figure 10. Comparison of success in meeting water conservation goals by GDM, current operation, and recommended 1125' target. WC1 = Average annual delivery of water to lower Colorado River (Lake Havasu); WC2 = Average annual Alamo Reservoir evaporation in Acre Feet for period 1929-93.

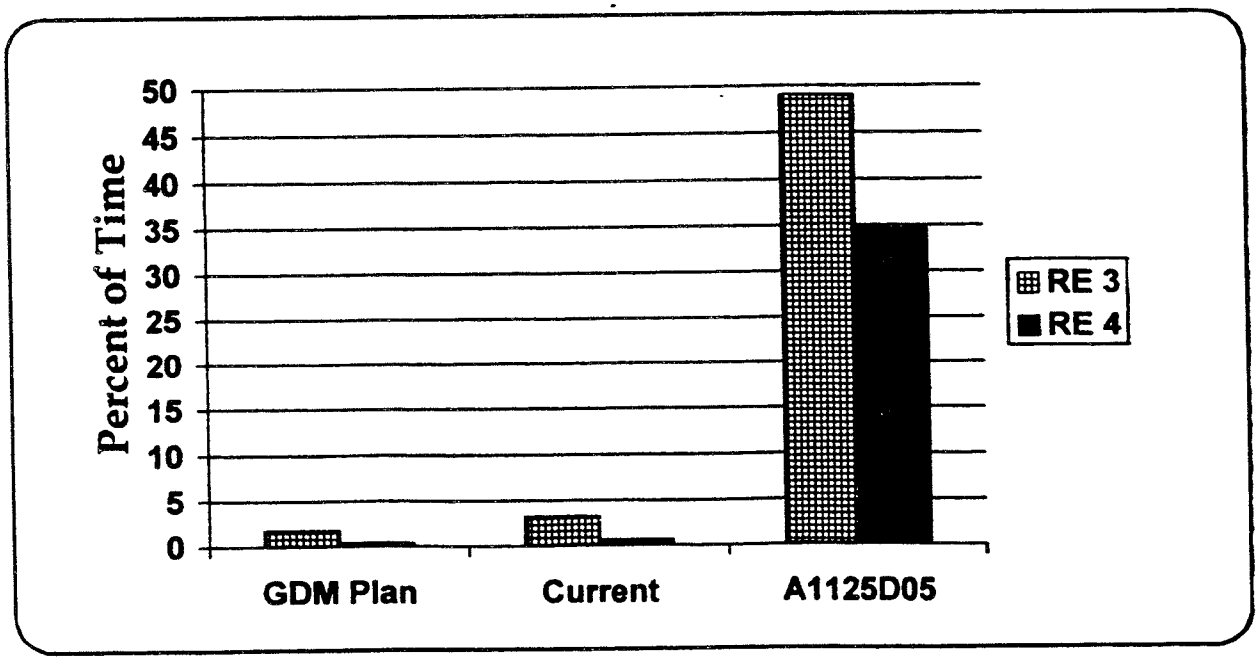


Figure 11. Comparison of success in meeting recreation goals by GDM, current operation, and recommended 1125' target. RE3 = Percent of time water surface elevation at or above 1108'; RE4 = Percent of time water surface elevation between 1115' and 1125'.

