STAGE II REPORT

Prepared by

ARIZONA PROJECTS OFFICE
WATER AND POWER RESOURCES SERVICE

Assisted by

LOS ANGELES DISTRICT
U.S. ARMY CORPS OF ENGINEERS

CENTRAL ARIZONA WATER CONTROL STUDY

MARCH 1981

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This report was prepared pursuant to Public Law 90-537, the Colorado River Basin Project Act. Publication of the findings and recommendations contained herein should not be construed as representing either the approval or disapproval of the Secretary of the Interior. The purpose of this report is to provide information and alternatives for further consideration by the Water and Power Resources Service, the Secretary of the Interior, and other Federal agencies.

SUMMARY

The Central Arizona Water Control Study (CAWCS) was born out of an effort to provide a consensus on what should be done to solve central Arizona's water problems of flooding and water supply. In 1968, the U.S. Congress authorized the construction of Orme Dam, or a suitable alternative, as part of the Central Arizona Project (CAP). A draft environmental impact statement was prepared for Orme Dam in 1976. Public response to the statement indicated substantial environmental, economic and social concerns regarding the inundation of a major portion of the Fort McDowell Indian Reservation and riparian habitats, and impacts upon habitat of the endangered bald eagle and other species. These and other concerns caused the Water and Power Resources Service (Service) to reassess the facility.

An Interagency Task Force was established in March 1977 to review alternative methods of achieving flood control and regulatory storage of CAP water, but before the Task Force could complete its findings, President Carter recommended elimination of Orme Dam from the CAP. This recommendation gave added urgency to the work of the Task Force which presented its findings in May 1978 identifying several alternatives for further study.

In July 1978, following the Task Force findings, the Service initiated the CAWCS to develop plans for the solution of flood problems along the Salt and Gila Rivers and for regulatory storage of CAP water. Because of the flood control aspect of the study, the U.S. Army Corps of Engineers (Corps) is assisting the Service, and is responsible for the flood control planning and analysis. Study organization is shown in the accompanying illustration.

As shown in the accompanying schedule, the CAWCS is being conducted in three stages. The first stage of the study, which identified problems and a wide array of possible solutions (elements) and recommended those meriting further study, was completed in May 1979. Stage II, now complete, developed and analyzed intermediate plans (systems) and recommended a number of actions for further detailed study as plans in Stage III. Stage II analysis carried out for flood control by the Corps and for regulatory storage by the Service involved:

- Hydrology and hydraulic analyses.
- Geotechnical investigations.
- Design and cost estimates.
- Economic analysis.
- Conceptual recreation plan development.
- Environmental and socioeconomic analysis.
- Institutional analysis.

Recommendations were based largely on performance, optimization, economics, environmental and social impacts and institutional factors. By October 1981, toward the end of Stage III, the recommended plan or plans will have been identified. At that time an environmental impact statement will be prepared. A field draft EIS will be completed in December 1981 and the final recommendation on the adopted plan will be made upon completion of the final EIS. The time required for processing the final report and filing the draft EIS, holding the public hearing, and filing the final EIS can be as short as 7 months, but typically takes 15 to 18 months.

A. Planning Area Description

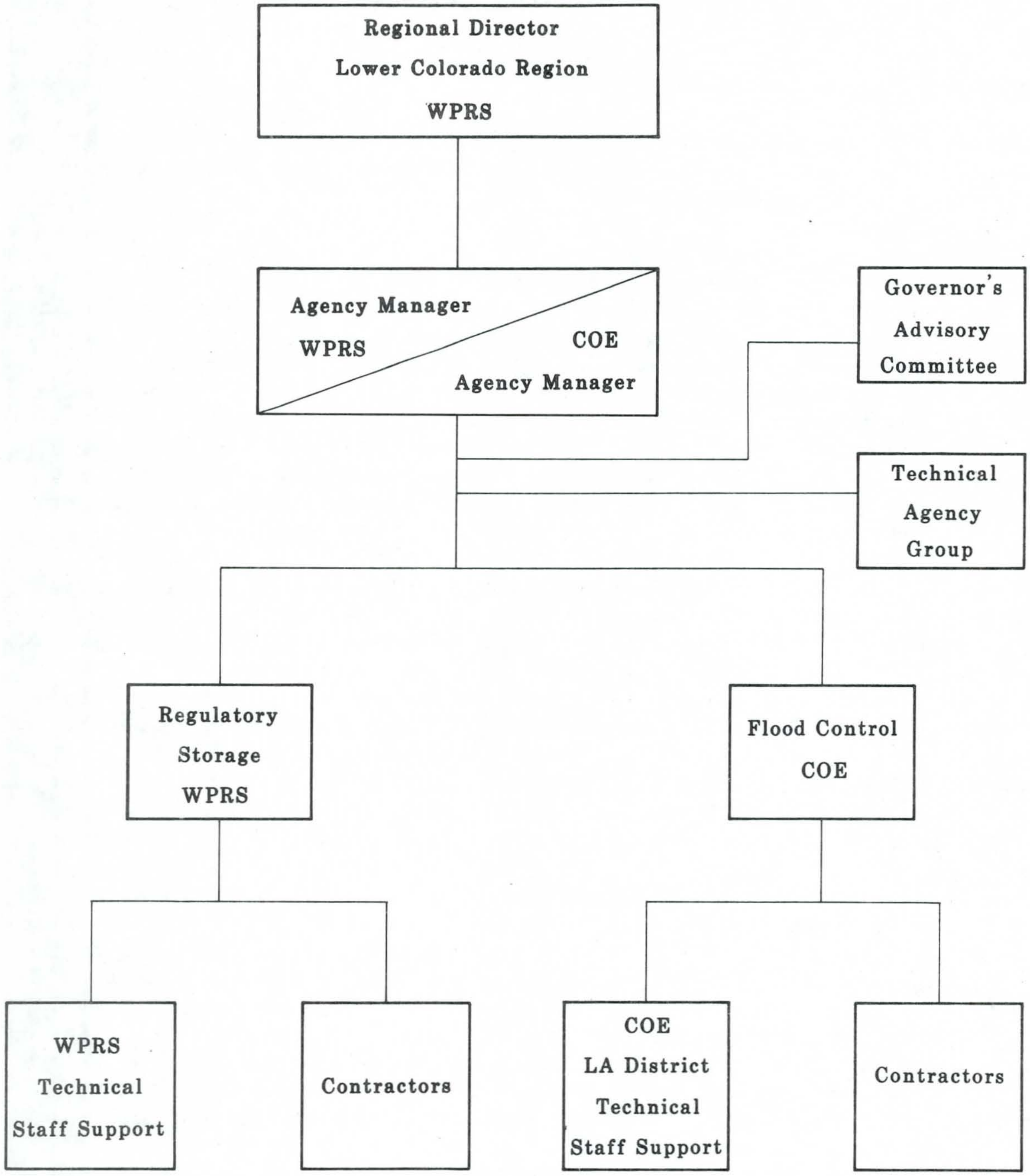
The CAWCS planning area encompasses about 12,800 square miles in Gila, Maricopa, and Pinal Counties, as shown in the accompanying figure. The planning area is characterized by mountain ranges with steep slopes and rugged topography separated by broad, gently-sloping, alluvium-filled valleys. The climate is arid to semiarid. Vegetation varies with elevation, available moisture, and temperature, with only the hardiest plant life, such as creosote bush in the desert plains, and lush Sonoran desert vegetation in the higher elevations. Wildlife is typical of that found in the desert and foothill regions of the Southwest, including gray fox, mule deer, and desert cottontail rabbit. Several threatened or endangered species are found in the area, namely the bald eagle, Yuma clapper rail, and peregrine falcon and two plants, the Arizona hedgehog cactus and the Turk's head cactus.

The total population of the area is about 1.5 million, almost 90 percent of which resides in Maricopa County. There are five Indian Reservations in the study area: the Fort McDowell Reservation on the lower Verde River, the Gila River Reservation, the Salt River Pima-Maricopa Reservation, the Ak-Chin Reservation, and two portions of the Papago Indian Reservation. The population of these Indian Communities is just over 13,000.

Vast areas of the CAWCS area remain in their natural state, unaltered or only slightly modified by man's activities. About 75 percent of the area is rangeland; agricultural lands, urban built-up lands, forest lands, barren lands, water bodies, and wetlands comprise the remainder. About 70 percent of the lands in the area remain in public ownership or are Indian Reservations.

The CAWCS area is a major center for economic activity in the Southwest. Leading factors in the area's economy are manufacturing, tourism, retail trade and services, government and agriculture. The economic importance of agriculture in the CAWCS area is expected to continue to decline as the urbanization of metropolitan Phoenix increases.

Water in the study area comes from major streams and their tributaries, supplemented by ground water. According to the Arizona Water Commission (1978), the total annual consumptive use of water in the Salt River Basin is estimated at 1.5 million acre-feet, while the total annual dependable surface supply is only 931,000 acre-feet (normalized 1970 conditions). Groundwater reserves are being overdrafted at an average rate of 632,000 acre-feet per year to supplement the dependable surface supply. Some treated municipal and



Study Organization

industrial wastewater is reused for irrigation and supplements the water supply. Of the total water used, over 80 percent is for agricultural purposes and converted urban use.

B. Problems, Needs and Issues

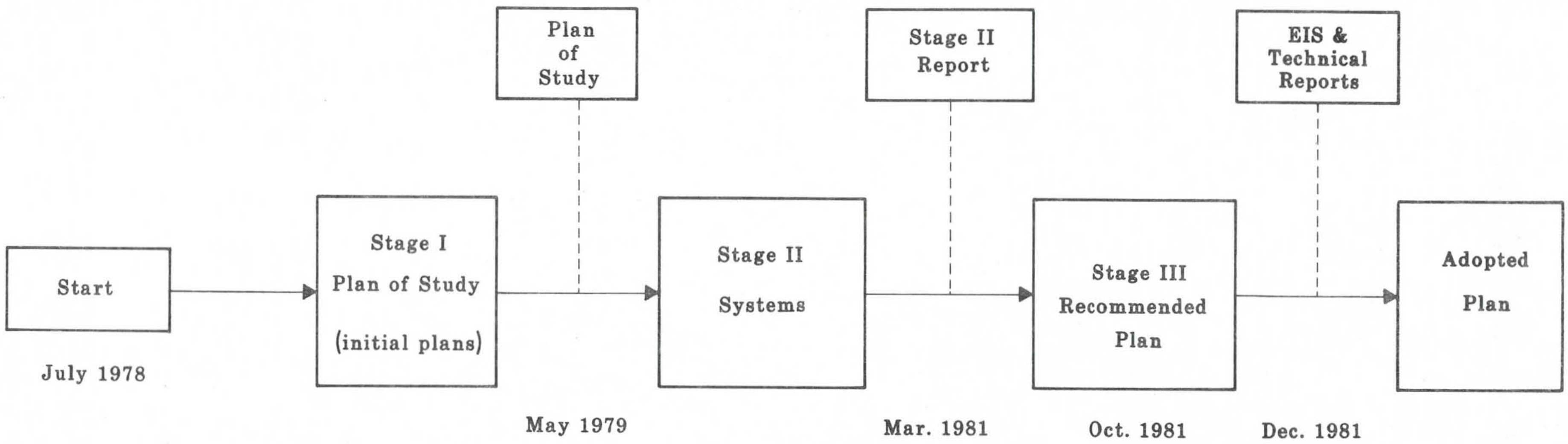
Identifying and addressing problems and issues is a continuing process in the CAWCS, assuring that public concerns are addressed throughout alternative development, evaluation and selection.

Flooding along the Salt and Gila Rivers has been a problem for the Phoenix area since its early settlement. The recent floods of 1978, 1979, and 1980 have confirmed the flood hazard conditions along the Salt and Gila Rivers and the need to formulate and implement a plan to reduce damages. Monetary damages along the two rivers were estimated at $31 million from the February and March 1978 floods and $46 million for the December 1978 flood. Flood damage reports for the February 1980 floods have not been published but were estimated to be in the range of $60 million. The Salt River Project (SRP) dams and reservoirs upstream on the Salt and Verde Rivers can reduce peak flows, but only if storage space is available since the primary purpose of the dams is water conservation.

The most severe flood that can reasonably be expected to occur in the region based on a combination of meteorological and runoff conditions is called a standard project flood (SPF). Most recent analysis by the Corps has established the SPF peak flow at 295,000 cubic feet per second (ft^3/s), and the Corps estimates that a flood of this magnitude on the Salt River would cause an estimated $477 million in damages. Not all flood damages are physical, however; the social ramifications of flooding are a major issue as well. Dislocation of residents and damage to public and transportation facilities impose hardship on residents and have ramifications which extend beyond the flooding itself to the time required to repair and recover from the damage.

Maintaining an adequate water supply for agricultural, municipal and industrial purposes is a major problem in the CAWCS area. The CAP will transport Colorado River water to the Phoenix metropolitan area by 1985 and to the Tucson metropolitan area by 1988. Average diversions by CAP are estimated to be approximately 1.2 million acre-feet/year over the 50-year period from 1987 to 2036. It is estimated that regulatory storage accounts for 5-15 percent of the annual CAP delivery. With regulatory storage extra water could be brought in during the winter months, put in storage and be available to add to the amount of Colorado River water that CAP can deliver during the high-use summer months. In addition to maximizing use of Colorado River water and meeting fluctuating water demands, regulatory storage would provide more operational reliability and flexibility in the CAP in emergency situations, and reduce dependence on the use of energy during peak periods.

The construction of a dam anywhere and particularly upstream of a major metropolitan area always involves consideration of the safety of the structure. With the February 1980 flood and questions raised about the safety of Stewart



CAWCS SCHEDULE

Mountain Dam, public awareness of the importance of dam safety has increased in the CAWCS area. Based on the Reclamation Safety of Dams Act (1978), the Service is conducting a dam safety study to evaluate the condition of the dams on the Salt and Verde Rivers and investigate alternative solutions to the dam safety problems found on the systems. The results of this dam safety study relate to the CAWCS in two ways. First, the CAWCS is looking at a flood control and water storage system among a series of existing dams which were designed for water conservation purposes and which would have to operate in conjunction with any new structures. Additional flood control storage cannot be considered at an existing dam before considering the safety of that dam. The CAWCS could be a vehicle to solve safety problems, through design of a new structure which could incorporate into it not only the flood control purpose of the CAWCS but also safety of dams. While the Safety of Dams study and the CAWCS are independent of each other, the alternatives examined in each can necessarily be coordinated.

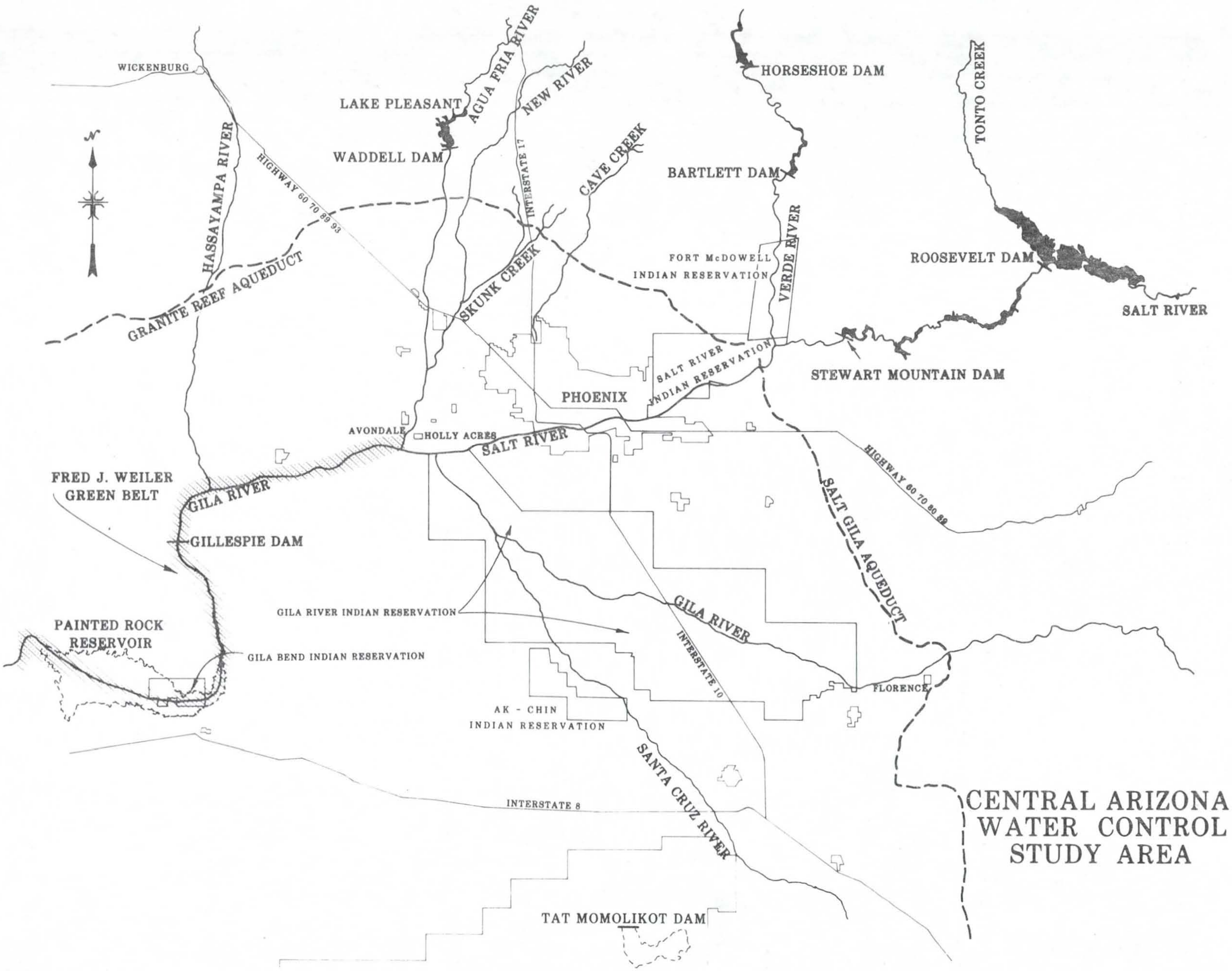
Other problems and issues considered in the study include:

- Impacts on wildlife and vegetation, particularly threatened and endangered species and cultural resources.
- Impacts on and benefits to recreation.
- Water rights, both Indian water rights and ground water rights.
- Energy conservation.
- Land use.
- Social and economic issues.

C. Description and Evaluation of Elements

In the first portions of Stage II, the aim was to evaluate a large number of elements and select the best for building systems. Initially, there were 20 flood control and/or regulatory storage elements. Some of these elements were "competing." In other words, two or more elements provided essentially the same function at different sites or with different actions. These elements could therefore be "screened" and the best selected for forming systems. Also, based on preliminary results of the dam safety study, two elements were added on the Salt River. Following is a brief description of the elements and results of the evaluation. Results are also summarized in the accompanying tabulation.

1. Verde River. Three sites were investigated primarily for flood control on the Verde River: 1) New Horseshoe Dam and Reservoir, 2) Cliff Dam and Reservoir, and 3) New Bartlett Dam and Reservoir. A new dam at any of these sites would provide flood control for the Verde River with enough storage space by itself to control the SPF to 150,000 ft^3/s. When operated in conjunction with a new or modified structure on the Salt River, the SPF could be reduced to as low as 50,000 ft^3/s below the confluence. At its largest


WICKENBURG
HASSAYAMPA RIVER
HIGHWAY 60 70 89 93
LAKE PLEASANT
WADDELL DAM
AGUA FRIA RIVER
NEW RIVER
INTERSTATE 17
CAVE CREEK
SKUNK CREEK
GRANITE REEF AQUEDUCT
HORSESHOE DAM
BARTLETT DAM
FORT McDOWELL
INDIAN RESERVATION
VERDE RIVER
TONTO CREEK
ROOSEVELT DAM
SALT RIVER
STEWART MOUNTAIN DAM
SALT RIVER
INDIAN RESERVATION
PHOENIX
AVONDALE
HOLLY ACRES
SALT RIVER
HIGHWAY 60 70 80 89
FRED J. WEILER
GREEN BELT
GILA RIVER
GILLESPIE DAM
SALT GILA AQUEDUCT
GILA RIVER INDIAN RESERVATION
GILA RIVER
INTERSTATE 10
PAINTED ROCK
RESERVOIR
GILA BEND INDIAN RESERVATION
FLORENCE
AK - CHIN
INDIAN RESERVATION
SANTA CRUZ RIVER
INTERSTATE 8
TAT MOMOLIKOT DAM
CENTRAL ARIZONA
WATER CONTROL
STUDY AREA

RESULTS OF ELEMENT EVALUATION

Element	Purpose: Flood Control	Purpose: Regulatory Storage	Further Study: Warranted	Further Study: Unwarranted
VERDE RIVER				
Horseshoe Dam	o	o		o
Cliff Dam	o	o	o	
New Bartlett Dam	o	o		o
SALT RIVER				
New/Enlarged Roosevelt Dam	o	o	o	
New Stewart Mountain Dam	o	o	o	
CONFLUENCE				
Confluence Dam	o	o	o	
Granite Reef Dam	o	o		o
SRP REREGULATION	o		o	
CHANNELIZATION				
Channels	o			o
Levees	o		o	
Phoenix Greenbelt	o			o
NONSTRUCTURAL MEASURES	o		o	
OFF-SALT REGULATORY STORAGE				
New Waddell Dam		o	o	
Lake Pleasant Storage		o		o
Buttes Dam		o		o
Tat Momolikot Dam		o		o
UNDERGROUND STORAGE		o	o	
WATER EXCHANGE		o	o	
NO ACTION			o	

embankment, a new dam would also provide new water storage space which could be used for CAP regulatory storage. It is estimated that the total net increase in CAP yield would be 40-60,000 acre-feet/year.

As these three elements provide essentially the same function in similar locations, the sites were screened to select the best for further study. The analysis showed that the New Horseshoe Site was clearly inferior to New Bartlett in terms of environmental impact. However, costs for New Bartlett were over twice that of the other elements. Cliff was comparable to New Horseshoe in cost and better in terms of impact. Based on these results, Cliff was selected because of its moderate cost and environmental impact.

2. Salt River. Two elements were considered primarily for flood control on the Salt River: 1) Enlarged or New Roosevelt Dam, and 2) New Stewart Mountain Dam. A dam at either site would provide flood control on the Salt River, with enough storage to by itself reduce the SPF to 200,000 ft^3/s below the confluence. In conjunction with a new or modified structure on the Verde, the SPF could be reduced to as low as 50,000 ft^3/s. New water storage space could be used for regulatory storage of CAP water, resulting in an increase of 49,000 acre-feet/year with Roosevelt, and 46,000 acre-feet/year with New Stewart Mountain Dam. While these elements appear to be competing, both elements have specific attributes which recommend them for further detailed study. Once the Safety of Dams action is better defined on the Salt River, it will be desirable to perform additional screening of Salt River elements early in Stage III.

3. Salt/Verde Confluence. Two sites were investigated at or near the confluence of the Salt and Verde Rivers for flood control and/or CAP regulatory storage: 1) Confluence Dam; and 2) Granite Reef Dam, 4 miles downstream of the confluence. Both multipurpose flood control and regulatory storage and single-purpose dams were investigated. A multipurpose dam or single-purpose flood control dam would control the SPF to 50,000 ft^3/s below the confluence. Relative to regulatory storage, it is estimated that with a multipurpose dam, regulatory storage would result in an increase of about 110,000 acre-feet/year of available water. A single-purpose regulatory storage only dam would result in an increase of about 140,000 acre-feet/year, directly attributable to the availability of more storage.

The Confluence and Granite Reef sites were compared. The comparison showed that while environmental and social impacts were essentially the same for both sites, geology and cost significantly favored the Confluence site. The Confluence Site was therefore selected for use in forming systems.

4. SRP Reregulation. Two actions were considered for SRP reregulation: 1) 439,000 acre-feet of flood storage with no modification of existing dams, and 2) 556,000 acre-feet of flood storage with modification (new flood outlets) of existing dams. Reregulation without modifications is designed to control the 50-year flood (175,000 ft^3/s) to a target flow of 150,000 ft^3/s. It would also reduce the SPF (295,000 ft^3/s) to 270,000 ft^3/s. Approximately 21 percent of SRP's existing storage would be dedicated to flood control purposes. With modifications, reregulation is designed to reduce the 100-year flood

(245,000 ft^3/s) to 100,000 ft^3/s. It would also reduce the SPF to 210,000 ft^3/s. Approximately 27 percent of SRP's storage would be dedicated to flood control. Both reregulation options were carried forward to system building.

5. Channelization. Three methods of channelization were considered for flood control downstream through Phoenix: 1) channels on the Salt River, from Country Club Drive to 35th Avenue; 2) two-sided levees on the Salt River from 35th Avenue to Country Club Drive and a one-sided levee on the Gila River from 91st Avenue to Gillespie Dam; and 3) greenbelt areas from Country Club Drive to 35th Avenue. While these elements would not reduce the peak flow, they would be designed to contain up to the SPF. The results of the screening of these three competing elements indicated that in all categories, except cost, the elements were similar. Cost therefore became the decisionmaking factor, and on that basis, Phoenix levees were selected as the most cost-effective element for use in system building.

6. Nonstructural Measures. Nonstructural measures considered in the CAWCS are flood loss reduction measures aimed at reducing flood damages due to development in flood-prone areas, rather than changing the flow of water. Measures considered include:

- Modification to existing structures.
  - Flood proofing.
  - Relocation.
- Regulation of future development.
  - Application of the existing ordinance in the 25-year and 500-year flood plains, in addition to the 100-year flood plain.
  - No development at all in the flood plain.
  - Modification of the existing ordinance for raising residential structures and flood proofing commercial and industrial structures.
  - Sand and gravel mining regulations.
- Preparedness Planning.
  - Development of a preparedness plan for the catastrosphic event.
  - Enhanced public awareness programs to keep the plan active.
  - SPF bridges.

Based on investigation of these measures, nonstructural measures determined feasible for combination in plans are:

- Flood proofing to the 50-year level.
- Preparedness planning.
- SPF bridges.
- Enforcement of the existing flood plain ordinance.
- Sand and gravel mining regulations.

7. Regulatory Storage Not Located on the Salt or Verde Rivers. Several sites not located on the Salt or Verde Rivers were considered primarily for regulatory storage purposes:

- New Waddell Dam. The new dam would be located on the Agua Fria, one-fourth mile downstream of the existing dam. It is estimated that with this feature the CAP would yield an increase of 106,000 acre-feet/year in available water. Although no flood control storage volume would be included, downstream flooding could be reduced if there is available storage in the new regulatory storage pool or existing conservation pool.

- Lake Pleasant Storage. Two options were examined which make use of storage in Lake Pleasant behind Waddell Dam: 1) use of the existing dam, storing CAP water whenever space may be naturally available, or 2) enlarging the existing dam up to 14 feet for additional storage space for CAP storage. Because of the vacant space constraints with use of the existing dam, the increase in CAP yield is minimal under the first option (14,500 acre-feet/year). With enlargement of the dam, if feasible, an increase of 45,600 acre-feet/year in available water would result.

- Buttes Dam and Florence Dam. Buttes Dam is an authorized feature of the CAP to be located on the Gila River for development of Gila water resources. No ability to regulate Colorado River water would be provided. However, the CAWCS investigated: 1) Buttes Dam with regulatory storage ability in addition to the authorized function, and 2) Florence Dam, as an alternative to Buttes and assuming the functions of Buttes. With Buttes, an increase of 91,000 acre-feet/year of available water would result. With Florence, an increase of 70,100 acre-feet/year would result. Both sites also provide the opportunity for development of local Gila flows.

- Tat Momolikot. Tat Momolikot is an existing flood control facility on Santa Rosa Wash on the Papago Indian Reservation. The CAWCS examined reoperation of the dam to provide a reservoir for CAP water. With this feature, an increase of 23,800 acre-feet/year in available water would result.

A screening of these regulatory storage elements indicated that in terms of performance, cost and environmental/social impacts, sites on the Agua Fria River were preferred over Gila River sites and Tat Momolikot. A comparison then of New Waddell Dam or increased storage at Lake Pleasant showed that New

Waddell Dam would provide a greater increase in CAP water yield with a minor increase in environmental and social impacts. New Waddell Dam was therefore selected as the preferred regulatory storage element not located on the Salt or Verde Rivers.

8. Underground Storage. Underground storage was investigated for purposes of providing regulatory storage of CAP water. The underground storage system would straddle the Salt River channel downstream of Granite Reef Diversion Dam. It is also possible that water from upstream storage facilities could be delivered to the infiltration basins and stored underground in place of CAP water. This could provide additional storage space in the SRP conservation reservoir which could be utilized to reduce flood volumes. With this feature, an increased CAP yield of 63,000 acre-feet/year would result. This element was carried forward to system building.

9. Water Exchange. Regulatory storage could be achieved through water exchange between the CAP and the Salt River Project system. Two options were investigated: 1) exchange with no increase in reservoir capacity, and 2) exchange with increased reservoir capacity. The amount of water available for exchange depends on the amount of excess water available in the Colorado River, the amount of releases SRP has during the exchange period, and the amount of vacant storage space available in the system. With no increase in reservoir capacity, an increase of 14,500 acre-feet/year would result; with increased capacity, an increase of 55,000 acre-feet/year in available water would result. Both exchange options were carried forward to system building.

10. No Action. The no action alternative is a description of the future conditions without implementation of a project. Without regulatory storage:

- The CAP would be constructed, but would provide no regulatory storage.
- Buttes Dam would be constructed to conserve Gila flows only.

Without flood control:

- Twelve new bridges would be constructed or modified. The majority will be capable of withstanding flows of up to 200,000 ft^3/s.
- Channelization of the Salt River near Sky Harbor would be completed.
- The Flood Control District of Maricopa County will complete channel clearing of the Gila River between 91st Avenue and Gillespie Dam.

D. Description and Evaluation of Systems

Based on the evaluation of elements, the remaining elements were combined into systems to optimize the ability to provide both flood control and regulatory storage. Seven critical factors which reflect important considerations to address in building and later in evaluating systems were identified:

- o Flood control performance.
- o Regulatory storage performance.
- o Dam safety.
- o Economics.
- o Environmental impacts.
- o Social impacts.
- o Institutional constraints.

Initially, six concepts were defined and then systems were built which fit those concepts. While "no action" is a possible course for the CAWCS, it is not included as a concept because it does not solve the problems of flood control and water supply. Rather it will be used as a basis of comparison in evaluating systems. Thirteen systems were developed under the various concepts. Data are summarized in the accompanying tabulation and described below.

1. Concept 1: Salt OR Verde Control. Under this concept, one structure provides both flood control and regulatory storage on either the Salt or Verde River. Three elements, which are systems in themselves, fit this concept:

1A Cliff Dam

1B Enlarged/New Roosevelt Dam

1C New Stewart Mountain Dam

All systems in this concept have particular advantages which recommend them for further study. No system is clearly inferior to the others in all factors evaluated.

2. Concept 2: Salt AND Verde Control. These systems would control both the Salt and Verde Rivers either through a single structure at the Salt/Verde confluence or a combination of two structures one on each river. Regulatory storage would be provided at the same structure or at New Waddell Dam on the Agua Fria River. The systems are:

2A Confluence Dam

2B Cliff Dam + Enlarged/New Roosevelt Dam

2C Confluence Dam + Enlarged/New Roosevelt Dam

2D Cliff Dam + New Stewart Mountain Dam + New Waddell Dam

Evaluation of the systems in this concept showed that System 2C had relatively high cost and highly adverse environmental and social impacts.

Although performance characteristics of the system are very good, other systems in the concept are comparable without the extremely severe combination of environmental and social impacts.

3. Concept 3: Downstream. The downstream system relies entirely on channelization options for flood control (two-sided levee through Phoenix and one-sided levee from 91st Avenue to Gillespie Dam on the Gila River). Regulatory storage would be provided at New Waddell Dam. The downstream system does meet project purposes and has virtually no environmental and social impacts. However, due to the extremely high cost of the system, it is unlikely that justification and implementation of the project would occur.

4. Concept 4: Upstream/Downstream. For flood control, systems under this concept combine a limited amount of upstream storage on the Salt River with levees on the Salt River and Gila River downstream. Regulatory storage would be included in the upstream structure. Two systems were developed:

4A Enlarged/New Roosevelt + Phoenix Levees + Gila Levee

4B New Stewart Mountain Dam + Phoenix Levees + Gila Levee

As with the downstream system, both systems meet the project purposes and have minimum impacts. However, both have extremely high costs that make their implementation unlikely.

5. Concept 5: Limited Structural. This concept takes advantage of opportunities for flood control and regulatory storage at existing storage facilities reducing the need for new structures. Systems rely on SRP reregulation for flood control and regulatory storage at an underground storage site in the Salt River channel. Two systems were developed:

5A SRP Reregulation (without modifications) + Underground Storage

5B SRP Reregulation (with modifications) + Underground Storage

Evaluation showed that both options appear to have potential for development in plans. But, underground storage for regulatory storage appears to have a number of adverse impacts, including institutional and social problems with land acquisition and implementation, and legal problems with recovery of the CAP water from the aquifer.

6. Concept 6: Nonstructural. The key factor to these systems is that while floods are generally allowed to occur uncontrolled, economic loss and social disruption are reduced by changing the use of the flood plain. However, because flow is not controlled, the level of protection is less than with a structural solution. For flood damage reduction this system(s) would rely on some combination of flood proofing, preparedness planning, flood plain regulations, gravel mining guidelines, and SPF bridge(s). For regulatory storage, the nonstructural system would rely on water exchange with the existing SRP system. Although the flood damage reduction measures have not been fully developed and evaluated at this time, they could be included as "add-ons" with many other

SYSTEM EVALUATION SUMMARY

	Regulatory Storage Avg. Annual Increase in CAP Water Supply (ac-ft)	Projected Flood Control at Confluence (ft^3/s)	DAM SAFETY: Problems Solved by the System	DAM SAFETY: Problems Not Solved by the System	Costs (million $)* (rounded to the nearest million): Construction 7 3/8%	Construction 3 1/4%	Annual Cost 7 3/8%	Annual Cost 3 1/4%	IMPACTS: Environmental	IMPACTS: Social	IMPACTS: Institutional
1A Cliff + Water Exchange	46,000	150,000	Bartlett Horseshoe	Roosevelt, Horse Mesa Mormon Flat, Stewart Mt.	254	232	20	10	Biological Resources; T&E species; cultural resources	No significant impacts	Need SRP AGREEMENT for exchange-unlikely
1B Modified Roosevelt + Direct Connection	121,000 (47,000 w/water exchange instead)	200,000	Roosevelt, Horse Mesa, Mormon Flat	Bartlett, Horse Mesa, Stewart Mountain	557	526	45	22	Archaeological & Historical sites.	Relocations	Impacts on institutional arrangements
1C New Stewart Mt. + Direct Connection	82,000 (46,000 w/water exchange instead)	200,000	Stewart Mt.	Horseshoe, Bartlett, Roosevelt, Mormon Flat, Horse Mesa	660	602	51	23	Archaeological resources	No significant impacts	Same as 1B
2A Confluence	112,000	50,000	None	All dams on Salt and Verde	598	546	46	21	Biological Resources; T&E species; recreation; cultural resources	Relocations	Institutional Arrangements
2B Cliff + Modified Roosevelt + Water Exchange	56,000	50,000	All dams on Salt and Verde except Stewart Mountain	Stewart Mountain	421	389	33	16	Biological Resources; T&E species; cultural resources	Relocations	Need SRP agreement for exchange-unlikely
2C Confluence + Modified Roosevelt + Direct Connection	141,000	50,000	Roosevelt, Horse Mesa, Mormon Flat	Horseshoe, Bartlett, Stewart Mountain	715	658	55	25	Same as 2A and 2B	Same as 2A and 2B	Same as 2A
2D Cliff + New Stewart Mt. + New Waddell	100,000	50,000	Bartlett, Horseshoe, Stewart Mountain	Roosevelt, Mormon Flat, Horse Mesa	788	720	62	28	T&E species; archaeological sites; recreation	Loss of some recreation	Same as 2A
3 Levees + New Waddell	100,000	300,000	None	All dams on Salt and Verde	1546	1466	154	90	Archaeological sites; recreation	Loss of some recreation of Lake Pleasant	Local Funding needed
4A Modified Roosevelt + Levees + Direct Connection	121,000	200,000	Roosevelt, Horse Mesa, Mormon Flat	Horseshoe, Bartlett, Stewart Mountain	1682	1600	158	88	Archaeological/Historical sites	Relocations	Local Funding Needed
4B New Stewart Mt. + Levees + Direct Connection	82,000	200,000	Stewart Mt.	Horseshoe, Bartlett, Roosevelt, Mormon Flat, Horse Mesa	1785	1676	164	89	Archaeological sites	No significant impacts	Same as 4A
5A SRP Regulation (w/o modifications + Underground Storage	63,000 (reduces SRP water by 88,000 ac-ft	270,000	None	All dams on Salt and Verde	112	106	16	11	Biological Resources; Loss of SRP water	None	Ownership of ground water replacement of lost water
5B SRP Reregulation (w/modifications + Underground Storage)	63,000 (reduces SRP water by 113,000 ac-ft	210,000	None	All dams on Salt and Verde	200	189	23	15	Same as 5A	None	Same as 5A
6 Nonstructural - SRP Exchange	14,500	NA	None	All dams on Salt and Verde	13	13	2	2	Potential adverse impacts on biological resources	None	Agreement w/SRP for exchange highly unlikely

* Costs reflect exchange only. Additional costs could be incurred depending on the final plan.

NOTE: Minor modifications required at existing Stewart Mountain even with upstream Storage on Salt for dam safety.

systems, particularly those flood control systems that do not provide high flow reduction.

E. Recommendations for Stage III

Based on the analysis and comparison of systems, the following recommendations were made for Stage III study:

1. Eliminate all screened elements and use only the preferred elements for Stage III formulation.

2. Retain all upstream elements for further study at the feasibility level: Confluence Dam, Cliff Dam, New/Enlarged Roosevelt Dam, New Stewart Mountain Dam, and New Waddell Dam.

3. The Confluence site should not be combined with any other upstream structural element. Rather, it will be considered further only as a single, multipurpose structure, because a "smaller" confluence dam offered no advantages relative to cost or environmental and social impacts.

4. Eliminate all large levees, but retain the option to use local levees where justified. Costs for any system including levees were so excessively high that the likelihood of ever implementing this solution was virtually nonexistent. Agencies recognized, however, that there may be local areas, such as Holly Acres or Buckeye, that could be protected by "limited levees," which could be added on to any system that did not sufficiently limit flows to prevent flooding of communities or areas requiring protection.

5. Retain reregulation options and consider partial reregulation in conjunction with other plans.

6. Eliminate underground storage for CAP regulatory storage, but retain ground water recharge as a possible mitigation for SRP reregulation water losses and for conservation of floodflows.

7. Delete water exchange with the existing SRP system (due to low performance, increased dam safety risks, and potential adverse environmental impacts), but retain the option to implement water exchanges with other upstream elements.

8. Retain nonstructural flood damage reduction measures both as a possible plan or as an add-on to the structural plans.

9. Elements may be combined across concepts in Stage III.

10. The best of the remaining regulatory storage elements may be selected independently of flood control elements. A screening of the remaining regulatory storage methods (storage at the confluence, storage at New Waddell, water exchange with an expanded SRP system, and direct connection from the CAP Aqueduct to the SRP system) could be performed to determine the best regulatory storage alternative to combine with a flood control alternative in Stage III.

F. Stage III Work Program

Based on the recommendations made in Stage II, a work program for Stage III was developed. The work program is divided into five phases:

1. Formulation of Alternative Plans and Identification of Candidate Plans. Alternative plans are formulated, developed in detail, tested for completeness, effectiveness, efficiency and acceptability. From these, a number of candidate plans will be selected.

2. Evaluation of Candidate Plans. Technical, economic, environmental, social and recreation analyses of each plan are conducted.

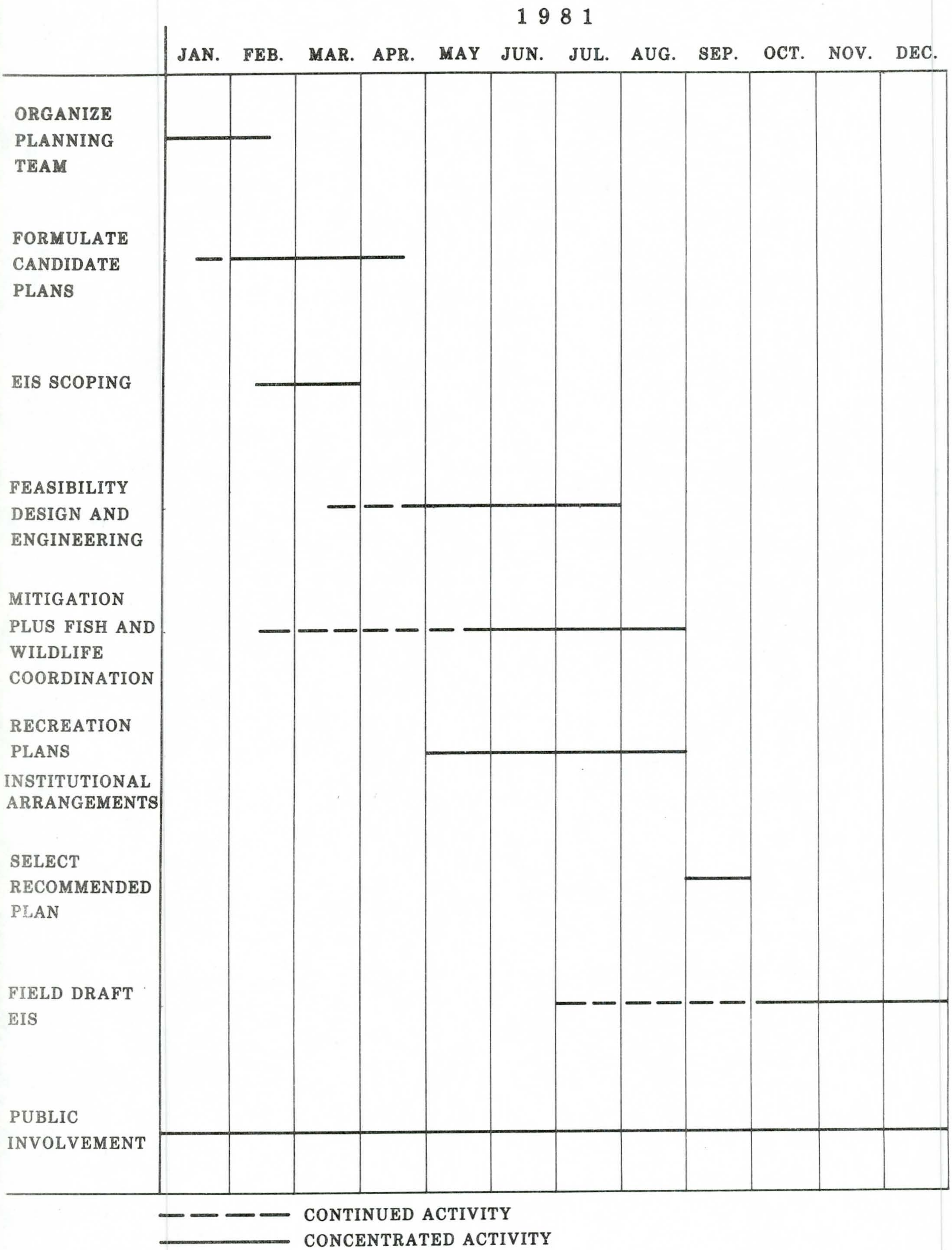
3. Comparison of Candidate Plans. Candidate plans are evaluated and compared to determine the difference among plans in terms of National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE).

4. Selection of Recommended Plan. Based on the comparison of candidate plans, a recommended plan will be selected.

5. Documentation and National Environmental Policy Act (NEPA) Compliance. Upon selection of the recommended plan, a field draft environmental impact statement (EIS) is prepared for agency review and revision as are planning documents and technical appendices. Following submission of the field draft EIS, the following tasks are carried out:

- File draft EIS,
- Public hearing,
- Prepare final EIS, and
- Record of decision for final plan approval.

The schedule for Stage III is shown in the following illustration.



CAWCS
STAGE III SCHEDULE

CAWCS STAGE II REPORT

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CHAPTER I

OVERVIEW OF THE CAWCS

The Central Arizona Water Control Study (CAWCS) was born out of an effort to provide a consensus on what should be done to solve central Arizona's water problems of flooding and water conservation. In 1968, the U.S. Congress authorized the Bureau of Reclamation (now the Water and Power Resources Service) to construct the Central Arizona Project (CAP) as part of the Colorado River Basin Act (Public Law 90-537). The CAP is being constructed to bring Colorado River water to water-deficient areas of central Arizona and western New Mexico. One of the proposed features of the CAP was Orme Dam and Reservoir, or a suitable alternative, to be located at the confluence of the Salt and Verde Rivers. While the primary CAP related purpose of Orme was to provide seasonal storage and regulation of Colorado River water, it would also have provided a high degree of flood protection through the Phoenix metropolitan area and conservation of flows from the Salt and Verde Rivers which are currently lost.

In May 1976, the Water and Power Resources Service (Service) issued a draft environmental impact statement for Orme Dam and Reservoir. Public response to this document identified major concerns regarding the inundation of the Fort McDowell Indian Reservation and riparian habitats, and the impacts upon habitat of the endangered bald eagle and other species. Also questioned were the safety aspects of the dam, adverse effects upon regional water quality, destruction of historical and archaeological resources, and conversion of recreational use of the Salt River from tubing and picnicking to lake-oriented activities. In general the feeling was expressed that more information should be developed on the alternatives to the structure.

The concern expressed by the public regarding Orme Dam caused the Service to reassess the facility. An Interagency Task Force was formed in March 1977 to review alternative methods of achieving regulatory storage of CAP waters and flood control along the Salt River through metropolitan Phoenix. On April 18, 1977, President Carter recommended the elimination of Orme Dam from the CAP. This recommendation gave added urgency to the work of the Interagency Task Force, which presented its findings in May 1978. Although it did not select a preferred alternative to Orme Dam, the Task Force recommended a number of CAP regulatory storage and flood control plans for further study.

In July 1978, following the Task Force findings, the Service requested that the Corps of Engineers, which was investigating flood control in light of the Orme Dam deletion through its Phoenix Urban Study, participate in a coordinated study to develop plans for the solution of flood problems along the Salt and Gila Rivers and for regulatory storage of CAP waters. The authority for this study, now called the Central Arizona Water Control Study, is derived from the Lower Colorado River Basin Project Act (Public Law 90-537) of 1968.

The Corps of Engineers has been examining flooding problems in the Gila River Basin under its Gila River and Tributaries Authority since the late 1930's. Actual planning for flood control in the CAWCS area did not begin until 1957 when the Los Angeles District of the Corps issued an Interim Report on Survey for Flood Control, Gila and Salt Rivers, Gillespie Dam to McDowell Damsite, Arizona. This report resulted in the authorization in 1960 of a project under the Gila River and Tributaries Authority for channel improvements along the Gila and Salt Rivers from Gillespie Dam to the confluence of the Salt and Verde Rivers. The project, however, has not been implemented because of environmental concerns and failure of the local sponsor to provide the necessary backing. The Flood Control Act of 1944 (Public Law 78-534) assigns to the Corps of Engineers responsibility to prescribe regulations for use of storage allocated for flood control at all reservoirs constructed with Federal funds. Therefore, based on this authority, the Gila River and Tributaries Authority, and the Economy Act, the Corps of Engineers is assisting the Service by formulating and evaluating alternative plans for flood control.

The relationship between the Service and the Corps was formalized through a Memorandum of Understanding entered into by the Regional Director, Lower Colorado Region, Water and Power Resources Service, and the District Engineer, Los Angeles District, Corps of Engineers, in December 1978. A copy of this Memorandum is contained in Appendix A.

A. Purpose, Goals, and Objectives

The overall purpose of the CAWCS is to study all suitable alternatives and recommend a plan to provide regulatory storage of CAP water and flood control along the Salt and Gila Rivers. Twelve planning objectives were adopted to guide in the development of plans which meet this twofold purpose to the maximum extent feasible. The objectives of the CAWCS are:

- Increase efficiency of the Central Arizona Project by providing regulatory storage capacity in central Arizona.
- Decrease flood damages along the Salt and Gila Rivers between Granite Reef Dam and Painted Rock Dam.
- Increase conservation of waters emanating from the Salt, Verde, Agua Fria, and Gila watersheds.
- Maximize energy efficiency as it relates to water resources, especially in regard to groundwater and CAP pumping requirements.
- Develop and illustrate opportunities for hydroelectric power production associated with structural alternatives.
- Take advantage of opportunities to protect and/or improve the quality of certain natural or cultural resources or ecological systems.
- Take advantage of opportunities to enhance the social well-being of Indian Communities.

- o Develop plans for recreational development which would provide opportunities for recreational enhancement at both upstream and downstream locations in the CAWCS area.

- o Improve water resource management by encouraging implementation of conservation measures.

- o Provide opportunities for improved management and protection of open space and wildlife areas.

- o Improve management and preservation of unique archaeological and historical resources in the CAWCS area.

- o Conserve and enhance fish and wildlife resources.

In the course of the CAWCS, the importance of dam safety increased significantly. Based on the Reclamation Safety of Dams Act of 1978 (Public Law 95-578), the Service is conducting a dam safety study to evaluate the condition of the dams on the Salt and Verde Rivers and investigate alternative solutions to the dam safety problem found on the systems. The CAWCS is independent of the Safety of Dams program and finding a dam safety solution is not a primary objective of the CAWCS, but dam safety is treated as an adjunct purpose which, if it can be accomplished in conjunction with regulatory storage and flood control, can provide a more cost-efficient system.

B. Study Organization

The CAWCS is being conducted by the Water and Power Resources Service's Arizona Projects Office with assistance from the Corps of Engineers' Los Angeles District Office, and contractors as needed.

The Service has overall responsibility for the CAWCS and maintains primary responsibility for policy, technical studies, and designs for regulatory storage components or structures. The Corps of Engineers' responsibilities encompass these same factors in relation to flood control measures. Coordination between the agencies is effected at the local level by an Agency Manager designated by each agency to assure continuity and adherence to the program schedule. Overall policy guidance for the CAWCS is provided by the Lower Colorado Region of the Water and Power Resources Service.

In addition, coordination is maintained with many other Federal, state and local organizations through a Technical Agency Group (TAG) which was formed for interagency cooperation and coordination. Also, a Community Advisory Committee, formed by Governor Babbitt to advise him on CAWCS issues, provides a link between the CAWCS and the public, identifying needs and concerns of their constituents and conveying information back to the public. A more detailed description of the function and membership of the TAG and Governor's Advisory Committee is presented in Chapter V, Public Involvement.

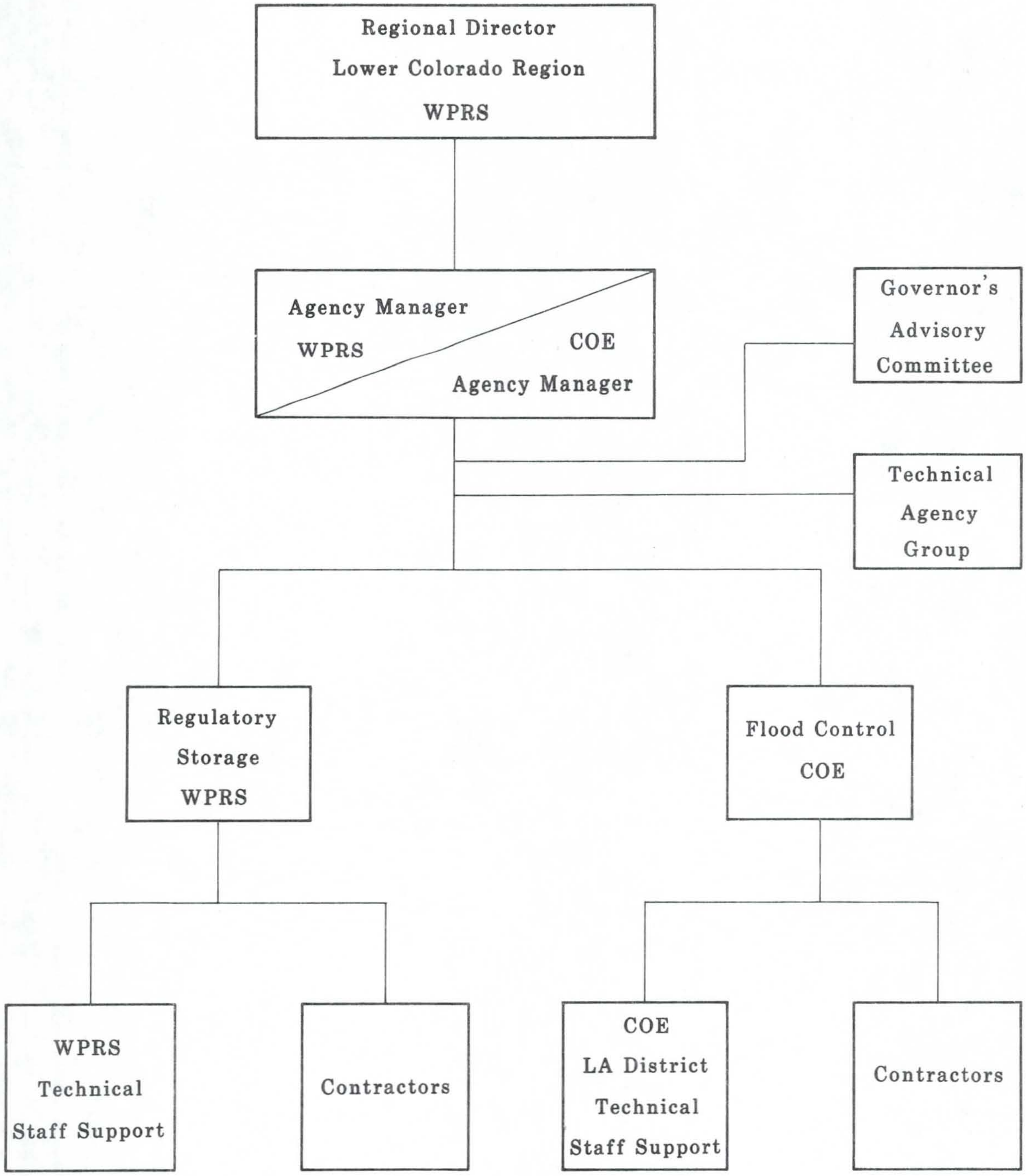
Figure 1 shows the study organization.

C. Status of the CAWCS

The CAWCS is being conducted in three stages. As shown in Figure 2, the first stage of the study, which identified problems and a wide array of possible solutions, and recommended those meriting further study, was completed in May 1979 with the publication of a Plan of Study. Stage II, now complete with publication of this report, developed and analyzed intermediate plans and recommended a number for further detailed study in Stage III. By October 1981, toward the end of Stage III, the recommended plan or plans will have been identified. At that time an environmental impact statement (EIS) will be prepared. A field draft EIS, which will display the adopted plan and all the alternatives, will be completed in December 1981 and the final recommendation on the adopted plan will be made upon completion of the final EIS.

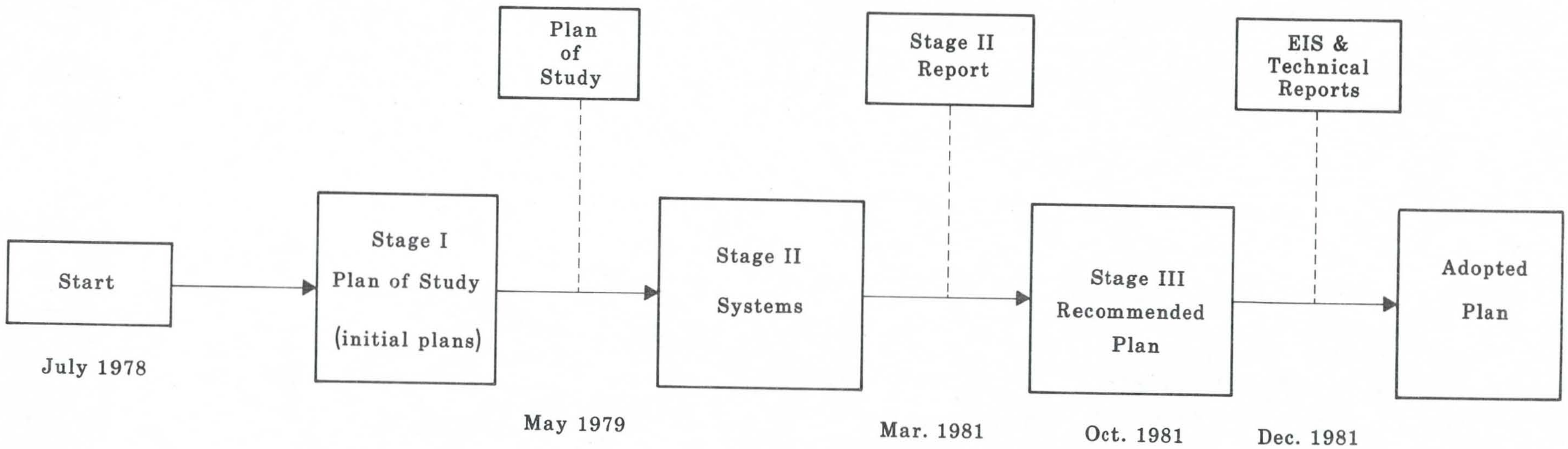
D. Purpose of this Report

This report documents the findings of Stage II, recommends a limited number of features to be formulated into plans for detailed study and design in Stage III of the study and outlines a work program for these studies.



