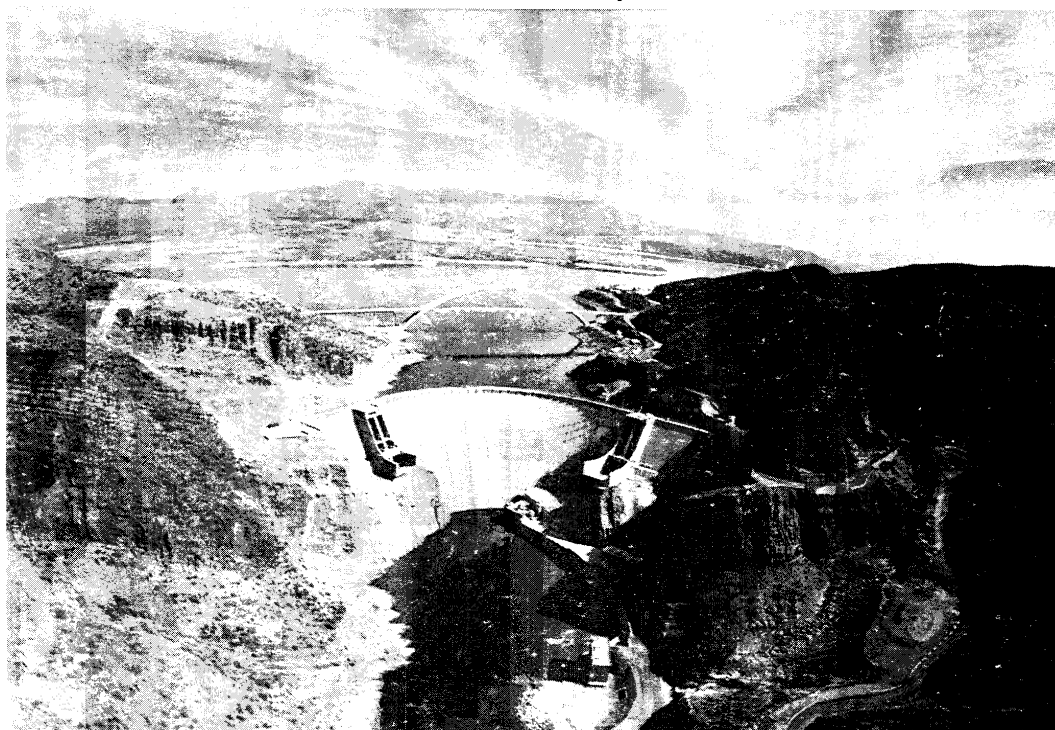


US Army Corps of Engineers  
Los Angeles District

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# WATER CONTROL MANUAL

## MODIFIED ROOSEVELT DAM (Theodore Roosevelt Dam) SALT AND GILA RIVERS, ARIZONA



SEPTEMBER 1997

**Modified Roosevelt Dam  
Pertinent Data Sheet**

Original Construction .....	1905-1911
Modified Dam Construction .....	1987-1995
Stream System .....	Salt River
Drainage Area .....	sq. mi. .... 5,830
Reservoir	
Elevation	
Streambed at Dam .....	ft., msl ..... 1870
Spillway (Sill) .....	ft., msl ..... 2100
Top of Active Conservation .....	ft., msl ..... 2151
Top of Flood Control .....	ft., msl ..... 2175
Top of Dam .....	ft., msl ..... 2218
Area (taken from the area-capacity tables computed using the 1995 reservoir survey)	
Spillway (Sill) .....	acres ..... 13,579
Top of Active Conservation .....	acres ..... 21,493
Top of Flood Control .....	acres ..... 24,978
Top of Dam .....	acres ..... 31,852
Capacity (taken from the area-capacity tables computed using the 1995 reservoir survey) 2	
Spillway (Sill) .....	ac-ft ..... 776,887
Top of Active Conservation .....	ac-ft ..... 1,653,0431
Top of Flood Control .....	ac-ft ..... 2,209,239
Top of Dam .....	ac-ft ..... 3,432,408
Allowance for Sedimanent (100-yr) .....	ac-ft ..... 268,000
Dam	
Type .....	Cyclopean-Masonry Gravity Arch
Ht. Above Original Streambed .....	ft ..... 357
Crest Length .....	ft ..... 1210
Crest Width .....	ft ..... 21.6
Maximum Base Width .....	ft ..... 196
Spillway	
Type .....	4 - 21'x30'top seal radial gates
Total Length .....	ft ..... 84
Maximum Capacity .....	cfs ..... 150,000
Outlet Works	
Type .....	4 - 90-in jet flow gates and ring follower gates
Maximum Capacity .....	cfs ..... 11,700
Power Plant	
Generator Capacity .....	mw ..... 36
Design Discharge .....	cfs ..... 2400

1. Includes a dead storage of 18,652 ac-ft (based on a projected sediment depth of 87 feet by year 2094). Total allowance for sediment over 100 years is also shown above.

2. The latest area and capacity tables (based on 1995 survey) can be found in Exhibit C of this manual.

3. At top of active conservation pool including generator by-pass.

**WATER CONTROL MANUAL**

**MODIFIED ROOSEVELT DAM  
(Theodore Roosevelt Dam)  
SALT AND GILA RIVERS, ARIZONA**

**U.S. ARMY CORPS OF ENGINEERS  
LOS ANGELES DISTRICT**

**September 1997**

**Prepared by:**

**U.S. ARMY CORPS OF ENGINEERS  
LOS ANGELES DISTRICT**

**Reservoir Regulation Section  
CESPL-ED-HR**



**Aerial Photograph of Modified Roosevelt Dam and Theodore Roosevelt Lake**

## **NOTICE TO USERS OF THIS MANUAL**

Regulations specify that this Water Control Manual be published in loose leaf form; and only those sections, or parts thereof, requiring changes will be revised and printed. Therefore, this copy should be preserved in good condition so that inserts can be made in order to keep the manual current.

## **EMERGENCY REGULATION ASSISTANCE PROCEDURES**

In the event that unusual conditions arise, contact can be made by telephone to the U.S. Army Corps of Engineers, Los Angeles District Office, Reservoir Regulation Section at (213)452-3527 or (213) 452-3623.

## PREFACE

The title "Modified Roosevelt Dam" is used throughout this water control manual to refer to Theodore Roosevelt Dam, modified structurally as authorized under PL 95-578 and shown on Plate 3-2 of this manual, to include additional storage for water conservation, new storage for flood control, additional surcharge storage, a new outlet works and a new spillway configuration. The reservoir formed by Modified Roosevelt Dam is referred to as "Theodore Roosevelt Lake" throughout the manual.