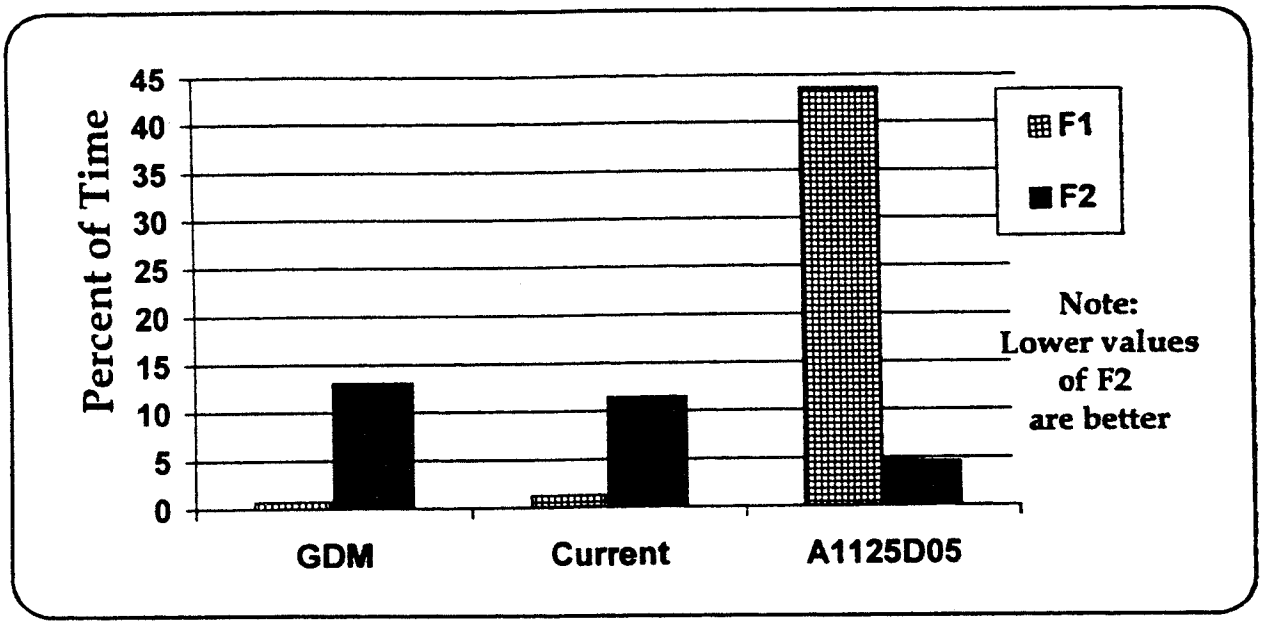


Figure 12. Comparison of success in meeting fisheries goals by GDM, current operation, and recommended 1125' target. F1 = Percent of time water surface elevation between 1110' and 1125'; F2 = Percent of time in March 15-May 31 water surface elevation fluctuates more than 2" per day.

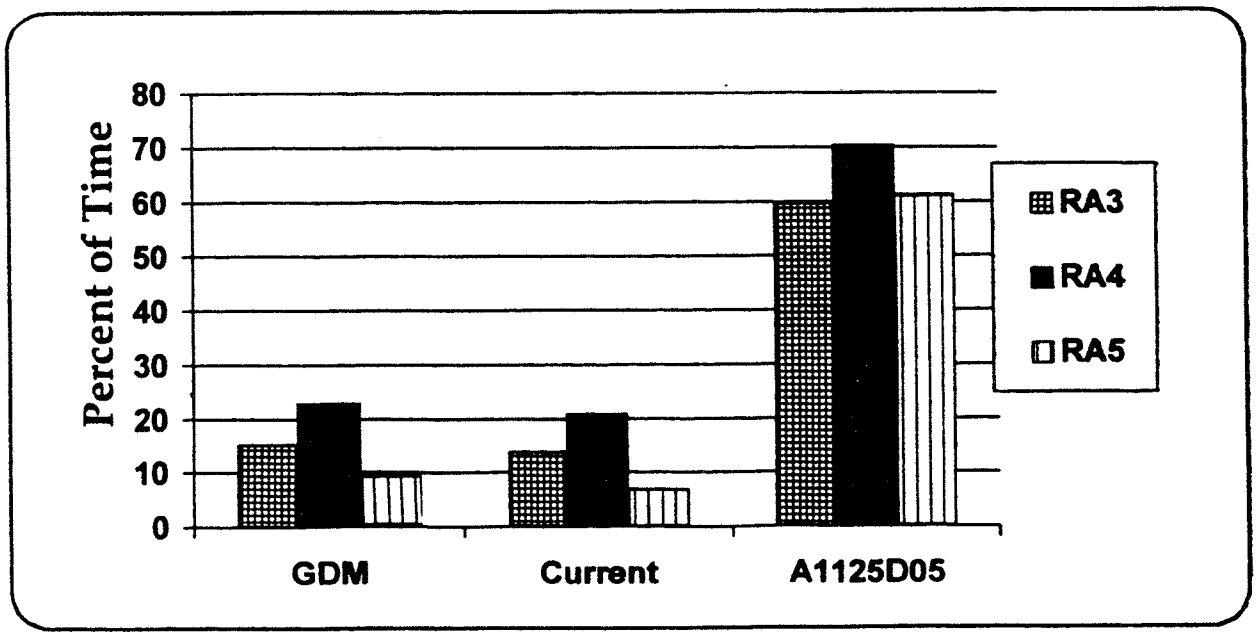


Figure 13. Comparison of success in meeting riparian goals by GDM, current operation, and recommended 1125' target. RA3 = Percent of time Alamo Dam releases greater than or equal to 25 cfs in November through January; RA4 = Percent of time Alamo Dam releases greater than or equal to 40 cfs in February through April and in October; RA5 = Percent of time Alamo Dam releases greater than or equal to 50 cfs in May through September.

