STAGE III REPORT ADDENDUM

CENTRAL ARIZONA PROJECT

MARCH 1984

REGULATORY STORAGE DIVISION

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LOWER COLORADO REGION

STAGE III REPORT ADDENDUM

CENTRAL ARIZONA PROJECT
REGULATORY STORAGE DIVISION
(PLAN 6)

MARCH 1984

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Robert A. Olson, Acting Commissioner
N.W. Plummer, Regional Director
Lower Colorado Region

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

Nothing in this study is intended to interpret the provisions of the Colorado River Compact (45 Stat. 1057), the Upper Colorado River Basin Compact (63 Stat. 31), the Water Treaty of 1944 with the United Mexican States (Treaty Series 994, 59 Stat. 1219), the decree entered by the Supreme Court of the United States in Arizona v. California, et al. (376 U.S. 340), the Boulder Canyon Project Act (45 Stat. 1057), the Boulder Canyon Project Adjustment Act (54 Stat. 774; 43 U.S.C. 618a), the Colorado River Storage Project Act (70 Stat. 105; 43 U.S.C. 620), or the Colorado River Basin Project Act (82 Stat. 885; 43 U.S.C. 1501).

SUMMARY SHEETS

Location

The plan would consist of dams located on the Salt, Verde, and Aqua Fria Rivers in Central Arizona.

Plan

The plan would consist of constructing New Waddell Dam for regulatory storage, flood control, and recreation. This dam would be located on the Agua Fria River, immediately downstream of the existing Waddell Dam. A 4.7 mile long reversible canal would connect New Waddell Reservoir with the Central Arizona Project (CAP) aqueduct. Colorado River water would flow through this canal and be pumped into the reservoir for storage. The water would be released back into the canal for distribution to CAP users during periods of peak demand. Cliff Dam would be constructed on the Verde River between Bartlett and Horseshoe Dams for flood control, additional water conservation, recreation, and dam safety. The existing Theodore Roosevelt Dam, located on the Salt River, would be modified. Stewart Mountain Dam, also located on the Salt River, would be modified as part of the plan to ensure its safety.

This project would provide regulatory storage and new conservation space for the CAP. The average annual yield would be 137,600 acre-feet. Sufficient flood control space would be provided to control the 200-year Salt River flood event to a flow of 92,000 cfs, measured at Phoenix Sky Harbor International Airport, and the 100-year event of 55,000 cfs. This plan would also alleviate safety problems at the existing Salt and Verde River dams. Additional hydropower, recreation, and fish and wildlife enhancement would also result from this plan.

These purposes would be accomplished without adversely impacting existing facilities. Any water supply, hydropower capacity, or recreation facilities lost would be replaced as part of the plan.

Project Features

Dams	New Waddell (Rockfill)	Modified Roosevelt (Concrete)	Cliff (Earth)	Modified Stewart Mountain (Concrete)
Crest Elevation (feet)	1,735	2,210	2,152	1,535
Height Above Streambed (feet)	400	340	335	116
Dam Volume (cubic yards)	16,000,000	240,000	16,500,000	130,000
Spillway Capacity (cfs)	330,000	99,500	148,700	210,000
Reversible Canal				
Capacity (cfs)	3,000	—	—	—
Length (miles)	5	—	—	—

Dams	New Waddell (Rockfill)	Modified Roosevelt (Concrete)	Cliff (Earth)	Modified Stewart Mountain (Concrete)
Storage Allocation (acre-feet)				
Dead	600	25,500	3,555	—
Inactive	5,000	308,300	6,445	—
Replacement	157,600	1,275,000	131,427	59,800
Regulatory Storage	728,800	—	201,313	—
New Conservation	—	—	451,000	—
Flood Control	—	557,000	948,000	—
Surcharge	257,300	993,300		—

NOTE: The storage data allows for projected 100-year sediment deposition.

Appendices to the Regulatory Storage Division Stage III Report Addendum have been prepared in five volumes as follows.

Appendix A
Designs and Estimates

Appendix B
Water Supply and Operations

Appendix C
Biological Resources
Cultural Resources
Recreation

Appendix D
Social Assessment

Appendix E
Economic and Financial Analyses
Plan Formulation

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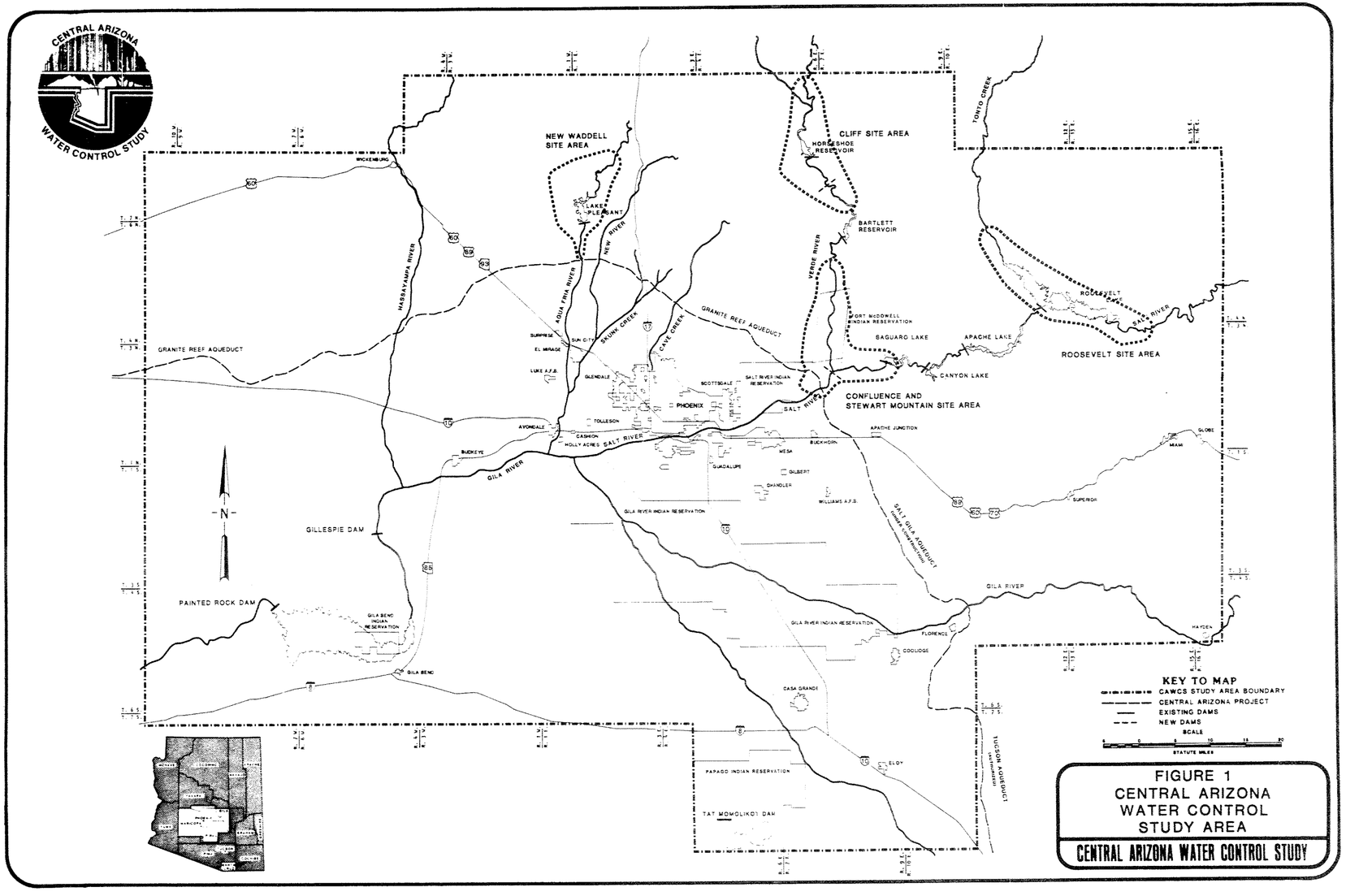
INTRODUCTION

The construction of Orme Dam or suitable alternative was authorized in 1968 by the Colorado River Basin Project Act (Public Law 90-537). It included the construction of Orme Dam, or suitable alternative, as part of the Central Arizona Project (CAP). A draft Environmental Impact Statement (EIS) was prepared for Orme Dam in 1976. Public response to the statement indicated substantial environmental, economic, and social concerns regarding inundation of a major portion of the Fort McDowell Indian Reservation and riparian habitats, impacts on flowing stream recreation, and impacts upon the endangered bald eagle and other wildlife. These and other concerns caused the Bureau of Reclamation (Bureau) to reassess the merits of Orme Dam and identify several alternatives for further study. The Central Arizona Water Control Study (CAWCS) was initiated in July 1978 to develop and evaluate alternatives, including a dam at the confluence of the Salt and Verde Rivers, for flood control in the Phoenix metropolitan area and regulatory storage of CAP water in central Arizona (see Figure 1).

This report is an addendum to the Stage III Report (April 1983) which documented the process used to determine the agency proposed action and provided plan formulation support for the Regulatory Storage Division EIS. This addendum documents the results of the more detailed engineering studies and other refinements for the proposed action. It has been determined that this refinement and more detailed information would not change the impacts as displayed in the EIS. This addendum is supported by the following appendices: Appendix A, Designs and Estimates; Appendix B, Water Supply and Operations; Appendix C, Biological Resources, Cultural Resources, and Recreation; Appendix D, Social Assessment; Appendix E, Economic and Financial Analysis; and Plan Formulation. The report and supporting appendices include the physical data and financial and economic analyses based on the requirements of the project authorizing act and current Federal policies relating to water resource development. All aspects of the plan are considered to be within the scope of the project as authorized by Congress.

This report also documents the dam safety repairs required because of hydrologic problems associated with dams on the Salt and Verde Rivers. These repairs were included in this addendum because of the multipurpose nature of the proposed features. Stewart Mountain Dam was also included as part of the plan even though it was single purpose Safety of Dams because there existed potential for significant environmental impacts. These repairs would be made in accordance with the Reclamation Safety of Dams Act of 1978. These repairs and additional repairs on the Salt and Verde Rivers for dam safety are also described in the 1984 report on Safety of Dams modifications.


CENTRAL ARIZONA WATER CONTROL STUDY
NEW WADDELL SITE AREA
CLIFF SITE AREA
HORSESHOE RESERVOIR
BARTLETT RESERVOIR
LAKES PLEASANT
NEW RIVER
VERDE RIVER
HASSAYAMPA RIVER
AGUA FRIA RIVER
SKUNK CREEK
CAVE CREEK
GRANITE REEF AQUEDUCT
TONTO CREEK
ROOSEVELT
SALT RIVER
FORT McDOWELL INDIAN RESERVATION
SAGUARO LAKE
APACHE LAKE
CANYON LAKE
ROOSEVELT SITE AREA
CONFLUENCE AND STEWART MOUNTAIN SITE AREA
SALT RIVER INDIAN RESERVATION
PHOENIX
SCOTTSDALE
GLENDALE
SUN CITY
SURPRISE
EL MIRAGE
LUKE A.F.B.
TOLLESON
AVONDALE
CASHION
HOLLY ACRES
BUCKEYE
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GILA RIVER INDIAN RESERVATION
GUADALUPE
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GILBERT
CHANDLER
WILLIAMS A.F.B.
BUCKHORN
APACHE JUNCTION
SALT GILA AQUEDUCT
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MIAMI
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PAPAGO INDIAN RESERVATION
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PAINTED ROCK DAM
GILA BEND INDIAN RESERVATION
GILA BEND
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NEW DAMS
SCALE
STATUTE MILES
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CENTRAL ARIZONA
WATER CONTROL
STUDY AREA
CENTRAL ARIZONA WATER CONTROL STUDY

CHAPTER 1

BACKGROUND

Project Setting

The Project area encompasses portions of Maricopa, Gila, and Yavapai Counties and is characterized by mountain ranges with steep slopes and rugged topography separated by broad, gently-sloping, alluvium-filled valleys. The climate is arid to semi-arid. 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 and includes gray fox, mule deer, and desert cottontail rabbit. Several Federally-designated 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.

Vast areas remain in their natural state, unaltered or only slightly modified by man's activities. About 75 percent 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 remain in public ownership or are Indian reservations.

The Project area is located near a major center for economic activity in the Southwest. Leading economic factors are manufacturing, tourism, retail trade and services, government, and agriculture.

Water comes from major streams and their tributaries, many located within the Project area, and from ground water. According to the Arizona Water Commission (1978), the total annual consumptive use of water in the Salt River Basin is estimated at 1.6 million acre-feet, while the total annual dependable surface supply is only 931,000 acre-feet (normalized 1970 conditions). Ground water 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 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.

Population

Almost all of the Project area lies within rapidly growing Maricopa County. With over 1,552,500 inhabitants as of 1981, it is the most populous of Arizona's 14 counties. Portions of Yavapai and Gila Counties are also in the Project area. Most of the population resides in the Salt River Valley, leaving much of the region sparsely settled or uninhabited. Phoenix, with a population of 810,000 is the principal community located near the Project area. Other prominent towns include Scottsdale, Tempe, Mesa, Glendale,

Buckeye, Gila Bend, Florence, Coolidge, and Casa Grande. Five Indian reservations are also included: The Fort McDowell Reservation on the lower Verde River, the Gila River Reservation, the Salt River Reservation north of the Salt River east of Phoenix, the Ak-Chin Reservation and two portions of the Papago Reservation including the northern portion near the Tat Momolikot Dam, and the Gila Bend Unit along the Gila River near Painted Rock Dam. For population statistics see Tables 1 and 2.

Economy

The Project area is located near a major center for economic activity in the Southwest. Leading economic factors are manufacturing (principally high technology products), tourism, retail trade and services, and government. 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.

Water Resources Profile

The major streams are the Salt, Verde, and Agua Fria Rivers. Their tributaries include New River, Skunk Creek, Cave Creek, Indian Bend Wash, and Sycamore Creek, as well as several smaller arroyos and washes. With the exception of the perennial Salt and Verde Rivers above Granite Reef 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.

The Salt and Verde Rivers are controlled by six dams, four on the Salt (Stewart Mountain, Mormon Flat, Horse Mesa, and Theodore Roosevelt) and two on the Verde (Bartlett and Horseshoe). These structures which, along with the operating agency, are known as the Salt River Project, impound reservoirs which provide irrigation and domestic water for metropolitan Phoenix and were not designed, nor authorized, for flood control even though they provide incidental flood damage reduction. At Granite Reef Diversion Dam, waters from the Salt and Verde Rivers are channeled into canals which serve the Phoenix area. The Agua Fria River is impounded by Waddell Dam, forming Lake Pleasant. This dam and reservoir are owned by and provide water to Maricopa County Municipal Water Conservation District #1 (MCMWCD#1).

In the Arizona Water Commission's Phase I - Arizona Water Plan (1975), the average annual consumptive use of water in the Salt River Valley Basin is estimated at 1,563,000 acre-feet, while the average annual supply is only 931,000 acre-feet. The ground water reserves are being overdrafted at the rate of 632,000 acre-feet per year to supplement the dependable surface supply. Comparable figures for the entire state show that the average annual consumptive use in Arizona is 4,800,000 acre-feet while the average

TABLE 1/

Population Growth and Racial Distribution
Arizona, Maricopa County

Year	Arizona	Maricopa County
1960 (census)	1,302,160	663,510
1965	1,584,000	852,000
1970 (census)	1,775,400	971,230
1975	2,212,000	1,209,800
1976	2,270,000	1,260,500
1977	2,364,000	1,292,000
1980 (census)	2,718,450	1,509,250
2000 (projected)	4,626,000	2,634,700

Racial Distribution 2/
(April 1982)

Race	Arizona	Maricopa County
White	2,240,750	1,307,450
Spanish Heritage	440,700	199,000
Indian	152,750	22,900
Negro	74,970	48,100
Other	227,700	117,450
TOTAL	3,136,870	1,694,900

1/ Census year data from the Bureau of the Census. Others from the Arizona Department of Economic Security.

2/ Valley National Bank, Arizona Statistical Review, 1982.

TABLE 2

Enrolled Populations of Indian Reservations[1/]

Ak-Chin Indian Community	414
Fort McDowell Mohave-Apache Indian Community	389
Salt River Pima-Maricopa Indian Community	4,085
Gila River Indian Community	9,784
Gila Bend Unit[2/]	357
Sif Oidak District[2/]	650
TOTAL	11,679

1/ Arizona Tribal Directory, 1983

2/ Districts of the Papago Tribe of Arizona

annual supply is 2,800,000 acre-feet. The state-wide ground water overdraft of approximately 2 million acre-feet per year is indicated by the difference in these numbers.

Vegetation

Vegetation varies considerably and correlates directly with elevation, available moisture, and temperature. The desert plains in the western portion of the area support only the hardiest plantlife, such as creosote bush and bursage. Stands of mesquite, palo verde, and ironwood are found along the intermittent creeks, washes, and rivers. More lush riparian vegetation occurs along flowing streams. Much desert and riparian plantlife, however, have been lost through agricultural development and urbanization of metropolitan Phoenix. In the higher elevations, up to about 4,000 feet, greater rainfall and rugged terrain support lush desert vegetation marked by large cacti, palo verde, ironwood, and mesquite trees. Stands of oak and pine are found in the well-watered mountains and drainage regions.

In historic times, non-native crops supported by intense irrigation were introduced into the Salt and Gila River Valleys. Leading agricultural products include seed crop (cotton, milo, barley, sorghum, and alfalfa), vegetables, fruit (citrus and grapes), and nut crops.

Recreation

Recreation and its economic manifestation, tourism, are significant factors. Central Arizona has diverse recreational resources which present a unique variety and abundance of recreational opportunities. Traditional promotional endeavors recognize and enhance the depiction and cognizance of the area as a year-round recreational utopia. The lakes, rivers, mountains, desert, and "warm winter weather" all combine to attract and satisfy residents and visitors. In addition, the proximity to such renowned attractions as the Grand Canyon, Lake Mead, and the Colorado River further attracts visitors. Phoenix has a major segment of its economy devoted to accommodating the recreational pursuits of the visitor. The water resources support such popular activities as boating, waterskiing, fishing, sailing, hiking, camping, picnicking, rafting, tubing, etc. The major lakes which have significant recreational use and facilities are Saguaro, Canyon, Apache, and Theodore Roosevelt Lakes on the Salt River; Bartlett and Horseshoe Lakes on the Verde River; and Lake Pleasant on the Agua Fria River. An existing and extensive network of recreational features, with emphasis on recreational uses of water, has developed. Over 80 percent of Arizona's population resides in the area and accounts for much of the demand on the existing recreational features.

Biological Resources

Wildlife is typical of that found in the desert Southwest. Faunal diversity is dependent upon habitat type, with creosote-bursage communities having less diversity than palo verde-mixed cacti. Riparian habitats support the greatest density and diversity of wildlife due to the intermingling of water dependent and independent species. Important species include the bald

eagle, Yuma clapper rail, mule deer, javelina, bob cat, kit fox, desert tortoise, and gila monster. Fisheries exist primarily in the Salt and Verde Rivers and their associated reservoirs, and in Lake Pleasant. Both native and introduced species occur in the area, including large mouth bass, bluegills, crappie, roundtail chub, gila topminnow, and several species of catfish.

Cultural Resources

The American Southwest has been occupied for at least 13,000 years. The history of the human use of the area has been recorded in written form for only the last three centuries and it is often sketchy. The only record for the prehistoric era, and portions of the historic era as well, lies in archeological sites, which are abundant within the project area. From initial settlement until around the time of Christ, human occupants of the area lived a nomadic life, hunting and gathering native plants and animals. Subsequently, a settled farming economy developed and the Hohokam Indians of the Salt-Gila Basin developed one of the most elaborate irrigation systems in the New World. Other surrounding similar cultural groups such as the Sinagua and Salado, lived north of the Hohokam but are less well documented. The complex sociocultural system of these sedentary farmers collapsed about a century prior to the arrival of the first European explorers. In the 1500's and 1600's when the Spanish conquistadors and priests arrived, Pima Indians were farming along the Gila River but had a smaller population and a simpler political and economic system than the Hohokam. The nomadic Yavapai and Apache lived in the more rugged country north of the Salt River valley.

After the Mexican War of Independence, the Spanish era ended in 1821. Mexican hegemony lasted only until 1848 and resulted in few changes. The United States acquired the area north of the Gila River in 1848 as a result of the Mexican-American War and the area south of the Gila was acquired in 1853 by the Gasden Purchase. Within a few decades, native Americans were relegated to reservations.

During the mid 1860's, American settlers resumed the earlier Hohokam practice of diverting water from the Salt River and irrigating farmlands. Later in the decade Phoenix was established. Construction of the Arizona Canal north of the Salt River and other canals to the south of the Salt River, and the arrival of branchline railroads connected to transcontinental routes resulted in expansion of agriculture with the subsequent growth of Phoenix and development of a number of satellite communities during the 1880's and 1890's.

Destructive floods in 1891, together with a drought which began in the 1890's and lasted into the early 20th century, caused farmers and townspeople to seek a dependable source of water. Their efforts resulted in construction of Theodore Roosevelt Dam, the first multipurpose dam authorized under the National Reclamation Act of 1902. Completed in 1911, this structure provided both irrigation water and hydroelectric power. In the 1920's and 1930's, three more dams were built on the Salt River to conserve water and generate hydroelectric power. Two dams were constructed on the Verde River as well.

During World War II, the Salt River Valley was the site of a number of military airfields and defense plants. After the war, the area entered into a sustained period of urbanization and industrialization. The development of air-conditioning made life in metropolitan Phoenix comfortable the year round. People and businesses continue to be attracted by the dry climate and increasing economic opportunities.

CHAPTER II

PROBLEMS, NEEDS, AND ISSUES

The problems, needs, and issues of the Region which were addressed in this study include flood control, water supply, and related environmental and socioeconomic factors. The following provides a discussion of the problems, needs, and issues identified during this study.

Flood Control

Flooding along the Salt and Gila Rivers has been recorded since the 1860's. The largest flood on record occurred in February 1891. A list of significant flows on the Salt River is provided in Table 3. These flows confirm the flood hazard conditions along the Salt and Gila Rivers and the need to formulate and implement a plan to reduce flood damages.

Although there have been numerous flows in the Salt River, the climate is still considered arid. Because of this, dams were built on the Salt and Verde Rivers to capture as much water as possible for future use. Although these dams and reservoirs were not designed to provide flood control, they incidentally reduce peak flows when storage space is available. Since the primary purpose of the dams is water conservation and not flood control, the reservoirs are often filled to capacity. Consequently there is no dedicated space in the system for controlling large floods.

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 metropolitan Phoenix isolate communities from vital services and impose hardships on residents who must cross the river. In fact, the cost to the region in traffic delays produced when all but three bridges across the Salt River were closed in December 1978 accounted for over 40 percent of the losses reported. Construction of larger bridges over the Salt River will reduce these losses significantly. On the Salt River, 12 bridges are planned or have been constructed by city, county, and state agencies. The majority (nine) of these bridges have a capacity of 200,000 cfs. Two large bridges are planned for the Gila River (200,000 cfs); one on the Verde River (55,000 cfs), and four on the Agua Fria River (85,000 - 160,000 cfs).

Water Supply

Because the climate is arid, maintaining an adequate water supply for agricultural, municipal, and industrial purposes is a major problem. A satisfactory solution to the water supply problem is being sought by the State of Arizona through the Arizona Department of Water Resources' comprehensive analyses of water supply and demand issues. Water conservation (efficient

TABLE 3

Floods on the Salt River Below
Granite Reef Dam

Date	Peak Flow cfs	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
December 1965/January 1966	67,000	6.0
February 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/
December 1982-June 1983	30,000	N/A
October 1983	41,000	N/A

1/ Not Estimated

2/ Not including agricultural damages

use of existing water supplies) is one means identified as a partial solution to the problem. Arizona's new ground water management law is aimed at achieving a "safe yield" (ground water withdrawal equal to replacement) in Maricopa County by the year 2025.

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.

Although efficient use alone would not resolve the State's water problems, it can supplement other measures designed to balance the region's water budget. Efficient use of local water supplies does not result directly from implementation of regulatory storage features; however, the result of the State's water conservation efforts would be reflected in future use of Central Arizona Project (CAP) water.

Another method the State will use to help solve its water problem is importation of Colorado River water via the CAP. 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 1991. The CAP will divert between 0.4 and 2.2 million acre-feet per year from the Colorado River, depending on the system's available storage capacity, user requirements, and the availability of water in the Colorado River.

It is estimated that with regulatory storage the CAP delivery could be increased 13 percent on an average annual basis. 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 the use of Colorado River water. According to the Colorado River Basin Project Act, which authorized the 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 during the year.

Providing regulatory storage capability in the CAP would increase the reliability of the system in meeting seasonal water demands, providing flexibility in emergency situations, reducing energy use during peak periods, and ultimately, influencing the amount of water that can be imported from the Colorado River.

Conservation of surplus local flows is another method that would help solve the State's water supply problem. 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.

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.

Water Quality

The impacts on water quality resulting from implementation of the regulatory storage plan were analyzed in relation to current beneficial uses (agricultural, fisheries, domestic) of water in the area. The three issues of most concern raised during plan formulation were salt loading, eutrophication potential, and possible degradation of existing surface water systems.

Salt loading occurs when saline irrigation water is applied to agricultural lands with inadequate drainage to remove the added salt from the soil profile. Salt accumulation in the soil may adversely affect crop production. The CAP, without regulatory storage, is expected to import an average 1,020,000 tons of salt per year. The increased water supply attributable to the regulatory storage plan would increase the salts imported by approximately 153,000 tons per year (15 percent). This increase is considered insignificant in comparison with the total salt imports. With or without regulatory storage, the concentration of dissolved salts in CAP import water is sufficiently low for long term irrigation of properly drained lands.

Eutrophication refers to increased biological productivity in a body of water which can result in degradation of water quality for many uses. Nuisance algae blooms are common in eutrophic water bodies and may impart taste and odor, decrease clarity, reduce dissolved oxygen, and cause unsightly films on the water surface. Eutrophication may increase water treatment costs, decrease recreation activities, and result in unaesthetic reservoir appearance. The results of the analysis for New Waddell Reservoir indicated a low-to-moderate probability of eutrophication. A more detailed discussion of eutrophication may be found in Chapter VI, page 63.

The quality of both surface and ground water within the CAP service area varies greatly. One indicator of water quality is Total Dissolved Solids (TDS), which is presented in Table 4 for the various surface water sources.

Any mixing of Colorado River water with existing surface water would alter the existing quality. New Waddell Reservoir was evaluated for possible degradation of various water quality constituents. Using a blending ratio of nine parts Colorado River water to one part Agua Fria River water, average TDS would increase 98 percent, from 358 mg/l to 710 mg/l. Other constituents, such as sulfate, sodium, chloride, and calcium, also would increase significantly. However, the mixed water would still meet all required standards and remain suitable for existing irrigation use.

Plan development did not include the mixing of Salt-Verde River water in the aqueduct. However, mixing may occur within SRP's local delivery system with or without regulatory storage.

TABLE 4

Average Total Dissolved Solids Concentrations of Surface Water Sources

	Milligram per Liter
Recommended Domestic Water Supply Standard	500
Lake Pleasant	358 1/
Verde River Below Bartlett Dam	314 2/
Salt River Below Stewart Mountain Dam	635 2/
Confluence Mix	497 3/
CAP Water at Diversion Point (Lake Havasu)	722 4/

1/ U.S. Bureau of Reclamation, unpublished data, 1982 January-April.

2/ Environmental Protection Agency Storet data retrieval system. Run made 2-16-80, using data for the period of record December 1950 - September 1979.

3/ Weighted average based on U.S. Geological Survey flow records resulting in a 43 percent Verde River mix and a 57 percent Salt River mix at the confluence of the two rivers.

4/ Environmental Protection Agency Storet data retrieval system, March 1981 version. Run made August 24, 1981, using data for the period of record October 1968 - June 1981 for Colorado River below Parker Dam.

Vegetation and Wildlife

Considerable public concern centers on the potential impact of the plan on threatened and endangered species and land and water habitats which could be degraded or destroyed.

The rapid growth of agriculture and urbanization has reduced substantially the amount of land and water available for wildlife. Of particular interest are areas of riparian habitat. Such areas exist along the Verde River, the Salt River above and immediately below Granite Reef Diversion Dam, and along the Salt-Gila River from the 23rd Avenue treatment plant in Phoenix to Gillespie Dam. While relatively few animals would die outright as the result of construction, the disruption of their habitat would lead to declines in population and possible local extinction of certain species. The U.S. Fish and Wildlife Service has determined the following Federally-designated endangered species occur in the area: Bald eagle, Yuma clapper rail, and peregrine falcon; Arizona hedgehog cactus and the Turk's head cactus; and the gila topminnow. No critical habitats have been designated. A Biological Opinion by the U.S. Fish and Wildlife Service on the effects the plan could have on these Federally-designated threatened and endangered species indicates that implementation of the plan would jeopardize the continued existence of the bald eagle unless proper mitigation measures are incorporated. No impact to endangered plant species is anticipated.

Not all the effects of the plan would be negative, however. Ground water recharge could encourage riparian habitat development and increased impoundments could increase available habitats for fish.

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. 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 the demand. Existing facilities receive heavy, often excessive, use from residents and visitors.

The types of recreation available is also a concern. Recreational use of the few water courses 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 such water-based recreation as fishing, boating, swimming, water skiing, and floating. The lakeshores and riverbanks serve as sites for picnicking, hiking, and other activities. The flowing streams 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 that is 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 who cannot afford or are not interested in flat-water recreation. A study to determine user characteristics (Natelson, 1979) concluded that according to the majority of the Salt

River users, no alternative to the Salt River for tubing exists. Other river areas such as those along the Verde and Gila Rivers are not as attractive to recreationists as the Salt River. A report by the Governor's Task Force on Parks and Recreation in Arizona stated that "the demand for water-based recreation experiences in Arizona continues to grow. The acquisition and development of additional water-based recreation must be given a high priority." It is further stated that "recreation development should be incorporated as an explicit objective into the planning of all water projects within or affecting Arizona." In 1980 it was estimated that there was a demand from within the area for over 12 million annual recreation days. This demand was for those activities normally associated with a water resource. The supply, in the area, should accommodate approximately 12.5 million annual recreation days by the year 2000. However, it is expected that the demand will have increased to over 27 million annual recreation days by the year 2000, the net result being a large unmet demand for water-based or water-oriented recreational facilities. Central Arizona has, and will continue to have, a significant unmet demand for outdoor recreation facilities and opportunities associated with water resources. The recreational aspects of this plan have been designed to meet identifiable demands and fully utilize resources and opportunities, where environmentally and economically feasible, to increase the supply of public recreational facilities. When implemented, the plan would insure enjoyment and utilization of it's water resources for recreational purposes.

Cultural Resources

Rapid urbanization over the past three decades has placed increasing pressure on archeological and historical resources. Prehistoric and historic populations tended to cluster along or near major water courses just as modern populations do. As a result, many archeological and historical sites could be affected by flood control and regulatory storage on the Salt, Verde, and Agua Fria Rivers.

Federal and State historic preservation policies have been substantially strengthened in the last two decades to conserve our disappearing prehistoric and historic heritages. Cultural resources are being considered while planning the CAP in order to avoid or minimize damage. Where adverse impacts are unavoidable, mitigation measures are being developed and instituted to conserve the scientific and heritage values of those resources within the path of construction.

Water Rights

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

Surface Water Rights and Agreements

Many entities have historic water rights and contractual relationships for water from the Salt, Verde, and Agua Fria Rivers. Construction of plan features would not interfere with these rights or contractual relationships. The Bureau of Reclamation has made application with the State of Arizona for

a state-approved water right for the beneficial use of waters from the Salt, Verde, and Agua Fria Rivers. These rights would arise from the construction of plan features. Waters derived under these rights be used to supplement other CAP water supplies and would be distributed in accordance with established CAP needs and priorities.

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. Since then, these and other tribes throughout Arizona have filed lawsuits against other water users which, in general, allege misappropriation of water which rightfully should be available to Indians. Two Indian water rights bills were passed by Congress and signed into law for the Ak-Chin Indian Community and the Papago Tribe. Additional adjudication related to the Winter's Doctrine water rights is being undertaken. Since the water supply is so limited, the outcome of adjudication can impact the non-Indian water users.

In this region, settlement of Indian water rights is a pressing matter which would have a traumatic impact if a major reapportionment of surface and ground water rights occurred. In March 1980, the Secretary of the Interior announced CAP allocations which increased the amount allocated to the Indians. In December 1980, the Secretary signed contracts with 11 of the 12 Indian communities that had previously been allocated water. It is generally accepted that negotiation of an acceptable solution to Indian water rights is preferable to litigation. One of the keys to successful water rights negotiations is the availability of a new source of water with which to negotiate. Floodwater that might be controlled by this project, CAP water, and sewage effluent are examples of additional water sources.

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 established "critical ground water areas" in basins not having sufficient ground water to provide an adequate supply for the irrigation of cultivated lands.

In May 1977, an emergency ground water bill was signed into law by the Governor. The Legislature adopted the Groundwater Management Act in June 1980. CAP water supplies were considered in framing this act and its management objectives. The act provides that there will be no expansion of agricultural irrigated acreage within an area designated as an Active Management Area. A person contracting for CAP water may, however, 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.

Safety of Dams

The construction of a dam anywhere, 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.

During a review of the safety of existing dams, it has been determined that should either a probable maximum flood (PMF) or a maximum credible earthquake occur, all six Salt River Project (SRP) dams would experience some degree of failure resulting in uncontrolled reservoir releases and catastrophic consequences to lives and properties downstream. SRP dams are owned by the United States and operated by SRP through a contract with the United States. Thus, the Bureau of Reclamation is responsible for insuring the safety of these dams and their operations.

Waddell Dam, on the Agua Fria River, owned and operated by Maricopa County Municipal Water Conservation District #1 (MCMWCD#1), was evaluated by the State of Arizona under the National Safety of Dams program. It was determined that under PMF conditions, the spillway would be inadequate. Currently, the owners are taking preliminary steps to rectify the problem. However, these steps will not be implemented if New Waddell Dam is constructed (see Chapter IV, page 25).

Energy

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

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

The addition of storage space or more efficient use of existing space would allow the capture and use of water that would otherwise be spilled. This would result in decreased ground water pumping and overdrafts.

To further enhance the CAP impact on regional power supplies, the pumping plants along the Granite Reef Aqueduct (particularly the Havasu Pumping Plant which 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 is needed to pump the water 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

requirements from summer to winter, power could be made available from the Navajo Powerplant during the high demand summer months and marketed at a higher rate than during the low demand winter months. A regulatory storage facility would provide the storage necessary to allow these energy shifts to take place.

Land Use

Water availability and flood control measures have the potential to influence the types, locations, growth patterns, ownerships, and uses of land. Alteration of the floodplain 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 in urban areas have levees to provide limited protection from flooding, may also experience development pressure. Implementation of the plan could lead to changes in land use along the floodplain.

Social and Economic Issues

The social and economic issues reflect the concerns of local residents, government officials, and special interest groups. Of all the socioeconomic issues related to flood control in central Arizona, flood damage to property, 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 businesses in floodprone areas. Enforcement of existing zoning regulations that preclude future development in the floodplain is expected; still, some way to solve the problems created by existing development is needed.

Implementing - or not implementing - a water development plan carries with it social and economic costs and benefits; some people benefit, while some "pay." For instance, communities could benefit from new jobs, businesses, etc. while persons living in the area affected by this plan may be forced to relocate.

The net benefits of alternative solutions were determined by assigning a monetary value to the benefits of flood control (damage prevented), regulatory storage, recreation, and hydropower to justify the plan from a national economic development standpoint.

CHAPTER III

DESCRIPTION OF PLAN 6 - THE PROJECT ACTION

Eight plans were developed that to different degrees address the problems, needs, and issues that were discussed in Chapter II. From these, Plan 6 was selected as the plan that best resolves those concerns. This chapter describes that plan.

Project Purposes

Plan 6 includes the construction or modification and operation of four dams and associated reservoirs. The plan calls for the construction of New Waddell Dam and Cliff Dam and the modification of Theodore Roosevelt and Stewart Mountain Dams.

The operation of three of these dams (New Waddell, Cliff, and Modified Roosevelt) would provide water supply, flood control, recreation, and fish and wildlife benefits. The dams on the Salt and Verde Rivers (Modified Roosevelt, Modified Stewart Mountain, and Cliff) would correct existing dam safety problems.

The plan would provide 660,000 acre-feet of regulatory storage and 266,000 acre-feet of new conservation capacity for the Central Arizona Project (CAP). Sufficient flood control space would be provided behind dams on the Salt and Verde Rivers to control the 200-year Salt River flood event to a flow of 92,000 cfs measured near the Sky Harbor International Airport.

These purposes would be accomplished without adversely impacting existing facilities. Any water supply, hydropower capacity, or recreational facilities lost would be replaced.

Project Location

New Waddell Dam would be located on the Agua Fria River, immediately downstream of the existing Waddell Dam. Cliff Dam would be located on the Verde River, between Bartlett and Horseshoe Dams. Modified Roosevelt Dam would be located on the Salt River, at the site of the existing Theodore Roosevelt Dam. Stewart Mountain Dam, located on the Salt River, would require modification to ensure its safety. The general location of the structures is shown on Figure 2.

Project Plan

The plan is multipurpose. As previously discussed, the plan includes construction of four dams for water conservation, flood control, and dam safety. It also includes development of recreational facilities and mitigation measures for biological, cultural, and social resources. As part of this plan, Horseshoe Dam would be breached and its storage capacity replaced at Cliff Reservoir.

Physical Facilities

New Waddell Dam and Reservoir. New Waddell Dam would be located approximately 1/4 mile downstream from the existing Waddell Dam within the Lake Pleasant Regional Park. The site area includes 41,080 acres. The dam, spillway, reservoir area, canal, pumping/generating facility, and transmission facilities, as well as roads, borrow areas, recreation areas, and other construction-related activities are shown on Figure 3. All lands, necessary easements, and rights-of-way for this feature would be acquired by the Federal government.

New Waddell Dam would be a zoned rockfill structure with an ungated spillway. Discharges from the spillway would be to the Morgan City Wash which flows into the Agua Fria River about 3/4 mile downstream of the new damsite. Flood control for the Agua Fria River would be provided through the operation of the conservation pool.

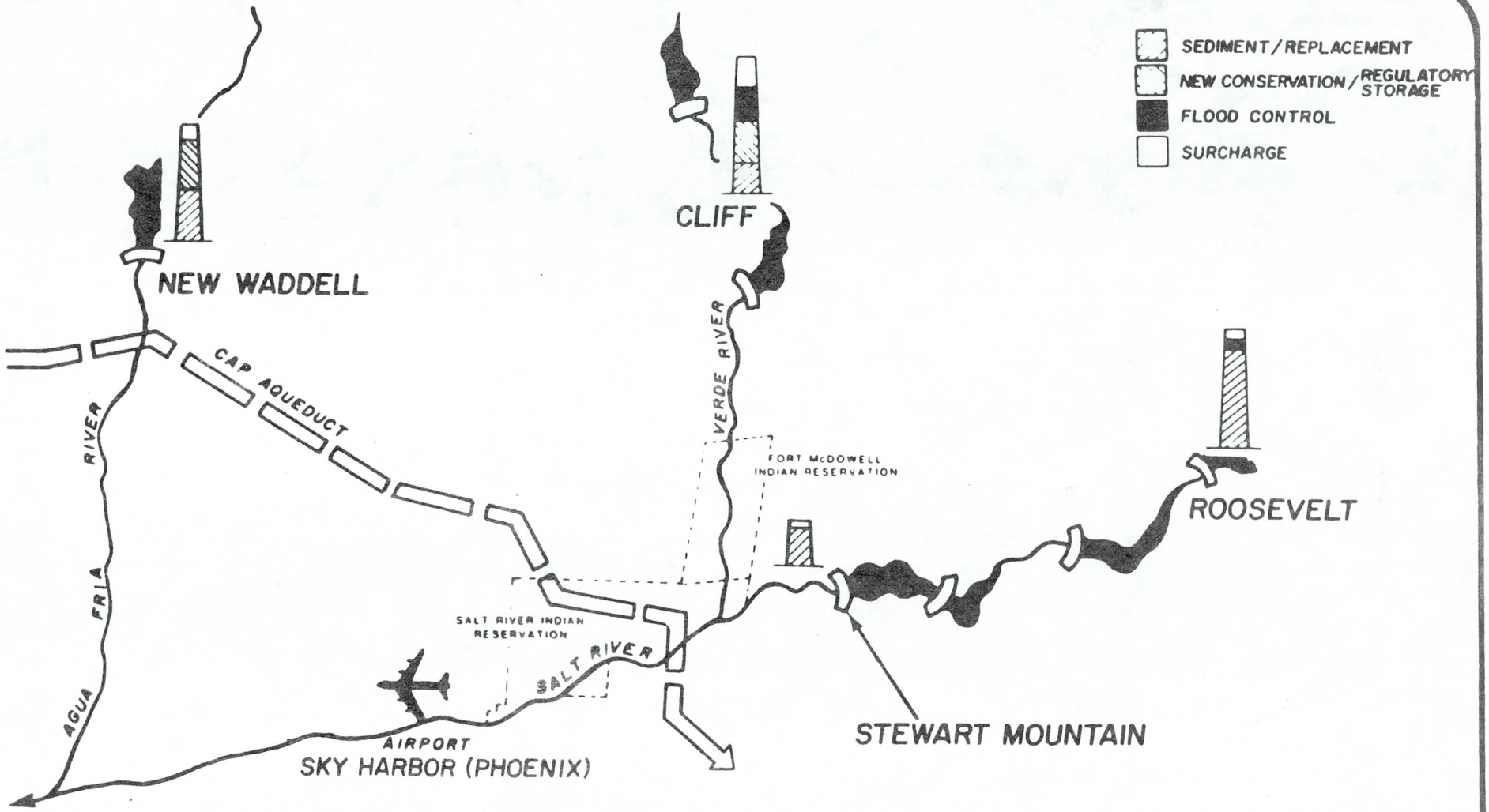
Two water supply outlet works would be part of the dam. Maricopa County Municipal Water Conservation District #1 (MCMWCD#1) presently uses water storage in Lake Pleasant. One service outlet would be required for MCMWCD#1 releases to Lower Lake Pleasant. The water would then be diverted into the existing Beardsley Canal. The other service outlet would release water into a reversible canal connecting the Granite Reef Aqueduct to the base of the dam.