Study Organization

Figure 1



CAWCS SCHEDULE

Figure 2

CHAPTER II

PLANNING AREA DESCRIPTION

The Central Arizona Water Control Study (CAWCS) planning area encompasses about 8.2 million acres (12,800 square miles) in Gila, Maricopa, and Pinal Counties (Figure 3). This area, comprising just over 11 percent of the total land area of the State of Arizona, includes portions of the Salt, Verde, Gila and Agua Fria drainage basins.

Although the planning area consists of 12,800 square miles, the Gila River Basin above Painted Rock Dam has a drainage area of approximately 50,000 square miles. The Gila River collects water from numerous tributary watersheds including the Salt and Verde systems above Phoenix.

The CAWCS planning area was established based on several considerations relative to CAP regulatory storage and flood control. For regulatory storage, proximity to the CAP aqueduct system was a major factor. An ideal reservoir site should be close to the CAP aqueduct system and areas that will receive water it delivers. Regarding flood control, the planning area had to include the primary damage areas in metropolitan Phoenix as well as upstream areas that would provide effective flood control sites.

Following is a description of the physical, biological, social, economic, cultural, and water resource characteristics of the planning area.

A. Physical Characteristics

1. Geology/Soils. The CAWCS lies generally within the Basin and Range Physiographic Province, characterized by mountain ranges with steep slopes and rugged topography separated by broad, gently sloping, alluvium-filled valleys. Despite the prevalence of faults throughout the area, the earthquake hazard in the area is not considered severe. While several major earthquakes have occurred in California and northern Mexico, few quakes of consequence have centered in central Arizona.

In general, the rock types within the Basin and Range Province are crystalline igneous and metamorphic rocks in the mountains and sedimentary in the basins. The alluvial beds form the reservoir for ground water deposits.

2. Elevations. Elevations in the study area vary from about 500 feet above sea level at Painted Rock Dam to about 2150 feet above sea level at Roosevelt Dam. Mountains in the study area rise to over 7000 feet above sea level. Elevations in metropolitan Phoenix range from 890 feet to 1380 feet above sea level. Slopes in the study area are, by and large, gentle, although steep gradients (10 percent or greater) occur in the mountains.

3. Mineral Resources. Arizona is particularly rich in a wide range of mineral resources, many of which are found in the general study area. A majority of the ore bodies are located within the mountainous region, but the

alluvial basins contain abundant sources of sand and gravel and other minerals. During recent decades, the mining and preparation of sand and gravel have expanded into one of the State's major mineral industries. The total value output in Arizona for sand and gravel has ranked second only to copper since 1954. Numerous mines and prospects occur throughout the area, some of which are still active.

4. Climate. The climate of the planning area is arid to semiarid. Temperatures range from relatively mild to hot. Daily summer temperatures average from highs of over 100°F to lows of about 70°F. During the winter, highs average about 60°F with lows of about 40°F. Temperatures in higher elevations tend to be lower in both summer and winter.

The study area is subject to two separate rainfall seasons, although at any time of the year there can be extended periods of a month or more when no precipitation is recorded. The winter rainfall season occurs from November to March when storms from the Pacific Ocean bring light though often widespread precipitation. The summer, or "monsoon", season usually lasts from July through mid-September. During this time moisture from off the west coast of Mexico and the Gulf of Mexico enters the area, resulting in scattered thundershowers. These storms can result in periods of high wind, severe blowing dust and flash flooding.

Normal annual precipitation over the planning area varies from about 6 inches in Gila Bend to about 20 inches to the east and south of Roosevelt Lake.

In the desert valley of the planning area, the average annual precipitation is generally less than 10 inches. In the higher northern and eastern sections of the study area, annual average precipitation tends to be greater. Snowfall amounting to more than a trace is rare in the desert valleys. However, snowfall is fairly common at elevations above 5000 feet in the northern and eastern sections of the planning area. There, snow accumulates in substantial amounts on the watersheds and is a major factor in the hydrology of rivers in the planning area.

B. Biological Characteristics

1. Vegetation. Vegetation in the CAWCS area varies considerably with elevation, available moisture, and temperature. The desert plains in the western portion of the CAWCS area support only the hardiest plant life, such as creosote bushes and catclaw. Stands of mesquite, palo verde, and ironwood are found along intermittent creeks, washes and rivers. Lusher riparian vegetation occurs along flowing streams. Much desert and riparian plant life, however, has been lost through agricultural development and urbanization of metropolitan Phoenix. Nonnative crops supported by intense irrigation were introduced into the Salt and Gila River Valleys. Leading agricultural products include seed crops (cotton, milo, barley, sorghum, and alfalfa), vegetables, fruit (citrus and grapes), and nut crops.

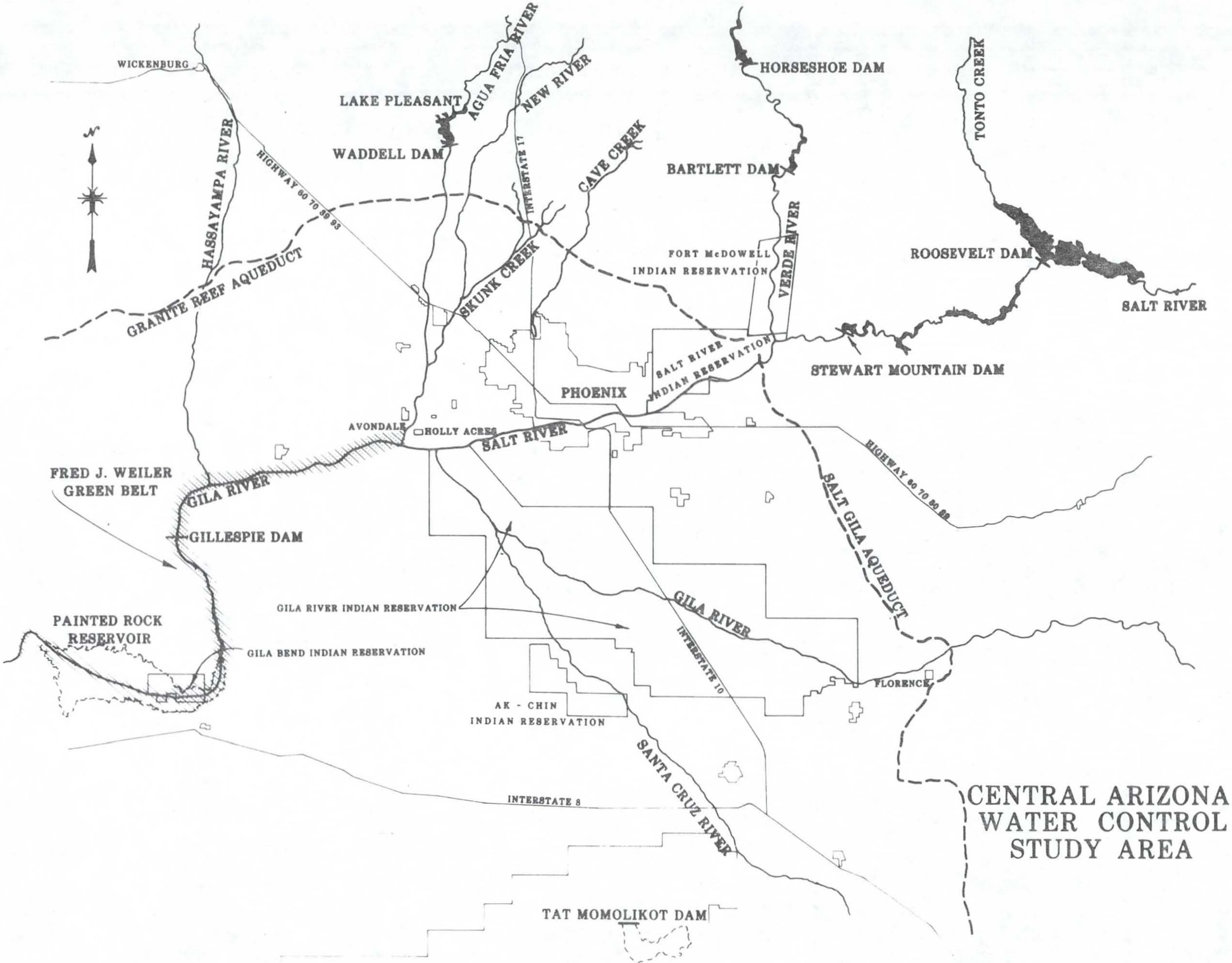

WICKENBURG
HASSAYAMPA RIVER
HIGHWAY 60 70 89 93
LAKE PLEASANT
WADDELL DAM
AGUA FRIA RIVER
NEW RIVER
INTERSTATE 17
CAVE CREEK
HORSESHOE DAM
BARTLETT DAM
TONTO CREEK
VERDE RIVER
FORT McDOWELL INDIAN RESERVATION
ROOSEVELT DAM
SALT RIVER
GRANITE REEF AQUEDUCT
SKUNK CREEK
SALT RIVER INDIAN RESERVATION
STEWART MOUNTAIN DAM
PHOENIX
AVONDALE
HOLLY ACRES
SALT RIVER
HIGHWAY 60 70 80 89
FRED J. WEILER GREEN BELT
GILA RIVER
GILLESPIE DAM
SALT GILA AQUEDUCT
GILA RIVER INDIAN RESERVATION
GILA RIVER
PAINTED ROCK RESERVOIR
GILA BEND INDIAN RESERVATION
INTERSTATE 10
FLORENCE
AK - CHIN INDIAN RESERVATION
SANTA CRUZ RIVER
INTERSTATE 8
CENTRAL ARIZONA WATER CONTROL STUDY AREA
TAT MOMOLIKOT DAM

Figure 3

In the high elevations of the CAWCS area, about 4000 feet or greater, rainfall and rugged terrain support lush Sonoran desert vegetation marked by large cacti, dense chapparal and, where there is sufficient subterranean water, palo verde, ironwood, and mesquite trees. Stands of oak and pine are found in the well watered mountains and drainage regions of the CAWCS area.

2. Wildlife. Wildlife in the CAWCS area is typical of that found in desert and foothill regions of the Southwest. The planning area includes a perennial water course which supports a substantial riparian habitat. Numerous species of birds, mammals, fish, amphibians, and reptiles thrive in undeveloped portions of the CAWCS area. Some of the species include the bald eagle, the Yuma clapper rail, the gray fox, the mule deer, the desert cottontail rabbit, and the beaver. For the most part, however, native fauna has disappeared from urban and agricultural portions of the CAWCS area and has been replaced by livestock and other domestic animals.

C. Socioeconomic Characteristics

1. Population. The total population of the study area is approximately 1.5 million, almost 90 percent of which resides in Maricopa County. Portions of Pinal and Gila Counties are also included in the study area. Table 1 shows the existing and projected population of the study area by county. The study area is projected to continue experiencing the high rates of growth that have occurred over the last 20 years.

Table 1
STUDY AREA POPULATION BY COUNTY

County	1978	2000
Maricopa	1,435,950	2,352,400
Pinal	95,921	127,527
Gila 1/	12,416	14,210
Total	1,544,287	2,494,137

1/ Gila County population in CAWCS area represented by Globe-Miami population
Source: Population Estimates and Projections, U.S. Department of Commerce, Service P-25, September 1978, and Arizona Department of Economic Security, 1978.

The Salt River Valley is the most heavily populated area in the study area, leaving much of the region sparsely settled or uninhabited. Phoenix is the principal community of the CAWCS area. Other major cities are Mesa, Scottsdale, Tempe, Chandler, Glendale, Buckeye, Gila Bend, Florence, Coolidge, Casa Grande, and Globe-Miami. Table 2 shows the existing and projected population of the major communities in the CAWCS area.

Table 2

POPULATION OF MAJOR COMMUNITIES

Community	1978	2000
Avondale	7,130	37,200
Buckeye	2,900	8,000
Carefree/Cave Creek	2,245	9,000
Chandler	24,000	95,100
Coolidge	7,280	10,250
El Mirage	3,800	12,400
Florence	3,195	4,163
Fountain Hills	2,500	22,500
Gila Bend	2,400	4,800
Gilbert	4,250	46,600
Glendale	80,000	158,900
Goodyear	2,745	85,000
Guadalupe	4,300	8,000
Mesa	130,000	229,300
Paradise Valley	10,570	17,800
Peoria	13,000	71,000
Phoenix	725,000	1,070,000
Scottsdale	85,070	109,800
Surprise	3,400	6,800
Tempe	106,675	180,000
Tolleson	3,890	19,000
Youngtown	2,000	2,200
Casa Grande	16,445	23,950
Globe/Miami	11,850	14,210
Apache Junction	9,345	19,607
Eloy	6,945	9,146
New River	NA	NA
Superior	5,600	6,797

Source: Population Estimates of Arizona, 1978. Department of Economic Security

Photograph 1 - Downtown Phoenix.

There are also five Indian Reservations in the CAWCS area: the Fort McDowell Reservation, the Gila River Reservation, the Salt River Reservation, the Ak-Chin Reservation, and two portions of the Papago Reservation--the northern Sif Oidak District and the Gila Bend Unit. Population of the Indian Communities is shown in Table 3.

Table 3
POPULATION OF INDIAN COMMUNITIES

Communities	Population
Ak-Chin	336
Fort McDowell Mohave-Apache	348
Salt River Pima-Maricopa	2,950
Gila River	8,600
Papago Indian Community	
Gila Bend Unit	357
Sif Oidak District	650
Total	13,241

Source: Valley National Bank, Arizona Statistical Review, 1978 and U.S. Department of the Interior, Bureau of Indian Affairs, 1978.

2. Land Use. From a regional perspective, vast areas of the CAWCS area remain in their natural state, unaltered or only slightly modified by man's activities.

Approximately 75 percent of the CAWCS area is rangeland. Some of these rangelands are leased for livestock grazing purposes from the Federal and state governments, which maintain jurisdiction over them.

Agricultural lands comprise the second largest land use category, currently accounting for about 13 percent of the total CAWCS area. Agricultural land includes irrigated croplands, citrus orchards, feedlots and privately owned pasture land. Most of these agricultural lands lie within boundaries of irrigation districts and are located directly west of metropolitan Phoenix and to the southeast of Phoenix toward Tucson.

Urban built up lands comprise the third largest land use category, accounting for 4.8 percent of the total CAWCS area, and includes residential, commercial, industrial, institutional, transportation, and utility land uses. The major urban and built-up lands within the CAWCS area are located within Phoenix and the adjacent cities of Tempe, Mesa, Scottsdale, Paradise Valley, Fountain Hills, Glendale, Peoria, Sun City, Surprise, El Mirage, and Youngtown.

Given the substantial population increases projected for the Phoenix metropolitan area during the next 20 years, the amount of urban/built-up lands will undoubtedly increase significantly, primarily at the expense of agricultural lands and rangelands.

The remainder of the planning area comprises forest lands, barren lands, water bodies, and wetlands. These areas are expected to remain the same to the year 2000. Table 4 shows the existing and projected land use in the planning area.

Table 4
EXISTING AND PROJECTED LAND USE

	Existing % of Total	Year 2000 % of Total
Rangeland	74.9	73.1
Agricultural	12.8	11.1
Urban	4.8	8.3
Forest	3.9	3.9
Barren Land	2.2	2.2
Water Bodies	0.9	0.9
Wetlands	0.5	0.5

Source: Maricopa Association of Governments, 1978.

Landownership patterns in the CAWCS area have essentially remained unchanged since the admission of Arizona as a State in 1912. Approximately

70 percent of the lands in the CAWCS area remain in public ownership or are Indian Reservations which have been set aside. These lands are predominantly rangelands which are managed by several governmental agencies (U.S. Forest Service, Department of Defense, U.S. Bureau of Land Management, Arizona State Land Department, Arizona Game and Fish Department, county/municipally owned). The privately owned lands are predominantly the urbanized and agricultural areas located in the central portion of the planning area. Table 5 shows the existing and projected landownership in the planning area.

Table 5
EXISTING AND PROJECTED LANDOWNERSHIP

Ownership	Existing Approximate % of Total	Year 2000 % of Total
Public Ownership		
Federal	47.5	46.4
State Trust/Owned	14.5	15.3
County/Municipal	1.3	1.4
Indian Trust	6.9	6.9
Privately owned	29.8	30.0

Source: Maricopa Association of Governments, 1978.

3. Economy. The CAWCS area is a major center for economic activity in the Southwest. Leading factors in the area's economy are manufacturing, tourism, retail trade and services, government, and agriculture. Industrial development is centered in metropolitan Phoenix, with agricultural districts extending to the west, southwest, and southeast of the urban area. Within the past 20 years, manufacturing has replaced agriculture as the main source of income in Maricopa County, although the County still leads the State in agricultural production. The economic importance of agriculture in the CAWCS area is expected to continue to decline as the urbanization of metropolitan Phoenix increases.

Per capita income in the study area as a whole increased about 70 percent between 1970 and 1977. In 1977, the median household income for metropolitan Phoenix was estimated at $14,000. Median household incomes were under $10,000 in the inner city, while many families in the north Phoenix, Scottsdale, and Paradise Valley areas earned over $35,000. In 1970, the income on Indian reservations in the CAWCS ranged from $950 on the Gila River Indian Reservation to $4,800 on the Fort McDowell and Salt River Indian Reservations.

4. Transportation. The transportation system of the study area is typical of other western U.S. regions. Rural communities outside of the Phoenix metropolitan area rely primarily on automobile travel, have limited bus service, and small airports. Highway facilities in rural towns and cities seem adequate for present needs and are uncrowded. In contrast, the transportation system in the Phoenix metropolitan area is more diverse but generally crowded, especially during rush hour and holiday periods.

The CAWCS area is connected to the rest of Arizona and the Nation by three interstate highways, two railroads, and 18 commercial air carriers. Over 100 transcontinental, interstate, and intrastate trucking companies and two transcontinental bus lines serve the area. Maricopa County leads Arizona in motor vehicle registrations, with 646,006 passenger cars, 100,194 commercial vehicles, and 95,893 noncommercial trucks registered in 1977. The large number of motor vehicles has increased traffic congestion in Phoenix. Efforts to implement mass transit and car pooling have met with limited success.

Four major freeways are found in the CAWCS area. Interstate 17 enters metropolitan Phoenix from the north and connects with Interstate 10, an important east-west link in the Interstate Highway System. The Superstition Freeway (Arizona State Route 360) connects the communities of Tempe and Mesa with Interstate 10. Interstate 8 comes from the west and connects with Interstate 10 just south of Casa Grande.

Sky Harbor International Airport is the major air terminal in the CAWCS area. It serves in excess of 4.5 million passengers annually. In addition, there are 22 other civilian airfields and two airbases in Maricopa County which handle an increasing volume of private and military traffic.

D. Cultural Resources

The Salt River Basin was a major population center during portions of the prehistoric past and contains abundant archaeological remains. In prehistoric times much of the study area was inhabited by an agricultural people known as Hohokam. For unknown reasons, the Hohokam disappeared from the area in about 1450 A.D. Over 800 known Hohokam sites are reported to exist within the Salt River Valley, most located along the area's major rivers and on irrigable land adjacent to the rivers. The remains of several major sites, e.g., Pueblo Grande, have been preserved and restored and are accessible to the public. Several prehistoric sites, including the Pueblo Grande Ruin and Hohokam-Pima Irrigation Sites in Phoenix and the Hohokam-Mormon Canals in Mesa, have been entered on the National Register of Historic Places. Numerous other archaeological sites have either been nominated to or are considered to be potentially eligible for inclusion in the State or National Registers of Historic Places.

With the disappearance of the Hohokam culture in about 1450 A.D., a hiatus of about 300 years appears in the archaeological record. Little physical evidence exists relative to the period through the early 1800's. An inventory of historical resources (Dames & Moore, 1979) indicates a broad range of cultural resources were present in the study area during the historical period (after 1800). Many of these resources, or sites, exist at present; many have been destroyed as a result of land use activities (urban development, agriculture, reservoir and highway construction) or due to natural factors (flooding, ground surface erosion).

E. Water Resources

Water used in the planning area presently comes from major streams and tributaries and ground water. Some surface and ground water is reused, such as effluent or tailwater from irrigation.

The major streams in the CAWCS area are the Salt, Verde, Agua Fria, and Gila Rivers. Their tributaries in the study area include the New River, Skunk Creek, Cave Creek, Indian Bend Wash, Sycamore Creek, the Santa Cruz River, and Santa Rosa Wash, as well as several smaller arroyos and washes. With the exception of the perennial Salt and Verde Rivers above Granite Reef Diversion Dam and the Gila River above Ashurst-Hayden Diversion Dam, these streams are ephemeral. The relatively light winter rainfall usually is insufficient to produce sustained major surface flows along the tributaries, although winter and spring runoff from rainfall and/or melting snow from the watersheds may cause significant flows on the larger streams. Intense summer thunderstorms occasionally result in flooding along tributary streams but not normally along the major water courses.

Surface water supplies are made more dependable by capturing the water in reclamation lakes and storing the water until it is needed. The Salt and Verde Rivers are impounded by six dams, four on the Salt (Stewart Mountain, Mormon Flat, Horse Mesa, and Roosevelt) and two on the Verde (Bartlett and Horseshoe). These structures, which along with the operating agency are known as the Salt River Project (SRP), impound reservoirs which provide irrigation and domestic water for metropolitan Phoenix. At Granite Reef Diversion Dam, waters from the Salt and Verde are channeled into canals which serve the Phoenix area. The Agua Fria River is impounded by Waddell Dam, forming Lake Pleasant. This reservoir supplies water to Maricopa County Municipal Water Conservation District No. 1. The Gila River is impounded by Coolidge Dam and San Carlos Reservoir. Water from the Gila River is diverted at the Ashurst-Hayden Diversion Dam for use by the San Carlos Project, a project which serves both Indian and non-Indian water users. The amount of surface water available from the latter two systems is far less in quantity and not as reliable as that from the Salt-Verde system. Table 6 shows the annual average diversion of the three systems and the amount used for municipal, industrial, and agricultural purposes.

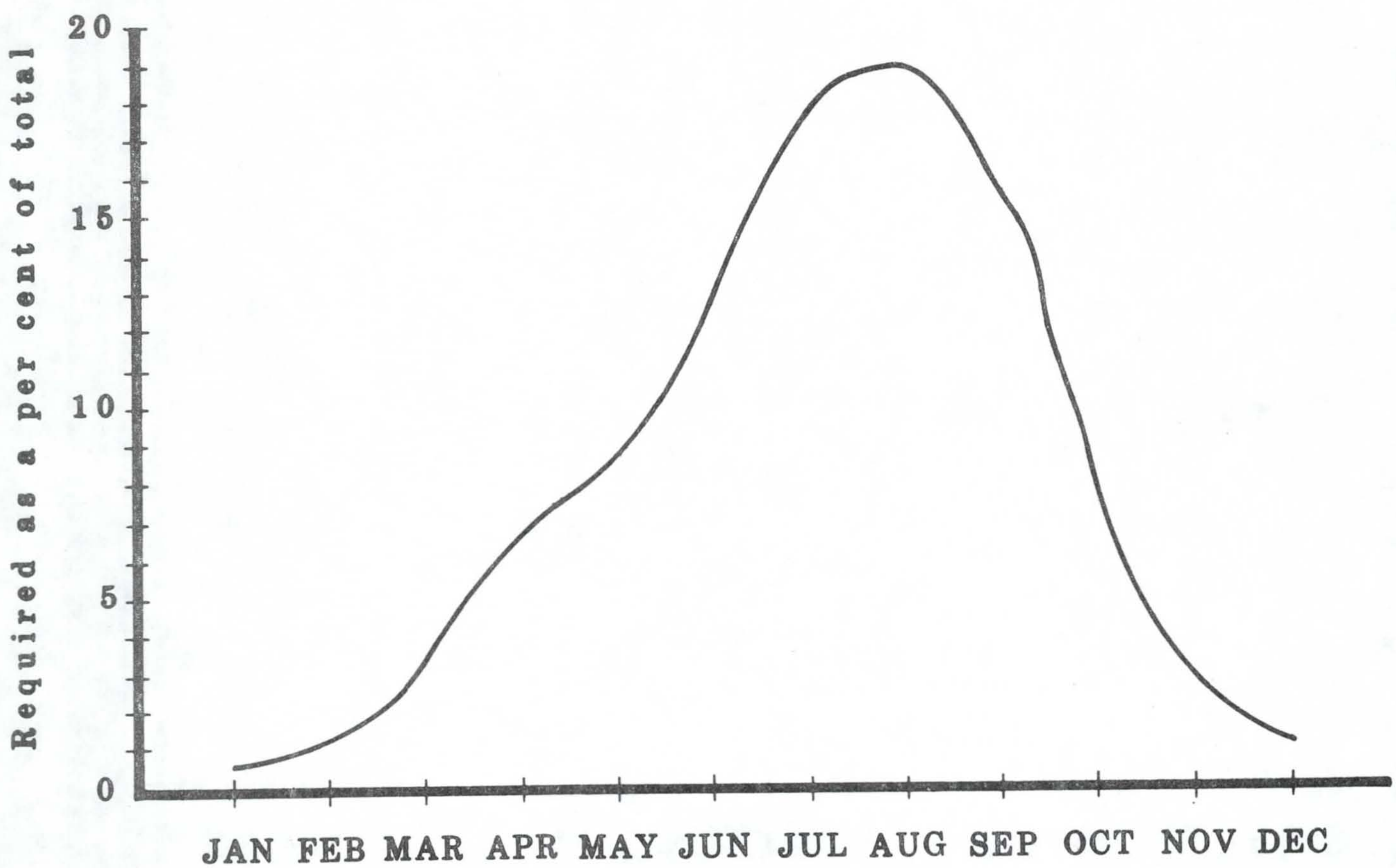
Table 6
AVERAGE ANNUAL DIVERSIONS (acre-feet)

	Total 1/	Percent Agriculture	Percent M&I
Salt River Project - 1914-1972 (Salt & Verde Rivers)	883,100	60 2/	40 2/
Maricopa Co. Municipal Water Conservation District 1929-1972 (Agua Fria River)	31,500	100	--
San Carlos Project - 1928-1972 (Gila River)	193,200	100	--

1/ Arizona Water Commission, 1975.
2/ Salt River Project, estimate based on average for 1977, 1978, 1979.

Runoff varies greatly from year to year and from watershed to watershed, and surface water supplies are often distant from the demand. Surface water supplies are therefore supplemented by ground water. Ground water pumping in the study area has increased steadily in volume since it became economically feasible in the 1930's, causing water levels to drop throughout most of the basins. According to the Arizona Water Commission (1978) the total annual consumptive use of water in the Salt River Valley Basin is estimated at 1.5 million acre-feet, while the total dependable annual surface supply is only 931,000 acre-feet (normalized 1970 conditions). The ground water reserves are being overdrafted at an average rate of 632,000 acre-feet per year to supplement the dependable surface supply. In 1975, the total annual overdraft exceeded one million acre-feet.

Municipal and industrial wastewater is treated and discharged by treatment facilities in the planning area. Some of this water is "reused" for irrigation purposes and supplements the water supply. Irrigation tailwaters can percolate to the ground water as irrigation return flow. However, some tailwater is collected and used for irrigation at lower elevations. Of the total water used in the study area, over 80 percent is directed to agricultural use and converted to urban uses. Water use also varies not only daily, but also yearly because of the hot dry summers and also the variable growing seasons for different crops. Peak demand in June or July can easily be more than twice the December or January peak demand (Figure 4).



IRRIGATION WATER REQUIREMENT PATTERN

Figure 4

Water quality also varies widely throughout the study area. Each surface source has an individual quality, and ground water quality varies not only with location, but with depth.

CHAPTER III

PROBLEMS, NEEDS AND ISSUES

Identifying and addressing problems and issues is a continuing process in the Central Arizona Water Control Study (CAWCS). It assures that concerns of the public are addressed throughout alternative development, evaluation, and selection.

The problems, needs, and issues identified in the CAWCS center on flood control, water supply, and related environmental and socioeconomic factors. Following is a discussion of the problems, needs, and issues identified so far in the CAWCS and their relationship to the study.

A. Flood Control

Flooding along the Salt and Gila Rivers has been recorded since the 1860's. The largest flood of record occurred in February 1891 (Table 7). The numerous floods that have occurred since then, and in particular the recent floods of 1978, 1979, and 1980 have confirmed the flood hazard conditions along the Salt and Gila Rivers and the need to formulate and implement a plan to reduce flood damages.

In March 1978, extensive snowmelt on the Salt and Verde watershed contributed to a flood with an estimated peak flow of 122,000 ft^3/s through the Phoenix area. The flood caused an estimated $33.2 million in damages, about 95 percent of which occurred on the Salt and Gila Rivers.

Table 7
FLOODS ON THE SALT RIVER

Date	Peak Flow ft^3/s	Damages ($ Millions)
February 1891	300,000	N/A
April 1905	115,000	N/A
November 1905	200,000	N/A
January 19-20, 1916	120,000	N/A
January 29-30, 1916	105,000	N/A
February 1920	130,000	N/A
March 1938	95,000	N/A
March 1941	40,000	N/A
Dec. 1965/Jan. 1966	67,000	6.0
Feb. 21-May 29, 1973	22,000	N/A
March 1978	122,000	33.1
December 1978	140,000	51.8
January 1979	100,600	N/E 1/
March 1979	67,400	N/E 1/
February 1980	180,000	60.0 2/

1/ Not Estimated
2/ Not including agricultural damages
Source: U.S. Army Corps of Engineers

In December of the same year, warm, moist air from the Pacific Ocean and the resulting rain caused another snowpack to melt. A peak of 140,000 ft^3/s on the Salt River occurred, causing an estimated $51.8 million damages on the Salt, Gila, and Agua Fria Rivers.

Photograph 2 - Flooding on the Salt River in the vicinity of Holly Acres.

In February 1980, a series of tropical Pacific Ocean storms moved through central Arizona, causing extensive runoff on the Salt and Verde River watersheds. The floodflows peaked at 180,000 ft^3/s on the Salt River. Significant inflow also forced releases from Waddell Dam into the Agua Fria River, causing damages along that river, as well as adding to flows in the Gila River west of Phoenix. In all, the February 1980 flood resulted in damages, which preliminary estimates put at $60 million.

The Salt River Project dams and reservoirs upstream on the Salt and Verde River can reduce peak flows, but only if storage space is available. Since the primary purpose of the dams is water conservation, during some years the reservoirs are filled to capacity toward the end of the annual runoff season and consequently there is little or no space in the system for flood control.

Each time a major flood occurs, the Corps of Engineers evaluates the level and type of damage which resulted. This information combined with runoff predictions in the region provides an estimate of the average annual damages in the area. Stage II analysis by the Corps estimates average annual damages of $8 million for the Salt-Gila system.

The most severe flood that can reasonably be expected to occur in the region based on a combination of meteorologic and runoff conditions is called a standard project flood (SPF). The most recent analysis of floodflows in the study area by the Corps of Engineers (1979) has established the peak flow of this hypothetical flood at 295,000 ft^3/s, very close to the largest flood of record on the Salt.

As shown in Figure 5, the SPF overflow boundary can vary in width from 0.15 to 2.5 miles at various locations along the Salt River. From its beginning at Granite Reef Diversion Dam, the boundary broadens to a total river width of about 2 miles at Gilbert Road in Mesa. As the boundary approaches the Mill Avenue bridge in Tempe, it narrows to a width of about one-third mile. The boundary broadens again in the reach from Mill Avenue in Tempe to 19th Avenue in Phoenix to a maximum width of 2-1/2 miles. In the reach from 19th Avenue to 83rd Avenue, just upstream from the Salt and Gila confluence, the boundary is relatively constant at a width of about 2 miles.

Should the SPF occur, it is anticipated that the Sky Harbor International Airport would be inundated; all of the existing bridges within the SPF boundary would be impassable, except possibly Mill Avenue which would be accessible and not inundated; the 91st Avenue and 23rd Avenue wastewater treatment plants would be inundated; several communities on both sides of the Salt River would be isolated; and portions of downtown Phoenix south of Washington Street, including the Southern Pacific Railroad yards at 16th Street would be inundated. The Corps of Engineers estimates that a flood of this magnitude on the Salt River would cause an estimated $477 million in damages. Table 8 shows anticipated damages by type for the SPF.

Table 8
ESTIMATED FLOOD DAMAGES ON THE SALT AND GILA RIVERS FROM GRANITE REEF TO GILLESPIE DAM - SPF (YEAR 2000)

Type	$ Millions
Residential	50
Commercial/Industrial	138
Public	16
Agricultural	7
Other	266
Total	477

Source: U.S. Army Corps of Engineers, December 1980.

Not all flood damages are physical; the social ramifications of flooding are a major issue, as well. Dislocation of residents and flood damage to public facilities which cause severe interruptions in essential services are ramifications which extend beyond the flooding itself to the time required to repair and recover from the damage. The bridge outages in metro Phoenix isolate communities from vital services and impose hardship on residents who must cross the river. In fact, the cost to the region in traffic delays produced when all three bridges across the Salt River were closed last December accounted for over 40 percent of the losses reported. Construction of larger bridges over the Salt River can reduce significantly these losses. Twelve bridges are planned or currently under construction by city, county, and state agencies, on the Salt River. The majority (9) of these bridges have a capacity of 200,000 ft^3/s. The larger Salt River bridges should all be completed by 1983, the majority of which will be completed during 1981. Two large bridges are planned for the Gila River (200,000 ft^3/s), one on the Verde River (55,000 ft^3/s), and four on the Agua Fria River (85,000-160,000 ft^3/s).

Alternative structures are studied and designed to control flows up to an SPF to an acceptable level of release downstream. Providing this level of protection of course reduces flood damages, but at the same time can result in some constraints. Possible inundation of lands would result from impoundments and may require relocation of portions of--and in some cases--entire communities within the CAWCS area. Determining the extent of these benefits and impacts is an important factor in selecting alternatives for flood control in the CAWCS.

B. Water Supply

Maintaining an adequate water supply for agricultural, municipal, and industrial purposes is a major problem in the CAWCS area. A satisfactory solution to the water supply problem is being sought by the State of Arizona through the Arizona Department of Water Resources comprehensive analysis of water supply and demand issues. Measures which could contribute toward a solution to the water supply problem are being investigated in the CAWCS.

1. Water Conservation. President Carter, in his Water Policy Message of June 6, 1978, placed a new national emphasis on water conservation and directed the Water Resources Council to add conservation as an economic and environmental objective of Federal water projects. The President's directive takes on added importance in the CAWCS in light of the long history of water scarcity in central Arizona.

As of 1970, agriculture accounted for 89 percent of water depletions in Arizona. Urban uses (municipal and industrial) amounted to less than 7 percent of the depletions. Mining consumed 3 percent, and fish and wildlife areas used a little over 1 percent. Although urban uses have increased since 1970, agriculture still consumes the largest amount of water. Arizona's farmers and ranchers are generally efficient in their irrigation practices, however implementation of advanced techniques could result in additional water savings. Urban water conservation measures also become increasingly important as more and more cropland is converted to commercial, residential, and industrial uses.

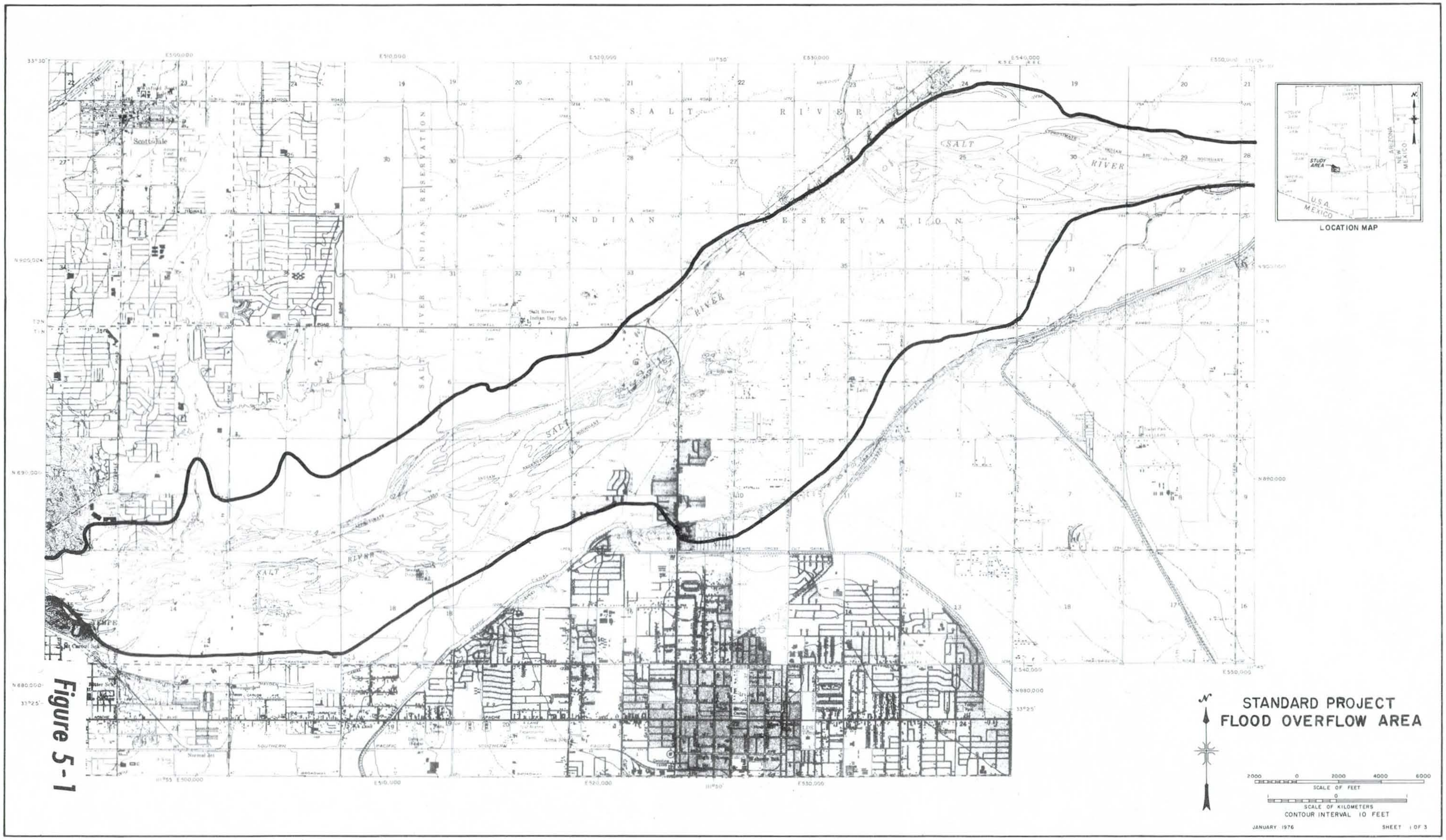
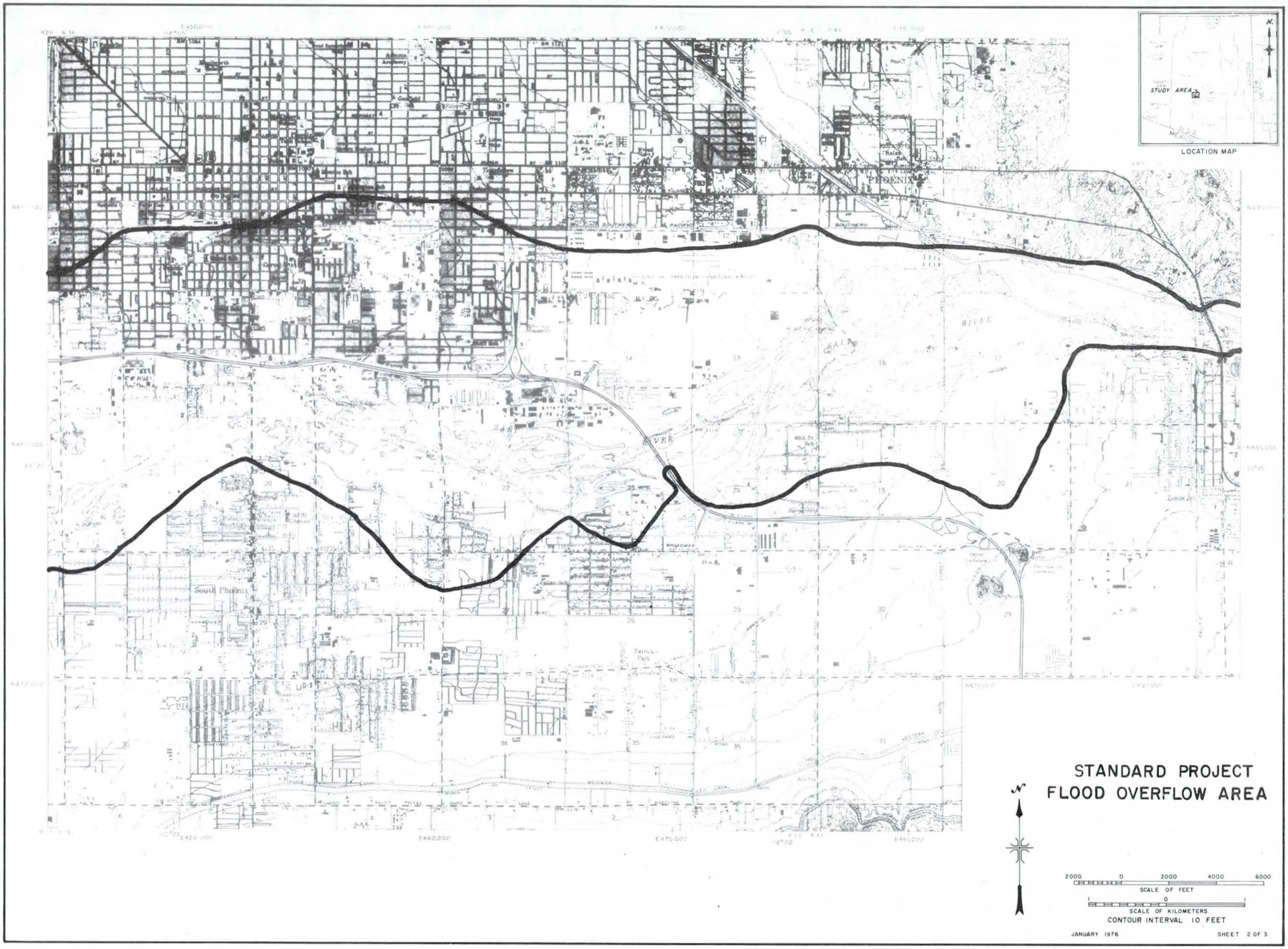

STANDARD PROJECT
FLOOD OVERFLOW AREA
LOCATION MAP
SALT RIVER INDIAN RESERVATION
SALT RIVER
Scottsdale
SCALE OF FEET
SCALE OF KILOMETERS
CONTOUR INTERVAL 10 FEET
JANUARY 1976
SHEET 1 OF 3

Figure 5-1



STANDARD PROJECT
FLOOD OVERFLOW AREA

Figure 5-2

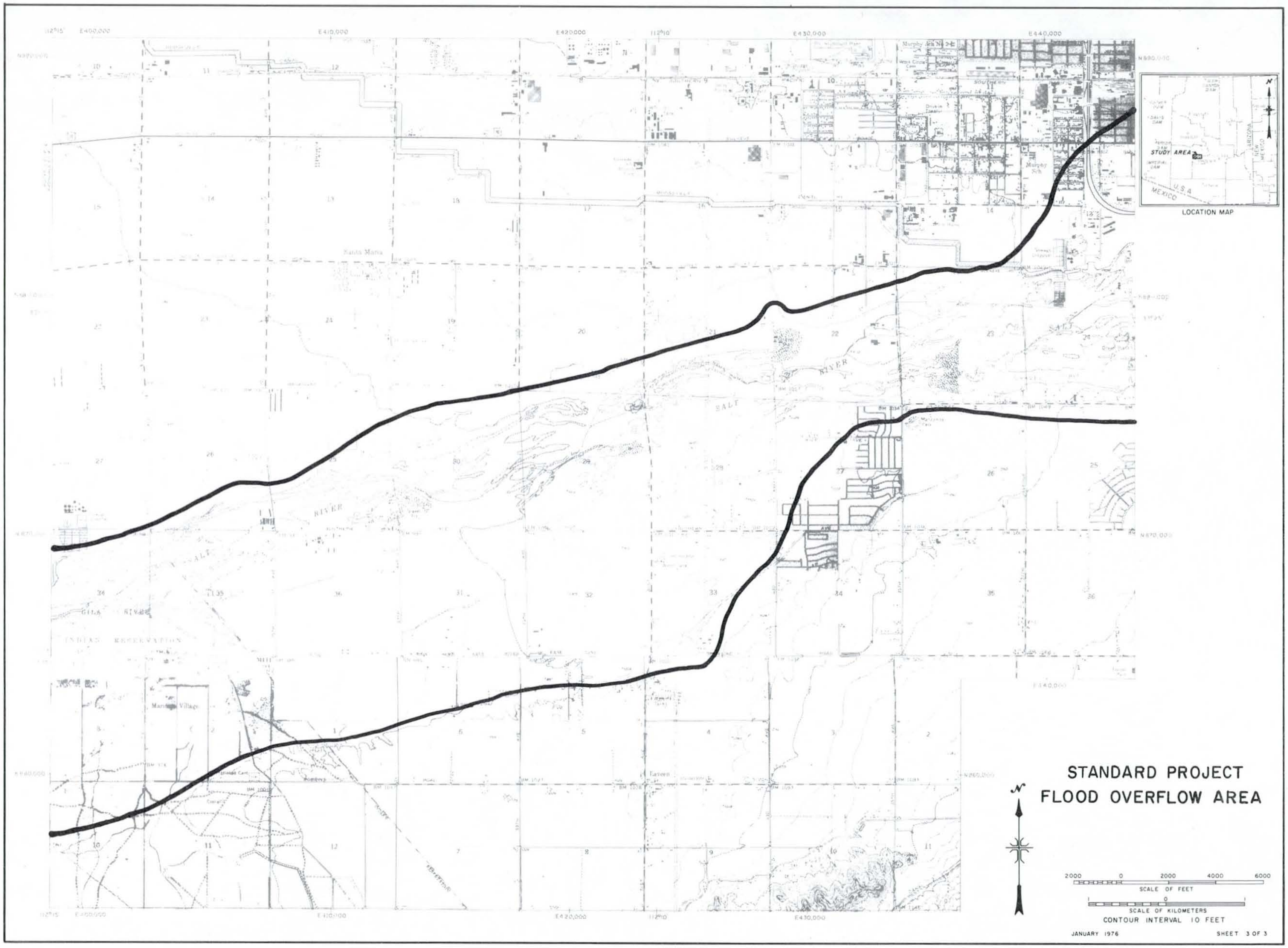

STANDARD PROJECT
FLOOD OVERFLOW AREA
LOCATION MAP
STUDY AREA
SALT
RIVER
GILA RIVER
INDIAN RESERVATION
2000 0 2000 4000 6000
SCALE OF FEET
SCALE OF KILOMETERS
CONTOUR INTERVAL 10 FEET
JANUARY 1976
SHEET 3 OF 3

Figure 5-3

In its June Phase III Report, the Arizona Water Commission (AWC) took the first step in the development of a program for water conservation at the State level in Arizona, by recommending several programs for urban and agricultural water conservation. For urban water conservation, the AWC recommended five feasible programs for implementation: a public education program to inform the public of the need to conserve water and how water can be conserved; a program designed to reduce water use by State agencies; water law clarification; water fixture standards; and ground water replenishment district legislation. Table 9 indicates the potential urban water savings in Arizona with implementation of the recommended programs.

Table 9
POTENTIAL URBAN WATER SAVINGS
ARIZONA-1980

Use	Est. Withdrawals w/o Conservation (acre-feet/year)	Assumed % Savings w/Conservation	Estimated Savings in Depletion (acre-feet/year)
Residential	462,000	15	38,000
Commercial	142,000	10	7,000
Government	36,000	15	2,000
Industrial	36,000	5	1,000
Losses	36,000	20	3,000
Total	712,000	14	51,000

Source: Arizona Water Commission, 1978.

The AWC recommended three specific acts by the State in support of agricultural water conservation: a study of tax incentives to farmers to undertake irrigation system improvements; a study of subsidy for professional irrigation management services; and additional programs for State lands by the State Land Department. According to the Commission, a 10 percent to 15 percent reduction in depletion would be a reasonable expectation and would yield a real savings of 430,000 to 640,000 acre-feet per year.

Arizona's new ground water management law also has conservation as its goal. The law is aimed at achieving a "safe yield" (ground water withdrawal equal to replacement) by the year 2025. It specifically calls for, among other controls, statewide registration of all wells; a pump tax and mandatory conservation for farmers; the latest conservation techniques for mines and industries; and established four Active Management Areas (AMA) which are subject to strict ground water control. These areas account for 69 percent of the State's ground water overdraft.

Although conservation alone will not resolve the CAWCS area's water problems, it can supplement other measures designed to balance the region's water budget. Water conservation is not tied to regulatory storage, but the

CAP is important in that increased conservation will be reflected in future use of CAP water.

2. Importation of Water. The CAP will transport Colorado River water from Lake Havasu, on the Arizona-California border, to the Phoenix metropolitan area by 1985 and to the Tucson metropolitan area by 1988. The CAP will divert between 0.4 and 2.2 million acre-feet/year from the Colorado River, depending on the system's capacity, user requirements, and the availability of water in the Colorado River. In years of low supply, the CAP may not receive its full allotment, as other water claims have priority. When a surplus of Colorado River water is available, however, Arizona would be entitled to additional water. Average diversions by CAP are estimated to be 1.0 million acre-feet/year without regulatory storage over the 50-year period from 1987 to 2036.

Photograph 3 - Central Arizona Project, Granite Reef Aqueduct, under construction.

It is estimated that with regulatory storage the CAP delivery could be increased 5-15 percent annually, depending on the alternative selected. The CAP system is designed to deliver a relatively constant amount of water throughout the year. With regulatory storage, extra water can be brought in during the winter months, put in storage and be available to add to the amount of Colorado River water that CAP can deliver during the high-use summer months. In addition to meeting fluctuating water demands, regulatory storage would maximize use of Colorado River water. According to the Colorado River Basin Project Act, which authorized construction of CAP, the CAP can divert continuously at capacity only when the Colorado River reservoirs are full or spilling. Regulatory storage would allow this additional water to be diverted and stored in the system for later use.

The CAP would have more operational reliability and flexibility with regulatory storage as well. The presence of a storage facility would decrease the possibility of CAP being unable to deliver water in the event of an aqueduct system failure or shutdown by providing an emergency water supply for the central Arizona water users downstream of the storage facility.

Providing regulatory storage capability in the CAP is one of the two main objectives of the CAWCS, and would increase the reliability of the system in meeting seasonal water demands, provide flexibility in emergency situations, reduce energy use during peak periods, and ultimately influence the amount of water that can be imported from the Colorado River.

3. Conservation of Surplus Local Flows. Large quantities of floodwaters flowing through normally dry river channels in the Phoenix area result not only in flood damages, but because these floodflows are presently uncontrolled, a great deal of water which could be obtained for beneficial use is permanently lost outside the CAWCS area. When upstream dams are unable to cope with the flows arriving from upstream, spillage occurs. This water flows through Phoenix and is retained behind Painted Rock Dam below Gila Bend. Water which arrives at Painted Rock Dam is essentially lost for beneficial use, except for the water which infiltrates into the ground and eventually reaches the ground water table. Some of this water can be recovered; some cannot and is lost for use. Table 10 shows the significant inflow to Painted Rock Dam in selected flood years.

Table 10
SIGNIFICANT INFLOW TO PAINTED ROCK RESERVOIR
(Selected Flood Years)

Date	(acre-feet)
1966 1/	432,200
1973 1/	941,100
1978 1/	667,700
1979 2/	1,435,200
1980 2/	1,848,200

1/ U.S. Geological Survey, Gaging Station, Gila River below Gillespie Dam.
2/ U.S. Army Corps of Engineers, estimate based on storage volumes at Painted Rock Reservoir.

It is evident that substantial water losses have occurred as a result of these unrecovered floodwaters. As an example, in terms of yearly water supply, average annual diversion by SRP on the Salt and Verde is 883,100 acre-feet. During the March 1978 flood, about 600,000 acre-feet of water flowed past Phoenix in the Salt River. These floodwaters lost for beneficial use equal 75 percent of a total average annual diversion by SRP.

The existence of CAP regulatory storage and flood control storage capacity would increase the opportunity to store portions of floodflows for later beneficial use either through direct water deliveries or ground water recharge. In a recent report (1978) to the Arizona Groundwater Management Study Commission, the Arizona Water Commission examined recharge as an alternative option for ground water management in the Salt River Valley. Floodwater was considered to be the major water source available for recharge. The report stated "the usable water supply of the basin might reasonably be augmented by an average of from 50,000 to 70,000 acre-feet per year through efforts to increase recharge from floodflows on the Salt River."

C. Water Quality

As described in Chapter II, Planning Area Description, the quality of both surface and ground water varies throughout the CAWCS area. Total dissolved solids (TDS) is one indicator of water quality. Table 11 indicates the TDS concentrations of surface water sources in the CAWCS area.

Table 11
AVERAGE TDS CONCENTRATIONS OF SURFACE WATER SOURCES IN CAWCS AREA

	Milligram per Liter
Domestic Water Supply Standard	500
Lake Pleasant 1/	266
Verde River Below Bartlett Dam 2/	265
Salt River Below Stewart Mountain Dam 2/	630
Confluence Mix 3/	473
Gila River at Kelvin 2/	1,137
CAP Water in Central Arizona 4/	755

1/ Water and Power Resources Service.
2/ National Stream Quality Accounting Network (NASQAN).
3/ U.S. Geological Survey Streamflow Data.
4/ Arizona Water Commission.

Water quality could be influenced in many ways by the plan developed by the CAWCS. The most representative evaluation of the impacts on water quality is analyzed at the point where the water user applies the water to its designated use, i.e., agricultural, fisheries, domestic, etc. Two issues of significant concern are salt loading and possible degradation of existing natural surface waters. Since regulatory storage will influence the amount of CAP water delivered, it will also influence the importation of dissolved solids. There has been significant concern over preserving the quality of the Verde River water for domestic purposes.

When water from the Colorado River is mixed with a local surface source in a regulatory storage reservoir, there will be a change not only in the quality of the natural surface water subsequently delivered through the existing system but also a change in the quality of the CAP water. Salt River water below Stewart Mountain Dam has an average concentration of 630 milligrams per liter (mg/L) TDS, while the Verde River average is 265 mg/L below Bartlett Dam. A flow-weighted average for the Salt-Verde system is about 470 mg/L. The Gila River, however, has an average concentration of over 1,100 mg/L TDS. The operation and location of a regulatory storage site and subsequent delivery methods will determine the extent to which these waters of various qualities are mixed. If CAP water were stored in underground reservoirs, there could also be a change in the quality of the water in the ground and the water later pumped out of the "recharged" aquifer.

D. Vegetation and Wildlife

Congress has passed a number of laws in recent years that require the evaluation of biological resources and the development of plans to protect them or mitigate the effects of proposed actions. In particular, there are very strong laws governing proposed actions which could have an effect on threatened or endangered animals or plants. Considerable public concern in the CAWCS area centers on the potential impact of CAWCS actions on threatened and endangered species and on land and water habitats which could be degraded or destroyed.

The rapid growth of agriculture and urbanization in large portions of the CAWCS area already has reduced substantially the amounts of land and water available for wildlife habitat. Of particular interest to the CAWCS are regions of riparian vegetation. Such growths exist in the CAWCS area along the lower Verde River; the Salt River above and immediately below Granite Reef Diversion Dam; the Salt-Gila River from the 23rd Avenue treatment plant in Phoenix to Gillespie Dam; and the Gila River above Ashurst-Hayden Diversion Dam. While relatively few animals would die outright as the result of construction, the disruption of their habitat could lead to declines in population and possible local extinction of certain species within the study area.

The U.S. Fish and Wildlife Service has determined that three endangered bird species occur in the CAWCS project area: bald eagle, Yuma clapper rail, and peregrine falcon. Two Arizona plants are designated as endangered species and occur in the CAWCS area: Arizona hedgehog cactus and the Turk's head cactus. No critical habitat has been designated in the planning area. An assessment (Dames and Moore, 1979) of the effects the various actions could have on the federally-designated threatened and endangered species in the CAWCS area shows that certain actions will adversely affect the bald eagle and the habitat of the Yuma clapper rail. The peregrine falcon is not anticipated to be adversely impacted. No impact to the endangered plant species is anticipated.