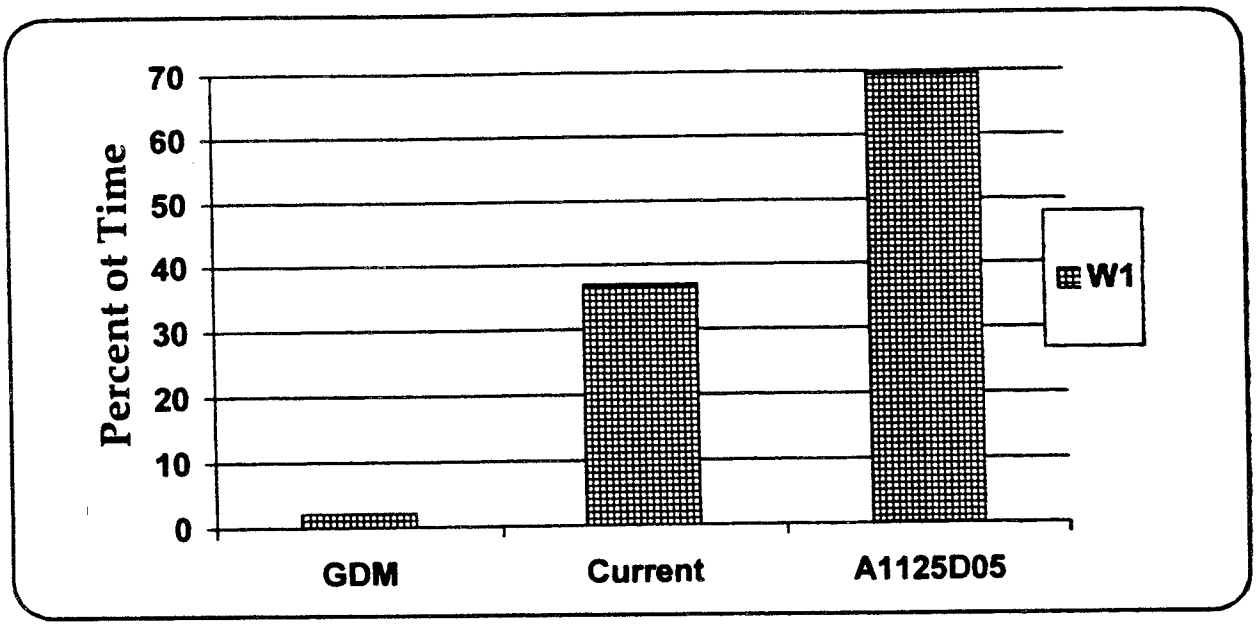


Figure 14. Comparison of success in meeting wildlife goals by GDM, current operation, and recommended 1125' target. W1 = Percent of time water surface elevation at or above 1100'.

Flood Control: Based on current operations, it is projected that lake elevations would reach the flood control pool (1171.3 feet) for 27 days for the 1929-93 period of record (FC1) and up to 16.8% of the flood control pool would be used at one point in time (FC2). Under the preferred 1125 foot plan, for the same period of record, lake elevations would never reach the flood control pool (Figure 9).

Water Conservation: The Technical Committee analysis for water conservation provides a relative comparison among alternative Alamo Dam operation plans by quantifying average annual Bill Williams River water deliveries to the Colorado River at Lake Havasu (WC1), and average annual Alamo Lake evaporation losses (WC2). Since each of the alternative plans produces higher average pool levels than the current operation plan, higher reservoir evaporation losses and reduced water deliveries to the Colorado River occur under all alternative plans (see Table 13). However, the actual reduction in water supply for the Colorado River is smaller than indicated by WC1 when the entire Colorado River system is considered. Furthermore, the consumptive use of water by riparian vegetation enhancements along the Bill Williams River under the recommended dam operation is anticipated to more closely resemble the consumptive use of water under pre-Alamo Dam conditions.

When water is stored in Alamo Lake and not used for delivery to Lake Havasu, that increment of water supply for the Lower Colorado River must be provided from Lake Mead. Although a portion of any additional water stored in Alamo Lake will evaporate, a reduction in evaporation loss occurs at Lake Mead due to a slightly reduced pool size. Evaporation losses at Alamo Lake are higher than at Lake Mead for a given volume of storage because of the greater increase in surface area at Alamo Lake versus the larger Lake Mead. A reservoir system simulation that

included Lake Mead would be required to precisely determine the net reduction in Colorado River system water supply that would occur with adoption of the recommended Alamo Dam operation. The values of average annual Alamo Lake evaporation losses (WC2) in Table 13 likely overestimate the net reduction in Colorado River system water supply by 15 to 35 percent.