Diversions from the Granite Reef Aqueduct would be made into the reversible canal from which the water would be pumped into the reservoir at the pump station. Power would be produced when CAP diversions from the reservoir flow through the pumping/generating facility into the reversible canal and back into the Granite Reef Aqueduct. The canal would be located on the east side of the Aqua Fria River. The pumping/generating facility would be located near the left abutment of the dam. Approximately 12 miles of transmission lines would be required to connect these facilities to existing transmission lines.

Cliff Dam and Reservoir. Cliff Dam and Reservoir would be located on the Verde River about 6 miles downstream of the existing Horseshoe Dam. The site area includes approximately 52,800 acres, most of which is under Federal ownership.

Cliff Dam would be an earthfill structure and would include flood and water supply outlet works. All releases would be to the Verde River channel. The location of the dam, spillway, reservoir area, recreation sites, borrow and waste areas, and other construction-related areas are shown on Figure 4.

Modified Roosevelt Dam & Reservoir. The existing dam and reservoir are located wholly within the Tonto National Forest about 76 miles northeast of Phoenix and 30 miles northwest of Globe, Arizona. The dam is constructed across the Salt River.



CAP YIELD 137,600 af/yr
FLOOD CONTROL
200-YEAR at AIRPORT 92,000 cfs
100-YEAR at AIRPORT 55,000 cfs

Figure 2

PLAN 6
NEW WADDELL + CLIFF +
ROOSEVELT +
STEWART MOUNTAIN DAM

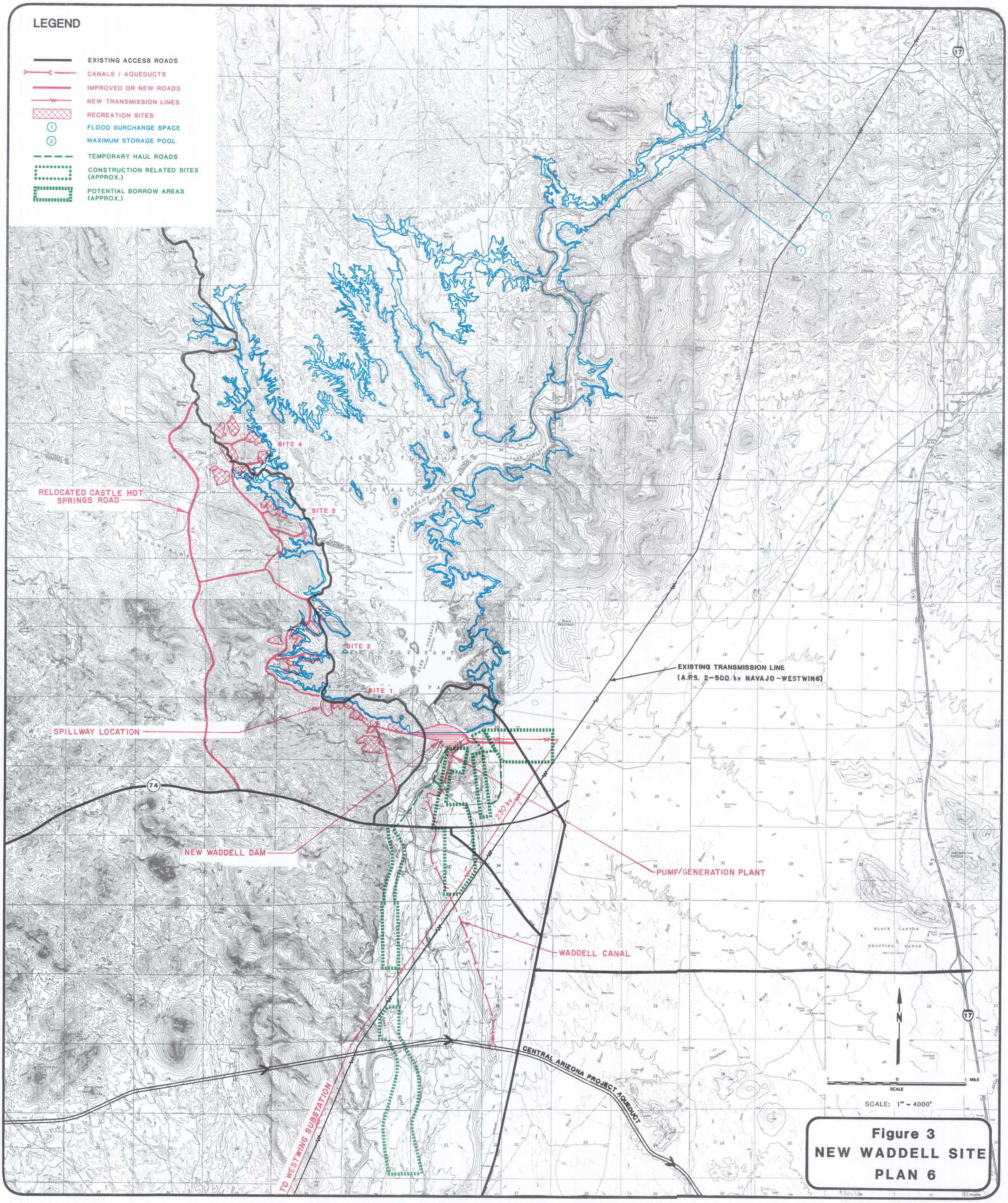


Figure 3
NEW WADDELL SITE
PLAN 6

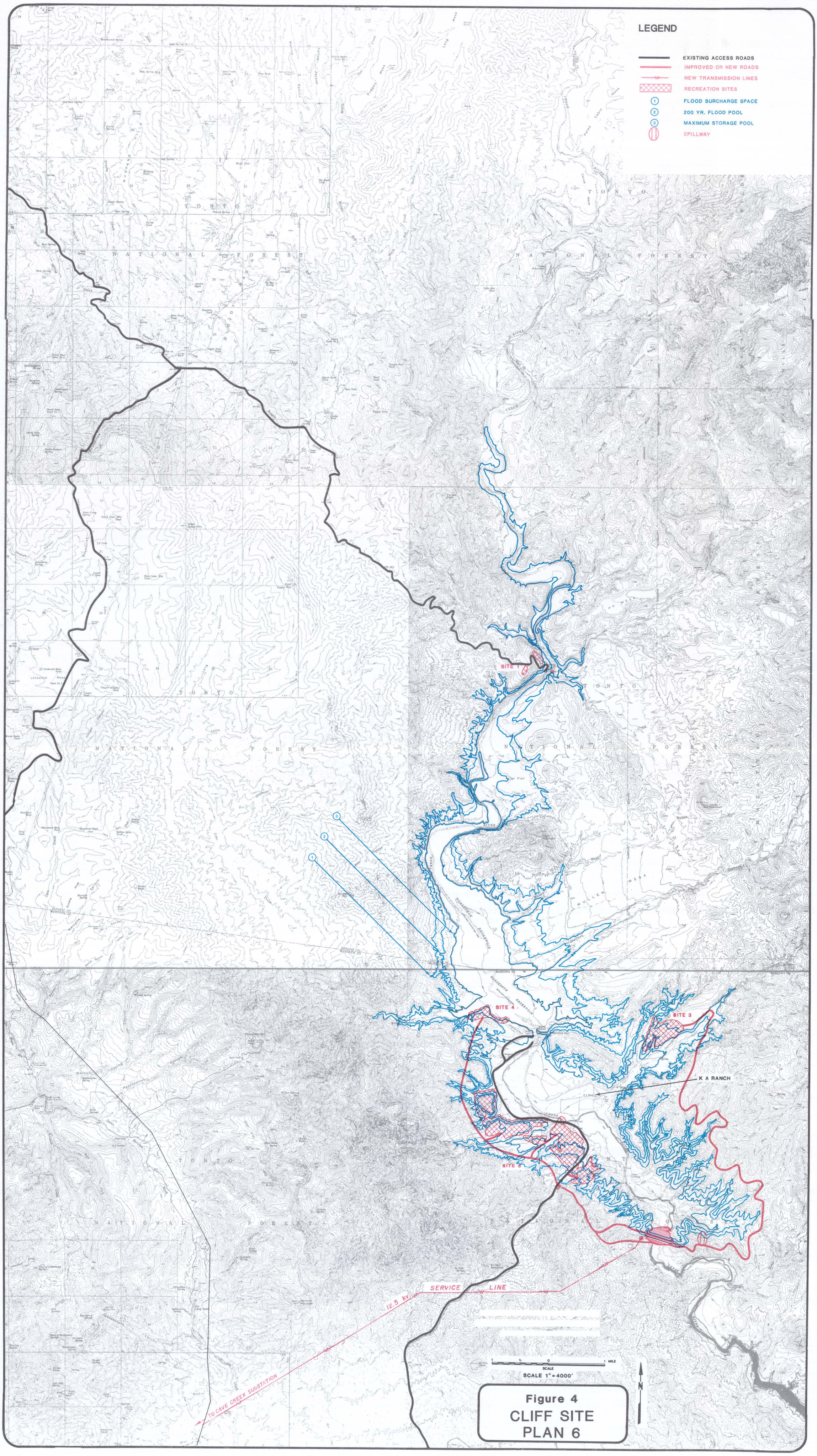


Figure 4
CLIFF SITE
PLAN 6

Theodore Roosevelt Dam modification would consist of raising the existing structure from elevation 2142 to elevation 2210. This would require removal of a portion of the existing dam and the placement of new concrete to elevation 2210. The existing spillways, outlet works, and power outlet works would also be replaced. The powerplant would remain at the downstream toe of the dam. The location and features of Modified Roosevelt Dam are shown on Figure 5.

Modified Stewart Mountain Dam. Dam safety problems at Stewart Mountain Dam necessitate modification to the existing dam. Modifications would include replacement of the top 40 feet of the arch section, construction of an auxiliary spillway, and rehabilitation of the arch right thrust block and the right and left gravity sections. These modifications are necesary to correct hydrologic problems which would be caused by the occurrence of an Inflow Design Flood (IDF) and to correct structural problems which could occur under Maximum Credible Earthquake (MCE) loading.

The auxiliary spillway, located on the right abutment of the dam, would have a crest elevation of 1,496 feet and would be a gated concrete structure with a capacity of 87,000 cfs. The total combined capacity of the existing and auxiliary spillways would be 210,000 cfs.

No new flood storage space would be provided nor would CAP regulatory storage space be included. Approximately 10 acres of land would be required for construction of the new spillway. The location and features of Modified Stewart Mountain Dam are shown on Figure 6.

Recreation Development

The recreation plans associated with the plan call for replacement of existing recreational facilities and expansion of other recreational opportunities associated with the proposed water resource developments. Facilities would be provided at Lake Pleasant, Cliff, and Theodore Roosevelt Lakes to accommodate outdoor recreational use. Specific recreational development for each reservoir would assure maximum public utilization, enjoyment, and protection of the resource. The following briefly describes the proposed recreational development associated with each feature. For a complete description, refer to Appendix C, Recreation.

New Waddell Dam and Reservoir. Recreational development at Lake Pleasant would primarily be restricted to the west shore of the reservoir. Four major sites, with a total of 67 acres, are planned. Specific facilities for camping, picnicking, hiking, swimming, boating, and fishing would be developed.

Cliff Dam and Reservoir. The proposed development at Cliff Dam and Reservoir would be designed to provide water-based recreational experiences and enhance the recreational utilization of the area. Four areas were selected as being appropriate for recreational development and would include equestrian facilities, camping, picnicking, hiking, swimming, fishing, boating, a marina, concessions, and an archeological interpretive area.

Modified Roosevelt Dam and Reservoir. Ten sites were selected as appropriate for recreational development at Modified Roosevelt. Proposed development would include camping, picnicking, boat launch and ramp, fishing, and parking. Some of the existing facilities would be upgraded, including the ranger station, concession buildings, floating dock, and boat ramp.

Fish and Wildlife Measures

The impacts to biological resources would result primarily from dam construction, reservoir inundation, and flow releases from reservoirs. The biological resources represented include biotic communities, specific cases of Federally-designated threatened and endangered species, and management and special use reservoirs. The impacts of dam operations would not occur at Modified Stewart Mountain Dam and Reservoir or Modified Roosevelt Dam and Reservoir since these elements would continue to operate as they have in the past.

Mitigation measures identified as part of the plan are briefly described in the following pages. A complete discussion of the mitigation plan may be found in Appendix C, Biological Resources, and in the Regulatory Storage Division Final Environmental Impact Statement.

Riparian/Wetland Communities. The revegetation of 250 acres of cottonwood-willow and 690 acres of mesquite would be done at the Cliff site.

The mixed scrub at all sites and cattail habitat at Cliff Dam would recover without revegetation through natural succession. To ensure full development of the habitat values, livestock grazing and off-road recreational vehicle (ORV) use would need to be eliminated in this riparian area and fencing may be required.

The draining of Horseshoe Reservoir and the breaching of Horseshoe Dam would be scheduled to coincide with the seeding and germination period of cottonwood and willow species in March and April.

All riparian habitat in the construction areas not required for construction purposes would be protected from damage. All lands containing riparian habitat which is removed due to construction outside the impoundment area would be contoured and revegetated to preconstruction conditions.

Other Terrestrial Communities. Vegetation clearing plans, which call for only partial conservation pool clearance to provide fish cover, would be put into effect at New Waddell and Cliff Reservoir sites. No clearing would occur in the conservation pool at Modified Roosevelt reservoir.

The Inflow Design Flood (IDF) areas at New Waddell, Cliff and Modified Roosevelt Dams would be managed for wildlife by restricting grazing and of road vehicles either by fencing or obtaining management agreements for withdrawn lands. Permanent water sources would be provided in areas where water is not now available to wildlife.

All areas of construction disturbance in sites not needed for permanent facilities would be returned to natural contours and revegetated with native plant species.

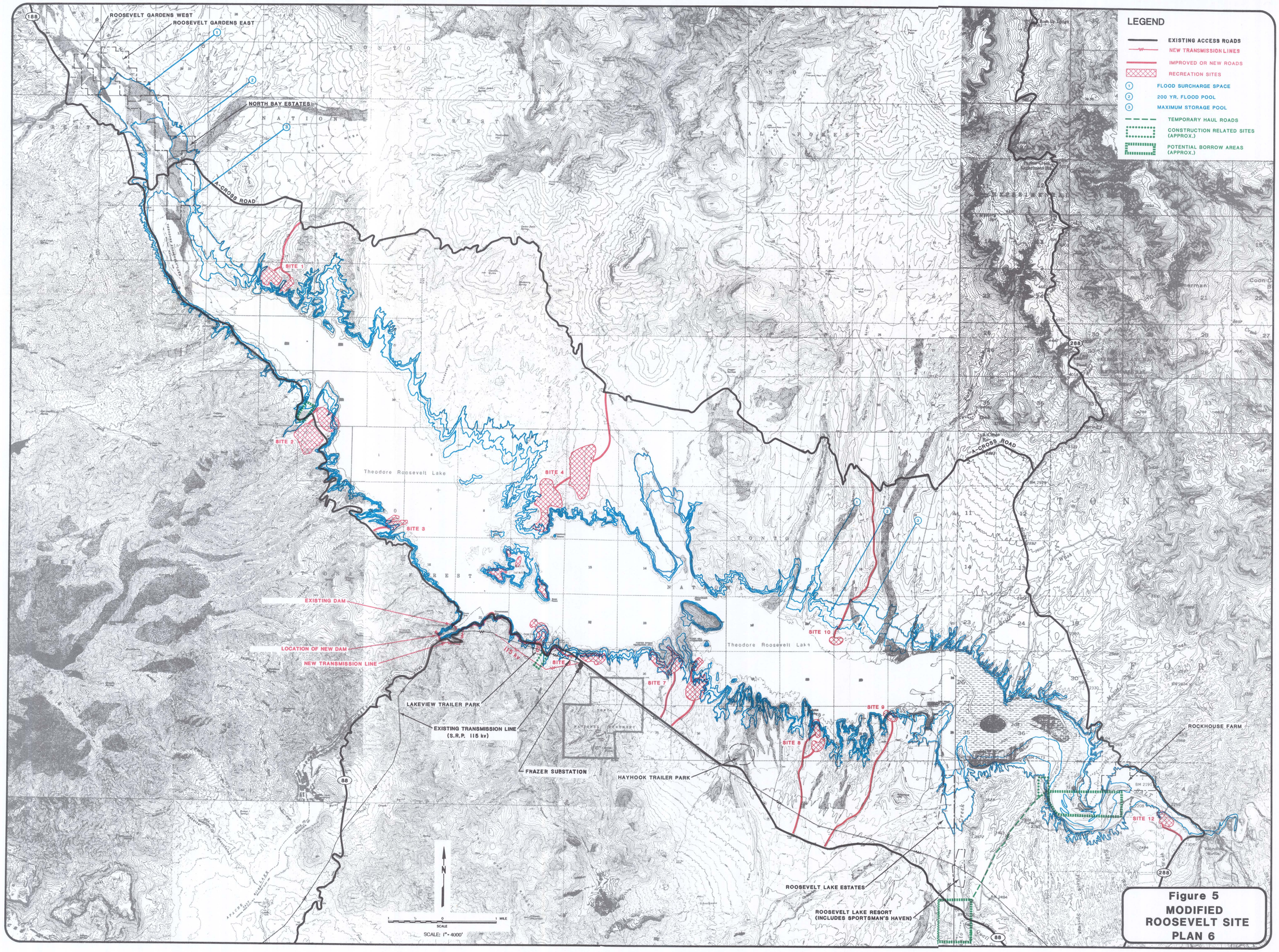


Figure 5
MODIFIED
ROOSEVELT SITE
PLAN 6

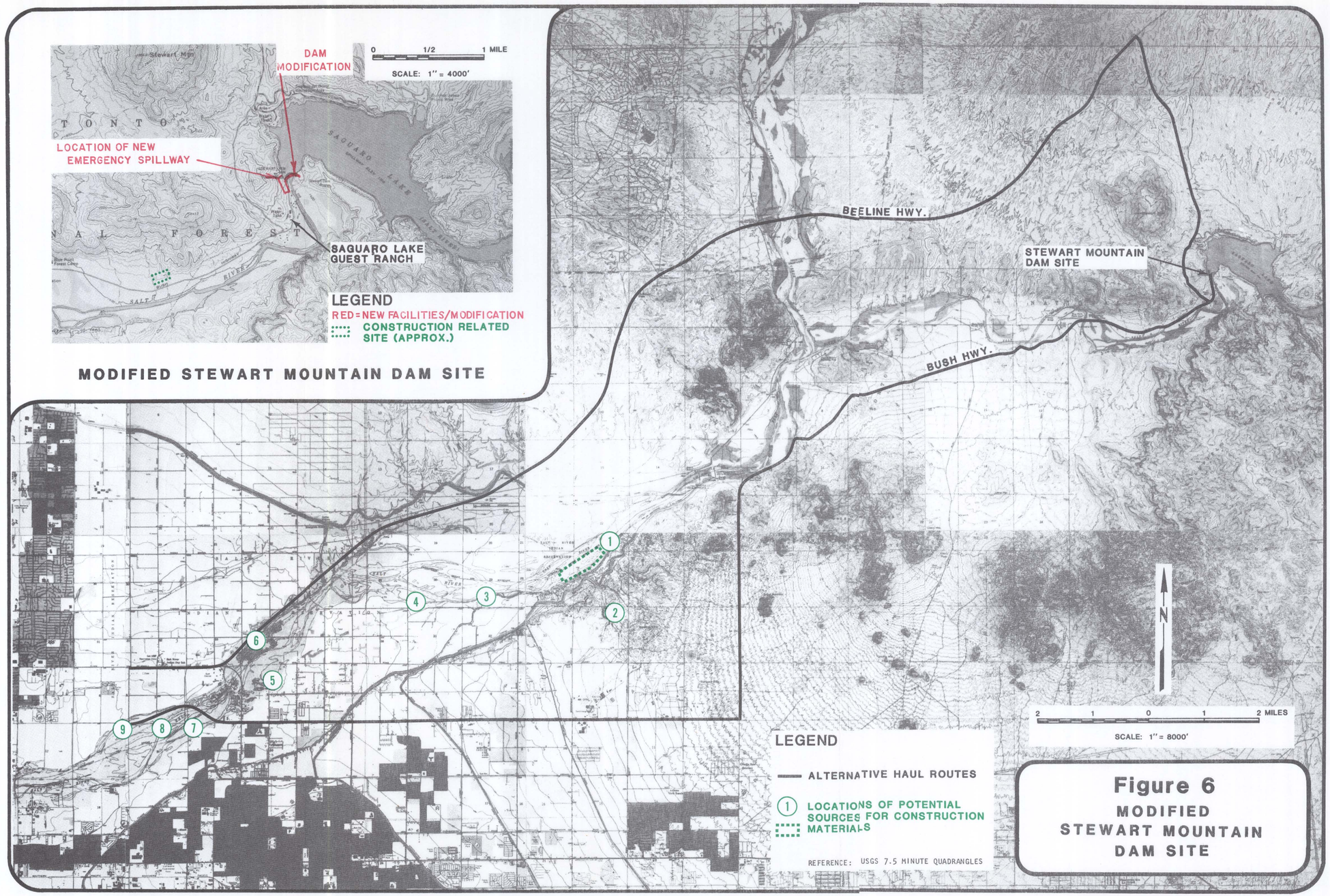


Figure 6
MODIFIED STEWART MOUNTAIN DAM SITE

Perennial Streams. The 7 miles available in Horseshoe Reservoir through stream management techniques would be reclaimed to replace the habitat value lost from the 6 miles of river inundated by Cliff Dam and Reservoir.

The Bureau would work with the U.S. Fish and Wildlife Service to design and evaluate a positive cutoff above the IDF elevation to provide a barrier to the movement of fishes upstream on Tule Creek into the Gila topminnow habitat. Fish barriers would be placed above the IDF elevation to avoid impacts to native stream fish.

Reservoir Aquatic Communities. Possible impacts resulting from the introduction of Colorado River ichthyofauna into the New Waddell Reservoir would be investigated through a Cooperative Effort with the Arizona Game and Fish Department, the U.S. Fish and Wildlife Service, and other interested parties.

The rate of drawdown at New Waddell Reservoir would be reduced to 5 feet or less during March and the first half of April as often as is practical.

Conservation pool clearing would be reduced to the minimum possible level. A total of 2,486 acres would be cleared at the Cliff and New Waddell Reservoirs primarily for human safety and navigation conservations as predicated on expected boat usage.

Minimum pools would be incorporated into the sediment and inactive storage pools at Cliff and New Waddell Reservoirs. At Cliff Reservoir, the pool would be 1,030 acres in size with an average depth of 30 feet; at New Waddell Reservoir, the pool would be 1,540 acres in size with an average depth of 26 feet.

The construction of a harvest basin immediately downstream of Horseshoe Dam would facilitate the salvage of sport fish for stocking in Bartlett Reservoir. A management agreement would be required with the Arizona Game and Fish Department for such salvage and restocking operations.

Special Use Areas. The recreation plan for Modified Roosevelt Reservoir would include closing the recreation sites within the waterfowl area during winter use periods and providing irrigation equipment and sufficient water to irrigate 100 acres of winter food crops for waterfowl.

Endangered Species. The U.S. Fish and Wildlife Service has issued a Biological Opinion under the Endangered Species Act that the plan as proposed would jeopardize the continued existence of the bald eagle in the southwest. In accordance with established policy, the Bureau would work with the U.S. Fish and Wildlife Service, Arizona Game and Fish Department, and the U.S. Forest Service to prepare an agreement to implement management strategies and actions to avoid adverse impacts on nesting bald eagles which would result from increased recreation activities.

The Bureau would continue to support the U.S. Forest Service efforts to maintain nest wardens and provide liaisons between construction forces. The Nest Watch Program would continue to receive funding from the Bureau.

Horseshoe Dam would be breached in a manner that would avoid excessive erosion and promote stream and riparian development in the exposed Horseshoe Reservoir.

Borrow excavation would be avoided at Meddler Point, if possible. If not, construction specifications would require removal of materials during the eagle non-breeding season and stockpiling materials outside the eagle breeding and foraging territory. Borrow areas would be restored to provide habitat suitable for eagle forage fish.

Award of the construction contracts associated with Modified Stewart Mountain Dam would be scheduled to permit initiation of construction in April or May and then continue uninterrupted except for blasting. Construction specifications would exclude initiation of construction from October through March. Blasting activities would be prohibited from December through March.

The Bureau would work with the Fish and Wildlife Service to design and evaluate a positive cutoff above the IDF elevation to provide a barrier to the movement of fishes upstream on Tule Creek into the Gila topminnow habitat. The positive cutoff would be constructed unless unforeseen design problems or extreme costs are encountered.

Project Monitoring. The Bureau would monitor the effects of the plan and the success of all mitigation measures.

Cultural Resource Measures

As part of the plan, extensive measures to mitigate adverse impacts upon cultural resources would be implemented concurrently with construction. These measures would be carried out in the context of the ongoing cultural resource program developed for the CAP and in accordance with a programmatic Memorandum of Agreement with the Advisory Council on Historic Preservation and the Arizona State Historic Preservation Officer. The mitigation measures include:

1. Implementing data recovery and research studies of sites immediately affected by the plan.

2. Developing a program to monitor, manage, and study archeological and historic sites in the indirectly affected areas.

3. Developing of a program for public distribution and interpretation of study results.

Social Measures

Approximately 90 families would be relocated as a result of the modification of Theodore Roosevelt Dam. These residents live near the northern boundary of Roosevelt Lake Estates. The full-time residents (approximately 38 families) would have the option of obtaining a replacement lot adjacent to the existing community while the remaining part-time residents would be

compensated for the acquisition of their property through the Uniform Relocations Assistance and Real Property Acquisitions Policies Act of 1970 (Public Law 91-646). Relocation of the KA Ranch at the Cliff damsite would also be required.

Operating Assumptions

The Bureau desires to transfer the operation and maintenance of completed features to a local entity or entities as rapidly as practicable. Because of the multifunctional and multipurpose nature of this plan's reservoirs, cooperative operating agreements between the respective interests would be necessary to ensure that each purpose would be properly served. These agreements would define the rights of each party and the responsibilities and limitations of the operating entity. The following operating guidelines have been assumed.

New Waddell Dam and Reservoir. The Bureau intends to transfer responsibility for the operation of the CAP aqueduct system to the Central Arizona Water Conservation District (CAWCD) along with all features which would be critical to water and power operations. Since the operation of New Waddell Dam and Reservoir is critical to CAP power-use management, which would be closely linked to the operation of the aqueducts, it is assumed the CAWCD would operate New Waddell Dam and Reservoir.

Salt and Verde Dams and Reservoirs. Cliff, Modified Roosevelt, and Modified Stewart Mountain Dams are located within the existing Salt River Project (SRP) system. Because of this and the fact that the operation of these dams and reservoirs would have little impact on CAP operations, it was assumed that SRP would operate plan features above Granite Reef Diversion Dam. These features would be operated consistent with existing guidelines and rights related to the following entities:

City of Phoenix
Phelps Dodge Corporation
Roosevelt Water Conservation District
Salt River Indian Agency
Roosevelt Irrigation District
Peninsula Horowitz/Roosevelt Irrigation District
Salt River Valley Water Users Association
Fort McDowell Mohave-Apache Indian Community

Under the provisions of the Flood Control Act of 1944, the Corps of Engineers has responsibility for flood control operating procedures at all federal dams that have flood control functions. Accordingly, the Bureau would work with the Corps to develop flood control operation criteria for Modified Roosevelt, Cliff, and New Waddell Dams.

CHAPTER IV

DESIGNS AND ESTIMATES

Project Features

As discussed in Chapter III, the plan includes the construction and operation of two new dams and the modification of two others. This chapter briefly describes the designs and costs for these features. For a more detailed discussion, refer to Appendix A.

The January 1983 construction cost for the plan is estimated at $1,035,500,000. The cost includes the dams, appurtenant structures, reservoirs, and all other associated costs. The annual appraisal operations, maintenance, and replacement (OM&R) costs associated with this plan are estimated at $4,781,000.

New Waddell Dam and Reservoir

The dam and portions of the reservoir would be located in Maricopa County within the boundaries of the Lake Pleasant Regional Park. The reservoir would have a storage capacity of 892,000 acre-feet as shown below.

	Storage (Acre-Feet)	Accumulative Storage (Acre-Feet)	Water Surface Elevation (Feet)	Area Inundated (Acres)
Surcharge			1725	12,310
CAP Conservation	728,800	892,000	1702	10,240
MCMWCD#1 Replacement	157,600	163,200		
Inactive (initial)	5,000	5,600	1508	300
Dead	600	600	1450	45
Streambed	0	0	1430	0

The storage data includes an allowance for 68,800 acre-feet of projected 100-year sediment deposition between the streambed and elevation 1702. The 68,800 acre-feet would be deposited above elevation 1496. The new impoundment would include the existing Lake Pleasant and would inundate the present Waddell Dam and recreational areas.

New Waddell Dam would be a zoned rockfill structure rising about 305 feet above the streambed to a crest elevation of 1,735 feet, where it would form a 4,900 foot crest length. A 600 cfs gated outlet located in the right abutment would be constructed for Maricopa County Municipal Water Conservation District #1 (MCMWCD#1) requirements. The intake structure would be designed with a sill elevation at 1450 feet. The tunnel, approximately 1,870 feet in length, would be constructed first so it could be used for diverting flows during construction.

A 3,000 cfs inlet-outlet works for CAP requirements would be constructed through the left abutment of the dam. The outlets, with an intake sill at elevation 1520, would consist of three 11-foot-diameter steel-lined tunnels extending through the abutment where steel penstocks would continue to the pump-generation plant.

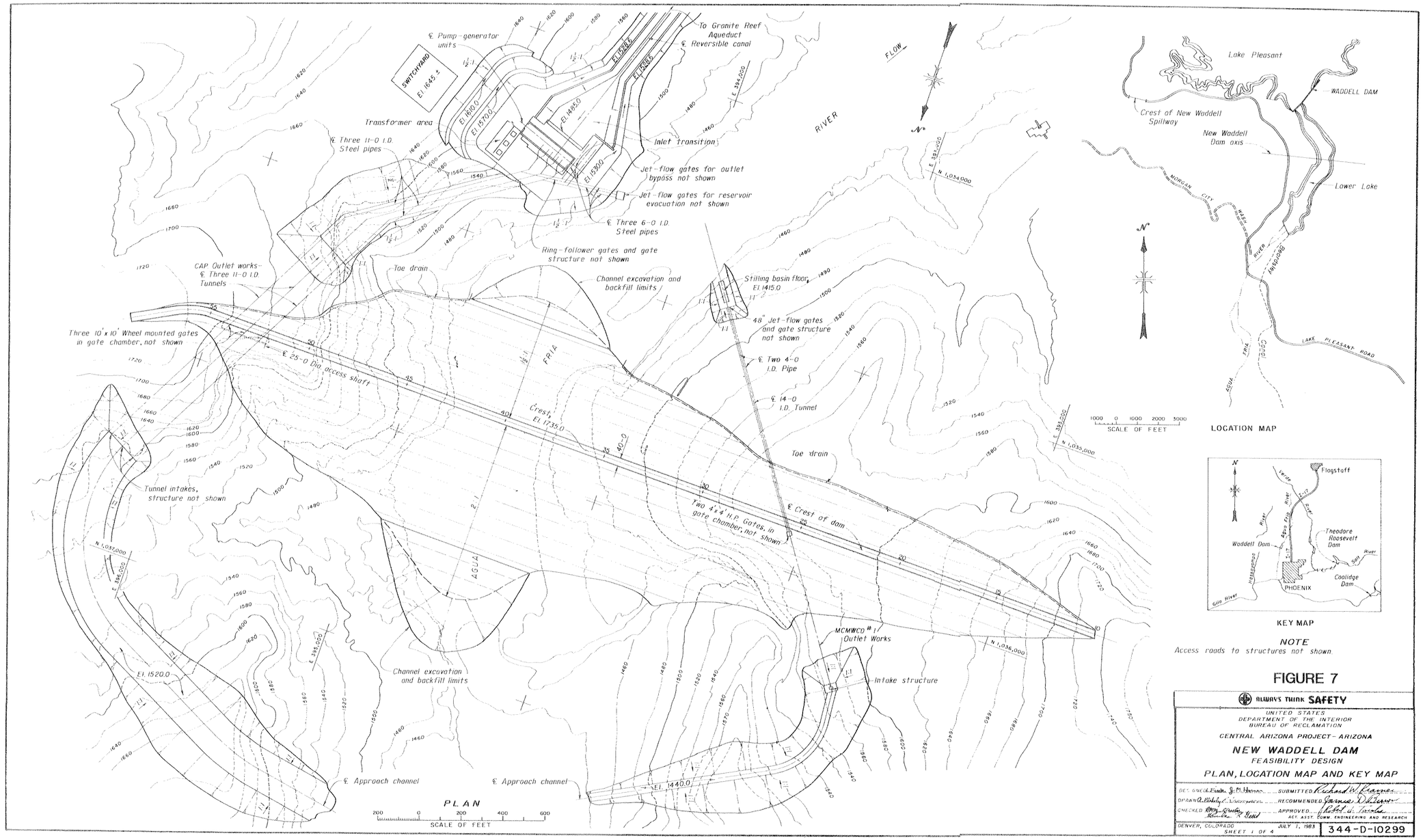
A 330,000 cfs free flow spillway located 7,500 feet west of the damsite would provide overflow protection to the dam. The spillway would be a 750-foot-wide structure with a crest elevation of 1,702 feet extending about 140 feet to discharge into a wash that empties into Morgan City Wash. Flows would be conveyed into the Agua Fria River below the Beardsley Diversion Dam.

A pumping-hydroelectric generation structure would be located on the east side of the Agua Fria River about 1,600 feet downstream of the dam crest. It would have five major floor levels and be approximately 150 feet wide and 370 feet long. The plant, with six vertical shaft pump-generating units, would have a pump and generation design capacity of 3,000 cfs. During releases, the plant could generate up to 35 megawatts of electrical power. Design drawings of New Waddell Dam are shown on Figures 7 and 8.

The 4.7-mile Waddell Canal would interconnect New Waddell Dam with the Granite Reef Aqueduct. It would be located on the east side of the Agua Fria River and connect with the aqueduct at a point just downstream of the Agua Fria River siphon outlet. At New Waddell Dam, the connection would be constructed at the pump-generation plant. The canal would be designed as a reversible flow structure capable of delivering up to 3,000 cfs by gravity to the pump-generation plant. A typical drawing of Waddell Canal is shown on Figure 9.

The transmission system would provide power for the dam and pump-generation plant. One, single-circuit, 230 kV, steel lattice construction, 795 kcmil ACSR conductor transmission line would be constructed to the pump-generation facility from the Bureau's Westwing Substation located to the southeast. The 12-mile line would parallel the double 500-kV Arizona Public Service transmission lines extending to and past the damsite. A switchyard and 230-kV transformer area would be located just east of the pump-generation plant. Station power would operate the valves, gates, spillways, elevators, and general station lights.

All removable facilities which might be impacted by the construction and/or new water surface levels in the reservoir would be relocated. Approximately 6 miles of existing Castle Hot Springs Road, which is located within the dam construction or high water impact zone, would require relocation. This would be done at the beginning of construction so the existing access road could be closed. A 1.75-mile road would provide access to the new park areas and recreational facilities. An estimated 4 miles of existing interior park roads would also need to be relocated. All project roads would be utilized initially as unpaved construction roads.



NOTE

Access roads to structures not shown

FIGURE 7

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CENTRAL ARIZONA PROJECT - ARIZONA

NEW WADDELL DAM

FEASIBILITY DESIGN

PLAN, LOCATION MAP AND KEY MAP

DES. GNEER Frank J. M. Herron SUBMITTED Richard A. Kramer
DFTMAN R. Bobby Lawrence RECOMMENDED James D. Dixon
CHECKED Harry Quiter, Kenneth R. Field APPROVED Robert A. Jacobs
ACT. ASST. COMM. ENGINEERING AND RESEARCH

DENVER, COLORADO JULY 1, 1983 SHEET 1 OF 4

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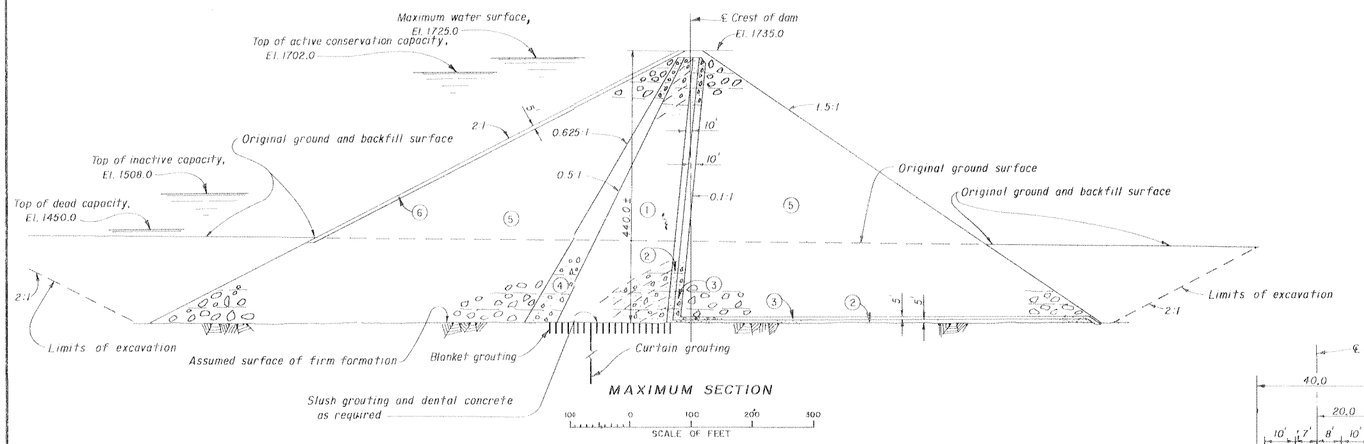
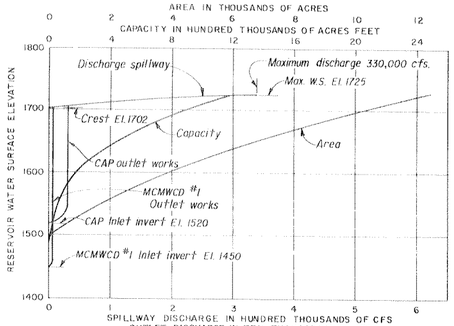


MAXIMUM SECTION



AREA-CAPACITY-DISCHARGE CURVES

RESERVOIR CAPACITY ALLOCATIONS

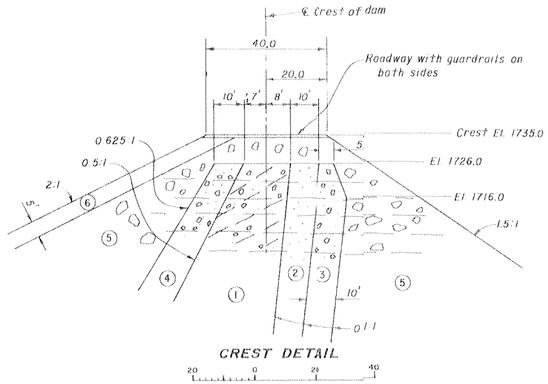
PURPOSE	ELEVATIONS	CAPACITY ACRE-FEET
Active conservation	1508 to 1702	886,400
Inactive	1450 to 1508	5,000
Dead	Riverbed to 1450	600
Total		892,000*

*Includes 68,800 acre-feet allowance for 100 year sediment deposition between streambed and El. 1702, of which 68,800 acre-feet is above El. 1496.

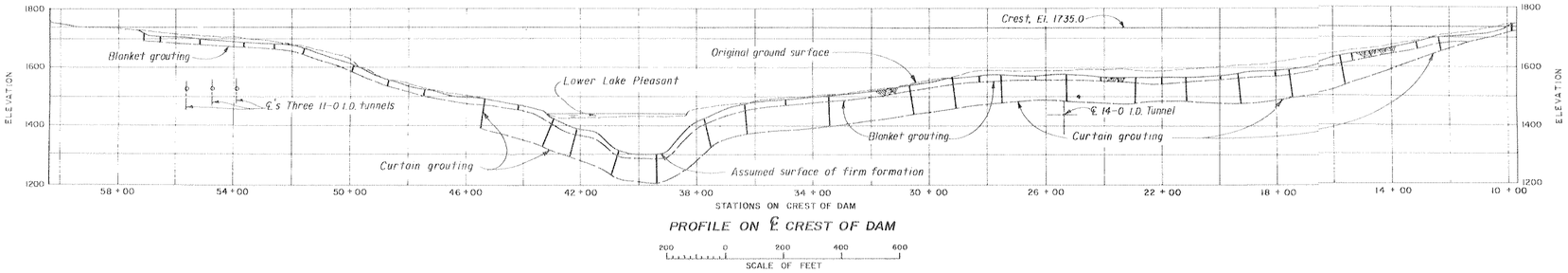
A surcharge of 244,000 acre-feet (Max. W.S. El. 1725) in combination with a spillway discharge of 330,000 c.f.s. is provided to protect against the inflow design flood which has a peak of 493,400 c.f.s. and a 7.3 day volume of 688,500 acre-feet.