The water control plan presented in this manual is a result of a hydrology study performed by the U.S. Army Corps of Engineers, Los Angeles District (COE) and documented in a report entitled, "Section 7 Study for Modified Roosevelt Dam, Arizona (Theodore Roosevelt Dam), Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam", dated March 1996. Some hydrologic information contained in this water control manual were also taken from this report including, but not limited to the following: 1) flow records, drainage areas and storage capacities of the Salt and Verde system reservoirs, 2) results of simulations of the operation of the project using the water control plan during historical and design flood events, and 3) peak elevation and peak discharge frequency relationships. The water control plan was developed using elevation, area and storage relationships based on a 1981 reservoir survey, as documented in the hydrology report. In 1995, while this water control manual was being developed, the USBR completed a reservoir survey the results of which are contained in Exhibit C of this manual. The difference in the reservoir storage capacities between the two surveys has a negligible effect on the water control plan contained in this manual or the other alternatives considered in the hydrology study. The elevation, area and storage relationships derived from the 1995 survey were used in the development of the water control manual.

The water control plan was formulated to correspond with the various release mechanisms at Modified Roosevelt Dam. However, it is not the objective of this manual to instruct the operators of Modified Roosevelt Dam - the Salt River Project (SRP) - on how to make the specified releases, but rather to establish the required flood control releases which are compatible with the outlet capabilities. As a consequence, the water control plan presented in the manual shows releases for ranges of water surface elevations, but does not specify the facilities by which these releases are to be made. The SRP will select the best means of making the scheduled releases during periods when the lake level is within the flood control and surcharge pools.

One of the water control plan's objectives is to limit the combined flow of the Salt River and Verde River (including local intervening runoff) to 180,000 cfs. At present, an estimate of the combined flow can be made at Granite Reef Diversion Dam which is located 3 miles downstream of the confluence. One of the requirements of the Water Control Agreement (WCA, see Exhibit A of this manual) is to install a streamgaging station to reliably measure this combined flow. To date, the exact location of this station has not been determined; therefore,

**the term "at the confluence of the Salt and Verde River" used repeatedly in this manual signifies the future relocation of the streamgaging station.**

**All abbreviations and acronyms used in this water control manual are listed in "List of Acronyms and Abbreviations" found on page xxi. The term "regulation" used in the manual means water control procedures and decisions that are normally determined by the watercontrol manager. The term "operation" means physical manipulation of spillway gates, outlet works or instrumentation associated with the project. Finally, the elevations used this water control manual are based on the 1929 National Geodetic Vertical Datum (NGVD).**

**WATER CONTROL MANUAL**  
**MODIFIED ROOSEVELT DAM AND RESERVOIR**  
**SALT AND GILA RIVERS, ARIZONA**

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	<b>2. Letter of Understanding</b>
	<b>3. Water Control Agreement</b>
<b>B</b>	<b>Code of Federal Regulations</b>
<b>C</b>	<b>Area - Storage Capacity Tables</b>
<b>D</b>	<b>Record of Public Meetings</b>
<b>E</b>	<b>Chain of Correspondence for Approval of the Modified Roosevelt Dam Water</b>
<b>E</b>	<b>Control Manual</b>

## LIST OF ACRONYMS AND ABBREVIATIONS

<b>ac-ft</b>	<b>Acre-feet</b>
<b>ADC</b>	<b>Association Dispatch Center, Salt River Project</b>
<b>BLM</b>	<b>U.S. Bureau of Land Management</b>
<b>CAP</b>	<b>Central Arizona Project</b>
<b>CAWCS</b>	<b>Central Arizona Water Control Study</b>
<b>cfs</b>	<b>Cubic feet per second</b>
<b>COE</b>	<b>Corps of Engineers</b>
<b>DO#</b>	<b>USGS Downstream Order Number</b>
<b>EIS</b>	<b>Environmental Impact Statement</b>
<b>EM</b>	<b>Engineering Manual</b>
<b>EOC</b>	<b>Emergency Operations Center</b>
<b>ER</b>	<b>Engineering Regulation</b>
<b>ETL</b>	<b>Engineering Technical Letter</b>
<b>ft/mi</b>	<b>Feet per mile</b>
<b>HEC</b>	<b>U.S. Army Corps of Engineers Hydrologic Engineering Center</b>
<b>HEC-5</b>	<b>Simulation of Flood-Control and Conservation Systems Computer Model</b>
<b>in</b>	<b>Inches</b>
<b>LAD</b>	<b>U.S. Army Corps of Engineers, Los Angeles District</b>
<b>LOU</b>	<b>Letter of Understanding</b>
<b>MSL</b>	<b>Mean Sea Level</b>
<b>MW</b>	<b>Megawatts</b>
<b>NOAA</b>	<b>National Oceanic and Atmospheric Administration</b>
<b>NGVD</b>	<b>National Geodetic Vertical Datum</b>
<b>NWS</b>	<b>National Weather Service</b>
<b>OCE</b>	<b>Office of the Chief of Engineers</b>
<b>PMF</b>	<b>Probable Maximum Flood</b>
<b>PMP</b>	<b>Probable Maximum Precipitation</b>
<b>PMS</b>	<b>Probable Maximum Storm</b>
<b>PDO</b>	<b>Power Dispatch Office, Salt River Project</b>
<b>PROP</b>	<b>Project Reservoir Operations Planning Committee, Salt River Project</b>
<b>QPF</b>	<b>Quantitative Precipitation Forecast</b>
<b>ROW</b>	<b>River Outlet Works</b>
<b>ROC</b>	<b>Reservoir Operation Center, Corps of Engineers</b>
<b>SOD</b>	<b>Safety of Dams</b>
<b>SOP</b>	<b>Standing Operating Procedures</b>
<b>SPD</b>	<b>South Pacific Division, U.S. Army Corps of Engineers</b>
<b>SPF</b>	<b>Standard Project Flood</b>
<b>SPS</b>	<b>Standard Project Storm</b>
<b>SRP</b>	<b>Salt River Project</b>
<b>TDS</b>	<b>Total Dissolved Solids (mg/l)</b>
<b>USBR</b>	<b>United States Bureau of Reclamation</b>
<b>USFS</b>	<b>United States Forest Service</b>
<b>USFWS</b>	<b>U.S. Fish and Wildlife Service</b>
<b>USGS</b>	<b>U.S. Geological Survey</b>
<b>WSE</b>	<b>Water Surface Elevation</b>

## I - INTRODUCTION

**1-01 Authorization.** This water control manual is prepared pursuant to the requirements set forth in the Code of Federal Regulations, Title 33, Part 208.11, subparagraph d-4, entitled, "Water Control Plan and Manual."