However, not all the effects of possible actions are negative. Such actions as ground water recharge or increased impoundments could induce growth of breeding habitats, not only of endangered species but of all wildlife in the CAWCS area.

E. Recreation

The desert climate which permits year-round enjoyment of outdoor activities together with increased income levels and leisure time has produced an unprecedented demand for recreation of all types in the CAWCS area. The steadily rising cost of gasoline has, at the same time, caused residents to orient their activities toward easily accessible facilities. The supply of recreational programs and facilities, both public and private, is unable to keep pace with demand. Existing facilities receive heavy, often excessive, use from residents and visitors to the area.

Photograph 4 - Free flowing river recreation.

The type of recreation available in the study area is also a concern of the CAWCS. Recreational use of the few water courses in the CAWCS area provides an example of this problem. During hot summer months, the flowing streams and man-made lakes on the Salt, Verde, and Agua Fria Rivers are used for water-based recreation such as fishing, boating, swimming, water skiing, and floating, while the lakeshores and riverbanks serve as sites for picnicking, hiking, and other activities. The flowing streams in the CAWCS area represent a unique and irreplaceable resource. Tubing has become a major water-based recreation activity for residents of central Arizona. The Salt River provides the only fast-water recreation opportunities in central Arizona which are relatively safe for tubing and easily accessible for users from the Phoenix area. The opportunity to tube down the river is particularly attractive to people in the area who cannot afford or are not interested in flat-water recreation. A study, undertaken as part of the CAWCS to determine user characteristics (Natelson, 1979), concluded that no alternative to the Salt River for tubing exists according to the majority of Salt River users. Other river areas such as the Verde and Gila Rivers are not as attractive to recreationists as the Salt. Any structure at the confluence of the Salt and Verde Rivers would greatly reduce this recreational opportunity.

F. Cultural Resources

Rapid urbanization over the past three decades has placed increasing pressure on the archaeological and historical resources in the CAWCS area and in some cases obliterated many sites of cultural importance. Because most of the prehistoric inhabitants of the CAWCS area practiced irrigated agriculture, the remains of their cultures tend to be located along or near major water courses. As a result, many archaeological sites could be impacted by flood control and regulatory storage alternatives on the Verde, Salt, Gila, and Agua Fria Rivers, and could affect historical sites along these major streams. The CAWCS is considering the value of such cultural resources in the study area and, where possible, will develop plans for their preservation.

G. Water Rights

Current water laws in Arizona assign ownership rights to ground water and prior appropriative rights to surface water. Two issues specific to the CAWCS are Indian water rights and ground water rights.

1. Indian Water Rights. In 1975, representatives of the Fort McDowell and Salt River Indian Reservations were among a group of Arizona Indian tribes presenting water rights claims before the Committee on Interior and Insular Affairs of the U.S. Senate. They protested the proposed allocation of CAP water as being too low. Several tribes throughout Arizona have filed lawsuits against other water users which, in general, allege misappropriation of water which rightfully should be available to Indians. A number of bills have been introduced in the Congress which would have more water made available to central Arizona Indians. Since the water supply is so limited, these would undoubtedly impact the non-Indian water users.

In this region, settlement of Indian water rights is a pressing matter which would have traumatic impact if a major reapportionment of surface and ground water rights occurred. In December 1980, the Secretary of the Interior announced CAP allocations which increased the amount allocated to the Indians. This action is currently in litigation. It is generally accepted that negotiation of an acceptable solution to Indian water rights is by far preferable to litigation. One of the keys to successful water rights negotiations is the availability of a new source of water to negotiate. CAP water, sewage effluent, and floodwater that might be controlled by the plan developed through the CAWCS are examples of additional water sources.

While the CAWCS has no direct role in settlement of Indian water rights issues or the allocations, it will influence to some extent the amount of water available through its proposed actions.

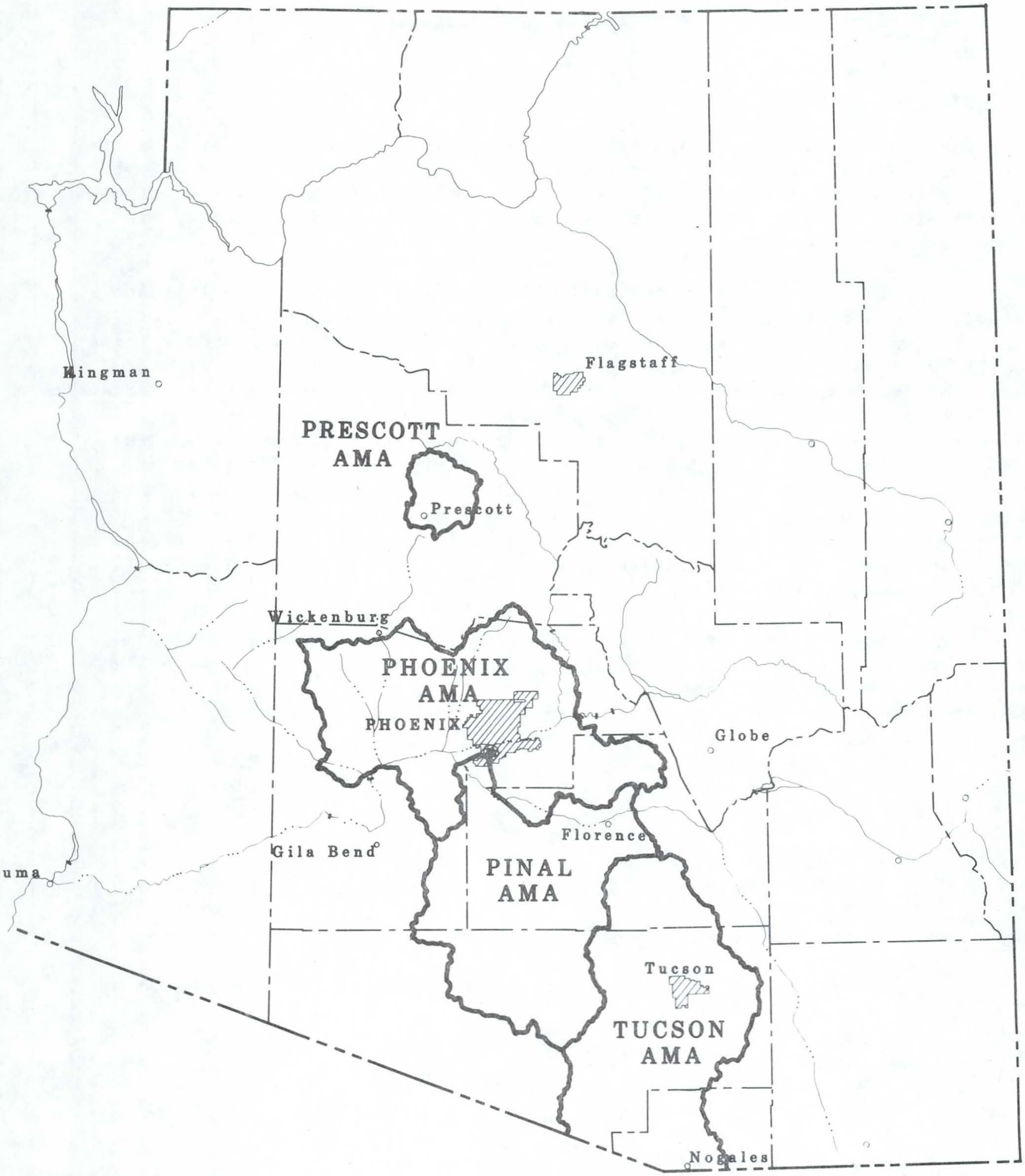
2. Ground water Rights. The depletion of the State's ground water supplies prompted the Arizona Legislature to adopt the Groundwater Code of 1948. This code provided for the establishment of critical ground water areas in basins not having sufficient ground water to provide an adequate term supply for the irrigation of cultivated lands in the basin at the then current rates of withdrawal. Much of the CAWCS area lies within these critical ground water basins. The Salt River Valley and the Queen Creek-Superstition, Gila-Santa Cruz, and Eloy areas were declared critical ground water basins. These four areas together comprise about 30 percent of the study area.

Drilling of new wells within the critical areas for irrigation of land not in cultivation when the designation was made was prohibited by the code. However, it did not control the extent of pumpage of wells already in existence, nor did it prohibit the drilling of new wells for purposes other than irrigation.

In May 1977, the emergency ground water bill was signed into law by the Governor. This act established a 25-member Groundwater Management Study Commission to draft a ground water management plan, which would become law in 1981 if the legislature failed to enact a new ground water code by that date. The legislature adopted the Groundwater Management Act on June 11, 1980. This Act creates a State Department of Water Resources whose director is appointed by the Governor. The legislation also established Active Management Areas (AMA) which would be subject to strict water control. Initially there are four AMA's: Phoenix, Tucson, Pinal, and Prescott (Figure 6). Subsequent AMA's could be established by the Director. All but two of the State's critical ground water areas are included in these AMA's.

The Act provides that in AMA's there will be no expansion of agricultural irrigated acreage. However, a person contracting for CAP water may substitute, on a one-to-one basis, acres irrigated between 1975 and 1980 with acres irrigated between 1958 and 1968 in order to effectively use CAP water.

Other major provisions of the Act outline rights and uses of water, rights to sell water, methods to reduce withdrawals, and other management and enforcement methods.



ACTIVE MANAGEMENT AREAS

Figure 6

Limitations imposed by this ground water legislation must be considered in the CAWCS.

H. Safety of Dams

The construction of a dam anywhere and particularly upstream of a major metropolitan area always involves consideration of the safety of the structure. With the February 1980 flood and the questions raised about the safety of Stewart Mountain Dam, public awareness of the importance of dam safety has increased in the CAWCS area.

In 1978, Congress passed the Reclamation Safety of Dams Act. This Act authorized the Secretary of the Interior (and authorized appropriation of $100 million) to construct, restore, operate, and maintain new and existing Federal reclamation dams for the purposes of dam safety. A review of the safety of existing dams in the CAWCS area identified Stewart Mountain, Roosevelt, and Bartlett Dams as requiring study and possible modification. Further, in connection with their responsibilities under the Safety of Dams Act and the CAWCS, the Service with the cooperation of the Corps initiated a joint re-evaluation of potential floodflows that could occur on the Salt and Verde Rivers. Based on this reevaluation, it appears that the maximum probable flood (MPF) into the two systems is substantially larger than those previously used. This increase will mean existing dams will have to be reevaluated with respect to dam safety criteria.

The inflow design flood (IDF) is the flood which controls the design of protective works of a specific dam and, in developed areas, is equal to the MPF. It is the maximum runoff, in peak flow, that could ever occur in the watershed under extreme climatological and meteorological conditions. The new IDF's being considered are nearly triple the old ones:

	Salt River Behind Roosevelt Dam*		Verde River Behind Horseshoe Dam*	
	Peak	10-day Volume	Peak	10-day Volume
Previous IDF	214,000 ft^3/s	1,182,000 ac-ft	237,000 ft^3/s	910,000 ac-ft
New IDF	680,000 ft^3/s	2,550,000 ac-ft	760,000 ft^3/s	2,260,000 ac-ft

*Does not include intervening flows below the dam.

Should the IDF occur, it would overtop dams along the Salt and Verde by 10 to 23 feet as shown below:

Verde River (revised IDF 760,000 ft^3/s)
- Horseshoe Dam: assumed failure if overtopped
- Bartlett Dam: overtops 20 feet

Salt River (revised IDF 680,000 ft^3/s)
- Roosevelt Dam: overtops 12 feet
- Horse Mesa Dam: overtops 13 feet
- Mormon Flat Dam: overtops 23 feet
- Stewart Mountain Dam: overtops 10 feet

Studies under the Safety of Dams Act are ongoing to evaluate the condition of the dams on the Salt and Verde Rivers and investigate alternative solutions to the dam safety problem.

Even though the CAWCS is independent of the Safety of Dams program and has a different focus and objective, the two studies have a definite interface in two key areas. Since both investigations are considering dams and reservoirs on the same watershed, although for different primary purposes, common solutions could in some cases result. If the CAWCS could design a new structure which could incorporate into it not only the primary purpose of the CAWCS but also safety of dams, the CAWCS would provide the opportunity for safety for other dams in the system. The timing of the implementation of the CAWCS plan will be very important in the determination.

In other cases, some CAWCS options could be precluded. In most of these cases the issue involved is the reanalysis of the inflow design floods. The routing criteria and the resultant flow to new downstream structures are critical. Any new operating criteria or structural changes at existing or new dams to provide flood control or regulatory storage must be compatible with dam safety criteria. If providing flood control or regulatory space in an existing structure through exchange or reregulation would create a situation in which the reservoir were so full as to endanger the structure should the inflow design flood occur, then regulatory storage or flood control would be precluded at that site.

The CAWCS must consider and coordinate modifications for CAWCS purposes along with the design for modifying and/or constructing the dams for safety purposes.

I. Energy

In recent years, energy demands and costs have risen dramatically. Substantial efforts are being made by power utilities in the CAWCS area to meet the demand and, in particular, to reduce demand during peak power periods. The plan developed by the CAWCS will influence and should be influenced by the energy picture in several ways.

If additional reservoir storage space is developed for either regulatory storage or flood control purposes, it may provide additional hydroelectric generating capability. This power might be provided on a continuous basis, thus augmenting baseload power capacity, or it could be provided only during periods of peak demand.

The addition of storage space or more efficient use of existing space might allow the capture and use of water that would otherwise be spilled and could reduce the amount of water required to be delivered by the Granite Reef Aqueduct from the Colorado River. This would result in obvious savings in the power required for pumping from the ground or the Colorado River.

To further enhance the CAP impact on regional power supplies, the pumping plants along the Granite Reef Aqueduct (particularly the Havasu Pumping Plant since it will consume over half of the CAP's pumping energy) will be operated whenever possible at full capacity during offpeak power demand periods and at reduced capacity during onpeak periods when consumer demands for electricity are the highest. This shift in use from onpeak to offpeak can be handled on a daily basis by the aqueduct itself. But on a seasonal basis summer to winter, a storage facility would be needed so that water could be pumped when energy use is low (the winter months), stored, and delivered at a later time when energy use is higher (the summer months). By shifting CAP energy requirement from summer to winter, power could be made available from the Navajo Powerplant for marketing during the high demand summer months. Because of this the power could be marketed at a higher rate than that marketed during the low demand winter months. A regulatory storage facility would provide the storage necessary to allow these energy shifts to take place.

J. Land Use

Water availability and flood control measures have the potential to influence the type, location, growth patterns, ownership, and use of land in the CAWCS area. Alteration of the flood plain is actually de facto land use planning.

Residential and recreational developments are frequently located on private and public lands adjacent to major reservoirs because of the environmental amenities and recreational opportunities afforded by the impounded surface waters. Open space areas within floodways that have levees to provide limited protection from flooding in urban areas may also experience development pressure. The CAWCS plan in this way could conceivably influence future land use patterns and redirect urban growth. Implementation of actions, especially nonstructural elements such as flood proofing and flood plain acquisition, could lead to changes in land use along the flood plain.

K. Social and Economic Issues

Social and economic issues reflect the concerns of local residents, government officials, and special interest groups. Of all the socioeconomic issues relating to flood control in central Arizona, flood damage to property and transportation disruption and service interruption affect the largest number of people. The lives of those who are not directly flooded are disrupted by traffic delays, bridge and utility outages, and damages to business in flood prone areas. Enforcement of existing zoning regulations that preclude future development in the flood plain is expected; still, some way to solve the problems created by existing development is needed.

The price of additional water supply developed by the operation of CAP regulatory storage, as well as the amount available and how often it will be available, will affect its marketability. Who gets the water, the willingness of potential users to pay for it, as well as its effect on smaller agriculture dependent communities are other factors which must be addressed. Other issues include changes in recreational use or the creation of new forms of recreation, changes in land use due to alteration of the flood plain (both of which have been discussed previously in this chapter), changes in property values, and gains or losses in business.

Implementing--or not implementing--a water development plan carries with it social and economic costs and benefits; some people benefit, some "pay." For instance, persons living in an area affected by a proposed plan may be forced to relocate, while those in another area will be beneficiaries of new jobs, businesses, etc. These "tradeoffs" must be determined to evaluate alternative solutions. On a broader scale, the net benefits of alternative solutions must be determined. This determination assigns a monetary value to the benefits of flood control (damages prevented), regulatory storage, recreation, and hydropower and is used to justify a project from a national economic development standpoint.

All of the social and economic issues described relate to some extent to Indian communities. But, in addition, certain actions are located on or near Indian reservations, and their development could have distinct cultural implications for Indians. The effects of certain actions on a community's ability to maintain its cultural heritage are of major concern.

CHAPTER IV

PLANNING PROCESS

The Central Arizona Water Control Study (CAWCS) follows a three-stage plan formulation process. While the basic tasks within each stage are similar, the level of detail and reliability of data and analysis increases with each stage (Figure 7).

Stage I planning is exploratory in nature and is carried out at a preliminary level of detail. Problems, needs, and issues of the CAWCS area are identified, and broad planning objectives are established. A wide array of possible solutions is developed and, after preliminary assessment, unsuitable alternatives are eliminated from further study. At the end of Stage I, a Plan of Study was prepared which documented alternatives for further study and outlined a management program for the remainder of the study.

During Stage II, the planning focus begins to shift from problem identification to formulation and testing of alternative solutions. Intermediate plans are developed, and more detailed technical analysis and environmental assessments are conducted. Once again, less attractive plans are eliminated, and a limited number of plans are recommended for further study in the next and final stage of the study.

In Stage III, the final planning stage, the focus of the planning effort shifts from alternative formulation (although plans are continually being modified) to thorough impact assessment and evaluation. A small number of candidate plans are developed in detail emphasizing assessment, modification, evaluation, and implementation arrangements and leading to the recommendation of one preferred plan. Technical documents and an environmental impact statement (EIS) are prepared, and the final plan is recommended for implementation based on a review of these documents.

Numerous regulations and laws guide the CAWCS planning process. The overall guideline is Principles and Standards for Planning Water and Related Land Resources, prepared in 1973 by the Water Resources Council under authority of the 1965 Water Resources Planning Act and revised and updated in 1978-1979. These guidelines stress a multiobjective approach to planning requiring that Federal and federally assisted water and related land planning have National Economic Development (NED) and Environmental Quality (EQ) as equal national objectives. Candidate plans which accomplish these two objectives will be identified in the CAWCS in Stage III. Other regulations, such as the National Environmental Policy Act (NEPA) and the Endangered Species Act, set forth guidelines to ensure that planning promotes restoration, protection, and enhancement of the environment. In the spirit of Principles and Standards, the Corps and the Service set forth Engineering Regulations and Water and Power Instructions, respectively. These regulations are an interpretation of Principles and Standards and are used to guide the technical studies.

A. Alternative Development

The development of alternatives in the CAWCS is a process of transition from a wide array of possible solutions to an adopted plan, eliminating infeasible solutions and combining feasible solutions at each stage of planning (Figure 8).

1. Elements. The first step in alternative development was to identify a wide array of possible actions, or ELEMENTS, that either singly or in combination with other elements could provide the two main CAWCS purposes of flood control or regulatory storage. The elements were identified based on several factors: provision of flood control or regulatory storage, location, and geotechnical feasibility. During Stage I, the elements were examined at an initial level of study to determine their effectiveness for regulatory storage or flood control, including a review of existing geological information, field review by geologists and engineers, preliminary analysis of the relationship between dam height and reservoir capacity, and preliminary cost estimates. Based on the analyses, the most acceptable elements were recommended for further study in Stage II; others were eliminated from further study. These recommendations were made by the Service and the Corps based largely on three factors: geology (site suitability), location, and economics.

During the initial portions of Stage II, the recommended elements received further study at an appraisal level to provide enough data regarding the element and its cost so that comparisons could be made among "competing" elements. Analysis of regulatory storage or flood control included operations and flood routing studies, more detailed geotechnical investigations (drilling program), site-specific engineering design and cost estimates, and environmental, social, economic, recreational, and other relevant nonengineering assessments. Based on these analyses, the best of the elements was recommended to be carried forth for more study. At this step of alternative development, elements were eliminated based on the selection of the best of "competing" elements. Elements were considered to be competing if they would perform the same function and could be substituted for each other in the combination of elements. In other words, they were essentially the same elements at different locations. Comparison of competing elements was based on technical, economic, geologic, and environmental/social impacts. (See Chapter VI, Description and Evaluation of Elements.)

2. Systems. The next step in alternative development (in Stage II) was to combine the remaining elements into SYSTEMS capable of providing both flood control and regulatory storage. While the total number of theoretical systems numbered in the thousands, the number of genuinely viable alternatives was much smaller. Still, to facilitate system building and evaluation, the most technically feasible systems were grouped into a number of "concepts," each concept representing a type of solution with a number of possible variations to each type. Systems were formulated by grouping together elements which fit the various concepts and at the same time accomplished the primary purposes of flood control and regulatory storage. Technical, economic and environmental/social analysis, and evaluation of systems resulted in recommendation of a limited number of possible solutions to be carried forward for detailed study

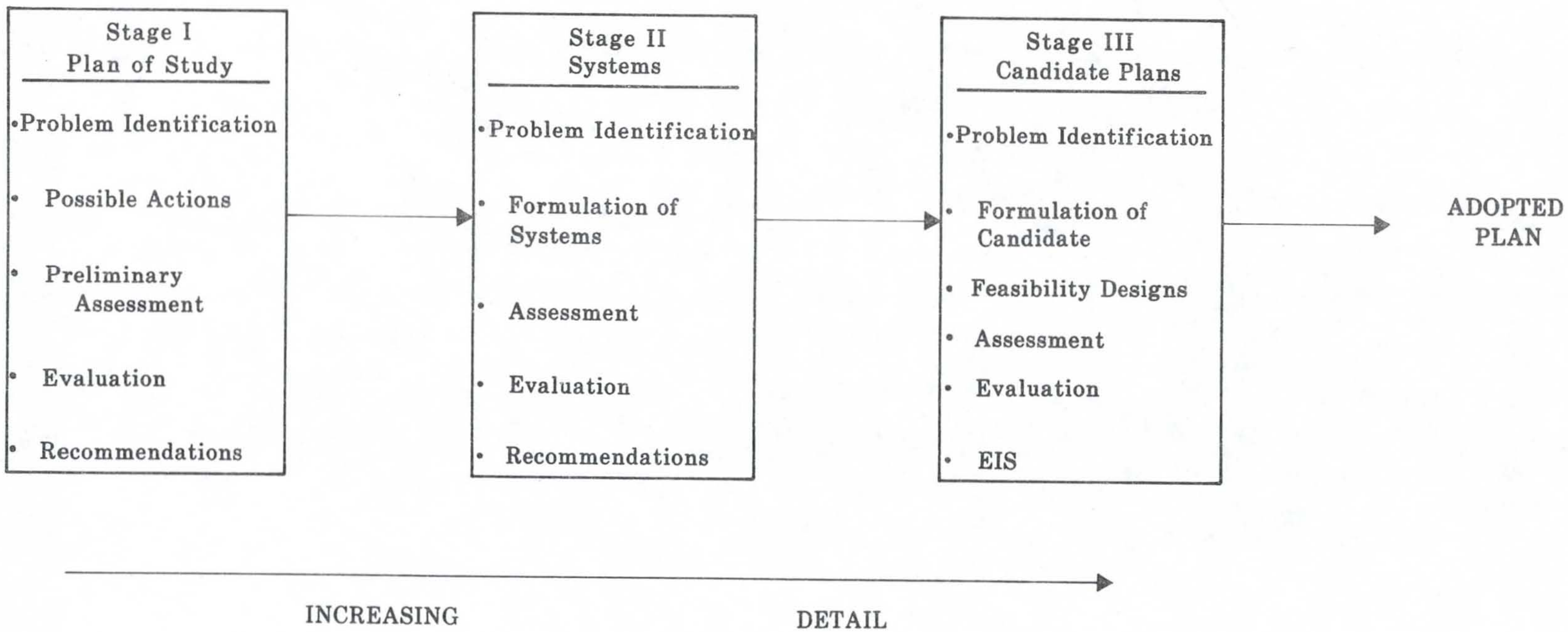


Figure 7

CAWCS PLANNING PROCESS

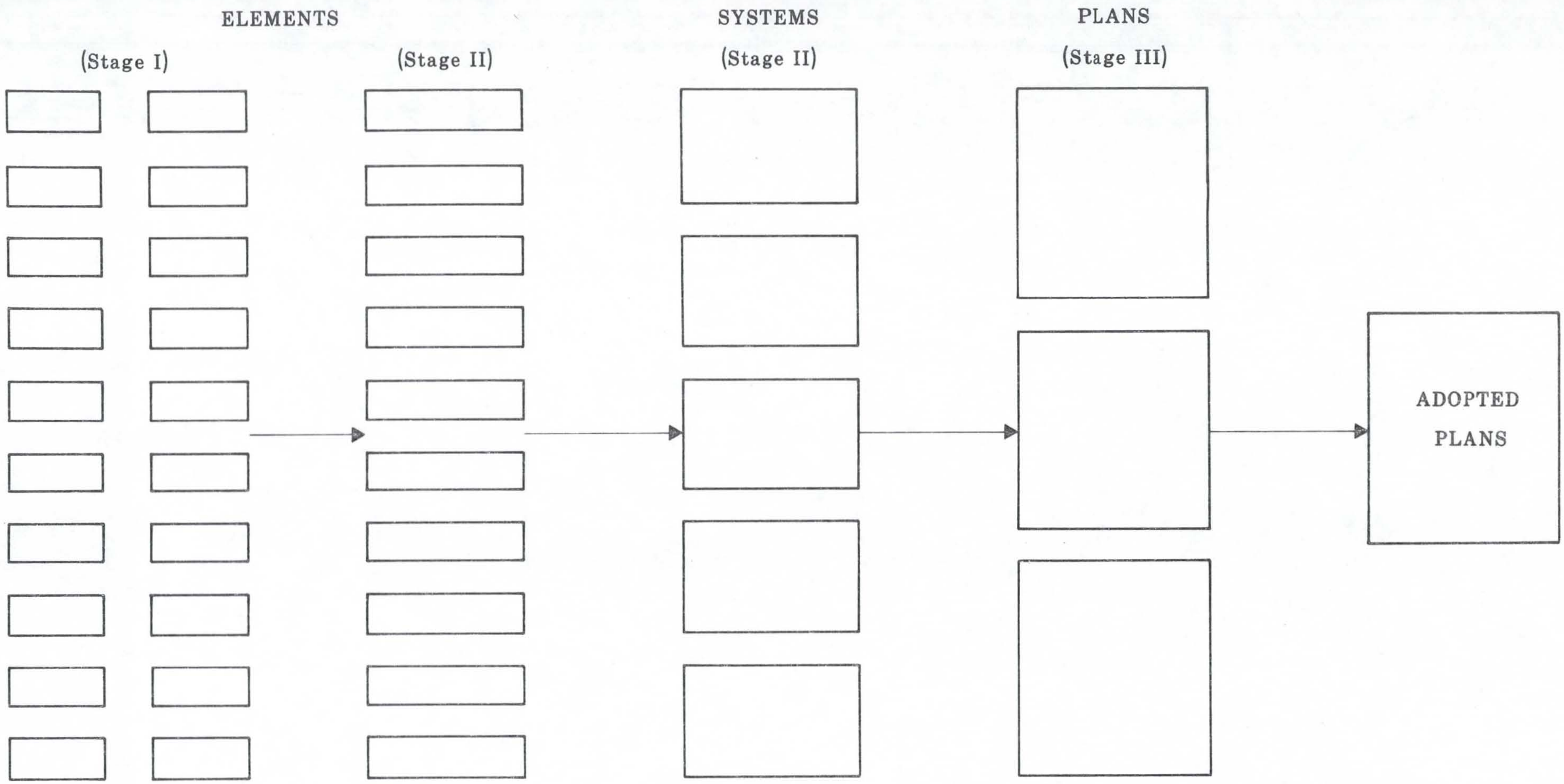


Figure 8

ALTERNATIVE DEVELOPMENT

in Stage III. Recommendations at this stage of alternative development were based largely on: operations (performance), optimization, economics, environmental and social impacts, and institutional factors. (See Chapter VI, Description and Evaluation of Systems and Chapter VII, Recommendations for Stage III.)

3. Plans. The final step in alternative development is to develop the systems into PLANS for detailed study in Stage III. This level of study, the feasibility level, is the most detailed level of study and sets out how each candidate plan would be implemented and operated. Each plan will include:

- Economic optimization (maximum net benefits).
- Recreation plan.
- Fish and wildlife plan.
- Institutional factors.
- Mitigation plans.
- Environmental impact analysis.
- Feasibility level design (relocation plan, operation guidelines, etc.).
- Benefit/cost analysis.

It is from these candidate plans that an adopted plan will be recommended for implementation.

B. Stage II Planning Process

The objective of Stage II planning was to evaluate elements in more detail, combine the best of the elements into systems for further study, and recommend a number of solutions for study as candidate plans in Stage III. The engineering, economic, environmental, socioeconomic, and institutional analyses carried out for regulatory storage by the Service and for flood control by the Corps during Stage II involved:

- Hydrology and hydraulics.
- Geotechnical investigations.
- Design and cost.
- Economic analysis.
- Hydropower (regulatory storage only).

- Recreation.
- Environmental and socioeconomic evaluation.
- Institutional analysis.
- Phreatophyte study (flood control only).

The majority of the effort in these areas during Stage II was devoted to the analysis of elements. Elements were developed in detail and, when combined into systems, the analysis became cumulative in nature. With most of the needed data generated for elements, the data needs for systems were limited.

Figure 9 shows the Stage II planning process. Following is a description of the approach used in the flood control and regulatory storage analyses. The description focuses on element analysis; additional analysis specific to systems is noted where appropriate.

1. Hydrology and Hydraulics

a. CAP Regulatory Storage. The purposes of Stage II hydrology studies for water supply (Figure 10) were to: determine CAP water supply yield with regulatory storage, and demonstrate system operation. Studies were based on an analysis of the CAP with and without regulatory storage. The first step was to determine the CAP water supply. This was done through a computer program, Colorado River Simulation Program (CRSP), developed by the Service which, based on historical runoff records (1906-1977), provided the baseline water supply at the Colorado River. The baseline data were then broken into 5-year increments and manipulated to obtain a wide range of statistical possibilities of CAP water supply in the future (13 different sequences). Future supply potential recognizes the fact that historical diversions will not remain constant; as Upper Colorado River Basin diversions increase, due to such factors as development of additional water projects, future CAP water supply will decrease.

Once the future water supply was determined, the Central Arizona Project Simulation (CAPSIM) computer model was used. CAPSIM "operates" the CAP on a monthly basis. It first projects the demand for water in the study area. This projection takes into account water allocations, priority uses, and assumes there will be no change in cropping patterns. Based on these assumptions, a demand model was developed. CAPSIM matches demand with supply for each of the 13 sequences to determine how much demand can be met by CAP supply. In months when demand is less than supply, water would be put into regulatory storage; when demand is more than supply, water would be drawn out.

To determine the CAP yield for the individual elements, CAPSIM operates the CAP first with storage and then without storage. The difference between the with storage and without storage condition is the CAP yield for that element. Figures used are statistical average annual amounts derived by averaging the 13 sequences.

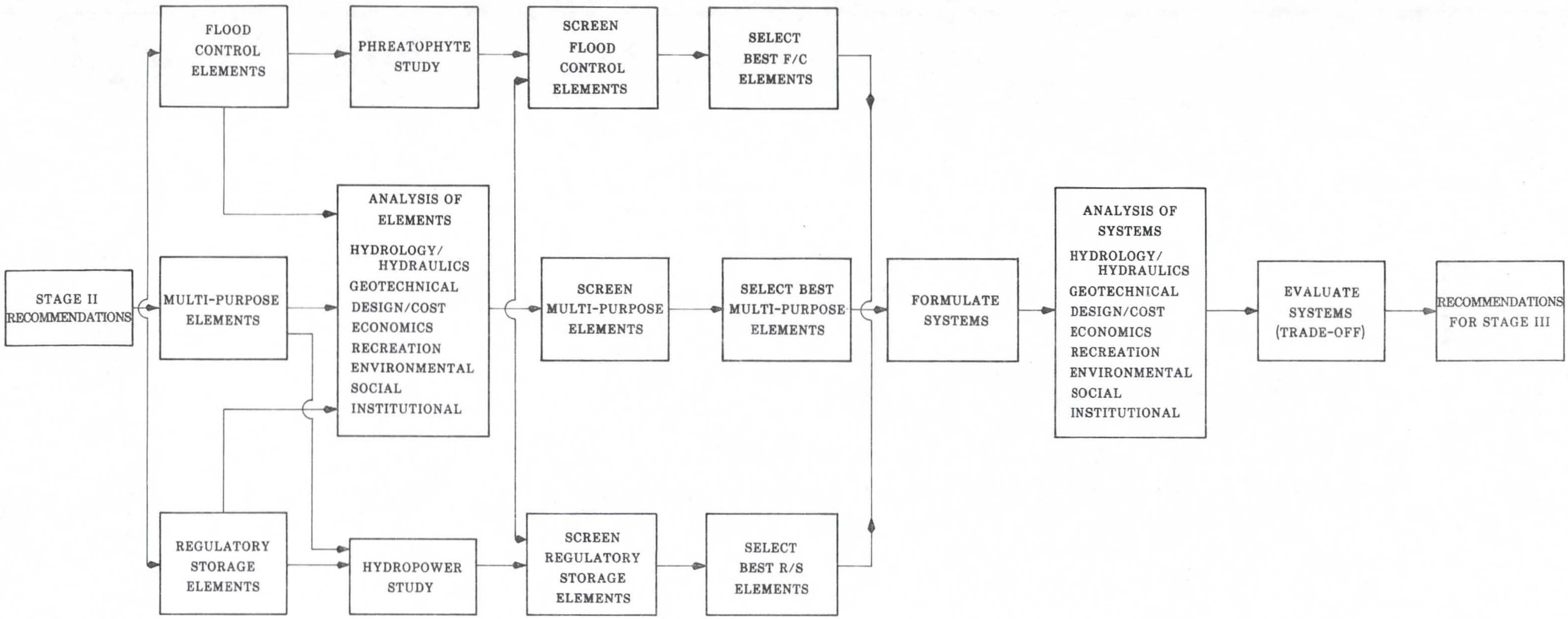
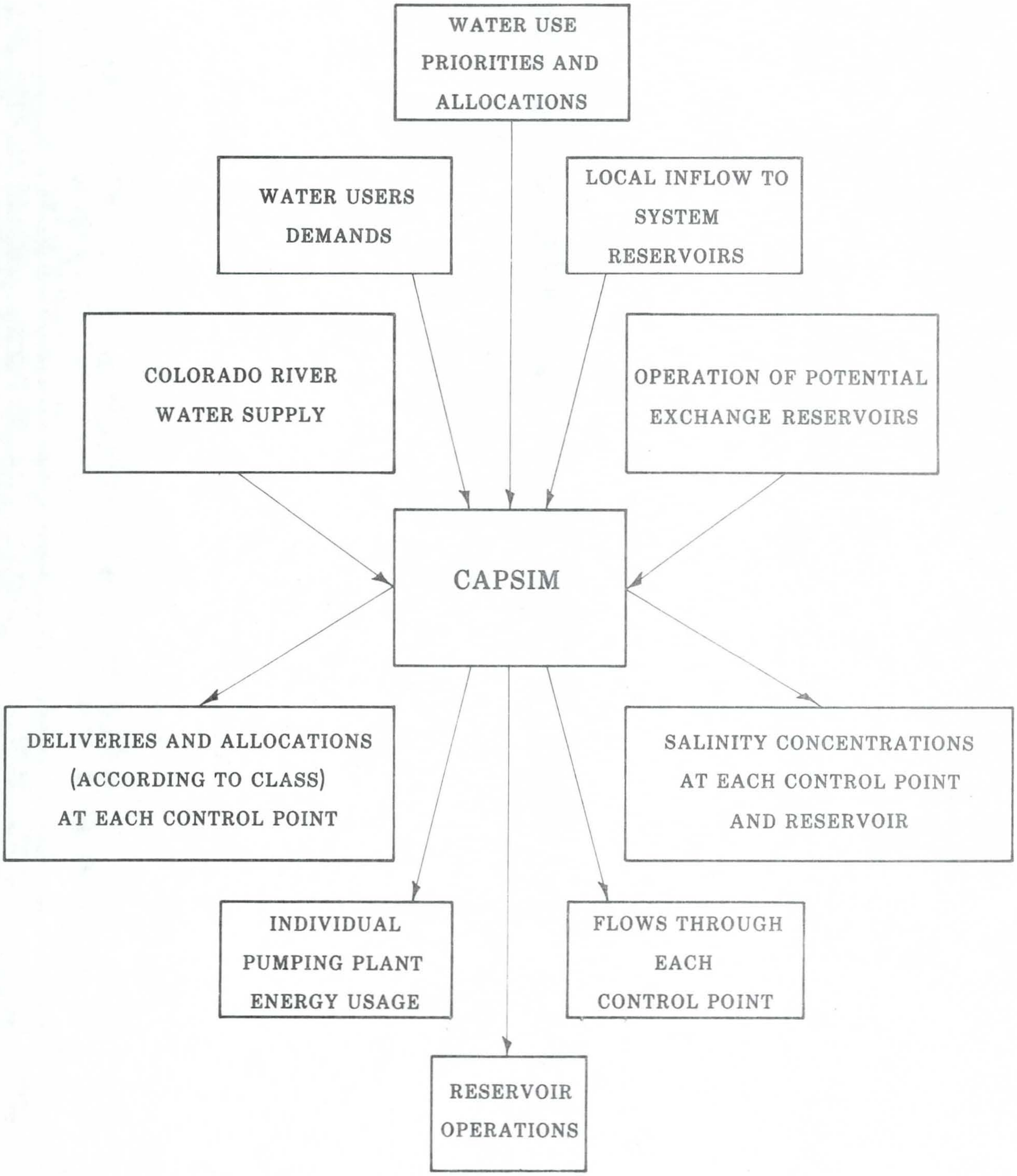


figure 9

STAGE II PLANNING PROCESS



HYDROLOGY STUDIES
WATER SUPPLY

Figure 10

b. Conservation of Local Flows. Additional studies were run to determine the potential for water development from surplus local water supply on the Salt and Verde Rivers. It was assumed that SRP storage increased through modification of existing dams. A computer model (SRPSIM) was developed to simulate the SRP series of dams and operation patterns. Increased water conservation would result from the ability to store water that would otherwise spill. The model was able to determine the increased conservation for the SRP system on either or both the Salt and Verde Rivers. The program was also applicable for flood control studies which result in a decrease in conservation space (i.e., reregulation). The result of the studies was a determination of the net increase or decrease in surface water supply, based on a long-term average.

c. Flood Control. Flood control hydrology studies, using historic streamflow records, estimate the exceedance frequency of various magnitudes of annual peak flow. Because exceedance frequency expresses the frequency with which certain events occur over time, it is used for computing damages on an average annual basis and for determining the degree of protection and risk of various actions. It is developed for a specific location in the system.

Also part of the flood control hydrology studies is a determination of the amount of flood control storage space required to limit flows to an acceptable level downstream. First, based on historical rainfall and runoff data in the basin and on data from similar basins, rainfall/runoff relationships are developed. The rainfall/runoff relationships determine the amount of runoff that will occur from the various drainage basins in the watershed from a storm event. This information is then used to develop flood hydrographs (relationship of flow over time in a flood event) for the basin. In Stage II, hydrographs were developed for the 50-year, 100-year, Standard Project Flood, 500-year, and Probable Maximum Flood. A computer model (HEC-5) then simulated operation of the flood control elements as part of a system for these floods to determine the amount of storage space needed to control flow to a selected release downstream. In Stage II, four levels of release were analyzed: 50,000 cubic feet per second (ft^3/s), 100,000 ft^3/s, 150,000 ft^3/s, and 200,000 ft^3/s, to provide a wide range of damage reduction for the flows.

The output of the hydrology studies is used in hydraulic analysis. Based on the projected floodflow plus the topography of the channel, obstructions or crossings, and channel roughness, a computer model (HEC-2) determines the overflow boundaries and water depths. Data were obtained for the 10-year flood, 100-year flood, and SPF, and for historical events. Hydraulic analysis is also carried out for design of outlet works, spillways, channels, and levees.

The data obtained in flood control hydrology and hydraulic studies are a direct input into design and cost studies and economic analysis as described in later sections of this report.

2. Geotechnical Investigations. Geotechnical investigations were carried out to assess the suitability of a potential dam or channel site. Four areas were investigated: the foundation (both surface and subsurface

geology); the reservoir (ability to hold water, potential for landslides, water table); seismicity (faults, earthquakes); and materials (availability and suitability for use in embankment). As the planning progressed and more data were needed, the level of detail of the investigations and analysis increased.

Foundation investigations during Stage II involved a drilling program at sites where sufficient data were not available to determine adequately the suitability of a site. The drilling provided data on the location of faults, the character of the materials which would support the dam, and the potential for seepage. During Stage II, drilling was conducted at the New Waddell, Horseshoe, Cliff, Bartlett, Roosevelt, and Buttes sites. The investigations identified the need for still more data for Buttes and Roosevelt, and drilling is ongoing at these sites. Sufficient drilling had been carried out previously at the Confluence, Granite Reef, and Florence sites.

Investigation of the reservoir area provided data on the ability of the site to hold water, faults, the water table, and the potential for landslides.

Seismicity investigations provided data on the location of faults, whether the fault was active or inactive (capability of movement), and the potential impacts on the structure should the fault move (intensity of movement, distance from the proposed structure, and the intensity of the earth wave when it reaches the structure).

Materials investigations focused not only on the quality of materials to be used in the embankment, but also the availability of suitable materials at or near the proposed site.

The results of the geotechnical investigations indicated where additional investigations would be needed, a determination of the alignment of the dam, spillway locations, design of the embankment, and the treatment of the foundation prior to construction.

Geotechnical investigations for channelization focused on geology of specific reaches of the channel, particularly depth to ground water, direction of ground water flow, subsidence, and soils for construction. Geotechnical investigations for channelization elements were less intensive than for dams, and the results were used mainly for design and costing.

More detailed geotechnical information is contained in a Geotechnical Appendix, prepared by the Corps of Engineers, and a Damsite and Structure Review Team Report, May 1979, prepared by the Service. Geotechnical information regarding individual sites is described briefly under the description of elements in Chapter VI of this report.

3. <u>Engineering Design and Cost Estimating</u>. Engineering design and cost studies determine what types of physical features are necessary to implement a structural concept, and then how much those features would cost. All estimates performed for Stage II were for an appraisal level of detail. Appraisal designs are site specific and represent an accurate portrayal of the requirements necessary to construct a project. However, they lack the intensive

detail which would be necessary to determine the actual cost for a particular site at a particular size. In general, to offset the cost of unknown design variables, appraisal estimates include percentage costs for unlisted items, contingencies, and general expenses and overhead. To facilitate the study of a range of structural sizes, a curve of cost versus size was developed for every alternative.

Costs for features fall into two categories: construction costs and annual costs, which include operation, maintenance, and replacement (OM&R) costs. In Stage II, costs were estimated using the current unit prices at the time the estimate was prepared. To ensure that a consistent comparison between alternatives would be made, all costs were indexed to January 1980 dollars.

Operation, maintenance, and replacement costs recur on an annual basis. These costs are determined based upon personnel needs, machinery, and replacement of parts which will wear out on a predictable basis.

a. Regulatory Storage. Regulatory storage structural requirements fall into three major feature categories: dams and reservoirs, canals, and underground storage features. Each feature category was divided into major design groupings for estimating purposes. These are:

DAMS AND RESERVOIRS

- Diversion and care of the river during construction.
- Lands and rights.
- Relocation of property of others.
- Reservoir clearing.
- Dam structure.
- Spillway.
- Outlet works.

CANALS

- Concrete-lined canals.
- Pumping plant.
- Discharge pipelines.
- Transmission lines and switchyards.

UNDERGROUND STORAGE

- o Spreading basins.
- o Recovery wells and pumps.
- o Collection canals.

For regulatory storage elements, the majority of OM&R costs are the result of pumping plant maintenance and supervisory control of reservoir operation.

Pumping energy costs were also calculated on an average annual basis. Pumping energy requirements and costs were divided into two categories: regulatory storage operation, and total CAP operations. The reservoir operation studies indicate how much water is pumped either into or out of the reservoir on an average basis. The height the water must be lifted depends upon the elevation of the CAP aqueduct and the elevation of the reservoir and is different for each alternative. An average annual energy requirement is then calculated and a cost determined.

Total CAP operation pumping cost relates to the cost of pumping water from the Colorado River to central Arizona water users. A comparison is made between energy requirements of the CAP with regulatory storage versus those required without regulatory storage. The difference is generally the result of having more water deliveries when regulatory storage is included in the CAP.

The measurement of the energy costs for systems pumping is complicated by the fact that they are related to the operation, maintenance, and replacement costs of the Navajo Generating Plant. For Stage II analysis, it was assumed that the cost remained fairly constant regardless of CAP water deliveries. In reality, cost could be related to rate structure which might not remain constant. Therefore, it was determined that the best measure of energy costs would be the net loss of energy revenues from commercial sale of surpluses from the Navajo Generating Plant.

b. Flood Control. Flood control structural alternatives fall into two categories: dams and reservoirs, and channelization (channels, levees, greenbelt). Design groupings for estimating purposes were:

DAMS AND RESERVOIRS

- o Foundation preparation.
- o Embankment.
- o Reservoir clearing.

- o Spillway.
- o Outlet works.
- o Demolition of existing structures.
- o Miscellaneous (roads, bridges, cleanup, building grounds, utilities).

CHANNELIZATION

- o Excavation.
- o Site preparation (e.g., diversion and control, fill).
- o Drop structures.
- o Relocations, modifications.
- o Land or right-of-way acquisition.

In estimating the cost of flood control alternatives, the HEC-5 program was used as the basis for determining the storage requirements and flood outlet works capacities needed to meet downstream flow objectives. Cost curves were used to estimate the costs for any particular size dam. Facilities were sized and preliminary designs prepared for the embankment, outlet works, and spillways. Then quantities of excavation and materials for the features and other features were estimated, and unit costs were applied to the quantities to develop cost curves.

In addition to unit prices, other costs were estimated to account for contingencies, engineering and design, and supervision and administration, and were estimated as a percentage of the total cost of the alternative. Operation and maintenance costs were based on Service and Salt River Project experience.

Channelization costs were estimated by applying unit prices to site preparation, excavation, drop structures, relocation and/or modifications, and land or right-of-way acquisition. O&M costs (repairs to channels and levees, debris removal, and replacement of plantings) are based on local experience.

4. Economics. The economic analysis in Stage II centered on determining the economic efficiency of alternatives. Two measures of economic efficiency are important: benefit/cost ratio (indication of whether a project would return more in benefits than it would cost); and net benefits (the difference between benefits and costs). Although it may not have the highest benefit/cost ratio, the project with the greatest net benefit demonstrates maximum economic investment.

a. Regulatory Storage. Regulatory storage is used to increase the amount of CAP water available for irrigation. The benefit of supplying regulatory storage was measured by the reduction (savings) in pumping cost of using regulatory storage water in place of ground water. The regulatory benefit for each element was determined as follows (Figure 11):

- o Data on well depth, acre-feet pumped, and equipment replacement costs were gathered.

- o The savings per acre-foot were computed for each district and an allocation-weighted average savings per acre-foot was then calculated for the study area ($34 per acre-foot).

- o This average savings in pumping cost was then multiplied by the net water yield for each element (output of hydrology studies) to determine the savings in pumping cost for the element over time.

- o The results were discounted and annualized to determine the benefits of the element.

The water supply benefit computation was based on several assumptions:

- o Water developed by regulatory storage will replace ground water rather than being used to irrigate new land.

- o The Arizona Department of Water Resources proposed non-Indian agricultural water allocations will be adopted and agricultural entities will contract for the full amount offered to them.

- o Because neither the CAP agricultural supply nor the CAWCS supply is a firm water supply, the irrigation districts will have to maintain ground water pumps for a standby water supply.

b. Flood Control. Economic benefits of flood control consist primarily of 1) inundation reduction, 2) location, and 3) intensification benefits. Based on a determination of the level of existing and future flood damages without a project, the extent to which those damages are reduced by a project constitutes the inundation reduction benefit (damages prevented).

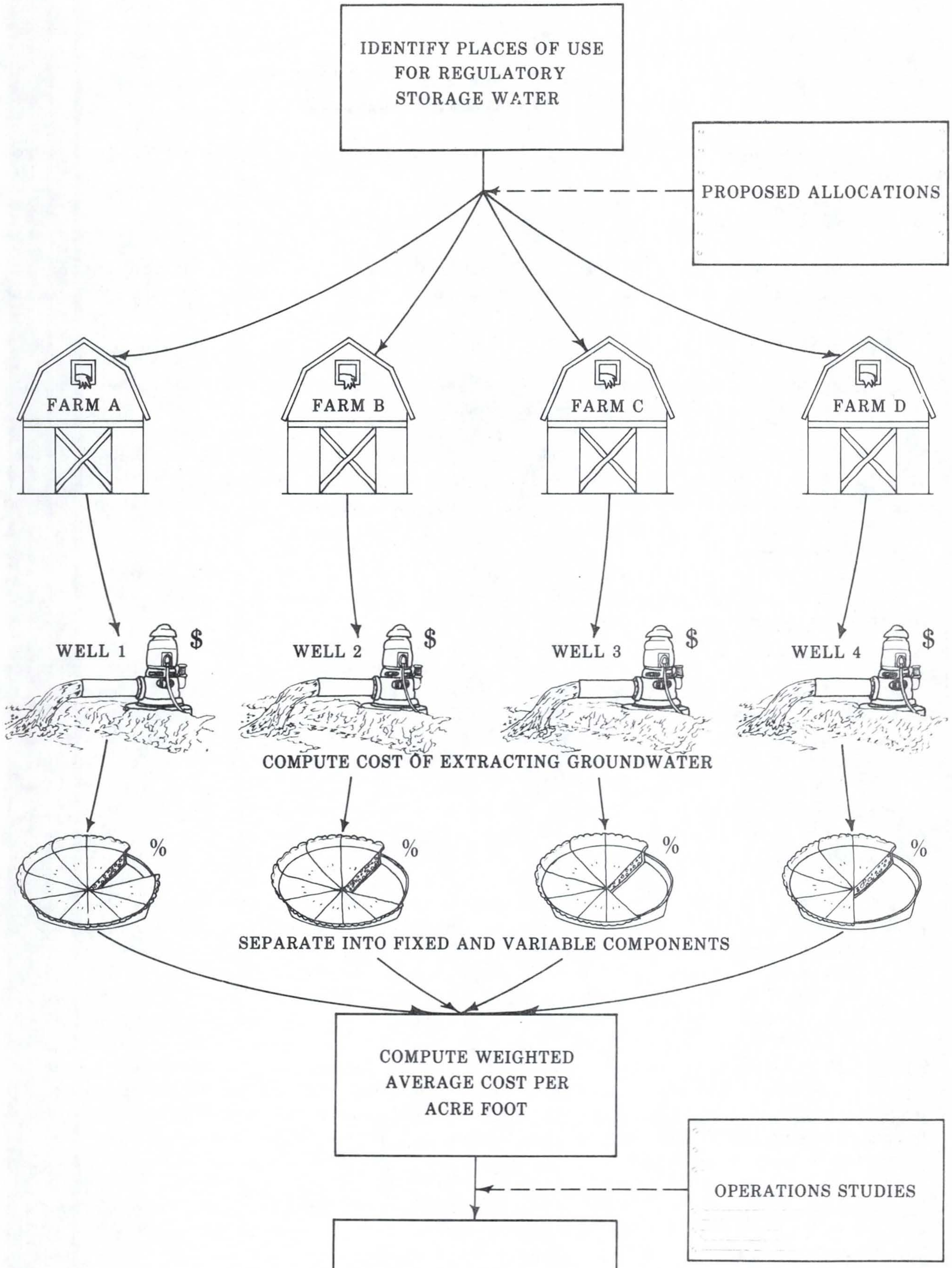
Types of damages considered are:

- o Physical (residential, commercial/industrial, public, agriculture, unique structures).

- o Emergency costs (public, private).

- o Income losses (transportation delays, changes in water table).

Location benefits are derived by analyzing undeveloped land without a plan as compared with new development with a plan. The difference between aggregate net incomes is the benefit. Intensification benefits consist of changes within present land uses, so that the land uses with a plan are more productive and efficient than without a plan. The benefit is the increased net income generated by the change. During Stage II, benefits of flood control



DETERMINATION OF CAWCS REGULATORY STORAGE BENEFITS

Figure 11

elements were measured in terms of inundation reduction and location. Intensification benefits were not quantified in Stage II.

As shown in Figure 12, the approach used in determining flood control benefits was:

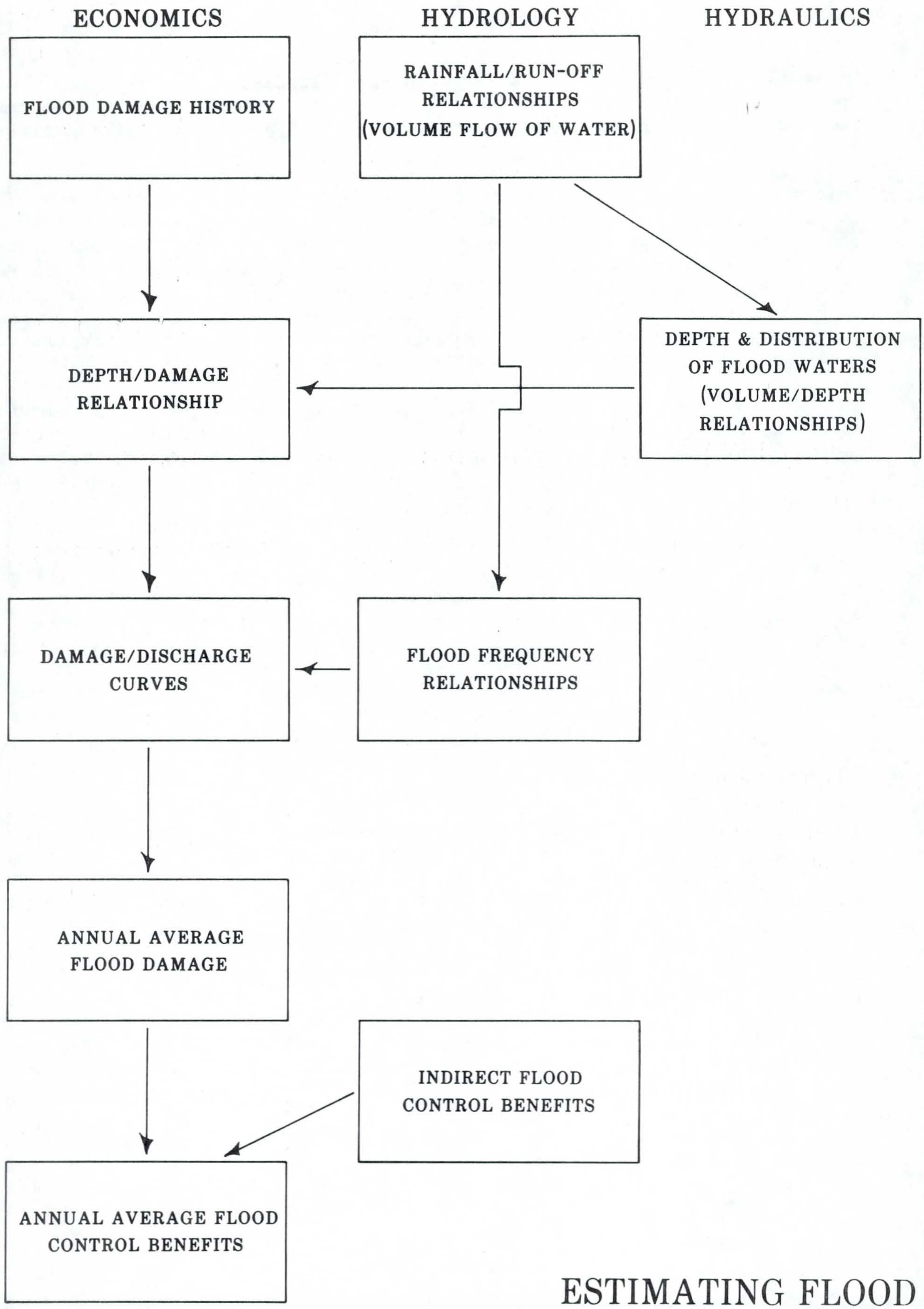
- o Develop a history of flood damages in the planning area.
- o Develop depth/damage relationship which, based on the depth and distribution (overflow area determined by hydraulics) of flood waters, determine the magnitude of dollar damages which may occur at a given river stage (depth).
- o Develop damage/discharge curves which determine the dollar damages which occur at various design discharges.
- o Determine average annual damages by equating damage/discharge and frequency of the discharge (from hydrologic studies). The amount to which the annual average damages are reduced by the project is the benefit of the element as part of a system.