EMBANKMENT EXPLANATION

1. Core material - Selected GC, SC, CL materials compacted by tamping roller to 6-inch layers
2. & 4. Filter material - Processed sand and gravel compacted by vibratory roller to 24-inch layers
3. Transition material - Processed coarse sand and gravel compacted by vibratory roller to 24-inch layers
5. Rockfill - Well graded free draining cohesionless material compacted by vibratory roller from 3-foot layers
6. Riprap



CREST DETAIL



PROFILE ON ℄ CREST OF DAM

SCALE OF FEET

FIGURE 8

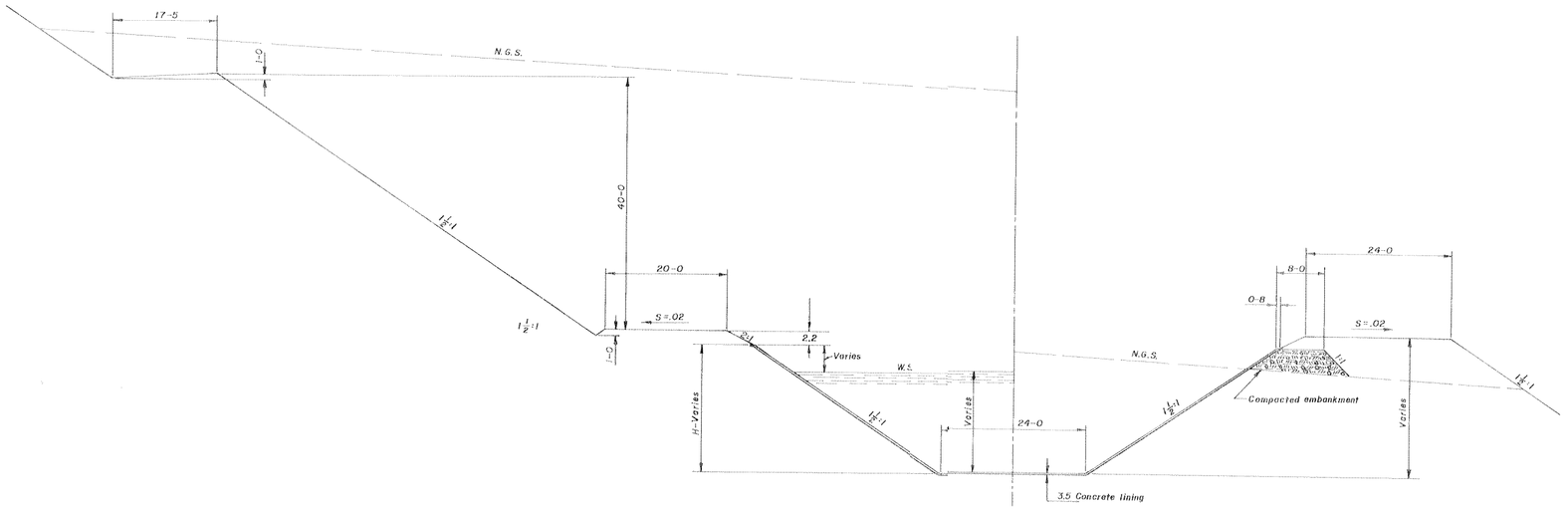
ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT - ARIZONA

NEW WADDELL DAM
FEASIBILITY DESIGN
EMBANKMENT
PROFILE AND SECTION

DESIGNED L. Jones & M. Brown SUBMITTED Richard D. Kramer
DRAWN A. Blake & E. Edwards RECOMMENDED James D. Bryson
CHECKED Harry Stanley APPROVED Robert A. Taylor
ACT. ASST. COMM. - ENGINEERING AND RESEARCH

DENVER, COLORADO JULY 1, 1983 SHEET 2 OF 4 344-D-10300



TYPICAL SECTION

10 0 10 20 30
SCALE OF FEET

HYDRAULIC PROPERTIES

Q	n	s	H
3000	.016	.00008	20.6 to 24.6

FIGURE 9

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT
REGULATORY STORAGE DIVISION–ARIZONA

NEW WADDELL
REVERSIBLE CANAL
TYPICAL SECTION

DESIGNED ..... FIELD APPROVAL .....
DRAWN HH ..... TECHNICAL APPROVAL .....
CHECKED ..... APPROVED .....

PHOENIX, ARIZONA FEB. 1982 344-330-3440

Additional construction roads and haul roads leading to the materials area south of the damsite would be built as deemed necessary. Those roads which are to remain after construction would be improved and/or paved to remedy construction deterioration.

Construction and operation of the new dam and reservoir would require the relocation of about 1 1/2 miles of 12.5 kV Arizona Public Service electrical distribution lines. It would also be necessary to relocate additional distribution lines providing service to Maricopa County's educational facility located on the east shore of the Lower Lake, which would itself be relocated. The park operates a sewage digester located within the proposed reservoir. This facility would have to be dismantled and moved to a new location.

The proposed development of New Waddell Dam and Reservoir would require the acquisition of approximately 13,071 acres of land. Of this total, about 160 acres represent acquisition from the MCMWCD#1. The remainder is State land, primarily within the boundaries of the Lake Pleasant Regional Park.

The construction and operation of this feature would impact several MCMWCD#1 facilities. The existing Waddell Dam would continue to operate for the MCMWCD#1 during the construction of the new dam and would serve to protect the construction site. A portion of the existing structure would be breached to elevation 1539.3 after the completion of the new dam. In addition, the existing spillway gates, hoists motors, and miscellaneous metal work would be removed.

Construction would also require draining the Lower Lake, which is formed by the Beardsley Diversion Dam. The construction plan would accommodate the diversion requirements of MCMWCD#1 during peak periods. The construction plan utilizes a care and diversion scheme consisting of upstream and downstream cofferdams along with a diversion tunnel located on the right abutment of the dam with the outlet portal discharging into the lake below the dam construction site, downstream from the diversion dam.

The total cost of constructing New Waddell Dam is estimated at $417,643,000. A summary of the construction cost estimates is shown on the Project Construction Cost Estimates at the end of this chapter. Detailed cost estimates are provided in Appendix A.

The total appraisal-level cost for OM&R for this feature is estimated at $2,738,000 for the dam structure and its appurtenant works. The appraisal-level OM&R costs are displayed in Chapter V, page 37.

Approximately 9 years are estimated to complete the development of New Waddell Dam and its associated features. Construction of the dam and its appurtenant works would require about 4 1/2 years.

Cliff Dam and Reservoir

The dam and reservoir would be located on the Verde River within the Tonto National Forest. The dam axis would be located about 6 miles downstream of Horseshoe Dam. The reservoir, located in Maricopa and Yavapai Counties, Arizona, would extend 11 river miles upstream and would inundate Horseshoe Dam.

The reservoir would have a storage capacity of 793,740 acre-feet. Under maximum water surface conditions, the reservoir would extend upstream 13 miles and inundate Horseshoe Dam. The storage allocation is shown below.

Purpose	Storage (Acre-feet)	Aggregate (Acre-feet)	Elevation (Feet)	Surface Area (Acres)
Surcharge			2,146.9	15,000
Flood Control	451,000	793,740	2,066	8,846
Active Conservation	332,740	342,740	2,001.5	5,367
Inactive	6,445	10,000	1,866	480
Dead	3,555	3,555	1,847	224

The storage data includes an allowance of 41,313 acre-feet of projected 100 years of sediment deposition between the streambed and elevation 2,001.5. Approximately 33,000 acre-feet of the sediment would be deposited above elevation 1,866.

Cliff Dam would be a 335-foot-high, zoned earthfill embankment structure with a 4,100-foot-crest length at elevation 2152. There would be a 20-foot-high dike with a 260-foot-crest length at elevation 2152 on the left abutment.

The river outlet works, consisting of a tunnel through the left abutment of the dam, would discharge 2,200 cfs at a reservoir water surface elevation of 1866. The box-type intake structure would provide for initially releasing reservoir water from below the 100-year sediment level by use of an adjustable sill. The upstream tunnel would be a circular tunnel about 1,650 feet long, concrete lined, and pressurized. A gate chamber would house two regulating outlet gates and two emergency outlet gates. Access to the gate chamber would be through an access shaft. The downstream tunnel would be a modified horseshoe-shaped tunnel about 1,550 feet long, concrete lined, and free flow. A chute and type II hydraulic jump stilling basin would be provided at the downstream end of the tunnel.

The flood outlet works would consist of three parallel tunnels through the left abutment of the dam. They are designed for a combined discharge of 25,000 cfs at a reservoir water surface elevation of 2001.5. All three of the tunnels and their corresponding structures would be identical with the exception of the upstream and downstream tunnel lengths. The intake structures would be box-type intakes. Upstream tunnels for the flood control

outlet works would consist of concrete lined and pressurized circular tunnels. Each gate chamber would house two regulating outlet gates. Access to the gate chambers would be gained by an adit extending from the river outlet works gate shaft. The downstream tunnels would be modified horseshoe tunnels that would be concrete lined and free flowing. Overall lengths of the tunnels would be 3,200 feet. A chute and type II hydraulic jump stilling basin would be provided at the downstream end of each tunnel.

The spillway would be located on the east side of the left abutment. The maximum combined release from the spillway and flood control outlet works would be limited to 186,000 cfs. The spillway would be at an elevation above the top of the flood control pool to allow the 500-year flood to pass through the flood control outlet works without utilizing the spillway. Because of the low probability of the spillway discharging and the relatively low cost, an open-cut channel was chosen for the spillway. Design drawings of Cliff Dam are shown on Figures 10 and 11.

There would be two methods for providing station power. One would be a 20-mile 12.5 kV transmission line from the Arizona Public Service Company's (APS) Cave Creek Substation to the dam. The cost of this line, including transformer facilities, is estimated at $750,000. The second method would be the installation of diesel or propane fueled engine generator equipment with solar/battery power included for continuous communications and reservoir water level and gate position monitoring. Using both methods would insure power to mechanical equipment (gates, valves, motors, etc.) in the event of failure in one or the other power sources. The cost of both is estimated at $990,000.

A 3.6-mile paved road from Horseshoe Dam to the Cliff damsite would provide access during construction and later serve as the O&M road to the dam. Two 3.5-mile roads would also be constructed to provide access to recreation areas.

The proposed development of Cliff Dam and Reservoir would require the acquisition of and/or right to use 17,000 acres of land within the Tonto National Forest. Of the total land requirement, 212 acres represent private ownership acquisition (KA Ranch). Livestock grazing rights in the area would have to be acquired.

Horseshoe Dam would be abandoned and partially breached. The existing facilities would be replaced at Cliff Dam.

The cost of constructing Cliff Dam is estimated at $346,179,000. A summary of the construction cost estimates showing the distribution of the costs among the various features is shown on the Project Construction Cost Estimates at the end of this chapter. Detailed construction cost estimates are provided in Appendix A.

The total appraisal-level cost for OM&R is estimated at $547,000. The cost includes supervision, labor, equipment, and overhead for operating and maintaining the dam structure and its appurtenant works. The appraisal-level OM&R cost estimates for this feature are displayed in Chapter V, page 39.

Approximately 12 years are estimated to complete the development of Cliff Dam and its associated features. Construction of the dam and its appurtenant structures would require about 4 1/2 years.

Modified Roosevelt Dam and Reservoir

The dam, reservoir, and related features for Modified Roosevelt Dam are located wholly within the Tonto National Forest, about 76 miles northeast of Phoenix and 30 miles northwest of Globe, Arizona.

The reservoir would have a total storage capacity of 2,166,200 acre-feet. The storage allocation is shown below.

Purpose	Storage (Acre-Feet)	Aggregate (Acre-Feet)	Elevation (Feet)	Water Surface Area (Acres)
Surcharge			2210	31,063
Exclusive Flood Control	101,300	2,166,200	2175	25,627
Joint Use	455,700	2,064,900	2171	25,010
Active Conservation	1,275,400	1,609,200	2151	19,200
Inactive	308,300	333,800	2060	8,230
Dead	25,500	25,500	1994.8	1,610

The reservoir would have a total flood control allocation of 557,000 acre-feet. As shown above, 455,700 acre-feet of the total flood control allocation is designated as joint use space. The storage data includes an allowance of 268,000 acre-feet of projected 100 years sediment deposition between the streambed and elevation 2151. The 268,000 acre-feet lies above elevation 1966.

Modification of Theodore Roosevelt Dam would include raising the existing structure to elevation 2210. Part of the existing dam would be removed prior to the placement of new concrete. The existing dam would be excavated down to elevation 2100. A 10-foot thickness of stone block and cyclopean masonry would be removed from the downstream face to obtain an unweathered contact surface suitable for placing new concrete. The downstream face would be excavated down to elevation 1947 and its surface sandblasted. Grouted anchor bars and a drainage system would also be installed. The anchor bars would be installed at 5-foot spacing each way and have an embedment of 8 feet into the existing dam. The new crest length would be 1,180 feet. The crest thickness would be 7 feet.

Foundation treatment would consist of a combination of drainage tunnels, solid circular 6-inch-diameter steel bars, or post tension wire cables, and a 25-foot-deep concrete shear key with an average thickness of about 15 feet. The foundation treatment would be needed only on the abutments.

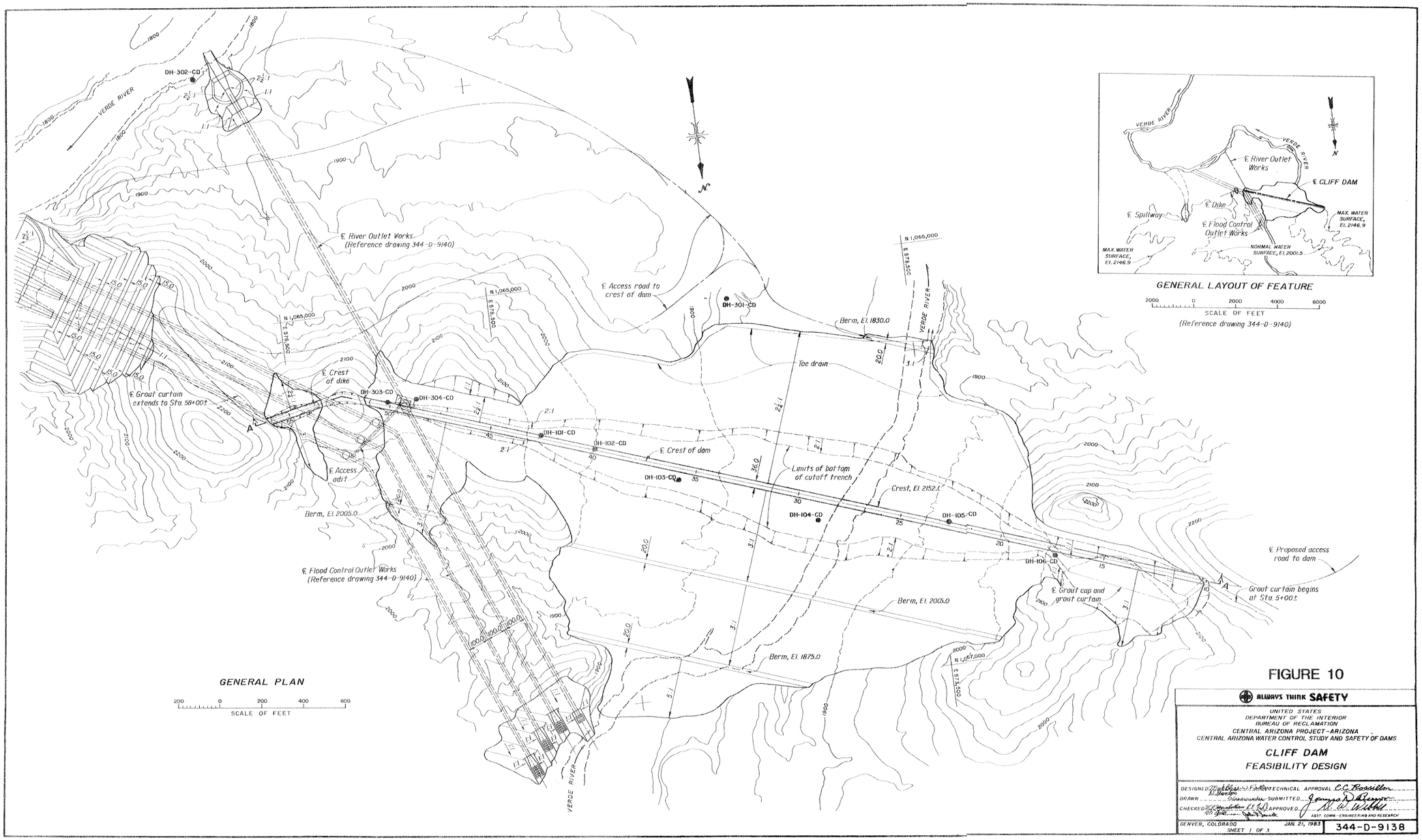


FIGURE 10

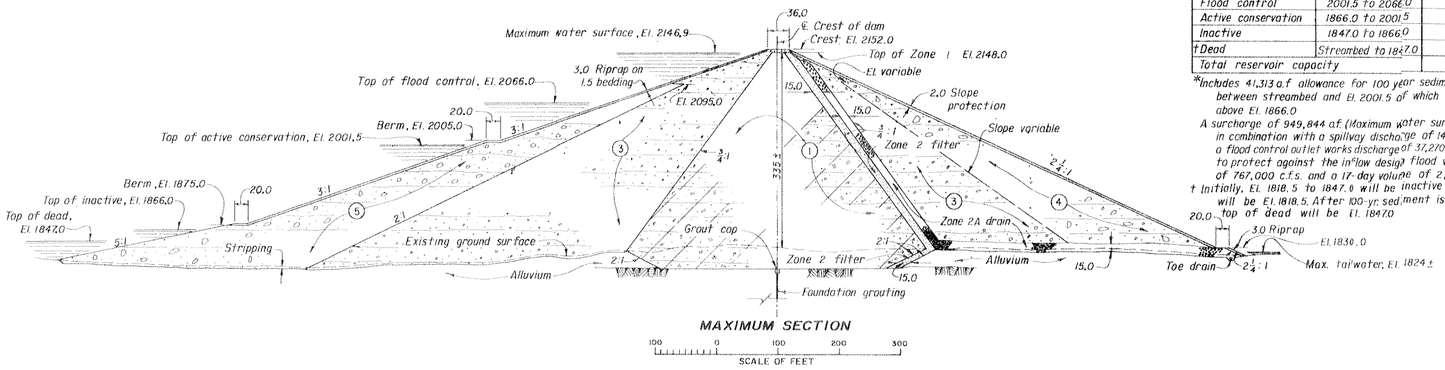
ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT-ARIZONA
CENTRAL ARIZONA WATER CONTROL STUDY AND SAFETY OF DAMS

CLIFF DAM
FEASIBILITY DESIGN

DESIGNED Hydraulic Laboratory TECHNICAL APPROVAL C.C. Fosdillon
DRAWN Steinwunder SUBMITTED James D. Bumer
CHECKED C.C. Fosdillon APPROVED N. C. Wilbur
ASST. COMM.-ENGINEERING AND RESEARCH

DENVER, COLORADO JAN. 21, 1983 SHEET 1 OF 3 344-D-9138



MAXIMUM SECTION

SCALE OF FEET

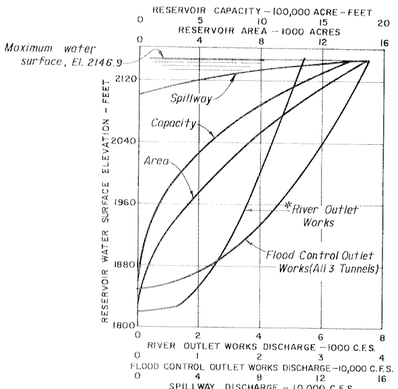
RESERVOIR CAPACITY ALLOCATIONS

PURPOSE	ELEVATIONS	CAPACITY ACRE-FEET
Flood control	2001.5 to 2066.0	451,000
Active conservation	1866.0 to 2001.5	332,740
Inactive	1847.0 to 1866.0	6445
†Dead	Streambed to 1847.0	3555
Total reservoir capacity		793,740*

*Includes 41,313 a.f. allowance for 100 year sediment deposition between streambed and El. 2001.5 of which 33,000 a.f. is above El. 1866.0

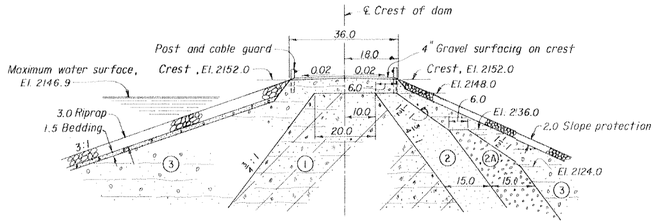
A surcharge of 949,844 a.f. (Maximum water surface El. 2146.9) in combination with a spillway discharge of 148,771 c.f.s. and a flood control outlet works discharge of 37,210 c.f.s. is provided to protect against the inflow design flood which has a peak of 767,000 c.f.s. and a 17-day volume of 2,300,000 a.f.

† Initially, El. 1818.5 to 1847.0 will be inactive and top of dead will be El. 1818.5. After 100-yr. sediment is deposited, top of dead will be El. 1847.0



*Curve reflects initial discharge capability below El. 1847.0 (100 yr. Sediment level)

AREA – CAPACITY – DISCHARGE CURVES



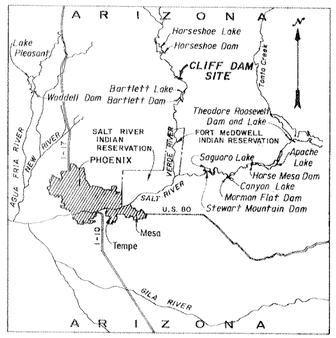
CREST DETAIL

(WITHOUT CAMBER)

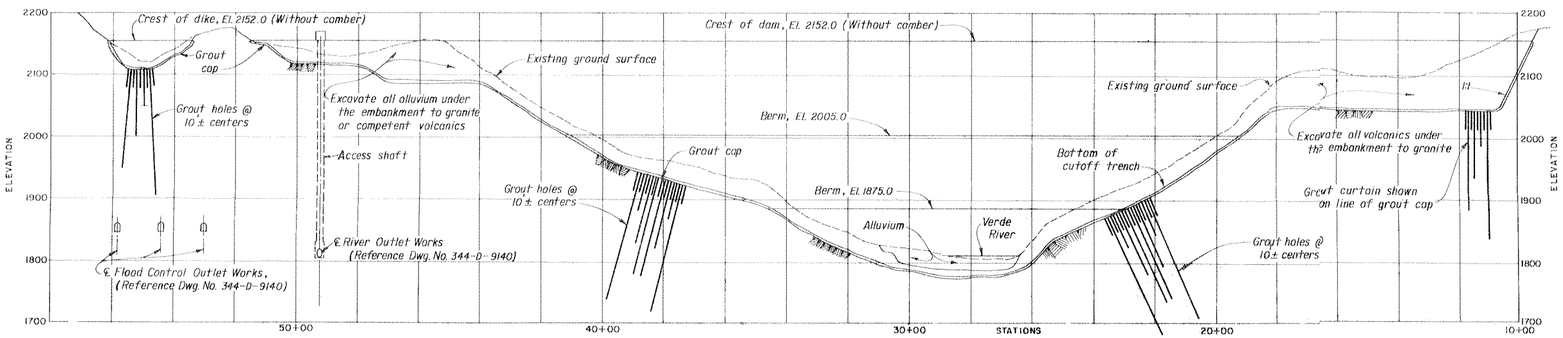
SCALE OF FEET

EMBANKMENT EXPLANATION

1. Impervious material of selected low to medium plasticity clays, clayey sands and gravels, and silty sands compacted by tamping rollers to 6" layers. (CL, SC, GC, SM)
2. Processed pervious sand filter material compacted by vibratory compactor in 12" layers. (SP, SW)
2A. Processed pervious sand and gravel drain material compacted by vibratory compactor in 12" layers. (GP, GW)
3. Selected pervious material of silt, sand, gravel, and cobble composition compacted by vibratory compactor in 12" layers.
4. Miscellaneous material from required excavation compacted by vibratory compactor in 18" layers.
5. Selected pervious material of sand, gravel, cobble, and rock fragment composition compacted by vibratory compactor in 18" layers.



LOCATION MAP



SECTION A-A

(PROFILE ON ℄ CREST OF DAM AND DIKE)

FIGURE 11

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL ARIZONA PROJECT–ARIZONA
CENTRAL ARIZONA WATER CONTROL STUDY AND SAFETY OF DAMS

CLIFF DAM
FEASIBILITY DESIGN

DESIGNED ... TECHNICAL APPROVAL ...
DRAWN ... SUBMITTED ...
CHECKED ... APPROVED ...
ASST. COMM. – ENGINEERING AND RESEARCH

DENVER, COLORADO — JAN. 21, 1983 — SHEET 2 OF 3 — **344-D-9139**

The outlet works would consist of two 10-foot 8-inch-diameter conduits with the inlet centerline at elevation 2000 and the exit centerline at elevation 1945. The outlet works would be located near the center of the dam. The construction of the outlet works would require some tunnel excavation through the existing dam and some underwater construction.

The power outlet works would have a rectangular bellmouth inlet with a centerline elevation at 2030. The inlet would transition to an 11-foot 6-inch-diameter conduit. The construction of the power outlet would require tunnel excavation through the existing dam and underwater construction on the upstream face.

The dam would include submerged orifice-type spillways. Each spillway conduit would have a 13-foot 4-inch by 20-foot 0-inch top seal radial gate. The intake centerline elevations were established at 2110 feet. There are three conduits on each abutment that would discharge into a chute with a flip at the end. The spillway chute would be designed to flip the water into a plunge pool. The plunge pool was designed to protect against scour during normal operation of the spillway. At a maximum water surface elevation of 2210 feet, the spillways would have a discharge capability of 115,500 cfs.

The existing 36 MW powerplant, located at the downstream toe of the dam, would be modified to operate under a revised operating head range. Modifications to the existing powerplant would be extensive and would involve removal of all equipment. A new turbine would be installed. The rewound generator would be reinstalled and all other removed mechanical and electrical equipment reinstalled or replaced as required.

A 115-kV switchyard would be reinstalled at its present location after the powerplant is modified.

Design drawings of Modified Roosevelt Dam are shown on Figures 12 and 13.

Several types of relocations would be involved in the development of Modified Roosevelt Dam. One major relocation item would involve the development of construction roads to accommodate traffic during construction and a permanent crossing over the Salt River after construction of the modified dam. This is perhaps the single most significant cost item of the collective relocation obligations.

The other relocation items would include portions of an impacted residential subdivision, a private concessionary, existing stream gaging and transmission system, and Salt River Project and U.S. Forest Service recreational and administrative improvements along the Salt Arm of Theodore Roosevelt Lake.

The cost of constructing the Modified Roosevelt Dam is estimated at $231,500,000. A summary of the construction cost estimate showing the distribution of the costs amongst the various features is shown on the Project Construction Cost Estimates at the end of this chapter.

Detailed construction cost estimates are provided in Appendix A.

The total appraisal-level OM&R is estimated at $1,496,000. The cost includes supervision, labor, equipment, and overhead for operating and maintaining the dam structure and its appurtenant works. The appraisal-level OM&R cost estimates are displayed in Chapter V, page 40.

Approximately 10 years are estimated to complete the development of modifications to Theodore Roosevelt Dam and its associated features. Construction of the dam and appurtenant works would require about 4 1/2 years.

Modified Stewart Mountain Dam

Stewart Mountain Dam is located on the Salt River about 25 miles northeast of Mesa, Arizona. The dam and its reservoir are located within the Tonto National Forest and within Maricopa County.

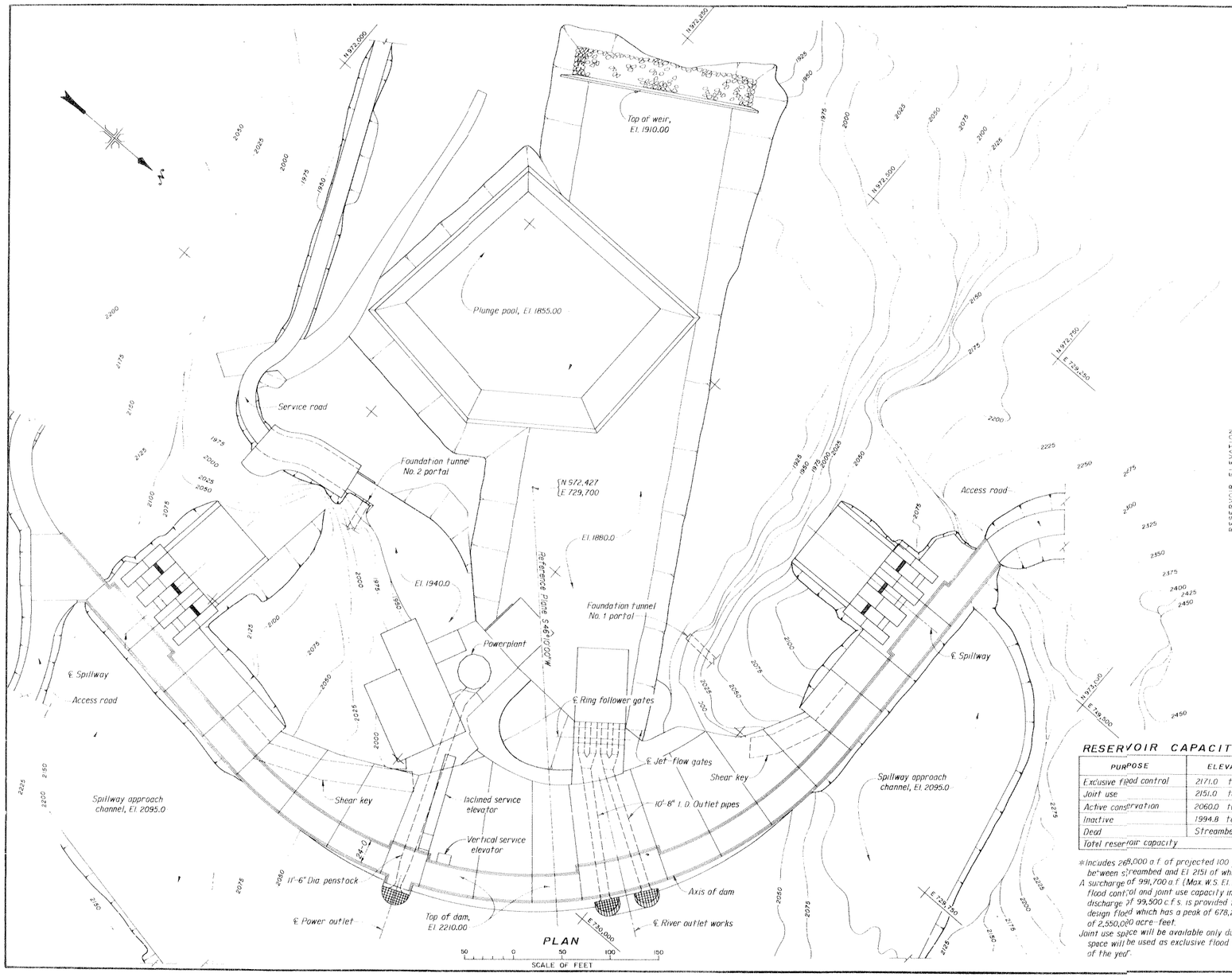
Stewart Mountain Dam impounds Saguaro Lake and has a total controllable capacity of about 69,800 acre-feet at elevation 1529. The 207-foot-high Stewart Mountain Dam is a concrete structure comprised of four distinct parts: A multicurvature arch dam, two gravity thrust blocks, two gravity wing dams, and ogee crest spillway with nine radial gates. The structural inadequacies of the dam's arch, thrust block, and gravity sections due to overtopping would be relieved by an auxiliary spillway placed on the right abutment.

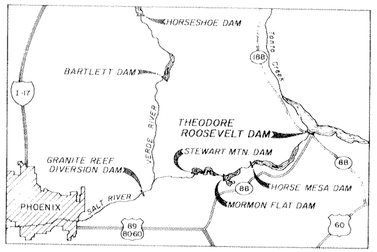
To remedy the instability problem that would result from a maximum credible earthquake (MCE) event, the following changes would be made. The top 40 feet of the arch would be reshaped and reinforced with passive steel to reduce horizontal tensions. The right gravity section would be reshaped to improve its stability and would bridge the distance between the proposed auxiliary spillway and the right thrust block. The left gravity section would be replaced with new concrete and an additional 6-foot thickness would be added to the downstream side of the section. The right thrust block would be stabilized by adding additional reinforced concrete to the south and west faces. The left thrust block would require no change.

The existing spillway is located east of the left thrust block and is a gated ogee crest-type spillway with a concrete lined chute. The spillway has nine 27- by 23-foot radial gates. The structure would not undergo any modification.

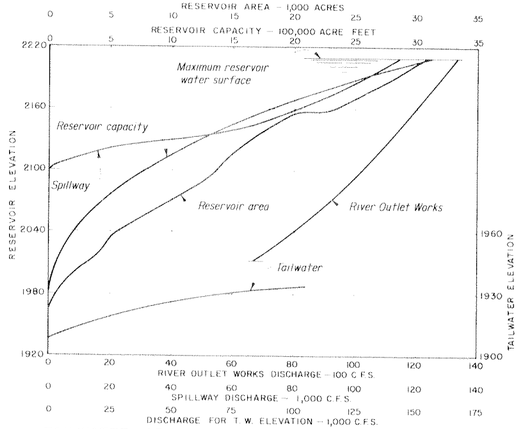
The auxiliary spillway would have a gated ogee crest, a concrete lined chute, a flip structure, and an unlined plunge pool. With a crest elevation of 1496 feet, it would be controlled by four 30- by 30-foot radial gates, with the capacity of 87,000 cfs at a surface water elevation of 1533 feet. The existing surface outlets and powerplant would not require any modifications.

Design drawings for Modified Stewart Mountain Dam are shown on Figures 14 and 15.





LOCATION MAP



TAILWATER, AREA, CAPACITY, AND DISCHARGE CURVES

RESERVOIR CAPACITY ALLOCATIONS

PURPOSE	ELEVATIONS	CAPACITY ACRE – FEET
Exclusive flood control	2171.0 to 2175.0	101,300
Joint use	2151.0 to 2171.0	455,700
Active conservation	2060.0 to 2151.0	1,275,400
Inactive	1994.8 to 2060.0	308,300
Dead	Streambed to 1994.8	25,500
Total reservoir capacity		2,166,200*

*Includes 268,000 a.f. of projected 100 years of sediment deposition between streambed and El. 2151 of which 268,000 a.f. is above El. 1966. A surcharge of 991,700 a.f. (Max. W.S. El. 2210.0) plus 566,900 a.f. in flood control and joint use capacity in combination with a spillway discharge of 99,500 c.f.s. is provided to protect against the inflow design flood which has a peak of 678,200 c.f.s. and a 17-day volume of 2,550,000 acre-feet.
Joint use space will be available only during April to November. This space will be used as exclusive flood control for the remainder of the year.

FIGURE 12

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
SALT RIVER PROJECT-ARIZONA

THEODORE ROOSEVELT DAM
FEASIBILITY DESIGN DRAWING
MODIFICATION-RAISE DAM TO EL. 2210.00
PLAN

DESIGNED R. Kelly SUBMITTED R. C. Stevens
DRAWN RECOMMENDED
CHECKED APPROVED
ACT. ASST. COMM.-ENGINEERING AND RESEARCH

DENVER, COLORADO APRIL 29, 1983 SHEET 1 OF 2 25-D-2785

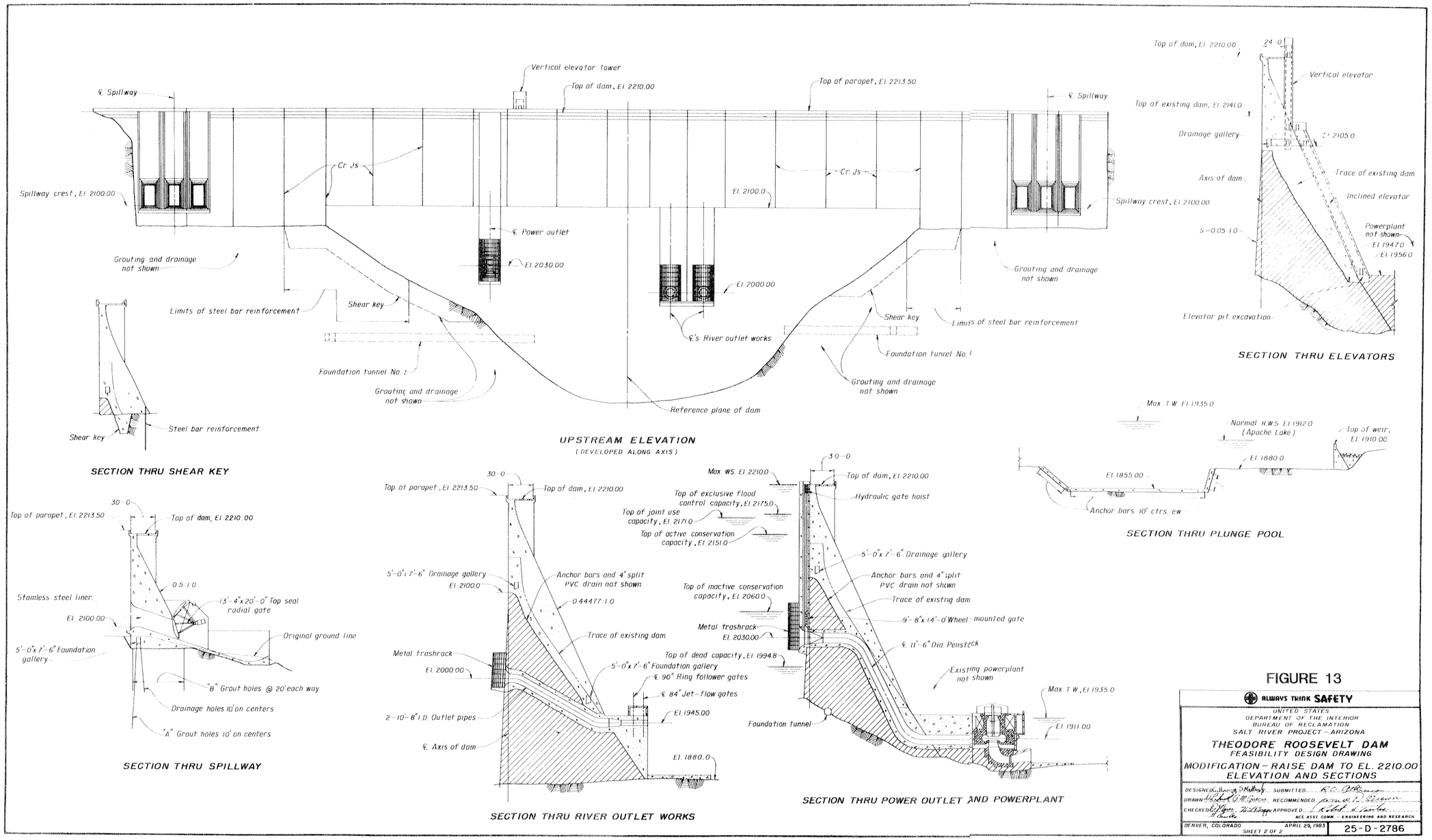


FIGURE 13

ALWAYS THINK SAFETY

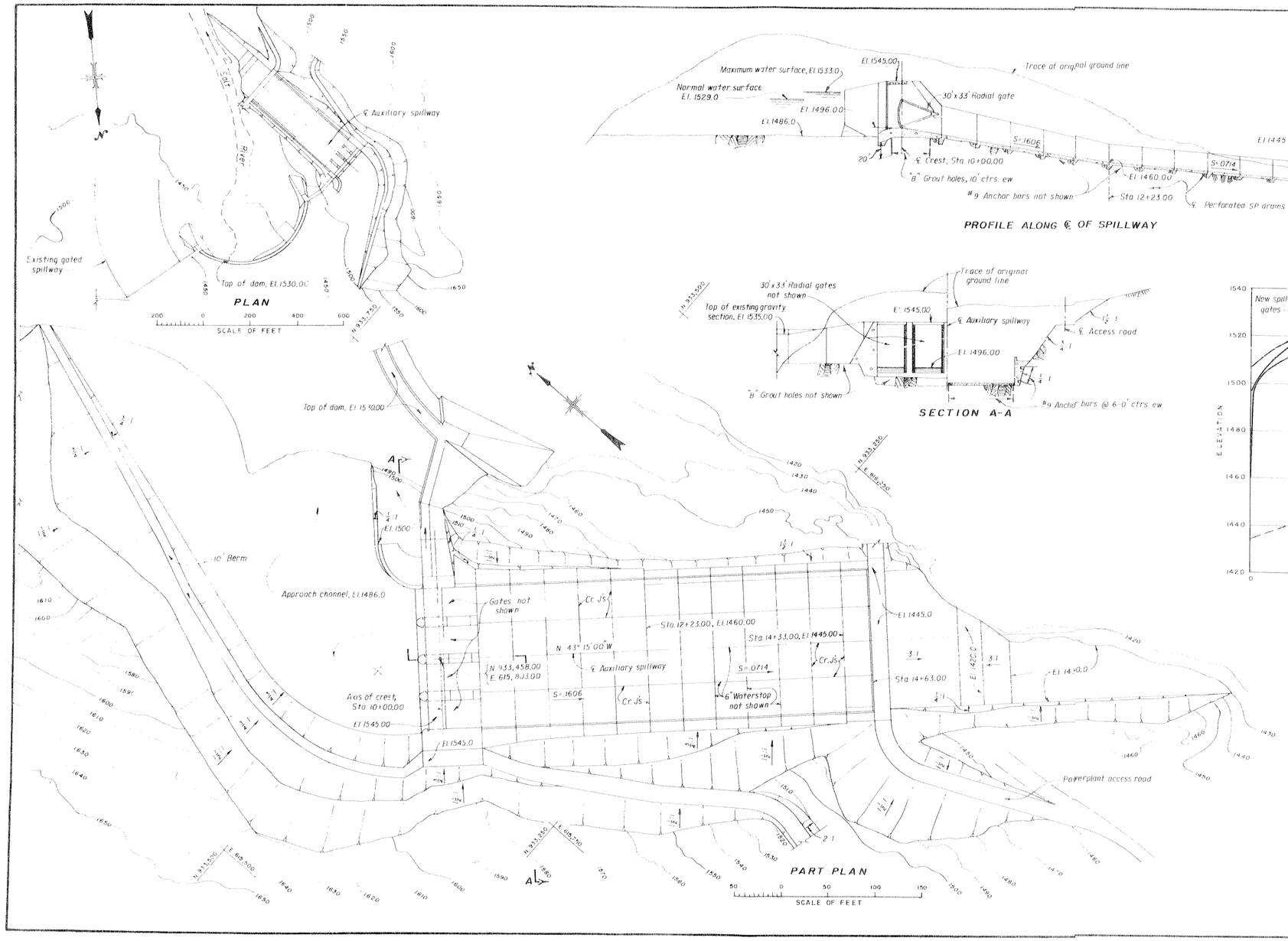
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
SALT RIVER PROJECT – ARIZONA

THEODORE ROOSEVELT DAM
FEASIBILITY DESIGN DRAWING

MODIFICATION – RAISE DAM TO EL. 2210.00
ELEVATION AND SECTIONS

DESIGNED SHEET 2 OF 2 SUBMITTED
DRAWN RECOMMENDED
CHECKED APPROVED
ACT. ASST. COMM. – ENGINEERING AND RESEARCH

DENVER, COLORADO APRIL 29, 1983 25-D-2786



NOTE

The maximum water surface of El. 1533.0 is based on existing gate steps. A higher water surface will impinge on the bottom of the gate when fully opened.