Comparing the recommended Alamo operation versus the current operation, and considering that the appropriate difference in water availability to the Colorado River is reflected by the net change in system-wide evaporation losses, then adoption of the recommended plan would result in an estimated reduction in water supply of about 2,000 to 2,500 acre-feet annually.

A small salinity increase on the Bill Williams River may occur because of longer reservoir retention times with the recommended plan. This results from more evaporation losses (WC2, Figure 10) and resultant concentration of salts. The salinity increase is negligible relative to the salt load in the Colorado River, based on an average annual contribution of 53,000 acre feet of water from the Bill Williams versus average annual lower Colorado River flows of 7 million acre feet. Salinity levels of the Bill Williams River are far below those of the lower Colorado River mainstem and will continue to remain low under the recommended plan.

Recreation: The percent of time lake elevations are above 1108 feet (RE3) improves from 3.2% (current operations) to 49% for the recommended plan (Figure 11). Improvements to the percent of time lake elevations are between 1115 and 1125 feet (RE4) are also significant. The recommended plan maintains higher lake elevations over a greater period of time, which translates into greater utilization of the existing boat ramps and recreational facilities at Alamo Lake. While these improvements are considerable, it should be noted that even under the recommended plan, lake elevations will be below 1108 feet for 51% of the time. These lower lake elevations are a reflection of drought periods and drawdown impacts projected over a 65 year period of hydrologic record. Eliminating the need for drawdowns or decreasing the frequency of drawdowns will improve the percent of time lake elevations are above 1108 feet to 61.8% (Table 14).

Fisheries: Improvements in percent of time lake elevations are held between 1110 and 1125 feet (F1) are similar to those just described under recreation for RE3. Lake fluctuations during the March-May spawning season affect fish reproduction success. The incidence of lake fluctuations greater than 2 inches per day during the spawning season (F2) decreases from 11.5% of the time under current operations to 4.6% of the time for the recommended plan (Figure 12).

Riparian: Riparian resources will greatly benefit from significant increases in base flow amounts and duration for all seasons (Figure 13). The percent of time recommended base flows are met or exceeded range from 6.8-20.9% under current operations to 59.6-70.3% for the 1125 foot plan. Additionally, the percent of time streamflows at the Refuge exceed 18 cfs is improved from 27.8% to 51.3% with the recommended plan (Table 13). The 1125 foot recommended plan also reduces the number of occurrences when Alamo Dam releases subject downstream riparian vegetation to stressful inundation conditions.

Wildlife and threatened and endangered species: For the wildlife criteria, dramatic improvement is achieved in keeping the lake above 1100 feet (W1) although nest inundation at an 1138 foot elevation site will increase (W2). Since nesting eagles used alternative sites away from

lake disturbance, after inundation of previously used nests in 1993, the significance of the inundation may be less than previously believed. Other wildlife species will benefit from the anticipated improvements to riparian resources.

VI. IMPLEMENTATION OF PLAN

A. IMMEDIATE STEPS

Once the Steering Committee approves the final proposed water management plan for Alamo Dam and the Bill Williams River, a public involvement process should begin that includes briefings with the Congressional delegation, regional legislative members, county and local officials, downstream landowners, and the City of Scottsdale. A press release on the Steering Committee-approved water management plan is recommended.

B. REMAINING ISSUES

Table 18 lists issues that may require consideration and resolution prior to final reservoir reallocation and reoperation steps.

Table 18. Remaining issues for the implementation of a revised Water Control Manual for Alamo Dam.

- **Public involvement process**
- **Instream water rights for the riparian habitat**
- **Reallocation of reservoir storage vs. reoperation**
- **Economic analysis of impacts and costs of reoperation vs. status quo**
- **Cost sharing requirements**
- **Planet Ranch pumping**
- **Threatened and Endangered species**
- **Biological and ecological monitoring studies**
- **Securing Alamo storage rights and downstream base flows**

A public involvement process will be decided by the Steering Committee. If significant public interest results from the press release, then informational, open house meetings should be held to advise the public of the process to date, the proposed changes, and probable implementation strategies. It is expected that any operational changes to Alamo Dam will require formal documentation by the Corps, which will necessitate full public involvement and National Environmental Policy Act compliance. Thus, a more formal public involvement process will occur prior to any changes in Alamo Dam operations.