The authority and directives for the preparation and publication of this manual are contained in the following U.S. Army Corps of Engineers publications and memorandum:

Engineering Regulation - ER 1110-2-8156: Engineering and Design, Preparation of Water Control Manuals; dated 31 August 1995.

Engineering Regulation - ER 1110-2-241: Engineering and Design, Use of Storage For Flood Control and Navigation at Non- Corps Projects; dated 24 May 1990.

Engineering Manual - EM 1110-2-3600: Engineering and Design, Management of Water Control Systems; dated 30 November 1987.

Interagency Agreement - No. 2-AA-32-01390: Between the U. S. Army Corps of Engineers and the U.S. Bureau of Reclamation; signed 12 February 1992 (see Exhibit A of this manual).

The chain of correspondence leading to approval of this manual is included in Exhibit E of this manual.

**1-02 Purpose and Scope.** The purpose of the manual is to provide current information about the dam and reservoir, the regulating policy, and a description of the organizations responsible for collecting data and regulating the reservoir. This manual contains (1) a brief description of the project and its history, (2) a description of the watershed characteristics, (3) the data collection and communications network, (4) a description of the water control plan, and 5) other information relevant to the regulation of the dam.

Broader emergency operations in flooding situations pertaining to Modified Roosevelt Dam, such as those related to failure, fall within the responsibilities of the Secretary of the Interior and as such are not evaluated within the scope of this manual.

**1-03 Related Manuals and Reports.** Manuals and reports relevant to Modified Roosevelt Dam, Theodore Roosevelt Lake, the drainage areas above and below Modified Roosevelt Dam, and significant hydraulic structures within these drainage areas are listed in Table 1-1. This list is not exhaustive and is only meant to provide information on key reports and manuals. A more comprehensive list of manuals and reports would include materials available from other agencies such as the United States Bureau of Reclamation (USBR), the Salt River Project (SRP), the United States Forest Service (USFS), and the United States Geological Survey (USGS).

**1-04 Project Owner.** Modified Roosevelt Dam, including Theodore Roosevelt Lake and the reservoir lands behind the dam, is owned by the Federal Government through the USBR. The operation of the dam was turned over to the SRP in 1917.

**1-05 Operating Agencies.** The Salt River Project (SRP) is charged with the responsibility for the operation and maintenance of Modified Roosevelt Dam. Staffing of the dam tenders is also the responsibility of the SRP.

**1-06 Regulating Agencies.**

**a. United States Army Corps of Engineers (COE).** Under Section 7 of the Flood Control Act of 1944, the COE is charged with the responsibility of prescribing regulations for the use of storage allocated for flood control at all reservoirs constructed wholly or in part with Federal funds. The Modified Roosevelt Dam water control plan presented in this manual is a result of coordinated effort by the COE and the USBR; however, the COE is responsible for providing the flood control regulations (operating criteria) and has the authority for final approval. Any deviation from the flood control operating instructions must be authorized by the COE.

**b. United States Bureau of Reclamation (USBR).** Under the Federal Act of 1902, the USBR is charged with the responsibility of administering Federal multiple-purpose projects and facilities including those on Salt River System which includes Modified Roosevelt Dam. The USBR built and owns Modified Roosevelt Dam. While ultimately responsible for the operation and maintenance of the dam, the USBR has delegated these responsibilities to the SRP through a September 6, 1917 contract signed by both the USBR and the SRP.

**c. United States Forest Service (USFS).** Under the Organic Act of June 4, 1897, the USFS is charged with the responsibility for the protection and development of national forest system lands including the Tonto National Forest.

**d. Salt River Project (SRP).** The SRP operates and maintains Modified Roosevelt Dam pursuant to contracts with the USBR dated September 6, 1917, and delivers water stored therein, in accordance with state water law, decrees and contracts.

**e. National Park Service (NPS).** The NPS has jurisdiction over withdrawn lands within the Tonto National Monument.

**f. U.S. Fish and Wildlife Service (USFWS).** The USFWS is charged with the responsibility for the conservation, protection and enhancement of fish, wildlife, and their habitats.

**1-07 Public Coordination.** On 18 and 19 July 1994, the USBR and the COE held open houses (public meetings) at the Tonto Basin Elementary School and at the office of the Flood Control District of Maricopa County regarding Modified Roosevelt Dam. The purpose of the open houses was to provide the public with an opportunity to examine the various flood control operation concepts and to receive an update on the status of the modifications underway at the dam.

On 17 and 18 October 1995, the USBR and the COE held open houses at the Tonto Basin Elementary School and at the office of the Flood Control District of Maricopa County regarding the Modified Roosevelt Dam Water Control Manual. The public was given the opportunity to examine the water control plan and manual for Modified Roosevelt Dam.

Summaries of these open houses can be found in Exhibit D of this water control manual.

**Table 1-1 Related Manuals, Reports, and Publications  
Modified Roosevelt Dam**

<b>Report No.</b>	<b>Title</b>	<b>Date</b>
1.	Water Storage on Salt River, Arizona, Water Supply Paper No. 73, U.S. Geological Survey	1903
2.	Interim Report on Survey for Flood Control, Gila and Salt Rivers, Gillespie Dam to McDowell Dam Site, Arizona, U.S. Army Corps of Engineers, Los Angeles District	Dec 1957
3.	Arizona Climate 1931 - 1972, Revised 2nd Edition, Sellers and Hill	1974
4.	Hydraulic Model Studies of Theodore Roosevelt Dam - South Spillway, Engineering Research Center, U.S. Department of the Interior, Bureau of Reclamation	May 1981
5.	Flood Preparedness Planning, Metropolitan Phoenix Area, The Hydrologic Engineering Center, U.S. Army Corps of Engineers	Jan 1982
6.	Gila River and Tributaries, Central Arizona Water Control Study, Hydrology, U.S. Army Corps of Engineers, Los Angeles District	May 1982
7.	Environmental Impact Statement, Regulatory Storage Division, Central Arizona Project, U.S. Department of Interior, Bureau of Reclamation, Lower Colorado Region, Volume I	Apr 1983
8.	Review of Feasibility Level Designs for New and Modified Theodore Roosevelt Dam, U.S. Department of the Interior, Bureau of Reclamation	Dec 1983
9.	Stage III Report Addendum, Central Arizona Project, Appendix A, Designs and Estimates, U.S. Department of the Interior, Bureau of Reclamation	Mar 1984
10.	Modification Report and Amendment, Salt River Project Dams, Salt River Project Arizona, Safety of Dams Program, U.S. Department of the Interior, Bureau of Reclamation	Jun 1985
11.	Theodore Roosevelt Dam Modifications and New Power Plant, Specifications Design Data, US Department of Interior, Bureau of Reclamation	Apr 1987
12.	Final Environmental Assessment, Theodore Roosevelt Dam Modifications, Maricopa and Gila Counties, Arizona, Regulating Storage Division, Central Arizona Project	Jul 1990
13.	Design Summary, Theodore Roosevelt Dam Modification, Salt River Project, Arizona, U.S. Department of Interior, Bureau of Reclamation	Jul 1991
14.	Three Dams in Central Arizona, Research Report, U.S. Department of the Interior, Bureau of Reclamation	Jun 1992
15.	Theodore Roosevelt Dam, Technical Report, Historic Engineering Record, U.S. Department of the Interior, Bureau of Reclamation	Jun 1992
16.	Plunge Pool Performance Study, Project Data Review/Literature Search, Theodore Roosevelt Dam, Lower Colorado Region, Salt River Project, Arizona, U.S. Department of the Interior, Bureau of Reclamation	Mar 1993
17.	Flood Damage Report, State of Arizona, Floods of 1993, U.S. Army Corps of Engineers	Aug 1994
18.	Emergency Reservoir Operating Procedures (SRP-160), Water Resource Operations, Salt River Project	Nov 1994
19.	Designers' Operating Criteria, Theodore Roosevelt Dam, Salt River Project, AZ USBR	Jun 1994
20.	Section 7 Study for Modified Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam	Sep 1995