FIGURE 14

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
SALT RIVER PROJECT–ARIZONA

STEWART MOUNTAIN DAM
FEASIBILITY DESIGN DRAWING
AUXILIARY SPILLWAY–RIGHT ABUTMENT

DESIGNED ____ SUBMITTED ____
DRAWN ____ RECOMMENDED ____
CHECKED ____ APPROVED ____
ASST. CHIEF ENGINEER AND RESEARCH

DENVER, COLORADO — OCTOBER 1, 1981 — 25-D-2772

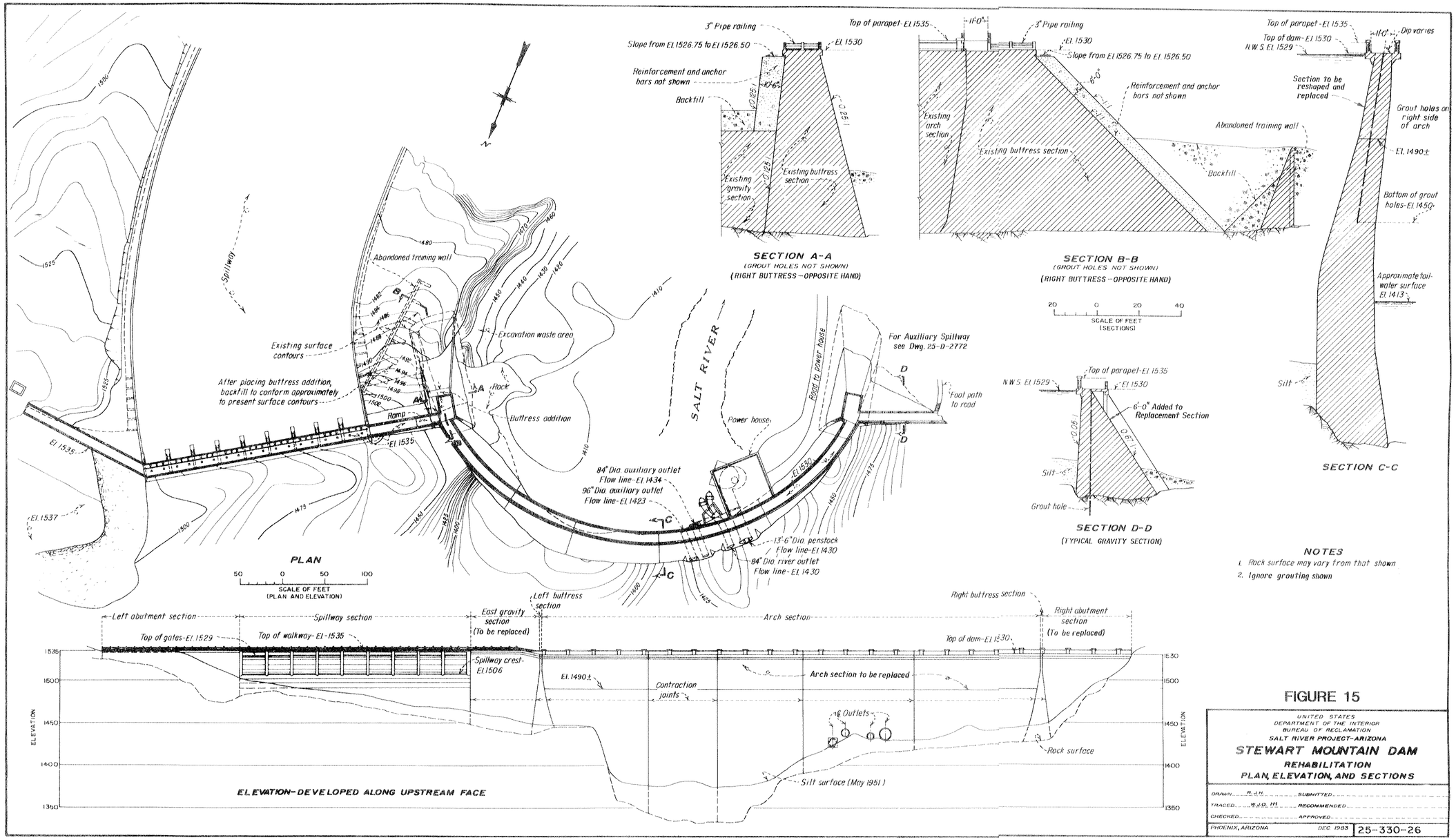


FIGURE 15

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
SALT RIVER PROJECT-ARIZONA

STEWART MOUNTAIN DAM

REHABILITATION

PLAN, ELEVATION, AND SECTIONS

DRAWN R.J.H. SUBMITTED
TRACED W.J.O. III RECOMMENDED
CHECKED APPROVED
PHOENIX, ARIZONA DEC 1983 25-330-26

The cost of constructing the modification of Stewart Mountain Dam is estimated at $40,160,000. A summary of the construction cost estimate is shown at the end of this chapter. Detailed Project Construction Cost Estimates are provided in Appendix A. Since the Salt River Project would continue the operation and maintenance of this feature, no OM&R costs were estimated.

It is estimated that a 2- or 3-year construction period would be required depending on upstream reservoir operations and associated downstream water user requirements. Approximately 1 year would be required for materials and foundation explorations programs.

Recreation Development

Recreational development at New Waddell would be largely confined to the western shore of the reservoir. Four sites would be developed. Access to the lake, for recreational purposes, would be relocated and controlled by a manned entrance station. Recreational development would include facilities to accommodate hiking, picnicking, camping, boating, fishing, and sightseeing activities. In addition, such management and support facilities as a ranger station, concession, gas docks, sanitary dump station, and an interpretive center are also included. The development, including replacement, would require about 240 acres and is estimated to cost $6,236,000 with an accommodation of 863,000 annual recreation days.

Recreational development at Cliff would consist of four sites. Access to the major recreational areas would be along Forest Highway 205, the Horseshoe Dam Road. Recreational development would include facilities to accommodate camping, picnicking, boat launching, a marina/concession area, fish cleaning station, visitor center, and archeological interpretive area. In addition, equestrian-oriented facilities and trailheads, connecting to existing trail networks, would be provided. The recreational development would involve approximately 275 acres and is estimated to cost $10,435,000 with an accommodation of 381,411 annual recreation days.

Recreational development of Modified Roosevelt Dam would consist of 10 sites, with one being primarily for river access. Development was planned to be conducive to environmental constraints involved in wildlife mitigation proposals for the lake. Current access routes to the area would be maintained and some would be improved. The paving of A-Cross Road, on the eastern shore of the reservoir, would greatly increase expected use. The plans call for paving of all recreational access roads and the use of guardrails as a management tool to prevent unauthorized off-road use. Recreational development would primarily consist of picnicking, camping, boat launching, fishing, a marina/concession, a sheriff's aid station, and a visitor center. The proposed development would require approximately 660 acres, with an estimated cost of $18,552,000, exclusive of road development, and have a capacity of 1,061,000 annual recreation days.

Mitigation Costs

The mitigation costs for the plan would total $20,427,000, including $13,489,000 for the cultural resource program and $6,930,000 for the biological resource program. The costs for the biological program include: $4,361,000 for planting cottonwoods and willows and breaching Horseshoe Dam to mitigate losses to the riparian wetland communities; $1,890,000 for fencing and water catchments to mitigate losses to the terrestrial communities; $667,000 for stream stabilization to mitigate losses to perennial streams; and $20,000 to manage special use areas.

Estimated Construction Costs

Project construction costs are estimated at $1,035,500,000 for Reclamation facilities financed through the Colorado River Basin Project Act of 1968 (Public Law 90-537), and the Reclamation Safety of Dams Act of 1978 (Public Law 95-578). The costs of the facilities were estimated by the Bureau of Reclamation on the basis of January 1983 prices. These estimates are based on feasibility designs that would provide a minimum useful project life of 100 years. The costs of the individual features are shown at the end of this chapter.

Development Program

An estimated 12-year development program would be needed to complete the development of the plan. The proposed construction program is shown at the end of this chapter. The beginning of construction would depend on Congressional appropriations. The initial delivery dates for CAP water are not contingent upon construction of the plan's features; however, the enhancement of the water supply and delivery would result from these features.

7 1720 (6-72)
Bureau of Reclamation
Formerly Basic Estimate DC-1 Summary

INSTRUCTIONS FOR USE OF THIS FORM ARE CONTAINED IN CHAPTER 6, PART 152 OF THE RECLAMATION INSTRUCTIONS.

Central Arizona Project
New Waddell Dam and Reservoir

PROJECT COST ESTIMATE

Feasibility Estimate

Code 2224

OFFICE PREPARED BY: Arizona Projects Office

PROJECT Central Arizona Project
Date of Estimate May 1983
Prices as of January 1983

Sheet 1 of 2

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	DESCRIPTION	CCE SHEET NUMBERS	LABOR AND MATERIALS BY CONTRACTOR Cost	LABOR AND MATERIALS BY GOVERNMENT Cost	FIELD COST Plant Account	TOTAL FIELD COST Identified Property	OTHER COSTS Identified Property	TOTAL COST Identified Property	TOTAL COST Property Class	TOTAL COST Identified Property
	1		2	3	4	5	6	7	8	9	10	11
			TOTAL PROJECT COST									417,643,000
01			Dams and Reservoirs								284,261,000	
	04		New Waddell Dam and Reservoir					227,409,000	56,852,000	284,261,000		
		100	Lands and Rights	1			23,250,000					
		110	Relocation of Property of Others		14,899,000		14,899,000					
			(1) Castle Hot Springs Road	1	(7,171,000)							
			(2) Spillway Access Road	2	(2,300,000)							
			(3) Right Abutment Access Road	3	(522,000)							
			(4) Left Abutment Access Road	3	(61,000)							
			(5) Recreation Facilities	4	(3,608,000)							
			(6) Recreation Roads and Structures	5	(637,000)							
			(7) 12.5 KV APS Transmission Line	5	(600,000)							
		120	Clearing Lands	5	460,000		460,000					
		151	Dam	5	188,800,000		188,800,000					
03			Pumping Plants								93,563,000	
	01		New Waddell Pump - Generator Plant					74,850,000	18,713,000	93,563,000		
		165	Waterwheels, Turbines, and Generators	5	74,850,000		74,850,000					
05			Canals and Conduits								22,163,000	
	01		Waddell Reversible Canal					17,730,000	4,433,000	22,163,000		
		100	Lands and Rights	6			362,700					
		110	Relocation of Property of Others		1,286,600		1,286,600					
			(1) Bridged Crossings for Unimproved Dirt Roads	6	(616,000)							
			(2) Bridge Approaches for Unimproved Dirt Roads	7	(66,400)							
			(3) Bridge - State Highway 74	7	(274,000)							
			(4) East Bridge Approach - State Highway 74	8	(14,200)							
			(5) West Bridge Approach - State Highway 74	8	(17,000)							
			(6) Bridge Construction Detour - State Highway 74	9	(261,000)							
			(7) Mobilization	9	(38,000)							
		130	Structures and Improvements	9	136,700		136,700					
		152	Waterway	10	13,134,000		13,134,000					

7-1720 (5-72)
Bureau of Reclamation
Formerly Basic Estimate DC-1 Summary

INSTRUCTIONS FOR USE OF THIS FORM ARE CONTAINED IN CHAPTER 6, PART 152 OF THE RECLAMATION INSTRUCTIONS.

Central Arizona Project
New Waddell Dam and Reservoir

PROJECT COST ESTIMATE

Feasibility Estimate

Code 2224

OFFICE PREPARED BY: Arizona Projects Office

PROJECT Central Arizona Project
Date of Estimate May 1983
Prices as of January 1983

Sheet 2 of 2

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	DESCRIPTION	CCE SHEET NUMBERS	LABOR AND MATERIALS BY CONTRACTOR	LABOR AND MATERIALS BY GOVERNMENT	FIELD COST	TOTAL FIELD COST	OTHER COSTS	TOTAL COST	TOTAL COST	TOTAL COST
					Cost	Cost	Plant Account	Identified Property	Identified Property	Identified Property	Property Class	Identified Property
1			2	3	4	5	6	7	8	9	10	11
05			Canals and Conduits (continued)									
	01		Waddell Reversible Canal (continued)									
		154	Waterway Protective Works	10	2,809,750		2,809,750					
13			Transmission Lines, Switchyards and Substations								7,675,000	
	04		New Waddell Transmission Line and Switchyard					6,140,000	1,535,000	7,675,000		
		180	Station Equipment	11	3,800,000		3,800,000					
		181	Towers and Fixtures	11	2,340,000		2,340,000					
15			General Property								9,981,000	
	04		New Waddell Dam and Reservoir					7,985,000	1,996,000	9,981,000		
		130	Structures and Improvements	11	618,000		618,000					
		170	Accessory Electrical Equipment	12	480,000		480,000					
		199	Recreation Facilities	12	6,236,000		6,236,000					
		280	Mitigation	12	651,000		651,000					

7-1720 (5-72)
Bureau of Reclamation
Formerly Basic Estimate DC-1 Summary

INSTRUCTIONS FOR USE OF THIS FORM ARE CONTAINED IN CHAPTER 6, PART 152 OF THE RECLAMATION INSTRUCTIONS.

Central Arizona Project
Cliff Dam and Reservoir

PROJECT COST ESTIMATE

Feasibtility Estimate

Code 2224
OFFICE PREPARED BY:
Arizona Project Office

PROJECT Central Arizona Project
Date of Estimate November 1983
Prices as of January 1983

Sheet 1 of 1

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	DESCRIPTION	CCE SHEET NUMBERS	LABOR AND MATERIALS BY CONTRACTOR Cost	LABOR AND MATERIALS BY GOVERNMENT Cost	FIELD COST Plant Account	TOTAL FIELD COST Identified Property	OTHER COSTS Identified Property	TOTAL COST Identified Property	TOTAL COST Property Class	TOTAL COST Identified Property
1			2	3	4	5	6	7	8	9	10	11
			TOTAL PROJECT COST									346,179,000
01			Dams and Reservoirs								316,154,000	
	05		Cliff Dam and Reservoir					252,923,000	63,231,000	316,154,000		
		100	Lands and Rights	1			630,000					
		110	Relocation of Existing Property		5,348,000		5,348,000					
			(1) Cliff Dam Access Road, 2.32 miles, 24 ft. rdwy.	1	(3,435,000)							
			(2) Recreation Facilities	2	(1,913,000)							
		120	Reservoir Clearing	2			895,000					
		151	Dam	2			246,050,000					
13			Transmission Lines, Switchyards and Substations								938,000	
	05		Cliff Transmission Line					750,000	188,000	938,000		
		182	Poles and Fixtures	2			750,000					
15			General Property								29,087,000	
	05		Cliff Dam and Reservoir					23,270,000	5,817,000	29,087,000		
		130	Structures and Improvements	3			618,000					
		199	Recreation Facilities	3			10,435,000					
		200	Miscellaneous Equipment	3			50,000					
		280	Mitigation	4			12,167,000					

7-1720 (5-72)
Bureau of Reclamation
Formerly Basic Estimate DC-1 Summary

INSTRUCTIONS FOR USE OF THIS FORM ARE CONTAINED IN CHAPTER 6, PART 152 OF THE RECLAMATION INSTRUCTIONS.

Central Arizona Project
Modified Theodore Roosevelt Dam Plan 1

PROJECT COST ESTIMATE

Feasibility Estimate

Code 2224
OFFICE PREPARED BY: Arizona Projects Office

PROJECT Central Arizona Project
Date of Estimate November 1983
Prices as of January 1983

Sheet 1 of 1

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	DESCRIPTION	CCE SHEET NUMBERS	LABOR AND MATERIALS BY CONTRACTOR Cost	LABOR AND MATERIALS BY GOVERNMENT Cost	FIELD COST Plant Account	TOTAL FIELD COST Identified Property	OTHER COSTS Identified Property	TOTAL COST Identified Property	TOTAL COST Property Class	TOTAL COST Identified Property
1			2	3	4	5	6	7	8	9	10	11
			TOTAL PROJECT COST									212,321,000
01			Dams and Reservoirs								178,407,000	
	01		Modified Theodore Roosevelt Dam					142,726,000	35,681,000	178,407,000		
		100	Lands and Rights	1			16,800,000					
		110	Relocation of Existing Property		18,822,000		18,822,000					
			(1) Concrete Bridge, Hwy 188-Dam Crest, 320 ft., 24 ft. rdwy.	1	(988,000)							
			(2) Highway 88, 2.1 miles, 34 ft. rdwy.	2	(4,676,000)							
			(3) Highway 188, 0.4 miles, 34 ft. rdwy.	3	(831,000)							
			(4) Apache Trail, 0.85 miles, 34 ft. rdwy.	4	(1,356,000)							
			(5) Construction Access/ Powerhouse Service Road, 0.32 miles, 20 ft. rdwy.	5	(1,053,000)							
			(6) Temporary Floating Bridge	6,7	(7,478,000)							
			(7) SRP 115 KV Transmission Line, 2.19 miles	8	(458,000)							
			(8) Recreation Facilities	8	(1,434,000)							
			(9) Mobilization	8	(548,000)							
		120	Reservoir Clearing	8			100,000					
		151	Modified Dam	8			92,950,000					
		165	Powerplant	8			14,054,000					
15			General Property								33,914,000	
	01		Modified Theodore Roosevelt Dam					27,131,000	6,783,000	33,914,000		
		199	Recreation Facilities	9			18,552,000					
		280	Mitigation	10			8,579,000					

GPO 835-542

Modified Stewart Mountain Dam
Project Cost Estimate

Item	January 1983 Field Costs [1]
Dam	
Rehabilitate arch, thrust block, and gravity sections	$14,500,000
Construct auxiliary spillway	15,500,000
Foundation treatment	2,000,000
Relocations	
Spillway access road	30,000
Mitigation	100,000
Other Costs (non-contract) - 25 percent	8,030,000
Construction Cost	$40,160,000

[1] All cost estimates are represented on January 1983 price levels.

CONSTRUCTION PROGRAM

		YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12	YEAR 13	YEAR 14	YEAR 15
NEW WADDELL DAM																
Design	28,200,000	6,300,000	13,100,000	9,800,000		Award Major Contract										
Dam Construction	287,200,000		9,300,000	19,800,000	15,700,000	28,300,000	86,700,000	69,900,000	62,300,000	6,200,000						
Pump-Generator Construction	15,700,000						5,100,000	7,300,000	3,300,000							
Waddell Canal Construction	17,700,000							500,000	17,200,000							
Breaching Waddell Dam	2,800,000									2,100,000	700,000					
Mitigation	700,000	50,000	50,000	100,000	100,000		200,000	200,000								
Non-Contract Costs	54,300,000		100,000	300,000	8,100,000	8,100,000	8,200,000	8,100,000	8,100,000	8,200,000	8,100,000					
Construction Cost	417,600,000	6,350,000	22,550,000	29,000,000	23,900,000	36,400,000	100,200,000	86,000,000	90,900,000	16,500,000	8,800,000					
CLIFF DAM																
Design	24,200,000				4,000,000	10,000,000	8,800,000	1,400,000	Award Major Contract							
Dam Construction	251,000,000						2,600,000	10,200,000	35,700,000	70,200,000	81,100,000	44,700,000	6,400,000	100,000		
Horseshoe Dam Salvage	1,500,000											1,300,000	200,000			
Recreation Facilities	12,300,000									1,800,000	2,100,000	2,100,000	2,100,000	2,100,000	1,800,000	300,000
Mitigation	12,200,000				500,000	1,800,000	3,400,000	3,800,000	2,500,000	400,000						
Non-Contract Costs	45,000,000					100,000	1,600,000	1,500,000	5,800,000	8,000,000	8,600,000	8,800,000	8,600,000	1,800,000	500,000	100,000
Construction Cost	346,200,000				4,500,000	11,700,000	16,400,000	16,900,000	43,800,000	80,400,000	91,800,000	56,700,000	17,300,000	4,000,000	2,300,000	400,000
MODIFIED ROOSEVELT DAM																
Design	16,200,000		2,200,000	6,800,000	5,500,000	2,000,000	Award Major Contract									
Dam Construction	157,000,000			700,000	4,200,000	9,700,000	15,400,000	26,400,000	38,700,000	41,000,000	20,900,000					
Roosevelt Estates	1,000,000								400,000	600,000						
Recreation Facilities	18,800,000						3,400,000			1,400,000	5,100,000	6,100,000	2,800,000			
Mitigation	8,800,000			1,700,000	2,100,000	2,400,000	1,600,000		500,000	300,000						
Non-Contract Costs	30,100,000			500,000	1,500,000	2,200,000	4,500,000	4,500,000	4,500,000	4,500,000	4,500,000	3,100,000	300,000			
Construction Cost	231,500,000		2,200,000	9,400,000	13,300,000	16,300,000	24,900,000	30,900,000	44,100,000	47,800,000	30,500,000	9,200,000	2,900,000			
MODIFIED STEWART MOUNTAIN DAM																
Design	2,000,000						400,000	1,100,000	500,000	Award Major Contract						
Dam Modification	32,000,000									5,700,000	10,000,000	11,700,000	4,600,000			
Mitigation	100,000									50,000			50,000			
Non-Contract Costs	6,100,000						100,000	300,000	800,000	1,200,000	1,500,000	1,400,000	800,000			
Construction Cost	40,200,000						500,000	1,400,000	1,300,000	6,950,000	11,500,000	13,100,000	5,450,000			
PLAN 6 CONSTRUCTION COST	1,035,500,000	6,350,000	24,750,000	38,400,000	41,700,000	64,400,000	142,000,000	135,200,000	180,100,000	151,650,000	139,600,000	79,000,000	25,650,000	4,000,000	2,300,000	400,000

Chapter V

OPERATIONS, MAINTENANCE, AND REPLACEMENTS

Introduction

As stated in Chapter III, the Bureau desires to transfer the operation and maintenance (O&M) of completed Central Arizona Project (CAP) works to a local entity or entities as rapidly as practicable. This chapter briefly describes the normal operation of the plan and presents appraisal-level O&M cost estimates.

New Waddell Dam and Reservoir

New Waddell Dam and Reservoir Reservoir would include 157,600 acre-feet of replacement space. The plan would not impose or require changes in the manner in which the existing reservoir has historically been operated. All natural inflows to the reservoir from the Agua Fria River would be credited to and available for use by Maricopa County Municipal Water Conservation District #1 (MCMWCD#1) under its existing water right until the replacement space is filled.

The release of water for MCMWCD#1 would be through an outlet to Lower Lake Pleasant. The water would then be available for diversion into the existing Beardsley Canal.

The remaining conservation space (660,000 acre-feet) would be operated to allow maximum pumping of Colorado River water through the Granite Reef Aqueduct as described in Chapter IV. New Waddell Dam would be connected to the Granite Reef Aqueduct by a 3,000 cfs capacity reversible canal. Diversions from the aqueduct would be made to the canal during the winter months (November through April). The water would then be pumped into the reservoir. The amount of the diversion would vary and equal the difference between the downstream demand at the time of the diversion and the aqueduct capacity.

During the summer months (May through October), water would be released through an outlet to the reversible canal and back to the Granite Reef Aqueduct. A generator would be operated to produce power during the release operations. The actual amount of water released would depend on system demands during the period.

Although no exclusive flood control space would be provided in the reservoir, flood control for the Agua Fria River below the dam would be provided by restricting the reservoir surface during potentially high flood months. The reservoir surface would be restricted to elevation 1694 during April, May, and June. Operating the reservoir in this manner would reduce the 200-year flood, currently 120,000 cfs, and the 100-year flood, currently 90,000 cfs, to 10,000 cfs as measured above the confluence of the Agua Fria and New Rivers.

Spillway operations would begin after the reservoir's controllable storage is completely full and outlets are operating at capacity. This would occur above water surface elevation 1702.

The construction plan utilizes a diversion scheme consisting of upstream and downstream cofferdams along with a diversion tunnel located in the right abutment of the dam, with the outlet portal discharging into the lake below the dam construction site but just downstream from the diversion dam.

A cost of $2,738,000 per year is estimated as the required appraisal-level operation, maintenance, and replacement (OM&R) costs for the New Waddell facilities and its associated operational requirement. Table 5 shows a summary of these appraisal-level OM&R costs.

Cliff Dam and Reservoir

The operation of Cliff Dam and Reservoir would be similar to the current operation of Horseshoe Dam except a flood control operation would be added. The conservation pool in the Cliff Reservoir would normally be the fullest in the late winter or early spring, and would be drafted throughout the spring and summer months to bring the reservoir to its lowest storage by late summer.

The water in the CAP portion of the conservation storage would be held for the CAP until CAP demands require their release. There would be no direct connection between the CAP aqueduct and Cliff Reservoir. Therefore, to deliver CAP water from Cliff Reservoir, it would either be released to the Verde River for diversion into the Salt River Project (SRP) canal system or transferred to SRP ownership. Water released to the canal would be used by CAP users along the canal. CAP water retained in storage and transferred to SRP ownership would be used as a credit for CAP water users who would receive their allocation through exchanges with SRP. Cliff Dam and Reservoir on the Verde River, together with Modified Roosevelt Dam on the Salt River, would be operated as a combined, coordinated flood control reservoir system. Flood control releases from the individual reservoirs would be made on the basis of monitored inflow into each reservoir. The existing available flood control space would be constantly evaluated in an effort to maintain a balanced flood control space posture. Releases from the Salt and Verde storage systems would therefore be made so as to not exceed a combined inflow of 50,000 cfs at the confluence of the Salt and Verde Rivers.

Flood control operations would begin when inflows into a full Cliff Reservoir (storage at elevation 2001.5) exceed downstream water demands. Thereafter, operations throughout the allocated flood control space would limit the maximum releases from Cliff storage to 25,000 cfs during operations.

This flood control operation would vary depending on the time of the year. The maximum flood control space would be maintained during the months of December, January, February, and March. From April through September, 351,000 acre-feet of 450,000 acre-feet of flood control space (called joint use space) could be used for additional water conservation.

TABLE 5

Summary of Appraisal-Level Annual OM&R Costs
New Waddell Dam and Reservoir 1/

Items	January 1983 Costs 2/
Dam	$ 90,100
Pump-Generation Plant	470,000
Transmission Lines	8,600
Switchyard	127,600
Plant Substation	8,400
Power 3/	1,527,300
Waddell Canal	106,300
Recreation Facilities	400,000
Total Annual Apraisal-Level OM&R Costs and Power Costs	$2,738,300

1/ Costs for the dam features obtained from curves applied in 1981 Tucson Aqueduct study, based on reservoir acre-feet and structure design capacities. Costs for remaining items estimated from empirical graphs and tables in the Reclamation Instructions, Series 150.

2/ Cost for substation and O&M costs for pump-generation plant and transmission lines indexed from January 1970 to January 1983 level using standard O&M cost indices.

3/ 1983 energy prices of 21.614 mills/kwh for the plant and 0.35 mills/kwh for the powerlines.

Staging of the reservoir to elevation 2066 signals the emergency operations phase and releases through outlets would be increased to outflow capability with the balance of outflows passing through the spillway. Flows would be maintained at capability until the reservoir is drawn back to elevation 2066 (top of conservation). The flows would then be cut back to the maximum flood control release (25,000 cfs) to allow the decrease to match inflow.

A cost of $547,000 per year is estimated as the required appraisal-level OM&R cost for the Cliff facilities and its associated operational requirements. Table 6 shows a summary of these appraisal-level OM&R costs.

Modified Roosevelt Dam and Reservoir

Operations for the modified dam would continue in a manner similar to the existing structure except for the addition of a flood control operation.

The enlarged reservoir would be operated to conserve the flows of the Salt River and Tonto Creek. Under normal operations, the conservation pool in the Modified Roosevelt Lake would normally be the fullest in late winter or early spring, and would be drafted throughout the spring and summer months to bring the reservoir to its lowest storage by late summer.

Excess water credited to CAP would be delivered through the same mechanism as Cliff Dam and Reservoir.

The Modified Roosevelt Dam on the Salt River together with the proposed Cliff Dam on the Verde River would be operated as a combined, coordinated flood control reservoir system.

Flood control operations would begin when inflows into a full Theodore Roosevelt Lake (storage at elevation 2151 feet) exceed downstream water demands. Thereafter, operations throughout the allocated flood control space would limit the maximum releases from Modified Roosevelt storage to 25,000 cfs during operations.

This flood control operation would vary depending on the time of the year. The maximum flood control space would be maintained during December, January, February, and March. From April through September, 455,700 acre-feet of 557,000 acre-feet of flood control space (called joint use space) could be used for additional water conservation.

Staging of the reservoir to elevation 2175 signals the emergency operations phase and releases would be increased to outflow capability and maintained at capability until the reservoir is drawn back to elevation 2175 (top of flood control). Then flows would be cut back to match inflow.

Spillway operations would begin when flood operations cause storage to exceed elevation 2151. The spillway, a submerged gated type, is designed to be operated as a controlled flood outlet.

The total appraisal-level OM&R costs for Modified Roosevelt Dam is estimated at $1,496,000. Table 7 shows a summary of these appraisal-level OM&R costs.

TABLE 6

Summary of Appraisal-Level Annual OM&R Costs
Cliff Dam and Reservoir 1/

Item	January 1983 Costs 2/
Dam	$116,000
Transmission Line	10,000
Auxiliary Power	1,000
Recreation Facilities	420,000
Total Annual Cost	$547,000

1/ Costs for the dam features obtained from curves applied in 1981 Tucson Aqueduct study, based on reservoir acre-feet and structure design capacities. Costs for remaining items estimated from empirical graphs and tables in the Reclamation Instructions, Series 150.

2/ Cost for transmission lines indexed from January 1970 to January 1983 level using standard O&M cost indices.

TABLE 7

Summary of Appraisal-Level Annual OM&R Costs[1/]
Modified Roosevelt Dam and Reservoir

Item	January 1983 Costs
Dam	116,000
Powerplant	263,000
Switchyard	432,000
Recreation Facilities	685,000
Total Annual Cost	$1,496,000

[1/] Costs for the dam features obtained from curves applied in 1981 Tucson Aqueduct study, based on reservoir acre-feet and structure design capacities. Costs for remaining items estimated from empirical graphs and tables in the Reclamation Instructions, Series 150.

Modified Stewart Mountain Dam

There are no operational changes anticipated as a result of the proposed modifications. Flood operations would begin when water storage reaches elevation 1529. At that point, gates would be opened to release at rates equaling inflow rates.

Recreation, Fish, and Wildlife Facilities

A major factor that contributes to the utilization of a recreational area or facility is the operation, maintenance and replacement (OM&R) function. The commitments made through recreational development would require management agencies to assume the responsibility of the OM&R for the recreational areas and facilities. The Bureau would not undertake the operation or maintenance of the recreational developments planned for New Waddell, Cliff, or Modified Roosevelt. The U.S. Forest Service and Maricopa County would be identified as the operators of the facilities. It is expected that minimal Bureau staff would be needed to oversee the necessary contracts and agreements. All funding for maintenance would be the responsibility of the operating entity. No Bureau appropriations are projected. The operation of the recreational areas would continue with no changes in current practices and policies.

New Waddell Dam and Reservoir

Maricopa County, acting through its Parks and Recreation Department, is expected to be the local sponsor and manager of the recreation facilities at New Waddell. Currently, the County operates Lake Pleasant Regional Park at the Lake where existing facilities would be replaced. Since the County has expressed an interest in continuing the operation of the new recreational resource, necessary agreements/contracts would have to be developed. The current cost of operating the existing facilities at Lake Pleasant was used as a base from which to develop an annual management cost. It is estimated that the annual appraisal-level OM&R costs for recreational development at New Waddell would be $400,000. These costs would be assumed by the County. The County would continue the imposition of an entrance/use fee to generate the revenue necessary for park operations. Minor increases in County staff would be necessary to accommodate the increased use.

Cliff Dam and Reservoir

The U.S. Forest Service (Tonto National Forest) would manage the recreational program and facilities for Cliff Dam and Reservoir. A formula, developed in conjunction with the Tonto National Forest, was used by the Bureau to identify operation costs. The annual appraisal-level OM&R costs for recreational development at Cliff Reservoir is estimated at $420,000. This cost would be funded through the U.S. Forest Service budgeting process with no Bureau funding anticipated above and beyond that necessary for initial development. Bureau staff would manage its participation after development.

Modified Roosevelt Dam and Reservoir

Management of the recreational areas and facilities at Theodore Roosevelt Lake would continue through the Tonto National Forest. It is estimated that the annual OM&R of the recreational facilities would be $684,400. Funding would be through U.S. Forest Service budgets with no additional costs to the Bureau. Bureau staff would manage its participation after development.

CHAPTER VI

WATER SUPPLY

Introduction

The CAP will derive its primary source of water supply from the Colorado River via pumped withdrawals from the Bill Williams arm of Lake Havasu near Parker, Arizona. This supply accrues to Arizona by virtue of a 1944 contract for delivery of water between the State and the Secretary of the Interior. Under the plan, the Colorado River supply would be supplemented from time to time by accruals to CAP storage on the Agua Fria River (New Waddell Dam and Reservoir), on the Verde River (Cliff Dam and Reservoir), and on the Salt River (Theodore Roosevelt Dam and Lake).

Water Resources

The amounts of water available to the CAP are governed by a number of acts, compacts, treaties, and U.S. Supreme Court decrees. The applicable rules and regulations used to estimate the amount of water available for Plan 6 development are listed below and described in greater detail in Appendix B.

- Colorado River Compact, 1922
- Boulder Canyon Project Act, 1928
- Seven Party Water Agreement, 1931
- Water Contracts - California, Arizona, and Nevada
- Boulder Canyon Project Act, 1940
- Power Contracts - Hoover Dam Power
- Allottees Mexican Water Treaty, 1944
- Upper Colorado River Basin Compact, 1948
- Colorado River Storage Project Act, 1956
- Decree of the Supreme Court in Arizona v. California
- Lake Mead Flood Control Regulations, Amended 1982
- Colorado River Basin Project Act, 1968
- Colorado River Reservoir Coordinated Long-Range Operation Criteria, 1970
- Federal Water Pollution Control Act and Colorado River Basin Salinity Control Act, 1972, 1974.

The decree in Arizona v. California confirmed Arizona's entitlement to the use of Colorado River water at 2.8 million acre-feet of annual consumptive use from the first 7.5 million acre-feet for use in the Lower Basin plus half of the Lower Basin surpluses. In addition, the decree defined the proportionate rights and priorities of Federal lands along the Colorado River.

CAP's capability to divert from the Colorado River under surplus conditions (those years in which more than 7.5 million acre-feet are available for Lower Basin consumptive uses) has been determined to be the design capacity

of the CAP Granite Reef Diversion Dam (3,000 cfs) on an assumed year-round basis, or 2,172,000 acre-feet per year. This assumption is consistent with the design of the Granite Reef Aqueduct and pumping plants which do not require annual shutdown for scheduled maintenance.

Colorado River Input Data

The Colorado River is one of the most highly controlled and institutionalized rivers in the world, providing water for use in seven states and Mexico. It is approaching a point when the natural water supply of the river will not be adequate to meet all of the demands placed upon it. While the natural supplies are adequate to meet quantitative needs today and in the years immediately ahead, if the Upper Basin States of Colorado, New Mexico, Utah, and Wyoming develop their resources at a rate commensurate with their expressed desires, shortages would develop within a timeframe that directly affects CAP supplies from the Colorado River. CAP studies of the Colorado River have consistently adhered to these Upper Basin desires. Assumptions regarding the Upper Basin development schedule are detailed in Appendix B.

The Bureau has responsibility for the operation, administration, planning, and forecasting of the water resources of the Colorado River Basin. As a basis for forecasting, the Bureau developed procedures based on the accumulation of historic basin runoff.

To assist in the evaluation of the complex interrelationships between river hydrology, basin development, river law, and reservoir operations, the Upper Colorado and Lower Colorado Regions developed computer models which simulate basin operations. The Colorado River Storage Project (CRSP) model was the modeling basis for all of the project and provided study data on water available to the CAP from the Colorado River.

There are three components to a river system simulation study: (1) The simulation model -- a computer program comprised of mathematical functions that maintain a water budget and operate the river within defined constraints; (2) water supply and salt loading data; and (3) projected depletion data. The CRSP model simulates river operations in accordance with current interpretations of rules and regulations established by Congress, court decree, and international treaty.

Among the information required for the CRSP model are hydrologic data, physical system constraints, schedules of new depletions, and other planned activities which affect river flows and management, diversion schedules, maximum objectives, etc. Results of the CRSP model studies for project planning purposes are summarized in Table 8. For more detailed information on the Colorado River input data, refer to Appendix B.

As with the CRSP model for the Colorado River, two models were developed to assist in the evaluation of the CAP. Central Arizona Project Simulation Model (CAPSIM) simulates the monthly operation of the CAP system of aqueducts, pumping plants, and reservoirs. It was developed to evaluate long term operating criteria and policies with respect to CAP water supply, energy consumption, water distribution, and salinity. The program was

TABLE 8

Colorado River Water Supply

FROM LAKE HAVASU BY CENTRAL ARIZONA PROJECT

C.R.S.P. SIMULATION MODEL DECEMBER 1981 RUN

UNITS: 1000 A.F.

RUNOFF SEQUENCE NUMBER

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1985	766	766	766	766	766	766	766	766	766	766	766	766	766	766	766
1986	1527	1527	1527	1527	1527	1527	1527	1527	1527	1527	1527	1527	1527	1527	1527
1987	2171	2171	2171	2171	2080	1524	1524	1524	1524	1524	1524	1524	1524	1615	1855
1988	2171	2171	2171	2171	1521	1521	1952	1521	1858	1521	1521	1521	1521	2083	2042
1989	2171	2171	2171	2171	1518	1518	2074	1518	1518	1518	1518	1518	1849	1518	2171
1990	2171	2171	2171	2171	1515	1515	1515	1515	1515	1515	1515	1515	1613	1515	2171
1991	2171	2171	2074	2171	1512	1512	1512	1512	1512	1512	1512	1512	2074	1512	2171
1992	2171	2171	1509	2077	1509	1509	1509	1509	1509	1509	1509	1509	1509	1850	2077
1993	2171	2171	1843	1507	1507	1507	1507	1843	1507	1041	1041	1041	1507	1943	2034
1994	2069	2171	2171	1504	1504	1504	1504	1504	1504	400	864	864	1504	2069	2171
1995	1606	2171	2171	1502	1502	1502	1502	1502	1502	400	1040	1502	1502	1943	2171
1996	2171	2075	2171	1499	1499	1035	1499	1499	1499	400	400	1499	1499	2171	2171
1997	2171	1496	2066	1496	1496	400	1496	1496	1035	400	400	1496	1496	2066	2171
1998	2171	1494	1494	1494	1034	400	1494	1494	400	400	400	1494	1941	2032	2171
1999	2171	2099	1491	1491	859	400	1491	1491	400	859	859	1491	2064	2171	2064
2000	2171	2171	1488	1032	1032	856	1488	1032	400	1032	1488	1488	1911	2171	1598
2001	2063	2171	1486	400	400	1486	1486	400	400	400	1486	1486	2171	2171	2171
2002	1483	2062	1483	857	400	1026	1483	400	400	400	1026	1483	2062	2171	2171
2003	1481	1481	1026	1481	400	855	1026	400	400	400	400	1827	1880	2171	2171
2004	2036	1479	853	1026	400	1479	400	400	400	400	400	2064	2171	2064	2171
2005	2110	1476	1026	400	400	1026	400	400	400	400	850	1899	2171	1592	2171
2006	2059	1473	400	400	854	400	400	400	400	854	1473	2171	2171	2171	2059
2007	1471	1019	852	400	1019	400	400	400	400	1019	1019	2057	2171	2171	1471
2008	1469	850	1019	400	400	400	400	400	400	400	850	1825	2171	2171	1469
2009	1466	1018	848	400	848	400	400	400	848	400	1979	2171	2053	2171	1935
2010	1464	400	1017	400	1017	400	400	847	1017	400	1871	2171	1464	2171	2107
2011	1466	400	400	400	400	400	400	1018	400	848	2171	2171	1935	2053	2053
2012	1466	848	400	400	400	400	400	400	400	1018	2059	2171	2171	1466	1466
2013	1466	1466	400	400	400	400	400	400	400	848	1817	2171	2171	1466	1466
2014	1018	1018	400	848	400	400	400	400	400	1466	2097	2053	2171	1935	1466
2015	400	400	400	1018	400	400	848	400	848	1871	2171	1466	2171	2107	1466
2016	400	400	400	400	400	400	1018	400	1018	2171	2171	1941	2059	2059	1466
2017	848	400	400	400	400	400	400	400	400	2053	2053	2171	1466	1466	1466
2018	1466	400	400	400	400	400	400	400	848	1817	2171	2171	1466	1466	1018
2019	1018	400	400	400	400	400	400	400	1466	2097	2053	2171	1817	1466	848
2020	400	400	400	400	400	400	400	849	1467	2171	1467	2171	1877	1467	1018
2021	400	400	400	400	400	400	400	1018	2097	2054	1935	2054	2054	1467	400
2022	400	400	400	400	400	400	400	400	2054	1935	2171	1467	1467	1467	849
2023	400	400	400	400	400	400	400	849	1818	2171	2171	1467	1467	1018	1018
2024	400	400	400	400	400	849	400	1467	1986	2060	2136	1824	1467	849	400
2025	400	400	400	400	400	1018	849	1467	1935	1467	2171	1871	1467	1018	849
2026	400	400	400	400	400	400	1018	1467	2054	1935	2054	2054	1467	400	1018
2027	400	400	400	400	400	400	400	1467	1871	2171	1467	1467	1467	849	400
2028	400	400	400	400	400	400	400	1824	2171	2171	1467	1467	1018	1018	400
2029	400	400	400	400	849	400	849	1980	2054	2130	1467	1467	400	400	400
2030	400	400	400	400	1018	400	1467	1935	1467	2171	1871	1467	400	400	400
2031	400	400	400	400	400	849	1467	2054	1935	2054	2054	1467	849	849	400
2032	400	400	400	400	400	1018	1467	1877	2171	1467	1467	1467	1467	1018	400
2033	400	400	400	400	400	400	1818	2171	2171	1467	1467	1018	1018	400	400
2034	400	400	400	400	400	849	1911	2054	2130	1467	1467	400	400	400	400
2035	400	400	400	400	400	1467	1935	1467	2171	1871	1467	400	400	400	400
2036	400	400	400	400	849	1467	2060	1941	2060	2060	1467	849	400	400	400
2037	400	400	400	400	1018	1467	1871	2171	1467	1467	1467	1467	849	400	400
2038	400	400	400	400	400	1467	2171	2171	1467	1467	1018	1018	1018	400	400
2039	400	400	400	400	400	1467	2054	2130	1467	1467	400	400	400	400	400
2040	400	400	400	849	849	1941	1467	2171	1877	1467	400	400	400	400	400
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TOTAL 1985-2040	67070	58728	51465	46429	43102	48327	61025	66848	71111	74276	81052	87569	85471	80880	75094
AVERAGES 1985-2040	1197.7	1048.7	919.0	829.1	769.7	863.0	1089.7	1193.7	1269.8	1326.4	1447.4	1563.7	1526.3	1444.3	1341.0
TOTAL 1988-2037	61406	53064	45801	40316	37080	39635	51516	56559	62483	66058	75417	81934	79836	75772	69746
AVERAGES 1988-2037	1228.1	1061.3	916.0	806.3	741.6	792.7	1030.3	1131.2	1249.7	1321.2	1508.3	1638.7	1596.7	1515.4	1394.9

written to be flexible enough to evaluate such unresolved situations as reservoir location, aqueduct design, water allocations, and water use priorities. The Salt River Project Simulation Model (SRPSIM) was developed to simulate the future operation of the SRP reservoir system and is used to determine operational data of that SRP system. SRPSIM operational criteria, objectives, input data, and demands were developed in strict cooperation with SRP.