More detailed information on the flood control economic analysis is contained in the Economic Appendix prepared by the Corps of Engineers as part of the Central Arizona Water Control Study.

c. Dam Safety. Although dam safety repairs are not really benefits to the CAWCS, it was assumed that when the construction of a CAWCS element eliminated the requirement for other dam safety modifications the cost of those modifications would be equal to cost foregone on an annualized basis in the analysis of that element. For example, instead of building Cliff Dam as a multipurpose dam that included dam safety, it would be necessary to provide a site-specific dam safety solution at Horseshoe Dam and Bartlett Dam (new spillways). With construction of Cliff, the cost of the site-specific solutions is foregone (i.e., the dam safety benefit).

d. Other Benefits. Other benefits could be attributed to recreation, power marketing, and fish and wildlife enhancement. However, these benefits were not quantified in Stage II.

e. Benefit/Cost Ratio. In any engineering analysis benefit/cost ratio calculations play a major role. But for Stage II benefit/cost analysis was not used as part of the screening criteria. It was not used because, although the benefits were available for water supply and flood control and costs were available for structures and operation and maintenance, they were not available for either benefits such as hydropower and power marketing or other costs such as generation facilities and mitigations measures. Because these and other benefits and costs were not available for the benefit/cost analysis, it was decided that using benefit/cost ratio as a screen for Stage II was premature. Economics were used when comparing elements but only became a factor, if it appeared other benefits were not available or that when the other benefits were quantified they would make little difference in the comparison between the elements.



ESTIMATING FLOOD CONTROL BENEFITS

Figure 12

5. Hydropower. To determine the hydropower production potential associated with regulatory storage elements, it was assumed that whatever power was produced would be sold. Stage II studies were limited to a determination of what power could be generated as a byproduct of water delivery.

The CAPSIM model was used to determine critical factors of reservoir elevation and outflow through a potential powerplant. Based on these relationships, the amount of energy that could be developed was determined. No attempt was made to determine peaking energy or pump-back storage. Because of the large number of alternatives studied and the simplified assumptions in reservoir operating criteria used in Stage II, the study results were not particularly meaningful in the overall planning process. The majority of the hydropower studies are deferred to Stage III when more definitive reservoir operating criteria are developed for a limited number of alternatives.

6. Recreation. The aim of recreation investigations was to provide analysis of the potential for recreational development at CAWCS elements. Toward this end, the recreation studies included an analysis of recreation needs and development of arrays of conceptual recreation plans for study elements.

The recreation needs analysis considered two factors: recreation supply (the number and size of recreational facilities and/or activities within an area); and recreation demand (the preference of the local market area population for various activities or facilities). In essence, the needs analysis compared supply and demand to identify current and projected deficiencies in recreation supply in the CAWCS area. Specifically, it involved:

- Determination of recreation market areas for each of the CAWCS elements, based on a determination of user origins and participation patterns (informal interview of approximately 300 recreationists at 11 sites throughout the CAWCS area).

- Development of a supply inventory for each recreation market area, including all recreation resources within the defined area and indicating site size, facilities, etc.

- Identification of recognized national, regional, and local standards for recreational sites and activities in urban and rural areas. These standards provided the basis for determining recreational supply surpluses or deficiencies within the study area.

- Evaluation of recreation supply within the study area against recreation standards for all activities, and market area user preferences (demand) for activities.

The recreation policies of local managing agencies and identified recreation needs provided the basis for development of recreation plans for each CAWCS element. Two conceptual plans, representing minimum and moderate levels of facility development, were prepared for each element. Every plan includes a preliminary layout of recreation areas, based on the physical assets and constraints of each site, and an indication of the types of facilities and activities included within each recreation area. (Detailed descriptions of the conceptual plans, are contained in Conceptual Recreation Planning Memos, prepared by Willdan Associates for the Corps of Engineers.)

In developing recreation plans, both aerial and ground reconnaissance were conducted to identify several potential sites for recreation development at each element. These sites were selected on the basis of access, topographic features, views, water orientation, and the capability of the site to accept recreational use without major environmental impact. Evaluation of the recreational potential of these sites considered, insofar as was possible, the potential fluctuation of the reservoir and water quality issues related to that operational procedure.

Subsequent to the site selection process, a more detailed evaluation of the site's physical features (e.g., soils, vegetation) was conducted so that, through planning, site disruption or deterioration as a result of recreational use could be minimized. Recreation designs were then developed for each site. Development and operation and maintenance costs for both minimum and moderate recreation plans were estimated and expected visitation to the site was projected; calculations of recreation benefits were then based on these figures. (See Chapters VI and VII for summaries of plans and costs for the potential sites.).

7. <u>Environmental and Socioeconomic Assessment</u>. The environmental analysis for Stage II was carried out at two different levels of assessment: site-specific analysis for each CAWCS element and a simplified, cumulative analysis for systems which included identification of regional impacts of providing the project purposes.

The general analytical procedure used to determine the environmental and socioeconomic consequences of elements included five sequential steps: identification of issues; inventory of existing conditions (baseline); projection of future without the project conditions; impact assessment; and effect evaluation.

For issues identification, sources of information included governmental and private agencies and organizations; individuals in the private sector; CAWCS advisory groups; CAWCS public involvement program; newspaper articles; and comments on the Orme Dam Draft Environmental Impact Statement. The results of this step were used to define categories for assessment of the elements.

Next, a description of the environmental and socioeconomic baseline (existing conditions in the CAWCS planning area) was developed based primarily on secondary data, supplemented by the data available from ongoing studies by the CAWCS technical team. The environmental and social baseline provided the base from which future conditions were projected, both with and without the project.

The next step in the analyses was development of the "future-without." This is a projection of baseline conditions for each element assuming that the CAWCS project actions are not implemented. The future without was established by identifying the most probable causes of change and predicting their effect on baseline conditions. To do this required establishment of a set of assumptions. For Stage II, site-specific assumptions that could affect land, air, and water resources of the impact areas of each element were defined. Assumptions for socioeconomic categories were developed for near site areas and for the region. The year 2000 was used as the target date primarily because of the high degree of reliability it offered in projecting future conditions. (In later analyses, future without projections will be developed for a longer time frame, i.e., 2035 and ultimately 2100.) In developing assumptions, agency projections, plans, and programs that can reasonably be expected to be implemented in the next 20 years were reviewed in light of their potential effect on the resource base of elements. Table 12 lists major assumptions for the future without. The most probable future without conditions for the year 2000 were then established by predicting the change that is expected to occur in each of the impact categories as a direct or indirect result of the assumptions.

The impact assessment procedure used in Stage II, which closely follows the Service's manual, Environmental Quality Assessment in Multiobjective Planning (1977), uses a hierarchial system of four levels of information: components (environmental and socioeconomic disciplines), categories (classes within components), factors (specific attributes within each category), and measurements (data). For purposes of assessing elements, a limited number of categories and factors were selected for analysis to reflect issues and technical concerns, serve as indicators of likely impacts, and provide relevant information for element and later system evaluation in Stage II. (See Table 13.) A more comprehensive assessment involving a wider selection of categories and factors will take place in Stage III when more technical data are available and project actions are defined in greater detail.

Once the categories and factors for assessment were selected, for each category, factors were measured for: the existing condition, the future without condition, and the future with project condition. The impact, which is the measurable difference between the future without and the future with conditions, was then determined. Within the data limitations of this stage of the CAWCS, the factors were measured in physical dimensions (e.g., acres of terrestrial habitat, number of archaeological sites, etc.). For environmental components, impacts were assessed within a limited geographic area--one mile from the maximum area of inundation for elements including reservoirs and one-half mile beyond the construction zone for levees and channels. For socioeconomic components, impacts extend beyond these boundaries into near site areas and the region.

The effects evaluation was the final step in analysis of the environmental and social consequences of the elements. While the impact of the action is the measurable change, the effect is the interpretation of the importance of the impact. Four dimensions were used in developing the effects evaluation: direction (adverse or beneficial effect), duration (temporary

Table 12

MAJOR ASSUMPTIONS FOR "FUTURE-WITHOUT"1/

- The Central Arizona Project will deliver Colorado River water to the study area, but there will be no regulatory storage in the system.

- No flood control measures or structures under study by the CAWCS will be implemented.

- Seven bridges (Alma School, 51st Avenue, Tuthill, Country Club Drive,Scottsdale Road, 19th Avenue, and 16th Street) will be constructed or modified by state local governments. The 24th Street bridge and the 7th Street bridge will be rebuilt.

- Buttes Dam, an authorized feature of CAP on the Gila River, will be constructed for development of additional CAP waters, flood control, and sediment control. But, there will be no regulatory storage as proposed by CAWCS. Other CAP features which will be constructed include the Granite Reef Aqueduct, Salt-Gila Aqueduct, and the Tucson Aqueduct.

- Flood plain management, including enforcement of existing laws and regulations is assumed. No existing structure would be abandoned, but new structures in 100-year flood plain fringes would be flood proofed to protect against a 100-year flood.

- Channelization around existing facilities at the airport will be carried out.

- Allenville will be relocated.

- Limited channel clearing from 91st Avenue to Gillespie Dam will be carried out by the Flood Control District of Maricopa County. Gillespie Dam will not be modified in conjunction with channel clearing.

- There will be an improved flood warning system, under an appropriation of $400,000.

- Several flood control facilities (New River, Cave Buttes and Adobe Dams, Soil Conservation Service dams, Indian Bend Wash) will be constructed.

- The U.S. Forest Service Cottonwood Recovery Program on the Verde River,designed to improve wildlife habitat, will be implemented.

- A Tempe Salado Project will be implemented. The overall Rio Salado concept was assumed not to be developed.

- Under the Dam Safety Act, Salt River Project Dams will be modified.

1/ A complete list of " future-without" assumptions is contained in the CAWCS Working Paper, " First Level Environmental Future-Without Conditions," January 1980.

Table 13

ENVIRONMENTAL ASSESSMENT CATEGORIES AND FACTORS

<u>Geology and Soils</u>

- Mineral resources
- Mineral collecting
- Unique geological areas
- Prime farmland
- Soil erosion

<u>Water Resources</u>

- Water quality (salt loading, limnology, water quality standards)

<u>Air Quality</u>

- Total Suspended Particulates (TSP)
- Others (Carbon monoxide, hydrocarbons, nitrogen dioxide, ozone,sulfur dioxide, and lead)

<u>Acoustics</u>

- Noise on recreational areas
- Noise on residential areas
- Noise on wildlife areas

<u>Biological Resources</u>

- Terrestrial habitat (plants, agricultural land, river and adjacent sand and gravel bars)
- Aquatic habitat (flowing, nonflowing)
- Threatened and endangered species (preferred habitat, nesting/breeding sites)

<u>Land Resources</u>

- Land use patterns (urban/built up, agricultural, wetlands, water, rangelands)
- Landownership patterns (public, public-reserved, private)
- Compatibility with adjoining land resources

<u>Recreation</u>

- Flat water facilities and resources
- Stream facilities and resources
- Land-related facilities and resources

<u>Cultural Resources</u>

- Archaeological sites
- Historical sites

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construction-related or permanent), magnitude of the impact, and quality of the resource affected. For each category in the impact assessment, criteria based on these dimensions were developed. The criteria were then used to rate effects as: high, medium, or low adverse; high, medium, or low beneficial; or no effect.

The results of the environmental assessment of elements were then used together with technical and operation data in evaluating competing elements and selecting the best elements to be carried forth to system building.

The assessment procedure was simplified for evaluating systems because reliable data had been developed for individual elements, and the effects of actions would therefore be cumulative in systems. The first step in system evaluation was to determine critical criteria which would influence selection of systems. These were: biological resources, archaeological and historical resources, water quality, recreation, and social conditions. The cumulative impacts of each system were then determined, including identification of the regional and subregional impacts which would result from providing the project purposes of flood control and regulatory storage (beyond site specific). Next, the systems were ranked within each concept by component--no categories were ranked at the system level--to determine the best of each type of solution. The results of this analysis funneled directly into the tradeoff analysis along with engineering, cost, and performance data to determine a limited number of alternatives to carry forward for study as plans in Stage III.

The results of the Stage II environmental evaluations are described in summary form in Chapter VI, Description and Evaluation of Elements, and Chapter VII, Description and Evaluation of Systems.

8. Institutional Analysis. The Principles and Standards require that alternative plans meet four tests of viability--acceptability, efficiency, effectiveness, and completeness. The institutional analysis is critical to development of plans which meet these tests. The acceptability test refers to acceptability to the public and the implementability within known institutional constraints. The completeness test requires that all plans include descriptions of any necessary changes to institutions required for implementation of the plans.

The Stage II institutional analysis focused on identification of institutional opportunities and constraints. An institutional inventory was compiled including those items which were relevant to actions being considered. These were:

- Legal authority.

- Funding.

- Programs.

- o Relationship to plan functions.
- o Involvement with individual elements.
- o Special considerations.
- o Areas for further study/problems.

Data on legal authority, funding, and programs were obtained from secondary sources where available. This information was compared against the description of the elements to determine their relationship to plan functions, involvement with individual elements, special considerations, and areas for further study. In cases where complex institutional situations existed, discussions were held with representatives to gather more detailed information.

In addition to functioning institutions, the relationship of actions under consideration to existing laws and regulations was examined. Specific areas which were examined included ground water law and water rights.

9. Phreatophyte Assessment. As part of the analyses of flood control elements, an assessment of phreatophytes was conducted. The analysis was specifically concerned with the western Gila River where the channel is overgrown with phreatophytes, contributing to flooding problems in the west end of the valley. The assessment consisted of research on the problems and development of possible solutions and included the following:

- o Through review of existing literature, demonstrated effective methods of controlling phreatophytes in other areas, especially those which are potentially the most effective for central Arizona, were identified.
- o The history of phreatophyte invasion in the lower Salt and middle Gila Rivers (from Phoenix to Gillespie Dam) was described.
- o The present distribution (including locations, types, and densities) of riparian vegetation, especially phreatophytes, in the Salt-Gila flood control area was described.
- o Probable future locations of the Gila River channel, particularly between the confluence with the Salt River and Gillespie Dam, were described, assuming no flood control measures are instituted by the Federal Government (no action).

Results of the study were integrated into the CAWCS in investigating potential channel clearing and channelization options in that portion of the CAWCS planning area.

CHAPTER V

PUBLIC INVOLVEMENT

Due to the previous controversy over Orme Dam and the recent flooding problems, a greater level of public interest exists in the CAWCS than in a typical planning study. The CAWCS must be conducted both with extreme political sensitivity and also with a visibility and openness which will lend credibility to the final conclusions. Public involvement, therefore, is absolutely crucial to its success.

The major objective of the CAWCS public involvement program is to provide timely information to the public so that individuals may participate in the planning process and so that the planning process is responsive to public needs and preferences. Obviously, not every citizen can be in a position of evaluating the technical adequacy and objectivity of a study, so the CAWCS public involvement program is designed to recognize different kinds of publics.

The public divides itself naturally into four levels of interest. On the lowest interest level, people have a "need to know" attitude but feel in many cases that the project will have little effect on them personally. On the next interest level, individuals have definite opinions, especially on issues which directly affect their lives, but they may not have the time or technical expertise to make a contribution to the planning process. Beyond this level is a group of about 100-150 individuals who are professional representatives of Federal, state, and local government agencies whose job responsibilities cover subject areas potentially affected by this study. This group also includes those with a direct stake in the outcome of the CAWCS, such as water user groups, environmental organizations, recreation clubs, Indian tribes, and landowners. Finally, at the highest interest level are the community leaders. These individuals have a special role in a public involvement program because they are able to focus and articulate needs and concerns of their constituencies.

The CAWCS public involvement program was designed to satisfy information needs at all four levels of public interest and facilitate the involvement of individuals in the CAWCS planning process.

A. Public Involvement Techniques

Various types of activities are conducted and techniques utilized throughout the CAWCS to meet the objectives of the public involvement program. These include advisory groups, interest groups, workshops and community meetings, and other ongoing activities such as brochures, newsletters, press and media coverage.

1. Advisory Groups. Community leadership on the CAWCS was organized with the formation by Governor Babbitt of the Governor's Advisory Committee to advise on CAWCS issues. The 28-member Committee, which represents the interests of political, environmental, business, Indian tribes, media and labor and

citizen groups, provides two-way communication between the CAWCS and the public, identifying needs and concerns of their constituents and conveying information back to the public. The Committee advises on the acceptability of alternative plans from political and legal viewpoints, offers suggestions on how to make alternatives more acceptable, and once the preferred plan is selected, may also aid in demonstrating to the public that all concerns have been considered in development of the plan. Membership of the Governor's Advisory Committee is listed in Appendix B.

The expert public has been organized as the Technical Agency Group (TAG), consisting of representatives of local, state and Federal agencies which have an interest in the CAWCS. The TAG meets periodically during the study and interacts with the Service and the Corps on a continuing basis. Specifically, the group assists in the collection of existing information and development of new data, reviews and analyzes information, assists in plan formulation and participates in development of public workshops and meetings. Membership of the TAG is listed in Appendix B.

2. Special Interest Groups. Several special interest groups have been identified throughout the course of the study. Periodic meetings between CAWCS planning and technical staff and special interest groups help to provide these groups with accurate, up-to-date information on the study's progress and the decisionmaking process. Each group has special informational needs and the public involvement program helps to insure that these needs are met. Periodic face-to-face interaction ensures that these group members can express their concerns, make suggestions and ask specific questions and aid planners in incorporating their views into the plan formulation process. Following are some of the special interest groups which participate in the CAWCS:

- Indian Inter-Tribal Council of Arizona.
- Orme Alternatives Coalition.
- Citizens for Flood Control - NOW.
- Salt River Project.
- Maricopa Audubon Society.
- Citizens Concerned About the Project.

3. Government Agencies. In accordance with CAWCS objectives and the requirements inherent in Service and Corps planning policy, numerous agencies at the Federal, state, and local levels have been directly involved in the CAWCS. One forum for intergovernmental coordination is participation in the Governor's Advisory Committee or the TAG as previously described. In addition, an Interagency Executive Committee was established at the outset of the CAWCS and meets bimonthly to provide coordination, information exchange and status briefings at the agencies' executive levels. The following agencies are represented on the Committee:

- Arizona Department of Water Resources.
- Flood Control District of Maricopa County.
- City of Phoenix.
- Central Arizona Water Conservation District.
- Salt River Project.
- Water and Power Resources Service.
- U.S. Army Corps of Engineers.

Periodic briefings are also given to state and local legislators to keep them abreast of the study's progress and to address questions which arise during the briefings.

A more detailed summary of the activities of these advisory groups so far in the CAWCS is presented later in this chapter.

4. Public Information/Communication Techniques. To both stimulate public awareness of and inform the general public about the CAWCS, several public information and communication techniques are utilized.

Workshops and community meetings, held at key decision points in the study, are used to involve the more active public in the planning. A regular monthly newsletter, "Extra's," and periodic brochures keep the public informed of CAWCS progress and discuss issues pertinent to the CAWCS area. Other techniques included presentations to community groups and organizations, news releases, bulletins and flyers, newspaper and magazine articles, and television and radio coverage. A more detailed summary of these activities in Stage II is presented later in this chapter.

5. Public Involvement and the Planning Process. The public involvement program is designed to insure that activities are integrated into the planning process. Different kinds of public involvement take place at these different stages of planning. Following is a general description of the Stage I public involvement activities, and a detailed description of Stage II activities and results.

B. Stage I Public Involvement Activities

The major thrust of Stage I public involvement was to establish the public involvement program in the community. Activities were geared toward obtaining information useful in directing the study, such as identifying problems, issues and alternatives to be studied; getting to know the leaders of various interest groups; and establishing media contacts.

During Stage I, Governor Babbitt established the Governor's Advisory Committee and the TAG was organized. Over 4,000 copies of a brochure, "You and Central Arizona's Water Future," were distributed. The brochure included a mail-in response on which respondants could indicate their interest in receiving future information and in attending workshops and meetings.

Three public meetings were held in January 1979 in Buckeye, Phoenix, and Mesa, Arizona. At the meetings, CAWCS issues were discussed, the alternatives under study were summarized, and the process and schedule outlined. These meetings provided valuable information on issues to be addressed in the study. The informational brochure was also handed out at these meetings.

There was substantial media coverage of the various committees and public meetings, and the general progress of the study, including: coverage of the January public meetings by several television stations and public service radio stations; participation in radio broadcast call-in shows which covered the flooding issue, including the progress of the study; and publication of a 16-page supplement on the flooding issue and possible actions by the Arizona Republic, a daily newspaper.

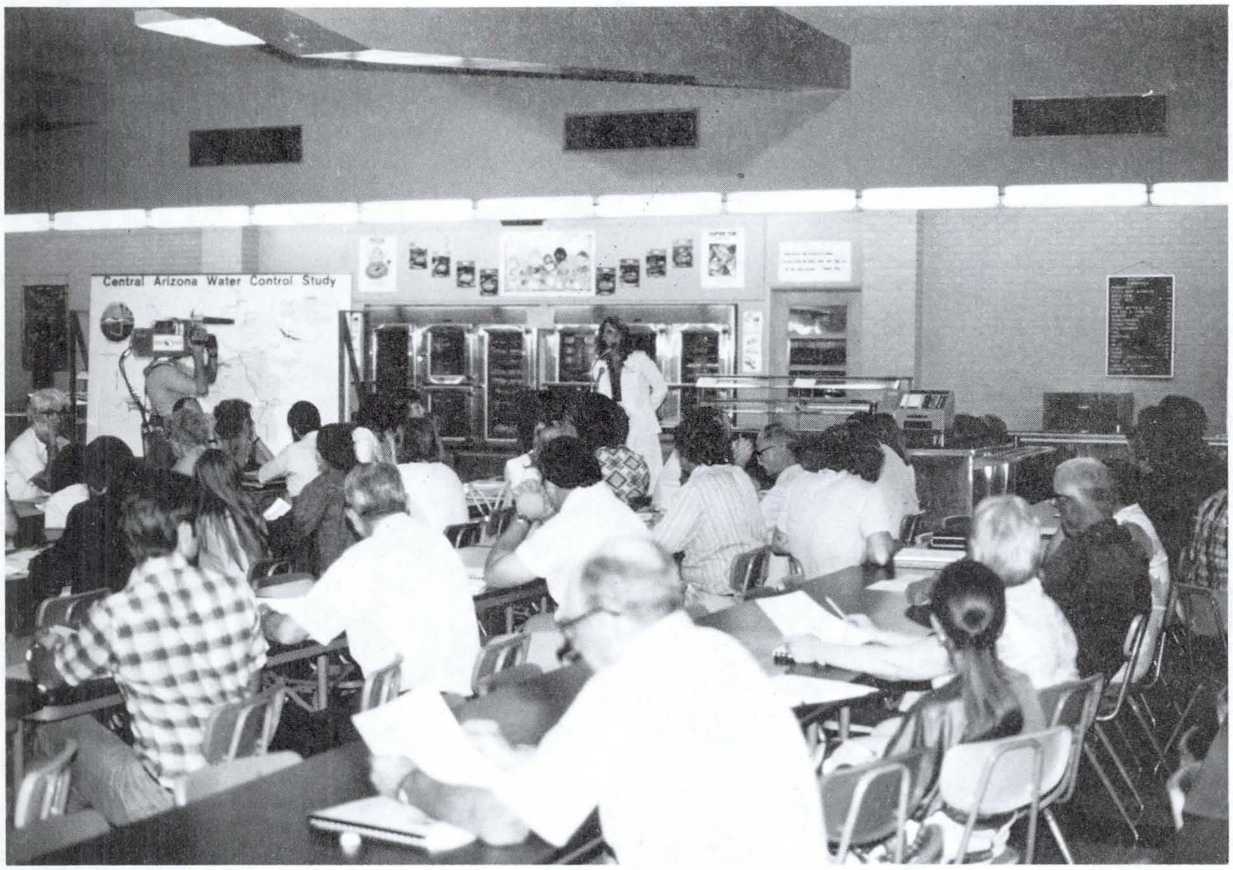
A more detailed description of Stage I public involvement is contained in, Public Involvement Plan, Water and Power Resources Service, June 1980.

C. Stage II Public Involvement Activities

During Stage II, as the focus of planning shifted from problem identification to formulation and more detailed analysis of alternatives, the emphasis of public involvement shifted to greater involvement of the public in evaluation and selection of alternatives. Stage II activities were therefore designed to fully integrate the public involvement program and the planning process. There was heavy advisory committee activity during this period of technical study and a larger number of presentations to civic and interest groups.

Initial activities included establishment of a project office and hotline as a single point of contact for the public with the project; initiation of a monthly newsletter; establishment of a mailing list, which is periodically updated and expanded; and initiation of a process for storing public comments and media coverage. Continuous media coverage was maintained. The major activities were public workshops and community meetings scheduled and carried out at key points in the study and special meetings with communities affected by CAWCS alternatives. Following is a summary of Stage II public involvement.

1. Community Meetings and Workshops. Two rounds of community meetings and workshops were held in Stage II at key points in the planning process.



Photograph 5 - Stage II Workshops, the first round focused on familiarizing the public with alternaties and providing an opportunity to suggest additional alternatives.

a. Workshops, April 1980. The first round of Stage II workshops was held in April/May 1980. At this point in the study, conceptual systems had been developed and the workshops focused on familiarizing the public with the alternatives and providing an opportunity to review and suggest additional alternatives. The purpose of the workshops was twofold:

- o To inform and educate the public regarding the status of the CAWCS and alternatives under study.
- o To obtain opinions of workshop participants on the adequacy of the alternatives, criteria used to evaluate the alternatives, and acceptable levels of floodflow along the Salt and Gila Rivers.

Nine separate workshops were held, covering the CAWCS area, in South Phoenix, North Phoenix, El Mirage/Peoria, Buckeye, Mesa, Superior, Casa Grande, Scottsdale, and Tucson. Approximately 350 attended the workshops. The Governor's Advisory Committee and the TAG participated in "dry-run" workshops prior to public presentation.

The format of the workshops was small group discussions addressing three areas: adequacy of alternatives, evaluation criteria, and acceptable level of floodflow. While the results were not a definitive representation of public opinion, they did allow staff to make observations and recommendations to guide further study. Workshop results could be grouped by geographic area based on related interests: Buckeye/Peoria; Phoenix, Scottsdale, and Mesa; and Tucson, Superior, and Casa Grande. Generally the results were:

Photograph 6 - Small Group Discussions at the Workshops, small groups were used to discuss alternatives, evaluation criteria, and acceptable level of floodflow through Phoenix.

- The alternatives were adequately covered. However, results indicated that additional work was needed to clarify why certain elements had been eliminated in Stage I and how the conceptual systems were developed.

- Regarding evaluation criteria, flood damage reduction was listed as a major criteria throughout the CAWCS area. The need for CAP regulatory storage, however, was not rated highly in the workshops. Since this is a major purpose of the CAWCS, subsequent articles were published in the CAWCS newsletter to clarify the water supply issue. Protection of Indian communities was rated among the top five criteria in all workshops.

- Regarding the acceptable level of floodflow along the Salt and Gila Rivers, results reflected a geographic orientation, and problem perception was the critical factor in level of floodflow. In areas subject to flooding, the problem was perceived in terms of inundation and therefore a higher level of protection was desired. In areas such as central Phoenix, the flood control problem was defined more in terms of bridge outages, and with higher capacity bridges authorized, higher levels of floodflow were acceptable. At the time of the workshops, technical analysis was looking at the impacts of three levels of flow: 50,000 ft^3/s, 100,000 ft^3/s, and 150,000 ft^3/s. Based on the results of this exercise, however, the 200,000 ft^3/s level (capacity of some new bridges) was added to the analysis.

In the workshops held in Superior, Casa Grande, and Tucson the "level of floodflow" discussion was replaced with an activity to determine the issues considered most important in planning for Buttes Dam and Reservoir. The activity was conducted to partially fulfill public involvement requirements for Buttes Dam as a CAP feature. Participants were asked to list issues of most concern regarding the proposed dam. The benefit/cost ratio of the project was of great concern to many participants, followed closely by protection of the environment. An increase in CAP water ranked third, followed by concerns for silt control and evaporation.

On May 12, 1980, a briefing on the CAWCS and related studies was made to approximately 40 representatives of seven Indian communities. Initially, another workshop was planned, but after discussions with various tribal representatives, more basic information was needed first. The purposes of the briefing were to: clarify the CAWCS and related studies for the central Arizona tribes; introduce and clarify CAWCS alternatives, and learn from tribal representatives the manner in which they wanted to be involved in the study.

Other observations, recommendations, and subsequent actions taken as a result of the workshops were:

- The relationship between Rio Salado and the CAWCS was misunderstood. To help clarify the issue, an article describing the history and current status of Rio Salado and better defining its connection to the CAWCS was published in the monthly newsletter. Additionally, formal contact was made with the newly-appointed Rio Salado Development District. At the meeting, considerable discussion was devoted to the relationship between the CAWCS and Rio Salado, resulting in a decision by the District to take an active role by developing a Rio Salado concept to present to the CAWCS. A subsequent meeting also had the CAWCS as the topic of discussion.

- o Closer liaison between the CAWCS and some special interest groups was an identified need. It was recommended that special "one-to-one" meetings be held with these groups to hear their viewpoints and consider their concerns. Subsequently, three meetings were held prior to the next round of workshops:

  - . Coalition in Support of Orme Alternatives.
  - . Flood Control District of Maricopa County Citizen Advisory Board.
  - . Central Arizona Water Conservation District.

  These meetings were most helpful to the study team in organizing the presentation of systems to the public. Areas of confusion and unsubstantiated assumptions were brought to the attention of the staff and improved the second round of workshops.

- o Several recommendations were made relative to the procedures of the workshops to guide future involvement activities, specifically public workshop formats and the need for increased media coverage.

A detailed summary of these workshops is contained in Summary and Analysis of CAWCS Public Workshops, April 16-May 6, 1980, Dames and Moore for the Water and Power Resources Service, June 10, 1980.

b. Information Fair, November 1980. Prior to the next round of workshops, an Information Fair was held at the Valley National Bank Center, Phoenix, November 17-21, 1980. The fair provided graphic displays and printed information, and technical experts were on hand to answer questions and discuss the CAWCS with interested persons. The public was invited to fill out response/comment forms and add their names to the mailing list.

A similar display was also included in as a CAWCS information booth at the Arizona State Fair in Phoenix, October 20-November 9, 1980. Approximately 1,000 people stopped by the exhibit. Many filled out comment cards or asked to be put on the mailing list.

These two activities also served as advertisement of the upcoming second round of workshops and provided a good backdrop for television coverage. Three stations reported on the Information Fair.

Photograph 7 - Information Fair, Valley Bank Center, Phoenix.

c. Public Forums, November/December 1980. The second round of workshops took the form of public forums. Forums were held in Tucson (November 24), Casa Grande (November 25), Mesa (December 1), and Phoenix (December 2). At this point in the study, systems had been formulated, analyzed, and staff recommendations for study of a limited number of plans in Stage II had been made. The purpose of the forums was twofold: to display and summarize Stage II information, conclusions and staff recommendations; and to ask participants to evaluate and respond to Stage II study results.

The public forums were designed, based on observations and recommendations from the previous workshops, to include more traditional public meeting activities than previous workshops. The forums included an initial overview of the study and Stage II activities in particular, followed by discussion of specific issues by a panel of experts. Forum participants then asked questions of the panel and were provided an opportunity to comment on

Stage II results, and their preferences and concerns. Proceedings were recorded and ultimately integrated into the final CAWCS Stage II recommendations.

A Factbook containing CAWCS background information and a summary of CAWCS planning to date was distributed prior to the workshops to all individuals on the mailing list. A response form was included in the Factbook in order to elicit feedback from those unable to attend the forums. The Factbook will continue to be a good source of information for the public well into Stage III.

Photograph 8 - Stage II Public Forums.

A total of 268 people signed in at the workshops. Attendance at Tucson, Mesa, and Phoenix forums exceeded 75 people each, and the Casa Grande forum was attended by 14. Based upon comments from the participants in the public forums, as well as advisory groups and interest groups, and a review of the response forms, the following observations and conclusions could be made:

- Confidence in the objectivity and impartiality of the CAWCS has grown tremendously during Stage II.

- It is important to keep the CAWCS on schedule.

- At every forum the question was asked "Are you sharing your findings with our elected officials?" Participants, aware that good alternatives to Orme Dam were being developed, expressed strong sentiment that elected officials should pay attention to the study findings.

- Orme Dam continues to be a controversial alternative, with opponents and proponents. Many public forum participants spoke against Orme Dam, including those who favored a structural solution. Those who listened to the findings of the study seemed to recognize the viability of other alternatives.

- Concern over the elimination of underground storage (See Chapter VIII) was expressed by many forum participants and through response forms. It was recommended that a more detailed briefing on this element should be given to the Governor's Advisory Committee and TAG, as well as space devoted to this issue in an upcoming newsletter.

- The deletion of greenbelts, channels, and levees (See Chapter VIII) was not challenged, as long as local levees for protection of certain areas are considered during Stage III. A misunderstanding of greenbelts and a tendency to confuse them with Indian Bend Wash or a "Rio Salado" was still evident. Further clarification was recommended.

- Clarification that Buttes Dam is still being considered as a CAP feature, even though not for regulatory storage, was achieved.

- Concern was expressed over incomplete benefit/cost information (unavailable at the time of the forums). Premature elimination of some elements was a concern. However, preliminary benefit/cost data were used in Stage II analysis and only those elements which obviously would have a low benefit/cost ratio due to excessive costs were eliminated from further consideration .

- A number of forum participants expressed a preference for nonstructural and limited structural alternatives.

- Requests were received for additional data on better upper watershed management as a deterrent to flooding. It was recommended that this issue be addressed with the Governor's Advisory Committee and/or the TAG and space devoted to the issue in an upcoming newsletter. Obviously, the question had not been sufficiently answered for a segment of the public.

- Another unresolved issue in the minds of some related to the possiblity of a flood from runoff below a Cliff or Roosevelt Dam. A similar approach as recommended for upper watershed management was recommended.

- o Some opposition to protecting people in the flood plain was heard, coupled with stricter enforcement of flood plain zoning regulations.

- o While appreciating the need for dam safety, concern was expressed that the Safety of Dams program being carried out by the Service not be mixed with the CAWCS, especially since critical information on Safety of Dams is not available. More information for the public on ways the study team is allowing for the time schedules of these two programs was recommended for a future newsletter.

A more detailed summary of these forums is contained in Summary of CAWCS Public Involvement Activities, September-December 1980, January 1981.

2. Special Meetings. Several special meetings were held in Stage II with elected officials, residents of affected communities, and special interest groups.

a. Briefings of Elected and Public Officials. With an identified need for visible public and government support of the CAWCS, the major benefit of these briefings is the exposure of the study progress and findings to critical local and national decisionmakers. A briefing of the Arizona Congressional Delegation was held on September 23, 1980, in Washington, D.C. The briefing described the status of the CAWCS to date, status of the CAP and issues relative to dam safety and its relationship to CAWCS.

Concern was expressed that CAWCS alternatives, other than Orme Dam, may not have congressional authorization, which, if so, could result in delays in construction of a selected plan. The Water and Power Resources Service Commissioner has requested a Solicitor's opinion on the issues. In addition, an opinion was requested as to whether a plan including flood control only, if selected, would be authorized.

Other briefings included:

- o Arizona Senate Leadership (October 2, 1980).
- o Governor, Arizona Republic and Phoenix Gazette Publisher and Editorial Staff (October 15, 1980).
- o Central Arizona Water Conservation District Board (November 11, 1980).
- o City of Phoenix Mayor and Council (November 18, 1980).
- o Valleywide City Managers (November 19, 1980).
- o Maricopa County Board of Supervisors (December 9, 1980).
- o Mayor of Scottsdale (September 5, 1980).

b. Roosevelt Lake Communities, November 1980. As a result of the CAWCS socioeconomic team interviewing residents in the Roosevelt Lake area, the residents became more aware of the CAWCS and the particular impact that raising Roosevelt Dam as a possible flood control solution could have. The Homeowners Association requested by letter to the CAWCS and the Salt River Project more information on the possible impacts of such an action. Through SRP two meetings were set up and held with the communities of Roosevelt Lake Resort and Punkin Center. Over 500 people attended these meetings.

c. Special Interest Group Meetings. Several presentations were made to special interest groups throughout Stage II. These included:

- Coalition in Support of Orme Alternatives.
- Flood Control District of Maricopa County Citizens Advisory Board.
- Phoenix Chamber of Commerce Flood Control Committee.
- Rio Salado Development District.
- Central Arizona Project Association.
- Annual Watershed Symposium.

3. Advisory Group Activities. The Governor's Advisory Committee, established in Stage I, continued to meet monthly during Stage II. The Committee activites focused on review of planning activities, methodologies and results, development of planning assumptions, and participation in workshop development. The public involvement staff also met with several committee members individually to better understand their needs and concerns. Following is a list of meetings and topics of discussion of the Committee during Stage II:

o August 28, 1979	CAWCS status and review draft of summary brochure for elements.
o September 23, 1979	Day-long workshops to generate "future-without" assumptions.
o November 29, 1979	Review of methodologies for flood damage reduction benefit/cost, water quality, water quantity, and ground water recharge studies.
o December 28, 1979	Review methodologies for assessment of biological and cultural resources.
o January 24, 1980	Review system formulation and impact assessment approach; tribal presentation on plans and how they relate to CAWCS.

- o March 11, 1980 — Fort McDowell Reservation tour and presentation.
- o April 3, 1979 — Presentation of conceptual systems; dry-run of workshops.
- o June 25, 1980 — Review approach to element screenings.
- o August 28, 1980 — Discussion of reregulation of SRP, dam safety, and nonstructural measures.
- o October 16, 1980 — Presentation and discussion of systems.
- o November 20, 1980 — Review of systems.

The TAG also met regularly during Stage II. Meetings included:

- o September 11, 1979 — Discussion of technical studies to date; "future without," Colorado River water supply, flood control assumptions, CAP without regulatory storage, planning assumptions.
- o September 25, 1979 — Special session; discussion of ground water recharge studies in the CAWCS.
- o February, 1980 — Discussion of procedures for review of CAWCS working papers and for system evaluation; outlined their participation in combining elements into systems and reducing systems to plans for detailed study during Stage II.
- o March 26, 1980 — Review of environmental and social impact assessment findings.
- o April 1, 1980 — Review of water supply engineering and economics, and water quality studies.
- o April 8, 1980 — Review of design/cost, hydrology, benefit/cost analysis, and nonstructural studies for flood control elements.
- o April 15, 1980 — Review of conceptual systems.
- o June 25, 1980 — Review of workshop results, review of screenings approach.
- o September 18, 1980 — Discussion of dam safety and the CAWCS, Salt River flood control elements, channels and levees and Verde River dams design and cost data.

- November 6, 1980 — Review of systems, selection of TAG preferred systems.

- December 9, 1980 — Review of forum results.

4. Slide-Tape Presentations. In November 1979, a slide-tape show was prepared. The 15-minute program provided a historical overview of the study, elements under investigation, and ways the public can be involved. Interest groups, agencies, tribal representatives, universities, etc., were contacted announcing the availability of CAWCS staff to conduct presentations. As a result, numerous presentations were made.

In February 1980, the slide show was revised to reflect the current status of the CAWCS. The show defined the need for regulatory storage and flood control, explained the conceptual systems which had been developed, and outlined the competing demands important to selecting preferred systems. This slide show was used in the first round of workshops and in subsequent presentations throughout the CAWCS area.

To date, over 100 presentations of the slide-tape show have been made. Groups have ranged from governmental agencies and tribal councils to civic interest groups and clubs. Feedback from these presentations is recorded during and after each presentation and is then placed into the public comment storage and retrieval system housed in the CAWCS office.

5. Newsletters, "Extra's," and Brochures. In the initial portions of Stage II, a monthly newsletter was initiated to keep the public informed of CAWCS activities. The newsletter, periodic brochures and Extra's are published to assure timely information as well as to solicit needed public input. These publications are sent to everyone on the CAWCS mailing list, which has grown from about 700 names in July 1979 to over 4,000 names to date. Mail-in response forms have been included in several newsletters and brochures to provide readers an opportunity to respond to topics discussed in the publication and to other issues pertaining to the study in general. Questions, comments, and suggestions are addressed in subsequent issues and public comment is also filed in the public comment storage and retrieval system. Following is a list of newsletters, Extra's, and brochures published to date:

- July 1979 — Overview of the CAWCS.

- August 1979 — Brochure: Summary of CAWCS elements.

- September 1979 — Goals and objectives of CAWCS as outcome of Stage I.

- November 1979 — Regulatory Storage: What Is It and Why Do We Need It?

- December 1979 — Cultural and biological resource studies methodologies.

- o January 1980 — Environmental issues (mail-in response form included).
- o March 1980 — Flood Control.
- o March 1980 — Extra: "Future-Without."
- o April 1980 — Announcement of public workshops and description of conceptual systems.
- o May 1980 — Social and economic issues (mail-in response form included).
- o June/July 1980 — Special Report: Workshop Results.
- o August 1980 — Planning with Safety in Mind (dam safety discussion).
- o September/October 1980 — Recreation (description of recreation plans, and relationship of Rio Salado and the CAWCS).
- o November 1980 — Extra: System formulation; description and evaluation of systems (mail-in response form included); announcement of public forums.
- o January 1981 — Description of Stage III recommendations; summary of public forums.

6. Other Continuing Public Involvement Activities. Throughout the CAWCS continuous media coverage is maintained, including newspaper, magazines, radio and television coverage. Periodic press releases are issued to keep the public informed of activities and to announce upcoming activities. In an effort to improve the media coverage and develop an open channel of communication between the CAWCS and area media, a press kit was assembled and provided to local newspapers and radio and television stations. The press kit, which includes information on the history and status of the CAWCS and related issues, is periodically updated. Distribution of the press kit has helped to develop better communication with the area media and has helped to improve the amount and accuracy of CAWCS coverage.

Members of the CAWCS staff also appear on local radio and television programs, talk shows, and newscasts. Public workshops and forums are covered by local television stations. These activities are most prevalent at major CAWCS decision points and when timely water resources management and flood control issues arise.

A news clipping service keeps track of all news stories from local newspapers and magazines relative to the CAWCS. Clippings are filed by discipline in the CAWCS library in the CAWCS office, and the Service also maintains a daily record.

CHAPTER VI

DESCRIPTION AND EVALUATION OF ELEMENTS

As described in Chapter IV, Planning Process, the first step in alternative development was to identify a wide array of possible actions, or elements, that singly or in combination could provide flood control and/or regulatory storage. Originally, 35 separate actions were identified. In Stage I these elements were screened at an initial level of study to determine those elements that warranted further study in Stage II. Recommendations were based largely on three factors: geology, location, and economics. Table 14 shows the elements, their purpose, and results of the Stage I studies.

During the initial portions of Stage II, the remaining elements were developed in more detail. Because of the nature of the CAWCS planning process, changes occurred to the elements and emphasis on issues shifted. Basically, these changes were:

- Some elements were competing (provided the same function at different sites and could be substituted for each other in systems). Therefore, these elements were screened and the "best" selected for system building. Screening results are presented under the individual element descriptions in this chapter.

- Reevaluation of the inflow design flood (IDF) by the Service identified potential safety problems at existing dams. This in turn presented potential problems in terms of providing CAWCS purposes and dam safety, particularly on the Salt River. This situation prompted the study of alternative sites on the Salt River and the addition of two elements--New Roosevelt Dam and New Stewart Mountain Dam--and an increase in the importance of dam safety issues relative to the CAWCS. More detailed discussion is contained in the individual descriptions of elements in this chapter.

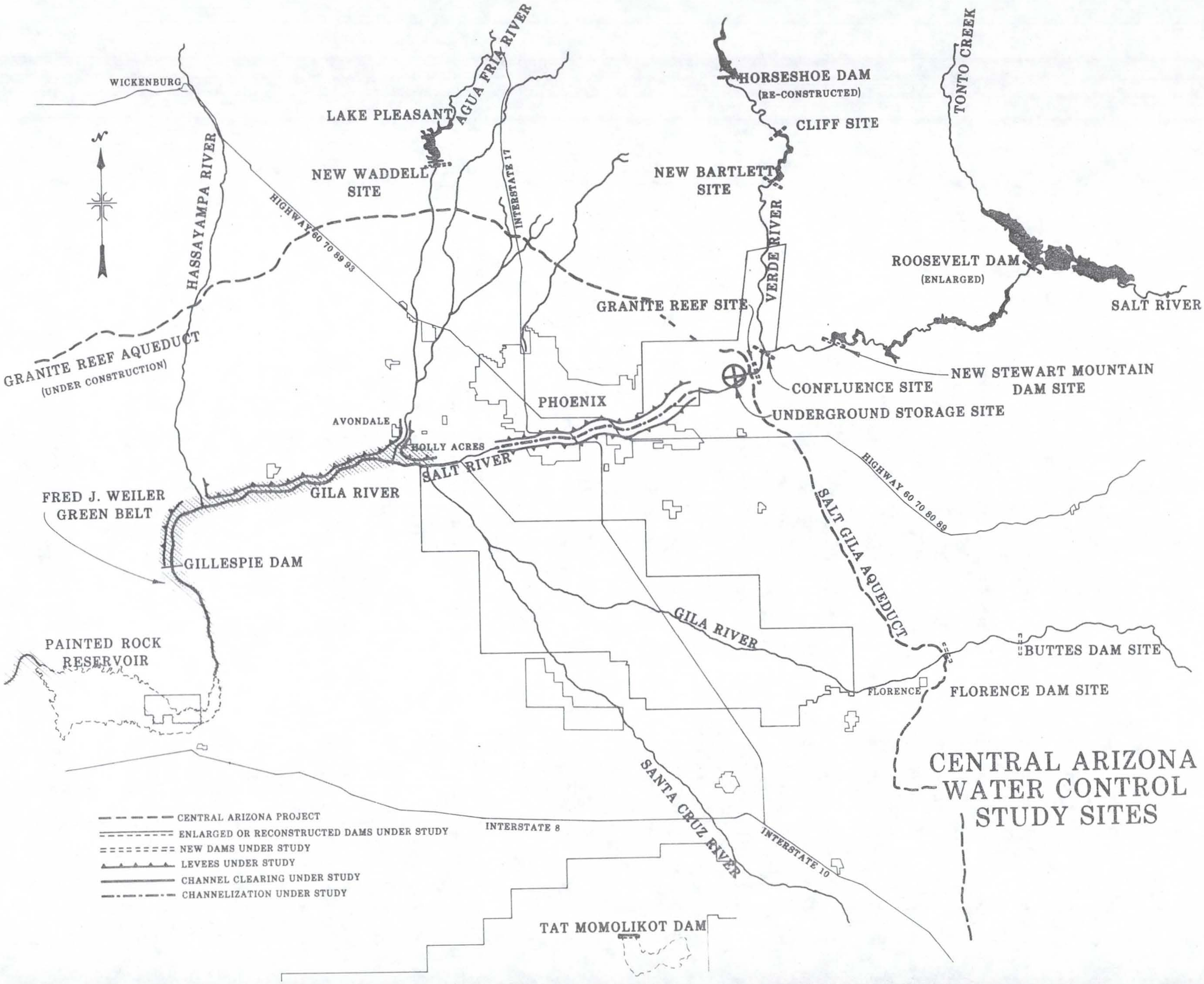
- Channel clearing, originally a CAWCS flood control element, is being carried out by the Flood Control District of Maricopa County, with technical assistance by the Corps of Engineers. Therefore, while not eliminated from consideration in the CAWCS, it is no longer considered as an element for system building.

A description and evaluation of the structural and nonstructural elements considered in Stage II of the CAWCS follows (Figure 13). It is important to note that analysis of structural elements was carried out for a range of sizes and operating methods. For purposes of comparison and simplicity of display in this report, one size is shown which represents use of the element in conjunction with other elements and is a larger capacity configuration. For ease of understanding and to facilitate evaluation and selection of elements, elements are grouped by geographic area and type of solution.

Table 14

STAGE I RECOMMENDATIONS

Element	Purpose: Flood Control	Purpose: CAP Storage	Further Study: Warranted	Further Study: Unwarranted
VERDE RIVER				
Tangle Creek	o	o		o
Modified Horseshoe	o	o	o	
Cliff Site	o	o	o	
New Bartlett	o	o	o	
SALT RIVER				
Carrizo Creek	o			o
Klondike Buttes	o			o
Modified Roosevelt	o	o	o	
Coon Bluff		o		o
Confluence	o	o	o	
Granite Reef	o	o	o	
Rio Salado Lows Dams		o		o
AGUA FRIA RIVER				
Lake Pleasant		o	o	
New Waddell		o	o	
Agua Fria Siphon		o		o
Calderwood Butte		o		o
North Phoenix Dams (for CAP)		o		o
GILA RIVER, SANTA ROSA WASH				
Coolidge		o		o
Florence		o	o	
Buttes		o	o	
Tat Momolikot		o	o	
Painted Rock Reservoir		o		o
CHANNELS				
Granite Reef to Country Club	o			o
Country Club to 35th. Ave.	o		o	
35th. Ave. to Gillespie Dam	o			o
LEVEES				
Granite Reef to Country Club	o			o
Country Club to 35th. Ave.	o		o	
35th. Ave. to Salt-Gila	o			o
Salt-Gila to Gillespie Dam	o		o	
CHANNEL CLEARING	o		o	
WATER EXCHANGE		o	o	
SRP REOPERATION	o		o	
NONSTRUCTURAL	o		o	
GROUND WATER RECHARGE	o	o	o	
NO ACTION			o	



WICKENBURG
HASSAYAMPA RIVER
LAKE PLEASANT
AGUA FRIA RIVER
NEW WADDELL SITE
INTERSTATE 17
HIGHWAY 60 70 89 93
HORSESHOE DAM (RE-CONSTRUCTED)
CLIFF SITE
NEW BARTLETT SITE
VERDE RIVER
TONTO CREEK
ROOSEVELT DAM (ENLARGED)
SALT RIVER
GRANITE REEF SITE
GRANITE REEF AQUEDUCT (UNDER CONSTRUCTION)
NEW STEWART MOUNTAIN DAM SITE
CONFLUENCE SITE
UNDERGROUND STORAGE SITE
PHOENIX
AVONDALE
HOLLY ACRES
SALT RIVER
GILA RIVER
FRED J. WEILER GREEN BELT
GILLESPIE DAM
HIGHWAY 60 70 80 89
SALT GILA AQUEDUCT
GILA RIVER
BUTTES DAM SITE
FLORENCE
FLORENCE DAM SITE
PAINTED ROCK RESERVOIR
SANTA CRUZ RIVER
INTERSTATE 8
INTERSTATE 10
TAT MOMOLIKOT DAM
CENTRAL ARIZONA PROJECT
ENLARGED OR RECONSTRUCTED DAMS UNDER STUDY
NEW DAMS UNDER STUDY
LEVEES UNDER STUDY
CHANNEL CLEARING UNDER STUDY
CHANNELIZATION UNDER STUDY
CENTRAL ARIZONA WATER CONTROL STUDY SITES

Figure 13

A. Verde River

Three sites were investigated primarily for flood control on the Verde River:

- o New Horseshoe Dam and Reservoir.
- o Cliff Dam and Reservoir.
- o New Bartlett Dam and Reservoir.

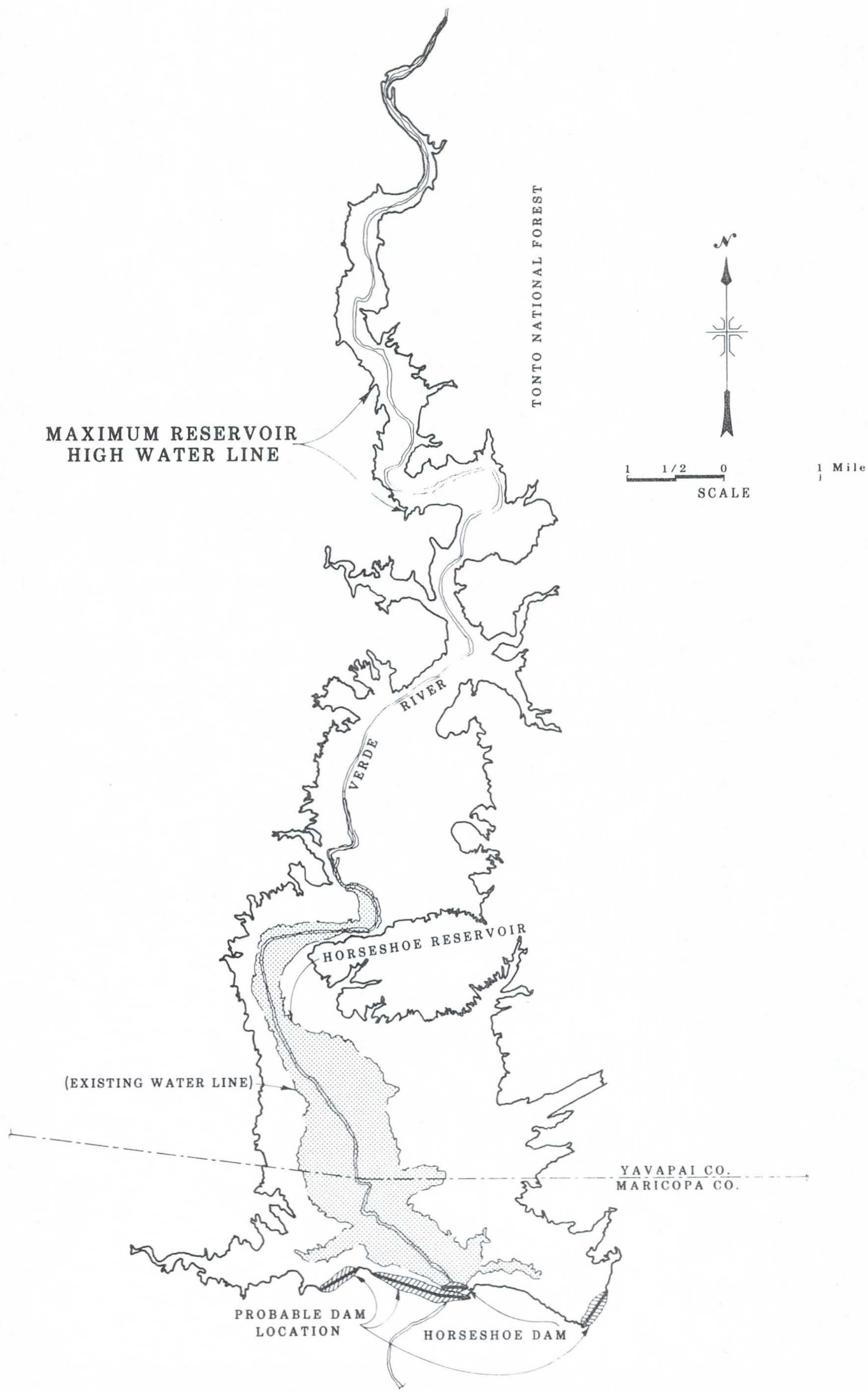
A new dam at any one of these sites would provide flood control for the Verde River and at the largest embankment it would also provide new water storage space which could be used for regulatory storage of CAP water. A range of sizes was considered for the element; for display purposes the size shown is 510,000 acre-feet for flood control storage and 100,000 acre-feet of CAP regulatory storage. Engineering and cost data are shown in Table 15.

A dam at any one of the three sites would consist of an earthfill structure; the reservoir would include a minimum fishery pool of 10,000 acre-feet which would be maintained above the sediment pool throughout the life of the project. A hydropower plant, if feasible, would be located at the downstream toe of the dam. The conservation pool would be operated by SRP much as in the past. Whenever inflow continues after the conservation and sediment pools are full, the water would be initiated through the flood outlet works. Releases would normally be coordinated with releases from the other dams on the Salt and Verde Rivers to limit the discharge over Granite Reef Diversion Dam to an acceptable flow rate.