## II - DESCRIPTION OF PROJECT

**2-01 Location.** Modified Roosevelt Dam is located on the Salt River approximately 76 miles northeast of Phoenix and approximately 30 miles northwest of Globe, Arizona. The geographic coordinates of the dam are 33° 33' 13" Latitude and 111° 26' 33" Longitude. The dam spans the Salt River to form a reservoir called Theodore Roosevelt Lake. The dam controls 5,830 square miles of the Salt River watershed, including that of Tonto Creek which terminates at Roosevelt Lake. Plate 2-1 shows a location map and the watershed above Modified Roosevelt Dam.

**2-02 Purpose.** The construction of the original Roosevelt Dam was authorized by the Secretary of the Interior on March 14, 1903, in accordance with the Reclamation Act of June 1902 (32 Stat. 338). Designed as a multiple purpose project from its very beginning, Theodore Roosevelt Dam has continuously provided water for irrigation, municipal and industrial uses, recreation, and hydroelectric power generation.

The inclusion of the Central Arizona Project (CAP) in 1968 in the Colorado River Basin Act (PL 90-537), authorized the modification of Roosevelt Dam. Although the CAP's main purpose was water conservation, it was also intended to provide extensive flood control protection to the Phoenix metropolitan area and other downstream communities. Thus, the modification of Roosevelt Dam included flood control as a project purpose. The Reclamation Safety of Dams Act, signed on November 2, 1978, added dam safety as a project purpose for the modified dam.

**2-03 Physical Components.** The main components of Modified Roosevelt Dam include: 1) a composite masonry/concrete thick arch embankment, 2) a river outlet works, 3) two similar spillway structures located on each side of the dam, 4) a power house, and 5) a plunge pool stilling basin. A general plan of the dam and its main components are shown on Plate 2-2.

**a. Dam Embankment.** Modified Roosevelt Dam is a composite masonry/concrete thick arch structure with a structural height of 357 feet above the original stream bed (see Plate 2-2). It has a crest width of 21.6 feet and a maximum base thickness of about 196.0 feet. The crest has a total length of approximately 1,210 feet, and is located at elevation 2218 feet. The reservoir freeboard (up to elevation 2222.5 feet) is provided by a 4.5-foot high concrete parapet wall constructed along the the upstream side of the dam crest.

The exterior of the original dam embankment was constructed from dolomite blocks set in mortar, while the interior portion is made of masonry rubble in a matrix of concrete. It is approximately 280 feet high, has a crest length of 723 feet, a top width of 16 feet, and a maximum base width of 184 feet. The modified structure is constructed of a concrete-overlay placed over the downstream face of, and above, the original structure. This concrete overlay provides an additional 77 feet in height, an increase of 5.6 feet on the crest width, and 487 feet on the crest length.

**b. Roosevelt Lake.** Modified Roosevelt Dam spans the Salt River to form a reservoir called Theodore Roosevelt Lake. The reservoir has a maximum active water conservation elevation of 2151 feet. The capacity at this elevation is approximately 1,653,000 ac-ft with a reservoir surface area of approximately 21,500 acres. Plate 2-3 shows a plan view of Theodore Roosevelt Lake.

**c. Left and Right Abutment Spillways.** Modified Roosevelt Dam has two similar spillway structures located on the left and the right sides of the dam. Each structure has two 21-foot x 30-foot top seal radial gates at the downstream face of a thrust block (see plate 2-4). The combined effective length of the spillways is 81 feet with the sill located at elevation 2100 feet. With all the gates fully open, the spillway maximum allowable release of 150,000 cfs occurs when the water surface elevation reaches 2187.6 feet. Above 2187.6 feet, the spillway gate openings are reduced to maintain a maximum outflow of 150,000 cfs. Downstream of the radial gates, spillway flows enter a diverging chute and a flip structure before plunging to an excavated basin within the river channel below. Plate 2-5 shows the spillway discharge curve.

**d. River Outlet Works (ROW).** With the exception of power plant discharges, the ROW located on the left abutment is the sole source of low level releases from Modified Roosevelt Dam. The outlet works structure includes a 943-foot long, 16-foot in diameter concrete and steel lined tunnel, a steel trash rack structure, a bell mouth drop inlet intake at elevation 1989 feet, and a 13-foot x 16-foot wheel mounted guard gate located within a concrete-lined chamber and shaft near the dam axis. Steel bifurcations at the downstream portal branch to four 90-inch diameter passages. Each passage contains a ring follower gate and a jet-flow regulating gate located within a downstream control structure. The ROW maximum discharge capacity of 12,100 cfs occurs when the water surface elevation reaches 2175 feet (see Section 7-02.h for restrictions). Plate 2-6 shows the ROW general plan and sections, and plate 2-7 shows the ROW discharge curve.

e. **Power House.** A steel-lined power penstock tunnel branches out from the outlet works tunnel downstream from the wheel mounted guard gate, to the downstream portal of the power house. The penstock tunnel is 408 feet in length, and 12.5 feet in diameter. A penstock pipe with a 150-inch diameter butterfly guard valve at the downstream portal serves a new turbine designed for higher operating heads. The maximum release capacity of this modified power plant is 2,400 cfs, with a generating capacity of 36 MW.

f. **Plunge Pool Stilling Basin.** A plunge pool stilling basin is located immediately downstream of the dam. The base of the pool was excavated down to elevation 1840 feet which involved a rock excavation of 40 feet. The plunge pool was not lined with concrete. A rock bolted reinforced concrete slab was designed to protect the rock mass adjacent to the power plant service yard retaining wall from erosion. The plunge pool stilling basin was designed to effectively dissipate the energy resulting from a discharge of 150,000 cfs.