Agua Fria River

To incorporate the Waddell site into the CAP simulation model, the existing operating records of Lake Pleasant were extended to the 1906-1980 data period. Published data include:

Reservoir inflow: water years 1915-1919 and 1934-Present (USGS)[1/]
water years 1914 and 1920-1933 (USBR)[2/]

Reservoir contents (annual): water years 1929-1938[1/]
(daily) : water years 1939-Present[1/]

Reservoir releases and spills (monthly): water years 1940-1951[3/]
water years 1952-Present[1/]

Estimates of reservoir inflow for the 1906-1913 period were obtained by monthly correlations of the Agua Fria River with the Verde River, an adjacent drainage to the Agua Fria River in the upper reaches. Continuous Verde River records are available from 1888 and are the only records in central Arizona applicable for the desired time period. Seasonal and annual runoff correlations were also tested but produced weaker relationships than the monthly correlations.

The drainage basin above Lake Pleasant is mountainous, sparsely populated, and largely in Federal ownership (forests). Therefore, historic runoff patterns were assumed to be representative of future conditions. Also, informal discussions with MCMWCD#1 management indicated that there were no formal operating criteria for regulated releases. Thus, the historic releases were assumed representative of future conditions (see Table 9). These data were entered directly into the CAPSIM model without further adjustment to reflect the potential future operation of MCMWCD#1 space in New Waddell. CAP operated inflows and outflows are superimposed on this baseline.

1/ "Water Resources Data for Arizona, Water Year 1979," U.S. Geological Survey, and preceding annual reports.

2/ "Report on Water Supply of the Lower Colorado River Basin," Bureau of Reclamation, November 1952.

3/ "Report on Central Arizona Project-Appendices," December 1947, Bureau of Reclamation, and unpublished MCMWCD#1 records.

TABLE 9

HISTORIC AND ESTIMATED HISTORIC RUNOFF OF THE AGUA FRIA RIVER AT LAKE PLEASANT
UNITS 1,000 ACRE-FEET

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1906	7.6	75.0	28.0	7.0	11.0	35.0	13.8	0.0	.6	3.0	9.5	2.7	193.2
1907	.2	1.2	112.0	45.0	58.0	24.0	10.0	0.0	1.0	2.8	5.6	5.1	264.9
1908	9.0	1.7	.2	.1	48.0	8.0	.5	.8	.6	6.0	11.0	4.5	90.4
1909	1.9	.9	135.0	72.0	15.0	12.0	18.0	0.0	.5	4.8	15.5	6.0	281.6
1910	0.0	.4	.3	155.0	1.0	7.5	10.0	0.0	0.0	1.9	4.1	2.8	183.0
1911	.4	1.3	.2	124.0	57.0	15.0	2.6	1.0	1.4	5.8	3.2	6.8	218.7
1912	10.8	2.9	15.0	.1	.2	9.0	34.0	0.0	1.1	4.0	6.3	2.7	86.1
1913	11.2	.6	.2	.1	2.0	11.0	21.0	0.0	.5	2.0	3.9	4.5	57.0
1914	1.0	3.0	.4	7.8	55.2	1.6	1.3	.1	.1	3.2	.1	3.8	77.6
1915	2.7	.4	10.1	73.6	48.3	9.2	2.5	9.9	.6	5.4	3.7	2.4	168.8
1916	.2	2.3	15.0	376.0	33.2	31.0	8.9	1.7	.4	1.5	3.8	7.1	481.1
1917	12.4	1.0	1.2	22.7	18.9	6.8	92.3	5.8	.9	63.9	9.0	5.6	240.5
1918	.5	.5	.7	3.7	1.3	16.9	1.2	.2	.8	.9	22.1	.6	49.4
1919	.4	1.8	2.0	.5	11.2	3.4	1.7	.6	.2	26.7	13.7	28.5	90.7
1920	1.9	180.0	16.4	80.4	128.9	22.4	7.5	4.3	.7	2.1	11.3	10.1	466.0
1921	1.0	4.4	2.4	1.8	3.1	1.3	1.5	.1	.1	21.0	20.7	8.6	66.0
1922	34.7	1.0	14.2	94.0	65.1	66.0	6.5	1.8	1.6	2.8	5.1	13.1	305.9
1923	1.3	1.4	5.3	.7	4.2	57.1	6.3	3.2	2.3	4.0	4.9	52.3	142.0
1924	.1	6.5	74.6	16.8	2.7	6.3	17.3	1.1	.9	1.0	7.4	7.8	142.5
1925	2.1	1.5	4.5	1.1	1.1	1.1	1.1	.8	1.1	6.5	10.4	11.5	42.8
1926	1.1	1.0	2.2	2.7	4.1	9.1	72.0	17.7	1.2	6.1	24.3	22.7	164.2
1927	6.0	4.0	40.0	1.0	170.0	24.0	23.0	2.0	1.0	.8	24.1	31.1	327.0
1928	1.8	.5	3.7	2.2	9.4	2.0	2.8	2.4	1.5	1.6	9.9	2.0	39.8
1929	1.6	.3	.6	.6	.4	.3	5.3	.1	.1	.6	4.5	8.8	23.2
1930	.4	.2	.2	1.2	.6	8.6	2.2	.4	.2	4.9	9.4	6.0	34.3
1931	.4	6.4	.6	.6	56.1	.9	.4	.3	.2	5.4	29.4	2.2	102.9
1932	1.7	1.0	6.2	1.7	58.1	9.1	.6	.4	.3	1.0	3.4	.7	84.2
1933	2.0	.3	1.1	9.2	2.6	4.4	1.0	.8	.8	1.8	3.1	5.4	32.5
1934	1.3	.5	.3	.3	.2	.4	.2	.2	.2	.4	8.7	.9	13.6
1935	.2	.8	2.1	8.3	28.1	14.9	2.1	.2	.8	3.4	9.2	8.4	78.5
1936	.2	.4	.4	.4	1.6	1.2	.5	.3	.3	5.0	9.7	3.9	23.9
1937	.6	.3	1.1	4.3	58.2	41.8	2.1	.1	1.4	1.3	2.2	1.2	114.6
1938	.6	.5	.4	.3	.2	23.7	.4	.1	0.0	0.0	.5	.4	27.1
1939	.3	.1	5.4	.4	1.2	1.9	.6	0.0	0.0	0.0	2.6	17.4	29.9
1940	.3	.5	.5	.2	2.5	.2	1.3	.5	.8	.4	1.3	1.7	10.2
1941	3.7	.3	19.0	11.5	17.0	74.2	68.2	3.8	.8	4.5	4.1	2.0	209.1
1942	1.5	.8	4.0	2.9	1.4	2.6	1.0	.2	0.0	.6	3.6	3.3	21.9
1943	1.2	.7	.5	1.6	.3	2.2	.2	.1	.1	.1	11.6	3.4	22.0
1944	.7	.4	.3	.2	12.5	19.8	2.6	.5	0.0	1.2	2.0	2.2	42.4
1945	.2	.7	.9	1.5	5.2	19.9	4.2	.5	1.0	2.3	4.0	.2	40.6
1946	1.4	.4	.7	.3	.2	.1	.1	0.0	.1	1.4	4.0	2.3	11.0
1947	.5	.7	1.3	.5	.2	.1	0.0	.2	.1	.1	3.9	.1	7.7
1948	0.0	0.0	.2	.1	.1	.1	0.0	0.0	0.0	.2	4.5	0.0	5.2
1949	0.0	0.0	.7	15.5	7.4	5.4	1.7	0.0	.9	1.0	.5	2.1	35.2
1950	4.0	.2	.6	.3	.5	.9	.1	0.0	0.0	3.1	.5	0.0	10.2
1951	.1	.1	0.0	.8	.1	.1	.1	.1	0.0	.8	101.8	.6	104.6
1952	0.0	3.0	1.9	18.1	1.0	21.4	4.9	1.0	0.0	1.9	4.6	1.6	59.4
1953	.3	.5	.6	.4	.2	.6	.4	.1	1.3	5.6	2.6	.4	13.0
1954	.1	.2	.2	.4	.3	13.2	1.3	.3	.6	1.9	4.8	2.9	26.2
1955	.1	0.0	.1	.4	.2	.3	.2	.1	3.4	6.3	16.7	.4	28.2
1956	.2	.1	.2	.2	.2	.3	.2	.2	.6	3.4	.9	0.0	6.5
1957	.1	.1	.1	11.1	4.4	1.2	.2	.2	.2	.2	.2	0.0	18.0
1958	.3	4.4	.2	.2	5.1	10.0	2.4	.1	.6	0.0	1.5	12.1	36.9
1959	.3	.1	.2	.2	.6	.3	.1	.2	0.0	1.0	13.6	0.0	16.6
1960	5.1	.7	19.3	8.6	2.0	1.7	.4	.3	.5	.6	4.6	1.8	45.6
1961	.5	.1	.1	.3	.3	.3	.3	.2	.2	1.7	.3	1.9	6.2
1962	.2	.1	.2	1.3	2.6	3.6	.5	0.0	.1	0.0	0.0	.3	8.9
1963	.1	.1	.1	.1	.1	.1	.1	.1	.1	0.0	11.1	1.9	13.9
1964	.1	.7	0.0	.1	.1	1.5	.5	.1	.1	1.2	7.5	.7	12.6
1965	.1	0.0	.1	6.3	6.3	11.6	38.4	.5	0.0	1.2	1.7	4.4	70.6
1966	.4	6.8	89.2	11.5	8.8	6.1	1.7	1.3	.8	1.4	2.4	6.3	136.7
1967	.3	.4	6.0	.7	.8	1.0	.7	1.4	1.2	2.5	4.4	1.8	21.2
1968	.3	.5	50.1	13.8	22.5	6.2	1.9	1.6	2.0	2.3	3.9	1.9	107.0
1969	.6	.2	.1	4.5	4.2	7.8	1.8	1.0	1.1	2.2	2.5	3.4	29.4
1970	0.0	.1	.2	.2	.5	6.1	.5	.8	1.1	1.8	3.8	24.6	39.7
1971	.2	.2	.3	.3	.4	1.0	.6	.5	.9	1.3	9.6	.6	15.9
1972	.1	.2	.2	.3	.6	.7	.5	.5	.6	1.4	3.4	.8	9.3
1973	27.1	2.6	7.9	3.8	23.0	55.0	20.8	3.5	1.8	1.5	1.9	1.3	150.2
1974	.2	0.0	0.0	.6	.2	1.2	1.2	1.5	1.7	2.8	3.3	1.0	13.7
1975	.4	.8	.1	.3	.3	.7	.9	1.3	.8	.8	.4	.2	7.0
1976	.1	.1	.2	.1	32.7	1.4	6.1	1.0	.7	1.9	.6	4.0	48.9
1977	.3	.1	.2	.4	.3	.2	.5	.1	0.0	0.0	.1	.4	2.6
1978	.2	.2	.5	9.9	31.4	164.0	6.9	2.0	1.2	2.0	2.2	1.6	222.1
1979	.1	14.8	91.1	67.7	20.8	58.9	21.8	6.7	3.3	3.1	4.7	1.6	294.6
1980	.3	0.0	.3	48.6	295.6	31.0	11.3	5.9	3.3	2.8	2.0	1.4	402.5
TOTAL	169.3	346.0	800.4	1361.4	1469.1	1019.9	577.8	94.8	55.4	270.1	569.4	394.8	7128.4
AVERAGE	2.3	4.6	10.7	18.2	19.6	13.6	7.7	1.3	.7	3.6	7.6	5.3	95.0

Verde River

The runoff of the Verde River at Cliff damsite is essentially equal to the runoff into the existing Horseshoe Dam, for which published inflow data are available for the entire 1906-1980 period. The Verde River inflow data, see Table 10, were entered directly into the SRPSIM without adjustment; historic runoff patterns were assumed to be representative of expected future conditions.

Salt River

Inflow to Theodore Roosevelt Lake consists of runoff from the Salt River and Tonto Creek for which published records are available for the entire 1906-1980 study period.

Theodore Roosevelt inflow for project study purposes has been generally defined as follows:

Water years 1906-1913, from unpublished SRP records.[1/]

Water years 1914-1940, from the gage Salt River near Theodore Roosevelt plus the gage Tonto Creek near Theodore Roosevelt.

Water years 1941-present, from the gage Salt River near Theodore Roosevelt plus Tonto Creek above Gun Creek, near Theodore Roosevelt.

The Salt-Tonto inflow data, Table 11, were entered directly into the SRPSIM model without further adjustments. This historic runoff is assumed to be representative of future conditions since much of the drainge area above Theodore Roosevelt Dam is mountainous Federal lands (Indian reservations and forests).

Water Rights

The CAP right to divert and use Colorado River water stems from three major parts of the "Law of the River." These include the 1964 Supreme Court Decree, the 1944 water service contract between the State of Arizona and the Secretary of the Interior, and the Colorado River Basin Project Act, 1968. Pertinent parts of these documents define the quantity of Colorado River water available to the CAP and its priority of use relative to other Lower Colorado River diversion rights.

The decree specifies the consumptive use entitlements of the three Lower Basin States from water apportioned to the Lower Basin under the 1922 Colorado River Compact as follows:

Arizona -- 2.8 million acre-feet per year (plus half of any surpluses)
California -- 4.4 million acre-feet per year (plus half of any surpluses)
Nevada -- 300,000 acre-feet per year

1/ These data differ slightly from published USGS data.

TABLE 10

HISTORIC RUNOFF OF THE VERDE RIVER ABOVE HORSESHOE DAM
UNITS 1,000 ACRE-FEET

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1906	31.0	187.6	50.0	46.1	63.4	331.2	59.5	13.4	7.8	10.6	33.9	10.3	844.8
1907	8.8	15.6	149.7	144.1	142.6	228.3	48.2	12.5	10.7	8.7	18.6	21.7	809.5
1908	30.5	19.2	17.0	14.9	106.7	83.1	16.2	25.4	7.2	21.8	48.5	18.0	408.5
1909	12.7	14.2	180.5	103.8	76.7	121.4	73.4	10.5	6.6	20.4	71.9	24.1	716.2
1910	7.4	10.8	17.7	214.3	25.9	76.5	48.3	6.8	1.9	3.4	15.2	10.9	439.1
1911	9.5	14.0	15.8	167.1	138.5	143.1	23.9	27.7	15.5	13.6	11.0	26.7	606.4
1912	32.9	28.2	34.3	15.2	14.6	97.3	122.6	13.4	11.8	11.1	23.2	9.4	394.1
1913	36.7	13.0	11.7	10.4	25.5	108.7	82.2	5.3	6.6	3.7	11.2	16.6	331.7
1914	10.0	13.5	15.0	54.7	164.6	38.6	13.6	7.6	4.9	7.6	9.1	11.3	350.5
1915	11.7	13.3	13.5	67.3	130.7	218.1	125.4	161.2	9.5	14.9	17.5	11.5	794.6
1916	8.5	11.5	13.2	481.5	213.8	315.3	39.4	12.3	8.1	8.7	25.8	70.1	1208.2
1917	40.1	17.2	17.5	68.0	79.0	106.3	354.9	72.2	12.6	16.2	42.8	19.4	846.2
1918	12.8	12.3	13.5	16.7	45.5	279.2	19.3	8.0	5.7	9.7	25.6	8.5	456.8
1919	8.5	15.2	18.7	18.3	44.8	93.7	77.5	8.4	5.6	118.6	51.5	21.6	482.4
1920	42.2	161.6	132.5	131.3	509.2	110.4	60.4	16.9	9.5	8.2	23.4	10.2	1215.8
1921	8.7	10.2	17.7	16.0	15.1	30.2	12.2	8.3	6.1	11.4	97.6	19.6	253.1
1922	23.0	14.5	82.5	151.2	149.2	197.3	61.6	12.9	8.0	9.4	16.3	11.0	736.9
1923	9.0	12.3	72.0	17.9	64.0	133.0	45.9	9.9	5.5	6.9	9.3	110.4	496.1
1924	13.9	51.4	205.5	57.9	18.0	26.4	96.2	8.7	4.5	8.7	3.5	9.6	504.3
1925	10.3	10.2	19.2	14.2	16.0	22.7	25.3	11.3	6.2	10.9	19.2	63.6	229.1
1926	45.1	19.0	21.0	16.6	14.8	40.7	256.1	23.7	6.0	9.5	13.7	17.3	482.5
1927	13.6	12.0	18.5	18.4	384.7	122.6	46.7	10.8	9.1	14.3	26.3	105.0	782.0
1928	15.7	16.4	22.8	28.3	78.4	60.6	13.7	9.0	5.7	6.3	25.9	9.8	292.6
1929	13.6	15.1	16.7	17.3	20.4	82.6	125.7	8.0	5.9	7.5	31.7	20.6	365.1
1930	9.0	12.1	13.3	12.3	23.3	79.4	31.0	8.4	4.7	16.3	35.1	14.5	259.4
1931	12.4	26.1	20.5	12.4	156.3	38.3	12.2	13.9	4.1	7.5	43.4	18.9	366.0
1932	9.1	26.2	53.3	27.0	365.1	222.8	45.1	11.0	7.2	11.2	13.1	6.2	797.3
1933	15.4	11.6	10.7	19.9	18.2	43.9	16.0	20.0	7.8	9.0	7.7	9.8	190.0
1934	12.5	10.7	14.2	14.5	12.0	12.9	14.4	5.8	5.3	5.9	24.5	10.5	143.2
1935	8.8	13.9	16.9	59.9	120.3	117.8	58.4	9.9	5.8	6.2	32.6	26.1	476.6
1936	13.2	11.7	15.5	14.3	44.7	56.9	40.6	8.0	4.5	10.8	23.6	16.6	260.4
1937	10.7	17.0	13.6	24.3	347.0	246.1	83.9	10.4	7.4	11.1	7.6	8.8	787.9
1938	11.0	12.0	14.0	15.0	18.9	296.0	12.4	6.7	4.0	6.8	14.2	10.3	411.3
1939	9.4	11.8	21.2	16.5	17.1	52.1	18.6	6.9	4.7	4.5	17.4	80.8	261.0
1940	11.8	12.5	14.7	19.5	51.7	23.3	15.1	8.5	7.2	5.4	20.1	17.5	207.3
1941	43.5	24.3	122.3	81.2	185.9	294.4	275.6	39.5	11.7	13.6	15.3	17.9	1125.2
1942	31.4	21.9	23.5	31.9	19.4	60.0	38.1	14.5	6.8	7.0	9.6	7.3	271.4
1943	10.1	13.3	15.1	23.4	34.8	106.2	14.8	7.7	5.5	5.3	24.3	10.1	270.6
1944	12.8	12.2	17.2	17.3	40.5	159.7	101.3	20.1	6.9	6.2	7.8	10.7	412.7
1945	12.4	14.9	16.3	17.3	29.4	129.6	102.9	14.0	6.4	8.1	19.7	6.9	377.9
1946	14.0	13.3	21.3	18.6	14.7	17.2	46.8	8.6	6.1	11.3	24.4	18.4	214.7
1947	11.8	26.3	31.8	22.7	18.0	14.1	10.3	9.1	6.1	7.3	23.4	16.1	197.0
1948	12.4	14.2	18.4	16.0	19.6	56.1	49.4	8.5	6.4	9.0	19.2	6.9	236.1
1949	10.4	13.7	21.4	59.4	66.1	165.2	97.7	12.0	10.3	11.4	12.9	16.9	497.4
1950	33.8	15.6	18.4	19.0	54.1	31.3	11.2	8.2	6.0	19.1	12.0	9.1	237.8
1951	9.5	12.2	14.0	15.3	14.6	16.1	12.3	16.2	5.6	5.8	72.8	16.6	211.0
1952	13.6	16.7	106.4	138.7	23.9	114.6	147.2	19.2	6.4	7.8	13.0	16.1	623.6
1953	11.5	17.8	20.1	25.3	13.5	19.3	10.5	9.9	6.0	26.4	25.7	10.8	196.8
1954	10.1	12.0	14.8	15.6	14.1	119.8	37.2	8.0	5.9	18.4	20.9	15.1	291.9
1955	12.2	12.8	14.7	17.5	14.9	22.3	10.6	8.3	18.8	20.4	51.7	8.4	212.6
1956	11.2	13.1	17.4	15.4	14.0	12.6	11.1	7.2	5.2	12.6	11.6	5.9	137.3
1957	9.7	12.5	14.2	8.3	124.3	36.2	10.4	12.4	10.4	11.9	19.8	8.1	278.2
1958	12.8	57.9	16.6	14.3	49.9	165.3	70.3	9.6	7.7	4.6	15.6	36.0	460.6
1959	16.5	14.5	14.7	13.9	21.0	20.3	10.1	8.2	5.6	14.0	33.6	7.8	180.2
1960	39.3	18.7	84.1	52.8	23.7	115.2	14.6	9.5	6.5	5.5	10.7	14.1	394.7
1961	13.8	13.6	14.2	13.8	12.5	14.3	24.5	7.5	5.1	8.2	16.5	20.2	164.2
1962	9.9	13.1	18.2	20.6	95.0	76.9	50.0	7.7	5.5	5.5	7.8	10.6	320.8
1963	11.7	11.4	15.2	15.4	13.9	13.7	9.2	7.0	4.9	5.5	48.8	24.1	180.8
1964	10.9	15.2	15.0	14.8	12.7	19.4	63.0	8.0	5.5	9.5	55.1	13.8	242.9
1965	9.6	12.5	15.7	96.1	52.3	91.7	257.5	16.3	7.7	10.0	14.0	20.1	603.5
1966	10.2	82.4	283.6	64.4	22.0	105.4	16.5	10.3	7.2	9.0	19.5	15.6	646.1
1967	15.4	15.7	172.5	19.1	14.5	14.1	15.9	10.3	9.8	10.8	20.1	13.7	331.9
1968	11.1	12.1	60.8	73.8	140.0	75.7	35.7	16.7	8.6	9.8	20.7	9.2	474.2
1969	14.2	15.8	17.6	146.5	40.5	114.5	51.4	12.3	7.5	9.1	12.9	16.0	458.3
1970	11.2	16.0	15.2	16.0	13.1	51.8	17.8	10.2	7.5	12.7	19.0	87.1	277.6
1971	13.9	15.2	17.1	17.5	13.8	16.0	11.8	9.1	6.4	6.7	27.2	10.3	165.0
1972	18.8	17.1	83.0	23.6	14.2	11.9	10.7	8.5	8.7	9.8	15.0	9.4	230.7
1973	257.9	64.8	84.1	36.1	89.7	239.4	335.5	81.3	12.8	12.6	13.4	9.8	1237.4
1974	12.2	16.0	17.8	24.3	14.5	20.9	13.8	9.8	6.7	11.3	12.1	9.5	168.9
1975	12.6	22.3	16.7	16.2	15.7	55.4	79.1	13.7	7.5	10.8	8.8	11.2	270.0
1976	10.9	13.5	16.9	15.6	162.1	44.2	66.3	16.8	7.6	12.4	10.3	15.6	392.2
1977	15.2	14.8	16.9	19.3	14.3	13.9	13.6	10.3	7.5	7.9	15.1	12.3	161.1
1978	16.1	12.6	14.9	38.4	114.0	640.6	38.4	12.9	7.6	7.4	13.3	9.9	926.1
1979	12.0	81.5	285.6	132.4	83.6	233.2	111.0	19.7	11.8	10.4	18.9	9.5	1009.6
1980	12.9	15.7	17.5	166.4	634.0	153.7	91.2	21.0	10.6	17.7	13.0	12.4	1166.1
TOTAL	1419.0	1713.1	3205.6	3721.3	6085.5	7909.0	4591.2	1173.8	550.5	879.6	1737.7	1476.7	34463.0
AVERAGE	18.9	22.8	42.7	49.6	81.1	105.5	61.2	15.7	7.3	11.7	23.2	19.7	459.5

TABLE 11

HISTORIC AND ESTIMATED HISTORIC RUNOFF OF THE SALT RIVER AND TONTO CREEK ABOVE ROOSEVELT DAM
UNITS 1,000 ACRE-FEET

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1906	22.0	309.4	98.6	91.4	80.0	467.9	304.3	105.4	41.3	31.4	44.8	28.8	1625.3
1907	19.4	16.7	264.9	195.1	142.8	226.1	117.1	48.6	31.8	22.4	72.9	68.0	1225.8
1908	75.8	53.1	30.0	25.0	199.2	234.2	106.9	56.7	25.5	36.5	117.2	64.8	1024.9
1909	19.8	23.0	202.4	71.6	195.0	184.5	234.5	32.2	39.4	24.8	63.4	143.2	1233.8
1910	28.3	67.8	18.6	95.6	34.9	74.0	61.2	31.7	8.9	8.0	15.6	13.9	458.5
1911	11.4	11.1	18.1	93.8	154.6	267.3	68.2	36.2	20.4	23.0	19.0	10.8	733.9
1912	48.8	24.7	15.7	14.8	14.5	76.4	130.5	70.7	25.4	15.8	29.4	26.7	493.4
1913	21.5	18.3	18.5	16.8	21.4	85.3	111.1	36.8	14.1	12.9	16.9	16.7	390.3
1914	14.2	17.6	24.2	24.2	108.5	73.1	66.2	27.9	15.7	36.9	66.5	45.4	520.4
1915	40.3	31.8	165.1	173.4	250.2	259.8	363.3	243.9	76.6	91.2	37.6	24.0	1757.2
1916	20.2	22.8	20.2	1116.3	272.9	524.5	263.2	114.6	51.7	28.9	48.1	61.4	2544.8
1917	90.5	28.5	20.6	*104.9	95.1	79.4	197.8	78.9	31.5	32.2	32.5	19.8	811.7
1918	15.3	16.2	16.8	15.5	30.1	143.4	45.0	23.9	17.6	25.1	28.3	12.4	389.6
1919	11.3	14.2	22.2	19.1	84.2	121.3	229.3	78.3	23.3	213.7	112.8	48.7	978.4
1920	31.6	145.2	331.4	186.9	607.4	201.2	149.1	106.2	39.4	19.6	40.9	18.9	1877.8
1921	18.7	34.3	22.0	21.3	22.6	26.8	20.6	18.7	14.0	46.9	233.2	66.1	545.2
1922	21.1	15.8	26.6	55.1	96.7	182.2	127.4	61.3	24.4	22.9	33.7	15.4	682.6
1923	12.2	13.6	41.9	19.2	48.2	138.0	79.5	41.4	15.5	26.3	58.8	116.3	610.9
1924	25.3	66.6	271.0	97.7	33.5	64.9	200.5	70.3	23.6	15.7	16.5	12.5	898.1
1925	11.1	12.2	16.2	15.3	14.2	68.0	41.1	17.0	12.5	17.5	38.6	61.0	324.7
1926	30.2	20.1	18.0	16.0	16.0	85.8	349.0	144.2	28.8	21.1	23.2	22.9	775.3
1927	16.9	15.8	27.7	23.0	329.0	156.9	138.4	84.4	40.6	24.0	31.8	53.7	942.2
1928	14.4	14.0	15.9	16.1	51.9	52.8	39.9	32.3	15.9	19.8	27.1	16.4	316.5
1929	16.3	18.6	16.9	19.1	23.1	52.5	131.2	29.0	13.3	18.8	70.3	62.0	471.1
1930	25.8	16.3	14.2	16.1	33.0	121.5	104.7	37.5	17.4	40.2	61.6	16.1	504.4
1931	10.4	21.6	18.1	12.5	173.6	54.9	87.1	67.7	15.9	19.7	66.5	73.2	621.2
1932	68.6	44.6	95.9	61.8	451.3	238.7	196.6	76.4	27.1	31.4	54.4	31.0	1377.8
1933	19.6	14.5	13.2	21.6	36.6	107.0	71.5	66.7	31.9	30.4	29.0	24.1	466.1
1934	29.8	17.9	19.9	16.1	16.0	26.8	19.8	12.6	7.9	11.4	49.4	28.8	256.4
1935	11.8	14.2	13.4	68.9	145.9	185.3	199.1	70.0	40.4	14.6	38.8	33.8	836.2
1936	14.1	14.1	15.9	14.4	126.4	132.3	203.9	71.1	21.8	14.9	27.3	30.8	687.0
1937	14.8	19.2	20.7	33.6	312.7	271.7	216.8	78.2	24.2	19.4	17.4	14.8	1043.5
1938	12.7	12.0	14.5	13.7	13.3	158.7	51.1	27.9	11.8	14.4	38.6	26.5	395.2
1939	9.6	9.6	15.3	15.7	27.1	93.1	118.8	32.6	9.9	8.1	23.8	17.4	381.0
1940	11.9	12.9	13.0	16.2	37.2	57.6	56.7	27.3	14.0	14.1	22.1	26.2	309.2
1941	32.1	30.0	216.2	250.5	210.6	611.5	347.2	340.3	84.2	43.6	40.1	35.5	2241.8
1942	45.9	31.0	51.2	76.8	38.1	87.1	142.3	60.5	18.3	13.6	26.0	18.6	609.4
1943	16.8	15.6	23.1	71.4	59.0	200.1	101.4	38.5	12.9	10.2	25.7	20.4	595.1
1944	15.9	13.0	14.1	14.3	38.2	108.9	92.0	44.4	15.8	12.0	16.4	22.8	407.8
1945	18.0	16.2	17.1	20.4	36.4	139.2	165.5	74.5	16.5	13.0	34.8	12.0	563.6
1946	16.7	10.8	18.1	18.2	14.7	31.6	35.8	15.2	6.5	11.0	41.9	118.8	339.3
1947	19.6	36.8	46.0	25.9	27.4	38.0	30.0	21.5	7.7	6.4	30.1	41.3	330.7
1948	44.1	16.5	23.4	18.3	23.7	73.0	192.0	50.5	12.6	13.3	18.5	7.2	493.1
1949	8.4	11.0	35.8	157.1	81.0	167.9	172.4	78.3	28.6	34.3	38.8	15.2	828.8
1950	14.8	12.4	15.1	15.6	26.6	40.4	35.3	14.8	7.1	15.7	13.7	10.8	222.3
1951	7.3	8.3	10.0	11.7	12.0	17.3	21.0	25.2	7.3	7.0	132.5	18.4	278.0
1952	10.6	14.4	90.0	462.5	46.6	192.6	342.2	147.1	41.7	17.3	30.4	14.8	1410.2
1953	10.1	18.7	21.1	21.4	14.0	92.3	38.0	22.8	12.4	20.6	16.3	6.3	294.0
1954	6.3	8.9	10.1	11.2	11.1	161.2	62.3	23.3	8.0	24.5	43.4	18.7	389.0
1955	9.0	8.7	9.7	11.8	10.5	15.8	13.4	9.9	13.4	26.5	135.2	16.6	280.5
1956	9.0	9.9	14.9	15.5	26.8	47.7	39.9	23.4	7.2	9.3	12.4	4.6	220.6
1957	5.7	7.8	8.4	107.2	76.6	54.2	38.9	32.4	19.7	12.2	68.8	21.2	453.1
1958	16.6	27.4	16.4	12.5	50.0	241.6	250.4	114.4	24.8	9.3	20.4	42.2	826.0
1959	45.0	14.9	13.9	12.2	13.5	16.0	15.4	8.2	4.7	15.5	97.0	14.3	270.6
1960	56.9	86.9	227.1	219.8	70.2	214.5	102.4	43.5	17.6	8.5	11.6	8.8	1067.8
1961	16.0	12.6	11.9	12.2	11.5	23.1	34.3	12.5	6.6	8.7	19.8	19.5	188.7
1962	9.2	16.9	38.1	76.8	134.2	133.8	246.4	74.4	18.9	11.9	9.8	14.7	785.1
1963	16.6	15.0	14.4	16.7	76.5	50.0	54.7	18.8	6.3	4.8	103.6	59.8	437.2
1964	21.2	20.0	13.6	11.1	10.5	16.5	62.5	23.7	8.5	19.9	44.0	50.7	302.2
1965	18.7	12.0	14.4	151.1	94.0	136.4	241.0	95.6	33.9	25.3	33.2	15.1	870.7
1966	10.3	38.3	532.0	127.2	45.3	207.8	152.7	55.4	16.5	12.8	29.9	36.4	1264.6
1967	15.6	14.3	42.9	14.8	13.9	19.9	19.8	11.3	8.0	25.6	86.1	42.1	314.3
1968	13.5	12.2	116.6	169.8	220.0	201.0	175.6	85.8	28.3	19.6	48.1	14.4	1104.9
1969	15.1	13.5	15.5	117.5	52.3	95.0	148.2	65.9	19.3	14.5	23.0	30.7	610.5
1970	15.0	19.3	17.3	15.5	13.7	44.4	57.7	42.2	12.4	11.8	22.6	86.6	358.5
1971	16.9	11.4	12.9	15.0	13.8	17.7	16.2	11.6	6.1	7.8	61.0	33.3	223.7
1972	147.8	46.2	105.5	43.0	20.3	31.1	15.9	9.6	12.4	9.6	11.5	13.2	466.1
1973	356.0	99.2	129.3	73.5	205.2	442.8	410.9	382.3	81.7	36.4	24.8	12.6	2254.7
1974	11.9	14.7	15.5	30.6	15.2	39.0	32.6	18.6	7.3	11.9	20.0	10.5	227.8
1975	36.7	33.3	15.1	14.8	29.7	147.6	200.0	110.3	29.1	21.7	11.5	20.7	670.5
1976	9.7	10.6	15.3	12.7	120.4	41.3	82.5	56.7	14.9	19.5	18.7	17.1	419.4
1977	13.0	11.5	11.4	15.7	13.4	16.0	39.6	20.6	8.6	14.0	26.2	19.9	209.9
1978	15.2	12.3	10.6	37.6	158.7	894.3	194.2	66.2	19.9	13.0	23.3	11.5	1456.8
1979	12.5	144.8	456.9	320.6	223.2	412.0	405.3	188.2	78.9	26.1	27.3	14.2	2310.0
1980	13.5	17.5	17.3	178.8	762.9	223.7	247.4	176.7	54.7	25.4	35.3	20.6	1773.8
TOTAL	2058.9	2183.1	4465.8	5827.1	7420.8	11038.2	9976.7	4873.7	1712.8	1718.1	3241.7	2364.6	56881.5
AVERAGE	27.5	29.1	59.5	77.7	98.9	147.2	133.0	65.0	22.8	22.9	43.2	31.5	758.4

While the Supreme Court decree specified how Colorado River water should be shared among the States during "normal" years and "surplus" years, it left to the Secretary of the Interior the manner in which shortages would be shared after satisfaction of present perfected rights in each state.

The 1944 contract is in accordance with the Boulder Canyon Project Act of 1928 and provides the contractual basis for which CAP may divert a portion of Arizona's entitlement. The Colorado River Basin Project Act of 1968 provides the authority.

Section 301(b) of the Basin Project Act is called the "California Guarantee" provision. This section directs the Secretary to administer shortage supplies by limiting CAP diversion from the Colorado River so as to "assure the availability of water in quantities sufficient to provide for the aggregate annual consumptive use...in the state of California...of 4,400,000 acre-feet of mainstream water, and by users of the same character (perfected rights, existing contracts, and Federal lands) in Arizona and Nevada.

The Lower Colorado Region has determined that limiting CAP diversions to 400,000 acre-feet in shortage years would accomplish the above and not cause Lake Mead to be drawn below minimum power head at any time through the year 2040, the end-point of Colorado River future operation studies.

Rights to the use of Arizona water from sources other than the Colorado River are derived from State law, based on the doctrine of prior appropriations. Arizona law includes an application-public notice-permit system to secure the right to store, divert and/or apply surface waters of the State. The Water Rights Registration Act of 1974 requires all claims to surface waters in Arizona (except those already adjudicated or derived from Federal actions) be registered with the State. This legislation also directs the Arizona Department of Water Resources to proceed with statewide court adjudications. Until these adjudications are completed, quantification of rights which may accrue to CAP through implementation of the project is uncertain.

The water rights of the Agua Fria basin have not been adjudicated. Uses of surface water from the Agua Fria River upstream from Lake Pleasant are limited, with diversions for mining and irrigation of less than 1,000 acres. The major existing water right of concern in this study was the stored diversion rights of the MCMWCD#1 which owns and operates Lake Pleasant. There are no other major, downstream water rights on the Agua Fria River.

Federal actions with respect to water rights necessary to implement construction of New Waddell Dam would include negotiation of agreements with MCMWCD#1 to define ownership rights, credits and charges, operating criteria, sharing of operation and maintenance costs, and filing of applications with the Arizona Department of Water Resources to secure the right to store Colorado River water in the new reservoir and to store and use unappropriated waters of the Agua Fria River for CAP purposes. Federal application for Agua Fria River water rights was filed July 15, 1983, with the State of Arizona.

There are complex water rights issues involving the Salt and Verde Rivers since new conservation storage space is proposed within a storage system (Salt River Project) already encumbered with legal water rights issues, and multi-party operating contracts and agreements.

Federal actions required to construct Cliff Dam as proposed include application to the State of Arizona for Verde River water rights associated with new conservation space, negotiation of operating agreements with Salt River Project to define ownership rights, credits, changes, and operating criteria, and sharing of operation and maintenance costs. Similar actions are required for Theodore Roosevelt Dam. Federal application was made September 1983 to secure the above Salt and Verde water rights on behalf of CAP.

Water Requirements

Water requirements associated with the CAP are neither static nor firmly established. Final decisions on who would receive how much CAP water lies with the Secretary of the Interior in accordance with the Boulder Canyon Project Act of 1928 (45 Stat. 1057). Water demand assumptions used in the study reflected the most recent expressions of the Secretary and the Arizona Department of Water Resources. Tables 12-14 summarize the allocations of CAP water for Indian uses, municipal and industrial (M&I) uses, and non-Indian irrigation, respectively, as used in the New Waddell Sizing Study. Subsequently, on March 24, 1983, the Secretary made final allocation decisions regarding both Indian and non-Indian water users, which differ slightly from those used in the studies. The differences have been analyzed and would not change the major assumptions or study results.

The CAP was authorized to provide water deliveries to its users at canalside. Facilities required to convey CAP water from the aqueduct system to the area of use are the user's responsibility with the exception of the Indian allottees. Therefore, all CAP water demands were assumed to be at canalside.

Aqueduct and reservoir losses in the form of seepage and evaporation were incorporated into the CAPSIM. Currently there are no instream flow requirements downstream of any of the existing dams although SRP is required to release 50 cfs for the Fort McDowell Indian Community. None were assumed for this study.

A version of the CAPSIM model was developed to represent the specific water use of this plan. Operational criteria were carefully constructed within the model. Complete descriptions of the model are included in Appendix B.

New storage totals 967,600 acre-feet including 660,000 acre-feet of regulatory storage and new conservation space at the New Waddell site, 170,000 acre-feet of new conservation space at the Cliff site, and 137,600 acre-feet of new usable space at Theodore Roosevelt Lake. As described in previous chapters, New Waddell Reservoir would be directly connected to the CAP aqueduct system by the Waddell Canal. It is assumed the Cliff and Modified Roosevelt space would be used only to capture and conserve Salt and/or Verde River water that would normally spill into the existing SRP system. As

TABLE 12

Central Arizona Project
November 1981 Tentative Allocations
for Indian Uses[1/]

	Irrigation[2/]	Tribal Homeland[3/]	Units: Acre-feet/Year Total
Ak Chin	58,300		58,300
Gila River	173,100		173,100
Salt River	13,300		13,300
Fort McDowell		4,300	4,300
Papago-Chuichu	8,000		8,000
Camp Verde		1,200	1,200
Papago-San Xavier		27,000	27,000
Papago-Schuk Toak		10,800	10,800
San Carlos	2,700	10,000	12,700
Pascui Yaqui		500	500
Tonto Apache		128	128
Yavapai Prescott		500	500
Total	255,400	54,428	309,828

1/ Department of the Interior news releases, November 12, 1981, Office of the Secretary.

2/ Subject to a 10 percent reduction in shortage years, except the Gila River which is subject to a 25 percent reduction.