1. New Horseshoe Dam and Reservoir. New Horseshoe Dam and Reservoir would be located at and adjacent to the existing dam, as shown in Figure 14.

a. Geology and Design. Geologic studies of the site indicate that the left abutment is volcanics consisting of interlayered basalts, agglomerates, tuffs, and andesites. The right abutment is sedimentary sandstone conglomerate in the saddle and the remainder is similar to the left abutment. Seepage could be a problem, particularly along the left abutment. An adequate site for the spillway exists in the saddle near the right abutment for a large capacity spillway. New outlet works would be tunnels located to the west of the existing Horseshoe Dam spillway. Outlet works would be capable of discharging flows of 45,000 ft^3/s and the spillway would have a capacity of approximately 450,000 ft^3/s. Suitable materials for construction of the embankment are located near the site.

b. Performance. The new dam would control about 44 percent of the watershed above the confluence of the Salt and Verde Rivers, with enough storage space to by itself control the Standard Project Flood (SPF) to 150,000 ft^3/s below the confluence. When operated in conjunction with control on the Salt River, it could reduce the SPF to as low as 50,000 ft^3/s below the confluence. The new water storage space would provide conservation of an additional 10,000 acre-feet/year of Verde River flow. When considered in



HORSESHOE DAM SITE

Figure 14

Table 15

VERDE RIVER ELEMENTS

Site	STRUCTURE			STORAGE VOLUME (acre-feet)					PERFORMANCE		COST ($ Millions)			
	Dam Height (feet)	Crest Elevation (feet)	Maximum Surface Area (acres)	Existing Conservation	Flood Control	New Water Storage (R/S)	Surcharge	Total	Increase in CAP Yield (ac-ft/yr)	Flood Control (% of Watershed Controlled)	Construction 7-3/8%	Construction 3-1/4%	Total Annual 7-3/8%	Total Annual 3-1/4%
New Horseshoe	282	2,212	11,000	139,000	510,000	100,000	429,000	1,178,000	40,000 to 60,000	44	287.9	262.8	23.2	10.8
Cliff	300	2,110	11,000	144,000	510,000	100,000	429,000	1,183,000	40,000 to 60,000	45	245.2	223.8	20.1	9.6
New Bartlett	374	1,981	10,984	327,500	510,000	100,000	429,000	1,366,500	40,000 to 60,000	45	618.5	564.7	47.6	21.1

conjunction with an SRP/CAP exchange system, the total net increase in yield would be 40-60,000 acre-feet/year.

c. Dam Safety. The spillway at the existing dam is undersized for the revised inflow design flood (IDF). Construction of a new dam with a larger spillway to accommodate the IDF would solve this problem. Because of the location of the dam upstream of existing dams on the Verde, a New Horseshoe Dam could contribute to the solution of dam safety problems at the downstream dam.

d. Recreation. Recreation which may be developed in conjunction with the new dam is limited to river-oriented recreation because of surface water limitations and a desire to leave the special features undisturbed. At a minimum, conceptual plans include a general use area which would provide only a limited amount of parking, a comfort station, and garbage facilities. More extensive development could include separate activity areas for camping, boating, and picnicking. Estimated costs for recreation development at this site range from $26,000 to $180,000, depending on the location and level of development.

e. Impacts. Major impacts at this site are:

- o Construction and operation of a new dam at this site would have a highly adverse effect on terrestrial and aquatic habitat, inundating vegetation and flowing stream.
- o Preferred bald eagle habitat and a bald eagle nest would be lost.
- o There would be a significant loss of archaeological and historical sites.

2. Cliff Dam and Reservoir. The Cliff Dam and Reservoir site is located on the Verde River, 6 miles downstream from the existing Horseshoe Dam, as shown in Figure 15. With construction of this dam, the existing Horseshoe Dam would be breached.

a. Geology and Design. The extreme upper portion of the left abutment is capped with soft volcanic tuff about 15 feet thick; the remainder is weathered granite, as is the remainder of the site. There is no seepage problem at this site. Several adequate spillway sites exist in the saddle in the vicinity of the left abutment. The outlet works would be tunnels located near the left abutment. The outlets would be capable of discharging flows of 45,000 ft^3/s and the spillway would have a capacity of approximately 450,000 ft^3/s.

b. Performance. A new dam at the Cliff site would control about 45 percent of the watershed above the Salt/Verde confluence, and could alone reduce the SPF to 150,000 ft^3/s below the confluence. When considered in conjunction with control on the Salt River, the SPF could be reduced to as low as 50,000 ft^3/s. The new water storage space would provide conservation of an additional 10,000 acre-feet/year of Verde River flow. When considered in conjunction with an SRP/CAP exchange system, the total net increase in yield would be 40-60,000 acre-feet/year.

c. Dam Safety. With the breaching of Horseshoe Dam, a dam at the Cliff site would solve the dam safety problem at Horseshoe and could contribute to solving dam safety problems downstream on the Verde River, reducing flow to safely pass the spillway at Bartlett Dam.

d. Recreation. Recreational facilities proposed for this site include at a minimum a general use area long the water's edge with a trail. More extensive development could include three separate activity areas for camping, boating, and picnicking. All activities would be connected by a trail network which also ties in with an existing trail. Estimated costs range from $16,000 to $375,000, depending on the location and level of development.

e. Impacts. Major impacts at this site are:

- Loss of terrestrial and aquatic habitat, with inundation of vegetation and flowing stream.
- Loss of preferred bald eagle habitat and nesting/breeding areas.
- Severe modification of aquatic habitat associated with flowing river; the creation of the conservation pool would, however, afford a lake fishery.

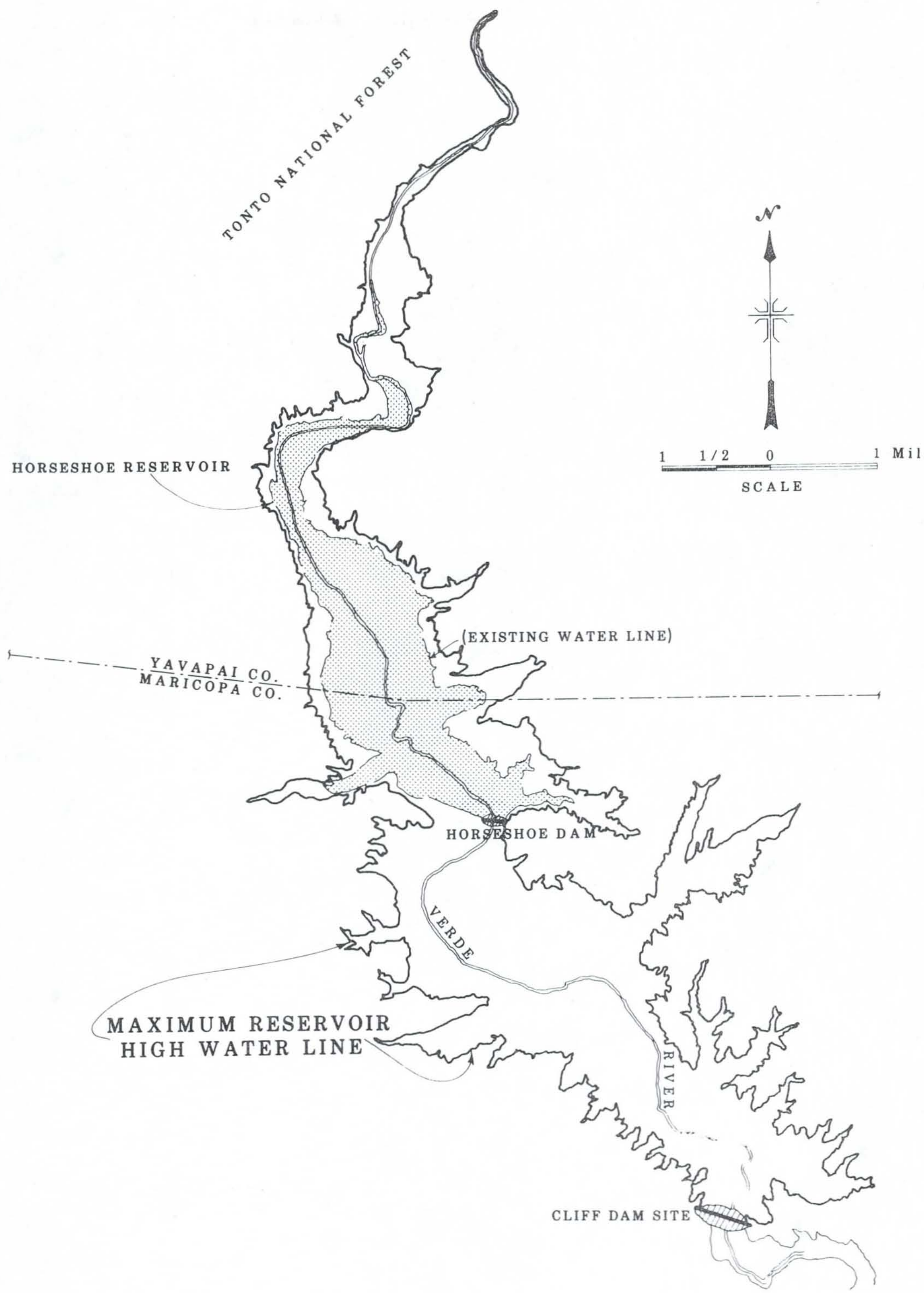
3. New Bartlett Dam and Reservoir. New Bartlett Dam and Reservoir would be located at and adjacent to the existing dam and reservoir, as shown in Figure 16.

a. Geology and Design. The site is underlain by coarse grained granite with some fine granite. There is no significant seepage problem. No suitable materials for the dam embankment are located at the site; materials would have to be brought to the site over a haul of 15 miles. An adequate spillway site is located in the saddle area of the right abutment. The outlet works would be tunnels located under the right abutment. The outlets would be capable of discharging a flow of 45,000 ft^3/s and the spillway would have a capacity of approximately 450,000 ft^3/s.

b. Performance. A dam at the Bartlett site would control about 45 percent of the watershed above the confluence and would by itself reduce the SPF to 150,000 ft^3/s below the confluence. When considered in conjunction with Salt control, the SPF could be reduced to 50,000 ft^3/s. The new water storage would provide conservation of an additional 10,000 acre-feet/year of Verde River flow. When considered in conjunction with an SRP/CAP exchange system, the total net increase in yield would be 40-60,000 acre-feet/year.

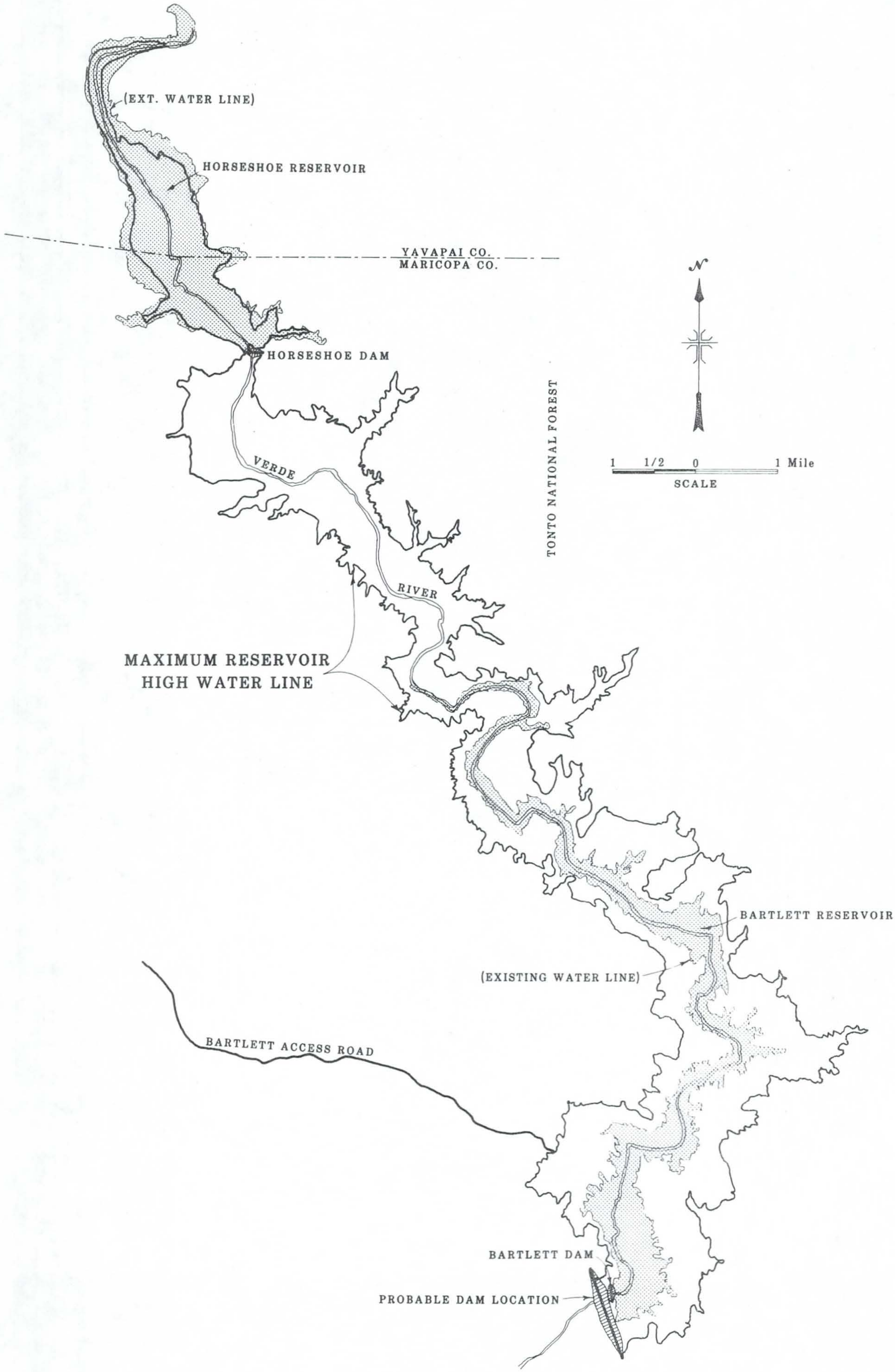
c. Dam Safety. The spillway at the existing dam is undersized for the revised IDF. Construction of a new dam with a larger spillway would solve this problem. Because of its location downstream, it could not, however, solve the general safety problem due to the high IDF on the Verde.

d. Recreation. The existing recreation area at the southern end of the site will be inundated and therefore must be relocated. Two potential



CLIFF DAM AND RESERVOIR SITE

Figure 15



BARTLETT DAM SITE Figure 16

sites were selected. One on the lower west side of Bartlett Lake would at a minimum consist of a general use area for dispersed recreation and trail development. More extensive development could include a boat launching area with immediate access to the major portion of the lake, and camping and picnicking areas. The other site, about one-fourth mile north, offers potential as a camping-concentrated area. Trails or roadways would connect all activity areas and would lead to an overlook with an excellent view of the Bartlett Lake area. Costs range from $16,000 to $400,000, depending on the location and level of development.

e. Impacts. Major impacts include:

- o Terrestrial habitat would be inundated; however, no additional flowing stream would be inundated.

- o Very little preferred bald eagle habitat would be inundated and no nesting areas would be affected.

4. Evaluation and Selection of Preferred Verde Site. As these three elements provide essentially the same function at different locations, the New Horseshoe, Cliff, and New Bartlett Dam sites were compared by CAWCS staff to select the one best site to be carried forward into system building. The comparison showed that:

- o From an engineering standpoint, Horseshoe and Cliff were preferable to Bartlett in terms of geology, because of the lack of suitable construction materials near the Bartlett site.

- o Environmentally, New Bartlett was preferable to the Cliff site, whereas New Horseshoe was clearly inferior to both New Bartlett and Cliff. New Horseshoe was therefore eliminated on the basis of having greater environmental impact.

- o Either New Horseshoe or Cliff were preferable to New Bartlett on the basis of cost, because costs for New Bartlett were over twice those for the other two elements. New Bartlett was, therefore, eliminated on the basis of having the greatest cost.

Based on these conclusions, Cliff Dam and Reservoir was, therefore, the selected site on the Verde River because of moderate cost and environmental impact.

B. Salt River

Originally, the analysis of flood control elements on the Salt River was limited to modification (raising 20 feet) of the existing Roosevelt Dam for flood control purposes. However, use of the dam for dam safety could preclude the use of modified Roosevelt Dam as a flood control facility. It is possible that modification of the dam to conform to Safety of Dam Standards would mean that any additional surcharge storage would be developed to accommodate the IDF to eliminate the potential of overtopping the existing structure. As a result, the Service and Corps evaluated alternative sites on the Salt River above and below the existing Roosevelt Dam to determine their feasibility as single-purpose flood control facilities and/or multipurpose flood control and CAP regulatory storage facilities.

Six sites were investigated:

Site	Purpose	
	Flood Control	Regulatory Storage
Coon Bluff	o	
New Horse Mesa	o	o
New Roosevelt	o	o
Klondike Buttes	o	
Tonto Creek Site	o	
New Stewart Mountain	o	o

The results of the investigation and evaluation were:

- o In terms of cost, Klondike Buttes had the lowest cost per acre-foot of flood storage of the sites studies. Coon Bluff, New Stewart Mountain and New Roosevelt had relatively comparable mid-range costs while New Horse Mesa and Tonto Creek had highest overall cost per acre-foot. From a regulatory storage and flood control viewpoint, however, New Roosevelt and New Stewart Mountain were the most cost-effective.
- o Relative to dam safety, New Roosevelt and New Stewart Mountain had the advantage because both would alleviate a portion of the dam safety problem.
- o Environmentally, New Horse Mesa appeared to have the least environmental impact because it is located in a narrow canyon. New Stewart Mountain, also located in a narrow canyon, followed.

- In terms of recreation potential, New Stewart Mountain and New Roosevelt provided the most opportunity for recreation development because larger reservoirs would be created, especially if CAP regulatory storage is added.

- From a geotechnical viewpoint, all of the sites were suitable.

- Relative to performance, the lower a dam is in the watershed, the more flood control is obtained. Thus, Coon Bluff had the advantage.

Based upon these results, two sites were considered primarily for flood control on the Salt River:

- Enlarged or New Roosevelt Dam.

- New Stewart Mountain Dam.

1. Enlarged/New Roosevelt Dam and Reservoir. Enlargement of the existing Roosevelt Dam at the confluence of Tonto Creek and the Salt River, or construction of a new dam and reservoir downstream (Figure 17) would provide flood control on the Salt River above its confluence with the Verde River and regulatory storage of CAP water. No flood control would be provided on the Verde; however, higher levels of flood control could be achieved if operated in conjunction with flood control on the Verde. Additional surcharge space would be provided for dam safety purposes. The additional surcharge space would be used to control the IDF to a lower flow rate to prevent overtopping the dam. Because of the large amount of storage available at the site, it is possible to reduce the IDF to the SRP system present spillway capacity of 150,000 ft^3/s or lower. Engineering and cost data are shown in Table 16.

CAP regulatory storage could be achieved either by water exchange or by direct connection. The exchange option would operate as the water exchange with existing SRP system element described later in this chapter, but with additional water conservation space at Roosevelt Dam on the Salt River. The additional conservation space allows conservation of local flows and eliminates the constraints (i.e., space availability) associated with exchange.

Under direct connection, surplus CAP water which is available during the winter months could be delivered from the Salt-Gila Aqueduct through the reversible canal to a pump station at the bottom of Stewart Mountain Dam. New pump stations at Mormon Flat and Horse Mesa Dams would operate independently of the existing SRP pumped storage facilities and would transport the water through Saguaro and Canyon Lakes and into Apache Lake. Releases from Roosevelt Lake would be minimized and the water accumulated in the reservoir would be credited to the CAP through an exchange agreement with SRP. During the summer and fall as the demand for CAP water increased, water would be released from Roosevelt Lake through Apache, Canyon, and Saguaro Lakes and back into the reversible canal which would discharge into the Salt-Gila Aqueduct. During flood events, pumping of CAP water would be halted and the incoming waters stored in the new conservation pool at Roosevelt Lake could be claimed for the CAP. Water stored in the flood pool would be detained only long enough to limit the downstream releases to an acceptable flow rate.

Table 16

SALT RIVER ELEMENTS

SITE	STRUCTURE			STORAGE VOLUME (acre-ft)					PERFORMANCE		COST ($million)			
	Dam Height (feet)	Crest Elevation (feet)	Maximum Surface Area (acres)	Existing	Flood Control	New Water Storage (R/S)	Surcharge	Total	Increase in CAP Yield (ac-ft/yr)	Flood Control (% of Watershed Controlled)	Construction		Total Annual	
Roosevelt (w/exchange)											7 3/8	3 1/4	7 3/8	3 1/4
New	288	2,190	27,555	1,381,000	230,000	200,000	764,000	2,575,000	46,900	45%	282.3	257.7	22.8	10.8
Modified	288	2,190	27,490	1,381,000	230,000	200,000	756,000	2,567,000	46,900	45%	229.8	217.0	18.9	9.3
Roosevelt (w/canal)														
New	294	2,196	28,540	1,381,000	230,000	372,000	760,000	2,743,000	121,000	45%	630.2	575.3	50.8	23.8
Modified	294	2,196	28,474	1,381,000	230,000	372,000	756,000	2,739,000	121,000	45%	557.1	526.0	45.4	22.1
New Stewart Mountain	271	1,681	5,582	127,000	-	300,000	139,000	566,000	110,700	48%	427.9	390.6	35.3	17.0

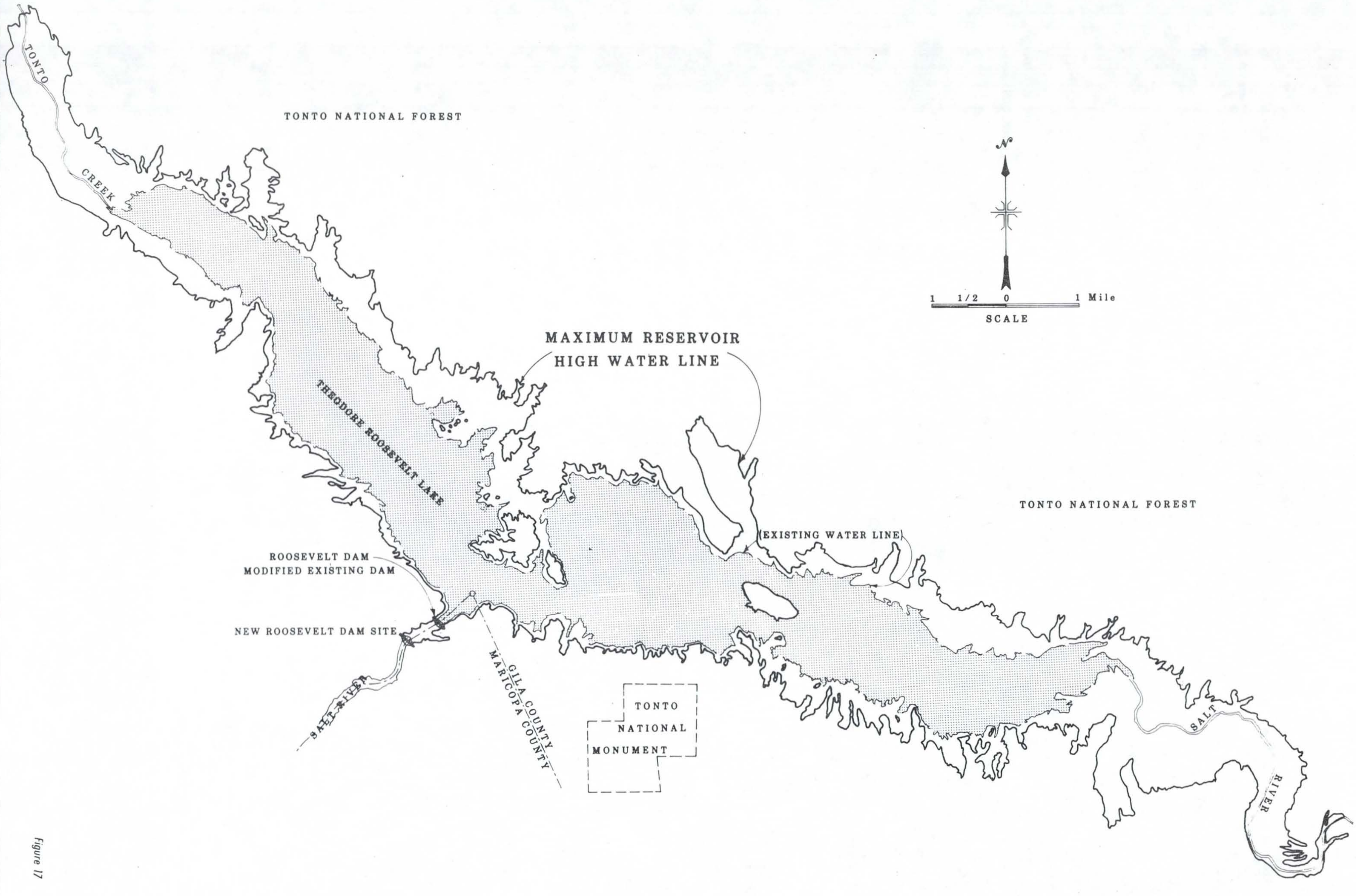


figure 17

ROOSEVELT DAM SITE

a. Geology and Design. Roosevelt Dam is founded on prominently bedded, somewhat infrequently jointed, hard, fine-grained, dense quartzite and/or slightly metamorphosed sandstone. Upward along the abutments, metasandstones are interbedded with moderately-jointed, medium-jointed, medium-bedded, hard, dense, limestone with minor partings of hard shale. The limestones become more prevalent near the top of the dam.

Several alinements were evaluated for a New Roosevelt Dam; the one chosen is about 1,500 feet downstream of the existing dam. There is a series of springs at this site, however, which issue along the river for about 100 yards. If the potential problems caused by these springs cannot be corrected, another alinement about 1,000 feet further downstream would be suitable. The canyon walls are higher and flatter than those at the existing dam. Since the walls are moderately steep, the site is suitable for a concrete dam. Because of the high canyon walls, no adequate site exists for a spillway. Therefore, the spillway must be incorporated into the dam. A good site for an outlet tunnel does not exist through either abutment, and thus would have to be incorporated into the concrete dam. The flood control outlets would be capable of discharging flows of 50,000 ft^3/s, service outlets would have a capacity of approximately 4,500 ft^3/s, and the spillway would have a capacity of 150,000 ft^3/s.

b. Performance. A new or enlarged Roosevelt Dam would control about 45 percent of the total Salt River drainage above the confluence. By itself, it has enough capacity to control the SPF to 200,000 ft^3/s below the confluence. When analyzed in conjunction with Verde control, it can control the SPF to as low as 50,000 ft^3/s. With a new/enlarged Roosevelt Dam, an additional 30,000 acre-feet/year of Salt River flows could be conserved. When the element is operated for CAP regulatory storage, the total net increase is 33,600 acre-feet/year by exchange and 46,900 acre-feet/year by direct connection.

c. Dam Safety. The spillway at the existing dam is undersized for the current IDF and would have to be modified. Because of the location of the enlarged or new Roosevelt Dam upstream of existing dams on the Salt River, it would solve most of the dam safety problems on the Salt River.

d. Recreation. Conceptual recreation plans call for the type of recreational activities to remain essentially the same as currently exist (camping, picnicking, and boating), but facilities would be developed to a greater extent. Minimum and moderate levels of development were planned for five potential sites. Estimated costs range from $145,000 to $2.2 million, depending on the location and level of development.

e. Impacts. Significant impacts include:

- Construction of a new dam or enlargement of the existing dam would have an adverse impact on the existing dam, a Historic Landmark.
- Several individuals from communities along Roosevelt Lake may have to be relocated with either action.

- o Terrestrial habitat, perennial stream, and bald eagle breeding/nesting sites would be lost.

2. New Stewart Mountain Dam and Reservoir. The New Stewart Mountain Dam site is located about 9 miles upstream of the Salt/Verde confluence, as shown in Figure 18. The dam would be operated similar to enlarged/new Roosevelt, with regulatory storage accomplished by direct connection to the CAP aqueduct or by exchange. Engineering and cost data are shown in Table 16.

a. Geology and Design. Several alinements were evaluated as potential damsites. The site selected requires fewer embankment quantities and has the best spillway and outlet works. The site has bedrock of competent granite with the southeast ridge underlain by volcanic dacite. Aerial geologic mapping indicates the site would not likely involve strong faulting and is suitable for an earth embankment. All materials could be granite with the southeast ridge underlain by volcanite dacite. All materials could be obtained within 5 miles of the site. The outlet works would consist of tunnels located in the southeast trending ridge. The outlets would be capable of discharging flows of 50,000 ft^3/s, and the spillway would have a capacity of 150,000 ft^3/s.

b. Performance. A dam at the New Stewart Mountain site would control about 48 percent of the watershed above the confluence and could by itself reduce the SPF to 200,000 ft^3/s. When analyzed in conjunction with Verde control, it can reduce the SPF to as low as 50,000 ft^3/s. The new storage space would allow conservation of an additional 30,000 acre-feet/year of Salt River flows. When operated for regulatory storage, the total net increase in yield is 82,000 acre-feet/year by direct connection and 46,000 acre-feet/year by exchange.

c. Dam Safety. The spillway at the existing dam is undersized for the current IDF. The dam safety problem would be solved by replacement of the structure, or construction of an auxiliary spillway.

d. Recreation. No recreation plan was developed during Stage II.

e. Impacts. Major impacts include:

- o Creation of a large lake resulting in increased surface for water-oriented recreation.

- o Relatively minimal loss of terrestrial habitat and perennial stream would occur.

- o No significant social impacts are associated with the site.

3. Evaluation of Salt River Elements. Although New Stewart Mountain and Enlarged/New Roosevelt appear to be competing, since they both are on the Salt River and provide essentially the same function, both elements have specific flood control, regulatory storage, dam safety, and environmental attributes which warrant carrying both forward to system building.

C. Salt/Verde Confluence

Two sites were investigated at or near the confluence of the Salt and Verde Rivers for flood control and/or regulatory storage purposes:

- Confluence Dam and Reservoir at the confluence (Figure 19).
- Granite Reef Dam and Reservoir, 4 miles downstream of the confluence (Figure 20).

1. Plan Description. Three project actions were studied at each site: a multipurpose dam and reservoir with 300,000 acre-feet of regulatory storage plus 970,000 acre-feet of flood storage; a single-purpose, regulatory storage-only dam and reservoir at a range of sizes (500,000 acre-feet shown); and a single-purpose, flood-control only dam and reservoir at a range of sizes (970,000 acre-feet shown). All reservoirs would include 47,000 acre-feet of additional inactive storage for a recreation and fish and wildlife pool. Engineering and cost data on the three actions at both sites are shown in Table 17.

a. Multipurpose Dam. A multipurpose dam at or near the confluence would provide regulatory storage of CAP water as well as flood control on the Salt River below the site.

At the confluence site, CAP water would be delivered to and returned from the reservoir through a 4-mile reversible canal. Water would flow through a pump-generation facility which would then produce electrical power from the falling water before it enters the regulatory storage pool. A separate powerplant would be located at the base of the dam. A transmission line would connect the pump-generation facility to the CAP power system.

At the Granite Reef site, the new dam would be located just upstream of the CAP siphon under the Salt River. Regulatory storage water would be delivered to and returned from the reservoir through a pump-generation facility. A hydropower facility is proposed at the site for the water supply outlet works. A transmission line would connect the pump-generation and hydropower facilities to the CAP power system.

When flooding occurs, the pumping of Colorado River water would be halted and the regulatory storage pool would then be filled from the flood water inflow, saving on pumping costs. Normally, water would be allowed to fill the regulatory storage pool before the flood outlets are opened. However, with water in the flood pool, the outlet would be opened to pass whatever the inflow is up to a design discharge, after which the flood pool would fill and, if necessary, the spillway gates would also be opened.

b. Single-purpose Regulatory Storage Dam. A single-purpose regulatory storage dam would provide CAP regulatory storage only. Although no flood control space would be allocated, downstream flooding could be reduced if there were available storage space in the regulatory storage pool during a flood. Operation of the facilities would be as described for the regulatory storage portion of the multipurpose dam.

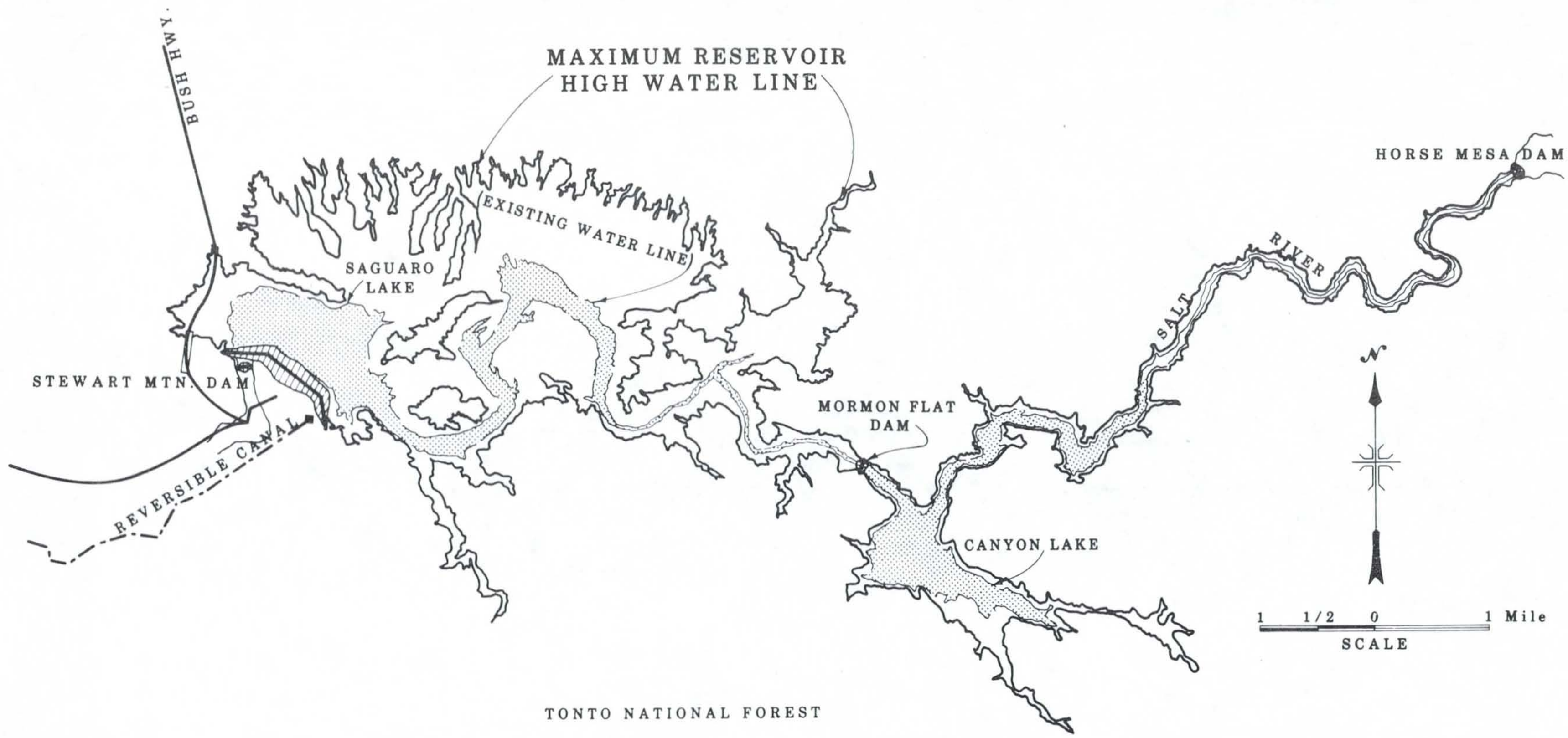
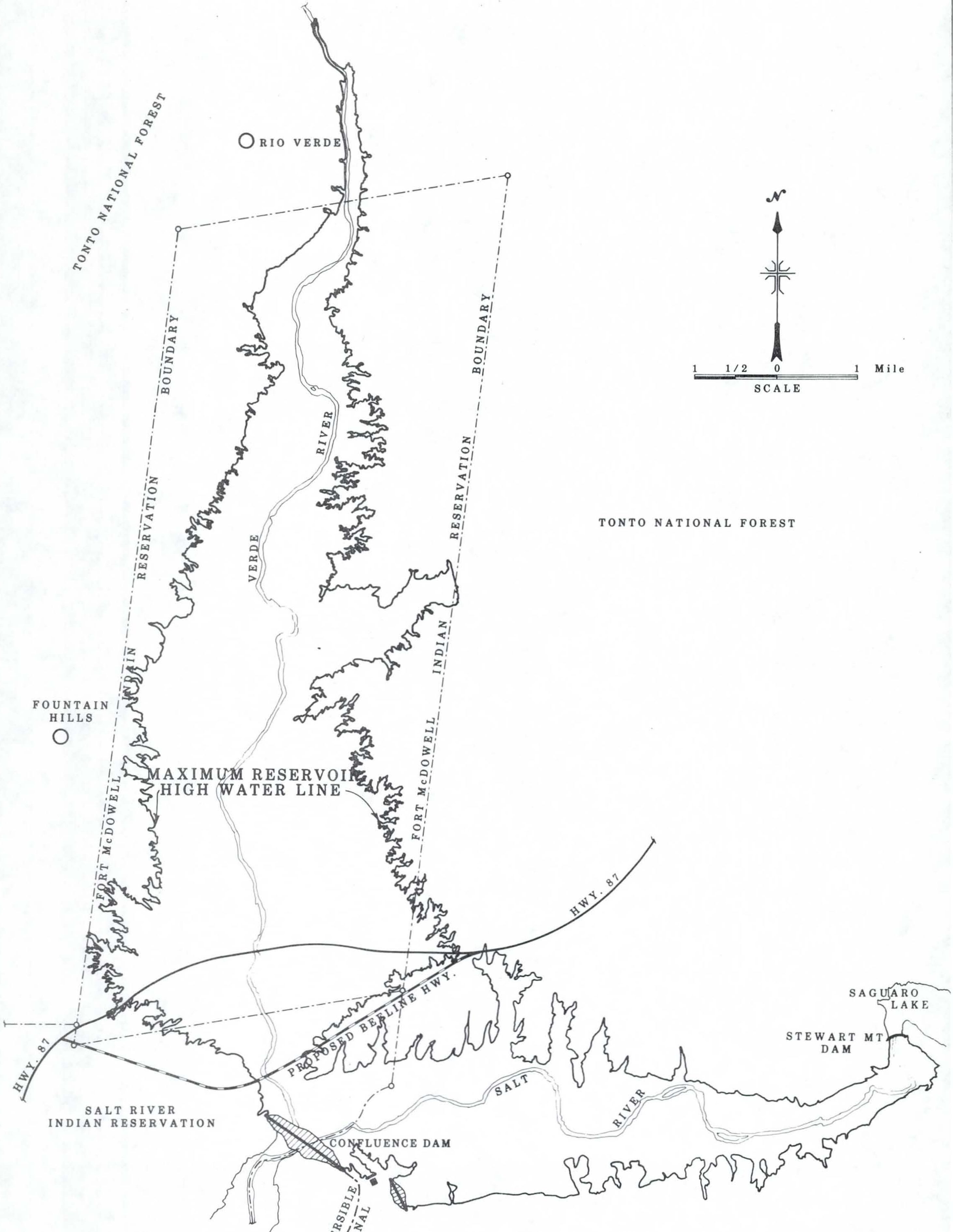


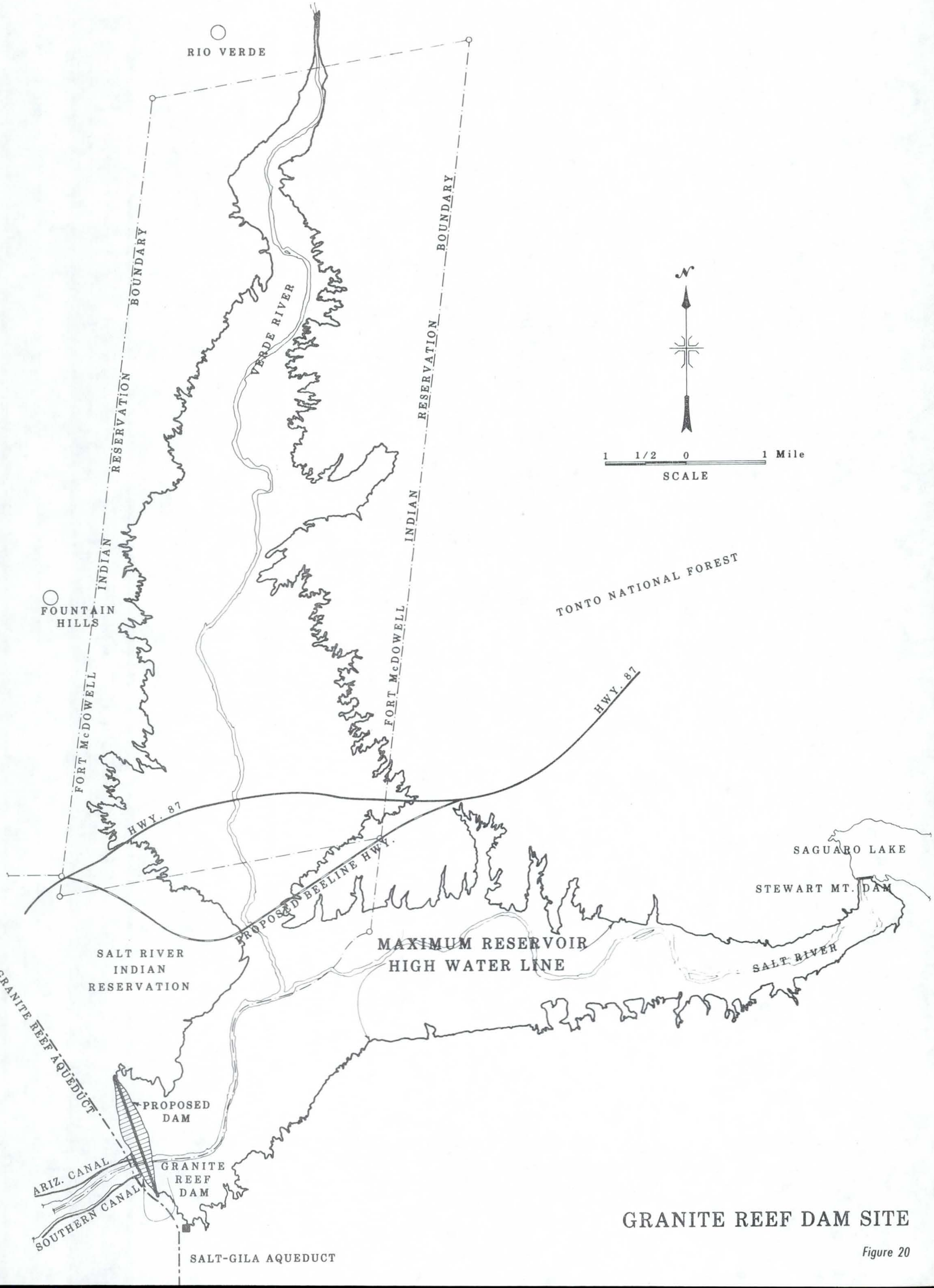
Figure 18

STEWART MOUNTAIN DAM SITE



CONFLUENCE DAM SITE

Figure 19



GRANITE REEF DAM SITE

Figure 20

Table 17
CONFLUENCE ELEMENTS

SITE	STRUCTURE			STORAGE VOLUME (acre-feet)					PERFORMANCE		COST ($millions)			
	Dam Height (feet)	Crest Elevation (feet)	Maximum Surface Area (acres)	Existing	Flood Control	New Water Storage (R/S)	Surcharge	Total	Increase in CAP Yield (ac-ft/year)	Flood Control (% of Watershed Controlled)	Construction		Total Annual	
											7 3/8%	3 1/4%	7 3/8%	3 1/4%
Confluence														
Multipurpose	188	1,508	21,960	-	970,000	347,000	132,000	1,449,000	112,000	100%	598.2	546.1	46.3	20.3
Regulatory Storage	144	1,464	13,500	-	-	547,000	129,000	676,000	140,900	-	425.4	388.3	33.7	15.5
Flood Control	176	1,496	19,520	-	970,000	47,000	183,000	1,200,000	-	100%	510.3	465.9	37.8	15.9
Granite Reef														
Multipurpose	190	1,493	22,235	-	970,000	347,000	201,000	1,518,000	112,000	100%	727.5	664.2	55.8	24.6
Regulatory Storage	140	1,443	12,745	-	-	547,000	115,000	662,000	140,900	-	535.8	489.2	41.9	18.9
Flood Control	174	1,477	18,795	-	970,000	47,000	173,000	1,190,000	-	100%	638.6	583.0	47.3	19.9

c. Single-purpose Flood Control Dam. A single-purpose flood control only dam would provide flood control for the Salt River below its confluence with the Verde River. No regulatory storage space would be provided. Operation of the dam would be as described in the flood control portion of the multipurpose dam.

2. Geology and Design. At the Confluence site, the left abutment is weathered conglomerate interbedded with sandstone; the right abutment is weathered granite with a fault zone near the base of the abutment. The channel section is generally 30-40 feet of unconsolidated alluvium overlying weathered conglomerate, with a buried channel of 100+ feet unconsolidated alluvium near the right side.

At the Granite Reef site, the left abutment is lightly to moderately weathered granite; the right abutment is weathered sandstone and conglomerate. The channel section is generally 40-60 feet of alluvium with a 2,000-foot-wide buried channel on the right side. The right terrace is entirely unconsolidated to variably cemented alluvium and terrace deposits. Adequate materials exist near both sites. Also at both sites, there is a possible seepage problem along fault zones and buried channels, but the seepage can be controlled with proper foundation treatment. Spillways and outlet works capacities would be as follows:

	Capacity (ft^3/s)			
	Spillway	Flood Outlets	CAP Outlets	Water Supply Outlets
Confluence				
Multipurpose	840,000	50,000	2,750	3,650
Flood Control	840,000	50-150,000	--	3,650
Reg. Storage	840,000	--	2,750	3,650
Granite Reef				
Multipurpose	840,000	50,000	2,750	3,650
Flood Control	840,000	50-150,000	--	3,650
Reg. Storage	840,000	--	2,750	3,650

3. Performance. A multipurpose dam at the confluence or a single-purpose flood control dam at either site could alone reduce the SPF to 50,000 ft^3/s downstream through Phoenix and would control 100 percent of the Salt/ Verde watershed above the confluence. Relative to regulatory storage, it is estimated that with a multipurpose dam, regulatory storage would result in an increase of 110,000 acre-feet/year of available water. A single-purpose regulatory storage only dam would result in an increase of 140,000 acre-feet/year, directly attributable to the availability of more storage.

4. Dam Safety. A dam at or near the confluence does not contribute to solving the dam safety problems on the Salt or Verde as it would be located downstream of all existing dams.

5. Recreation. Recreational facilities planned for either site focus on supplying intensive types of activities to take advantage of the proximity

of the site to the Phoenix area. Conceptual plans developed for the sites provide various levels of camping, picnicking, hiking, fishing and swimming; a floating marina; and a boat-launching ramp. Because of the fluctuating reservoir level and flatness of the confluence site, facilities would be located at sites close to the dam and in areas with steeper dropoffs. Estimated costs range from a minimum of $198,000 to a maximum of $4.9 million, depending on the site and level of development.

6. Impacts. Significant environmental and social impacts include:

- With construction of either site, nesting sites, breeding areas, and preferred habitat of the endangered bald eagle and Yuma clapper rail would be destroyed.

- A significant number of cultural sites would be lost at either site.

- A considerable amount of the Fort McDowell Indian Community land would be inundated, resulting in relocations of people and homes, the number of which varies with the sites and reservoir sizes.

- Regarding recreation, at both sites a major impact would be loss of the tubing activity on the Salt River due to inundation of flowing stream. The recreation flat water resource would, however, be increased significantly.

7. Evaluation and Selection of Preferred Confluence Site. As these elements were competing, the sites were compared for each action by CAWCS staff to select the preferred site to be carried forward to system building. Since both reservoirs behind the two dams are nearly identical, environmental impacts in most categories are equal. Both have significant impacts on threatened and endangered species and a considerable amount of cultural sites would be lost.

There are significant differences between the two sites in geology, cost, and potential inundation of the Fort McDowell Indian Community lands. The factors of geology and cost significantly favor the Confluence location. The Granite Reef site has the disadvantage of a deeper, more extensive buried channel and also a long crest length. These factors translate into a much higher cost for the dam structure. On the other hand, the Confluence site, being about 20 feet higher in elevation, would inundate a larger portion of the Fort McDowell Indian Community lands.

Depending on the dam size, there is some difference between the two sites in terms of relocations. However, the overall effect on the Indian Community would be the same--severe and adverse--no matter how many actual relocations occur. Due to the Community's traditions and identification with the land, any permanent relocation of community members would cause serious social disruption.

In the final analysis, it was concluded that, on the basis of geology and cost, the Confluence Site was superior to the Granite Reef Site. On the basis of social impact from relocations, the effect was equally severe. Therefore, the Confluence Site was recommended to be carried forward to system building.

D. SRP Reregulation

Reregulation of the Salt River Project (SRP) would take place within the SRP system of dams and reservoirs on the Salt and Verde Rivers upstream of Phoenix, particularly at Horseshoe and Bartlett Dams on the Verde and at Roosevelt Dam on the Salt River. While reregulation would not significantly alter the total volume of floodwater released down the Salt and Gila Rivers, it would provide a significant reduction in the peak flow rate in the Salt River through Phoenix and downstream in the Gila River.

Two actions are being considered for SRP reregulation: 439,000 acre-feet of flood storage with no modification to existing dams, and 556,000 acre-feet of flood storage with modifications (new flood outlets) to existing dams. These two actions represent just two of many variations of reregulation examined. Action 1 was selected because it provided the greatest degree of flood protection without requiring any construction. Action 2 was selected because it produces significant flood control at reasonable costs for new outlet construction. Table 18 displays engineering and cost data on the two actions.

Table 18
SRP REREGULATION

	Without Modifications	With Modifications
STORAGE (acre-feet)		
Volume released	439,000	556,000
Volume retained	1,252,000	1,135,000
% Total dedicated	21%	27%
FLOOD REDUCTION (ft^3/s)		
SPF (295,000 ft^3/s)	270,000	210,000
100-year (245,000 ft^3/s)	185,000	100,000
50-year (175,000 ft^3/s)	150,000	100,000
COSTS		
Construction	--	87,000,000
Annual O&M	--	200,000
Other costs 1/	6,600,000	8,100,000
Total Annual		
@ 7-3/8%	6,600,000	14,700,000
@ 3-1/4%	6,600,000	11,247,560

1/ Other cost category includes loss of hydropower production, loss of water, increase in pumping costs, and increase in depth to ground water.

For each action, water could be stored in the designated flood pools from April to December. However, water in these pools would have to be released and the pools emptied prior to the winter storm season in anticipation of flood inflows. Incoming flows from winter storms and spring runoff would be captured in the vacant space. Flow volumes up to the allowable downstream target flows would be released through the outlets and spillways. Larger flow volumes would be detained in the available flood control space until they could be released.

1. Design and Performance. Reregulation without modifications is designed to control the 50-year flood (175,000 ft^3/s) to a target flow of 150,000 ft^3/s on the Salt River through Phoenix. No structural changes would be made to the existing dams. Both Horseshoe and Bartlett Lakes would be drained down to the spillway crest elevation each year in anticipation of floodflows on the Verde. In addition, about 270,000 acre-feet of storage in Roosevelt Lake would be reserved for floodflows from the upper Salt and/or Tonto Creek. This volume of storage to be vacated constitutes about 21 percent of SRP's total existing storage space.

Reregulation with modifications is designed to use flood outlets rather than flood storage to control the 100-year flood (245,000 ft^3/s) to a target flow of 100,000 ft^3/s below the Salt/Verde confluence. Roosevelt Dam would be drained 50,000 acre-feet below the spillway crest and 45,000 ft^3/s flood outlets would be installed at the dam. Horseshoe Dam would be drained only to the spillway crest and neither flood control nor drawdown outlets would be installed. Bartlett would be drained down to a 5,000 acre-foot minimum pool and 20,000 ft^3/s flood control outlets would be installed. The volume of storage space to be vacated for flood control constitutes 27 percent of SRP's total existing storage space. Approximately 236,000 acre-feet of flood storage would be available on the Verde River and 320,000 acre-feet on the Salt River.

2. Dam Safety. Neither action contributes to solving dam safety problems on the Salt or Verde Rivers.

3. Recreation. Recreation facilities would be as currently exist.

4. Impacts. Reregulation would result in flows in the river more frequently during the drawdown period prior to flood season. The net result of SRP reregulation as described would be a 60 percent or 100 percent increase in frequency of releases over existing conditions for reregulation without and with modifications, respectively.

If the winter and spring inflows do not refill the three reservoirs, the difference would be a water loss to the SRP service area. The lack of sufficient replacement inflow to the reservoirs would limit releases from the dams. The Verde River reservoirs have a small combined storage volume relative to those on the Salt River, and years with low runoff volumes would result in little or no water in the Verde River.

While reregulation would involve improvement of SRP's flood reduction capability, it does so at the expense of water conservation and power production.

No significant environmental or social impacts are associated with re-regulation. However, institutional constraints are a limiting factor with this element in terms of implementation.

E. Channels and Levees

Three methods of channelization were considered for flood control downstream through Phoenix (Figure 21):

- Channels on the Salt River.
- Levees on the Salt and Gila Rivers.
- Phoenix Greenbelt.

All would control the areal extent, depth, and velocity of a selected design flow to reduce flood damage. Engineering and cost data are shown in Table 19.

1. Channels. Channelization includes a 17.5-mile-long channel from Country Club Drive to 35th Avenue. Four channel capacities were evaluated: 300,000 ft^3/s, 200,000 ft^3/s, 100,000 ft^3/s, and 50,000 ft^3/s. From hydraulic analysis, it was determined that the existing Salt River channel could accommodate up to 100,000 ft^3/s. Therefore, channel designs were made for 200,000 ft^3/s and 300,000 ft^3/s. For purposes of display, the 300,000 ft^3/s size is shown. With this large size, the channel would consist of about 8.5 miles of earth-bottom channel and about 9 miles of narrower concrete-lined channel below the Hohokam Freeway. Typical channel sections are shown in Figure 22.

a. Geology and Design. The Salt River below the Granite Reef Diversion Dam flows across the margins of two very deep basin valleys before its confluence with the Gila River. The basins, called the East and West Basins, are part of the designated Salt River Valley Groundwater Basin.

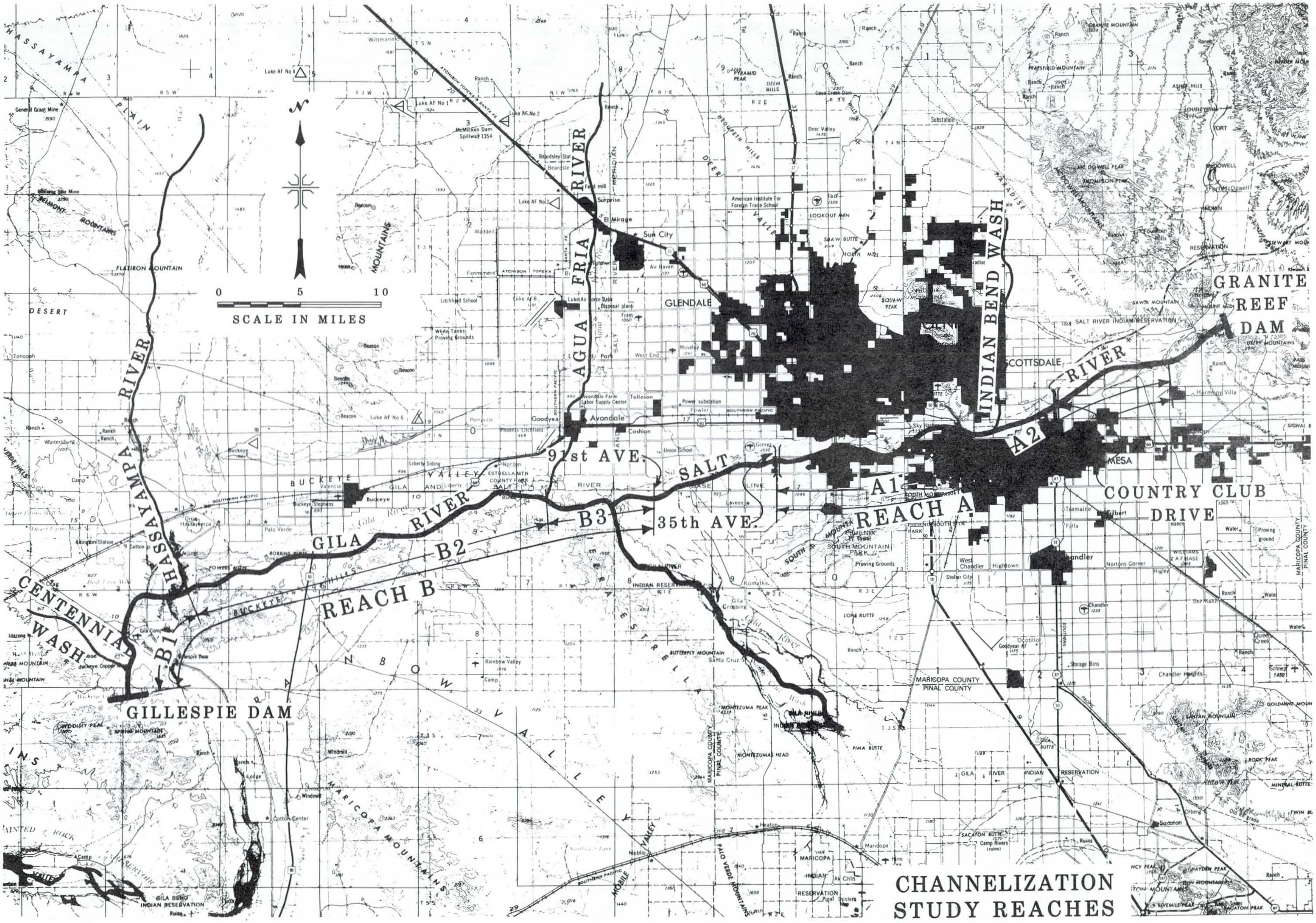
They are typical of most other basins in central Arizona and of the Basin and Range Physiographic Province in general. The basins are alluvial-filled, discontinuously bounded by basement rocks which rise abruptly as precipitous mountains above the valley surface. In the East Basin, the depth to ground water along the river downstream of Granite Reef Dam is well over 300 feet. In the West Basin, the depth rises to less than 50 feet.