**2-04 Related Control Facilities.** There are four primary dams along the Salt River system, namely: 1) Modified Roosevelt Dam, 2) Horse Mesa Dam, 3) Mormon Flat Dam, and 4) Stewart Mountain Dam. These dams form a continuous chain of lakes almost 60 miles long. These four dams provide municipal and irrigation water supply, and hydropower to Central Arizona. In addition, Modified Roosevelt Dam is designed to provide downstream flood control protection. The Salt River Project (SRP) is charged with the responsibility of operating these dams. Recreation benefits include year round boating and fishing on all reservoirs. Granite Reef Diversion Dam, located three miles downstream of the Salt and Verde River confluence diverts water from the Salt River storage system into a system of distribution canals. It has essentially no storage capacity. Plate 2-9 shows a schematic diagram of the Salt River Project system.

Other projects in the overall Gila River system include Horseshoe and Bartlett Dams on the Verde River, New Waddell Dam on the Agua Fria River, and Coolidge Dam and Painted Rock Dam on the Gila River. These dams and other related projects are shown on Table 2-1 and further discussed in Section 3-04.

There are twenty-six dams located upstream of Modified Roosevelt Dam having a combined storage capacity of 45,000 ac-ft. The failure of one or more of these upstream structures will have a negligible effect on Modified Roosevelt Dam.

**Table 2-1**  
**Other Major Water Storage Facilities <sup>1</sup>**  
**Within the Salt, Verde, and Gila River Watersheds <sup>2</sup>**

Name of Dam	Reservoir	River	Drainage Area <sup>3</sup> (sq-mi)	Storage <sup>4</sup> (ac-ft)	Purpose
Horse Mesa Dam	Apache Lake	Salt	5,935	245,000	Irrigation and Power
Mormon Flat Dam	Canyon Lake	Salt	6,095	58,000	Irrigation and Power
Stewart Mt. Dam	Saguaro Lake	Salt	6,221	70,000	Irrigation and Power
Horseshoe Dam	Horseshoe	Verde	5,657	131,000	Irrigation
Bartlett Dam	Bartlett	Verde	5,872	178,000	Irrigation
Painted Rock Dam	Painted Rock	Gila	50,800	2,496,400	Flood Control
Coolidge Dam	San Carlos	Gila	12,886	1,100,000	Irrigation and Power
New Waddell	Lake Pleasant	Agua Fria	1,459	812,000	Irrigation
Granite Reef Dam	Located at the confluence of Salt and Verde Rivers. No storage capacity.				
Notes:					
1. There are other structures located upstream and downstream of Modified Roosevelt Dam, but they do not greatly influence the regulation of the dam.					
2. The Salt and Verde are subbasins of the Gila watershed.					
3. Based on subarea delineations conducted on COE's 1982 CAWCS Hydrology Report. These delineations represent effective drainage area only, and may be in disagreement with drainage areas from other sources which report total areas.					
4. Storage data at top of water conservation pool, except for Painted Rock Dam storage which is at top of flood control pool.					

**2-05 Real Estate Acquisition.** The Theodore Roosevelt reservoir and adjacent area encompasses both privately-owned and publicly managed lands. The public lands are managed by Federal government entities. The NPS has jurisdiction over withdrawn lands within the Tonto National Monument. This consists of 1,120 acres and is managed as a national monument preserving archeological resources. The USFS is responsible for all other publicly withdrawn lands.

The reservoir taking line for Modified Roosevelt Dam was established at the top of the flood control pool (el 2175 feet), with an additional buffer of 300 linear feet. As a result, the USBR acquired all private lands below the established taking line. Private land owners and residents were relocated onto the adjacent national forest lands above the PMF elevation (see Section 8-02.a).

**2-06 Public Facilities.** The United States Forest Service (USFS) administers the recreation facilities along Roosevelt Lake, which is located within the Tonto National Forest. Existing facilities include boat launches, a marina, a recreation vehicle park, and a resort area. Activities

at the lake center around pleasure boating, fishing, and camping. In addition, there are numerous recreation facilities planned including the following: 1) ten separate picnic and camping areas totaling 660 acres, 2) eighty picnic sites, 3) approximately two thousand four hundred campsites, 4) seven boat launch areas, 5) a marina/concession, and 6) a visitor center/ranger station.

The Tonto Arm of Roosevelt Lake (the area enclosed by A-Cross Road and SR 188) is known as Roosevelt Lake Wildlife Recreation Area and is jointly managed by the Arizona Game and Fish Department and the USFS. Three other parcels within the reservoir area have also been set aside as publicly-managed special use areas: 1) the 1,120-acre Tonto National Monument, 2) the 38,897-acre Three Bar Wildlife Management Area, and the 19,180 acre (7,680-acre land and 11,500-acre water) Salt River Natural Wildlife Goose Refuge Management Area.



**Photo 2-1. Modified Roosevelt Dam - Upstream View.**



**Photo 2-2. Modified Roosevelt Dam - Downstream View**



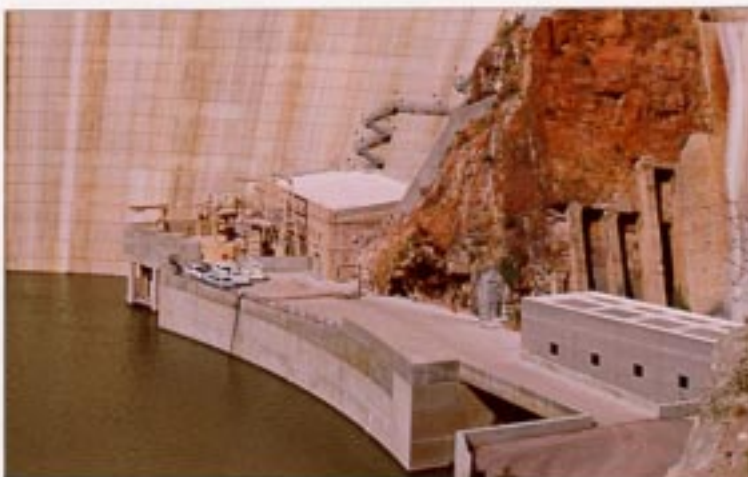
**Photo 2-3. Modified Roosevelt Dam - Left Spillway Structure**