3/ Shares priority during shortages, prorata with up to 510,000 acre-feet of M&I uses and the remaining Indian irrigation after 10 and 25 percent reductions.

TABLE 13

State of Arizona Recommended Allocation of
Central Arizona Project Water for
Municipal and Industrial Uses[1/]

Units:
Acre-feet/Year

M&I Sector	Year 1985 Allocation	Year 2005 Allocation	Year 2034 Allocation
Municipal[2/]			
Maricopa County	97,512	188,025	279,566
Pinal County	4,582	14,954	24,130
Pima County	25,073	65,417	163,034
Other Counties	4,665	14,035	28,014
Subtotal	131,832	282,431	494,744
Power[3/]	0	0	43,218
Mines[2/]			
Pima County	29,157	26,072	18,332
Gila River Basin	14,000	50,110	37,275
Salt River Basin	0	7,932	5,177
Subtotal	43,157	84,314	60,784
Recreation[2/]			
Arizona Game & Fish	755	378	324
Maricopa County	852	777	665
Subtotal	1,607	1,155	989
Other[2/]			
Phoenix Memorial Park	45	71	84
State Land Department[4/]	15,000	18,240	39,006
Subtotal	15,045	18,311	39,090
TOTAL	191,641	386,211	638,825

1/ From letter dated January 18, 1982, from Arizona Department of Water Resources to the Secretary of the Interior and the corresponding computer run.

2/ Assumed to vary uniformly between allocation years.

3/ Assumed to begin with 1,650 acre-feet in year 2006 and increase uniformly until 2034.

4/ Not identified by location. Assumed to be shared equally by Maricopa and Pima Counties.

TABLE 14

State of Arizona Recommended Allocation of Central Arizona Project Water for Non-Indian Irrigation[1/]

Entity	Percent of Available Water		
	1985 Allocation	2005 Allocation	2034 Allocation
Arcadia Water Company	0.13	0.14	0.15
Avra Valley Association	3.69	3.84	4.21
Central Arizona I.D.	18.01	18.73	20.55
Chandler Heights I.D.	0.28	0.28	0.30
Cortaro-Marana I.D.	2.14	2.05	1.99
Farmers Investment Corp.	1.39	1.44	1.58
Harquahala Valley I.D.	7.67	7.98	8.75
Hohokam I.D.	6.36	6.61	7.25
La Croix	0.04	0.04	0.05
Maricopa-Stanfield I.D.	20.48	21.30	23.35
Marley, Kemper, Jr.	0.04	0.04	0.05
McMicken I.D.	7.28	5.60	2.61
MCMWCD#1	4.66	3.37	2.88
New Magma I.D.	4.34	4.52	4.96
Queen Creek I.D.	4.83	4.99	5.42
Rood, W.E.	0.04	0.04	0.05
Roosevelt I.D.	2.61	2.72	2.98
Roosevelt Water Conservation District	5.98	5.92	4.84
Salt River Project	2.97	3.05	0.00
San Carlos I.D.	4.09	4.25	4.66
San Tan I.D.	0.77	0.80	0.86
Tonopah I.D.	1.98	2.06	2.26
U.S. Forest Service	0.22	0.23	0.25
Total	100.00	100.00	100.00

1/ From letter dated January 18, 1982, from Arizona Department of Water Resources to the Secretary of the Interior.

needed for CAP, water stored in new Salt or Verde storage space would be released to the rivers and delivered to those CAP water users capable of taking water through SRP facilities.

When water in the aqueduct exceeds the scheduled monthly CAP demand, the excess water would be stored in New Waddell for later release. When scheduled monthly CAP demand exceeds water in the aqueduct, the model would first release any CAP conservation water remaining in ownership at either Cliff or Modified Roosevelt Reservoirs, then release CAP water stored in New Waddell.

Water Quality

Water quality studies in support of regulatory storage plan selection and environmental impact analyses consisted of three basic parts: Evaluation of changes in constituent, concentrations projections of salt loading, and assessment of reservoir eutrophication potential.

Salt loading studies were done using future projections of Colorado River salinity concentrations furnished by the CRSP model and Bureau estimates of salinity concentrations of other local surface water sources. These projections were used as inputs to the CAPSIM model which traces the influences of CAP operations on total salinity. The salt loading analysis focused on the increase in CAP water supply (CAP yield) attributable to regulatory storage and the accompanying increase in imported salts.

The major salt load attributable to the CAP is a result of importing Colorado River water into Central Arizona and not a direct result of adding regulatory storage as a feature of the CAP. The CAP is expected to import an average of approximately 1,020,000 tons of salt per year from "future without" conditions. This salt import figure assumes that the salinity standard for the Colorado River below Parker Dam of 747 mg/l (1.016 tons/acre-feet) is maintained in the future. Salt import would increase by 153,000 tons per year (15 percent) with implementation of the proposed regulatory storage plan. This increase was considered insignificant in comparison to the total salt import. Salt concentrations in delivered water would remain sufficiently low for irrigation and other current uses.

The constitutent evaluations were based on water quality data collected by the U.S. Geologic Survey and accessed, for most sites, from the EPA's Storet data base. Long term average constituent concentrations for various sources were used to determine changes following mixing of CAP imports with the current supplies in the project area. Although the accuracy of these predictions may be limited, they were considered adequate for comparison of alternative plans.

The water in storage in Lake Havasu, formed by Parker Dam, originates from a combination of Colorado River water and Bill Williams River water. The published water quality data for the Colorado River below Parker Dam were evaluated for maximum, minimum, and average values for various reported constituents. These data are displayed in Table 15. Water quality data for

TABLE 15

SURFACE WATER QUALITY, COLORADO RIVER BELOW PARKER DAM[a]
(mg/l, unless otherwise noted)

	Constituent	No. of Samples	Minimum	Average	Maximum
	Alkalinity as $CaCO_3$	156	98.0	128.	150.
D	Arsenic	1	0.00400	0.00400	0.00400
T	Arsenic	56	BDL	0.00284	0.00500
D	Barium	1	BDL	BDL	BDL
T	Barium	57	BDL	0.135	0.500
	Bicarbonate	145	120.	156.	177.
T	Boron	65	0.0500	0.196	0.360
D	Cadmium	7	BDL	0.000286	0.00100
T	Cadmium	65	BDL	0.00462	0.0130
	Calcium	146	73.0	85.6	100.
T	Carbon (organic)	59	1.90	4.55	14.0
	Carbonate	139	BDL	0.0288	4.00
	Chloride	166	75.0	94.5	140.
	Chromium (Hexa)	1	0.00100	0.00100	0.00100
T	Chromium	58	BDL	0.00357	0.0200
D	Copper	1	BDL	BDL	BDL
T	Copper	57	BDL	0.00793	0.0290
T	Cyanide	58	BDL	0.000862	0.0200
	Oxygen (dissolved)	109	5.10	8.53	11.7
	Fecal Coliforms (cols/100 ml)	49	0.990	4.78	41.9
D	Fluoride (84.7°)	127	0.200	0.378	0.500
	Hardness (total, as $CaCO_3$)	166	290.	339.	380.
	Hardness (noncarbonate)	165	170.	211.	243.
T	Iron	57	0.0300	0.159	0.550
D	Lead	9	BDL	0.00144	0.00400
T	Lead	57	BDL	0.0408	0.100
	Magnesium	146	26.0	30.9	40.0
T	Manganese	58	BDL	0.0208	0.0400
T	Mercury	58	BDL	0.0000431	0.000600
T	Nitrate (as N)	1	0.170	0.170	0.170
	pH (pH units)	202	7.10	7.95	8.80
T	Phosphorus (as P)	66	BDL	0.0258	0.100
	Potassium	139	4.50	5.21	6.80
D	Selenium	1	0.00300	0.00300	0.00300
T	Selenium	58	BDL	0.00279	0.00500
	Specific Conductance (µU/cm)	700	950.	1120.	1720.
D	Silver	1	BDL	BDL	BDL
T	Silver	58	BDL	0.00350	0.0100
	Sodium	119	90.0	107.	120.
	Sodium Adsorption Ratio (no units)	119	2.20	2.54	2.88
	Sulfate	167	240.	309.	380.
	Dissolved solids (180°C)	636	602.	722.	848.
	Turbidity (JTU)	43	1.00	2.58	10.0
D	Zinc	9	BDL	0.00889	0.0200
T	Zinc	57	BDL	0.0239	0.310
	Phenolics	62	BDL	0.00127	0.00700

Note: D = Dissolved Fraction; T = Total Recoverable; BDL = Below Detection Level

[a]Environmental Protection Agency STORET Data Retrieval System, March 1981 invent version. Run made on August 24, 1981 using data for the period of record October 1968 - June 1981. All constituent levels shown rounded to three significant figures.

the Agua Fria River and Lake Pleasant were very limited. The water stored in Lake Pleasant originates from tributaries which include the Agua Fria River, Boulder Creek, Cottonwood Creek, Humbug Creek, and French Creek. The Agua Fria River is the largest volume contributor. Water quality sampling of the Agua Fria River at Rock Springs began in January 1982. These data are shown on Table 16. The network of sampling stations around the New Waddell site has been expanded and water quality data are now being collected from reservoir releases and several tributaries. Water quality characteristics of the Verde River below Bartlett Dam and the Salt River below Stewart Mountain Dam are shown in Tables 17 and 18, respectively. Table 19 represents the combination of these records to characterize the quality of water near the confluence of those rivers immediately upstream of the SRP diversion point.

The Colorado River at Lake Havasu is estimated to contain an average Total Dissolved Solids (TDS) concentration of 722 mg/l. The principal dissolved components are sulfate (average 309 mg/l), sodium (average 107 mg/l), chloride (average 94.5 mg/l), and calcium (average 85.6 mg/l). TDS of the Agua Fria River is relatively low, at an average concentration of 358 mg/l. The principle dissolved components are sulfate (average 85 mg/l), sodium (average 37.8 mg/l), chloride (average 36 mg/l), and calcium (average 50.8 mg/l). Under the proposed plan, Agua Fria River water would be mixed with CAP imported Colorado River water in an enlarged Lake Pleasant. The effects of this mix were estimated using a blending ratio of nine parts Colorado River to one part Agua Fria based on a typical year operating schedule. TDS in the reservoir would increase 98 percent, from 358 mg/l to 710 mg/l. Other increases include sulfate (254 percent), sodium (178 percent), chloride (157 percent), and calcium (66 percent). However, the mixed water would still meet all required standards would remain suitable for existing irrigation use.

Mixing CAP water with the present SRP domestic supply may increase the concentration of dissolved organic substances in this supply. This could result in a higher potential for trihalomethane (THM) formation following water treatment. THM production is dependent upon the amount of organic compounds in the water, the amount of chlorine used in disinfection, and the length of the time chlorine is in contact with the water prior to final use. Colorado River water is known to have a high concentration of organic compounds (THM precursors). Currently, some Phoenix area municipal waters are near the Federal maximum contaminant level (0.1 mg/l). CAP operation does not require mixing Colorado River water with the SRP supply. If such mixing does occur, it is unlikely to be affected by regulatory storage. Lake Pleasant water, which would be affected by such storage, is not currently used as a domestic supply. Releases from Lake Pleasant back into the CAP system may contain a larger organic load than imports due to biological production within the reservoir. However, since eutrophication potential of the enlarged reservoir is relatively low, organic load increases are expected to be insignificant. Overall, implementation of the regulatory storage plan should have no impact on domestic supplies beyond that of CAP operation without storage.

TABLE 16

SURFACE WATER QUALITY, AGUA FRIA RIVER AT ROCK SPRINGS[a]
(mg/l, unless otherwise noted)

	Constituent	No. of Samples	Minimum	Average	Maximum
	Alkalinity as $CaCO_3$	4	140.	175.	190.
D	Arsenic[b]	2	0.00900	0.0100	0.0110
T	Arsenic	4	0.00900	0.0133	0.0160
D	Barium[b]	2	0.0650	0.0730	0.0810
T	Barium	4	<0.100	<0.100	0.100
	Bicarbonate	0	--	--	--
T	Boron	4	0.0900	0.165	0.230
D	Cadmium[b]	2	<0.00300	<0.00300	<0.00300
T	Cadmium	4	<0.00100	<0.00150	0.00200
	Calcium	4	39.0	50.8	58.0
T	Carbon (organic)	4	2.50	4.10	5.20
	Carbonate	0	--	--	--
	Chloride	2	32.0	36.0	40.0
	Chromium (Hexa)	0	--	--	--
T	Chromium	4	0.00300	0.00725	0.0190
D	Copper[b]	2	0.00700	0.00750	0.00800
T	Copper	4	0.00700	0.0138	0.0290
T	Cyanide	4	<0.0100	<0.0100	<0.0100
	Oxygen (dissolved)	4	8.60	8.88	9.10
	Fecal Coliforms (cols/100 ml)	4	4.00	36.3	120.
D	Fluoride (84.7°)	4	0.300	0.325	0.400
	Hardness (total, as $CaCO_3$)	4	160.	215.	240.
	Hardness (noncarbonate)	4	23.0	41.3	54.0
T	Iron	4	0.0600	2.04	6.40
D	Lead[b]	2	0.00200	0.00200	0.00200
T	Lead	4	0.00100	0.00425	0.00800
	Magnesium	4	16.0	21.8	25.0
T	Manganese	4	0.0100	0.0850	0.270
T	Mercury	4	<0.000100	<0.000100	<0.000100
T	Nitrate (as N)	2	3.20	3.85	4.50
	pH (pH units)	4	8.30	8.43	8.60
T	Phosphorus (as P)	4	0.0900	0.150	0.180
	Potassium	4	1.60	1.98	2.30
D	Selenium[b]	2	<0.00100	<0.00100	<0.00100
T	Selenium	4	<0.00100	<0.00100	0.00100
	Specific Conductance (µ℧/cm)	4	420.	582.	676.
D	Silver[b]	2	<0.00100	<0.00100	<0.00100
T	Silver	4	<0.00100	<0.00100	<0.00100
	Sodium	4	25.0	37.8	45.0
	Sodium Adsorption Ratio (no units)	4	0.900	1.20	1.40
	Sulfate	4	53.0	85.0	100.
	Dissolved solids (180°C)	4	257.	358.	401.
	Turbidity (NTU)	4	0.600	31.6	110.
D	Zinc[b]	2	<0.0120	<0.0120	<0.0120
T	Zinc	4	0.0200	0.0325	0.0600
	Phenolics	0	--	--	--

Note: D = Dissolved Fraction; T = Total Recoverable; -- Data Not Available

[a] U.S. Geological Survey from U.S. Bureau of Reclamation unpublished data, 1982; period of record January-April 1982. All constituent levels shown rounded to three significant figures.

[b] Samples taken below Lake Pleasant.

TABLE 17

SURFACE WATER QUALITY, VERDE RIVER BELOW BARTLETT DAM[a]
(mg/l, unless otherwise noted)

	Constituent	No. of Samples	Minimum	Average	Maximum
	Alkalinity as $CaCO_3$	328	28.0	185.	350.
D	Arsenic	16	0.00500	0.0121	0.0180
T	Arsenic	15	0.00700	0.0133	0.0210
D	Barium	6	BDL	0.0550	0.100
T	Barium	6	BDL	0.100	0.200
	Bicarbonate	520	34.0	236.	427.
T	Boron	1	0.190	0.190	0.190
D	Cadmium	16	BDL	0.00156	0.0140
T	Cadmium	16	BDL	0.00619	0.0100
	Calcium	541	19.0	42.5	75.0
T	Carbon (organic)	23	1.80	4.20	9.60
	Carbonate	399	BDL	1.57	15.0
	Chloride	352	2.00	18.8	130.
	Chromium (Hexa)	0	--	--	--
T	Chromium	16	BDL	0.00375	0.0100
D	Copper	16	BDL	0.00275	0.00700
T	Copper	16	0.00300	0.00888	0.0200
T	Cyanide	0	--	--	--
	Oxygen (dissolved)	21	8.60	11.6	17.8
	Fecal Coliforms (cols/100 ml)	31	1.00	8.35	99.0
D	Fluoride (84.7°)	210	BDL	0.340	0.800
	Hardness (total, as $CaCO_3$)	540	79.0	212.	413.
	Hardness (noncarbonate)	519	BDL	18.9	182.
T	Iron	71	BDL	0.192	3.50
D	Lead	16	BDL	0.00300	0.0120
T	Lead	16	0.00400	0.0714	0.100
	Magnesium	541	6.40	25.7	55.0
T	Manganese	16	BDL	0.0900	0.380
T	Mercury	16	BDL	0.000263	0.00260
T	Nitrate (as N)	3	0.0200	0.0967	0.140
	pH (pH units)	512	6.80	8.01	8.80
T	Phosphorus (as P)	53	BDL	0.206	0.400
	Potassium	219	1.30	3.39	7.40
D	Selenium	16	BDL	0.000750	0.00300
T	Selenium	15	BDL	0.000600	0.00100
	Specific Conductance (μ℧/cm)	522	150.	510.	929.
D	Silver	6	BDL	BDL	BDL
T	Silver	6	BDL	BDL	BDL
	Sodium	502	4.20	30.4	290.
	Sodium Adsorption Ratio (no units)	502	0.210	0.880	8.21
	Sulfate	350	11.0	52.9	107.
	Dissolved solids (180°C)	482	109.	314.	550.
	Turbidity (JTU)	39	1.00	83.3	2800.
D	Zinc	16	BDL	0.00700	0.0300
T	Zinc	16	0.0100	0.0356	0.200
	Phenolics	0	--	--	--

Note: D = Dissolved Fraction; T = Total Recoverable; -- Data Not Available; BDL = Below Detection Level

[a]Environmental Protection Agency STORET Data Retrieval System. Run made on February 16, 1980 using data for the period of record December 1950 - September 1979. All constituent levels shown rounded to three significant figures.

TABLE 18

SURFACE WATER QUALITY, SALT RIVER BELOW STEWART MOUNTAIN DAM[a]
(mg/l, unless otherwise noted)

	Constituent	No. of Samples	Minimum	Average	Maximum
	Alkalinity as $CaCO_3$	323	15.0	130.	189.
D	Arsenic	16	0.00200	0.00338	0.00600
T	Arsenic	15	0.00100	0.00387	0.00700
D	Barium	7	BDL	0.0771	0.200
T	Barium	7	BDL	0.100	0.200
	Bicarbonate	385	18.0	160.	230.
T	Boron	2	0.140	0.185	0.230
D	Cadmium	16	BDL	0.000813	0.00400
T	Cadmium	16	BDL	0.00669	0.0100
	Calcium	406	36.0	50.4	420.
T	Carbon (organic)	20	2.20	4.79	18.0
	Carbonate	162	BDL	0.358	35.0
	Chloride	303	70.0	234.	610.
	Chromium (Hexa)	0	--	--	--
T	Chromium	16	BDL	0.00188	0.0100
D	Copper	16	BDL	0.00250	0.00600
T	Copper	16	BDL	0.00868	0.0200
T	Cyanide	0	--	--	--
	Oxygen (dissolved)	20	1.60	6.61	13.7
	Fecal Coliforms (cols/100 ml)	28	1.00	22.0	470.
D	Fluoride (84.7°)	182	0.200	0.380	1.10
	Hardness (total, as $CaCO_3$)	404	121.	180.	270.
	Hardness (noncarbonate)	400	BDL	49.4	113.
T	Iron	27	BDL	0.187	2.10
D	Lead	16	BDL	0.00663	0.0600
T	Lead	16	BDL	0.0743	0.100
	Magnesium	406	5.50	13.7	28.0
T	Manganese	16	BDL	0.0625	0.170
T	Mercury	16	BDL	0.0000438	0.000400
T	Nitrate (as N)	3	BDL	0.0533	0.160
	pH (pH units)	396	4.50	7.74	9.10
T	Phosphorus (as P)	46	0.0100	0.223	8.30
	Potassium	185	2.40	5.83	42.0
D	Selenium	16	BDL	0.000188	0.00100
T	Selenium	15	BDL	0.000267	0.00200
	Specific Conductance (µ℧/cm)	405	505.	1140.	2340.
D	Silver	7	BDL	BDL	BDL
T	Silver	7	BDL	0.00171	0.0100
	Sodium	377	47.0	161.	382.
	Sodium Adsorption Ratio (no units)	377	1.29	5.13	10.4
	Sulfate	299	32.0	51.4	360.
	Dissolved solids (180°C)	362	316.	635.	1300.
	Turbidity (JTU)	33	1.00	2.91	10.0
D	Zinc	16	BDL	0.0160	0.120
T	Zinc	16	0.0100	0.0331	0.100
	Phenolics	0	--	--	--

Note: D = Dissolved Fraction; T = Total Recoverable; -- Data Not Available; BDL = Below Detection Level

[a]Environmental Protection Agency STORET Data Retrieval System. Run made on February 16, 1980 using data for the period of record December 1950 - September 1979. All constituent levels shown rounded to three significant figures.

TABLE 19

SURFACE WATER QUALITY, SALT RIVER PROJECT WATER[a]
(mg/l, unless otherwise noted)

	Constituent	No. of Samples[b]	Minimum[c]	Average[d]	Maximum[c]
	Alkalinity as $CaCO_3$	323	15.0	154.	350.
D	Arsenic	16	0.00200	0.00761	0.0180
T	Arsenic	15	0.00100	0.00792	0.0210
D	Barium	6	BDL	0.0676	0.200
T	Barium	6	BDL	0.100	0.200
	Bicarbonate	385	18.0	193.	427.
T	Boron	1	0.140	0.187	0.230
D	Cadmium	16	BDL	0.00113	0.0140
T	Cadmium	16	BDL	0.00648	0.0100
	Calcium	406	19.0	47.0	420.
T	Carbon (organic)	20	1.80	4.54	18.0
	Carbonate	162	BDL	0.879	35.0
	Chloride	303	2.00	141.	610.
	Chromium (Hexa)	0	--	--	--
T	Chromium	16	BDL	0.00268	0.0100
D	Copper	16	BDL	0.00261	0.00700
T	Copper	16	BDL	0.00877	0.0200
T	Cyanide	0	--	--	--
	Oxygen (dissolved)	20	1.60	8.76	17.8
	Fecal Coliforms (cols/100 ml)	28	1.00	16.1	470.
D	Fluoride (84.7°)	182	BDL	0.363	1.10
	Hardness (total, as $CaCO_3$)	404	79.0	194.	413.
	Hardness (noncarbonate)	400	BDL	36.3	182.
T	Iron	27	BDL	0.189	3.50
D	Lead	16	BDL	0.00507	0.0600
T	Lead	16	BDL	0.0731	0.100
	Magnesium	406	5.50	18.9	55.0
T	Manganese	16	BDL	0.0743	0.380
T	Mercury	16	BDL	0.000138	0.00260
T	Nitrate (as N)	3	BDL	0.0720	0.160
	pH (pH units)	396	4.50	7.86	9.10
T	Phosphorus (as P)	46	BDL	0.216	8.30
	Potassium	185	1.30	4.78	42.0
D	Selenium	16	BDL	0.000430	0.00300
T	Selenium	15	BDL	0.000410	0.00200
	Specific Conductance (µ℧/cm)	405	150.	869.	2340.
D	Silver	6	BDL	BDL	BDL
T	Silver	6	BDL	0.000975	0.0100
	Sodium	377	4.20	105.	382.
	Sodium Adsorption Ratio (no units)	377	0.210	3.30	10.4
	Sulfate	299	11.0	52.0	360.
	Dissolved solids (180°C)	362	109.	497.	1300.
	Turbidity (JTU)	33	1.00	37.5	2800.
D	Zinc	16	BDL	0.0121	0.120
T	Zinc	16	0.0100	0.0342	0.200
	Phenolics	0	--	--	--

Note: D = Dissolved Fraction; T = Total Recoverable; -- Data Not Available; BDL = Below Detection Level

[a]Environmental Protection Agency STORET Data Retrieval System. Run made on February 16, 1980 using data for the period of record December 1950 - September 1979. All constituent levels shown rounded to three significant figures.

[b]Minimum number of samples from Salt or Verde data.

[c]Minimum and maximum are for the Salt or Verde Rivers and could be experienced if the other river was not flowing.

[d]Weighted average based on USGS flow records resulting in a 43 percent Verde and 57 percent Salt mix at the confluence of the two rivers.

Assessing the eutrophication potential of proposed reservoirs is a developing science. Presently, there is no single approach that would result in unequivocal conclusions concerning the status of or potential for eutrophication. All the techniques have assumptions and limitations that must be considered in analyzing and interpreting study results. Recognizing the inherent limitations, an assessment was performed for the proposed reservoir sites in which Colorado River water would be introduced.

The procedure used to assess eutrophication potential was a nutrient loading analysis. This analysis estimates the nutrient loads and relates this to a potential for algae production. Nutrient loads were calculated from discharge records, and nutrient concentrations were determined for periodic water samples. Based on the Bureau's publication, "Guidelines for Studies of Potential Eutrophication," it was further assumed that phosphorus is the most important factor limiting algae growth. The "Guidelines" state that the Canfield and Bachmann model was the most accurate phosphorous loading equation in a test using data on 68 reservoirs in 11 western states. The CAP assessment was based on this model. The eutrophication analysis for New Waddell was performed for two cases of CAP operations. Case one was based on average operational information and presumed that the reservoir would contain a mix of nine parts of Colorado River water and one part local Agua Fria River runoff. Case two was performed in the same manner except the reservoir content was assumed to be entirely Colorado River water. The eutrophication analysis and results are summarized in Appendix B. The resultant probability of eutrophication ranges from 33 percent for case one to 16 percent for case two. These computed probabilities are less than that computed for the existing reservoir.

The quality of the Colorado River mainstream is largely dependent on the amount of annual runoff experienced in the Colorado River basin. The water to be diverted by CAP has in the past been diverted by California users: The Metropolitan Water District (MWD), which diverts from Lake Havasu; and the Imperial and Coachella Irrigation Districts, which divert at Imperial Dam downstream of Lake Havasu. Implementation of the regulatory storage plan would increase CAP's ability to take additional water from the river during surplus conditions, which would otherwise be diverted by California users. Therefore, the effect of CAP operations on the quality of Colorado River water would be very limited.

The mixing of Colorado River water with Agua Fria River water in the New Waddell Reservoir would alter the quality of water stored in the reservoir. Agricultural users of Agua Fria water downstream would experience a change in quality as explained earlier; however, the water would remain suitable for agricultural uses. Eutrophication-related water quality problems may actually be diminished. The water released from the reservoir back to the aqueduct would be of generally better quality depending on the amount of Agua Fria water introduced during the mix. The majority of the water in the reservoir during most years would be Colorado River water; therefore, very little change would be experienced in the quality of water returning to the aqueduct.

Plan development does not require mixing Salt and Verde River water with Colorado River water in the aqueduct. If mixing does occur, users of Salt-Verde water would experience a change in water quality by the introduction of Colorado River water into the SRP delivery system regardless of plan development.

CHAPTER VII

RECREATION, BIOLOGICAL, AND CULTURAL RESOURCES

Recreation

The implementation of this plan would greatly assist in meeting the outdoor and water-oriented recreational needs of the area. The reservoirs would provide additional recreational facilities and the Modified Roosevelt and New Waddell features would provide extensive boating opportunities. The recreational features were planned by the Bureau with input from local, State, Federal, and private agencies and the public. The facilities that could be developed are identified in Chapters III and IV. This section identifies expected uses. More detailed information is contained in Appendix C (Recreation) and in the recreation supporting documents to the Regulatory Storage Division Final Environmental Impact Statement.

New Waddell Reservoir (Lake Pleasant)

Recreational facilities at Lake Pleasant would accommodate boating, fishing, water skiing, picnicking, camping, sightseeing, hiking, and a nature study. Existing facilities would be replaced and current use should continue. There are no special use zones proposed for the lake and the Maricopa County Parks and Recreation Department and Sheriff's Department would be responsible for management and law enforcement. The lake is expected to have significant use. The lake level would fluctuate from approximately 9,600 surface acres to 2,600 surface acres. The lake would have approximately 7,200 surface acres during the heaviest use season, April to June. The current high level of use and unique water setting, close to the Phoenix metropolitan area, should attract residents and tourists. Current access would be replaced and upgraded to provide for ease of travel to the lake. It is estimated that the planned facilities would accommodate 863,200 annual recreation days. Current recreational use is over 1 million annual recreation days, so the overcrowding that exists and would continue to exist in the park is evident. Use of the park is not restricted. As the water level fluctuates, users follow the water level. Much of this use is not associated with the existing developments and accounts for much of the discrepancy between existing use and planned facility use/development. Reported use is only for the developed facilities. The impacts of the recreational use should be continuous from project initiation to completion since the existing resource would continue to be used for recreational purposes during construction activities.

Cliff Reservoir

Recreational facilities that would be developed or replaced at the Cliff site would include boating, fishing, camping, picnicking, hiking, a nature study, equestrian activities, and sightseeing. Current recreational use of the Cliff area, including Bartlett Reservoir, is somewhat limited due to difficulty in travelling to the area, time involved in travel, and proximity

of other areas to the Phoenix metropolitan area. Current use at all the lakes on the Verde is estimated at 174,000 annual recreation days. The planned recreational developments would accommodate 381,200 annual recreation days. Cliff is located approximately 25 miles northeast of Phoenix. The improvement of access and attractiveness of the Cliff setting would attract more people to the area for recreational pursuits. The recreational development has specifically been designed to accommodate this use and still protect the unique environmental resources of the area. Cliff Reservoir would fluctuate from a high of 2,840 surface acres to a low of 340 surface acres, with the mean surface area, from April through October, being 1,270 surface acres. Recreational plans were based on the main surface area and considered the fluctuation problems. For this reason, most of the major development is planned near the dam. A major exception would be the development in the Sheep Bridge area, which would provide improved access to the Verde River, the Mazatal Wilderness Area, and an equestrian-oriented recreational use area. Access to the recreational sites would be from Horseshoe Dam Road and Tangle Creek, on Forest Service/County roads. It is possible that portions of the reservoir and the Verde River, particularly in the Chalk Mountain area, would be closed to public use during eagle breeding seasons to accommodate wildlife needs. The Cliff area has a high occurrence of cultural resources. The recreational plans identify an archeological interpretive area and trail. The U.S. Forest Service would administer the facilities at the lake.

Theodore Roosevelt Lake

The recreational uses at Theodore Roosevelt Lake would include fishing, boating, waterskiing, sailing, camping, picnicking, hiking, a nature study, and sightseeing. Theodore Roosevelt Lake is located on the Salt River approximately 30 miles northeast of Phoenix. Access is currently difficult; thus use is somewhat limited. In addition, recreational development at the lake has been limited. Use at Theodore Roosevelt Lake is estimated at 688,000 annual recreation days. The replacement and new facilities developed should accommodate 1,061,600 annual recreation days. Access to the lake and its eastern shore would be improved. All primary recreational access roads would be paved and guardrailed as an environmental control measure. The public and the U.S. Forest Service have recommended extensive development of the Theodore Roosevelt Lake area for recreational use. This development has been tempered with a need to protect specific resources such as bird breeding areas. The recreational plans address measures to accomplish this objective. Theodore Roosevelt Lake would fluctuate from a high of 14,640 surface acres to 11,930 surface acres in the typical year, with the mean level during the use season being 12,000 surface acres. The management of the recreational facilities at Theodore Roosevelt Lake would be the responsibility of the U.S. Forest Service.

Recreation Benefits

Recreation benefits have been estimated based on anticipated use from new developments. A unit value was assigned to the various activities based on similar settings and recreational attractiveness of the proposed

developments. The losses of recreational opportunities are minimal in that in-kind replacement would minimize losses. Estimated recreational benefits are displayed in Chapter X and in Appendix E.

Biological Resources

The project area contains a variety of habitats which are generally classified as upland desert and riparian terrestrial vegetative types and riverine and lacustrine aquatic habitats. The major vegetative community is the palo verde-mixed cacti cover type. The riparian complexes of cottonwoods and willow are found along the floodplains of perennial rivers throughout the area. Riverine environments include the Agua Fria River flowing through the New Waddell site, the Verde River at the Cliff site, and the Salt River at the Modified Roosevelt and Modified Stewart Mountain sites.

Several special interest and use areas exist within or adjacent to the project area. Portions of the Verde River have been recommended for inclusion in the National Wild and Scenic Rivers System. The Theodore Roosevelt Lake Wildlife Area, located on the Tonto Creek arm of Theodore Roosevelt Lake, serves as a wintering area for Pacific Flyway Great Basin Canada geese. The Tonto National Forest Management Plan includes a 480-acre tract along the Salt River designated as the Blue Point Cottonwood Botanical Area. Other special use areas include: Designated wintering areas for bald eagles and peregrine falcons; restricted areas surrounding bald eagle nesting sites; riparian habitat rehabilitation sites along the Salt and Verde Rivers; and the Three Bar Research Area adjacent to Theodore Roosevelt Lake.

Terrestrial wildlife species are common to all cover types. The faunal assemblage is typical of the Arizona Upland Division. The ichthyofauna is comprised of non-native fishes. Native fish are found primarily in the riverine habitats.

Special status species include the river otter, bald eagle, peregrine falcon, Yuma Clapper rail, black hawk, osprey, desert bighorn, razorback sucker, Gila topminnow, roundtail chub, desert tortoise, as well as other species for which there is a moderate threat to the habitats they occupy.

Cultural Resources

Investigation of cultural resources followed the CAWCS three-stage planning process. Initial considerations were based on extant information about previously recorded sites or available historical documents and maps. As the range of alternatives under consideration was narrowed, on-the-ground sample surveys were conducted. Subsequently, virtually complete survey coverage of construction zones and reservoir pools was achieved. All potential historical sites within the area were also inspected. Much of the area in the indirect impact zones, defined as extending approximately 1 mile beyond the maximum water surface elevations, was not surveyed but the numbers and types of sites present were estimated on the basis of survey results within the reservoir pools.

The results of these surveys indicated that more than 3,200 prehistoric and historic sites are present within the project areas (See Table 20). The most significant resources are those at Theodore Roosevelt Dam and Lake where almost 1,500 prehistoric and 87 historic sites or components are present. The prehistoric resources include a few potential archaic era sites which could date from the millenia preceeding the Christian era, but most could date to the Hohokam and Salado occupations. Prehistoric villages include pithouses, compounds, and masonary pueblos ranging up to more than 100 rooms. The most significant prehistoric sites are five clusters centered on artificially constructed platform mound sites. Apartment-style pueblos and compound sites are present within these clusters along with various limited activity and agricultural features. These evidently reflect the relatively high degree of socioeconomic complexity of the later part of the prehistoric occupation.

The historic sites include Theodore Roosevelt Dam, a National Historic Landmark. This is the world's highest masonry dam and dates from the beginning of the Reclamation era. Numerous other related sites, such as construction camps and facilities, are present. Some significant sites related to ranching and development of transportation routes are also present.

The resources at Cliff are only slightly less significant. The range of prehistoric site types is similar to that at Theodore Roosevelt Dam, but the sites in general tend to be smaller. However, more and larger Hohokam pithouse villages are present. The surveys reported fewer masonry pueblos and compound sites than at Theodore Roosevelt Dam. Only one potential platform mound complex has been identified. The historic occupation was also less intense and related primarily to construction of Horseshoe Dam and limited ranching activities.

The resources at New Waddell are far less abundant. Only an estimated 120 prehistoric and 16 historic sites are present. The prehistoric sites are primarily small artifact scatters and small habitation sites. The historic sites are related primarily to water resource development and dam construction. At Stewart Mountain Dam only a single prehistoric petrograph site and three historic sites related to construction of the dam are present.

TABLE 20

Archeological and Historical Resources

	Prehistoric 1/	Historic 2/	Both 1/
New Waddell	120	16	0
Cliff	1,464	16	4
Modified Roosevelt	1,478	64	23
Modified Stewart Mountain	1	3	0
	3,063	129	27

1/ Recorded

2/ Known and projected

CHAPTER VIII

ENVIRONMENTAL ANALYSIS

This chapter describes anticipated environmental impacts of Plan 6 as described in Chapter III. The information contained here is included in greater detail in Appendix C and D and in the Regulatory Storage Division Final Environmental Impact Statement.

Recreation

Project recreation facilities would accommodate 2,306,100 annual recreation days. This would be an increase of 2,080,850 annual recreation days over what existing facilities can accommodate. The increase would assist in meeting the area's projected recreational needs for camping, boating, picnicking, fishing, water skiing, hiking, sightseeing, and sailing. No white-water or "tubing" activities or use areas would be adversely affected. The effects on stream-oriented recreational uses would be negligible.

Biological

Coordination

As part of the biological analysis, various publics were contacted. The U.S. Fish and Wilflife Service and the Arizona Game and Fish Department were the principal contributors to the biological analysis under authorities provided under the Fish and Wildlife Coordination Act and Endangered Species Act. As members of the Habitat Evaluation Team, these agencies assisted in the evaluation and quantification of project effects and developed the initial mitigation measures for Plan 6. The U.S. Fish and Wildlife Service had the lead role in the Habitat Evaluation Procedure studies. The Technical Agency Group, organized as part of the study's overall planning process, provided information on plan development which was incorporated into the biological analysis.

Project Impacts

Impacts to biological resources would result primarily from dam construction, reservoir inundation, and flow releases from reservoirs. The environmental processes would be influenced by construction and operation activities. The alteration of environmental processes would result in a modification of the resource condition, both in amount and quality.

The element areas are defined by the Inflow Design Flood (IDF) inundation area. Areas for Plan 6 facilities outside the IDF area (haul roads, reversible canals, powerlines, etc.) and other areas where direct impacts would occur were also included.

Adverse construction impacts would occur on a project-wide basis. These impacts relate to the actual destruction of habitat caused by the creation of project facilities, clearing vegetation for haul and access roads, borrow areas, conservation pool clearing, and work and storage yards. Additional impacts would occur from the presence of the construction forces and general construction activities. Noise and disturbances created by the movement of equipment, material hauling, blasting, concrete batch plant operations, aggregrate excavation, and the like would have the effect of driving wildlife from the construction areas to areas of little or no disturbance.

The effect of this habitat distruction and eviction on resident wildlife would be the immediate reduction in densities and resource utilization in the construction areas. Nearby populations would be affected by the increase in competition for limited resources and a reduction in breeding potential as the displaced populations immigrate into the undisturbed habitats surrounding the site areas. These types of impacts would be relatively short term and would have an impact similar to natural perturbations such as a large wildfire.

Long term impacts would result from the placement of permanent structures and facilities, human activity around the facilities and recreation sites, and the actual operation of the dams with their fluctuating storage levels and release schedules. The adverse impacts of dam operations would not occur at Modified Stewart Mountain Dam and Reservoir or Modified Roosevelt Dam and Reservoir since these elements would continue to operate as they have in the past. New Waddell Dam and Reservoir operations would cause significant adverse impacts but Cliff Dam and Reservoir may actually enjoy an improvement over the present operation of Horseshoe Reservoir.

Human activities in and around Plan 6 facilities would have the same effect as described above; but the temporal nature of these impacts would be long term. The most significant effect of these activities would be from the six-to-eight-fold increase in recreation at Cliff, Modified Roosevelt, and New Waddell Dams and Reservoirs.

The greatest impact from the operation of Cliff, Modified Roosevelt, and New Waddell would be the loss of habitat through permanent and periodic inundation. This would affect all terrestrial and riverine biotic communities and constitute a long term impact over existing and future conditions.

New Waddell Dam and Reservoir

Terrestrial Communities. The greatest loss of upland desert would occur at the New Waddell site. The loss of habitat and displacement of wildlife due to construction impacts in this community would have the effects described above. Additional impacts would result from the construction of a 4.7-mile reversible canal that would parallel the east bank of the Agua Fria River south to the CAP aqueduct. The impacts related to construction of the canal would be similar to those resulting from road construction except the canal would require a 300-foot right-of-way. The canal would limit or reduce wildlife movement between the river channel and the habitat to the east. There is also the likelihood of animal drownings in the canal should they attempt to cross.

In assessing the impacts of the operation of the plan, the assumption was made that within the first 10 years of operation the conservation pool would be filled at least once. Given this situation, all desert-type vegetation in the conservation pool would be lost and the oft described habitat hiatus would come into being.

This loss of upland desert would not stop at the top of the conservation pool. While New Waddell Dam is not designed for flood control, a surcharge pool would be provided to limit releases from the reservoir in a semi-controlled fashion. The filling of the surcharge pool would cause the inundation of additional vegetation above the conservation pool.

The extent of riparian habitat at the New Waddell site is limited. Only two areas, Morgan City Wash and the Agua Fria channel upstream of Lake Pleasant, contain stands of willow trees. The Agua Fria channel has a few scattered cottonwoods. Mesquite makes up the greatest part of the riparian community, followed by salt-cedar. Impacts to this habitat would be limited in extent and occur primarily during the operational phase.

Wetlands, represented by stands of cattails in the Lower Lake, would be totally lost due to dewatering for construction. Recovery would be dependent on the morphology of the basin after construction.

Aquatic Resources. Aquatic resources would seemingly benefit from the larger lake and increased habitat availability. This is true for most species dependent on aquatic habitat, waterfowl, pelagic fish, periphyton, phytoplankton, zooplankton, and invertibrates such as crayfish and larval stages of fish. The increased habitat would result in a beneficial change in habitat quality for these creatures due to the inundation of freshly aerated soils and vegetation and the resultant decomposition of that vegetation. This increased habitat quality and quantity would be a boom-and-bust situation because of the large seasonal fluctuations of the reservoir. The long term impact should stabilize at a somewhat better level than what presently exists.

Seasonal drawdown rates of the reservoir would have a significant affect on centrachids (bass, bluegills, crappies, etc.), spawning success, and densities. Of primary importance to this reservoir is a sport fishery whose primary product is large mouth bass and allied species.

There would also be a significant increase in total dissolved solids (TDS) concentrations. The mixing of Colorado River and Agua Fria River water would result in a concentration of 722 parts per million (ppm) as opposed to 369 ppm which is considered an almost optimal condition. This change would represent a decrease in habitat quality. New Waddell Reservoir would suffer a reduction in habitat quality for centrachids. In general, the decreased spawning success and reduced survivability of young fish would result in lower centrachid densities and biomasses. These reductions would directly correspond to lower fishermen success (catch/unit effort) and a loss of economic value for this fishery.