Water rights and water conservation are significant issues to address. In October 1989, the AGFD and ASP submitted a joint application to ADWR for water storage rights (321,480 acre-feet per annum) to the Alamo Dam water conservation pool for fish, wildlife, and recreational purposes. This application was in response to the City of Scottsdale's efforts to gain additional rights to the waters of the Bill Williams River. BLM filed for an instream flow appropriation below Alamo Dam in April 1988. In 1994, the USFWS filed for instream flow water rights at the Bill Williams National Wildlife Refuge. Unquestionably, these water right applications will require future amendment when 1) revisions to Alamo Dam operations are implemented, and/or 2) the probable Interior Department's acquisition of Planet Ranch has been completed. The Technical Committee strongly recommends that water rights be obtained for lake storage and Bill Williams River instream flows that support and secure the 1125 foot proposed water management plan. It may be necessary to modify or withdraw these applications so that a single (or joint) entity may pursue water rights that secure the recommended lake storage and base flows under this proposal. These activities will require close coordination with ADWR and the Corps.

The 1125 foot target plan may result in a mean annual reduction of about 5,561 acre-feet of water delivered to the Lower Colorado River compared with current operations. Arizona has no binding requirement to deliver water from the Bill Williams River to the Colorado River. However, once Bill Williams River water reaches the Colorado River at Lake Havasu, it becomes subject to the Colorado River Compact and consequently the "Law of the River."

It was estimated by Stephens and Associates (1988) that there is an annual average available volume of surplus water of over 73,000 acre-feet from the Bill Williams River system. At present, this volume of water is lost to the Colorado River whereupon it is not appropriable under state water rights statutes. These and other studies demonstrate that a considerable amount of unappropriated public water is available for beneficial use from the Bill Williams River system.

In a May 1990 letter addressing water rights issues in the Bill Williams River, the Central Arizona Water Conservation District (CAWCD) expressed concerns that "Any depletion of the water supplies of the Bill Williams River will eventually require greater releases from storage on the Colorado River system to satisfy downstream demands and, directly or indirectly, reduce the water supplies available to mainstream users, including particularly the CAP." Since the Central Arizona Project (CAP) is the major junior rightholder on the Lower Colorado River, the CAP and its water users would be most affected by any reductions in Bill Williams River water supplies to Lake Havasu.

It is the opinion of the Corps that they can not formally reoperate Alamo Dam for environmental enhancements until reallocation of reservoir storage (Water Conservation Pool) is approved by Congress. There are specific institutional and procedural implications if the recommended operational changes are considered reoperation or reallocation. Reallocation of water storage at Alamo would include only the 362,560 acre foot Water Conservation Pool (1070-1171.3 feet) and would change its purpose from water conservation to threatened and endangered species, fish and wildlife, downstream riparian habitat, and recreation.

Native fish have recently become a more significant issue due to the listing of razorback sucker and bonytail chub as Federally endangered. In a 1994 Federal Register Notice, critical habitat for

bonytail chub included Lake Havasu. Although there are no conclusive historic records of threatened or endangered fish populations in the Bill Williams River, ongoing investigations into potential introduction sites for native fish recovery efforts have included the Bill Williams River. A future listing of the willow flycatcher as endangered would also have significant implications in evaluating Alamo Dam releases and their effects on downstream riparian habitats of the flycatcher.

Biological and ecological monitoring studies need to be established along with any reoperation proposal for Alamo Dam. Fish, wildlife, and riparian resources of Alamo Lake and the Bill Williams River corridor are valuable and unique and are expected to benefit greatly from reoperation of Alamo Dam. The question of how well these resources respond to enhanced water management and if they meet optimal goals can only be answered conclusively by establishing and maintaining monitoring studies. How these studies will be conducted, coordinated, and cost-shared among resource agencies will need resolution.

This Technical Committee report further serves the general, intended purpose of a Corps' follow-on water control study. A follow-on water control study was recommended in the 1990 Corps Alamo Lake Reconnaissance Study as a means to develop an optimum storage allocation and operation schedule of all Alamo Lake project purposes.

C. FUTURE ACTIONS, ACTIVITIES

It is important to recognize that reoperation of Alamo Dam itself may not be sufficient to fully achieve all resource potentials. Management and monitoring of environmental and recreational resources by agencies will continue to be a critical component in the overall optimization of resources associated with Alamo Lake and the Bill Williams River.

There are five principle, sequential administrative steps in reallocation by the Corps:

1. Preparation of a Initial Appraisal Report (IAR),
2. Preparation of a Reconnaissance Report,
3. Preparation of a Feasibility Report,
4. Approval of Feasibility Report recommendation by Corps' Office of the Chief of Engineers, and Secretary of Army, and
5. Congressional reallocation approval.