**Photo 2-4. Modified Roosevelt Dam - Right Spillway Structure**



**Photo 2-5. Modified Roosevelt Dam - Plunge Pool Area**



**Photo 2-6. Modified Roosevelt Dam - Power Plant**



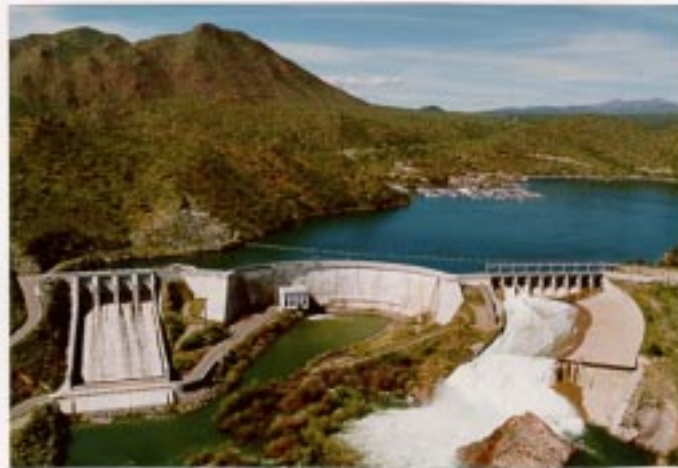
**Photo 2-7. Modified Roosevelt Dam - River Outlet Works**



**Photo 2-8. Modified Roosevelt Dam - Lake Area**



**Photo 2-9. Granite Reef Diversion Dam**



**Photo 2-10. Stewart Mountain Dam and Saguaro Lake**



**Photo 2-11. Horse Mesa Dam and Apache Lake**



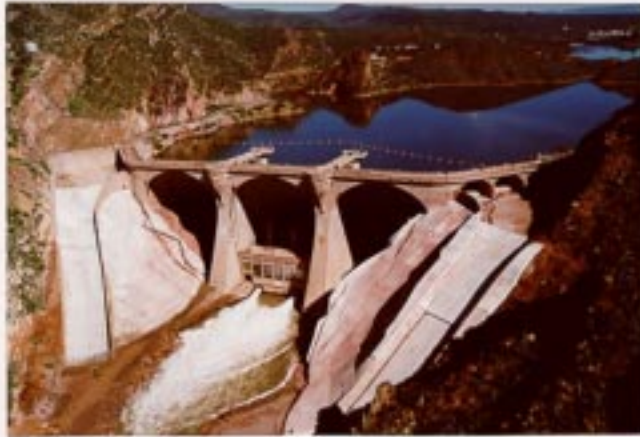
**Photo 2-12. Mormon Flat Dam and Canyon Lake**



**Photo 2-13. Bartlett Dam and Lake**



**Photo 2-14. Horseshoe Dam and Lake**



**Photo 2-15. Coolidge Dam and San Carlos Lake**



**Photo 2-16. New Waddell Dam and Lake Pecos**

### III - HISTORY OF PROJECT

**3-01 Authorization.** The construction of the original Roosevelt Dam was authorized by the Secretary of the Interior in accordance with the Reclamation Act of June 17, 1902 (32 Statute 338) on March 14, 1903. Originally named "Tonto Dam" and then later "Salt River Dam", Theodore Roosevelt Dam was constructed as a part of the Salt River Project which also included the construction of a power plant below the dam, the construction of Granite Reef Diversion Dam located 3 miles downstream of the Salt River and Verde River confluence, and improvement of existing main canals. The main purpose of the original Roosevelt Dam was to increase and control the region's water supply.

Section 2 of the Reclamation Act of 1902 reads in part:

*"Section 2. That the Secretary of the Interior is hereby authorized and directed to make examinations and surveys for, and to locate and construct, as herein provided, irrigation works for the storage, diversion, and development of waters, including artesian wells, and to report to Congress at the beginning of each regular session as to the results of such examination and surveys, giving estimates of cost of all contemplated works, the quality and location of the lands which can be irrigated therefrom, and all facts relative to the practicability of each irrigation project; also the cost of works in process of construction as well as of those which have been completed."*

The said Act read further:

*"Section 4. That upon the determination of the Secretary of the Interior that any irrigation project is practicable, he may cause to be let contracts for the construction of the same, in such portions or sections as it may be practicable to construct and complete as parts of the whole project, providing the necessary funds for such portions or sections are available in the reclamation funds..."*

In 1968, the U.S. Congress authorized the USBR to construct the Central Arizona Project (CAP) as a part of the Colorado River Basin Act (PL 90-537). While the primary purpose of the CAP was water conservation, it was also intended to provide extensive flood control protection to the Phoenix metropolitan area and other downstream communities. However, public opposition caused the deletion of some of the proposed features of the CAP. As a result, the USBR initiated the Central Arizona Water Control Study (CAWCS) to find alternatives to the deleted features of the CAP. The Reclamation Safety of Dams Act (Public Law 95-578), signed on November 2, 1978, authorized the Secretary of the Interior to construct, restore, operate, and maintain new or modified features at existing Federal Reclamation dams to insure their safety.

As a result, the USBR widened the focus of the CAWCS and included safety of dams as a major objective. The passage of PL 95-578 authorized the USBR to modify Theodore Roosevelt Dam.

Modified Roosevelt Dam was designed to provide flood control, hydropower, water conservation, and dam safety, along with other project purposes and benefits consistent with objectives of the CAWCS. Under Section 7 of the Flood Control Act of 1944, the COE through Los Angeles District (LAD) has the responsibility for developing a water control plan for the flood control regulation of Modified Roosevelt Dam.

**3-02 Planning & Design.** The history of the original Roosevelt Dam and Modified Roosevelt Dam is outlined in Plate 3-1. Plate 3-2 shows a comparison diagram of the original dam and the modified dam.

**a. The Original Dam.** The irrigation of farmlands in the Salt River Valley began as early as the mid-1860's. Diversion dams, canals and laterals were constructed through both private companies and community efforts between 1867-1902. As the requirements for more irrigation waters grew, engineers and surveyors began to explore the possibility of building large scale storage structures to increase and control the region's water supply. The length of the Salt River, from Phoenix to the river's headwaters in the northeastern Arizona mountains, and the Verde River, the Salt River's major tributary, were surveyed to determine the best location for a major storage structure. One of these investigations concluded that the confluence of Salt River and Tonto Creek appeared to be an ideal site for a storage reservoir with a capacity exceeding a million acre-feet of water.

In 1903, the Salt River Valley Water Users' Association (later named the Salt River Project - SRP), was formed to represent the Salt River Valley's farmers in their negotiations with the Reclamation Service (today known as the Bureau of Reclamation - USBR). On March 14, 1903, the Salt River Project was authorized by the Secretary of the Interior. This original project system was composed of a storage dam (originally named Tonto Dam or Salt River Dam) to be located at the confluence of Tonto Creek and Salt River, a power plant, Granite Reef Diversion Dam, and improved main canals. The storage dam, later renamed Theodore Roosevelt Dam, was completed in 1911 and had a structural height of 280 feet and a crest length of 723 feet.