Endangered Species. The only Federally-designated endangered species in the New Waddell area is the Gila topminnow. This fish occurs above the maximum high waterline of the surcharge pool in Tule Creek, a tributary of the Agua Fria River. Normally, water flowing in Tule Creek does not reach the Agua Fria; however, if the surcharge pool is full or nearly so, and the creek is flowing, the existing natural barriers, which now prevent the non-native fish predators of the topminnow from accessing the population, would be rendered ineffective. If this occurred, predators could gain access to the isolated population and destroy it. Fish barriers would be placed above the IDF elevation to avoid impacts to native stream fish.

Special Use Areas. Currently there are no special use or management areas solely dedicated to conservation or protection of wildlife.

Cliff Dam and Reservoir

Terrestrial Resources. Construction and operational impacts would affect all terrestrial habitats in this site area. The loss of habitat and displacement of wildlife due to construction impacts in this community would have the effects described above.

Total conservation pool clearing would occur on 1,428 acres in the lowest portion of the reservoir between elevation 1866 and 1968 for water quality reasons. Partial clearing would occur between elevation 1968 and 2000.5, the top of the conservation pool, for a total of 1,833 acres. Clearing would lessen the hazards of navigation and provide human safety benefits in the recreation site areas. The vegetation in this area would be inundated with the first filling of the pool. This represents a foregoing of beneficial protective cover for fish and only a temporal loss to terrestrial habitat over what would occur anyway. The clearing plan would likely undergo further modification prior to implementation since current information shows that total clearing of the vegetation would have little impact in increasing water quality. The partial clearing may also be reduced in extent if the Arizona Game and Fish Commission imposes horsepower restrictions and "no wake zone" areas on the management of this reservoir.

In assessing the impacts of the operation of Cliff Reservoir, the assumption was made that within the first 10 years of operation the conservation pool would be filled at least once. Given this, all desert-type vegetation in the conservation pool would be lost and the bathtub ring effect (habitat hiatus) would become obvious. This loss of upland desert would not stop at the top of the conservation pool. The reservoir is designed for flood control with a surcharge pool to control releases from the reservoir. The filling of the surcharge pool would cause the inundation of additional vegetation above the conservation pool and create a vegetational gradient ranging from flood tolerant species to highly flood susceptible species. Vegetation would also be distributed along this gradient according to the duration and frequency of inundation. Once a destructive inundation event occurs, this surcharge area would exist in a successional disclimax for as long as the periodic flooding occurs, probably the life of the project or until a major change in operations occured. A quantitative analysis of this

impact has not been attempted due to the highly unpredictable nature of floods and the lack of reservoirs in this area that are in a fashion similar to the Plan 6 reservoirs in operation.

The riparian habitat at Cliff is not limited in extent as at New Waddell. The riparian community type occurs all along the Verde River channel upstream and downstream of Horseshoe Reservoir. There is a mesquite fringe at the approximate high water line of this reservoir. Mixed cottonwood/willow and mesquite stands occur fringe-like along the entire course of the river. The greatest development is immediately downstream of Horseshoe Dam. This area provides excellent habitat for nesting birds and winter migrants. Impacts to the riparian habitat would be extensive and occur during both the construction and operational phases. The cottonwood/willow, mesquite, and mixed scrub communities lying downstream of Horseshoe Dam would be lost either during construction through the direct loss of the vegetation or during operations through inundation. The Horeseshoe lakebed lies partially outside the conservation pool high water line of the new lake but within the flood control pool. Above the conservation pool and within the surcharge pool the growth of riparian groves would be dependent on the duration of inundation. Salt-cedar and willow would withstand greater periods of inundation than mesquite or cottonwood. These former species would likely form a sparse, scattered cover within the upper portions of the conservation pool, becoming quite dense at the edge of the conservation pool and along the major drainages running into the lake.

Wetlands in the area are seasonal in nature and are represented by stands of cattails, johnson grass, and immature cottonwood and willow in dewatered portions of the Horseshoe lakebed that overlie deep alluvial silt deposits. These areas are generally inundated each year during the winter fillup period and exposed in late spring. When winter flows down the Verde are minimal, this area provides excellent winter waterfowl habitat. This area would suffer impacts from increased inundation with the Cliff operation.

After the construction of the facilities, all construction disturbed areas not required for operation would be reclaimed. These areas include all borrow and spoil areas, haul roads, maintenance and storage sites, and disturbed areas around the facilities and in unneeded portions of rights-of-way. The reclamation would consist of recontouring and revegetation to natural conditions similar to the surrounding habitat.

Aquatic Resources. Aquatic resources would benefit from a larger lake and increased habitat availability at Cliff. This is true for all species dependent on aquatic habitat, waterfowl, broadcast and nesting spawning fish, periphyton, phytoplankton, zooplankton, invertebrates such as crayfish, and larval stages of fish. Associated with the increase of habitat would be a beneficial change in the quality of the habitat for these creatures due to the inundation of freshly aerated soils and vegetation and the resultant decomposition of that vegetation. This increased habitat quality and quantity would be a boom-and-bust situation because of the large seasonal reservoir fluctuations. The long-term impact should stabilize at a somewhat better level then what presently exists.

The seasonal drawdown rates of the reservoir would have a significant effect on centrachid (bass, bluegills, crappies, etc.) spawning success, and densities. This reservoir has little importance as a sport fishery now due to the seasonal fluctuations of water levels and an almost annual dry up. The original construction and operation plan for Cliff would have cleared the entire conservation pool of vegetation. The plan as described above has been modified. The spring drawdown rate for Cliff is suitable for centrachid spawning on a far more regular basis than what occurs now. These two parameters combine to make an enhanced sport fishery. The operation of the inactive pool and sediment pool, however, may have a detrimental effect on the fishery at Barlett Reservoir two miles downstream. Currently, when spawning does occur in Horseshoe Reservoir, a portion of the juvenile fish are flushed downstream to Bartlett when Horseshoe is evacuated. This situation would not occur with Cliff in place and the densities of juvenile fish would decrease in Barlett.

The impacts to the riverine aquatic habitat would occur primarily in response to the blockage of nutrients that normally are discharged downstream when Horseshoe is totally evacuated in the late spring and summer. Additionally, there may be some clear water scouring in this river section where normally heavily silt-laden flows now occur. There may also be a change in the temperature regime of the remaining river due to increased storage and greater depths in the Cliff Reservoir. Upstream impacts on the Verde would likely be insignificant if they occur at all, and would be related to short-term storage of floodflows. The conservation pool would not inundate additional portions of this upstream section of river.

One live stream occurs in the site which supports populations of native fish. Lime Creek on the west shore of Horseshoe Reservoir is maintained by permanent springs. Impacts to these populations could occur as described for the Gila topminnow population at New Waddell.

Endangered Species. The only Federally-listed endangered species occurring in the Cliff area is the bald eagle. The Chaulk Mountain breeding territory occurs at the upper end of Horseshoe Reservoir and normally exists along a flowing section of the river. During recent yers, high water levels in the reservoir flooded a tree nest repeatedly and the eagles are now using a cliff nest, well above the high waterline. With the operation of Cliff, this territory would have more river within its boundaries and would not be as likely to be flooded out if the tree nest is used. The main impact to this breeding pair would come from the six-to-eight-fold increase in recreation pressure caused by the availability of additional river miles. The Endangered Species Opinion prepared for Plan 6 (see Appendix C) describes the impacts to this species. As indicated in the Bureau's response to the Endangered Species Opinion, this element has been modified to prevent impacts from occurring.

Modified Roosevelt Dam and Reservoir

Terrestrial Resources. Construction impacts would primarily affect upland desert, mesquite, and mixed scrub habitats. Riparian habitats would be affected during the operational phase to a minor degree. The greatest loss

of habitat would occur in areas used for haul roads, borrow and material storage sites, and construction staging. The actual construction of the facilities would take place in an area with little resource value. The impacts associated with the construction activities are described in Appendix C.

Operational impacts would essentially be insignificant due to similar operations and resultant water levels that now occur at the existing reservoir. The new conservation pool elevation would be only 12 feet higher than the existing pool but the frequency of occurrence would be such that the fringe of mesquite around the reservoir would not be significantly reduced in extent on a long term basis. The mesquite fringe would shift from its present position slightly upslope encroaching on the desert upland habitat.

Aquatic Resources. During construction, the only anticipated impact to aquatic resources would be from the possible dewatering or reduction in the reservoir level to an extent that it would affect the survival of the fish population. This is an unlikely event and one that would necessitate a rather large salvage effort.

Analysis of the new operation of this reservoir detected no change in the overall value of the habitat for aquatic habitat dependent species.

Endangered Species. Construction impacts to endangered species would occur at the Meddler Point borrow site. Activities would affect the ability of the Pinal Creek bald eagle nest pair to forage in the area. Meddler Point is the prime early nest season foraging area for this pair.

Additionally there would be recreation impacts associated with the operation of Plan 6 facilities.

Special Use Areas. The Roosevelt Waterfowl Area is managed for conservation of migrating winter waterfowl. The area is located on the Tonto arm of the reservoir and is maintained to provide winter nesting and foraging areas for migrating ducks and geese. The area is closed to human entry each year from November 15 to February 15 to protect waterfowl. Some of the proposed recreation sites are either within or immediately adjacent to the waterfowl area (see Appendix C). The use of these sites plus the overall increase in project-related recreation would tend to reduce the value and effective acreage of the waterfowl area.

Modified Stewart Mountain Dam

Terrestrial Resources. Construction impacts at this site would primarily involve upland desert habitat. Early in the planning process, a commitment was made to avoid obtaining material for construction from the Salt River downstream from Stewart Mountain Dam due to the sensitive nature of the area. By this commitment, the major impacts of this element would be avoided. The remaining impacts would be rather insignificant in nature and extent.

Aquatic Resources. The construction and operation of this element would not significantly affect aquatic resources.

Endangered Species. The Blue Point/Stewart Mountain bald eagle nest is approximately one mile downstream from this site. It is currently the most productive nest in the entire breeding population. For the last three years this nest has produced three fledglings per year.

Special Use Areas. There are no special use areas that would be affected by this element.

Mitigation

The principal method for determining mitigation needs was the Habitat Evaluation Procedure developed by the U.S. Fish and Wildlife Service. This methodology quantifies changes in wildlife habitat quality and quantity over time.

Based on these Habitat Evaluation Procedures, the mitigation measures and Plan 6 modifications would fully alleviate impacts to Riparian/Wetland Communities, Reservoir Aquatic Communities, Perennial Streams, and Special Use Areas and avoid jeopardizing endangered species. Other terrestrial communities have mitigation measures which are reasonable and feasible but provide less than full compensation for losses due to cost and operational constraints. Reservoir aquatic communities would benefit from the plan due to increases in habitat and prey availability. However, the largemouth bass and allied species, which are the mainstay of the sport fishery at New Waddell, would be adversely affected. This would directly affect the economic value of this resource.

The primary impacts described in the previous section are based on the effects of impounding water. The amount of water impounded and the operation of the reservoir were determined by forecasting the availability of water based on historical records. The mitigation of the effects of the reservoirs is therefore dependent on the accuracy of these forecasts.

Riparian/Wetland Communities. The plan would result in no net loss of habitat values to the Riparian/Wetland Communities upstream of Bartlett and Stewart Mountain Dams and at Lake Pleasant. Methods for meeting this commitment would include revegetating cottonwood/willow and mesquite habitat types in suitable areas within the exposed bed of Horseshoe Reservoir above elevation 1940. Based on current information, a sufficient area would be exposed to recover all habitat value lost to construction and operation, including losses at Modified Roosevelt and New Waddell Dams.

The mixed shrub at all sites and the cattail habitat at Cliff Dam would recover without revegetation through natural succession. To ensure full development of the habitat values, livestock grazing and off-road vehicle use would need to be eliminated and fencing may be required.

The draining of Horseshoe Reservoir and the breaching of Horseshoe Dam would be scheduled to coincide with the seeding and germination period of cottonwood and willow species in March and April.

All riparian habitats in areas not required for construction purposes would be protected from damage. All riparian habitat removed due to construction outside the impoundment area would be contoured and revegetated to preconstruction conditions.

Other Terrestrial Communities. The upland desert habitat represents the major vegetative type within the Cliff, Modified Roosevelt, and New Waddell site areas and would be subjected to the greatest acreage loss within the reservoir inundation zone. To mitigate the loss of habitat value to the greatest extent practical or to compensate for the losses, values in other habitats would be increased.

The most practical means to decreasing losses would be to manage the Inflow Design Flood (IDF) areas at New Waddell, Cliff, and Modified Roosevelt damsites for wildlife by restricting grazing and off-road vehicle use. This management would increase habitat values by 87 percent over the unmitigated project action. An additional 5 percent of the lost value could be regained by providing permanent water sources in areas where water is not now available to wildlife.

To implement these measures, the IDF would be fenced and/or management agreements established with the U.S. Forest Service (for Cliff and Modified Roosevelt damsites) and the Maricopa County Parks and Recreation Department and/or the Arizona State Land Department for the New Waddell damsite.

All areas of construction disturbance in sites not needed for permanent facilities would be returned to natural contours and revegetated with native plant species.

Perennial Streams. The Bureau would replace all habitat value lost due to the construction and operation of the plan. Impacts to the native fisheries in perennial streams caused by the increased water storage elevations at Cliff and New Waddell damsites which could introduce non-native reservoir fish into isolated native fish habitat would also be avoided.

Up to 7 miles of river which would be available in Horseshoe Reservoir would be reclaimed through stream management techniques to replace the value lost from the 6 miles of river inundated by Cliff Dam and Reservoir.

Reservoir Aquatic Communities. Lost habitat values would be replaced to the greatest extent practical. These values would be compensated by increasing habitat values elsewhere, or by increasing the density of game fish in the reservoirs as measured by catch/unit effort.

The rate of drawdown at New Waddell Reservoir would be reduced to 5 feet or less during March and the first half of April as often as is practical.

Conservation pool clearing would be reduced to the minimum possible level. A total of 2,486 acres would be cleared at Cliff and New Waddell sites primarily for human safety and navigation considerations, predicated on expected boat usage.

Minimum pools would be incorporated into the sediment and inactive storage pools at Cliff and New Waddell Reservoirs. At Cliff Reservoir, this pool would be 1,030 acres in size with an average depth of 30 feet; the New Waddell Reservoir pool would be 1,540 acres in area and average 26 feet deep.

Special Use Areas. The Roosevelt Waterfowl Management Area would incur direct and indirect impacts from the anticipated eight-fold increase in recreation use of Roosevelt Lake. This would reduce its value to migrating waterfowl. To reducing the effect of this disturbance, the value of the management area would be increased.

The recreation plan for Modified Roosevelt Reservoir includes recreation sites within the Waterfowl Area during winter use period. Irrigation equipment (either portable or permanent) and sufficient water to irrigate 100 acres of winter food crops for waterfowl would be provided. This measure would increase the Arizona Game and Fish Department's ability to provide winter food crops by approximately 50 percent.

Endangered Species. The U.S. Fish and Wildlife Service has issued a Biological Opinion under the Endangered Species Act that the plan as proposed would jeopardize the continued existence of the bald eagle in the Southwest. The Jeopardy Opinion was issued because of the impacts from recreation developments and opportunities at Cliff and Modified Roosevelt Reservoirs and because of construction impacts at Modified Roosevelt and Modified Stewart Mountain Dams.

In accordance with established policy, the Bureau would work with the U.S. Fish and Wildife Service, Arizona Game and Fish Department, and the U.S. Forest Service to prepare an agreement to implement management strategies and actions to avoid adverse impacts on nesting bald eagles.

The Bureau would continue to support the U.S. Forest Service' efforts to maintain nest wardens and provide liaisons between construction forces. The nest watch program would continue to receive funding from the Bureau for this effort.

The Bureau supports breaching Horseshoe Dam in a manner that would promote stream and riparian development in the exposed Horseshoe Reservoir and avoid excessive erosion. The Bureau would coordinate with the U.S. Fish and Wildlife Service to develop requirements for evacuation of Horseshoe Reservoir, which would be included in the data submitted for final design and construction specifications.

If possible borrow excavation would be avoided at Meddler Point. If not, construction specifications would require removal of materials during eagle nonbreeding season and stockpiling materials outside the eagle breeding and foraging territory. Borrow areas would be restored to provide habitat suitable for eagle forage fish.

Award of construction contracts associated with Stewart Mountain Dam would be scheduled to permit initiation of construction in April or May and then continue uninterrupted, except for blasting. Construction specifications would exclude initiation of construction from October through March. Blasting activities would be prohibited from December through March.

The Bureau would work with the U.S. Fish and Wildlife Service to design and evaluate a positive cutoff above the IDF elevation to provide a barrier to the movement of fishes upstream on Tule Creek in the Gila topminnow habitat. The positive cutoff would be constructed unless unforeseen design problems or extreme costs are encountered.

The Bureau would participate in fishery investigations as part of an Interagency Agreement.

Cultural Resources

Impacts

The estimated 3,300 prehistoric and historic sites within the area are subject to various of types of impacts. In general, the impacts are expected to be adverse rather than beneficial, concentrated rather than dispersed, caused rather than induced (although induced recreational impacts could be substantial), and of a long-term nature because the resources are nonrenewable and the effects are permanent. Many of the impacts would occur over the short term, during the first few years of the project; but some flooding impacts would be delayed.

To analyze the severity of the impacts, three types of impact zones were differentiated: Construction, inundation, and secondary usage. Construction impacts are the most severe because they often lead to total site destruction. Inundation can lead to mechanical, chemical, and biological alterations. In general, the severity increases with the frequency of flooding and would be most severe within the conservation pool. Impacts would be less damaging in the floodpools but could be substantial at the lower zones where frequency of inundation would be relatively high. Impacts in the surcharge pool and surrounding secondary impact zones would be much less severe although increased recreational use would lead to degradation of site integrity through inadvertent damage or vandalism. In summary, sites within construction zones and the conservation pool could be expected to be destroyed over the short term. Those sites lying within floodpools, surcharge space, and secondary impact zones could be expected to be degraded over the long term. Table 21 shows the numbers and relative percentages of significant prehistoric and historic sites within these zones.

TABLE 21

Significant Historic and Prehistoric Sites

Site	Destroyed Over the Short Term		Destroyed Over the Long Term	
	Prehistoric	Historic	Prehistoric	Historic
New Waddell	47(40%)	10(60%)	73(60%)	6(40%)
Cliff	182(10%)	6(30%)	1282(90%)	14(70%)
Modified Roosevelt	36(2%)	22(25%)	1463(98%)	65(75%)
Modified Stewart Mountain	0	0	1(100%)	3(100%)
	165(5%)	38(30%)	2819(95%)	88(70%)

Mitigation

Mitigation measures for cultural resources are aimed at preserving the significant values of the site. Extensive measures to mitigate adverse impacts upon cultural resources would be implemented concurrently with construction of Plan 6 features. These would be carried out in the context of the ongoing cultural resource program developed for the CAP and in accordance with a programmatic Memorandum of Agreement with the Advisory Council on Historic Preservation and the Arizona State Historic Preservation Officer. The mitigation measures for the plan include:

1. Implementing data recovery and research studies of sites immediately affected by the plan.

2. Developing a program to monitor, manage, and study archeological and historic sites in the indirectly affected areas.

3. Developing a program for public distribution and interpretation of study results.

Plans to implement these measures are outlined in Figure 16 and further discussed in Appendix C.

The proposed data recovery studies would focus on about 45 historic sites (approximately one-third of those recorded). The studies would focus on the history of water resource development and use in central Arizona. The prehistoric data recovery would concentrate on about 35 of the major sites (approximately 1 percent of those estimated to be present or 20 percent of those to be destroyed or disturbed over the short term). The studies would investigate the development and decline of complex cultural systems. The monitoring and management program would deal with the remaining 3,000 sites. The total cost of the mitigation plan, including development of a visitor center at Theodore Roosevelt Lake, is estimated at $10.5 to $13.5 million.

Figure 17 outlines the estimated level of effort and funding for cultural resource mitigation.

Consultants in Plan Development

When the development of a general historic preservation plan for the entire CAP was initiated in January 1982, almost 250 individuals and organizations were solicited for ideas, comments, and suggestions. The planning of the cultural resource aspects of the plan benefited from consultation and coordination with various agencies and individuals. Members of the Bureau's CAP Ad Hoc Committee for Cultural Resources include representatives of the Arizona State Historic Preservation Office, Advisory Council on Historic Preservation, affected Federal agencies, local agencies such as Salt River Project, and professional societies.

FRAMEWORK FOR CULTURAL RESOURCE MITIGATION,
REGULATORY STORAGE DIVISION, CENTRAL ARIZONA PROJECT

MITIGATIVE ACTION	PLAN 6 ELEMENTS			
	NEW WADDELL	STEWART MOUNTAIN	MODIFIED ROOSEVELT	CLIFF
Data Recovery Studies				
historic	combined historic archeology study focusing on water resource development sites historic analysis of social, economic and political aspects of water resource development in Central Arizona Historic American Building Survey/Historic American Engineering Record documentation			
prehistoric	no further study anticipated	no further study anticipated	major study of one Salado platform mound complex	major study of Sinagua site complex and Hohokam villages
Monitoring/Management			interagency agreement with Tonto Forest for long-term (10 year) study of sites in less immediate and indirect impact zones	
Public Interpretation			develop visitor facilities with Forest Service, Salt River Project, or Tonto National Monument	

Figure 16

ESTIMATED LEVEL OF EFFORT AND FUNDING FOR CULTURAL RESOURCE MITIGATION,
REGULATORY STORAGE DIVISION, CENTRAL ARIZONA PROJECT

MITIGATIVE ACTION	PLAN 6 ELEMENTS			
	NEW WADDELL	STEWART MOUNTAIN	MODIFIED ROOSEVELT	CLIFF
Data Recovery Studies				
historic	8 to 12 person years field effort for historic archeology studies 2 to 4 person years for social, political and economic history 3 to 4 person years field effort for HABS/HAER recording total funding estimated at $1 to $1.5 million			
prehistoric			70 to 80 field person years of effort	70 to 80 field person years of effort total funding estimated at $8 to $10 million
Monitoring/Management			3 to 5 person years of effort annually for 10 years = 30 to 50 person years $100,000 to $150,000 estimated annually for 10 years for a total of $1 to $1.5 million	
Public Interpretation			rehabilitation of existing structure or construction of 5000 square foot facility and furnishings $500,000 estimated contribution	

Figure 17

CHAPTER IX

SOCIAL RESOURCES

As discussed in Chapter III, social resources in the area would be affected by implementation of the plan in two distinct ways. Construction of Cliff and Modified Roosevelt Dams would require the relocation of residents living in the reservoir areas. This would cause negative social effects. Providing flood control for the Phoenix metropolitan area would result in significant beneficial social effects.

Many factors were identified for the relocation and flood reduction impacts judged to best "capture" the social consequences of Plan 6 actions. The selection of factors was based on an extensive review of the research literature and on discussions with members of the affected community. Both primary and secondary data sources were incorporated into the assessment.

The literature review yielded a list of characteristics associated with success in adapting to relocation and with the ability to cope with disaster. The affected community was compared with these lists of characteristics. Projections were made about the general level of expected impacts. Factors were measured for existing conditions, based on primary data that were collected, using three techniques. First, case histories were conducted with members of the affected community. These histories were recorded and transcribed; they contained information about the recent characteristics of the community and about the factors that would be traced across the project conditions. Second, interviews were conducted with key informants who were chosen for their specialized knowledge about some aspect of impact assessment. Third, field observations were made and recorded by researchers who visited affected communities. They attended community functions and public meetings and made notes on their observations.

Secondary data were used extensively in the assessment. Demographic information obtained from census data and local, state, and federal government agencies was incorporated.

Data analysis consisted of making impact projections, rating the level of impact, and assessing the probable effect of the impacts. Impacts were rated according to one of five levels. Depending on the probability of occurrence, likely duration, number of people affected, reversibility of the impact, and extent to which many areas of life were affected, changes were rated as follows: 1) no change, 2) slight change, 3) moderate change, 4) substantial change, or, 5) extreme change.

The effect rating was contingent upon the value system of those experiencing the impact and the magnitude, duration, extent, and probability of impact.

Relocations

Four communities at Theodore Roosevelt Lake would be directly affected by relocation: Rockhouse Farm, Roosevelt Lake Estates, Roosevelt Gardens East, and North Bay Estates. A large number of people in each community are part-time residents. The populations of these communities are as follows:

Rockhouse Farm	47
Roosevelt Lake Estates	359
Roosevelt Gardens East	130
North Bay Estates	60

People living at Theodore Roosevelt Lake are geographically divided into two distinct populations: Those living on the east side of Theodore Roosevelt Lake (Globe) and those living on the west side of the Lake (Payson). Residents living on the same side share facilities and participate in the same social events and community projects. Very little social interaction occurs between east- and west-side residents. Rockhouse Farm and Roosevelt Lake Estates are located on the east side, while Roosevelt Gardens and North Bay Estates are on the west side of the lake. Also, three ranches on the east side and ten ranches on the west side would be affected by the plan.

The east-side communities differ from the west-side communities in two important ways. First, the east side is more developed with a more dense population and the neighborhoods are more residential. Second, there are more businesses on the east side that cater primarily to the tourist trade. Lakeview Marina, on the east side near the dam, provides docking and boat services. Roosevelt Lake Resort is also located on the east side. A small gas station is located near the resort, and Spring Creek Store, a large grocery store, is about 1 mile away. In addition to these businesses, one small store is located at Rockhouse Farm.

The communities on the west side are not as developed as those on the east side of Theodore Roosevelt Lake. There are more uncleared lots and more lots without buildings, houses, or trailers. Also, there are fewer businesses.

While each of the four affected communities have unique features, generalizations can be made about all of the Theodore Roosevelt Lake residents. Collectively, their most distinguishing characteristic is their commitment to a rural, independent lifestyle. They relish their isolation and the peacefulness of the rural, desert setting. Residents spend a great deal of time out-of-doors. The area is very scenic and residents have a deep appreciation of nature. The lake is an important feature of the residents' lifestyle and their primary source of recreation.

KA Ranch, located 1 mile south of Horsehoe Dam, would be inundated by Cliff Reservoir. The ranch, in existence since 1887, includes 212 acres of family-owned land used for growing feed and for other ranching operations. Additionally, the family has obtained grazing permits from the U.S. Forest Service to use 36,848 acres of Tonto National Forest land near the ranch. Two people live on the ranch year round.

In addition, five to seven ranch hands reside there part-time. During the summer months, nine additional family members live at the ranch. The nearest services are 20 miles away in Cave Creek.

By comparing the characteristics of the approximate 350 residents that would be relocated with the results of what the literature shows has happened to other relocations, the following impacts are projected:

1. Moderate (temporary) increase in stress levels.

2. Slight increase in physical and mental health problems resulting from increased stress.

3. Substantial decrease in personal autonomy.

4. Moderate reduction in potential for self-sufficiency.

5. Moderate decrease in informal support networks. Slight decrease in informal interactions between households.

6. Moderate decrease in community cohesion and slight decrease in social organization.

7. Substantial decrease in potential for sustained community viability.

The mitigation plan developed to reduce these impacts includes the following provisions and recommendations:

1. Require relocation of only those residents within the 200-year floodpool.

2. Provide U.S. Forest Service land in the Theodore Roosevelt Lake area bordering Roosevelt Lake Estates for relocatees, and allow enough space for neighbors to resettle near each other in similar housing patterns.

3. Monetarily compensate all expenditures and new expenses incurred by residents as a result of their relocation in accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646).

4. Provide an accurate and reliable system for disseminating information to residents so that they are constantly informed about relocation proceedings.

5. Initiate a resettlement plan that ensures the participation of the entire community in all decisions and plans relevant to their relocation.

6. Provide special services to meet the needs of residents during and after relocation, including moving services for the elderly, ill, or disabled, or for those without the transportation to move themselves.

Approximately 90 families would be required to relocate even if no relocations occurred within the flood surcharge area. These are residents who live at elevations below 2,171 feet, near the northern boundary of Roosevelt Lake Estates (closest to the lake). About one-half are part-time residents, many of whom eventually plan to retire in the community. If the mitigation recommendations are followed, residents would be reimbursed for any financial losses resulting from their move. They would be relocated together adjacent to their own community so that friendships and support networks would not be disrupted. They could still retain their preferred lifestyle and remain involved in community activities and would be provided with moving support services. As a result, the impacts of relocation of these 90 families would be significantly reduced and community level impacts would virtually be eliminated since the relocated residents would remain in the community.

Flood Control

The affected area comprises a portion of the metropolitan area of central Arizona which most directly experiences problems associated with flooding along the Salt and Gila Rivers. These communities have experienced flooding three times in the last decade: March 1978, December 1978, and February 1980.

The current population in the 200-year flood inundation area is estimated to be 36,700 persons, which constitutes 2 percent of the 1980 Maricopa County population of 1,508,000. The eastern and western extremities are in a rural, agricultural setting. The central sector contains both residential neighborhoods and mixed residential-industrial-commercial uses.

The communities located in the downstream area that have experienced problems associated with flooding include:

- City of Mesa
- City of Tempe
- City of Phoenix
- Holly Acres Subdivision
- Salt River Pima-Maricopa Indian Community (SRPMIC)
- Gila River Indian Community (GRIC)
- Buckeye area

Mesa, Tempe, and Phoenix are urban areas, while Holly Acres, the Salt River Indian Community, the Gila River Indian Community, and Buckeye are rural areas.

In addition to these seven communities, a number of area-wide systems are located in the Salt River floodplain. These include automobile, air, and rail transportation routes and equipment, public utility lines and towers, telecommunication lines, and business operations.

Major highways in and around the floodplain include Beeline Highway, Maricopa Freeway, and Interstates 10 and 17. In addition, a number of transportation routes connecting Phoenix with its suburbs run directly through the floodplain. There are 29 roads crossing the floodplain, of which 15 are bridge crossings and the remainder are "dip" or surface crossings.

Air and rail facilities bordering the floodplain include Sky Harbor International Airport and the Southern Pacific Railroad yard and accompanying tracks and equipment. Both facilities are located in Phoenix.

Public utilities in or bordering the floodplain include two wastewater treatment plants, two sewage treatment plants, five sewage lines, six water lines, 14 power transmission lines, 12 natural gas lines, 11 telephone lines, and many active landfills.

The types of businesses in the floodplain include light manufacturing, supply houses, scrap yards, sand and gravel mining operations, and wholesale facilities.

Business, public utility, and transportation losses resulting from prior flooding have amounted to several million dollars.

Reducing the 200-year flood to a flow of 92,000 cfs through the Phoenix metropolitan area would have significant beneficial effects. The following are the impacts:

1. Net Disaster Losses - $86,690,000 in residential property damage would be reduced by the year 2000. The majority of directly affected individuals are in low-to-moderate income brackets. Loans and depletion of personal savings for property repairs by a majority of approximately 46,000 individuals would be extremely reduced.

2. Lifestyle Disruption - Lifestyle disruption would be extremely reduced for approximately 46,000 individuals. Elimination of loss of work and school time for these same individuals would be eliminated.

3. Automobile Transportation Disruption - The 14-15 bridge crossings would be maintained and the costs of flood-related damages to bridges and roads would be substantially reduced. Significant transportation disruptions would be eliminated.

4. Air and Rail Transportation Disruption - $7,021,000 in flood-related damage costs and flood-related damages to the airport channel clearing project would be eliminated by the year 2000.

5. Public Utilities - Substantial reduction of damages to electrical transmission towers and power lines would be substantially reduced. Damages to sewage and wastewater treatment plants and active landfills would also be substantially reduced.

6. Communication - Elimination of disruption to delivery service of published material (i.e., mail, newspapers, etc.) would be eliminated and disruption of phone service would be substantially reduced.

7. Business Community - $62,519,000 in damages to the business community would be reduced and revenues lost due to transportation disruptions would be eliminated.

8. Tourism - There would be a substantial reduction in short- and long-term losses (trip cancellations) that have resulted from adverse publicity on flooding in the area.

9. Public Safety - There would be a reduction of approximately $1 million in emergency costs. Elimination of needed aid from outside the Phoenix metropolitan area would be eliminated.

10. Communities Inundated - Residential property damage and breakdowns in informal support networks and community cohesion for approximately 46,000 individuals in 7 communities (Mesa, Tempe, Phoenix, SRPMIC, GRIC, Buckeye, Holly Acres) would be eliminated.

11. Additional Land Use - An additional 3,563 acres valued at $107,311,000 by year 2000 would be available for higher urban uses.

12. Physical and Mental Health - Elimination. The potential for inundation of approximately 46,000 individuals would be eliminated along with a high probability of a large number of flood-related deaths. Potential for physical injury and illness and severe stress would be eliminated for these same individuals. Substantial reduction of potential for disorganized (panic) activity would be reduced substantially.

CHAPTER X

ECONOMIC AND FINANCIAL ANALYSIS

Introduction

This chapter describes the methodology and results of the benefits and cost estimates for Plan 6 along with the data, procedures, and results of the cost allocation and repayment analyses.

Economic Analysis

Benefits and costs were estimated at January 1983 price levels. All values of benefits and costs were annualized over 100 years at 7 3/8 percent. All prices were assumed to remain constant in real terms except for the prices of fossil fuel use in energy production. Agricultural prices were normalized.

Benefits

For ease in display, the benefits were categorized as regulatory storage benefits which include all water-and power-related benefits, flood control benefits, Safety of Dams (SOD) benefits, and recreation and fish and wildlife benefits. The 7 3/8 percent rate was used since this formulation rate was in effect when the Secretary of the Interior selected Plan 6 as the proposed action.

Regulatory Storage. Regulatory storage benefits are the direct benefits accruing to the project from increased water supply as well as from increased project operational flexibility. The water supply benefits were grouped into three categories: Irrigation, Indian, and municipal and industrial (M&I). It should be noted that regulatory storage would provide the opportunity to increase both project water supply and power benefits and would also confront the operator with the tradeoff between maximizing either of these benefits. The analysis assumed the water supply would take precedence over power management in operating regulatory storage.

With regard to power management, it appears likely that given regulatory storage, water interests would be willing to make a firm commitment to the utilities for project power during summer peak periods. To date, however, no contractual power commitments have been made. Consequently, no capacity benefits were claimed.

Flood Control. The economic benefits for flood control were calculated for two categories: Inundation reduction and location benefits. When final flood control benefits from the Corps of Engineers are received, they will be incorporated in the economic analysis.

Safety of Dams. The plan incorporates modification of Theodore Roosevelt Dam and construction of a new dam at the Cliff site to assure the safety of the existing Salt River Project (SRP) dams during an inflow design flood (IDF). With each plan, the dam safety benefits were assumed to be equal to the avoided costs of the least cost Safety of Dams (SOD) solution.

Costs

Construction costs for the plan are described in Chapter IV. They are:

New Waddell Dam	$ 417,600,000
Cliff Dam	346,200,000
Modified Roosevelt Dam	231,500,000
Modified Stewart Mountain Dam	40,200,000
TOTAL	1,035,500,000

The interest during construction (IDC) calculated for Plan 6 was complicated by the fact that the plan is multipurpose and multistructural. The total construction period extends over 14 years.

Minor costs would be associated with the loss of existing stream-related recreation at the project sites. These costs would be offset by a gain in stream miles at Horseshoe Reservoir which would be breached as part of the proposed action. Since there would be a net gain in station-oriented recreation and since use in these areas is minor, neither the costs nor the benefits were estimated in monetary terms.

Water quality changes were investigated and determined to be monetarily insignificant. Operation, maintenance, and replacement (OM&R) costs were also calculated for the plan. The annual benefits and costs are summarized on Table 22. The net benefits are $22,700,000.

Financial Analysis

The cost allocation and repayment analyses are at the appraisal level and subject to change as more refined estimates of costs are made. The procedures used are subject to legal and policy interpretations and subject to future change. As a result, any conclusions drawn from the results of the analyses presented here should be properly qualified with regard to the nature of the data and assumptions used.

Methodological Overview

The primary purpose of the financial analysis was to equitably allocate costs among the various functions served (e.g. water supply, flood control, recreation, etc.) and establish the basis for the repayment of those costs that would be reimbursable. The financial analysis for this study was somewhat unique. The alternative plans were developed to satisfy the needs of both CAP regulatory storage and SOD. This was unique because the two functions, CAP and SOD, were authorized under different Congressional

TABLE 22

Summary of Benefits and Costs

(7 3/8 Percent)

Benefits	
Regulatory Storage	
Power Management	34,800,000
Water Supply	13,400,000
Irrigation	(11,200,000)
Indian	(500,000)
Municipal & Industrial	(1,700,000)
Flood Control	27,500,000
Inundation Reduction	(11,000,000)
Location	(16,500,000)
Safety of Dams	44,400,000
Construction	(34,400,000)
Interest During Construction	(10,000,000)
Recreation	7,300,000
Total Benefits	127,400,000
Costs	
Construction Cost	76,400,000
Interest During Construction	22,300,000
Operation, Maintenance, & Replacement	6,000,000
Total Cost	104,700,000
Net Benefits	22,700,000

authorities and have different cost sharing and repayment rules. The analysis was further complicated by the fact that regulatory storage is only a small part of the total CAP and must be financially integrated with the total CAP to determine the allocation and repayment impacts of regulatory storage.

In an attempt to simplify the study, the financial analysis was separated into two parts. The first part developed a basic allocation of the costs for each plan between regulatory storage and SOD. The second part financially integrated those costs allocated to regulatory storage into the larger CAP cost allocation and repayment analysis.

Both parts of the allocation utilized the Separable Cost Remaining Benefit (SCRB) method of allocation. SCRB is the standard method used to allocate the costs of federally-funded multipurpose water projects and is prescribed as the most acceptable allocation method by both the Water Resources Council's "Principles and Guidelines" and Reclamation Instructions (Series 110, Part 116).

Basically, the SCRB method allocates costs by directly assigning costs that are separable to each function and proportioning the remaining joint costs among the various functions roughly in proportion to the benefits received. A more detailed overview of these procedures is provided in Appendix E.

Repayment of the CAP would primarly be the responsibility of Central Arizona Water Conservation District (CAWCD). CAWCD encompasses the entire three-county area served by the CAP and has broad authority to levy taxes and collect revenues from the sale of project water for the purpose of repaying project costs. Revenues from the sale of excess energy from Navajo Powerplant and Arizona's portion of the revenues credited to the Lower Colorado River Basin Development Fund from Boulder Canyon and Parker-Davis Projects would also be available to assist the project repayment. The following presents the repayment analysis for regulatory storage costs only. The repayment of the regulatory storage costs were evaluated with regard to repayment of the CAP as a whole which is repaid in accordance with Reclamation law and contractual agreements between the United States and CAWCD.

Allocation of Costs Between CAP and Safety of Dams

Based on the benefits and costs presented below in Tables 23 and 24, an allocation of costs between the regulatory storage and SOD functions was completed using the SCRB procedure. A short summary of the data and results of that analysis is provided in the following tables. Table 25 summarizes the CAP/SOD allocation for Plan 6.

As shown, the $1035.3 million total construction cost would have $782.3 million allocated to CAP and $253.0 million allocated to SOD. In a similar manner, the IDC of $124.4 million would have $94.1 million allocated to regulatory storage and $30.4 million to SOD. Because O&M would be a separable cost serving CAP functions only, the O&M cost would be allocated entirely to CAP. The result would be a total project cost of $1,335.4 million (including IDC and capitalized OM&R) which would have $1052.1 million allocated to regulatory storage and $283.3 million allocated to SOD.

TABLE 23

Summary of Costs by Feature
(Unit: $ Million)

	Cost
Cliff Dam	346.2
Modified Roosevelt Dam	231.5
Modified Stewart Mountain Dam	40.2
New Waddell Dam	417.6
Total Construction Cost	1035.5
Interest During Construction	124.4
TOTAL COST	1159.9
Annual Operation, Maintenance, & Replacement[1/]	6.0
Capitalized Operation, Maintenance, & Replacement @ 3 1/4%	175.7

1/ Includes Project Pumping

TABLE 24

Summary of CAP/Safety of Dams Benefits by Function
(Unit: $ Million)

Function	Cost
Irrigation	284.0
Indian Irrigation	50.5
Municipal & Industrial Water Supply	102.7
Flood Control	574.0
Power	1240.5
Recreation	214.7
Total CAP Benefits	2466.4
Total Safety of Dams Benefits	521.7
Total Benefits	2988.1

TABLE 25

Regulatory Storage/Safety of Dams Allocation
(Unit: $ Million)

	Regulatory Storage	Safety of Dams	Total
Total Cost			
Construction			1035.3
Interest During Construction (IDC)			124.4
Operation, Maintenance, & Replacement (OM&R)			175.7
OM&R (Annual)			6.0
Total			1335.4
Benefits	2466.4	521.7	2988.1
Single-Purpose Cost	1290.4	521.7	1812.1
Justifiable Expenditure	1290.4	521.7	1812.1
Multipurpose Without	512.7	1290.4	
Multipurpose Without IDC	55.9	119.5	
Separable Cost			
Construction	569.6	40.2	609.8
IDC	68.4	4.8	73.2
OM&R	175.7	0.0	175.7
Total	813.7	45.0	858.7
Remaining Justifiable	476.7	476.7	953.4
Allocation Factors	.5	.5	1.0
Remaining Joint Cost			
Construction	212.8	212.8	425.6
IDC	25.6	25.6	51.2
OM&R	0.0	0.0	0.0
Total	238.4	238.4	476.8
Total Allocated Cost			
Construction	782.3	253.0	1035.3
IDC	94.1	30.3	124.4
OM&R	175.7		175.7
Total	1052.1	283.3	1335.4

NOTE: Costs and benefits are calculated at 3 1/4% interest. After review of the designs and estimates, the cost of Modified Roosevelt Dam was increased $198,000. Half of these costs ($99,000) would be allocated to Safety of Dams and half to Regulatory Storage. Interest during construction would increase proportionately.

Financial Integration of Regulatory Storage with CAP

This section describes how the allocated regulatory storage costs would be financially integrated into the total cost allocation and repayment analysis for the CAP.

The approach used in the financial integration first developed a baseline CAP allocation that did not include any regulatory storage features. This allocation, in essence, represented the "No Action" alternative. The baseline allocation then served as the basis for comparison with the new allocation which added the allocated regulatory storage costs and benefits. Comparisons then showed the impacts the plan had on reimbursable and non-reimbursable CAP costs and CAWCD's total repayment obligation.

