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.

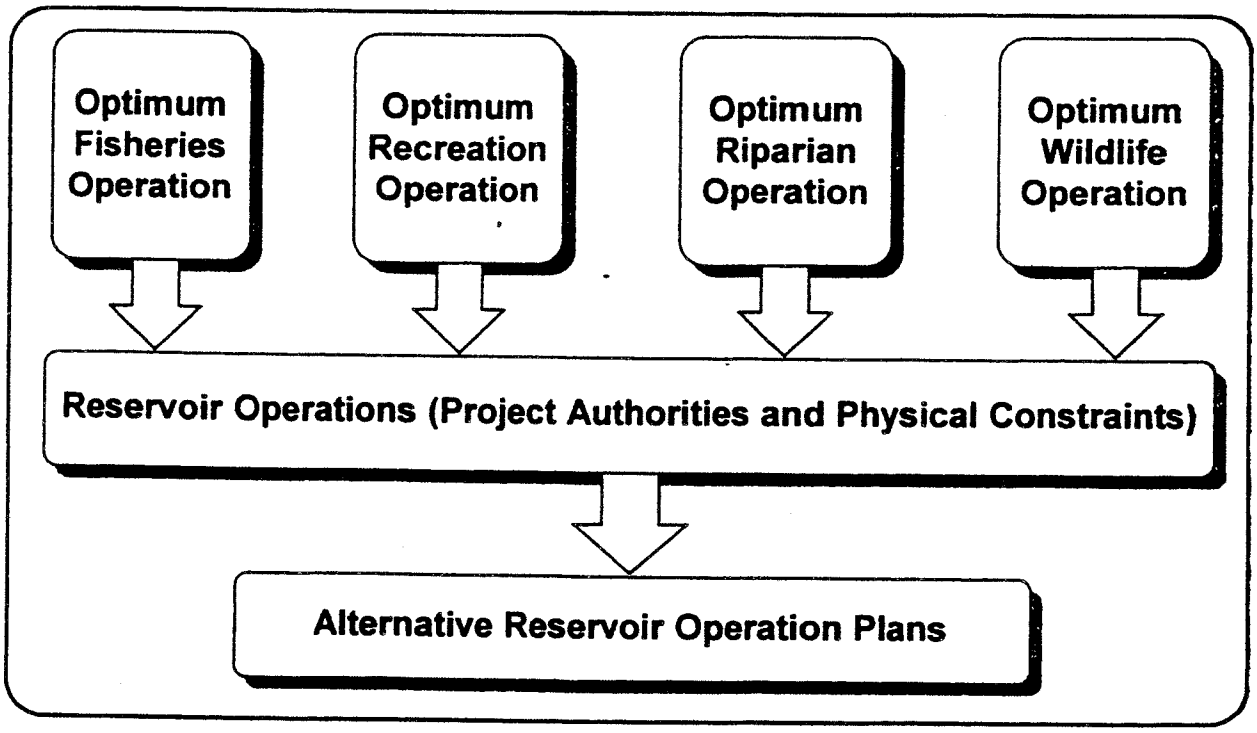

Figure 5. Generalized process to formulate water operation plan alternatives from subcommittee optimal recommendations.

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.