**b. The Modified Dam.** In 1968, the U.S. Congress authorized the USBR to construct the Central Arizona Project (CAP) as a part of the Colorado River Basin Act. One of the proposed features of the CAP was the construction of Orme Dam at the confluence of the Salt and Verde Rivers, or a suitable alternative. While the primary CAP-related purpose of Orme dam was to provide seasonal storage and regulation of Colorado River water, it was also designed to provide extensive flood protection to the Phoenix metropolitan area and other downstream communities. In 1977, as a result of growing public opposition, Orme Dam was deleted from the CAP. The Central Arizona Water Control Study (CAWCS) was formulated to develop a suitable alternative to Orme Dam. The development of alternatives was aimed at meeting the major planning objectives of flood control and CAP regulatory storage, together with other study purposes such as water conservation, recreation, fish and wildlife preservation, enhancement of social conditions, and energy management opportunities. The passage of Reclamation Safety of Dams (SOD) Act of 1978 (PL 95-578) widened the focus of the CAWCS to include the evaluation of the structural safety of USBR dams. Under this dam safety program, Theodore Roosevelt Dam was identified as having significant safety deficiencies. It was listed among the 13 dams originally identified in testimony for the passage of the Reclamation Safety of Dams Act as requiring modifications to safely accommodate the Probable Maximum Flood (PMF) and the Maximum Credible Earthquake (MCE).

In 1981, the Department of the Interior selected one of the CAWCS alternatives known as "Plan 6" as the proposed action for purposes of detailed planning, design and completion of the CAP. Plan 6 included a modified Roosevelt Dam on the Salt River, a modified Stewart Mountain Dam also on the Salt River, Cliff Dam on the Verde River, and New Waddell Dam on the Agua Fria River. On April 3, 1984, the Secretary of the Interior announced the decision to proceed with the implementation of Plan 6. Implementing instructions directed the USBR to proceed with the final design and construction of Stewart Mountain, Roosevelt, and New Waddell Dams but delayed the implementation of plans for Cliff Dam. In 1987, Cliff Dam was deleted from Plan 6 because of environmental issues. Immediately thereafter, a construction contract for the modifications at Roosevelt Dam on the Salt River was awarded. Dedicated flood control for the modified dam was determined and real estate acquisitions were based on the top of the flood control pool elevation of 2175 feet with an additional buffer of 300 lineal feet. Modified Roosevelt Dam was designed to have a structural height of 357 feet and a crest length of 1,210 feet. It is intended to provide flood control, water conservation, and dam safety, along with other project purposes and benefits consistent with objectives of the CAWCS.

c. **Spillway Structure.** The original design of the Roosevelt Dam included two large spillways - one on each abutment, designed to pass excess flood waters and prevent overtopping of the structure. Each spillway structure was about 350 feet long with a sill 27 feet below the top of dam, and was designed to pass a maximum flow 220,000 cfs with approximately 7 feet of freeboard. During construction, the design of the spillways was altered to include nineteen tainter gates that, when closed, provided an additional 15 feet of reservoir height, and increased the reservoir capacity to 1,367,300 ac-ft. However, this alteration decreased the spillway design capacity to 150,000 cfs. Lifting motors and gears were mounted above the gates on a steel footbridge which spanned across the piers.

In the early 1920's the spillway design capacity of 150,000 cfs was further reduced by modifications intended to increase the reservoir storage. In 1936, the spillway capacity was restored back to 150,000 cfs by lowering the spillway crest by 6 feet and installing nineteen 20 feet x 15.9 feet radial gates. Individual gate hoists, operating motors and two 5-kilovolt-ampere gasoline-engine-driven generators were also installed. The current modification of Roosevelt Dam includes the replacement of the existing spillway structures with two new spillway structures located on the left and right abutments. Each spillway structure has two 21-foot x 30-foot top seal radial gates. The combined capacity of the left and right spillways is 150,000 cfs when the water surface reaches elevation 2187.6 feet. Above this elevation, the gates are lowered in order to maintain 150,000 cfs release, the maximum regulated spillway discharge.

### **3-03 Construction.**

a. **Original Dam.** The construction of the original dam (named "Tonto Dam" at the time) started in 1903. The primary contractor was J.M. O'Rourke and Company of Galveston, Texas. By 1905, the dam was re-named "Theodore Roosevelt Dam" in honor of President Theodore Roosevelt who signed the federal legislation facilitating its construction. A series of floods washed out the temporary coffer dam and other facilities and delayed the construction, and the dam was not completed by the set deadline of April 1907. Finally, in February 1911, the final stone was laid and the construction of the dam was declared complete. The original dam had a structural height of 280 feet and a crest length of 723 feet. Originally budgeted at \$3 million, the costs more than tripled to over \$10 million by the time the dam was completed.

During construction, the spillways were altered by the addition of 19 tainter gates, which when closed, would provide an additional 15 feet of reservoir height, increasing the total reservoir

storage capacity to more than 1,367,300 ac-ft. Three cast iron penstocks, which were not part of the original plan, were added to the north abutment after 1908 to reduce the need to use the sluicing tunnel under high pressure when the reservoir is filled to capacity.

The dam was formally dedicated in March 1911. In 1917, the management of Theodore Roosevelt Dam was turned over to the Water Users' Association. Upon completion, Theodore Roosevelt Dam had an immediate and dramatic impact on the valley. Finally, after decades of concern and work, farmers in the Phoenix area were no longer dependent only upon the natural flow of the Salt River to irrigate their farm crops.

**b. The Modified Dam.** In August 1989, the USBR awarded a \$28.9M contract for the construction of the lake tap and tunnels. This work was completed in November 1991. In February 1991, USBR awarded a \$103.3M contract to J.A. Jones Construction Company to raise the dam an additional height of 77 feet, construct the new spillways and perform additional construction on the ROW. In May 1991, Neypric, Inc. (which later changed its corporate name to GEC Alstom Electromechanical Corp.) was awarded the contract to replace the hydraulic turbine in the power house.

**3-04 Related Projects.** The major projects located in the Salt, Verde and Gila River systems that directly or indirectly affect the regulation of Modified Roosevelt Dam are listed in Table 2-1 and are briefly discussed as follows:

**a. The Salt River Project Reservoir System.** The Salt River Project reservoir system in central Arizona provides the water supply for much of the metropolitan Phoenix area. Hydroelectric power is also generated by the system. The project system is comprised of six reservoirs on the Salt and Verde Rivers, including Modified Roosevelt Dam, and a diversion dam located 3 miles downstream of the Salt River and Verde River confluence. The other reservoirs are Horse Mesa Dam, Mormon Flat Dam and Stewart Mountain Dam on the Salt River, Horseshoe Dam and Bartlett Dam on the Verde River, and the diversion dam is Granite Reef Diversion Dam. The reservoirs drain a combined watershed of more than 13,000 sq. mi. Modified Roosevelt Dam is the oldest and has the largest reservoir storage. These other dams are discussed in detail in Section 4-11 of this water control manual.