The IAR is a Corps internal document that tiers off the 1990 Alamo Lake Reconnaissance Study and considers the water management proposal in this report. An IAR is currently under development by the Corps and is a necessary precursor to a Reconnaissance and Feasibility Report. The issue identification, modeling and concensus building developed in this report will likely represent a substantial portion of the Reconnaissance Study. The Reconnaissance Study requires a non-Federal sponsor, but the Corps provides 100% of the funding.

The Feasibility Report will primarily address all impacts associated with the proposed 1125 foot target plan relative to current conditions. When Corps' project changes are for environmental enhancements, a variety of procedural criteria are involved. Determinations must be made

whether: 1) project benefits are local or national in character, 2) enhancements benefit threatened and endangered species, or 3) changes benefit values on federal lands. Federal lands in the project area include BLM lands and Wilderness areas, and the USFWS Bill Williams River National Wildlife Refuge. Some of the federal values may include fish and wildlife, riparian/wetland habitat, water rights, and long-term reliability of Lower Colorado River water deliveries. The Feasibility Report, which includes environmental and economic evaluations, requires a non-Federal sponsor to share, 50/50, study costs. If environmental benefits of a reoperation are largely of a federal nature, non-Federal costs may be reduced or replaced with congressionally approved funds.

Any additional Operation and Maintenance (O&M) costs to operate Alamo Dam under the proposed plan will require economic compensation to the Corps by either a non-federal entity or by congressional appropriation. Reoperation of Alamo Dam, according to the proposed plan, is not anticipated to result in any significant increase in Alamo Dam operation and maintenance costs. Further, reoperation of Alamo Dam according to the proposed plan will not require any foreseeable structural modifications to Alamo Dam facilities.

Since the magnitude of this reallocation (in terms of water storage) exceeds Corps' existing authority, it is anticipated that implementation of the proposed plan will require Congressional approval to reallocate the entire 362,560 acre-foot Water Conservation Pool for threatened and endangered species, fish and wildlife, riparian habitat, and recreation purposes. Congressional action may be requested by formal Corps recommendations from the Feasibility Report or prompted by legislation from the Arizona delegation.

Following Congressional reallocation of Alamo Lake storage, the final step for formal reoperation is to revise the Water Control Manual for Alamo Dam. It is estimated that all these steps may take from 3-5 years. During the interim period the Technical Committee recommends the Corps exercise operational flexibility, as legally allowed, under the current Manual to operate Alamo Dam in a manner approximating the proposed 1125 foot target plan. The Technical Committee also recommends that the Corps coordinate interim operations with them as has been done in recent years. In anticipation of the reallocation, advance preparations of a draft revised water control manual could occur to expedite this final implementation step. It is important to recognize that these steps may be reduced or expedited by specific Congressional actions in the future.

D. FUTURE OF THE TECHNICAL COMMITTEE

The Technical Committee will need direction from the Steering Committee on their role and involvement in implementing the proposed water management plan. There is merit in continuing in a cooperative, interagency framework to actively pursue resolution of the numerous remaining issues. Further, the Technical Committee demonstrated its effectiveness as a forum for collaborative input to the Corps on lake level management and Alamo Dam release prescriptions during the 1993 flooding.

VII. BIBLIOGRAPHY

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VIII. APPENDICES

APPENDIX A. Technical Committee Membership and Participant List

(members of the five Subcommittees are listed in their respective reports found in Appendices D-H, Volume II)

ARIZONA GAME AND FISH DEPARTMENT

Dennis Kubly - Technical Committee
Eric Swanson - Technical Committee Coordinator
Larry Voyles - Technical Committee
Jim Burton
Dave Conrad
Brad Jacobson - Fisheries Subcommittee Chair
Robert Posey
Jerry Sako
Mike Senn
Bill Werner

ARIZONA STATE PARKS

Dave La Pointe - Steering Committee, Technical Committee
William Ballinger - Recreation Subcommittee Chair
Bob Sejkora

ARIZONA DEPARTMENT OF WATER RESOURCES

Frank Barrios - Technical Committee
Joe Stuart

U.S. ARMY CORPS OF ENGINEERS

Ted Carr - Technical Committee
Charles S. Dwyer - Steering Committee
Joe Evelyn - Technical Committee, Reservoir Operations Subcommittee Chair
Mike Burnham
Joe Dixon
Bob Stuart
Billy Thomas

U.S. BUREAU OF LAND MANAGEMENT

Sarah Hooper - Technical Committee, Riparian Subcommittee Chair
Clif Bobinski
Al Doelker
Jim Renthal
Brenda Smith
Bill Watters