Because of the complexity of the CAP allocations, the financial integration incorporated four stages.

Stage I was the preallocation of the Navajo Powerplant. These results are summarized in Table 26.

TABLE 26

Comparison of Preallocation of Navajo
Construction Costs With and Without Regulatory Storage

Plan	Irrigation (Mil. $)	M&I (Mil. $)	Power (Mil. $)	Total (Mil. $)
Baseline	70.2	38.3	51.0	159.5
Regulatory Storage	64.0	29.8	55.1	148.9

Table 26 shows a significant change from baseline analysis in the preallocation of Navajo. Total costs, as well as costs allocated to each function except power, are less than the baseline analysis. There are two reasons for this. The first relates to the adjustment made in the preallocation factors for the baseline analysis. The costs preallocated to the irrigation and M&I functions were reduced due to the change in factors which accounts for the decreased allocation to those functions. The power allocation increased since the power factor was not decreased like the other two factors.

Stage II was the SCRB allocation of CAP construction costs. The comparison with and without regulatory storage allocations is displayed on Table 27.

In general, Table 27 shows that most of the plan costs would be allocated to the irrigation, M&I, and flood control functions. Although the other functions would be affected, they would not be changed as substantially as the flood control and irrigation functions. The recreation allocation increase is due to the large proportional increase in benefits expected from regulatory storage. The fact that the power function would be the other primary

TABLE 27

Summary of SCRB Allocation of CAP Construction Costs
With and Without Regulatory Storage[1/]
($ Million)

Plan	Irrigation	Power	M&I	Fish & Wildlife	Recreation	Flood Control	Total
Baseline	1,082.6	51.0	663.8	41.0	9.1	75.3	1,922.8
Regulatory Storage	1,434.2	55.1	673.5	37.3	90.4	404.1	2,694.6

1/ Does not include Interest During Construction

Beneficiary and substantial additional costs would not be allocated to that function because of Navajo's preallocation is based on a "use of facilities" allocation instead of a SCRB analysis.

Table 28 provides a detailed comparison of the allocation of Plan 6 costs among the various functions. The costs were derived by subtracting the total allocation of CAP costs of the baseline analysis from the total allocated CAP costs with regulatory storage financially integrated.

TABLE 28

Summary of SCRB Allocation of Regulatory Storage
Construction Costs [1/]
($ Million)

Irrigation	Power	M&I	Fish & Wildlife	Recreation	Flood Control	Total[2/]
351.6	4.1	9.7	-3.7	81.3	328.8	771.8

1/ Does not include Interest During Construction

2/ Total cost is less than the multipurpose allocated cost by the amount of power layoff revenues, $10,500,000.

The allocation to the M&I function would slightly increase with regulatory storage. This would occur because the increase in flood control benefits would cause an increase in the joint costs allocated to flood control, resulting in a minor increase in joint costs allocated to M&I.

Stage III was the determination of CAWCD's repayment obligation. Table 29 provides a summary of CAWCD's total CAP repayment obligation after the financial integration of regulatory storage.

TABLE 29

Comparison of CAWCD Total CAP Repayment
With and Without Regulatory Storage
($ Million)

Plan	Irrigation 1/	M&I 2/	Power 2/	Total
Baseline	747.8	610.3	54.0	1,412.1
With Regulatory Storage	1019.5	649.0	58.2	1,726.7

1/ Does not include Interest During Construction (IDC)

2/ Includes IDC

The integration of regulatory storage plans with the rest of CAP would increase the CAWCD's repayment obligation by $314.6 million. For all practical purposes, the increased costs were allocated to irrigation.

The repayment analysis was performed during Stage IV of the financial integration. Table 30 summarizes the results of the repayment analysis. The numbers shown summarize the total revenues that would be received over the project's entire repayment period from each of the various revenue sources.

TABLE 30

Comparison of Total CAP Repayment
Revenues for Regulatory Storage
($ Million)

Plan	Irrigation Revenues	M&I Revenues	Ad Valorem Taxes	Power Revenues	Total Revenues
Baseline	48.5	551.9	574.4	801.1	1,975.9
With Regulatory Storage	61.2	563.6	454.5	1,206.3	2,285.6

The point of most significance in Table 30 is the increase in power revenues that would be obtained with regulatory storage. Total power revenues would be increased by approximately $405 million over the repayment period. The power revenues would more than offset the additional regulatory storage costs, and reduce the revenue requirements from other sources. Table 31 displays the construction cost allocation changes between the project under baseline conditions and the project with regulatory storage.

TABLE 31

Changes in Construction Cost Allocation from
Baseline to Regulatory Storage
($ Million)

SOD	Power	Indian Irrigation	Non-Indian Irrigation	M&I	Flood Control	Fish & Wildlife	Recreation	Total[1/]
253.0	4.1	37.7	271.7	52.1	328.8	-3.7	81.3	1025.0

1/ Sum of total cost changes from regulatory storage do not sum to the total cost of the proposed action since $10.15 million less is added to total costs to be allocated due to retirement of Navajo costs during the layoff period and rounding differences.

CHAPTER XI

PLAN FORMULATION

Introduction

Identifying and addressing problems and issues assured that the concerns of the public were addressed throughout plan development, evaluation, and selection. As discussed in Chapter II, the problems, needs, and issues centered around flood control, water supply, dam safety, and related environmental and socioeconomic factors.

In order to develop plans that met the problems and needs, the Bureau initiated the Central Arizona Water Control Study (CAWCS). Through a Memorandum of Understanding, the U.S. Army Corps of Engineers assisted the Bureau in the flood control planning and analysis. The Reclamation Safety of Dams Act of 1978 authorized the Bureau to assess the safety of six Salt and Verde River dams. Since the corrective measures identified on these structures closely interrelated with the flood control and water storage objectives of the CAWCS, dam safety was added as a CAWCS objectives. In November 1981, during the third stage of a three-stage planning process during which a wide array of possible solutions were developed and analyzed, the Secretary of the Interior selected Plan 6 as the agency proposed action. As discussed in Chapter III, the plan calls for the construction of New Waddell Dam, Cliff Dam, Modified Roosevelt Dam, and Modified Stewart Mountain Dam. In April 1983, the Bureau filed the draft Regulatory Storage Division Environmental Impact Statement with the Environmental Protection Agency. Along with the proposed action, the draft displayed four alternative solutions and a "No Action" plan. As a result of public comments on the draft, another plan was added. This plan did not include Cliff Dam but instead proposed modifying Bartlett and Horseshoe Dams to solve Verde River dam safety problems.

Public Involvement Program

Due to public concerns over Orme Dam and the flooding problems in the area, a very high level of public interest in the study existed. It was essential that the studies be conducted with extreme political sensitivity and with a visibility and openness which would lend credibility to the final conclusions. Public involvement (PI), therefore, was absolutely crucial to this study.

Various types of activities and techniques were utilized to meet the objectives of the PI Program. They included formation of technical or appointed groups, interest groups, workshops, community meetings, and other activities such as brochures, newsletters, press and media coverage. Prior to each stage of the study, the PI techniques used during the previous stage were evaluated and public involvement plans for the next stage were formulated. A complete description of the techniques employed throughout the study are documented in Appendix E.

The major thrust of the Stage I Public Involvement Program was to establish a highly visible program in the community. Activities were geared toward obtaining information useful in directing the study and included identifying problems, issues, and alternatives; getting to know the leaders of the various interest groups; and establishing media contacts. Arizona Governor Babbitt established a Governor's Advisory Committee and the Bureau formed a Technical Agency Group. Public meetings were held to discuss issues, alternatives, the planning process, and schedule. These meetings provided valuable information on issues that warranted consideration during the study. Media coverage, which was substantial during the first stage of the study, included coverage of the public meetings, participation by Bureau personnel in radio call-in shows, and newspaper supplements that addressed the flooding issue and possible actions the Bureau could take to resolve those issues.

During Stage II, as the planning focus shifted from problem identification to plan formulation and detailed analyses of alternatives, the emphasis of the PI shifted to increased participation by the public in evaluation and selection of alternatives. Stage II activities were therefore designed to fully integrate the PI Program with the planning process. A project office and hotline were established, a monthly newsletter and mailing list were developed, and a process for storing public comments and media coverage was initiated. Major activities included public workshops and community meetings at key points in the study and special meetings with communities that could be affected by the alternatives.

The PI Program for Stage III emphasized involvement of the public in formulation, development, and evaluation of the plans. Monthly newsletters and presentations continued while Congressional briefings and tours for the media kept key publics abreast of study progress. In October 1981, the CAWCS Factbook was published. This report explained how the alternatives were developed and provided a description and comparison of the impacts and effects of each alternative. Public meetings were used to obtain public reaction to the information displayed in the Factbook. Then, in November 1981, the agency proposed action was selected by former Secretary of the Interior James Watt. As the study focus next shifted to refining plans, the PI effort continued in the form of newsletters, special briefings, and Technical Agency Group meetings.

In April 1983, the Regulatory Storage Division Draft Environmental Impact Statement was filed and public hearings were conducted to receive comments on its adequacy. In February 1984, the Final EIS was filed with the EPA. It identifies Plan 6 as the agency proposed action.

Plan Selection

The CAWCS followed a three-stage plan formulation process. While the basic tasks within each stage were similar, the level of detail and reliability of the data and analyses increased with each stage (See Figure 18).

CAWCS PLANNING PROCESS

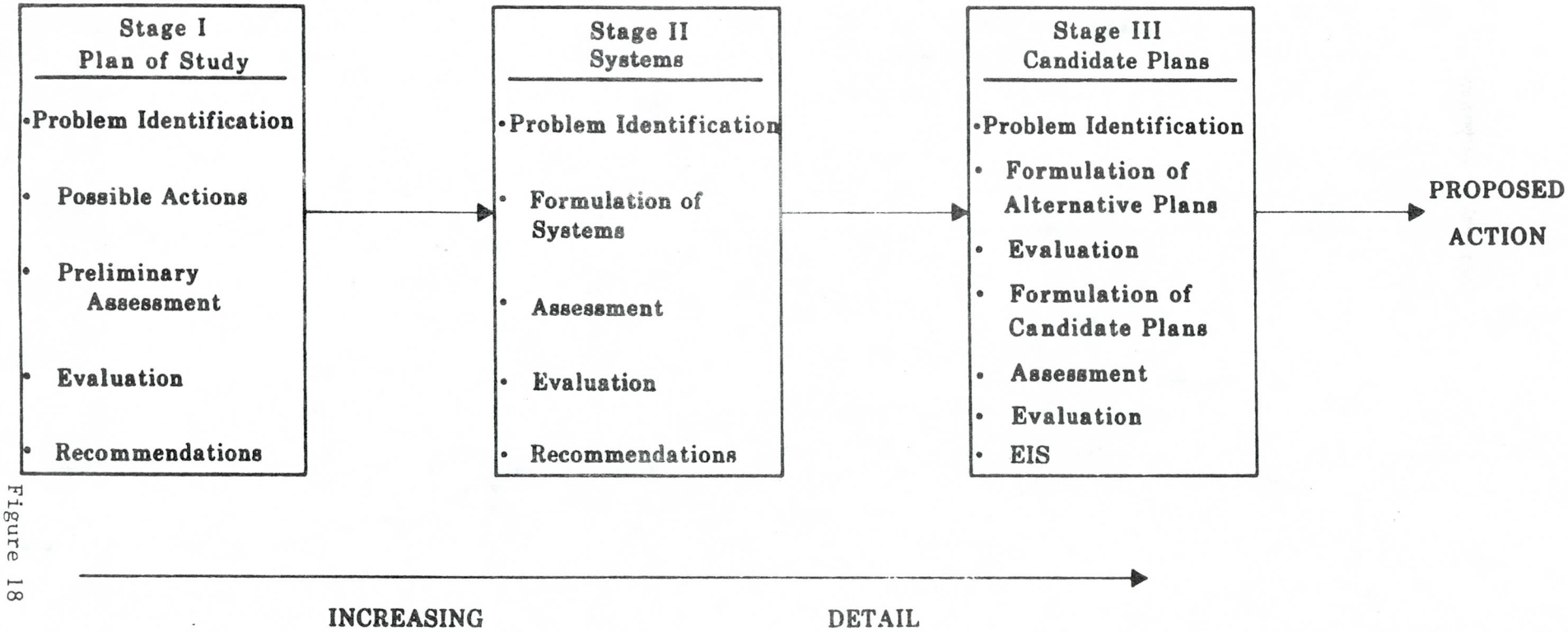


Figure 18

Stage I was exploratory in nature. Problems, needs, and issues were identified and a wide array of possible solutions were developed that, singly or in combination, could provide flood control and/or regulatory storage. Recommendations made by the Bureau and the Corps of Engineers were based on site suitability (geology), location, and economics. At the end of Stage I, a Plan of Study documented the alternatives warranting further study and outlined a management program for the remainder of the study.

During Stage II, the planning focus shifted from problem identification to formulation and testing of alternative solutions. The elements from Stage I were screened and the best of the "competing" elements were identified for further study. In order to optimize the ability to provide both flood control and regulatory storage, single-purpose and multipurpose systems were developed. Recommendations were based on operations (performance), optimization, economics, environmental and social impacts, and institutional factors.

In Stage III, with the development of specific plans, the focus of the planning effort shifted from alternative formulation (although alternatives were continually being modified) to thorough impact assessment and evaluation. These studies provided the basis for development of 8 candidate plans and selection of the proposed action. These plans included Stewart Mountain Dam even though its objective was single-purpose because repairs were complex and there existed potential for significant environmental impacts.

After the plans were formulated and technical studies completed, a process for systematic comparison of plans was developed, trade-off meetings were conducted, and the agency proposed action was identified. At the time of the decision it was recognized that more planning and studies were needed prior to implementation, and an approach for addressing these issues was developed. Appendix E provides a detailed description of the issues and the process used to refine the agency proposed action.

Alternatives to the Proposed Action

The project plan (Plan 6) presented in the previous chapters is the result of extensive plan formulation studies. Of the eight plans developed and studied in detail during Stage III, 6 plans were carried forward and displayed in the draft EIS. Another alternative, Plan 9, which was studied and eliminated during Stage II, was reintroduced as a result of comments received on the draft EIS. Many people expressed concern that each alternative plan in the draft included Cliff Dam and Reservoir. In response to this Plan 9, an alternative not including Cliff Dam, was evaluated and displayed in the Final EIS. Table 32 describes the physical facilities of the proposed action and the seven alternative plans, including Plan 9. The following section briefly describes these plans and more detailed information is provided in Appendix E.

Plan 8, "No Action". The "No-Action" plan provided the baseline against which all other plans were compared. Under Plan 8, CAP would be constructed, but no CAP regulatory storage or flood control would be provided.

TABLE 32

Description of Plans
Displayed in Final EIS

Plan 1:	Cliff + Modified Roosevelt + Modified Stewart Mountain
Plan 2:	Cliff + Modified Roosevelt + Modified Stewart Mountain + Nonstructural
Plan 3:	Confluence + Cliff + Modified Roosevelt + Modified Stewart Mountain
Plan 6:	New Waddell + Cliff + Modified Roosevelt + Modified Stewart Mountain
Plan 7:	New Waddell + Cliff + Modified Roosevelt + Modified Stewart Mountain (environmental emphasis)
Plan 8:	No CAWCS project; safety of dams studies continue to select a preferred dam safety solution
Plan 9:	New Waddell + Modified Roosevelt + Modified Stewart Mountain + Verde River Dams Modifications

However, Safety of Dams (SOD) studies would continue toward selection of a preferred SOD solution. Such a solution may differ from the Cliff and New/Modified Roosevelt combination in the alternative plans.

Plan 1, Cliff + New/Modified Roosevelt + Stewart Mountain Dams. This plan consists of constructing Cliff Dam on the Verde River and New/Modified Roosevelt Dam on the Salt River to provide flood control, additional water conservation, hydropower, recreation, and dam safety and New/Modified Stewart Mountain Dam on the Salt River for dam safety purposes. The general location of these structures is shown on Figure 19. The projected average annual water yield would be 107,000 acre-feet. Sufficient flood control space would be provided to control the 200-year event (275,000 cfs) to a flow of 92,000 cfs measured at Sky Harbor International Airport, and the 100-year event (215,000 cfs) to 55,00 cfs at the same point. The hydrologic safety problems at the existing Salt and Verde River dams within the Salt River Project (SRP) system would be corrected. Water supply, hydropower capacity, and recreation facilities at the existing Theodore Roosevelt and Stewart Mountain Dams would be maintained or replaced.

Plan 2, Cliff + New/Modified Roosevelt + Stewart Mountain Dams + Nonstructural Measures. This plan limits construction to that necessary for dam safety purposes. The plan consists of construction of Cliff Dam on the Verde River, New/Modified Roosevelt Dam on the Salt River, and Stewart Mountain Dam on the Salt River for dam safety purposes, and nonstructural flood damage reduction measures downstream. The general location of these structures is shown on Figure 20. The plan would provide no new conservation space for CAP, but through dual use of the sediment space at New/Modified Roosevelt Dam over the life of the project the CAP yield could be increased by 16,000 acre-feet per year. Incidental flood control provided by the use of the surcharge space at Cliff and New/Modified Roosevelt Dams (no dedicated flood control space) would reduce the 200-year flood to 157,000 cfs measured at Sky Harbor International Airport, and the 100-year flood to 150,000 cfs at the same point. Because of this lower level of flood control, nonstructural flood damage reduction measures may be required downstream. These measures, however, would be local actions implemented with local funds. The hydrologic safety problems at the existing Salt and Verde River dams within the SRP system would be alleviated.

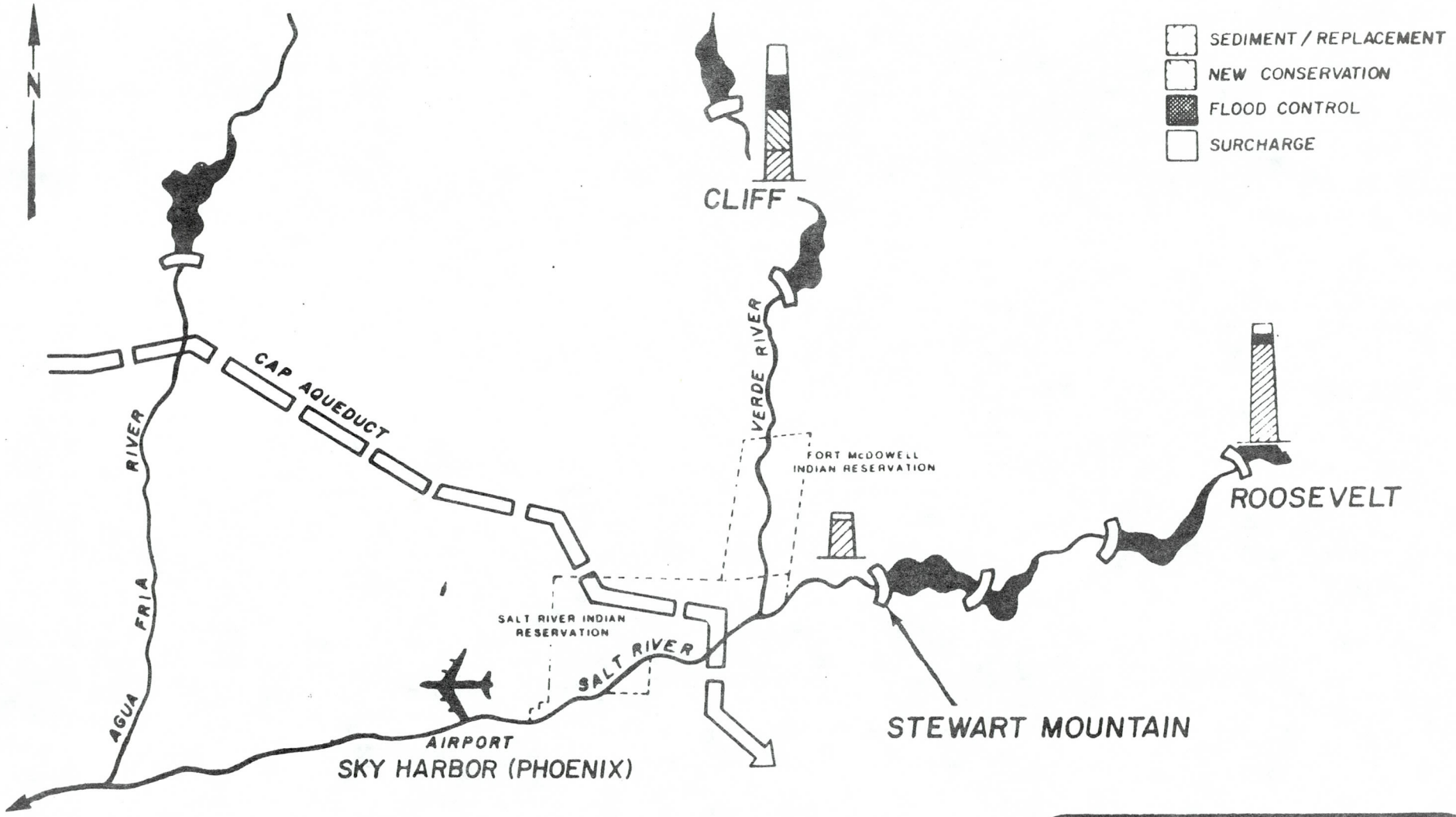
Plan 3, Confluence + Cliff + New/Modified Roosevelt + Stewart Mountain Dams. In Plan 3, Cliff Dam on the Verde River and Theodore Roosevelt Dam on the Salt River would be constructed for flood control, additional water conservation, hydropower, and SOD. Confluence Dam would be constructed at the confluence of the Salt and Verde Rivers to provide CAP regulatory storage. Stewart Mountain Dam would be constructed on the Salt River for SOD only. The general location of the structures is shown on Figure 21. This plan would provide 330,000 acre-feet of regulatory storage space in the Confluence Reservoir, 170,000 acre-feet of new CAP conservation space in Cliff Reservoir, and could use one-half of the sediment pool at Theodore Roosevelt Lake to increase CAP yield by 163,000 acre-feet per year. Sufficient flood control space would be provided at Cliff and New/Modified Roosevelt to control the 200-year flood to between 70,000 and 92,000 cfs at Sky Harbor

International Airport, and the 100-year flood to 50,000 cfs at the same point; routing floodwaters through the Confluence Reservoir may provide some additional reduction in flows compared to the other plans. The plan would provide potential for additional hydropower and recreation.

Plan 6 (Agency Proposed Action), New Waddell + Cliff + New/Modified Roosevelt + Stewart Mountain Dams. Cliff Dam on the Verde River and New/Modified Roosevelt Dam on the Salt River would be constructed for flood control, additional water conservation, and SOD. New Waddell Dam on the Agua Fria River would be constructed for regulatory storage purposes and would provide incidental flood control. Stewart Mountain Dam on the Salt River would be replaced or modified for SOD only. The general location of the structures is shown in Figure 22. This plan would provide 660,000 acre-feet of regulatory storage space at New Waddell Reservoir, 170,000 acre-feet of new conservation space at Cliff Reservoir, and would use one-half of the sediment pool at Theodore Roosevelt Lake to increase the CAP yield by 137,600 acre-feet per year. Sufficient flood control space would be provided to control the 200-year Salt/Verde flood event to a flow of 92,000 cfs at Sky Harbor International Airport, and the 100-year flood event to 55,000 cfs at the same point. This plan would also alleviate the hydrologic safety problems at the Salt and Verde River dams within the SRP system, and would provide the potential for additional hydropower and recreation. Cliff, New/Modified Roosevelt, and Stewart Mountain Dams would be as described in Plan 1. Water storage capacity and recreation facilities at the existing Waddell Dam would be replaced at the new reservoir.

Plan 7, New Waddell + Cliff + New/Modified Roosevelt + Stewart Mountain Dams. This plan is the same as Plan 6 except water would be made available to maintain minimum flows (enough water to sustain fish populations) in the Salt River between Stewart Mountain and Granite Reef Diversion Dams and in the Verde River below Bartlett Dam. Also, water would be made available to provide the potential for recreation and fish and wildlife enhancement on the Salt River through the Phoenix area by providing approximately 30,000 acre-feet of water for the proposed Rio Salado development. The method of delivery of this Rio Salado water from the CAP system is yet to be determined. The CAP water supply would be increased by 114,000 acre-feet per year. This plan provides for a minimum pool at Cliff Reservoir as well as at New Waddell Reservoir for fish and wildlife enhancement and recreation purposes.

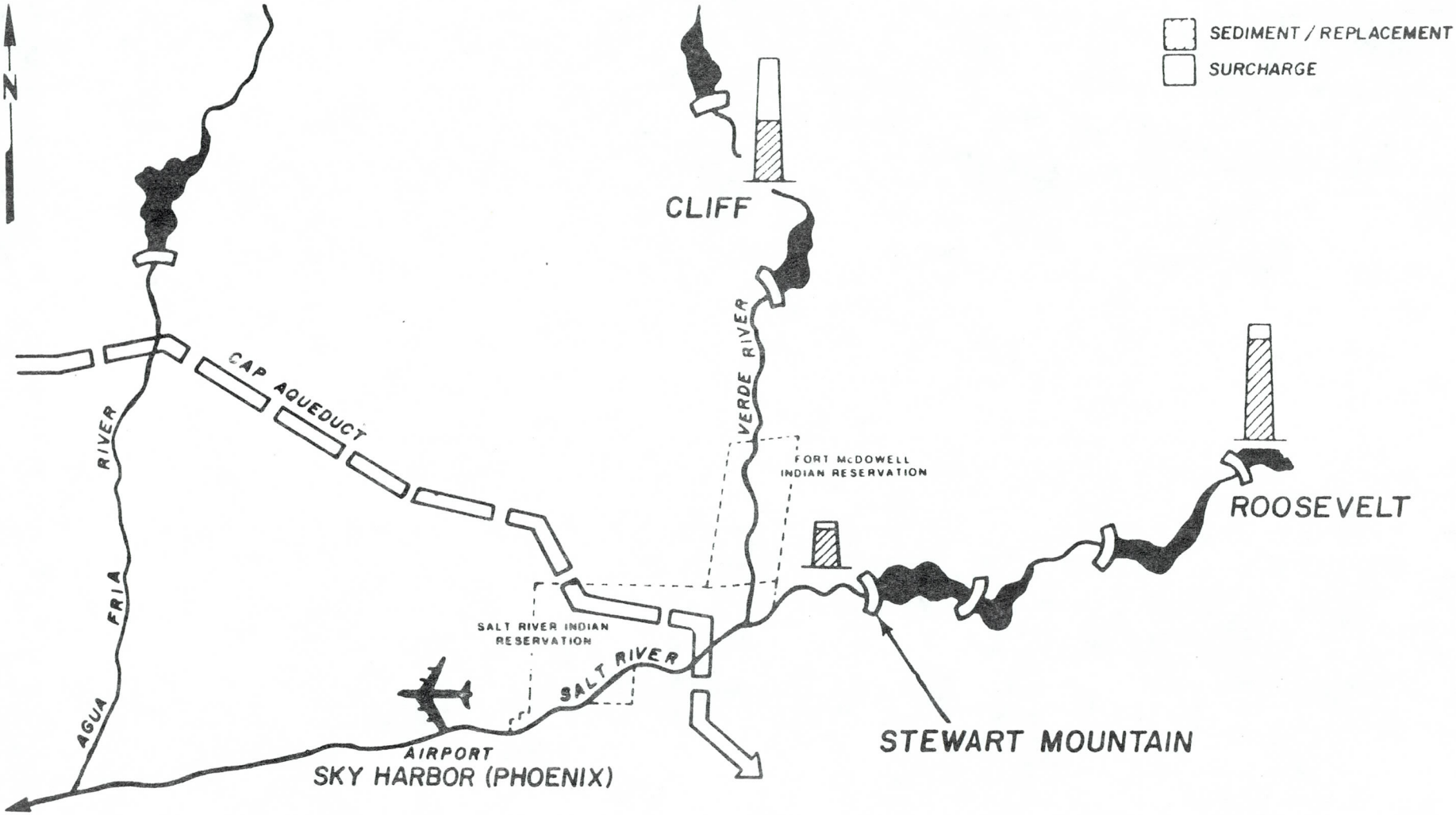
Plan 9, New Waddell + Modified Roosevelt + Modified Stewart Mountain Dams + Verde River Dams Modifications. This plan would consist of constructing New Waddell Dam on the Agua Fria River for regulatory storage purposes. Theodore Roosevelt Dam on the Salt River, would be modified for flood control, additional water conservation, and SOD purposes. Stewart Mountain Dam on the Salt River would be modified for SOD only. Bartlett Dam on the Verde River would be raised 27 feet and an auxiliary spillway would be added for SOD purposes. A spillway would also be added to Horseshoe Dam on the Verde River for SOD purposes. The general location of the structures is shown on Figure 23. This plan would provide 660,000 acre-feet of regulatory storage space at New Waddell Reservoir and would use one-half of the sediment space



CAP YIELD	107,000 af/yr
FLOOD CONTROL	
200-YEAR at AIRPORT	92,000 cfs
100-YEAR at AIRPORT	55,000 cfs

Figure 19

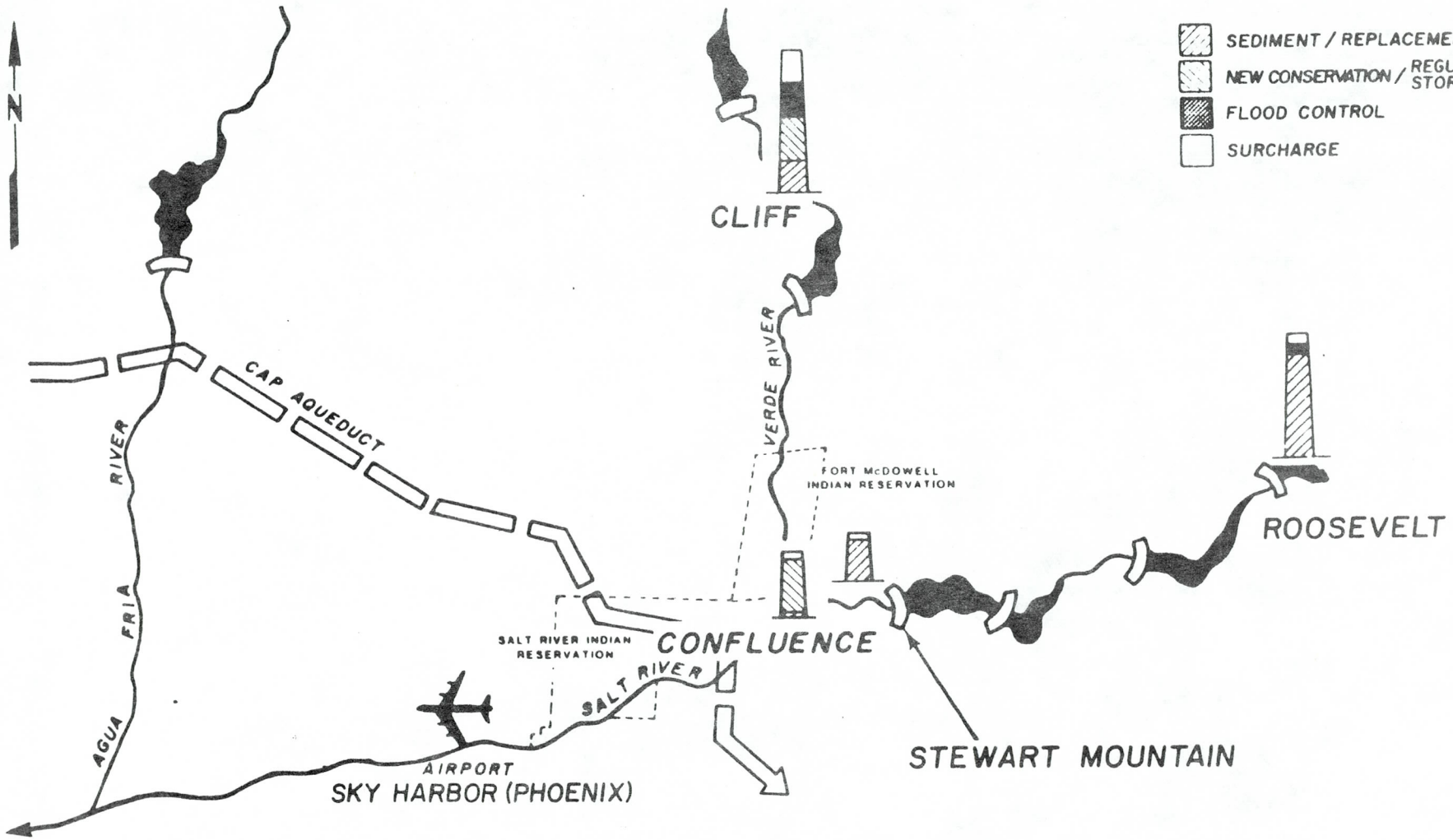
PLAN 1
CLIFF + ROOSEVELT +
STEWART MOUNTAIN DAM



CAP YIELD	16,000 af/yr
FLOOD CONTROL	
200-YEAR at AIRPORT	157,000 cfs
100-YEAR at AIRPORT	150,000 cfs

Figure 20

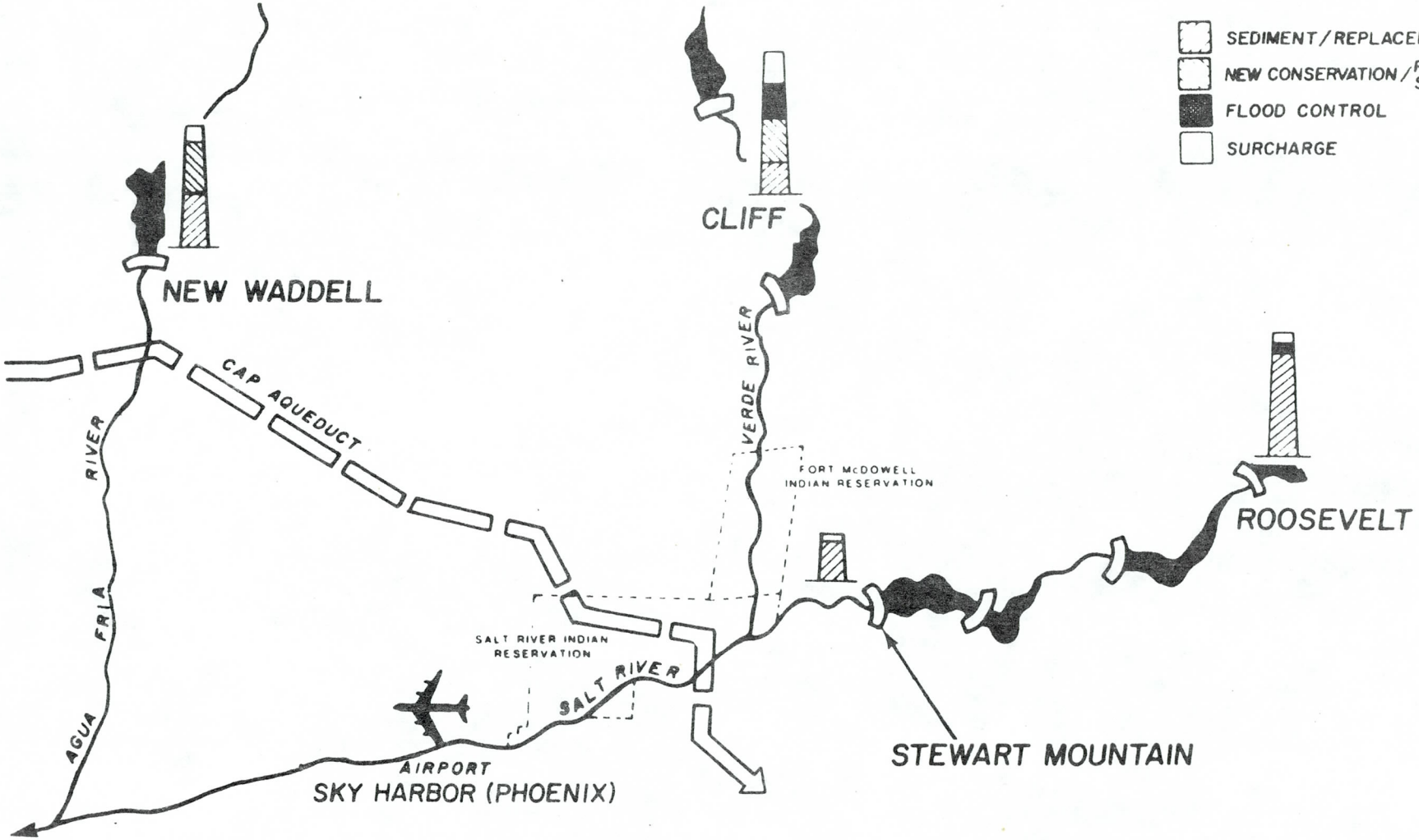
PLAN 2
CLIFF + ROOSEVELT +
STEWART MOUNTAIN +
NONSTRUCTURAL



CAP YIELD	163,000 af/yr
FLOOD CONTROL	
200-YEAR at AIRPORT	80,000 cfs
100-YEAR at AIRPORT	50,000 cfs

Figure 21

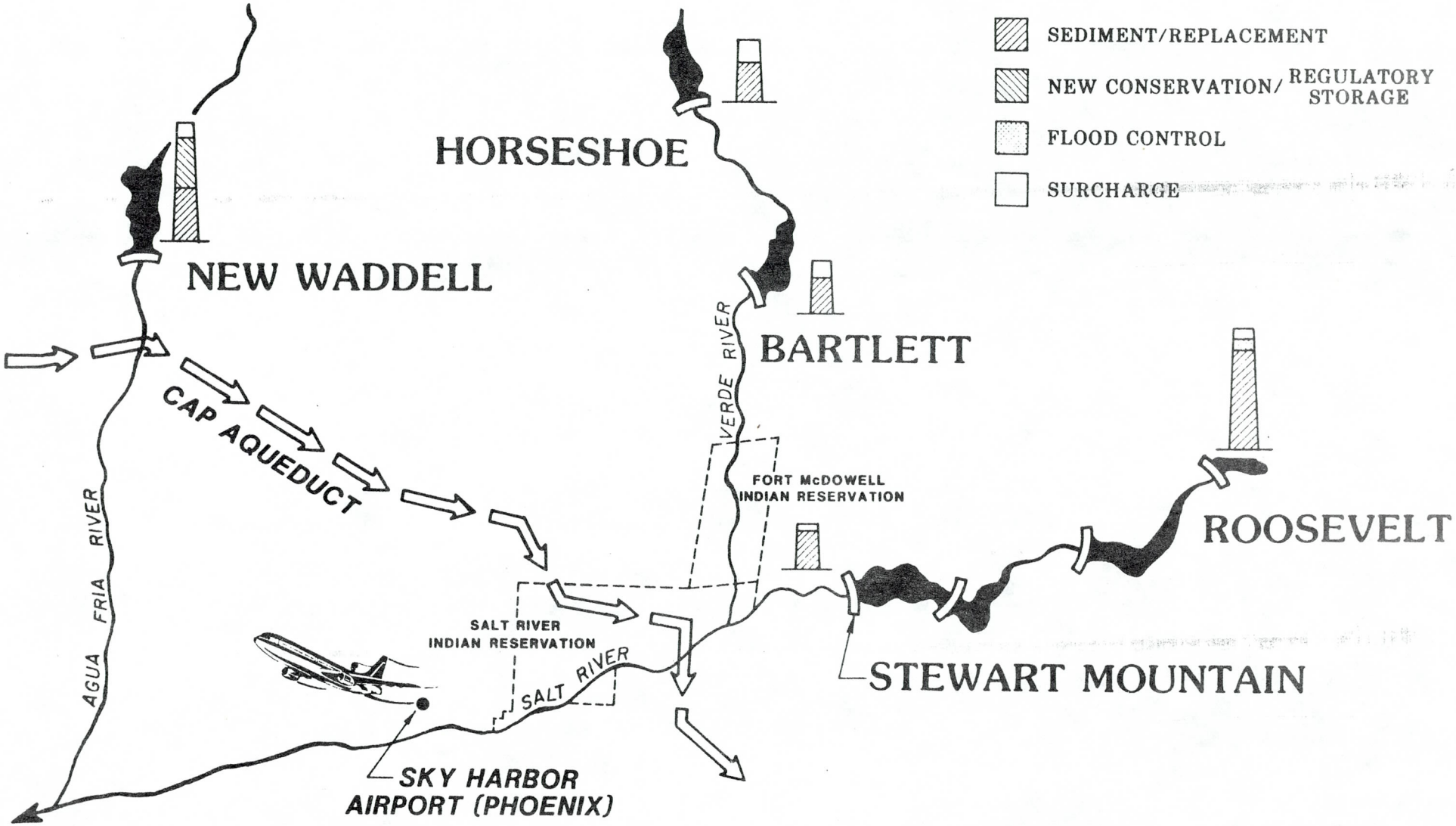
PLAN 3
CONFLUENCE + CLIFF +
ROOSEVELT +
STEWART MOUNTAIN DAM



CAP YIELD	137,600 af/yr
FLOOD CONTROL	
200-YEAR at AIRPORT	92,000 cfs
100-YEAR at AIRPORT	55,000 cfs

Figure 22

PLAN 6
NEW WADDELL + CLIFF +
ROOSEVELT +
STEWART MOUNTAIN DAM



CAP YIELD	115,500 af/yr
FLOOD CONTROL	
200-YEAR at AIRPORT	215,000 cfs
100-YEAR at AIRPORT	170,000 cfs

PLAN 9
NEW WADDELL + ROOSEVELT + STEWART MOUNTAIN DAM + VERDE RIVER DAMS MODIFICATIONS

Figure 23

at Theodore Roosevelt Lake to increase the CAP yield by 115,000 acre-feet. Modified Roosevelt Dam would have sufficient flood control space available to control the 200-year Salt/Verde River flood event to a flow of 215,000 cfs at Sky Harbor International Airport, and the 100-year flood event to 170,000 cfs at the same point. This plan would also alleviate the hydrologic safety problems at the existing Salt and Verde River dams within the SRP system and would provide the potential for additional hydropower and recreation.