Channel alinements were set to pass through major existing and proposed new bridges, unless the bridge would not be able to be incorporated into the channel plans. Where possible, the alinements follow the existing low-flow channels to reduce excavation cost. Major utilities, gravel pits, and landfills were avoided where possible. The channel design for 300,000 ft^3/s is earth bottom only upstream of the Hohokam Expressway area. The design is based on allowable velocities and the need to maintain a specified slope. A concrete channel was designed downstream from the Expressway to near 35th Avenue, based on the need to establish stable flow, maintain flow through the

Table 19

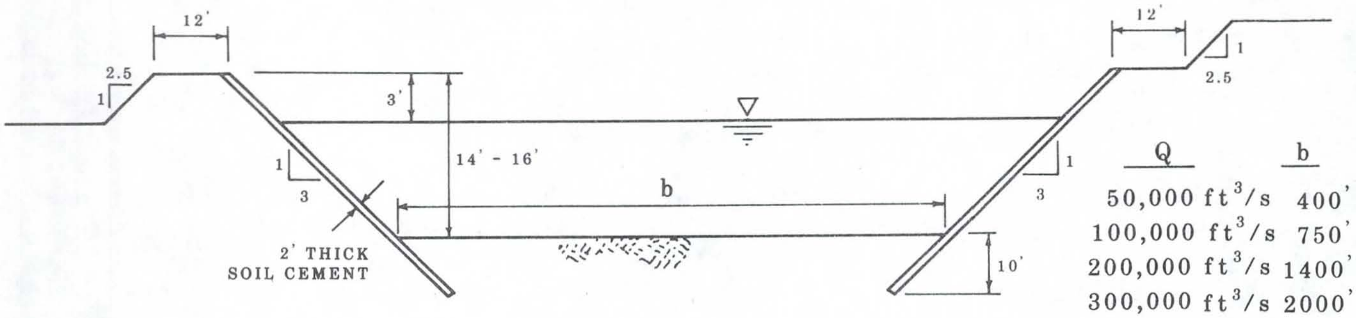
CHANNELIZATION OPTIONS

OPTION	Capacity (ft^3/s)	Width (ft)	Height (ft)	Length (mi)	Velocity (ft/s)	Depth (ft)	COST ($millions) Construction	OM&R	Total Annual
Channels	300,000						1,050.4 1,002.8	11.6 11.6	89.1@ 7 3/8% 45.6@ 3 1/4%
Earth-bottom		2000	-	8.5	11.6	12.7-16			
Concrete-lined		600	-	9.0	28.1	16.9-19			
Levees									
Salt River	300,000	Variable	3-20	21			787.1 751.4	20.0 20.0	78.1@ 7 3/8% 45.5@ 3 1/4%
Gila River	300,000	Variable	3-20	27			521.3 497.7	16.7 16.7	55.2@ 7 3/8% 33.6@ 3 1/4%
Greenbelt	300,000	Variable	3-20	21	8	20	844.6 806.0	21.0 21.0	83.3@ 7 3/8% 48.3@ 3 1/4%



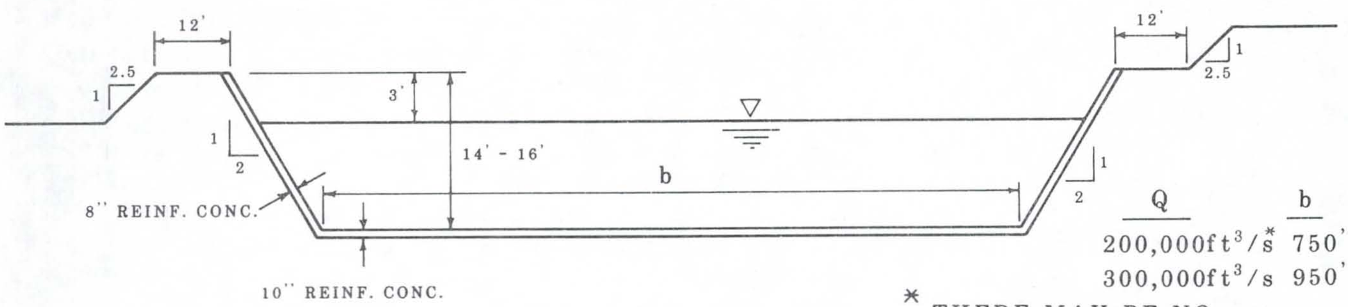
CHANNELIZATION
STUDY REACHES
SCALE IN MILES
0
5
10
GILLESPIE DAM
GRANITE REEF DAM
REACH A
REACH B
A1
A2
B1
B2
B3
91st AVE.
35th AVE.
COUNTRY CLUB DRIVE
HASSAYAMPA RIVER
AGUA FRIA RIVER
INDIAN BEND WASH
CENTENNIAL WASH
GILA RIVER
SALT RIVER
GLENDALE
SCOTTSDALE
MESA
MARICOPA COUNTY
PINAL COUNTY

Figure 21



TYPICAL SECTION
EARTH-BOTTOM CHANNELS

NOT TO SCALE



* THERE MAY BE NO CONCRETE CHANNELS FOR 200,000 ft^3/s

TYPICAL SECTION
CONCRETE CHANNELS

NOT TO SCALE

NATURAL SLOPE CHANNEL SECTION

Figure 22

bridges, and for a smooth transition of flow both upstream and downstream from the concrete channel.

b. Performance. The channels would not reduce the peak flow but would be designed to contain up to the standard project lfood (295,000 ft^3/s).

c. Recreation. Recreation facilities associated with these channels would consist of equestrian and bicycle paths on the access roads and picnic or park facilities located along the corridor. Costs are yet to be estimated.

d. Impacts. Significant environmental and social impacts are:

- A significant amount of known and potential sand and gravel mining areas would be given up in production due to acquisition of land for the project.

- While there would be a loss of terrestrial and aquatic habitat, over half of the amount consists of urban and built-up land. No threatened or endangered species would be impacted, and there would be minimal impact on archaeological/historical sites.

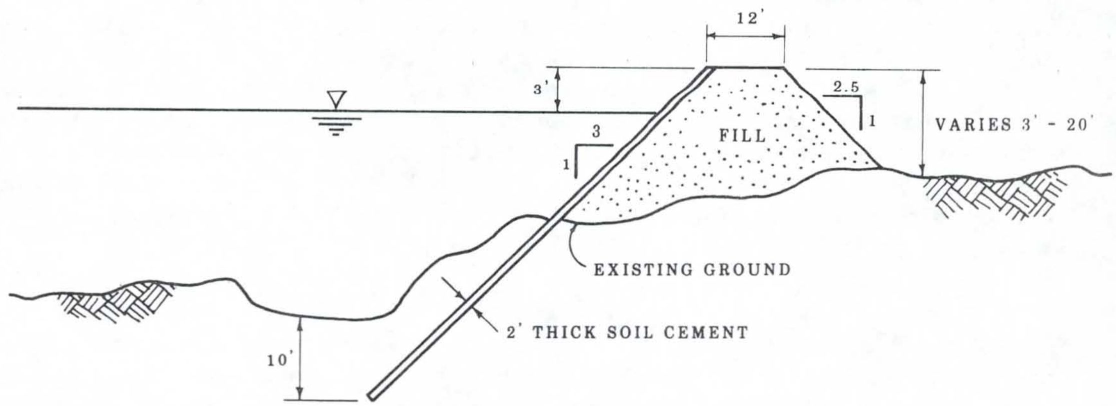
- Recreation opportunity and open space would be increased.

2. Levees. Levees were examined for the Salt River through Phoenix and on the Gila River as shown in Figure 21. The Salt River levees would consist of two earthfill dikes, one on each side of the river, extending from 35th Avenue about 21 miles upstream to an area east of Country Club Drive. Proposed levees on the Gila River include about 38.5 miles of embankment on the north side of the river only from 91st Avenue to Gillespie Dam. Two capacities were examined for the levees: 300,000 ft^3/s and 200,000 ft^3/s. For display purposes, the 300,000 ft^3/s size is shown.

a. Geology and Design. The foundation materials for the levees would be recent alluvium consisting of irregular lenses of sand, gravel, and boulders and occasional lenses of silt and clay. These materials, which are of medium density, would be competent to support the anticipated loads. Most of the expected settlement would occur during construction. The occurrence of underseepage, which would be detrimental to levee stability, is not considered likely except where the levees would cross old stream channels. An ample supply of suitable embankment materials would be available at the sites. Rock for facing the embankment would be available from local sources from 3 to 6 miles from the project. Figure 23 shows a typical levee section.

b. Performance. Levees would not reduce the peak flow but would be designed to contain the standard project flood (295,000 ft^3/s). Levees must be designed for the SPF to reduce risk of catastrophic failure.

c. Recreation. Recreation facilities would be similar to channels, including equestrian and bicycle paths on the access roads or park facilities located along the corridor. Costs are yet to be estimated.



TYPICAL SECTION LEVEES

NOT TO SCALE

TYPICAL SECTION LEVEES

d. Impacts. Significant impacts include:

- o A significant amount of known and potential sand and gravel mining areas would be given up in production due to acquisition of land for the project.

- o While there would be a loss of terrestrial and aquatic habitat, over half of the amount consists of urban and built-up land. No threatened or endangered species would be impacted, and there would be minimal impact on archaeological/historical sites.

- o Recreation opportunity and open space would be increased.

3. Phoenix Greenbelt. The Phoenix greenbelt is essentially a levee system, consisting of a depressed corridor about 21 miles long from Country Club Drive to 35th Avenue, as shown in Figure 21. Four capacities were evaluated for this element: 300,000 ft^3/s, 200,000 ft^3/s, 100,000 ft^3/s, and 50,000 ft^3/s. From hydraulic analysis, it was determined that the existing Salt River channel could accommodate up to 100,000 ft^3/s. Therefore, designs were made for 200,000 ft^3/s and 300,000 ft^3/s. For the purposes of display, the 300,000 ft^3/s size is shown. On each side of a low flow channel, there would be areas designed to provide control of high flows which exceed the design capacity of the low flow channel.

a. Geology and Design. Geology is as described for channels. The greenbelt floodway element is a modified levee system with three noncontiguous greenbelt subreaches. Potential suitable greenbelt areas were limited by: very wide floodways, relatively narrow bridge openings, presence of large gravel pits, and the existing channel shape. Low flow channels are similar in design to those for channels; levees are similar in design to those for levees described previously and generally are located along the same alignments (Figure 24).

b. Performance. The greenbelt element would not reduce the peak flow but would be designed to contain the standard project flood (295,000 ft^3/s).

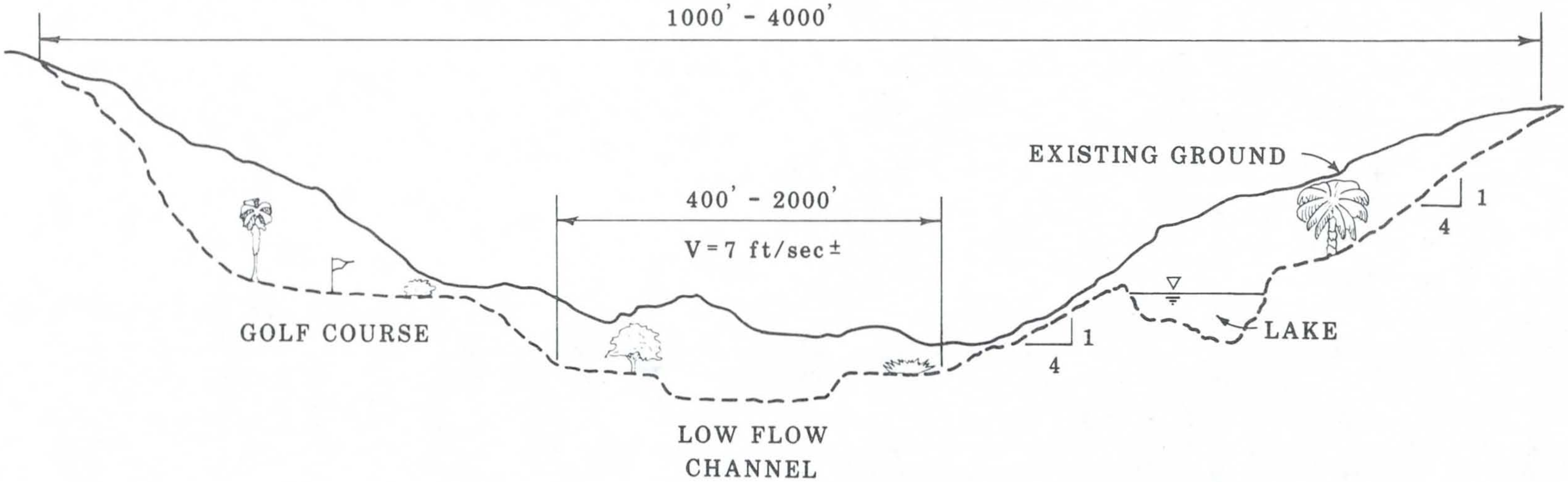
c. Recreation. Three distinct greenbelt areas could be provided: Phoenix near the Sky Harbor Airport, Tempe, and Mesa. Large parcels of land would be required. Facilities in the greenbelts could include golf courses, softball and soccer fields, as well as bike and equestrian paths. Vegetation would be encouraged in the greenbelt with widespread planting of grass and selected positioning of trees and shrubs. There would be small lakes for recreation and fishing.

d. Impacts. Significant impacts include:

- o All land within the flood control greenbelt would be acquired.

- o Similar environmental impacts would occur as with channels and levees.

- o All buildings in the low flow channel would be removed; other buildings in the greenbelt corridor may require relocation if their location or elevation is not compatible with the greenbelt.



TYPICAL CROSS SECTION
NOT TO SCALE

Figure 24

GREENBELT FLOODWAYS

- Greater recreational opportunity would be provided.

4. Evaluation and Selection of Preferred Channelization Element. Competing channelization elements were screened to select the preferred element for system building. All three elements provide the same level of protection. However, of the three, levees are the least costly and are therefore preferred in terms of cost.

All three elements were essentially equal in terms of environmental impact. In addition, none of the impacts would be of a high magnitude. Social impacts are generally minor, as there are no relocations involved in any of the downstream elements.

Based on this evaluation, economics were seen to be the major deciding factor, as all other factors were essentially equal. Levees were therefore chosen as the preferred element because of least cost.

F. Nonstructural (Flood Damage Reduction) Measures

Nonstructural measures considered in the CAWCS are flood loss reduction measures aimed at reducing flood damages due to development in flood prone areas, rather than changing the flow of water. Although they do not provide as complete a solution as structural measures might, nonstructural measures offer potential courses of action at a time when structural solutions may be less acceptable for environmental or other reasons. Seven nonstructural measures were identified, not only as alternatives to structural solutions but also for possible combination with structural solutions. These were:

- Flood proofing.

- Relocation.

- Preparedness planning.

- Acquisition of vacant land.

- Gravel mining guidelines.

- Salt River bridges (limited structural).

- Flood plain regulations and flood insurance.

Based upon initial analysis, it was determined that acquisition of vacant land (as a land use control) was not considered necessary because of current land use ordinances regulating flood plain use. Flood insurance, since already in existence and use, would not be considered any further in the plan formulation process.

Another potential nonstructural measure investigated was watershed management. The CAWCS investigated the potential of increasing vegetative cover in the Salt-Verde watershed to reduce flood problems downstream. The study indicated that vegetative management could potentially offer some flood reduction for small floods which would typically occur in the summer in a small drainage area. However, floods on the Salt River typically occur in the December-to-April period when rainfall on frozen ground at high altitudes causes surface runoff and flooding. Because of the kind of flooding, great size of the drainage area, and topography and soil conditions in the watershed, vegetative management would have little effect on flooding along the Salt River through Phoenix. For this reason it was eliminated from further consideration.

Nonstructural measures now under consideration fall into three categories: modification of existing structures, regulation of future development, and preparedness planning. Damage reduction data are shown in Table 20.

1. Modification to Existing Structures. Several types of nonstructural measures are designed to permanently modify the damage potential of existing structures. Two methods of modifying existing structures were investigated as being feasible in the study area: flood proofing and relocation.

a. Flood Proofing. The primary objective of flood proofing is to prevent damages to structures in the flood plain. The CAWCS investigated two methods of flood proofing: raising existing structures and flood walls or dikes. In the CAWCS area flood plain, only protecting existing structures by flood walls or dikes was investigated as being physically feasible. Flood walls would be more suitable for residential and commerical structures for aesthetic reasons, while dikes might be more appropriate for industrial buildings. In addition to the walls or dikes themselves, flood proofing would involve sump pumps, sewer backup valves, flood gates, and drainage protection.

Three levels of protection were examined for flood proofing: the 50-year, 100-year, and 500-year events. Although studies have shown that flood proofing is economically justified only within areas of the flood plain which are frequently flooded, the CAWCS did evaluate beyond that level to provide a range of damage reduction.

b. Relocation. Permanent relocation of persons and/or property out of the flood plain not only reduces damage caused by flooding but would also provide a public resource through conversion of floodway land use to another use. Two options were investigated for relocation in the study area: relocation of both structures and individuals to a flood-free site, and relocation of only individuals to a structure in a flood-free site and demolition of the structure at the existing site in the flood hazard area.

Relocations were considered on the Salt and Gila Rivers within the 50-year, 100-year, and 500-year flood plains.

2. Regulation of Future Development. Flood plain regulations are legal tools, intended to control development in the flood plain. Regulation of the flood plain is usually the responsibility of the state and local governments and can be accomplished by revised building codes. The CAWCS investigated two actions in this category: flood plain regulations and sand and gravel operations regulations.

Table 20
NONSTRUCTURAL MEASURES

Measure	Existing 1/ EAD ($ Millions)	EAD w/ Measure ($ Millions)	Annual Damage Red. ($ Millions)
Modification of Existing Structures			
50-year Flood plain	1.8	1.5	.3
100-year Flood plain	1.8	1.2	.6
500-year Flood plain	1.8	3.0	1.5
Regulation of Future Development 2/			
No Enforcement of Ordinance	2.2	3.8	+1.6
Future Development on Fill to: 3/			
20-year Level	2.2	3.1	+0.9
100-year Level (existing ordinance)	2.2	2.9	+0.7
500-year Level	2.2	2.7	+0.5
No Future Development in: 3/			
20-year Flood plain	2.2	2.9	+0.5
100-year Flood plain	2.2	2.8	+0.6
500-year Flood plain	2.2	2.8	+0.6
Future residential development on 100-year fill; future commercial/industrial development flood proofed to 100-year level 3/	2.2	3.0	+0.8
Preparedness Planning 4/			

1/ Existing expected annual damages include damages to existing structures in the specific reaches studied only, and do not include agriculture, transportation, commercial or mobile home damages. Specific reaches studied were in Mesa, Tempe, Phoenix, and Phoenix to Buckeye, along the Salt River.
2/ Figures include damages to commercial and mobile home structures.
3/ Under all options, damages will continue to increase in the future as a result of floods that exceed the level of protection provided.
4/ Damages are reduced by preparedness planning, but actual amount has not been quantified.

The existing ordinance in the study area pertains to structures in the 100-year flood plain. The CAWCS investigated three measures relative to the ordinance:

- Application of the existing ordinance in the 20-year and 500-year flood plains, in addition to the 100-year flood plain.
- No development at all in the 20-year, 100-year, and 500-year flood plains.
- Modification of the existing ordinance for raising residential structures and flood proofing commercial and industrial structures.

In the process of gravel mining operation, earth and fill are removed from the riverbed. This can result in erosion or deposits of material in the channel which may divert or block the flow of water and cause greater flood damage. The CAWCS investigated ways to regulate the mining activities to limit the damage it causes, and the feasibility of regulating and compensating the mining entities for enhancement of the channel.

3. Preparedness Planning. Preparedness planning reduces flood damages by providing sufficient warning to individuals to leave the threatened flood plain, elevate belongings above the projected flood levels, or, given sufficient time, evacuate property and install temporary protective measures. The objectives of preparedness planning are realized through installation of flood forecasting equipment, enhancement of the capabilities of existing systems, improvement of techniques for warning and information dissemination, and development of emergency action procedures. Currently a preparedness planning system exists in the study area. The Central Arizona Hydrometeorological Data Management Association (CAHDMA), an association of local, state, and Federal agencies, is already developing an improved early flood threat recognition system for the major drainages of central Arizona.

The CAWCS investigated ways to enhance the existing preparedness plan, including: warning dissemination, emergency response actions, post flood recovery plan, and enhanced public awareness programs which would keep the plan active and the public aware during periods of no flooding.

Critical transportation problems for police, fire, and emergency vehicles occurred in the past several years when the Salt and Gila Rivers inundated or damaged dip crossings and bridges. Construction is underway to build or modify seven bridges on the Salt and Gila, and funds have been appropriated for additional bridges to withstand floods up to 200,000 ft^3/s. Still these bridges are not large enough to withstand floods as large as could occur in the future.

The CAWCS investigated the feasibility of one bridge capable of withstanding the SPF (295,000 ft^3/s). The SPF bridge would be for emergency use only. The existing Mill Avenue Bridge was considered as is or with modifications to determine if it was structurally capable as well as if the approaches would be maintained in the event of the SPF. Alternative locations will also be investigated.

4. Evaluation of Nonstructural Measures. An evaluation of nonstructural measures, as described, indicated that:

a. Existing Structures. Evaluations of nonstructural flood damage reduction measures designed to permanently modify existing structures indicate that nonstructural plans to achieve 100-year and 500-year uniform protection levels are not economically feasible. The most promising measures identified are 2-3 feet high earthern dikes implemented on small scale (around several structures for selected locations) for lower frequency protection levels; 20- to 50-year. Mobile homes located between the 50- and 100-year frequency levels appear to warrant further consideration. Another possible measure appears to be small scale relocation of residents of substandard single family residential structures in conjunction with other Federal agency programs such as those of the Federal Emergency Management Agency. However, most flood plain occupants will have to rely on flood insurance to indemnify losses associated with flood events.

b. Regulation of Future Development. Present flood plain regulations need to be broadened in scope and stringently enforced. Regulations should include flood plain activities involving land use development, land fills and gravel mining operations. Analysis of a projected Maricopa County land use plan for year 2000 indicates future damage to structures and contents will increase about 68 percent over present conditions if regulations are relaxed or not enforced. The analysis indicated an estimate of only a 27 percent increase in future damage even with continued enforcement of present regulations due to probability assessments of damage associated with greater than 100-year events. Based on the analysis, it appears that enforcement of the existing ordinance is the most feasible option for regulation of future development, as it provides a practical and economic balance between protection provided and opportunities for flood plain development. Explicit regulations are needed for land fills and in particular, gravel mining operations to prevent increased induced damage from such activities during future floods. Detailed fluvial hydraulic analyses will be required to formulate precise regulatory policies and to determine the feasibility of gravel mining operations enhancing the conveyance capacity of the river.

c. Preparedness Planning. There is a need for immediate implementation of proposed enhancements to flood preparedness planning arrangements and procedures for flood threat recognition, warning dissemination, emergency response actions, post flood recovery and continuous plan management activities. There is a need for at least one bridge crossing for emergency transportation linking the north and south metropolitan areas during floods greater than a 100-year event, for instance in the order of magnitude of the SPF.

Based on this analysis, the nonstructural measures carried forward for further analysis are:

- Small localized dikes (neighborhood) in the 50-year flood plain.

- Preparedness plan enhancement.
- Enforcement of flood plain regulations.
- SPF bridge.
- Sand and gravel mining regulations.

G. Regulatory Storage Not Located on the Salt or Verde Rivers

Several sites not located on the Salt or Verde Rivers were considered primarily for regulatory storage purposes. These were:

Agua Fria River

- New Waddell Dam and Reservoir.
- Lake Pleasant Storage.

Gila River

- Buttes Dam and Reservoir.
- Florence Dam and Reservoir.

Santa Rosa Wash

- Tat Momolikot Dam.

Engineering and cost data are shown in Table 21.

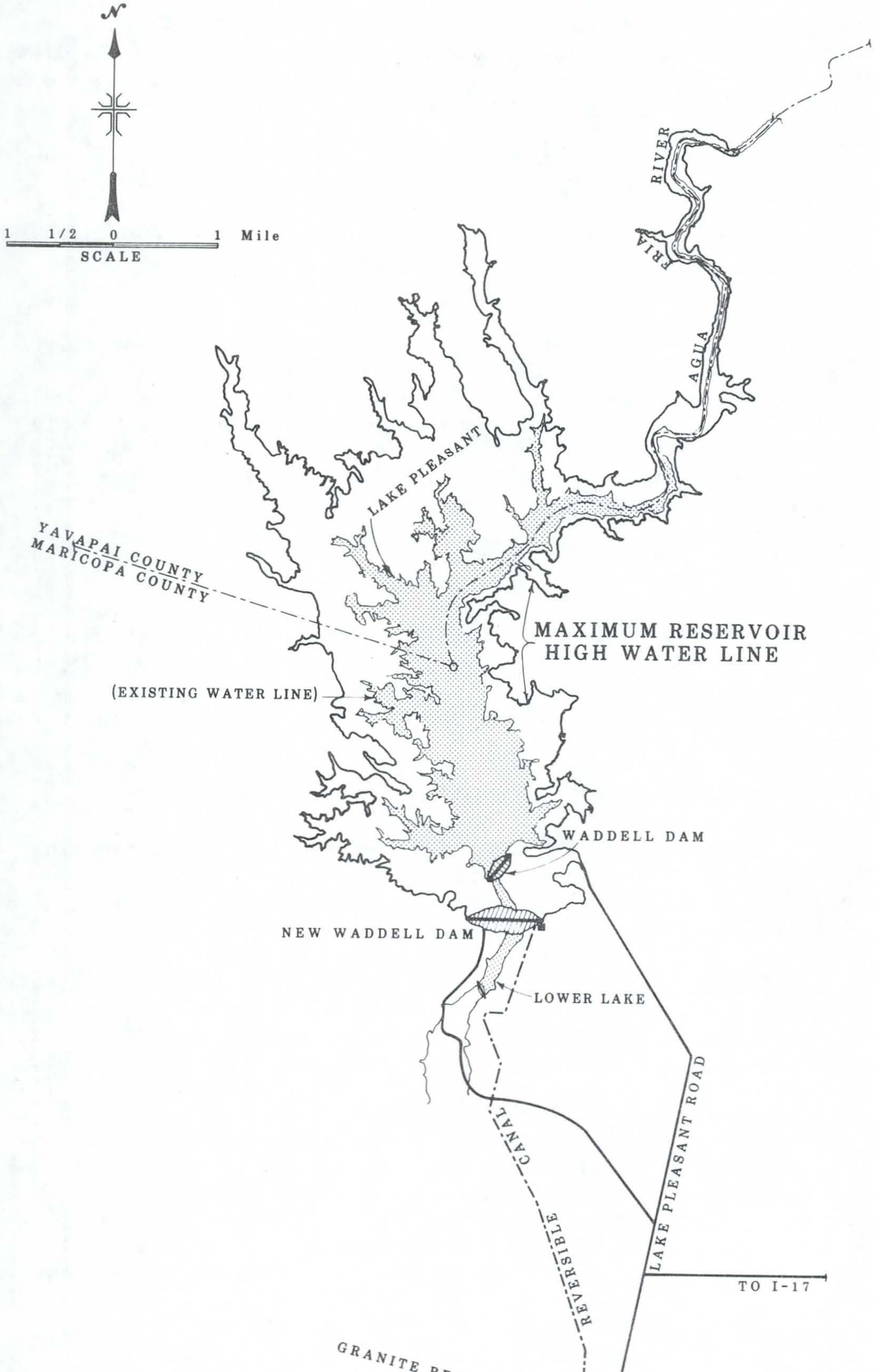
1. New Waddell Dam and Reservoir. New Waddell Dam and Reservoir would be located on the Agua Fria River one-fourth mile downstream of the existing Waddell Dam, as shown in Figure 25. Regulatory storage would be accomplished by direct connection to the CAP aqueduct with CAP water being delivered to and returned from the reservoir through a 4-1/2 mile reversible canal. The additional CAP water from regulatory storage would be available for discharge back into the Granite Reef Aqueduct during periods of peak demand. The element would maintain the existing storage in Lake Pleasant presently utilized by the Maricopa County Municipal Water Conservation District #1.

Although no flood control storage volume would be included, downstream flooding could be reduced if there is available storage in the new regulatory storage pool or existing conservation pool. A hydropower facility, if feasible, would be located at the base of the dam.

a. Geology and Design. A thick series of sedimentary beds form the foundation of the damsite. The left abutment is on alluvial fan and terrace gravels occasionally cemented by caliche. The right abutment would be on volcanic rock and pyroclastic rock. The bulk of the foundation would be variably cemented sand, silt, and gravel. For the most part, conglomerates,

Table 21
OFF-SALT REGULATORY STORAGE ELEMENTS

SITE	STRUCTURE			STORAGE VOLUME (acre-feet)					PERFORMANCE		COST ($millions)			
	Dam Height (feet)	Crest Elevation (feet)	Maximum Surface Area (acres)	Existing	Flood Control	New Water Storage (R/S)	Surcharge	Total	Increase in CAP Yield (ac-ft/year)	Flood Control (% of Water-shed Controlled)	Construction		Total Annual	
											7 3/8	3 1/4	7 3/8	3 1/4
New Waddell	276	1,696	9,500	157,000	-	500,000	92,000	749,000	106,600	-	240.4	219.5	21.2	10.8
Lake Pleasant Storage (raise existing dam 14')	199	1,619	4,729	157,000	-	56,000	45,000	258,000	50,000	-	93.3	88.1	8.5	4.6
Buttes	262	1,857	12,925	-	-	593,000	367,000	960,000	91,000	-	194.0	177.1	19.1	10.8
Florence	166	1,681	10,171	-	-	593,000	82,000	675,000	70,100	-	224.6	205.0	19.2	9.6
Tat Momolikot	84	1,566	20,527	-	126,000	150,000	258,000	534,000	23,800	-	112.3	102.5	10.4	5.5



NEW WADDELL DAM AND RESERVOIR SITE AND LAKE PLEASANT STORAGE

Figure 25

volcanics, limestones, and channel deposits form the boundaries of the reservoir sites. Adequate permeable and semipermeable materials would be available from the channel. The CAP outlets would be capable of discharging flows of 3,880 ft^3/s, and the spillway would have a capacity of 227,000 ft^3/s.

b. Performance. As shown in Table 21, the CAP with this feature would yield an increase of 106,000 acre-feet/year in available water.

c. Dam Safety. The spillway would be constructed to provide additional safety. Currently there are no identified safety issues at the site.

d. Recreation. Conceptual recreation plans developed for this site focus on preserving the native characteristics of the existing park. Three sites were selected for potential development. At a minimum, the existing Maricopa County Parks and Recreation Department facilities, which would be inundated with construction of the new dam, would be relocated. A moderate level of development would include camping, fishing, swimming, hiking, picnicking, and a marina. Estimated costs range from $1.6 million to $8.6 million.

e. Impacts. Significant impacts include:

o Loss of aquatic habitat and associated recreational activities due to draining of Lower Lake Pleasant. However, there would be a gain in lake surface for recreational activities.

o Landownership changes would involve acquisition of State Trust Lands and privately owned land.

o There would be no impact on threatened and endangered species.

2. Lake Pleasant Storage. Two options which make use of storage in Lake Pleasant behind Waddell Dam for regulatory storage of CAP water were examined: use of the existing dam and reservoir, and raising the existing dam 14 feet. Engineering and cost data are shown in Table 21.

a. Existing Dam and Reservoir. With use of the existing dam and reservoir, CAP water would be stored whenever space may be naturally available. CAP regulatory storage would use only that portion of the conservation pool (127,000 acre-feet) not full of Maricopa County Municipal Water Conservation District #1 waters. During years of heavy runoff, Lake Pleasant could be full and no CAP water could be stored. Conversely, if runoff is low, up to 127,000 acre-feet of CAP water could be stored. For use of the existing dam and reservoir, modifications to the structure would be limited to modification of the spillway to meet Service standards, and modification of the outlet works to accommodate CAP water. CAP water would be delivered to and returned from the reservoir through a feeder canal (direct connection) and a pumping plant near the base of the dam would be required to deliver the water to the reservoir.

b. Raised Dam. Very preliminary analysis indicates it may be possible to enlarge the existing structure up to 14 feet. The enlargement would require raising the buttresses and constructing left and right abutment walls. Additionally, the spillway, as well as the bridge structures, would have to be modified. Enlargement of the dam would increase the available reservoir storage by 56,000 acre-feet. A feeder canal similar to that described under Option 1 would be required, and a slightly larger pumping plant would be necessary.

c. Design. With enlargement of the existing dam, the left abutment wall would be approximately 600 feet long, and the right abutment would be 1,500 feet long. Outlets would be capable of discharging flows of 3,880 ft^3/s, and the spillway would have a capacity of 227,000 ft^3/s. Under Option 1, use of the existing storage space, modified outlets would be capable of discharging flows of 3,000 ft^3/s, and the enlarged spillway would have a capacity of 227,000 ft^3/s.

d. Performance. Because of the vacant space constraints with use of the existing dam, the ability to increase CAP yield is minimal under Option 1 (14,500 acre-feet/year). With enlargement of the dam, an increase of 45,600 acre-feet/year in available water would result.

e. Dam Safety. The spillways at the existing dam are undersized for the potential IDF. Therefore, under either option, spillways would have to be reconstructed to ensure safety of the dam.

f. Recreation. Recreation facilities would be as currently exist.

g. Impacts. There are no major environmental or social impacts associated with this element.

3. Buttes and Florence Sites. An authorized feature of the CAP is Buttes Dam and Reservoir to be located on the Gila River (4 miles upstream of Ashurst-Hayden Diversion Dam) to store and regulate the flows of the river for optimum development of the surface water resources. No regulatory storage space would be provided. The dam (without regulatory storage) would be sized as follows:

	Buttes
Dam Height	186 feet
Crest Elevation	1,781 feet
Outlet Capacity	2,400 ft^3/s
Spillway Capacity	231,000 ft^3/s
Total Storage Volume	329,000 acre-feet

The CAWCS investigated three actions relative to the Buttes site, each for the purpose of providing regulatory storage of CAP water in addition to the authorized functions. These were: Buttes Dam and Reservoir with regulatory storage; and Florence Dam and Reservoir, an alternative site 4 miles downstream of Ashurst-Hayden Diversion Dam, for regulatory storage; and Buttes in conjunction with Florence. Preliminary analysis showed, however, that environmental impact and costs increased significantly with construction of two dams on the Gila

River. For this reason, Florence Dam in conjunction with Buttes Dam was eliminated from further consideration.

Engineering and cost data are shown in Table 21.

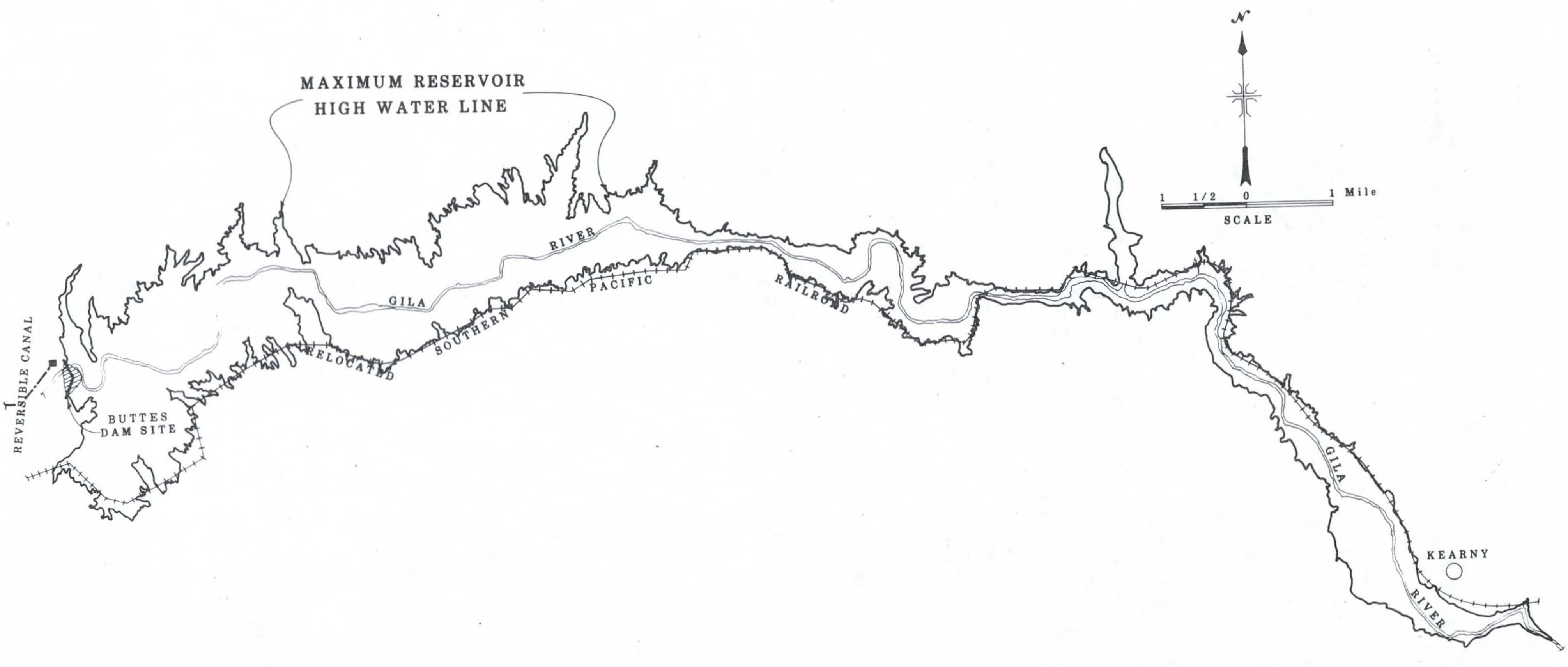
a. Buttes Dam and Reservoir. With Buttes Dam and Reservoir (Figure 26), CAP water would be transported from the Salt-Gila Aqueduct to the Buttes Reservoir site through a regulatory storage feeder canal. The water would then pass through a pumping plant which would deliver the water from the regulatory storage feeder canal into the reservoir. A hydropower facility is planned for the site at this time. A transmission line would connect the pumping plant and the hydropower plant to the CAP power system.

b. Florence Dam and Reservoir. With Florence Dam and Reservoir (Figure 27), it is assumed that Florence Dam would be constructed instead of Buttes Dam and would assume the functions of Buttes. The new dam would be located just upstream of the Gila River Siphon, which is part of the Salt-Gila Aqueduct. CAP water would be delivered to the reservoir by a pumping station near the right abutment of the dam. Water would return to the aqueduct from the reservoir by gravity flow. If feasible, hydroelectric facilities could be installed at the water supply outlets and/or the CAP water supply outlets. A transmission line would connect the pumping plant and the powerplants to the CAP power system.

c. Geology and Design. At the Buttes site, in the reservoir area the Gila River flows westward across a mountainous area comprising north to northwest trending blocks of granite and volcanic rocks. The rock types are in fault contact. An intervening alluvium-filled basin about 2 miles wide occurs about one-half mile upstream from the damsite, and large alluvial fans locally cover the slopes on the south side of the river. The damsite is in a narrow gorge where the river cuts through an erosion resistant mass of volcanic rock. The abutments of the dam are agglomerate, rhyolite, and volcanic glass. The feeder canal would have a capacity of 2,250 ft^3/s, outlets a capacity of 2,400 ft^3/s, and the spillway would have a capacity of 231,000 ft^3/s.

The Florence site is on the broad valley of the Gila River. Alluvial fan deposits of gravel, sand, and silt in various mixtures partly fill the valley. On the right side of the damsite there is a faulted volcanic interflow at a shallow depth. The volcanics diminish out near the left abutment and are covered by approximately 45 feet of alluvial material. In the channel section the volcanics are overlain by up to 60 feet of channel and flood plain deposits. There appears to be a strong possibility of seepage losses from a storage pool through and around the right abutment. Lining, if feasible, may be required. Outlets would be capable of discharging flows of 3,600 ft^3/s, and the spillway would have a capacity of 280,000 ft^3/s.

d. Performance. With Buttes Dam, an increase in available water of 91,000 acre-feet/year would result. With Florence Dam, an increase of 70,100 acre-feet/year would result. Both sites also provide the opportunity for development of local Gila flows, in addition to CAP water.



BUTTES DAM SITE

Figure 26

e. Dam Safety. Neither site would have an effect upon safety of existing dams.

f. Recreation. Although under both actions described, the operation of the reservoir is not conducive to intensive recreation development, adequate facilities for day-use would be provided. The recreation development would typically include boat launching and mooring facilities, a concession area, parking areas, and defined areas for picnicking. Estimated costs are $3.9 million at the Buttes site and $1.9 million at Florence.

g. Impacts. Significant impacts include:

- Good quality riparian habitat would be lost.
- There would be no impact on threatened or endangered species.
- At both sites, a lake would be created, but there would be a loss of flowing stream.
- There would be no significant impact on archaeological and historical sites.
- Relocations would occur at the Buttes site, but these are viewed as beneficial by those to be relocated. No relocations occur at the Florence site.

4. Tat Momolikot Dam. Tat Momolikot Dam is an existing flood control structure located on Santa Rosa Wash on the Papago Indian Reservation, as shown in Figure 28. Since construction of the dam, the reservoir (Lake St. Clair) has not filled and is presently dry.

The CAWCS examined reoperation of the existing dam to provide a reservoir for regulatory storage of CAP water. Reoperation would include: raising the existing 75-foot dam 8 feet to maintain present flood control effectiveness, construction of a feeder canal to connect the CAP Tucson Aqueduct to the reservoir, and modification of the spillway and outlet works. Engineering and cost data are shown in Table 21.

CAP water stored behind the dam would not be returned to the aqueduct from storage but would flow by gravity directly from the reservoir to downstream users in fulfillment of their CAP allotment. Service outlets would be enlarged to equal the size of the feeder canal, and modifications would be made to the ungated spillway and outlet works to enable full capacity use of the dam for storage. A hydroelectric plant, if included, would be located at the base of the dam and would be connected to the CAP power system.

a. Geology and Design. The dam is located where a gentle alluvial slope crowds Santa Rosa Wash against foothills of the Tat Momoli Mountains. The foundation of the right abutment would be a hard, gray, almost massive schist bedrock. The embankment across the valley and on the left abutment would be founded on alluvial fan deposits. The reservoir occupies the east

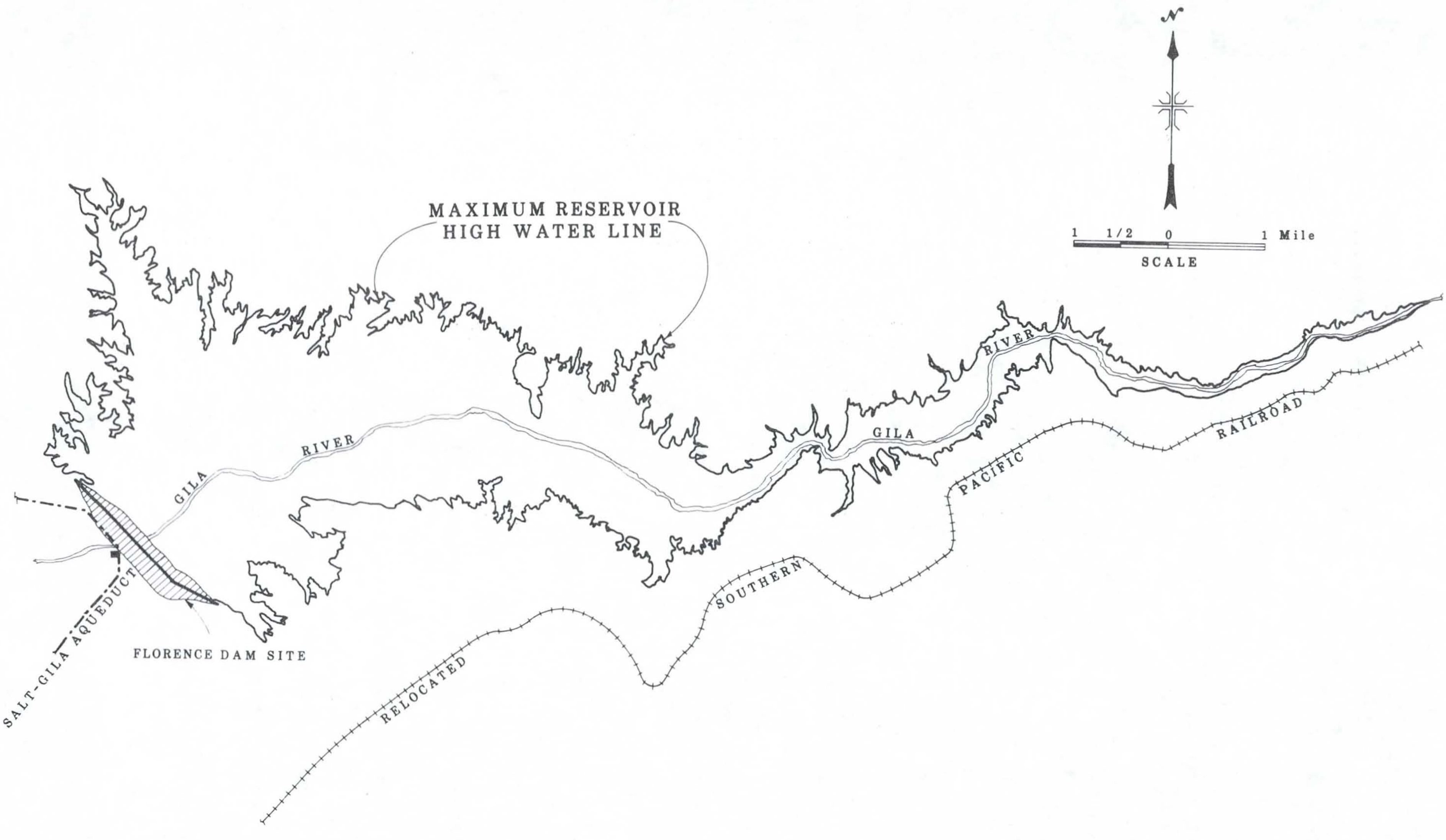


Figure 27

FLORENCE DAM SITE

side (roughly one-third) of a 10-mile-wide alluvial basin, the Santa Rosa Valley. On the east side of the site, the alluvial fill is either thin or absent. The adverse hydrogeologic conditions at the site may result in excessive water losses in the form of both a large amount of dead bank storage and seepage losses (chiefly through gravel and limestone aquifers under and around the dam to the north).

b. Performance. With this feature, an increase of 23,800 acre-feet/year in available water would result. No opportunity for development of local flows would be provided.

c. Dam Safety. The existing structure is safe as constructed, and modification for regulatory storage would not affect dam safety.

d. Recreation. Conceptual recreation plans, developed in coordination with the Papago Indians, include self-sustaining, revenue-producing activities at three potential sites. Development would typically include boat launching facilities, picnic areas, parking areas, and water and sanitary facilities. Estimated costs range from $618,000 to $2.7 million.

e. Impacts. Environmental and social impacts include:

- Primarily desert vegetation would be lost; there would be a gain in surface acres of aquatic habitat with an assured minimum pool for lake fishery.

- Potential institutional problems exist relative to ownership of the water. Agreements with the Papago Indian Reservation would be required, and contacts with the tribe indicate they may not be favorable to use of the site.

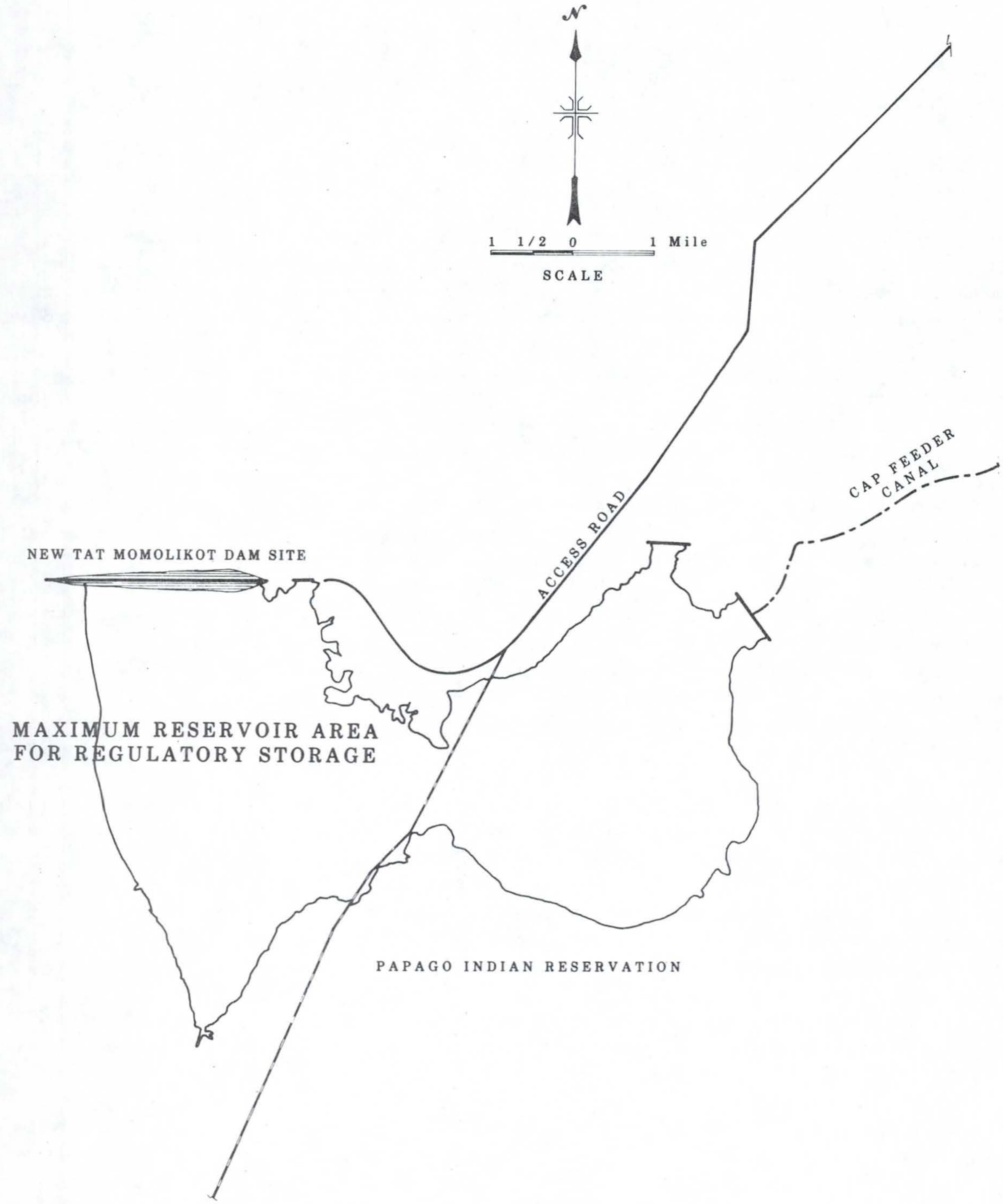
- There would be increased recreational potential.

- Some relocations of permanent residents of the Papago village of Jackrabbit would be necessary.

5. Evaluation and Selection of Preferred Regulatory Storage Element Not Located on the Salt or Verde Rivers. As the non-Salt/Verde regulatory storage elements were competing, CAWCS staff evaluated them to select the preferred element for system building.

The evaluation showed that in terms of all engineering, economic, environmental, and social factors considered, sites on the Agua Fria were preferred. Tat Momolikot could not perform well enough as a regulatory storage element to justify further study, in spite of relatively low environmental impact. While Buttes and Florence could serve well for regulatory storage, high costs were required and significant environmental impacts would result.

A comparison then of New Waddell Dam or Lake Pleasant Storage indicated that New Waddell Dam and Reservoir provided greater water efficiency. While Lake Pleasant Storage was less costly and resulted in less environmental



TAT MOMOLIKOT DAM SITE

Figure 28

impact, it was limited in its capability to develop water supply because of reservoir capacity constraints inherent in modification of an existing structure. New Waddell was also preferred in terms of geology as well as in its potential to provide other benefits (flood control, recreation).

Therefore, on the basis of providing the project purposes, New Waddell Dam and Reservoir was selected as the preferred regulatory storage element not located on the Salt or Verde River to be carried forward to system building.

H. Underground Storage

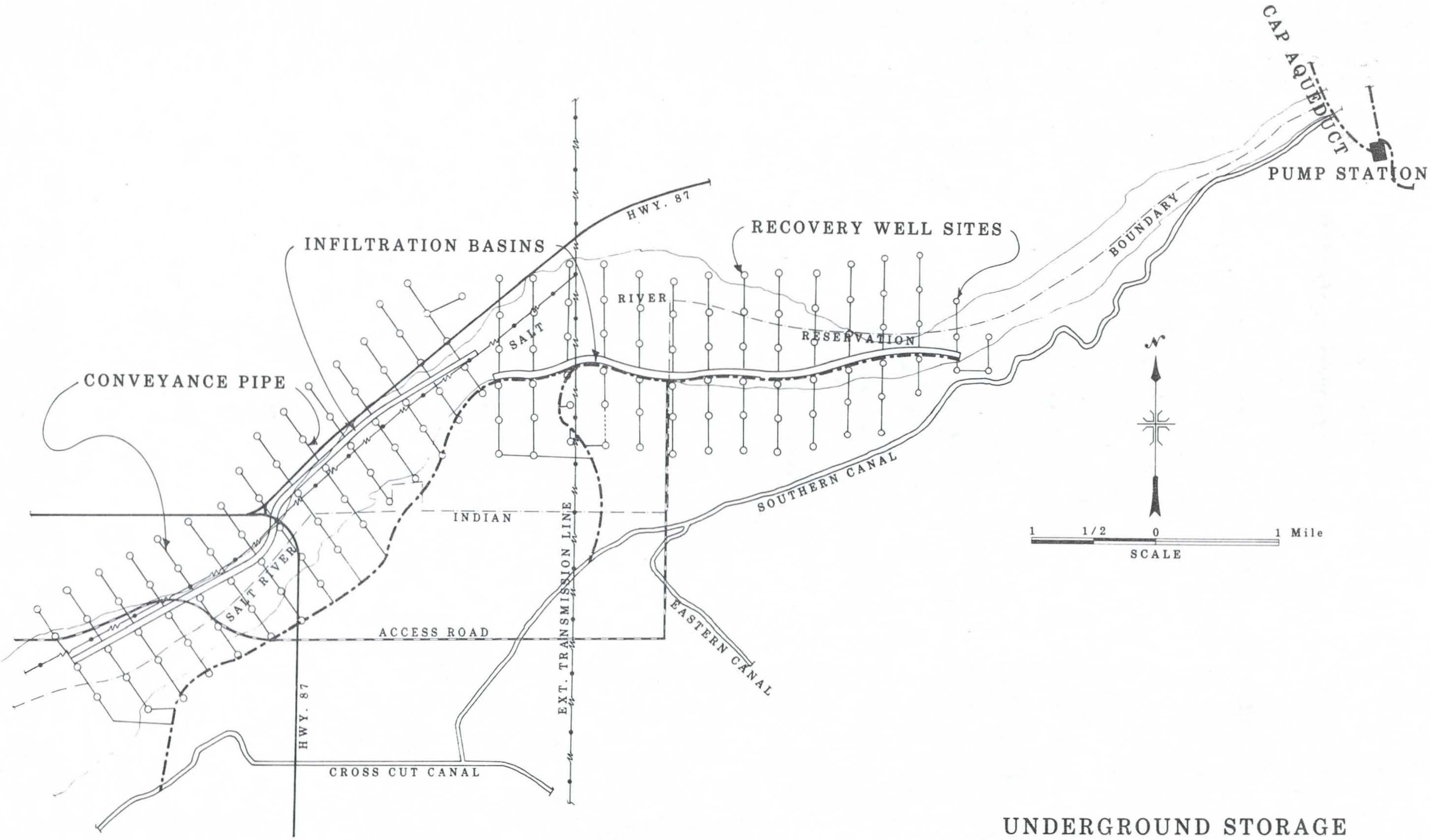
Underground storage was investigated for purposes of providing regulatory storage of CAP water. It is also possible that water from upstream storage facilities could be delivered to the infiltration basins and stored underground in place of CAP water. This could provide additional storage space in the SRP conservation reservoirs which could be utilized to reduce flood volumes.

The underground storage system would straddle the Salt River channel between 4 and 12 miles downstream of the Granite Reef Diversion Dam, as shown in Figure 29. Recharge would be accomplished by two infiltration basins. Ground water would be recovered by means of pumping to a pipe network and canal to deliver the water to existing SRP canals. CAP water would be pumped out of the Salt-Gila Aqueduct through a discharge line and released into the Salt River channel above Granite Reef Diversion Dam during periods when the demand is low. Some of this water would be diverted through the east infiltration basin. Water not picked up in the east basin will remain in the channel to be picked up downstream in the west basin. Operation of the element would depend on the availability of source water (CAP or SRP) and the characteristics of the ground water system under the river at the selected location. Normal operation would see water infiltrated during the fall and winter months and pumped during the late spring and summer. Engineering and cost data are shown in Table 22.