U.S. BUREAU OF RECLAMATION

Walt Muir - Technical Committee
Alden Briggs
Dave Busch
Bill Martin
Tom Shrader

U.S. FISH AND WILDLIFE SERVICE

Nancy Gilbertson - Technical Committee
Ron McKinstry - Technical Committee
Dick Steinbach - Technical Committee
Steve Cullinan
Les Cunningham
Nita Fuller
Jim Good
Celina Harshman
Barbara Raulston
Paul Tashjian
Tim Tibbitts - Wildlife Subcommittee Chair

APPENDIX B. Chronology of Technical Committee Activities

October 16, 1990	Initial meeting of agencies (AGFD, ASP, USFWS, BLM, Corps). Initiation of coordinated effort to resolve conflicts surrounding management of waters in the Bill Williams River corridor. Adoption of 13 step process. Phoenix.
August 6, 1991	First Technical Committee meeting. Phoenix.
October 24, 1991	Technical Committee meeting. Tucson.
December 4, 1991	Technical Committee meeting. Phoenix.
August 17, 1992	Technical Committee meeting. Phoenix.
December 15, 1992	Technical Committee meeting. Phoenix.
September 17, 1992	Technical Committee Briefing Report distributed to Steering Committee for concurrence and signatures.
January 6, 1993	Notification of coordinated interagency efforts to Congressional delegation and landowners. Press release.
April 1, 1993	Technical Committee meeting. Phoenix.
July 20-21, 1993	Technical Committee meeting. Lake Havasu City.
October 5, 1993	Technical Committee meeting. Phoenix.
November 4, 1993	Technical Committee meeting. Phoenix.
December 8, 1993	Technical Committee meeting. Phoenix.
January 25, 1994	Technical Committee meeting. Phoenix.
March 1, 1994	Technical Committee meeting. Phoenix.
April 27, 1994	Technical Committee meeting. Phoenix.
June 28, 1994	Technical Committee meeting. Phoenix.
September 7, 1994	Technical Committee meeting. Phoenix.

APPENDIX C. Agency Goals

ARIZONA GAME AND FISH DEPARTMENT

Bill Williams River Corridor Planning

Identified Goals -

1. Maintain or restore riparian/wetland ecosystems to site potential.

2. Maintain or enhance habitat requirements of endangered, threatened, sensitive, and native wildlife species.

3. Maintain or enhance the quality of the recreational and warmwater fishery resources at Alamo Lake.

4. Maintain or enhance habitat requirements for waterfowl and shorebirds.

5. Evaluate the potential for a native fisheries at the Bill Williams River below the dam.

6. Evaluate the potential for cold water and warmwater sport fisheries below the dam.

Technical Committee members:

Dennis Kubly, Phoenix Nongame Branch
Eric Swanson, Phoenix Habitat Branch
Larry Voyles, Yuma Regional Office

Proposed Subcommittee members:

Riparian/Wetlands

Mary Jo Croonquist, Kingman Regional Office
Bill Werner, Yuma Regional Office

T&E Species, Waterfowl and Other Wildlife

John Hervert, Yuma Regional Office
Fenton Kay, Habitat Branch, Phoenix
Phil Smith, Game Branch, Phoenix

Fisheries

Brad Jacobson, Yuma Regional Office - **Chairman**

Recreation and Access

Jim Glass, Development Branch, Phoenix
Brad Jacobson, Yuma Regional Office

Reservoir Operations and Stream Hydrology

Jim Burton, Development Branch, Phoenix
Jerry Sako, Development Branch, Phoenix

SIGNATURES

Duane Shroufe, Director — 17 Sep 92 Date

ARIZONA STATE PARKS

Bill Williams River Coridor Planning

Identified Goals -

1. Develop a water model that results in minimum fluctuations to the lake surface, preferably between 1108' and 1120'.

2. Develop, maintain, operate and enhance recreational facilities at Alamo Lake.

3. Develop new master plan for Alamo Lake State Park.

Technical Committee member: Dave La Pointe

Proposed Sub-committee members:

T&E Species, Waterfowl and other Wildlife
Dave La Pointe, Lake Havasu Regional Office

Fisheries
Dave La Pointe, Lake Havasu Regional Office

Recreation and Access
William Ballinger, Alamo Lake State Park - **Chairman**

Reservoir Operations and Stream Hydrology
William Ballinger, Alamo Lake State Park

SIGNATURES

David A. LaPointe
Dave La Pointe, Regional Manager

Sept. 23, 1992
Date

BUREAU OF LAND MANAGEMENT

Bill Williams River Corridor Planning

Identified Goals -

1. Maintain or restore a properly functioning riparian/wetland ecosystem in the Bill Williams River Corridor.

2. Enhance fish and wildlife habitat, including habitat for waterfowl and threatened, endangered, and sensitive species, by providing habitat requirements of these species in the Bill Williams River Corridor.

3. Preserve the wilderness character of the designated wilderness areas in the Bill Williams River Corridor.

~~4. Maintain the recreational fishery in Alamo Lake.~~ NA

5. Provide for multiple-use activities on public lands within the Bill Williams River Corridor, applying special management guidelines when necessary to protect, enhance, and rehabilitate the riparian resources.

Technical Committee members:
Sarah Hooper, Lake Havasu Resource Area
Bill Watters, Yuma District

Proposed Subcommittee members:

Riparian/Wetlands
Ron Hooper, Arizona State Office
Sarah Hooper, Havasu Resource Area - **Chairman**

T&E species, Waterfowl and Other Wildlife
Brenda Smith, Yuma District

Fisheries
Al Doelker, Havasu Resource Area

Recreation and Access
Don Applegate, Yuma District
Clif Bobinski, Havasu Resource Area
Ron Morfin, Yuma District

Reservoir Operations and Stream Hydrology
Cory Bodman, Yuma District

SIGNATURES

Beaumont C. McClure — 12/7/92

Beaumont McClure, Deputy State Director — Date

CORPS OF ENGINEERS

Bill Williams River Corridor Planning

Identified Goals -

1. Develop a recommended reservoir water control plan which best meets the coordinated objectives of the Bill Williams River Corridor Study participating agencies, while satisfying the project's authorized purposes, applicable authorities established after project construction, and Corps of Engineers water control management guidance.

2. Seek Corps of Engineers, and if necessary congressional, authority to implement the recommended water control plan. The recommended water control plan may require a reallocation of reservoir storage to be fully implemented.

3. Prepare a water control manual for Alamo Dam in which the recommended water control plan is adopted. Obtain Corps of Engineers approval of that water control manual.

4. Maintain Alamo Lake Fishery for water sport.

5. Provide for effective land management activities within the flood control basin for wildlife, recreation, public access, riparian and wetland habitats, endangered species and enhancement opportunities.

Technical Committee members:
Ted Carr, LA District, Operations Branch
Joe Evelyn, LA District, Hydrology and Hydraulics Branch

Proposed Subcommittee members:

Riparian/Wetlands
Mark Durham, Operations Branch (213) 894-6423

T&E Species, Waterfowl, and Other Wildlife
Carvel Bass, Operations Branch (213) 894-6422
Mark Durham, Operations Branch

Fisheries
Carvel Bass, Operations Branch

Recreation and Access
Ted Carr, Operations Branch (213) 894-5635

Reservoir Operations and Stream Hydrology
Joe Evelyn, Hydrology and Hydraulics Branch - **Chairman**
(213) 894-5520

Bob Stuart, Reservoir Regulation Section (213) 894-3001
Lowell Flannery, Chief, Engineering Evaluation Section
(213) 894-4926
Terry Wotherspoon, Engineering Evaluation (213) 894-4926

SIGNATURES

Carl F. Enson, PE
Chief, Construction-
Operations Division

12/18/92
Date

U.S. FISH AND WILDLIFE SERVICE

Bill Williams River Corridor Planning

Identified Goals -

1. Preserve, maintain, and enhance the integrity of the Bill Williams River ecosystem with primary emphasis on the riparian community and wetland habitats.

2. Provide habitat for federally and state listed endangered and threatened species, and species of special management concern including the bald eagle, Yuma clapper rail, black rail, yellow-billed cuckoo, Yavapai leopard frog, and willow flycatcher.

3. Provide habitat for migratory birds, including nesting species and wintering waterfowl.

4. Provide high quality wildlife-oriented recreation to the extent these activities are compatible with the purposes for which the refuge was established.

Technical Committee members:
Nita Fuller, Albuquerque Regional Office
Nancy Gilbertson, Bill Williams Wildlife Refuge
Ron McKinstry, Phoenix Ecological Services

Proposed Subcommittee members:

Riparian/Wetlands
Nancy Gilbertson, Bill Williams Wildlife Refuge
Sue Rutman, Phoenix Ecological Services

T&E Species, Waterfowl and Other Species
Jim Clark, Refuges, Albuquerque Regional Office
Ron McKinstry, Phoenix Ecological Services
Tim Tibbits, Phoenix Ecological Services - **Chairman**

Fisheries
Chuck Minckley, Parker Fisheries Assistance Office

Recreation and Access
Cheryl Simpson, Refuges, Albuquerque Regional Office

Reservoir Operations and Stream Hydrology
Steve Cullinan, Water Management, Albuquerque Regional Office

SIGNATURES

John G. Rogers — 9/25/92

John Rogers, Regional Director — Date