1. Geology and Design. The Salt River below the Granite Reef Diversion Dam flows across the margin of a very deep basin valley. The basin, called the East Basin, is part of the designated Salt River Valley Groundwater Basin.

It is typical of most other basins in central Arizona and of the Basin and Range Physiographic Province in general. The basins are alluvial-filled, discontinuously bounded by basement rocks which rise abruptly as precipitous mountains above the valley surface. In the East Basin, the depth to ground water along the river downstream of Granite Reef Dam is well over 300 feet. Infiltration rates in the Basin could range from 2 to 3 feet/day after initial wetting and drop to about 1 to 2 feet/day after about 30 days.

Each basin will vary in depth between 2 and 5 feet with automatic monitoring devices to control the flow and measure the quantities of water being infiltrated. The basins are designed to provide sufficient retention time to allow 250,000 acre-feet of water to be infiltrated over a 6-month period. Once the water has been infiltrated, it would be pumped out of the ground,



UNDERGROUND STORAGE

Figure 29

Table 22

UNDERGROUND STORAGE

Infiltration Basins	
East Basin	
Length (ft)	20,000
Width (ft)	315
West Basin	
Length (ft)	21,766
Width (ft)	280
Wells	
Total Number	157
Capacity of each (gal/min)	3,000
Pump and Discharge Line	
Capacity at Granite Reef (ft^3/s)	2,000
Canals	
Length of 500 ft^3/s Canals (ft)	21,000
Length of 250 ft^3/s Canals (ft)	53,400
Performance	
Increase in CAP yield (ac-ft)	63,000
Flood Control (% of Watershed Controlled)	N/A
Cost ($Millions)	
Construction	
7-3/8%	112.4
3-1/4%	106.1
Total Annual	
7-3/8%	11.0
3-1/4%	6.3

through a collector pipe system, and into an open gravity flow concrete-lined canal which would transport 500 ft^3/s to the Tempe Canal and 550 ft^3/s to the Consolidated Canal. This peak season supply would then be resupplied to the CAP through an exchange with the SRP at the Granite Reef Diversion Dam. Design assumptions include recovery of the same quantity of water that was infiltrated. All facilities would be designed to survive the 100-year flood.

2. Performance. With this feature, an increased CAP yield of 63,000 acre-feet/year would result. This additional water would be used by SRP to fulfill or partially fulfill their CAP allotment or could be delivered to other allocations in the SRP service area.

3. Impacts. While there are no significant environmental or social impacts associated with underground storage, the extreme complexity of the ground water systems creates institutional constraints (impacts on local ground water, authority, and management of the system). A demonstration underground storage project would be required to be completed prior to final design. Other institutional problems are associated with the fact that much of the site is on the Salt River Indian Reservation, which is not obligated to operate within local ground water regulations.

I. Water Exchange

Regulatory storage could be achieved through water exchange between the CAP and the Salt River Project (SRP) system, as shown in Figure 30. Several options were investigated. For display purposes, two options--no increase in reservoir capacity, and with increased reservoir capacity--are shown. In order to maximize the amount of Colorado River water diverted by CAP to be used in Arizona, it would be necessary to import Colorado River water during the late fall, winter, and early spring months in excess of the demands in the CAP service area. The excess water would be used to meet some or all of SRP's water demand during this period normally met by releases mainly from the Verde River. In order for exchanges to take place, it would be necessary for the SRP system to have vacant storage space available and for SRP to have releases within its own service area at the time the CAP has excess water. SRP would have to agree to hold planned releases in storage as CAP water and accept CAP water from the CAP aqueduct to fulfill its demand requirements. SRP would then be required to release, in the spring and summer, the water stored as CAP water. The water would be delivered either to SRP, to fulfill or partially fulfill its CAP allotment, or the water would be released to other CAP customers.

The amount of water that can be exchanged depends on: the amount of excess water available in the Colorado River, the amount of releases SRP has during the period exchanges would take place, and the amount of vacant storage space available in the system that could be used to store water for exchange purposes. The lesser of these amounts controls the amount of water that could be exchanged. Exchanges would generally take place from November to April. CAP water would then be recalled during the period from May to December. Engineering and cost data are shown in Table 23.

Table 23

SRP WATER EXCHANGE

	A		B	
Reservoirs (acre-feet)				
Increase in Cliff	-		100,000	
Increase in Roosevelt	-		150,000	
Water Supply				
Total Inflow	87,600		128,700	
Total Releases	63,900		109,200	
Increased Losses	2,100		10,200	
Exchange Spills	21,600		6,200	
Increased CAP Delivery	14,500		55,500	
Costs ($Millions)	7-3/8%	3-1/4%	7-3/8%	3-1/4%
Construction Cost	12.0	12.0	235.6	235.6
Total Annual Cost	2.2	1.7	22.8	10.9

1. Performance. With this feature, an increase of up to 55,500 acre-feet/year in available water would result.

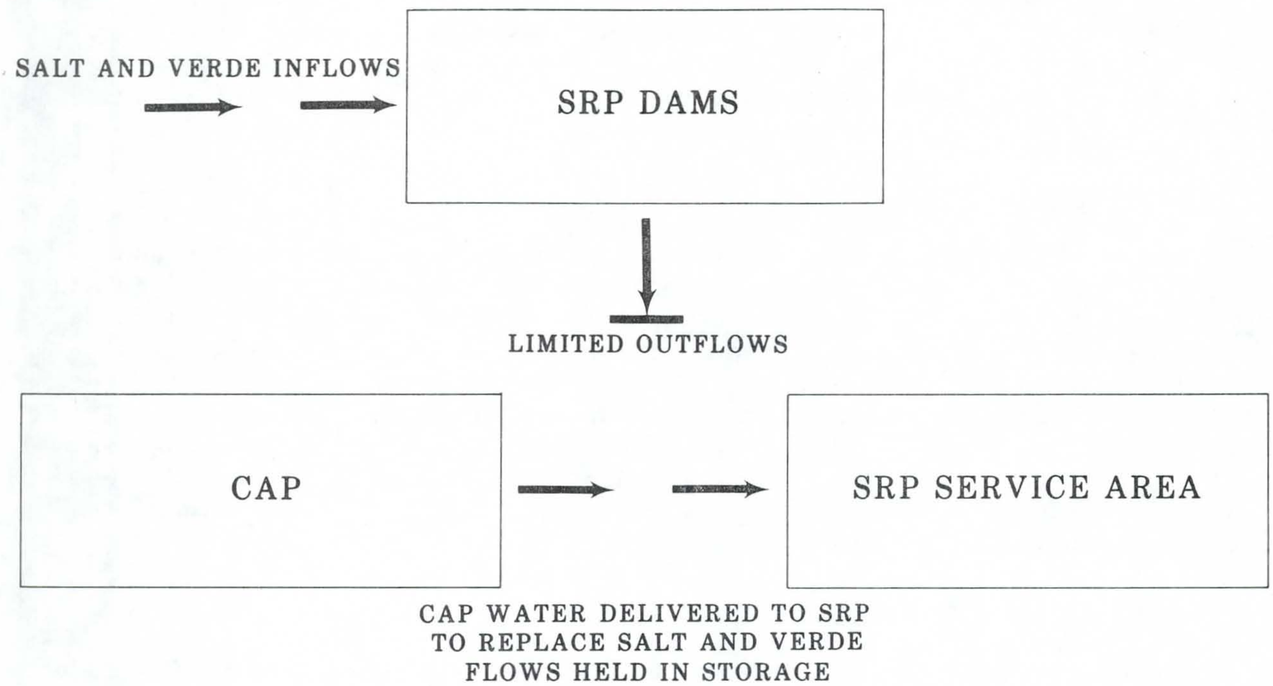
2. Dam Safety. Dedication of space in the SRP system for the IDF may limit exchange possibilities due to the limits placed on the amount of water that can be kept in storage.

3. Impacts. While there are no significant environmental or social impacts associated with water exchange, there are institutional and other constraints which may limit its feasibility.

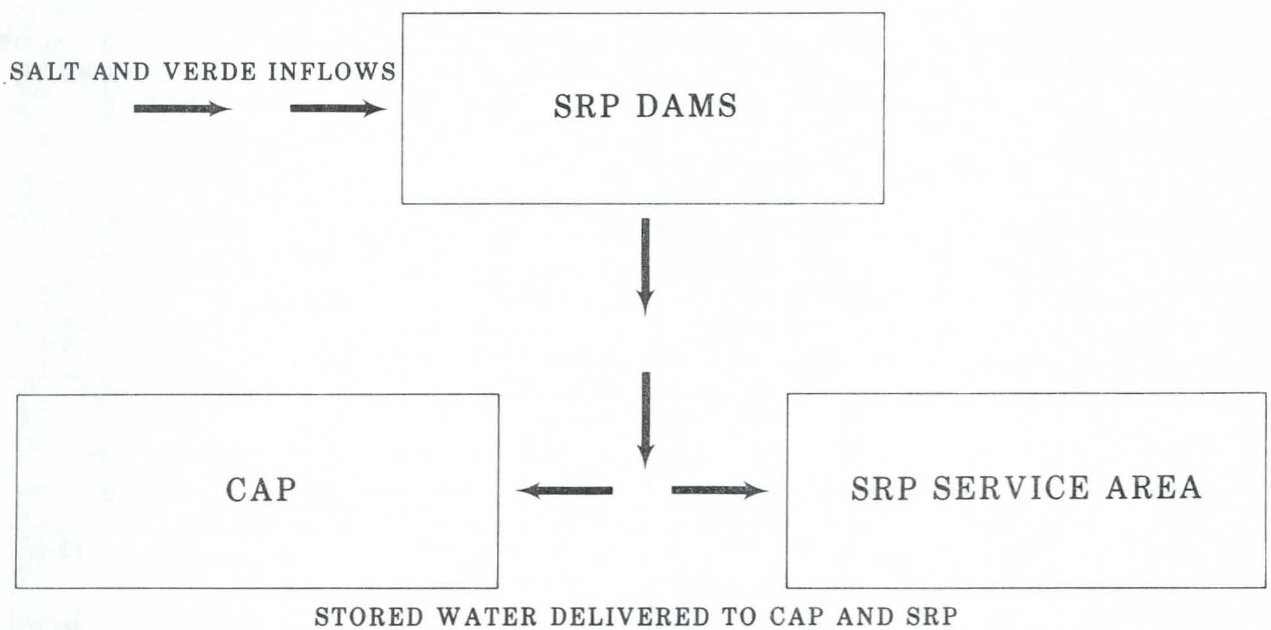
- o Exchanges could take place only during a range of space availability in the SRP reservoirs. The upper limit of exchange would be when there is a high probability of spills from the SRP system. Any spills would be credited against the stored CAP water first.

- o Hydropower potential during the winter months would be reduced due to the decreased releases from the dams. During the summer months when increased flows would occur, the hydropower potential would be limited by the size of the existing plants.

WINTER



SUMMER



SRP WATER EXCHANGE

Figure 30

- There would be a significant impact on flowing water recreation above Granite Reef Diversion Dam. During the winter there would be little, if any, water flowing in the rivers. In the summer, increased releases to meet SRP and CAP demands would result in increased riverflows which could pose safety problems for recreationists.

J. No Action

The no-action alternative is a description of the future conditions without a project. Both the Council on Environmental Quality guidelines and Principles and Standards suggest the description of no action in plan formulation reports. The primary purpose of considering no action is that it provides a basis for comparing the effectiveness of other actions. In the CAWCS area, there are a number of important considerations relating to CAP storage and flood control which will occur even if none of the actions are implemented. Some of these factors are described below; a thorough description of the conditions without a project is provided in "Future Without the Project," Working Paper, December 1980.

1. Without Regulatory Storage

- The CAP aqueduct system would be constructed and would deliver Colorado River water to the Phoenix area by 1985, and the Tucson area by 1988. The aqueducts would operate essentially as a demand system. Studies indicate that an average annual water supply of 1,030,000 acre-feet would be delivered without regulatory storage. This number could be increased to about 1,040,000 acre-feet if CAP operations plans were refined to include water supply and demand forecasting and scheduling.

- Buttes Dam and Reservoir would be constructed as authorized by Public Law 90-537. This feature would conserve surplus Gila River flows and would contribute about 50,000 acre-feet average annually to the CAP water supply. No physical connection between Buttes and the CAP aqueduct would be included, and therefore no aqueduct water can be placed into Buttes, and no Gila River water can enter the aqueduct. Buttes Reservoir operations would be coordinated with CAP aqueduct operations and increased consumptive use in New Mexico through water exchanges with the San Carlos Project.

2. Without Flood Control

- The state, county, and city governments will construct a number of new bridges which will stand up better to floodflows. While several of the bridges will withstand flows of up to 200,000 ft^3/s, none would be large enough to remain open if large floods such as the Standard Project Flood were to occur. The effect of the new bridges will be to eliminate much of the traffic disruption which now results during floods.

- The City of Phoenix will construct an interim 100-year channel in the Salt River near Sky Harbor Airport. The channel will prevent most of the damages to the runways which have occurred in the past. The city insists, however, that the channel will have a limited life and is therefore only an interim protection plan.

- o The Flood Control District of Maricopa County will undertake and complete a channel clearing project, primarily on the Gila River, between 91st Avenue and Gillespie Dam. The clearing project will ultimately be 1,000-feet-wide and will be regularly maintained to keep it free from reinfestation by salt cedar. The effectiveness of the project on damage reduction is not known.

K. Summary

Following is a summary of the elements described in this chapter, their purpose, and the results of Stage II element analysis:

	Purpose		Further Study	
Element	Flood Control	Regulatory Storage	Warranted	Unwarranted
VERDE RIVER				
Horseshoe Dam	o	o		o
Cliff Dam	o	o	o	
New Bartlett Dam	o	o		o
SALT RIVER				
New/Enlarged Roosevelt Dam	o	o	o	
New Stewart Mountain Dam	o	o	o	
CONFLUENCE				
Confluence Dam	o	o	o	
Granite Reef Dam	o	o		o
SRP REREGULATION	o		o	
CHANNELIZATION				
Channels	o			o
Levees	o		o	
Phoenix Greenbelt	o			o
NONSTRUCTURAL MEASURES	o		o	
OFF-SALT REGULATORY STORAGE				
New Waddell Dam		o	o	
Lake Pleasant Storage		o		o
Buttes Dam		o		o
Tat Momolikot Dam		o		o
UNDERGROUND STORAGE		o	o	
WATER EXCHANGE		o	o	
NO ACTION			o	

CHAPTER VII

DESCRIPTION AND EVALUATION OF SYSTEMS

Based on the evaluation of elements, as described in the previous chapter, the remaining elements were combined into systems to optimize the ability to provide both flood control and regulatory storage. This chapter describes the system building process and provides a description and evaluation of the systems. The results of the evaluation (recommendations for Stage III study) are presented in the next chapter.

A. System Building

The purpose of system building is to take advantage of the interaction effect of combining elements to obtain the best solution to flood control and water supply problems. It is important to note that while systems are combinations of elements, they are not cumulative in performance. Rather, in combination the elements interact for optimum flood control and regulatory storage.

Theoretically, with the number of elements still remaining, thousands of systems could be formulated. Since it would be neither practical nor particularly useful to analyze all possible systems, the approach taken in the CAWCS was to first define generic types of solutions (concepts) and then build systems which fit these concepts. The concepts focused on different types of flood control in combination with compatible regulatory storage. The concepts are:

- Salt OR Verde Control: Upstream control of either the Salt or the Verde River, but not both, with compatible regulatory storage.

- Salt AND Verde Control: Upstream control of both the Salt and the Verde Rivers, with compatible regulatory storage.

- Downstream: Downstream flood protection (no upstream control) and regulatory storage not located on the Salt or Verde Rivers.

- Upstream/Downstream: Combination of upstream flood control on the Salt or Verde Rivers and downstream flood protection through Phoenix, plus compatible regulatory storage elements.

- Limited Structural: Use of existing structures (with little or no new construction) for flood control and regulatory storage.

- Nonstructural: Measures that would reduce flood damage without controlling the flow of the river and regulatory storage elements that would require no new construction.

While "no action" is still a possible course for the CAWCS, it is not included as a concept because it does not solve the problems of flood control and regulatory storage. Rather, it is used as a basis of comparison.

Several factors were considered in developing and evaluating systems:

1. Flood Control and Regulatory Storage Performance. This factor relates to the levels of flood protection provided by a system (measured as the flow at the confluence of the Salt and Verde Rivers) and the increase in CAP yield provided by regulatory storage. Not all systems provide the same level of flood protection or increased CAP yield. For purposes of system building, a range of sizes was developed for each element as part of a system. Cost estimates were prepared and the level of protection, increase in CAP yield and dollar benefits provided by each size within a particular system were analyzed. The most cost-effective size was selected for system building.

Dams within the systems were designed to reduce the SPF (295,000 ft^3/s) to levels of 50,000 ft^3/s, 150,000 ft^3/s or 200,000 ft^3/s. Under current conditions, a flow of 100,000 ft^3/s is substantially contained in the existing channel through the Phoenix area and, therefore, would produce minimum impact except on dip crossings and riverbed quarry operations. Flows of 150,000 ft^3/s and 200,000 ft^3/s (comparable or slightly higher than recent floods in the area) would have greater impact, some of which would be significantly reduced by construction of larger bridges capable of withstanding these flows. Levees, which do not reduce the flow of water, must be designed to contain the SPF to prevent overtopping and reduce the risk of catastrophic failure.

Depending on the location and economics of sites, systems can accomplish regulatory storage by direct connection to the CAP aqueduct or through water exchange. With direct connection a canal would be constructed from the main aqueduct to the reservoir. Under exchange, Colorado River water would be imported during the late fall, winter, and early spring months in excess of CAP service area demands. The excess water would be used to meet some or all of SRP demands during this period. Generally, direct connection has the advantage of yielding more CAP water than exchange. However, exchange is less costly since no connecting canal is required. Some of the systems developed include regulatory storage by exchange, others by direct connection. It is important to note, however, that either method could be used in any of the Salt/Verde systems.

Further analysis of element sizing will be conducted in Stage III. The sizes shown in the system descriptions which follow should be considered preliminary.

2. Dam Safety. As discussed in previous chapters, dam safety problems are found at existing dams due to higher inflow design flood (IDF) flows, which could affect the feasibility of certain CAWCS actions. The degree to which a system contributes to solving the problems on the Salt and/or Verde Rivers differs from system to system. Generally, the further upstream the structure, the more it can contribute to solving safety problems at downstream dams.

Results and recommendations of the Safety of Dams Study (being conducted by the Service) will be available in early 1981. For purposes of system building and evaluation, the possibility of safety of dams solutions has been taken into account. Costs to meet dam safety requirements have been included in system costs. Adaptation to systems, if required, based on dam safety solutions will be made in Stage III.

3. Economics. Preliminary estimates of system cost, flood control and water supply benefits, and dam safety costs foregone were developed in Stage II. Energy management and hydropower benefits, as well as recreation and fish and wildlife benefits will be developed in Stage III. In Stage II, economic information was used in two ways. First, in analyzing competing elements, only the most cost effective in terms of the two major purposes were retained for more detailed study as part of Stage II systems. Second, elements were eliminated if it appeared other benefits were not available or that when quantified would make little difference in the ultimate economic justification.

4. Environmental and Social Impacts. All of the systems developed have varying degrees of environmental and social impacts. Evaluation of environmental impacts of systems focuses on biological resources, water quality, recreation, and archaeological and historical resources. While numerous other factors were considered in Stage II, these were considered to be the most critical in system building and evaluation. Critical social factors considered were relocations, recreation amenities gained or lost, lifestyle satisfaction and community viability effects.

5. Institutional Constraints. Legal and institutional constraints are associated with each system. In some systems, these could be major barriers to project implementation. The analysis focuses on project authorization, impacts on existing institutional arrangements and those to be negotiated, existing legal doctrines, and anticipated negotiations. For Stage II, it was assumed that all institutional constraints would be resolved.

B. Description and Evaluation of Systems

The CAWCS has two equal national objectives: National Economic Development (NED) and Environmental Quality (EQ). Due to the nature of the system building process, some of systems developed emphasize particular factors, such as a high level of flood protection or maximum net NED benefits; others may emphasize environmental quality. While the difference often is not clearcut, generally systems which provide a high degree of flood damage reduction and a significant amount of CAP regulatory storage stress NED. EQ systems emphasize management, conservation, preservation, creation or improvement of natural or cultural resources. Some entire concepts, such as limited structural and nonstructural, by their nature have a strong EQ emphasis, while other structural concepts have an NED emphasis. At this point in plan formulation, no attempt was made to deliberately develop NED and EQ systems; specific plans as required will be developed in Stage III.

Thirteen systems were developed under the various concepts. Following is a description and evaluation of each system, organized by concept. Detailed comparative engineering, cost and impact data are displayed in tabular form for each concept and systems within it. It is important to note that the systems developed at this stage are not final, but rather are representations of possible solutions. Elements will continue to be analyzed in more detail during Stage III and have the potential to be recombined for final plans.

1. Concept 1: Salt OR Verde Control. Under this concept, one structure provides both flood control and regulatory storage on either the Salt or Verde River, but not both. The difference between this concept and others is that construction would be limited to only one site, and the flood control and water supply problems could be solved with a minimum number of new dams and reservoirs. However, because only one river is controlled, the systems are limited in the ability to reduce the flow downstream. Three elements, which are systems in themselves, fit this concept. Comparative data on the systems are shown in Tables 24 through 27.

a. System 1A--Cliff Dam. This structure would control floodflows emanating from the Verde River only and reduce the standard project flood (SPF; 295,000 ft^3/s) to 150,000 ft^3/s below the confluence. The Salt River remains uncontrolled. An additional amount of water conservation space would be provided for CAP regulatory storage. Regulatory storage would be accomplished by means of water exchange with SRP as the long distance from the site to the CAP aqueduct precludes direct connection. Operation would be as presented under the description of elements in the previous chapter. Cliff Dam could also be designed to solve the general dam safety problem on the Verde caused by higher inflow design floodflows, because it is located upstream of Bartlett Dam and would replace Horseshoe Dam. It could solve no dam safety problems on the Salt River.

b. System 1B--Enlarged Roosevelt. This system would control floodflows on the Salt River only and reduce the SPF to 200,000 ft^3/s below the confluence. (The alternative exists for construction of a New Roosevelt Dam downstream of the existing dam should raising the dam prove infeasible due to dam safety problems.) Regulatory storage is provided by direct connection. CAP water would be put directly into Saguaro Lake behind Stewart Mountain Dam and pumped back up the SRP system. An enlarged Roosevelt Dam could contribute to solving the general dam safety problems on the Salt River as it is upstream of existing dams. No dam safety problems would be solved on the Verde River.

c. System 1C--New Stewart Mountain Dam. This system is similar to 1B in providing flood control and regulatory storage by direct connection to the CAP aqueduct. As with Roosevelt, flood control for only the Salt River would mean that Verde River flows would remain uncontrolled. However, because of its location downstream of three structures on the river, only the specific safety problems at the existing dam would be eliminated by replacement of the structure. Operation of the system would be as described in Chapter VI.

d. Salt OR Verde System Evaluation. In terms of performance, of the three systems within this concept, Cliff Dam has the advantages of least cost, a higher level of flood protection (150,000 ft^3/s) and a significant contribution to solving dam safety problems. However, it provides the least in terms of increased CAP yield (46,000 acre-feet/year) by exchange with SRP.

Table 24-1

CONCEPT 1 - SALT OR VERDE CONTROL
SYSTEM 1A - ENGINEERING AND COST DATA

	Cliff With Exchange			
Storage Volume	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)
Streambed	1,810	0	0	0
Replacement	1,952	144,000	144,000	2,912
CAP Storage	1,991	150,000	294,000	4,816
Flood Control	2,043	315,000	609,000	7,332
Surcharge	2,085	360,000	969,000	9,849
Crest	2,090			

Costs ($ millions)		7-3/8%	3-1/4%
Construction Cost			
Structure		110.9	110.9
CAP Facility		16.4	16.4
Flood Outlets		87.0	87.0
Interest During Construction	(5 years)	39.5	17.4
Total		253.8	231.7
Annual Costs			
Annual Equivalent		18.7	7.9
OM&R		0.5	0.5
Pumping Energy		0.3	0.3
Energy Sales Foregone		1.2	1.2
Total		20.7	9.9

Total System Costs & Benefits ($ millions)	7-3/8%	3-1/4%
Construction Cost	253.8	231.7
Annual Cost	20.1	9.9
Benefits		
Water Supply	1.6	1.6
Flood Control	5.4	5.4
Total	7.0	7.0

Performance	
SPF Flood Release through Phx (ft^3/s)	150,000
Increased CAP Yield (ac-ft/yr)	46,000
Dam Safety	
Problems Solved	The Verde River Dams.
Problems Not Solved	The Salt River Dams.

Table 24-2

CONCEPT 1 - SALT OR VERDE CONTROL
SYSTEM 1A - ENGINEERING AND COST DATA

	MODIFIED ROOSEVELT WITH DIRECT CONNECTION			
Storage Volume	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)
Streambed	1,902	0	0	0
Replacement	2,136	1,381,000	1,381,000	18,890
CAP Storage	2,153	372,000	1,753,000	21,962
Flood Control	2,163	230,000	1,983,000	23,719
Surcharge	2,192	756,000	2,739,000	28,474
Crest	2,196			

Costs ($ millions)		7-3/8%	3-1/4%
Construction Cost			
Structure		95.5	95.5
CAP Facility		309.9	309.9
Flood Outlets		96.2	96.2
Interest During Construction	(3 years)	55.5	24.5
Total		557.1	526.1
Annual Costs			
Annual Equivalent		41.1	17.8
OM&R		1.0	1.0
Pumping Energy		1.6	1.6
Energy Sales Foregone		1.7	1.7
Total		45.4	22.1

Total System Costs & Benefits ($ millions)	7-3/8%	3-1/4%
Construction Cost	557.1	526.1
Annual Cost	45.4	22.1
Benefits		
Water Supply	4.1	4.1
Flood Control	3.0	3.0
Total	7.1	7.1

Performance	
SPF Flood Release through Phx (ft^3/s)	200,000
Increased CAP Yield (ac-ft/yr)	121,000
Dam Safety	
Problems Solved	The Salt River Dams except Stewart Mt. Dam.
Problems Not Solved	The Verde River Dams and Stewart Mt. Dam.

Table 24-3

CONCEPT 1 - SALT OR VERDE CONTROL
SYSTEM 1C - ENGINEERING AND COST DATA

Storage Volume	New Stewart Mountain With Direct Connection: Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)
Streambed	1,410	0	0	0
Replacement	1,563	128,000	128,000	2,063
CAP Storage	1,620	160,000	288,000	3,580
Flood Control	1,672	230,000	518,000	5,274
Surcharge	1,694	124,000	642,000	6,110
Crest	1,699			

Costs ($ millions)	7-3/8%	3-1/4%
Construction Cost		
Structure	161.8	161.8
CAP Facility	259.4	259.4
Flood Outlets	135.6	135.6
Interest During Construction (5 years)	102.7	45.2
Total	659.5	602.0
Annual Costs		
Annual Equivalent	48.7	20.4
OM&R	1.3	1.3
Pumping Energy	0.7	0.7
Energy Sales Foregone	0.7	0.7
Total	51.4	23.1

Total System Costs & Benefits ($ millions)	7-3/8%	3-1/4%
Construction Cost	659.5	602.0
Annual Cost	51.4	23.1
Benefits		
Water Supply	2.8	2.8
Flood Control	3.0	3.0
Total	5.8	5.8

Performance	
SPF Flood Release through Phx (ft^3/s)	200,000
Increased CAP Yield (ac-ft/yr)	82,000
Dam Safety	
Problems Solved	Stewart Mountain Dam.
Problems Not Solved	The Verde River and the Salt River Dams except Stewart Mountain Dam.

Table 25

CONCEPT 1 - SALT OR VERDE CONTROL
ENVIRONMENTAL IMPACTS 1/

System	Biology	Water Quality	Recreation	Archaeological Resources	Historical Resources
1A-Cliff (with Water Exchange)	960 acres riparian habitat inundated; 5,450 total acres of habitat inundated; loss of 10 miles of perennial stream with altered flow in 37 additional miles; loss of 220 acres preferred habitat, 1 bald eagle nest site and possibly adverse effect on 3 breeding sites. HIGHLY ADVERSE2/	Average TDS concentrations decrease 68 mg/L in CAP water, increase 84 mg/L in local surface water.	Exchange affects Verde flows and may inhibit tubing; 364,000 annual recreation days added; 10 stream-miles lost; 4,200 acres of surface water added.	44 sites affected by construction, 278 by inundation; 359 indirectly: total of 681 sites. Sites are important but not unique.	5 sites would be affected, none of which are "problem sites."
1B-Modified Roosevelt	1,400 acres riparian habitat inundated; 7,950 total acres of habitat inundated; loss of 4 miles of perennial stream; loss of 130 acres preferred habitat.	Average TDS concentrations decrease 43 mg/L in CAP water, increase 85 mg/L in SRP System.	613,000 annual recreation days added; 4 stream-miles lost in area being studied for designation in Wild and Scenic River System; 6,500 acres of surface water added.	17 sites affected by construction, 219 by inundation; 1,076 indirectly: total of 1,312 sites. Roosevelt sites are unique. Highly Adverse	25 sites would be affected. Problem site is Roosevelt Dam, a National Historic Landmark. Highly Adverse
1C-New Stewart Mountain	670 acres riparian habitat inundated; 4,870 total acres of habitat inundated.	Average TDS concentrations decrease 44 mg/L in CAP water, increase 71 mg/L in SRP System.	Saguaro Lake drained during construction; 418,000 annual recreation days added; no stream segments affected; 3,000 acres of surface water added.	21 sites affected by construction, 85 by inundation, 320 indirectly: total of 426 sites. Sites are important but not unique.	13 sites would be affected, none of which are "problem sites".

1/ Impacts were assessed without mitigation.
2/ Adverse Flag indicates extremely adverse impacts, usually with legal implications.

Table 26

CONCEPT 1 - SALT OR VERDE CONTROL
SOCIAL IMPACTS

System	Relocation	Recreation Amenities Gained or Lost	Life Style Satisfaction	Community Viability
1A Cliff	1 ranching operation, including 3 persons	Loss of some tubing due to effects of exchange	Adverse effect due to relocation	None
1B Modified Roosevelt	450-500 individuals, over 1/2 retired	Some loss of tubing	Same as 1A	Adverse effect on 1 community due to relocation
1C New Stewart Mountain	Temporary relocation of dam operators	None	None	None

Table 27

CONCEPT 1 - SALT OR VERDE CONTROL
INSTITUTIONAL CONSTRAINTS

System	Authorization	Impacts on Institutional Arrangements	Constraints
1A Cliff	Undetermined	o Corps would determine operating criteria for flood control o Institutional agreements with SRP and CAWCS required for water exchange o Impacts on existing SRP operation o Acquisition of land from USFS	SRP would have to agree to water exchange. May be difficult to obtain.
1B Modified Roosevelt	Undetermined	o Corps would determine operating criteria for flood control o Institutional agreements required for direct connection o Impacts existing SRP operations o Affects existing Tri-Party Agreement (SRP, WPRS, USFS,) o Historic Advisory Council must approve mitigation plan	
1C New Stewart Mountain	Undetermined	o Corps would determine operating criteria for flood control o Institutional agreements required for direct connection o Affects Tri-Party Agreement o Impacts SRP operations, including pump-back storage	

When the other two systems accomplish regulatory storage through exchange rather than direct connection, however, the three systems become comparable in increased CAP yield.

Enlarged Roosevelt Dam with direct connection has mid-range costs, the highest regulatory storage capability and partial contribution to solving dam safety problems on the Salt River. New Stewart Mountain Dam, while comparable to the other systems in most aspects of performance, provides the least in terms of solving dam safety problems. Only the problems at the existing dam would be solved by its replacement.

In terms of environmental and social impacts, New Stewart Mountain clearly has the advantage with relatively minor environmental impacts and no significant social impacts. Cliff has the disadvantages of significant effect on riparian habitat, flowing streams and threatened and endangered species and would result in the relocation of individuals. Roosevelt has the disadvantages of major impacts on archaeological sites and the existing dam, which is a National Historic Landmark, and would result in the relocation of a significant number of individuals from the communities near Roosevelt Lake.

2. Concept 2: Salt AND Verde Control. Systems under this concept would control both the Salt and Verde Rivers either through a single structure at the Salt/Verde confluence or a combination of two structures, one on each river. Regulatory storage would be provided at the same structure or at New Waddell Dam on the Agua Fria River. Under this concept, the SPF could be controlled to a much higher degree (50,000 ft^3/s at the confluence) because both the Salt and Verde are controlled. Five elements were combined in various ways to build the systems: Cliff Dam, Enlarged Roosevelt Dam, Confluence Dam, New Stewart Mountain Dam, and New Waddell Dam. Comparative data on the systems are shown in Tables 28 through 31.

a. System 2A--Confluence Dam. Under this system, one structure at the confluence of the Salt and Verde Rivers would control runoff from both rivers and provide regulatory storage of CAP water through direct connection to the CAP aqueduct. Operation would be as described in Chapter VI. The dam does not contribute to solving any dam safety problems because of its location downstream of all existing dams on the Salt and Verde Rivers.

b. System 2B--Cliff Dam + Enlarged Roosevelt Dam. Under this system both structures would be multipurpose, including both flood control and regulatory storage. Cliff Dam would control the Verde River flows and Enlarged Roosevelt would control the Salt River flows. While regulatory storage could be accomplished through exchange or direct connection to the CAP aqueduct, this system shows regulatory storage by exchange at both structures. Operation would be as described in Chapter VI. Because both structures are upstream of existing structures, the new sites can be designed to eliminate dam safety problems for all the SRP dams downstream.

c. System 2C--Confluence Dam + Enlarged Roosevelt Dam. This system provides essentially the same flood control plan as 2B, except that a smaller Confluence Dam would control the Verde River. Regulatory storage space would be provided in the Confluence Dam only. Operation would be as described in Chapter VI. Dam safety problems could be solved on the Salt River only.

Table 28-1

CONCEPT 2 - SALT AND VERDE CONTROL
SYSTEM 2A - ENGINEERING AND COST DATA

	Confluence			
Storage Volume	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)
Streambed	1,320	0	0	0
Replacement	1,374	47,000	47,000	2,300
CAP Storage	1,430	300,000	347,000	8,712
Flood Control	1,498	970,000	1,317,000	20,780
Surcharge	1,504	132,000	1,449,000	21,960
Crest	1,508			

Costs ($ millions)		7-3/8%	3-1/4%
Construction Cost			
Structure		410.1	410.1
CAP Facility		44.5	44.5
Flood Outlets		50.5	50.5
Interest During Construction	(5 years)	93.1	41.0
Total		598.2	546.1
Annual Costs			
Annual Equivalent		44.2	18.5
OM&R		0.4	0.4
Pumping Energy		0.3	0.3
Energy Sales Foregone		1.4	1.4
Total		46.3	20.6

Total System Costs & Benefits ($ millions)	7-3/8%	3-1/4%
Construction Cost	598.2	546.1
Annual Cost	46.3	20.6
Benefits		
Water Supply	3.8	3.8
Flood Control	7.6	7.6
Total	11.4	11.4

Performance	
SPF Flood Release through Phx (ft^3/s)	50,000
Increased CAP Yield (ac-ft/yr)	112,000
Dam Safety	
Problems Solved	None
Problems Not Solved	The Salt and Verde River Dams.

Table 28-2

CONCEPT 2 - SALT AND VERDE CONTROL
SYSTEM 2B - ENGINEERING AND COST DATA

	CLIFF				MODIFIED ROOSEVELT WITH EXCHANGE			
Storage Volume	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)
Streambed	1,810	0	0	0	1,902	0	0	0
Replacement	1,952	144,000	144,000	2,912	2,136	1,381,000	1,381,000	18,890
CAP Storage	1,981	100,000	244,000	4,299	2,143	150,000	1,531,000	20,155
Flood Control	2,061	510,000	754,000	8,413	2,166	510,000	2,041,000	24,211
Surcharge	2,105	429,000	1,183,000	11,029	2,195	756,000	2,797,000	28,802
Crest	2,110				2,199			

Costs ($ millions)	Cliff 7-3/8%	Cliff 3-1/4%	Modified Roosevelt 7-3/8%	Modified Roosevelt 3-1/4%
Construction Cost				
Structure	118.1	118.1	96.0	96.0
CAP Facility	System Cost	System Cost	18.0	18.0
Flood Outlets	88.9	88.9	43.2	43.2
Interest During Construction	(5 years) 38.2	16.8	(3 years) 17.4	7.7
Total	245.2	223.8	174.6	164.9
Annual Costs				
Annual Equivalent	18.1	7.6	13.0	5.6
OM&R	0.2	0.2	0.5	0.5
Pumping Energy	System Energy	System Energy	0.4	0.4
Energy Sales Foregone	System Sales	System Sales	1.2	1.2
Total	18.3	7.8	15.0	7.7

Total System Costs & Benefits ($ millions)	7-3/8%	3-1/4%
Construction Cost	419.8	388.7
Annual Cost	33.3	15.5
Benefits		
Water Supply	1.9	1.9
Flood Control	7.4	7.4
Total	9.3	9.3

Performance	
SPF Flood Release through Phx (ft^3/s)	50,000
Increased CAP Yield (ac-ft/yr)	56,000
Dam Safety	
Problems Solved	The Verde River Dams and the Salt River Dams except Stewart Mountain Dam.
Problems Not Solved	Steward Mountain Dam.

Table 28-3

CONCEPT 2 - SALT AND VERDE CONTROL
SYSTEM 2C - ENGINEERING AND COST DATA

	CONFLUENCE				MODIFIED ROOSEVELT			
Storage Volume	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)
Streambed	1,320	0	0	0	1,902	0	0	0
Replacement	1,374	47,000	47,000	2,300	2,136	1,381,000	1,381,000	18,890
CAP Storage	1,450	500,000	547,000	11,750	N/A	N/A	N/A	N/A
Flood Control	1,484	510,000	1,057,000	17,840	2,159	510,000	1,891,000	23,046
Surcharge	1,490	183,000	1,240,000	19,940	2,189	756,000	2,647,000	27,982
Crest	1,494				2,193			

Costs ($ millions)	CONFLUENCE 7-3/8%	CONFLUENCE 3-1/4%	MODIFIED ROOSEVELT 7-3/8%	MODIFIED ROOSEVELT 3-1/4%
Construction Cost				
Structure	385.1	385.1	94.5	94.5
CAP Facility	44.5	44.5	N/A	N/A
Flood Outlets	45.1	45.1	43.2	43.2
Interest During Construction	(5 years) 87.5	38.6	(3 years) 15.2	6.7
Total	562.2	513.3	152.9	144.4
Annual Costs				
Annual Equivalent	41.5	17.4	11.3	4.9
OM&R	0.4	0.4	0.2	0.2
Pumping Energy	0.3	0.3	N/A	N/A
Energy Sales Foregone	1.6	1.6	N/A	N/A
Total	43.8	19.7	11.5	4.1

Total System Costs & Benefits ($ millions)	7-3/8%	3-1/4%
Construction Cost	715.1	657.7
Annual Cost	55.3	24.8
Benefits		
Water Supply	4.8	4.8
Flood Control	7.6	7.6
Total	12.4	12.4

Performance	
SPF Flood Release through Phx (ft^3/s)	50,000
Increased CAP Yield (ac-ft/yr)	141,000 @ Confluence
Dam Safety	
Problems Solved	The Salt River Dams except Stewart Mountain Dam.
Problems Not Solved	The Verde River Dams and Stewart Mountain Dam.

Table 28-4

CONCEPT 2 - SALT AND VERDE CONTROL
SYSTEM 2D - ENGINEERING AND COST DATA

	CLIFF				NEW STEWART MOUNTAIN				NEW WADDELL			
Storage Volume	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)
Streambed	1,810	0	0	0	1,410	0	0	0	1,420	0	0	0
Replacement	1,952	144,000	144,000	2,912	1,563	128,000	128,000	2,063	1,595	157,000	157,000	3,500
CAP Storage	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,669	400,000	557,000	7,556
Flood Control	2,049	510,000	654,000	7,692	1,694	510,000	638,000	6,110	N/A	N/A	N/A	N/A
Surcharge	2,097	390,000	1,044,000	10,262	1,716	148,000	786,000	7,005	1,680	93,000	650,000	8,577
Crest	2,097				1,721				1,684			

Costs ($ millions)	CLIFF 7-3/8%	CLIFF 3-1/4%	NEW STEWART MOUNTAIN 7-3/8%	NEW STEWART MOUNTAIN 3-1/4%	NEW WADDELL 7-3/8%	NEW WADDELL 3-1/4%
Construction Cost						
Structure	128.0	128.0	193.3	193.3	147.7	147.7
CAP Facility	N/A	N/A	N/A	N/A	53.3	53.3
Flood Outlets	68.0	68.0	75.4	75.4	N/A	N/A
Interest During Construction	(5 years) 36.1	15.9	(5 years) 49.5	21.8	(5 years) 37.1	16.3
Total	232.1	211.9	318.2	290.5	238.1	217.3
Annual Costs						
Annual Equivalent	17.1	7.2	23.5	9.8	17.6	7.4
OM&R	0.2	0.2	0.2	0.2	0.4	0.4
Pumping Energy	N/A	N/A	N/A	N/A	0.8	0.8
Energy Sales Foregone	N/A	N/A	N/A	N/A	2.0	2.0
Total	17.3	7.4	23.7	10.0	20.8	10.6

Total System Costs & Benefits ($ millions)	7-3/8%	3-1/4%
Construction Cost	788.4	719.7
Annual Cost	61.8	28.0
Benefits		
Water Supply	3.4	3.4
Flood Control	7.4	7.4
Total	10.8	10.8

Performance	
SPF Flood Release through Phx (ft^3/s)	50,000
Increased CAP Yield (ac-ft/yr)	100,000 @ New Waddell
Dam Safety	
Problems Solved	The Verde River Dams and Steward Mt. Dam.
Problems Not Solved	The Salt River Dams except Steward Mt. Dam.

Table 29

CONCEPT 2 - SALT AND VERDE CONTROL

ENVIRONMENTAL IMPACTS1/

System	Biology	Water Quality	Recreation	Archaeological Resources	Historical Resources
2A - Confluence	4,300 acres riparian habitat affected; 21,340 total acres of habitat inundated; loss of 22 miles of perennial stream; loss of 280 acres preferred habitat, 3 bald eagle nesting sites HIGHLY ADVERSE2/	Average TDS concentrations decrease 121 mg/L in CAP water, increase 73 mg/L in local surface water. Large volume of Salt/Verde water affected, some is used for M&I.	Loss of 8 stream-miles on Salt River used for tubing; increase in flat-water resources (21,000 acres), 771,000 annual recreation days added. HIGHLY ADVERSE	16 sites affected by construction, 115 by inundation; 72 indirectly: total of 203 sites. High quality resources at Confluence would be affected.	Loss of 55 sites. Problem sites are the Fort McDowell Military Post and the Fort McDowell Community. HIGHLY ADVERSE
2B - Cliff + Modified Roosevelt	2,370 acres riparian habitat affected; 13,490 total acres of habitat inundated; loss of 14 miles of perennial stream, with potential flow depletion in 37 additional miles; loss of 400 acres of preferred habitat, 1 bald eagle nesting site, possibly adverse effect on 3 breeding sites. HIGHLY ADVERSE	Average TDS concentrations decrease 68 mg/L in CAP water and increase 84 mg/L in local surface water. Relatively small volume of Verde water affected, some of which is used for M&I.	Variability of Verde flows (potential impact on tubing), increase in flat-water resources (12,400 acres), loss of 14 stream-miles (not used for tubing), 977,000 annual recreation days added.	52 sites affected by construction, 543 by inundation; 1,260 indirectly: total of 1,855 sites. High quality resources at Cliff and unique resources at Roosevelt would be affected. HIGHLY ADVERSE	Loss of 29 sites. Problem site is Roosevelt Dam, a National Historic Landmark. HIGHLY ADVERSE
2C - Confluence + Modified Roosevelt	5,500 acres riparian habitat affected; 24,570 total acres of habitat inundated; loss of 27 miles of perennial stream; loss of 400 acres of preferred habitat, 3 bald eagle nesting sites amd 2 breeding sites. HIGHLY ADVERSE	Average TDS concentrations decrease 119 mg/L in CAP water and increase 104 mg/L in local surface water. Large volume of Salt/Verde water affected, some of which is used for M&I.	Loss of 8 stream-miles on Salt River used for tubing, increase in flat-water resources (24,000 acres). 1,348,000 annual recreation days added. HIGHLY ADVERSE	24 sites affected by construction, 345 by inundation, 1,008 indirectly; total of 1,377 sites. High quality resources at Confluence and unique resources at Roosevelt would be affected. HIGHLY ADVERSE	Loss of 75 sites. Problem sites are Roosevelt Dam, Fort McDowell Military Post and Fort McDowell Community. HIGHLY ADVERSE
2D - Cliff + New Stewart Mountain + New Waddell	1,690 acres riparian habitat affected; 18,160 total acres of habitat inundated; loss of 10 miles of perennial stream; loss of 230 acres of preferred habitat and 1 bald eagle nesting site. HIGHLY ADVERSE	Average TDS concentrations decrease 8 mg/L in CAP water and increase 466 mg/L in local surface water. Small volume of Agua Fria water affected, all of which is used for agriculture.	Loss of 10 stream-miles on Verde, increase of flat-water resources (12,200 acres), loss of Lower Lake Waddell, Saguaro Lake drained during construction, 1,782,300 days added.	66 sites affected by construction, 375 by inundation 797 indirectly: total of 1,238 sites. High quality resources at Cliff and New Stewart Mountain and low quality resources at New Waddell affected.	Loss of 27 sites. No problem sites.

1/ Impacts were assessed without mitigation.

2/ Adverse Flag indicates extremely adverse impacts, usually with legal implications.

Table 30

CONCEPT 2 - SALT AND VERDE CONTROL
SOCIAL IMPACTS

	System	Relocations	Recreation Amenities Gained or lost	Lifestyle Satisfaction	Community Viability
2A	Confluence	290 individuals from the Ft. McDowell Indian Community	Elimination of 93% of flowing water suitable for tubing	Adverse impact due to relocations	Adverse impact due to relocations
2B	Cliff + Modified Roosevelt	450-500 persons in Lake Roosevelt area; over ½ retired	Potential loss in tubing due to effects of exchange at Cliff	Adverse impact due to relocations	Adverse impact on 2 communities due to relocations
2C	Confluence + Modified Roosevelt	700+ people from the two impact areas	Loss of flowing water suitable for tubing	Highly adverse impact due to relocations in two impact areas	Highly adverse impact on 3 communities due to relocations
2D	Cliff + New Stewart Mt. + New Wadell	1 ranch, including 3 individuals	Loss of low-cost, family-oriented recreation due to draining of Lower Lake Pleasant	Adverse impact due to relocations	None

Table 31

CONCEPT 2 - SALT AND VERDE CONTROL
INSTITUTIONAL CONSTRAINTS

Systems	Authorization	Impacts on Institutional Arrangements	Constraints
2A Confluence	Authorized under CAP	o Land acquistion required from Ft. McDowell Indian Community and Salt River Pima-Maricopa Indian Community	
2B Cliff + Modified Roosevelt	Undetermined	o Corps would determine operating criteria for flood control o Institutional agreements required for exchanges o Impacts existing SRP operations o Affects Tri-Party Agreement o Historic Advisory Council must approve mitigation plan o Acquisition of USFS land	SRP would have to agree to water exchanges. May be difficult to obtain.
2C Confluence + Modified Roosevelt	Confluence authorized; Roosevelt undetermined	o Land acquisition from Indian Communities o Land transfer from USFS o Corps determines operating criteria for flood control o Affects Tri-Party Agreement o Historic Advisory Council must approve mitigation plan	
2D Cliff + New Stewart Mt. + New Waddell	Undetermined	o Corps determines operating criteria for flood control o Impacts SRP operations, including power o Affects Tri-Party Agreement o Arrangement required with MCMWCD#1 for New Wadell o Acquisition of USFS LAND	

d. <u>System 2D--Cliff Dam + New Stewart Mountain Dam + New Waddell Dam</u>. Under this system, Cliff Dam on the Verde and New Stewart Mountain Dam on the Salt would be primarily flood control dams and regulatory storage would be provided at New Waddell Dam on the Agua Fria. Operation would be as described in Chapter VI. Cliff Dam could solve dam safety problems on the Verde, but on the Salt River only the specific dam safety problem at the existing Stewart Mountain Dam could be solved by replacement of the structure.

e. <u>Evaluation of Salt AND Verde Control Systems</u>. In terms of flood control performance, all systems under this concept provide the same level of protection (50,000 ft^3/s).

While the Confluence system (2A) provides a high increase in CAP yield at a comparable cost and has the advantage of congressional authorization, it provides no solution to dam safety problems, has an extremely adverse environmental impact on endangered species, recreation (tubing) and cultural resources, and has a highly adverse social impact on the Fort McDowell Indian Community (relocation of 78 percent of the population). When combined with Enlarged Roosevelt (System 2C), the highest increase in CAP yield results (242,000 acre-feet/year), but the environmental and social impacts are compounded. Over 700 people may be relocated from the two impact areas, and a highly adverse impact on endangered species, flowing stream and cultural resources at both sites would result.

Cliff + Enlarged Roosevelt (2B) has the advantages of least cost and solution of dam safety problems on both rivers, but the system provides the smallest increase in CAP yield (56,000 acre-feet/year).

Cliff + New Stewart Mountain + New Waddell (2D), while having the highest cost, provides good regulatory storage capability and the least environmental and social impacts.

3. <u>Concept 3: Downstream</u>. The downstream system (3A) relies entirely on channelization options for flood control. As no upstream reservoir storage is provided, there would be no reduction in peak flows. Rather, the system is designed to pass the flow through the area to be protected. A two-sided levee designed to contain a flow of 295,000 ft^3/s (SPF) would provide flood control on the Salt River through Phoenix from Country Club Drive to 35th Avenue. A one-sided levee from 91st Avenue to Gillespie Dam on the Gila River would provide local westside flood protection. Regulatory storage would be provided at New Waddell Dam. Comparative data on the system are shown in Tables 32 through 35.

The evaluation of the downstream system has identified these advantages:

- Minimal environmental and social impact (draining of Lower Lake Pleasant results in loss of some low-cost, family-oriented recreation).

Table 32

CONCEPT 3 - DOWNSTREAM
SYSTEM 3 - ENGINEERING AND COST DATA

	NEW WADDELL				PHOENIX LEVEES				GILA LEVEES			
Storage Volume	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)	Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)
Streambed	1,420	0	0	0								
Replacement	1,595	157,000	157,000	3,500		N/A				N/A		
CAP Storage	1,669	400,000	557,000	7,556								
Flood Control	N/A	N/A	N/A	N/A								
Surcharge	1,680	93,000	650,000	8,577								
Crest	1,684											

Costs ($ millions)	New Waddell 7-3/8%	New Waddell 3-1/4%	Phoenix Levees 7-3/8%	Phoenix Levees 3-1/4%	Gila Levees 7-3/8%	Gila Levees 3-1/4%
Construction Cost						
Structure	147.7	147.1	705.5	705.5	467.3	467.3
CAP Facility	53.3	53.3	N/A	N/A	N/A	N/A
Flood Outlets	N/A	N/A	N/A	N/A	N/A	N/A
Interest During Construction	(5 years) 37.1	16.3	(4 years) 81.6	45.9	(4 years) 54.0	30.4
Total	238.1	217.3	787.1	741.4	521.3	497.7
Annual Costs						
Annual Equivalent	17.6	7.4	58.1	25.5	38.5	16.9
OM&R	0.4	0.4	20.0	20.0	16.7	16.7
Pumping Energy	0.8	0.8	N/A	N/A	N/A	N/A
Energy Sales Foregone	2.0	2.0	N/A	N/A	N/A	N/A
Total	20.8	10.6	78.1	45.5	55.2	33.6

Total System Costs & Benefits ($ millions)	7-3/8%	3-1/4%
Construction Cost	1,546.5	1,466.4
Annual Cost	154.1	89.7
Benefits		
Water Supply	3.4	3.4
Flood Control	6.0	6.0
Total	9.4	9.4

Performance	
SPF Flood Release through Phx (ft^3/s)	300,000
Increased CAP Yield (ac-ft/yr)	100,000 @ New Waddell
Dam Safety	
Problems Solved	None.
Problems Not Solved	The Salt and Verde Dams.

Table 33

CONCEPT 3 - DOWNSTREAM

ENVIRONMENTAL IMPACTS[1/]

System	Biology	Water Quality	Recreation	Archaeological Resources	Historical Resources
Phoenix Levees + Gila Levee + New Waddell	490 acres riparian habitat and 10,030 acres total habitat affected. No stream-miles, acres of preferred habitat, or threatened/endangered nesting/breeding areas affected.	Average TDS concentrations decrease 8 mg/L in CAP water and increase 446 mg/L in local surface water. Relatively small volume of water affected, all of which is used for agriculture.	Loss of Lower Lake Pleasant, increase in flat-water resources (3,360 acres), 1,000,000 annual recreation days added.	25 sites would be affected by construction, 14 sites by inundation, 155 indirectly: total of 194 sites. Low and medium quality resources would be affected.	Loss of 24 sites No problem sites.

1/ Impacts were assessed without mitigation.

Table 34

CONCEPT 3 - DOWNSTREAM

SOCIAL IMPACTS

System	Relocation	Recreation Amenities	Lifestyle Satisfaction	Community Viability
Phoenix Levees + Gila Levee + New Waddell	None	Loss of some low-cost family-oriented recreation due to draining of Lower Lake Pleasant	None	None

Table 35

CONCEPT 3 - DOWNSTREAM

INSTITUTIONAL IMPACTS

System	Authorization	Impacts on Institutional Arrangements	Constraints
Phoenix Levees + Gila Levee + New Waddell	Flood control authorized under Flood Control Act of 1960 (PL86-645)	o Local sponsor must provide rights-of-way and maintain levees (Flood Control District of Maricopa Co.) o Arrangements required w/MCMWCD#1	Capability of local sponsor to provide funding

- Good increase in CAP yield (100,000 acre-feet/year).

Disadvantages include:

- Extremely high cost ($1.6 billion).
- No contribution to dam safety solutions.
- Limited potential for implementation due to high cost.

4. Concept 4: Upstream/Downstream. For flood control, systems under this concept combine a limited amount of upstream storage on the Salt River with levees on the Salt and Gila Rivers downstream. These systems reduce peak flows through upstream reservoir storage, but with limited upstream storage, levees are required to handle residual flows through Phoenix. With dams on the Salt River, residual flow is such that levees would be required. Greater control can be obtained on the Verde, therefore, levees are not as necessary. On this basis, Upstream/Downstream systems use sites on the Salt River for upstream control. Regulatory storage would be included in the upstream structure. The elements used in system building were: Enlarged Roosevelt Dam, New Stewart Mountain Dam, Phoenix Levees, and Gila Levee. Comparative data on the systems are shown in Tables 36 through 39.

a. System 4A--Enlarged Roosevelt + Phoenix Levees + Gila Levee. Roosevelt Dam under this system would be multipurpose, controlling Salt River floodflows and providing regulatory storage to the SRP Salt River system through direct connection to the CAP aqueduct. The Phoenix levees and Gila levee would control floodflows emanating from the Verde River (residual flow). Under this system the SPF would be reduced to 200,000 ft^3/s. Roosevelt Dam would solve dam safety problems on the Salt River; no dam safety problems would be solved on the Verde River.

b. System 4B--New Stewart Mountain Dam + Phoenix Levees + Gila Levee. This system is basically the same as 4A, except that New Stewart Mountain Dam would control the Salt River flows. Only the dam safety problems at the existing Stewart Mountain Dam would be solved with replacement of the structure.

c. Evaluation of Upstream/Downstream Systems. In terms of performance, both systems under this concept provide the same level of flood protection (200,000 ft^3/s); however, Enlarged Roosevelt provides more than twice the increase in CAP yield at a comparable cost and a significant contribution to solving dam safety problems on the Salt River. New Stewart Mountain Dam solves only the problems at the existing dam by replacement of the structure. Both systems have the disadvantage of extremely high cost.

In terms of environmental and social impacts, Enlarged Roosevelt would significantly impact archaeological and historic resources and may require the relocation of up to 500 individuals from communities near Roosevelt Lake. Environmental and social impacts are minimal at New Stewart Mountain.

Table 36-1

CONCEPT 4 - UPSTREAM/DOWNSTREAM
SYSTEM 4A - ENGINEERING AND COST DATA

Storage Volume	MODIFIED ROOSEVELT WITH DIRECT CONNECT Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)	PHOENIX LEVEES Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)	GILA LEVEES Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)
Streambed	1,902	0	0	0								
Replacement	2,136	1,381,000	1,381,000	18,890								
CAP Storage	2,513	372,000	1,753,000	21,962		N/A				N/A		
Flood Control	2,163	230,000	1,983,000	23,719								
Surcharge	2,192	756,000	2,739,000	28.474								
Crest	2,196											

Costs ($ millions)	Modified Roosevelt 7-3/8%	Modified Roosevelt 3-1/4%	Phoenix Levees 7-3/8%	Phoenix Levees 3-1/4%	Gila Levees 7-3/8%	Gila Levees 3-1/4%
Construction Cost						
Structure	95.5	95.5	583.5	583.5	425.1	425.1
CAP Facility	309.9	309.9	N/A	N/A	N/A	N/A
Flood Outlets	96.9	96.2	N/A	N/A	N/A	N/A
Interest During Construction	(3 years) 55.5	24.5	(4 years) 67.5	37.9	(4 years) 49.1	27.6
Total	557.1	526.1	651.0	621.4	474.2	452.7
Annual Costs						
Annual Equivalent	41.1	17.8	48.1	21.1	35.0	15.3
OM&R	1.0	1.0	16.0	16.0	13.1	13.1
Pumping Energy	1.6	1.6	N/A	N/A	N/A	N/A
Energy Sales Foregone	1.7	1.7	N/A	N/A	N/A	N/A
Total	45.4	22.1	64.1	37.1	48.1	28.4

Total System Costs & Benefits ($ millions)	7-3/8%	3-1/4%
Construction Cost	1,682.3	1,600.2
Annual Cost	157.6	87.6
Benefits		
Water Supply	4.1	4.1
Flood Control	N/A	N/A
Total	4.1	4.1

Performance	
SPF Flood Release through Phx (ft^3/s)	200,000
Increased CAP Yield (ac-ft/yr)	121,000 @ Modified Roosevelt
Dam Safety	
Problems Solved	The Salt River Dams except Stewart Dam.
Problems Not Solved	The Verde Dams and Stewart Mountain Dam.

Table 36-2

CONCEPT 4 - UPSTREAM/DOWNSTREAM
SYSTEM 4B - ENGINEERING AND COST DATA

Storage Volume	NEW STEWART MT. WITH DIRECT CONNECT Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)	PHOENIX LEVEES Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)	GILA LEVEES Elevation (feet)	Increased Storage (ac-ft)	Total Storage (ac-ft)	Surface Area (acres)
Streambed	1,410	0	0	0								
Replacement	1,563	128,000	128,000	2,063								
CAP Storage	1,620	160,000	288,000	3,580		N/A				N/A		
Flood Control	1,672	230,000	518,000	5,274								
Surcharge	1,694	124,000	642,000	6,110								
Crest	1,684											

Costs ($ millions)	NEW STEWART MT. 7-3/8%	NEW STEWART MT. 3-1/4%	PHOENIX LEVEES 7-3/8%	PHOENIX LEVEES 3-1/4%	GILA LEVEES 7-3/8%	GILA LEVEES 3-1/4%
Construction Cost						
Structure	161.8	161.8	583.5	583.5	425.1	425.1
CAP Facility	259.4	259.4	N/A	N/A	N/A	N/A
Flood Outlets	135.6	135.6	N/A	N/A	N/A	N/A
Interest During Construction	(5 years) 102.7	45.2	(4 years) 67.5	37.9	(4 years) 49.1	27.6
Total	659.5	602.0	651.0	621.4	474.2	452.7
Annual Costs						
Annual Equivalent	48.7	20.4	48.1	21.1	35.0	15.3
OM&R	1.3	1.3	16.0	16.0	13.1	13.1
Pumping Energy	0.7	0.7	N/A	N/A	N/A	N/A
Energy Sales Foregone	0.7	0.7	N/A	N/A	N/A	N/A
Total	51.4	23.1	64.1	37.1	48.1	23.4

Total System Costs & Benefits ($ millions)	7-3/8%	3-1/4%
Construction Cost	1,784.7	1,676.1
Annual Cost	163.6	88.6
Benefits		
Water Supply	2.8	2.8
Flood Control	N/A	N/A
Total	2.8	2.8

Performance	
SPF Flood Release through Phx (ft^3/s)	200,000
Increased CAP Yield (ac-ft/yr)	82,000 @ New Stewart Mountain
Dam Safety	
Problems Solved	Stewart Mountain Dam.
Problems Not Solved	The Verde River Dams and the Salt River Dams except Stewart Mountian Dam.

Table 37

CONCEPT 4 - UPSTREAM/DOWNSTREAM
ENVIRONMENTAL IMPACTS 1/

System	Biology	Water Quality	Recreation	Archaeological Resources	Historical Resources
4A Modified Roosevelt + Phoenix Levees + Gila Levee	1,740 acres riparian habitat and 11,750 total acres of habitat affected; loss of 4 stream-miles and 130 acres of preferred habitat. No threatened/endangered nesting/breeding areas affected.	Average TDS concentrations decrease 43 mg/L in CAP water and increase 46 mg/L in local surface water. Relatively large volume of Salt River water affected, some of which is used for M&I.	Loss of 4 stream-miles on Upper Salt (possible Wild and Scenic River designation), increase in flat-water resources (6,100 acres), 613,000 annual recreation days added.	35 sites would be affected by construction, 219 sites by inundation, and 1,157 indirectly:total of 1,411 sites.Unique resources at Roosevelt would be affected. HIGHLY ADVERSE2/	Loss of 40 sites. Problem site is Roosevelt Dam, a National Historical Landmark. HIGHLY ADVERSE
4B New Stewart Mountain + Phoenix Levees + Gila Levee	960 acres riparian habitat and 8,980 total acres of habitat affected.	Average TDS concentrations decrease 44 mg/L in CAP water and increase 26 mg/L in local surface water. Smaller volume of Salt River water affected by this system than System A.	Saguaro Lake drained during construction, no flowing stream segments permanently affected, increase in flat-water resources (3,900 acres), 418,300 annual recreation days added.	39 sites would be affected by construction, 85 sites by inundation, and 401 sites indirectly: total 525 sites. High quality resources in the New Stewart Mountain area and medium quality resources in the Salt River floodplain would be impacted.	Loss of 28 sites. No problem sites.

1/ Impacts were assessed without mitigation.
2/ Adverse Flag indicates extremely adverse impacts, usually with legal implications.

Table 38

CONCEPT 4 - UPSTREAM/DOWNSTREAM

SOCIAL IMPACTS

	System	Relocations	Recreation Amenities Gained or Lost	Lifestyle Satisfaction	Community Viability
4A	Modified Roosevelt + Phoenix Levees + Gila Levee	450-500 persons in 5 communities, over ½ retired	None	Adverse impact due to relocations	Adverse impact for 2 communities projected to have community structures
4B	New Stewart Mt. + Phoenix Levees + Gila Levee	None	Temporary loss of recreation during construction	None	None

Table 39

CONCEPT 4 - UPSTREAM/DOWNSTREAM
INSTITUTIONAL CONSTRAINTS

	System	Authorization	Impacts on Institutional Arrangements	Constraints
4A	Modified Roosevelt + Phoenix Levees + Gila Levee	Levees authorized by PL86-645; Roosevelt undetermined	o Local sponsor must provide rights-of-way and maintain levees (Flood Control District of Maricopa County) o Corps determines operating criteria for flood control o Institutional agreements required for direct connection o Impacts SRP operation o Affects Tri-Party Agreement o Historic Advisory Council must approve mitigation plan	Capability of local sponsor to provide funding
4B	New Stewart Mountain + Phoenix Levees + Gila Levee	Levees authorized by PL86-645; New Stewart Mt. undetermined	o Local sponsors must provide rights-of-way and maintain levees o Corps would determine operating criteria for flood control o Institutional agreements required for direct connection o Affects Tri-Party Agreement o Impacts SRP operations, including pump-back storage	Capability of local sponsor to provide funding

5. Concept 5: Limited Structural. This concept takes advantage of opportunities for flood control and regulatory storage at existing storage facilities, reducing the need for new structures. Systems under this concept have the advantage of generally low construction cost and local implementation since time-consuming major construction would not be involved. However, because the systems are constrained by what exists, they are limited in their function. Systems developed for this concept rely on SRP Reregulation for flood control and regulatory storage at an underground storage site in the Salt River channel downstream of the Granite Reef Diversion Dam. The proximity of this site to the CAP aqueduct provides an advantage relative to providing a delivery mechanism for water once it is pumped back out. Comparative data on the systems are shown in Tables 40 through 43.

a. System 5A--SRP Reregulation (without modifications) + Underground Storage. This system is designed to control the 50-year flood to 150,000 ft^3/s. Under the system, 439,000 acre-feet of existing water storage in the SRP system on the Salt and Verde Rivers would be converted and dedicated to flood control purposes during that time period. There would be no structural changes made to the dams. Use of the dedicated flood control space would also result in a reduction of the SPF (295,000 ft^3/s) to 270,000 ft^3/s.

Regulatory storage would be accomplished through underground storage. CAP water would be pumped out of the Salt-Gila Aqueduct and released into the infiltration basins when the demand is low (fall and winter). It would be stored underground and pumped out in the high-demand spring and summer months. Dedication of existing water conservation space to flood control purposes would result in a loss of surface water resources, which would have to be offset through increased ground water pumping. It may be possible to store a portion of the floodflows underground rather than spilling them, and pump them out for later use. No dam safety problems would be solved.

b. System 5B--SRP Reregulation (with modifications) + Underground Storage. With modifications to existing dams, more water storage can be dedicated to flood control purposes and reduce the peak flow to a greater extent. This system is designed to control the 100-year flood to 100,000 ft^3/s. Under the system, 556,000 acre-feet of existing water storage on the Salt and Verde Rivers would be dedicated to flood control purposes during the flood season. New flood outlet works would be required at Roosevelt and Bartlett Dams. This system also results in a reduction of the SPF to 210,000 ft^3/s. Regulatory storage would be provided through underground storage as described under 5A. No dam safety problems would be solved.

c. Evaluation of Limited Structural Systems. Systems under this concept provide the same increase in CAP yield and have similar impacts. Both result in a loss of SRP water (a greater loss with modifications), neither solves dam safety problems, and environmental and social impacts are similar.

A specific advantage of SRP Reregulation with modifications is that greater flood control is provided (145,000 ft^3/s).

Table 40

CONCEPT 5 LIMITED STRUCTURAL
SYSTEMS 5A AND 5B - ENGINEERING AND COST DATA

Storage Volume	SYSTEM 5A SRP Reregulation (w/o Mod's) + Underground Storage (ac-ft/year)	SYSTEM 5B SRP Reregulation (w/ Mod's) + Underground Storage (ac-ft/year)
% Dedicated to Flood Storage	21%	27%
Water Loss to SRP System	88,000	113,000
Hydropower Loss to SRP System	41,000	42,000

Costs ($ millions)	5A 7-3/8%	5A 3-1/4%	5A 7-3/7%	5A 3-1/4%	5B 7-3/8%	5B 3-1/4%	5B 7-3/8%	5B 3-1/4%
Construction Cost								
Structure	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CAP Facility	N/A	N/A	101.2	101.2	N/A	N/A	101.2	101.2
Flood Outlets	N/A	N/A	N/A	N/A	79.2	79.2	N/A	N/A
Interest During Construction (3 year)	N/A	N/A	11.2	4.9	8.8	3.9	11.2	4.0
Total	0	0	112.4	106.1	88.0	83.1	112.4	106.1
Annual Costs								
Annual Equivalent	4.8	4.8	8.3	3.6	12.4	8.7	8.3	3.6
OM&R	N/A	N/A	N/A	.4	N/A	N/A	0.4	0.4
Pumping Energy	N/A	N/A	1.0	1.0	N/A	N/A	1.0	1.0
Energy Sales Foregone	N/A	N/A	1.3	1.3	N/A	N/A	1.3	1.3
Total	4.8	4.8	11.0	6.3	12.4	8.7	11.0	6.3

Total System Costs & Benefits ($ millions)	5A 7-3/8%	5A 3-1/4%	5B 7-3/8%	5B 3-1/4%
Construction Cost	112.4	106.1	200.4	189.2
Annual Cost	15.8	11.1	23.4	15.0
Benefits				
Water Supply	2.1		2.1	
Flood Control	5.8		5.6	
Total	7.9		7.7	

	System 5A	System 5B
Performance		
SPF Flood Release through Phx (ft^3/s)	270,000	210,000
Increased CAP Yield (ac-ft/yr)	63,000	63,000
Dam Safety		
Problems Solved	None	None

Table 41

CONCEPT 5 - LIMITED STRUCTURAL
ENVIRONMENTAL IMPACTS 1/

System	Biology	Water Quality	Recreation	Archaeological Resources	Historical Resources
5A SRP Reregulation (without modification) + Underground Storage	70 acres of riparian habitat and 1,450 total acres of habitat affected; potential depletion of 35 miles of perennial stream; adverse impact to 10 acres of preferred habitat and assuming flow depletion-possible adverse impact on 2 bald eagle breeding areas. HIGHLY ADVERSE2/	No impacts	Lowering of reservoirs detracts from recreational use along shorelines; variation in Salt/Verde flows (potential tubing impact); potential of no flow in Verde in dry years.	53 sites affected by construction (underground storage area) and 71 indirectly: total of 124 sites.	Loss of 15 sites. No problem sites.
5B SRP Reregulation (with modification) + Underground Storage	80 acres of riparian habitat and 1,470 total acres of habitat affected; potential depletion of 35 miles of perennial stream; loss of lake fishery at Bartlett Lake; adverse impact to 20 acres of preferred habitat and assuming flow depletion-possible adverse impact on 2 bald eagle breeding areas. HIGHLY ADVERSE	No impacts	Lowering of reservoirs detracts from recreational use along shorelines; Bartlett Lake drained seasonally; variation in Salt/Verde flows (potential tubing impact); potential of no flow in Verde in dry years.	Same as 5-A	Loss of 15 sites, and potential adverse impacts to 2 additional sites: Bartlett Dam and Roosevelt Dam.

1/ Impacts were assessed without mitigation.
2/ Indicates extremely adverse impacts, usually with legal implications.

Table 42

CONCEPT 5 - LIMITED STRUCTURAL
SOCIAL IMPACTS

	System	Relocation	Recreation Amenities Gained or Lost	Lifestyle Satisfaction	Community Viability
5A	SRP Reregulation w/o mod's + Underground Storage	None	None	Possible impact of Salt River Pima-Maricopa Indians due to land acquisition and effect on mining	
5B	SPR Reregulation w/ mod's + Underground Storage			Same as 5A	

Table 43

CONCEPT 5 - LIMITED STRUCTURAL
INSTITUTIONAL CONSTRAINTS

	System	Authorization	Impacts on Institutional Arrangements	Constraints
5A	SRP Reregulation w/o mod's + Underground Storage	Undetermined	o Requires modification of SRP charter o Impacts SRP operation o Corps determines operating criteria for flood control o Impacts SRP water contracts o SRPMIC land acquisition required	Replacement of water lost due to reregulation must come from outside Phoenix AMA; ownership of ground water after infiltration not established
5B	SRP Reregulation w/ mod's + Underground Storage	Undetermined	Same as 5A	Same as 5A

6. Concept 6: Nonstructural. Nonstructural flood loss reduction measures are aimed at reducing flood damages due to development in flood prone areas, rather than changing the flow of water. The key factor in the nonstructural system is that while floods are generally allowed to occur uncontrolled, economic loss and social disruption are reduced by changing the use of the flood plain. However, because the flow of water is not controlled, the level of protection obtained is often less than with a structural solution. For regulatory storage, a nonstructural system relies on water exchange with SRP. No dam safety problems would be solved.

No specific nonstructural system was proposed in Stage II. The following nonstructural measures are under investigation and a specific plan will be developed in Stage III:

- Modifications to Existing Structures.
  - Flood proofing to the 50-year flood levels.
- Regulation of Future Development.
  - Enforcement of existing flood plain ordinance.
  - Sand and gravel mining regulations.
- Preparedness Planning (modification to existing plans), including SPF bridge for emergency use only.

Although these measures are shown as a separate concept/system, many could be implemented in conjunction with a structural solution, if selected as the preferred plan. Performance and impact data are shown in Tables 44 through 47.

One difficulty with nonstructural measures is that they do not alter floodflows, but rather involve changing human behavior. Most nonstructural measures are implemented by local groups and agencies rather than the Federal Government. Congressional authorization of economically and environmentally justified actions would be required for an 80 percent (Federal) -20 percent (local) cost sharing for nonstructural flood control.

The major disadvantages to water exchange are potential adverse impacts to wildlife and vegetation as a result of maximizing water storage in the winter, thereby reducing releases and hence streamflows. Depletion of these flows could partially affect breeding and feeding areas on the Verde River. Also, exchange provides minimal increase in CAP water supply (15,000 acre-feet/year).

C. Evaluation Summary

Based on the comparative information presented in the preceding sections of this chapter, CAWCS staff evaluated the systems to make recommendations as to which alternatives would be carried on for further study in Stage III of

Table 44

CONCEPT 6 - NONSTRUCTURAL
SYSTEM 6 - ENGINEERING AND COST DATA

Storage Volume	Nonstructural		SRP Exchange	
	N/A		N/A	
Costs ($ millions)	**7-3/8%**	**3-1/4%**	**7-3/8%**	**3-1/4%**
Construction Cost	N/A	N/A		
Structure			-	-
CAP Facility			12.0	12.0
Flood Outlets			-	-
Interest During Construction			1.3	0.6
Total			13.3	12.6
Annual Costs				
Annual Equivalent			1.0	0.4
OM&R			0.2	0.2
Pumping Energy			0.2	0.2
Energy Sales Foregone			0.8	0.8
Total			2.2	1.6

Total System Costs & Benefits ($ millions)	Nonstructural	SRP Exchange
Construction Cost	13.3	12.6
Annual Cost	2.2	1.6
Benefits		
Water Supply	0.5	0.5
Flood Control	N/A	N/A
Total	0.5	0.5
Performance		
SPF Flood Release through Phx (ft^3/s)	N/A	N/A
Increased CAP Yield (ac-ft/yr)	-	14,500
Dam Safety		
Problems Solved	None	
Problems Not Solved	All Dams on Salt and Verde Rivers.	

Table 45
CONCEPT 6 - NONSTRUCTURAL
ENVIRONMENTAL IMPACTS1/

System	Biology	Water Quality	Recreation	Archaeological Resources	Historical Resources
Nonstructural Flood Control + SRP Water Exchange	20 acres of mixed scrub habitat, 30 total acres affected; potential flow depletion in 37 miles of perennial stream; assuming flow depletion-adverse impact to 3 bald eagle breeding areas. HIGHLY ADVERSE2/	Average TDS concentration would decrease 68 mg/L in CAP water and increade 84 mg/L in local sources.	Seasonal variability of stream flow could affect tubing.	No impacts	No impacts

1/ Impacts were assessed without mitigation.
2/ Adverse Flag indicates extremely adverse impacts, usually with legal impications.

Table 46

CONCEPT 6 - NONSTRUCTURAL

SOCIAL IMPACTS 1/

System	Relocations	Recreation Amenities Gained or Lost	Lifestyle Satisfaction	Community Viability
Nonstructural Flood Control + SRP Water Exchange	None	Loss of some tubing activity due to exchange	None	None

1/ Impacts relate to water exchange only. No assessment of nonstructural completed as yet.

Table 47

CONCEPT 6 - NONSTRUCTURAL

INSTITUTIONAL CONSTRAINTS

System	Authorization	Impacts on Institutional Arrangements	Constraints
Nonstructural + SRP Exchange	Authorization required for 80-20 cost sharing on flood control	Agreement with SRP required for water exchange	SRP agreement highly unlikely for exchange without some storage control

the CAWCS. Systems were compared within each concept to determine if any were clearly superior or inferior. In addition, entire concepts were evaluated to determine if they were justified. Following is a summary of the evaluation. Comparative engineering, cost, and impact data are summarized for all systems in Table 48. Recommendations are presented in the next chapter.

1. Concept 1: Salt OR Verde Control. Of the systems in this concept--Cliff, Enlarged Roosevelt, and New Stewart Mountain--all have particular advantages which recommend them for further study. No system is clearly inferior to the others in all factors evaluated.

2. Concept 2: Salt AND Verde Control. Of the systems in this concept--Confluence, Cliff + Enlarged Roosevelt, Confluence + Enlarged Roosevelt, and Cliff + New Stewart Mountain + New Waddell--none appear to be clearly superior. However, System 2C, Confluence + Enlarged Roosevelt has relatively high cost and highly adverse environmental and social impacts. Although performance characteristics of the system are very good, other systems in the concept are comparable without the extremely severe combination of environmental and social impacts.

3. Concept 3: Downstream. The downstream system--Phoenix Levees + Gila Levees + New Waddell--does meet project purposes and has virtually no environmental and social impacts. However, due to the extremely high cost of the system, it is unlikely that justification and implementation of the project would occur.

4. Concept 4: Upstream/Downstream. There are two systems in this concept: Enlarged Roosevelt + Levees, and New Stewart Mountain + Levees. As with the downstream system, both systems meet the project purposes and have equal overall impacts. However, both have extremely high costs that make their implementation unlikely.

5. Concept 5: Limited Structural. Both reregulation options in this concept--SRP Reregulation (without modifications) + Underground Storage and SRP Reregulation (with modifications) + Underground Storage--appear to have potential for development in plans. But, the underground storage for regulatory storage appears to have a number of adverse impacts, including high cost for relatively small yield, institutional and social problems with land acquisition and implementation, and legal problems with recovery of the CAP water from the aquifer.

6. Concept 6: Nonstructural. Although the flood damage reduction measures have not been fully developed and evaluated at this time, they could be combined in a nonstructural plan and/or included as "add-ons" with many other systems, particularly those flood control systems that do not provide high flow reduction. Water exchange with the existing SRP system for regulatory storage provides little in the way of increased CAP yield (14,500 acre-feet/year) and could increase flooding and dam safety problems due to the fact that reservoirs would be fuller during the winter flood season. In addition, there are potentially severe impacts to legally-protected wildlife species for the exchange system.

Table 48

SYSTEM EVALUATION SUMMARY

	Regulatory Storage Avg. Annual Increase in CAP Water Supply (ac-ft)	Projected Flood Control at Confluence (ft^3/s)	DAM SAFETY: Problems Solved by the System	DAM SAFETY: Problems Not Solved by the System	Costs (million $)* (rounded to the nearest million): Construction 7 3/8%	Construction 3 1/4%	Annual Cost 7 3/8%	Annual Cost 3 1/4%	IMPACTS: Environmental	Social	Institutional
1A Cliff + Water Exchange	46,000	150,000	Bartlett Horseshoe	Roosevelt, Horse Mesa Mormon Flat, Stewart Mt.	254	232	20	10	Biological Resources; T&E species; cultural resources	No significant impacts	Need SRP AGREEMENT for exchange-unlikely
1B Modified Roosevelt + Direct Connection	121,000 (47,000 w/water exchange instead)	200,000	Roosevelt, Horse Mesa, Mormon Flat	Bartlett, Horse Mesa, Stewart Mountain	557	526	45	22	Archaeological & Historical sites.	Relocations	Impacts on institutional arrangements
1C New Stewart Mt. + Direct Connection	82,000 (46,000 w/water exchange instead)	200,000	Stewart Mt.	Horseshoe, Bartlett, Roosevelt, Mormon Flat, Horse Mesa	660	602	51	23	Archaeological resources	No significant impacts	Same as 1B
2A Confluence	112,000	50,000	None	All dams on Salt and Verde	598	546	46	21	Biological Resources; T&E species; recreation; cultural resources	Relocations	Institutional Arrangements
2B Cliff + Modified Roosevelt + Water Exchange	56,000	50,000	All dams on Salt and Verde except Stewart Mountain	Stewart Mountain	421	389	33	16	Biological Resources; T&E species; cultural resources	Relocations	Need SRP agreement for exchange-unlikely
2C Confluence + Modified Roosevelt + Direct Connection	141,000	50,000	Roosevelt, Horse Mesa, Mormon Flat	Horseshoe, Bartlett, Stewart Mountain	715	658	55	25	Same as 2A and 2B	Same as 2A and 2B	Same as 2A
2D Cliff + New Stewart Mt. + New Waddell	100,000	50,000	Bartlett, Horseshoe, Stewart Mountain	Roosevelt, Mormon Flat, Horse Mesa	788	720	62	28	T&E species; archaeological sites; recreation	Loss of some recreation	Same as 2A
3 Levees + New Waddell	100,000	300,000	None	All dams on Salt and Verde	1546	1466	154	90	Archaeological sites; recreation	Loss of some recreation of Lake Pleasant	Local Funding needed
4A Modified Roosevelt + Levees + Direct Connection	121,000	200,000	Roosevelt, Horse Mesa, Mormon Flat	Horseshoe, Bartlett, Stewart Mountain	1682	1600	158	88	Archaeological/Historical sites	Relocations	Local Funding Needed
4B New Stewart Mt. + Levees + Direct Connection	82,000	200,000	Stewart Mt.	Horseshoe, Bartlett, Roosevelt, Mormon Flat, Horse Mesa	1785	1676	164	89	Archaeological sites	No significant impacts	Same as 4A
5A SRP Regulation (w/o modifications + Underground Storage	63,000 (reduces SRP water by 88,000 ac-ft	270,000	None	All dams on Salt and Verde	112	106	16	11	Biological Resources; Loss of SRP water	None	Ownership of ground water replacement of lost water
5B SRP Reregulation (w/modifications + Underground Storage)	63,000 (reduces SRP water by 113,000 ac-ft	210,000	None	All dams on Salt and Verde	200	189	23	15	Same as 5A	None	Same as 5A
6 Nonstructural + SRP Exchange	14,500	NA	None	All dams on Salt and Verde	13	13	2	2	Potential adverse impacts on biological resources	None	Agreement w/SRP for exchange highly unlikely

* Costs reflect exchange only. Additional costs could be incurred depending on the final plan.

NOTE: Minor modifications required at existing Stewart Mountain even with upstream Storage on Salt for dam safety.

CHAPTER VIII

RECOMMENDATIONS FOR STAGE III

Based on the analysis and comparison of systems within each concept, as presented in Chapter VII, the following recommendations were made:

A. Eliminate all acreened elements and use only the preferred elements for Stage III formulation.

Four screenings were held: among Verde River elements, confluence sites, channelization options, and regulatory storage elements not located on the Salt or Verde Rivers. Although at the time of the screenings some of the data was preliminary, a review (during the trade-off) of the decisions made showed that the approach was valid and the conclusions sound. If an element was superior to other competing elements, it would remain so in combination with other elements and warranted no reconsideration.

B. Retain all upstream elements for further study at the feasibility level: Confluence Dam, Cliff Dam, New/Enlarged Roosevelt Dam, New Stewart Mountain Dam, and New Waddell Dam.

This recommendation is based on the determination that all upstream elements have the potential for recombination and optimization and specific advantages which warrant further study.

C. The confluence site should not be combined with any other upstream structural element.

Analysis of a "smaller" confluence dam in combination with another structure showed that:

- On the basis of performance, a low or medium-sized confluence dam was inferior to a large confluence dam.
- A single-purpose confluence dam (flood control only or regulatory storage only) was lacking on the basis of performance efficiency.
- While a smaller dam would result in a lesser magnitude of impacts the significance of the impacts would be equal to those of larger dam.
- A lower confluence dam in combination with a second structure compounds impacts.

Therefore, a confluence dam will be considered further only as a single, multipurpose structure, <u>not</u> in combination with other elements. It is important to note, however, that while the dam will be the same in nature as a large confluence dam, it may differ in scope (e.g., size, amount of storage).

D. Eliminate all large levees, but retain the option to use local levees where justified.

Large levees were eliminated on the basis of:

- Excessive cost.
- Prohibitive non-Federal costs (exceeds local ability to fund).
- Unknown effect on sand and gravel mining operations.
- No positive environmental/social advantages to offset high cost.

Studies showed, however, that the concept of local "limited levees" would be considered further in conjunction with upstream control. Limited levees are not viable without upstream control to significantly reduce peak flow. Therefore, limited levees will be considered particularly in reaches where residual damages make them economically feasible. If upstream control leaves little residual damage, limited levees would not be needed.

E. Retain reregulation of SRP for flood control and consider partial reregulation in conjunction with other plans.

Both methods of SRP reregulation (with and without modification of existing structures) accomplish a limited measure of flood control without requiring major construction cost and, on that basis, were recommended for further evaluation in Stage III. The possibility of combining partial reregulation of SRP on the Verde or Salt Rivers with other actions will also be investigated.

F. Eliminate underground storage for CAP regulatory storage, but retain ground water recharge as a possible mitigation for SRP reregulation water losses and for conservation of flood flows.

The study of underground storage as a regulatory storage alternative indicates that the storage of surplus Colorado River water is very likely possible, but not particularly desirable. While it does have the advantages of low environmental impact, low evaporation losses (average 190 acre-feet/year) due to small exposed surface areas in spreading basins, and moderate cost ($102/acre-feet, as compared with $104/acre-feet with the confluence site and $101/acre-feet with New Waddell), underground storage has many disadvantages:

- Operationally difficult to function for regulatory storage (complex interface and exchange with SRP, extensive recovery system, limited ability to increase supplies in surplus years).
- Institutional and legal problems associated with recovery of the water (ownership of water once it reaches ground water table).
- Dependent on energy for water recovery (recovery and aqueduct recharge required summertime energy use, coincident with peak demands; no flexibility in case of system shutdown due to power outage; no power available to run recovery system in case of power outage).

- Optimistic technical assumptions: system assumes 100 percent recovery; less that that would result in increased losses, which tend to offset low evaporation advantage and affect project economics; since underground storage cannot store water as readily as surface storage, the increase of 63,000 acre-feet/year in CAP yield may be optimistic. Studies indicate that project cost would rise dramatically with more detailed study and refinement of assumptions.

Therefore, due to the many deficiencies of the alternative compared to relatively few advantages, no additional investigation of underground storage as a regulatory storage alternative was warranted.

It was determined, however, that ground water recharge has potential for further investigation relative to water conservation: it will be investigated as a means to mitigate water losses due to reregulation (water evacuated to make space for flood flows could be stored underground for later use); and flood flows unable to be stored in surface reservoirs, which currently flow to Painted Rock Dam and are lost to beneficial use, could be conserved through ground water recharge.

G. Delete water exchanges for regulatory storage with the existing SRP system, but retain the option to implement water exchanges with other upstream elements.

Water exchange with the existing SRP system was eliminated on the basis of:

- Low performance (14,500 acre-feet/year increased CAP yield).

- Potential adverse environmental impacts (depletion of stream flows could affect legally-protected species and vegetation).

- Increased risks to dam safety due to fuller reservoirs in winter flood season.

- No potential for increase in conservation of additional local water as with exchange with an expanded SRP system.

However, exchange with an expanded system (i.e., exchange in conjunction with additional flood control) still appears feasible and will be studied further in Stage III.

H. Retain nonstructural flood damage reduction measures both as a possible plan or as an add-on to the strucutral plans.

While nonstructural flood damage reduction measures were not fully developed and evaluated in Stage II, preliminary indications show that a number of them would be effective in reducing flood damages and could be combined with structural solutions to create an effective plan for flood control.

I. Elements may be combined across concepts.

While concepts and systems that were developed for Stage II have been helpful for this phase of the study, they should not necessarily be used in subsequent phases. In the process of evaluating the systems, some elements and some combinations of elements that appear to warrant more study and optimization were identified, and they are not always in the configurations displayed (as described above). Further analysis will not therefore be constrained by concepts nor limited to systems only within specific concepts, but will focus on finding the best alternatives using the reduced set of elements and systems recommended. These are:

- Cliff Dam.
- New/Enlarged Roosevelt Dam.
- New Stewart Mountain Dam.
- Confluence Dam.
- New Waddell Dam.
- SRP Reregulation.
- Water Exchange (with upstream storage).
- Limited Levees.
- Nonstructural Elements.
- Ground water Recharge.

J. The best of the remaining regulatory storage elements may be selected independently of flood control elements.

With the elimination of water exchange with the existing SRP system and underground storage, regulatory storage can be provided by:

- Storage at the confluence.
- Storage at New Waddell.
- Water exchange with an <u>expanded</u> SRP system.
- Direct connection to the CAP aqueduct.

With the exception of confluence storage which was recommended not be considered in combination with other elements, these options have the potential for recombination with any flood control alternative. The selection of best method of regulatory storage is independent of flood control alternatives.

Following review and approval of these recommendations at the regional level of the Service, some additional recommendations were made for initial activities to be conducted at the outset of Stage III. These are:

- Conduct a screening of New Stewart Mountain Dam and Roosevelt Dam to determine the "best" Salt River element.

- Conduct further analysis and screen SRP reregulation methods to determine the "best" method for combination in plans.

- Conduct further analysis and screen nonstructural measures to determine those that could be incorporated into plans.

CHAPTER IX

STAGE III WORK PROGRAM

Based on the recommendations made in Stage II, the agencies developed a work program for Stage III. The work program is divided into five phases:

- o Formulation of alternative plans and identification of candidate plans.
- o Evaluation of candidate plans.
- o Comparison of candidate plan.
- o Selection of recommended plan.
- o Documentation and NEPA compliance.

Following is a summary description of the Stage III work program and the tasks involved. Figure 31 shows the tasks and schedule for Stage III.

A. <u>Formulation of Alternative Plans and Identification of Candidate Plans</u>

The objective of this phase of Stage III is to identify and develop a number of alternative plans incorporating remaining elements, and select candidate plans for detailed analysis. Tasks include:

- o Identify critical environmental/social issues to be addressed in plan formulation.
- o Public review of issues.
- o Identify a number of structural, limited structural, and nonstructrual plans for flood control and regulatory storage.
- o Develop detailed flood control and regulatory storage operating plans, including:
    - . Water operation studies (CAPSIM, SRPSIM), based on site-specific, detailed operating criteria, to determine sizing, reservoir fluctuation, and hydropower potential.
    - . Inflow/outflow flood routing criteria based on target flow through Phoenix, to determine sizing.
    - . Operation criteria to facilitate ground water recharge.
- o Incorporate information from Fish and Wildlife Service and other environmental considerations, including:

- Critical areas which could be avoided if smaller reservoir pools are possible.
- Minimum lake pools needed to support a viable fishery.
- Minimum instream flows to sustain present ecological quality.

o Incorporate information from Safety of Dams, including:

- Identify the most probable solution under the Safety of Dams Act on the Salt and Verde Rivers, independent of the CAWCS.
- Identify alternative plan(s) to meet the combined purposes of Safety of Dams solution and CAWCS.

o Test each plan for completeness, effectiveness, efficiency, and acceptability.

o Select candidate plans.

o Develop a Project Action Description for each candidate plan, detailing:

- Reservoir sizes for structural plans.
- Storage allocation.
- Other factors associated with implementation (e.g., location, operating criteria, approach to construction, length of construction).

Selection of candidate plans is scheduled for completion in May 1981.

B. Evaluation of Candidate Plans

During this phase, candidate plans undergo detailed technical, economic, environmental, social, and recreation analyses, to determine the effects of the plans. Tasks include:

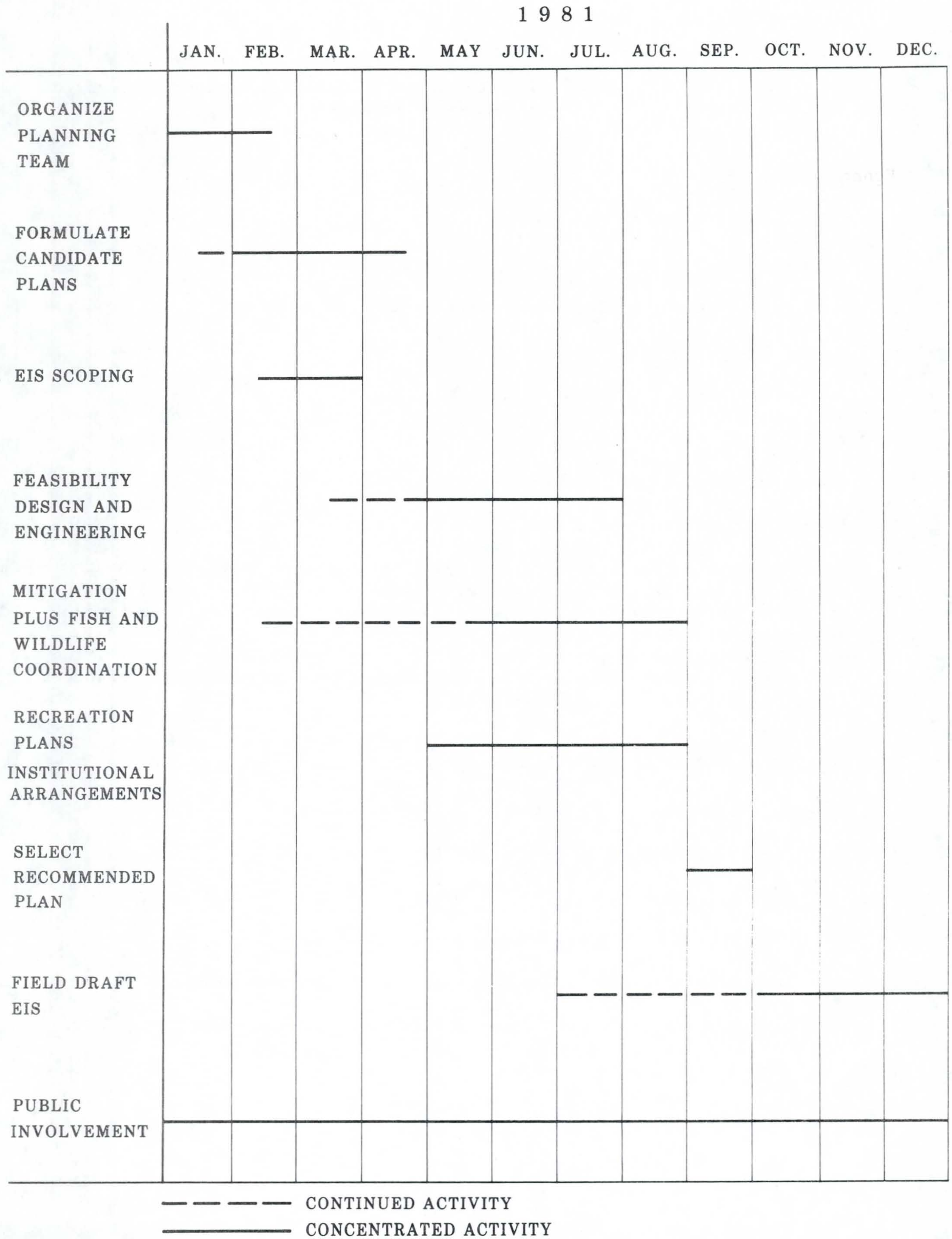
Technical Analysis

o Refine project action hydrology and benefits data, including:

- Reevaluation of flood frequency based on reestablishment of baseline.
- Recalibration of damages caused by specific flow at a specific frequency.

o Complete feasibility design of plan components, including:

- Analysis of practicality and feasibility of design.



CAWCS
STAGE III SCHEDULE

Figure 31

- Identification of design criteria and preliminary engineering design.

- Estimate of feature costs.

Economic Analysis

- Conduct benefit/cost comparisons.

- Determine cost allocation among the various feature purposes.

- Determine Federal/non-Federal cost sharing.

Environmental Effects Analyses

- Develop evaluation methodology.

- Prepare baseline inventory.

- Develop future without the plan.

- Develop future with the plan.

- Based on action descriptions and comparison of future with and without the plan, identify the environmental impacts and effects of each plan, including but not limited to, special studies for impacts on threatened and endangered species (Section 7, Endangered Species Act), historical and archaeological resources (Section 106, National Historic Preservation Act), water quality (Section 404, Clean Water Act), and wildlife resources (Fish and Wildlife Coordination Act).

- Preparation by U.S. Fish and Wildlife Service of a report documenting the impacts and effects of plans on fish and wildlife in the project area.

- Develop mitigation and enhancement plans, including:

  - Identification of areas of potential mitigation.

  - Identification of alternative mitigation/enhancement measures.

  - Negotiation with interested agencies and groups.

  - Identification of candidate mitigation/enhancement plans.

  - Reassessment of impacts with candidate mitigation plans.

Social Effects Analysis

- Develop evaluation methodology.

- Prepare baseline inventory.

- Develop future without the plan.

- Develop future with the plan.

- Based on action descriptions and comparison of future with and without the plan, identify social impacts and effects of each plan, including special economic study as required by Corps of Engineers (Section 122).

- Develop candidate mitigation and enhancement plans.

Recreation Analysis

- Based on conceptual recreation plans developed in Stage II, develop specific, detailed recreation plans of action for each candidate plan, including:

  - Types of recreation.

  - Number of facilities.

  - Projected use.

  - Cost of facilities.

This phase of Stage III is scheduled for completion in September 1981.

C. Comparison of Candidate Plans

During this phase, candidate plans are evaluated and compared to determine:

- Effectiveness of plans in solving the problems and taking advantage of opportunities identified in the planning process.

- Benefit/cost.

- Difference among plans in terms of their effect as shown in four accounts:

  - National Economic Development (NED).

  - Environmental Quality (EQ).

  - Regional Economic Development (RED).

  - Other Social Effects (OSE).

- Public review of plan analysis and comparison.

D. Selection of Recommended Plan

Based on the comparison of the effects of candidate plans and consideration of how well each plan meets the four accounts, a recommended plan will be selected.

Selection of a recommended plan is scheduled for October 1981, at which point, according to the House and Senate Committee reports on Energy and Water Development Appropriation Bill, preconstruction on the recommended preferred plan will be initiated in anticipation of plan approval.

E. Documentation and NEPA Compliance

Upon selection of the recommended plan:

- o Prepare and submit field draft of the environmental mipact statement (EIS). This task will be completed in December 1981.

Following submission of the field draft EIS, the following tasks will be carried out over a period of time:

- o Agency review and revision of field draft EIS.
- o Prepare planning documents and technical appendices.
- o File draft EIS with Environmental Protection Agency.
- o Public hearing and comments.
- o Prepare final EIS, incorporating all comments.
- o Record of decision for final approval of selected plan.

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APPENDIX A

MEMORANDUM OF UNDERSTANDING
BETWEEN

CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

AND

BUREAU OF RECLAMATION
DEPARTMENT OF THE INTERIOR NO. 9-07-30-X0057

PERTAINING TO A STUDY OF ALTERNATIVES
FOR CONTROL OF FLOODS ALONG THE SALT AND GILA RIVERS
AND REGULATION OF CENTRAL ARIZONA PROJECT WATERS

THIS MEMORANDUM OF UNDERSTANDING, entered into this 15th day of December, 1978, between the Corps of Engineers of the Department of the Army, hereinafter referred to as the "Corps," and represented by the District Engineer, Los Angeles District, and the Bureau of Reclamation of the Department of the Interior, hereinafter referred to as the "Bureau," and represented by the Regional Director, Lower Colorado Region together hereinafter termed the "Agencies." This is entered into under the authority of the Act of June 20, 1932, as amended (47 Stat. 382) which is commonly known as the "Economy Act."

WITNESSETH THAT:

WHEREAS, the Central Arizona Project (CAP) was authorized by Public Law 90-537 on September 30, 1968, "for the purpose of furnishing irrigation water and municipal water supplies to the water-deficient areas of Arizona. . . control of floods. . ." and to consist. . ." of the following principal works: . . . (2) Orme Dam and Reservoir and power-pumping plant or suitable alternative . . . ; and

WHEREAS, the President in his Statement on Water Projects dated April 18, 1977, recommended that the CAP be modified by eliminating Orme Dam which would have provided flood control along the Salt and Gila Rivers and regulation of CAP waters; and

WHEREAS, the Council on Environmental Quality Guidelines for Preparation of Environmental Impact Statements pursuant to the National Environmental Policy Act (NEPA) require the responsible agency to study, develop, and describe all reasonable alternatives, including those not within the existing authority of the responsible agency; and

WHEREAS, the Interagency Task Force on Orme Dam Alternatives was unable to make a recommendation on a suitable alternative to Orme Dam, but concluded in its final report, dated May 5, 1978, that further work needs to be done and it now appears possible to select a realistic number of alternatives for detailed analysis; and

WHEREAS, the Resolution by the United States Senate Committee on Public Works, dated July 31, 1973, directed the Board of Engineers for Rivers and Harbors to conduct the Phoenix Urban Study which addresses, among other things, flood problems on the Salt River; and

WHEREAS, the Agencies agree that a multipurpose plan to accomplish the goals of flood control along the Salt and Gila Rivers in the metropolitan Phoenix area and regulation of CAP waters to be imported from the Colorado River is urgently needed.

NOW, THEREFORE, we the undersigned, recognizing the importance of developing a multipurpose plan resulting from a Study of Alternatives for the Control of Floods along the Salt and Gila Rivers and the Regulation of Central Arizona Project Waters, hereinafter referred to as "the Study," hereby agree as follows:

I. Objectives:

A. Development of viable alternative plans for flood control and regulation of CAP waters;

B. Identification of other needs including, but not limited to, water-based recreation, fish and wildlife, hydropower, ground-water recharge, and environmental protection and enhancement;

C. Obtaining of technical, environmental, economic, and social data required for the formulation and evaluation of alternative plans;

D. Fulfillment of the requirements of NEPA regarding the preparation of an environmental impact statement from which the appropriate administrative or legislative action can be taken;

E. Maintenance of a high degree of public and other agency involvement to insure clear and accurate two-way exchange of information on the plans, the decision-making process, and other major study areas of interest.

II. General Provisions:

A. The Agencies shall assign the highest priority to the Study consistent with other responsibilities.

B. The applicable elements of the Principles and Standards for Planning Water and Related Land Resources adopted by the Water Resources Council shall be applied.

C. The applicable elements of President Carter's Water Policy message of June 6, 1978, shall be used in the conduct of the Study.

D. All information developed by the Study or other applicable studies shall be available to each Agency.

E. The Agencies recognize the need to enter into contracts to procure outside services. The Bureau will contract for services involving a public involvement program, and for environmental, social, and economic demographic studies. Other contract services will be procured by either Agency as required; however, procurement of contract services by the Corps will be coordinated with the Bureau.

F. The Agencies will prepare a Plan of Study, describing the specific tasks to be accomplished, responsibilities for the tasks, the schedule, a public involvement program, and other pertinent information. Upon completion and agreement by both Agencies on the Plan of Study, such Plan of Study will become a part of this Memorandum of Understanding.

III. Responsibilities:

The Bureau will have full responsibility for accomplishing the Study. The Corps will provide input as agreed to in the Plan of Study. The Corps input will meet Corps survey report standards for flood control planning.

IV. Program Management:

The Agencies will each name an agency manager to assure continual coordination and adherence to a program schedule. The agency managers shall:

A. Coordinate with their respective agencies to assure adherence to study scope, logic, and schedules, as defined in the Plan of Study.

B. Maintain a study schedule showing tasks to be accomplished by the Agencies, other agencies, and contractors; funding requirements, and personnel needs and services to assure that study objectives are being met.

C. Solicit, as needed, assistance and cooperation from other agencies and the public.

D. Assure adequate public involvement.

E. Prepare periodic progress reports to the Agencies and the public involvement groups.

V. Funds:

Funds for the Study will be those authorized for appropriation by Public Law 90-537 or other applicable law. Should Congress fail to provide the funds required, the Memorandum may be terminated by either Agency.

VI. Modification:

Modification of the Memorandum, consistent with its purpose and within its general scope, may be accomplished by written agreement between the Agencies either by exchange of letters or in the form of an amendment.

VII. Duration:

This Memorandum shall continue in force through September 1982, unless terminated earlier by either of the Agencies by the giving of sixty (60) days notice in writing. It may be extended by written agreement between the Agencies either by exchange of letters or in the form of an amendment.

Bryon A. Teague
District Engineer
Corps of Engineers

Dated: 21 Dec 78

M. Lopez Jr.
Regional Director
Bureau of Reclamation

Dated: Jan 3, 1979

APPENDIX B - Advisory Group Membership

Governor's Advisory Committee

Dr. Lee Thompson, Chairman
Arizona State University

Herschel Andrews
Salt River Pima-Maricopa Indian Council

Ben Avery
Wildlife Groups

Tom Chauncey, Sr.
KOOL-TV

Joan Enos
Fort McDowell Tribal Council

Tom Fannin
Real Estate

Honorable Art Hamilton
State Representative, District 22, South Phoenix

Honorable Margaret Hance
Mayor of Phoenix

Honorable John B. Hawley
Mayor of Buckeye

Honorable Herbert R. Drinkwater
Mayor of Scottsdale

Thomas Jones
Fort McDowell Tribal Council

Sue Lofgren
League of Women Voters

Honorable Dessie M. Lorenz
Mayor of Avondale

Manuel G. Marin
South Phoenix

Chet McNabb
Superintendent, Buckeye School District

Honorable Harry Mitchell
Mayor of Tempe

John R. Norton, III
Agriculture

Ed Pastor
Maricopa County Board of Supervisors

Eva Patten
Governor's Commission on the Environment

Honorable Don Strauch
Mayor of Mesa

Hank Raymond
Central Arizona Project Association

Bill Schultz
Developer

Norris Soma
San Carlos Irrigation and Drainage District

Don Tostenrud
Arizona Bank

Keith Turley
Arizona Public Service Company

Mason Walsh
Publisher, Phoenix Newspapers

Howard Wuertz
President, Central Arizona Water Conservation District

Dr. Robert Witzeman
The Maricopa Audubon Society

Technical Agency Group

Federal Representatives

Advisory Council on Historic Preservation - Robert Fink
Army Corps of Engineers - LTC Joseph Gross, Joe Dixon, Carol Grooms
Bureau of Indian Affairs - Richard Jefferies
Bureau of Land Management - Hal Ramsbacher
Bureau of Mines - Joe B. Smith
Soil Conservation Service - Thomas Rockenbaugh
Fish and Wildlife Service - Jennifer Fowler
National Park Service - Roy Allen
Environmental Protection Agency - Pete Uribe
Federal Highway Administration - Lawrence O'Toole
Interagency Archaeological Services - Garland Gordon
Tonto National Forest - James L. Kimball, Larry Forbis
Geological Survey - Robert MacNish
Western Area Power Administration - David Onstad
Department of Housing and Urban Development - Walter Durant, Thomas Webster
Department of the Interior - Pat Port

Indian Reservation Representatives

Fort McDowell Mohave-Apache Tribal Council - Clinton Pattea, Patricia Mariella, Don Schaffer
Gila River Indian Community - Alexander Lewis, Arnold Juan
Salt River Pima-Maricopa Indian Community - Herschel Andrews, Roger Evans

State Representatives

Governor's Office - Larry Landry
Senate, Research Assistant to the President - Victoria Greenfield
House, Minority - Staff - Lynn Dunton
Bureau of Mineral and Geology Technology - Robert Scarborough
Department of Game and Fish - John Carr
Department of Health Services - Dr. Ronald L. Miller, Martin Garz
Department of Transportation - Bruce Meyers, Bert Solano
Outdoor Recreation Coordinating Commission - Mary Alice Bivens
State Land Department - Joe Fallini
State Parks Board - Michael Ramnes
Department of Water Resources - Frank Barrios
Division of Emergency Services - Mark Fooks, Charles Ott

County Representatives

Maricopa Association of Governments - Mark Frank, James Reynolds
Maricopa County:
  Health Services - Harry T. Crohurst
  Parks and Recreation - Bill Richwine
  Planning - Don McDaniel
  Highway - Harry R. Keller

Special District Representatives

Central Arizona Water Conservation District - Zada Darter
Flood Control District of Maricopa County - William Mathews
Maricopa County Municipal Water Conservation District No. 1 - H. S. Raymond
Rio Salado Development District - Tim Bray

Local Representatives

City of Avondale - Larry Ramirez
City of Glendale - S. F. Van De Putte
City of Mesa - Dean Sloan
City of Peoria - Bill Parks
City of Phoenix - Jim Attebury
City of Scottsdale - Leonard L. Dueker
City of Tempe - Kenneth McDonald
City of Tolleson - David M. Mansfield
City of Buckeye - Steven L. Thompson
City of El Mirage - Harold Branch
Salt River Project - Don Womack

Other

Willdan Associates - Peggy Garrington
Inter-Tribal Council of Arizona - Michael Hughes
Maricopa County Audubon Society - Sue Monroe, Frank Welsh, Dr. Robert Witzeman

APPENDIX C - GLOSSARY

ACRE-FEET: A measure of the volume of water to cover 1 acre of land to a depth of 1 foot.

AVERAGE ANNUAL DAMAGES: An estimate of the amount of flood damage to be expected over an estimated period of time, based on a combination of historical flood damage and projected runoff level from a variety of different storms.

BENEFIT/COST RATIO: A measure of economic efficiency which indicates whether a project would return more in benefits than it would cost.

CENTRAL ARIZONA PROJECT (CAP): A system of aqueducts, being constructed by the Water and Power Resources Service as part of the Lower Colorado River Basin Project Act, to bring Colorado River water to water-deficient areas of central Arizona and western New Mexico. Water will be delivered to the metropolitan Phoenix area by 1985 and to the Tucson metropolitan area by 1988.

CUBIC FEET PER SECOND (ft^3/s): Measure of the magnitude of flow in a stream. Streamflow is measured by the number of cubic feet of water passing a given point each second.

DESIGN DISCHARGE: The amount of flow through an area to keep damages to an "acceptable" level.

ENDANGERED SPECIES ACT OF 1973: The Federal Act which requires Federal agencies to protect and conserve endangered species against any adverse effects of Federal actions. Section 7 of the Act outlines a consultation process under which Federal actions are reviewed by the President's cabinet for exemption.

FISH AND WILDLIFE COORDINATION ACT OF 1958: The Federal Act which requires that during planning of a Federal water project, equal consideration be given to fish and wildlife as to all other resources. Under the Act, agencies must consult with the U.S. Fish and Wildlife Service and the State agency, and reports and recommendations of these agencies are made part of the Federal agency report.

FLOOD CONTROL ACT OF 1944: This Act assigns to the U.S. Army Corps of Engineers the responsibility to prescribe regulations for use of storage allocated for flood control at all reservoirs constructed with Federal funds.

FLOOD: Overflow of water on lands not covered by water under normal flows.

FLOOD CONTROL: The temporary capture and control of water in a reservoir regardless of source or rate of inflow for the purpose of decreasing downstream damage which would otherwise occur from such flows.

FLOOD PEAK: The highest flow rate encountered during a flood event.

FLOOD PLAIN: Land adjacent to the channel of a river or stream that has been or may be inundated by water.

"FUTURE WITHOUT": Future without the project conditions; a projection of physical, environmental, social and economic conditions, assuming no regulatory storage of CAP water or new federally funded flood control projects as proposed by CAWCS are implemented.

INFLOW DESIGN FLOOD (IDF)/PROBABLE MAXIMUM FLOOD (PMF): The maximum runoff, in peak flow, that could ever occur in the watershed under extreme climatological and meteorological conditions; the IDF/PMF controls the design and sizing of protective works for a dam itself (e.g., spillway, outlet works or surcharge space). In developed areas the IDF is equal to the PMF.

NATIONAL ENVIRONMENTAL POLICY ACT OF 1969: The Act which insures the restoration, protection and enhancement of the environment, establishes procedures to ensure that alternative actions are studied and that environmental concerns are used in decisionmaking, and requires preparation of an environmental impact statement (EIS) for all major Federal actions.

NET BENEFITS: A measure of economic efficiency of a project; the difference between benefits and costs.

NATIONAL HISTORIC PRESERVATION ACT: This Act provided for the creation of the National Register of Historical Places and a special advisory council that would review and comment on any federally sponsored action that could affect properties on or eligible for the National Register (Section 106 Consultation).

PRINCIPLES AND STANDARDS: Procedures established by the U.S. Water Resources Council under congressional authority, which specifically requires that Federal and federally-assisted water and land activities must be planned with National Economic Development (NED) and Environmental Quality (EQ) as co-equal national objectives.

RECLAMATION SAFETY OF DAMS ACT: Legislation authorizing the Secretary of the Interior to construct, restore, operate and maintain new and existing Federal reclamation dams for the purposes of dam safety.

REGULATORY STORAGE: A specific purpose for which conservation storage space in a reservoir may be used to balance the water supply and water demands over a given period of time.

SPILLWAY: A structure on or adjacent to a dam, designed to pass the flow in excess of the capacity of the reservoir and outlets.

STANDARD PROJECT FLOOD (SPF): The most severe flood that can reasonably be expected to occur in a region based on its geographic and meteorological historic characteristics. In the CAWCS area, this flood has been established as 295,000 ft^3/s as it passes the Salt/Verde confluence.

SURCHARGE SPACE: Space in a reservoir where the volume of floodwater in excess of the normal reservoir level can be stored temporarily. It serves to force the water through the spillway.

THREATENED AND ENDANGERED SPECIES: An endangered species in any fish, wildlife or plant that is in danger of extinction throughout all or a significant portion of its range. A threatened species is any fish, wildlife or plant that is likely to become an endangered species within the foreseeable future.

WATERSHED: Area or region in which the rainfall or snowmelt drains to a particular water course or body of water.