**b. Other Projects.** Other projects on the Salt and Gila River system that directly or indirectly influence the operation of Modified Roosevelt Dam include Painted Rock Dam on the lower Gila

River, Coolidge Dam on the upper Gila River, and New Waddell Dam on the Agua Fria River. These dams are also discussed in detail in Section 4-11 of this water control manual.

### **3-05 Modifications to Regulations.**

**a. Original Dam.** The original Roosevelt Dam did not include flood control as a project purpose. However, the dam underwent several design and construction modifications that were intended to pass excess flood waters during large storm events. These modifications affected the regulation of the dam during large flood events and are outlined as follows:

**1. Spillway Modification During Construction** - the original design of the dam included two large spillways - one on each abutment, designed to pass excess flood waters in order to prevent overtopping of the structure. The spillways were originally designed to pass a maximum flow of 220,000 cfs with approximately 7 feet of freeboard. However, during the construction of the original dam, the spillway design was altered to include gates, thus increasing the reservoir capacity. This modification reduced the spillway design capacity to 150,000 cfs.

**2. 1920 and 1936 Spillway Modifications** - In the early 1920's, the spillway design capacity was further reduced by modifications designed to increase the reservoir storage. However, in 1936, the spillway capacity was restored to 150,000 cfs by lowering the crests 6 feet and installing radial gates.

**b. The Modified Dam.** The modification of Roosevelt Dam adds flood control, and dam safety as new project purposes, in addition to water conservation, hydropower, recreation, and other project purposes of the original dam. Because of the addition of flood control as a project purpose, a scheme for regulating the flood control storage was required. Thus, the regulation procedure shown on Plate 7-1 of this manual was developed. Under this plan, Modified Roosevelt Dam is regulated for flood control purposes between WSE 2151 feet to WSE 2175 feet with a maximum flood control release of 53,100 cfs to the downstream channel. Above WSE 2175 feet, the spillway gates are gradually adjusted in order to release excess flood waters up to a maximum rate of 150,000 cfs (when WSE 2187.6 feet is reached). Above 2187.6 feet, the spillway gates are adjusted so as to maintain a total flow of 150,000 cfs. This plan is discussed in detail in Section 7-5 of this manual.

**3-06 Principal Regulation Problems.** During the development of this water control manual, Modified Roosevelt Dam was still undergoing construction; Therefore, problems that can seriously affect the flood control regulation of Modified Roosevelt Dam were unknown at the time. However, anticipated difficulties that may be encountered in the implementation of the water control plan during large storm events are summarized as follows:

**a. Limiting the Combined Discharge of the Salt and Verde River to 180,000 cfs.**

One of the main objectives of the water control plan is to limit the discharge at the confluence of Salt and Verde Rivers to a maximum of 180,000 cfs. This can be accomplished by restricting the flood control releases from Modified Roosevelt Dam when the combination of releases along with Bartlett Dam releases (Verde River contribution), Stewart Mountain Dam releases (Salt River contribution) and local runoff approaches 180,000 cfs. During actual flood events, the water control manager may find it difficult to meet this objective due to the following reasons:

**1. Verde River Discharge.** Since the reservoirs on the Verde River do not have storage dedicated for flood control and have a relatively small quantity of water supply space, during large flood events the Verde River discharge to the Salt River can become “uncontrolled”. The “uncontrolled” Verde River discharge has the capability to become so large, and that when combined with local runoff, may result in a flow that exceeds the limiting discharge of 180,000 cfs at the confluence (even with no flow contribution from Modified Roosevelt Dam).

**2. Inability to Accurately Measure the Actual Combined Flow at the Confluence.**

As mentioned previously, the flow at the Salt River and Verde River confluence is a combination of the Salt River discharge, Verde River discharge and the intervening local runoff. The Salt and Verde River discharges are measured at Stewart Mountain Dam and Bartlett Dam, respectively. In addition, streamgages located between these dams and the confluence can be used to measure the flows on both rivers, namely: 1) Salt River below Stewart Mountain Dam, and 2) Verde River at Beeline Bridge. However, the absence of a reliable streamgaging station at the confluence prevents an accurate measurement of the actual combined flow from the entire upstream drainage area during large flood events. The inaccurate measurement of this vital information prevents the water control manager from fully utilizing the maximum scheduled flood control releases provided by the water control plan for Modified Roosevelt Dam (if the estimated flow is higher than the actual). Inversely, inaccurate measurement of the combined flow at the confluence may unknowingly result in a peak discharge which exceeds the limiting flow of 180,000

cfs (if estimated flow is lower than actual). The installation of a reliable streamgaging station is essential in the implementation of the water control plan, thus it is required by the water control agreement between SRP, USBR and COE (see Exhibit A of this manual).

## IV - WATERSHED CHARACTERISTICS

**4-01 General Characteristics.** The State of Arizona, in general, can be subdivided into two regions: 1) that draining directly into the Colorado River lying to the north and west of Prescott, and 2) the greater portion of the south and east which forms the Gila River Basin, which eventually drains into the Colorado River also, near Yuma.

The Gila River Basin is an irregular area of approximately 58,200 square miles extending from the Continental Divide in southwestern New Mexico to the Colorado River at Yuma Arizona. It includes practically all the southern half of Arizona and constitutes a region of widely varying topographical and climatological characteristics. The Salt River is the largest tributary of the Gila River and drains approximately 13,700 square miles (13,400 excluding all closed drainages) within central and eastern portions of Arizona. The Verde River which joins the Salt River downstream of Modified Roosevelt Dam, is the main tributary of the Salt River and drains an area of approximately 6,620 square miles (6,320 excluding closed areas, e.g. the Audrey Basin). Out of the total Salt River watershed, approximately 5,830 square miles is located above Modified Roosevelt Dam. The Gila River basin, its subbasins (which include the Salt River basin), and the existing water control structures in the basin are shown on Plate 4-1.

The Salt River above Modified Roosevelt Dam is formed by the confluence of the Black and White Rivers and drains the White Mountains and the Mogollon Rim in east-central Arizona. Other major streams which drain to the Salt River upstream of Modified Roosevelt Dam are Carrizo Creek, Cibecue Creek, Cherry Creek, and Pinal Creek, each of which drains an area of more than 200 square miles. Tonto Creek, which joins the Salt River at the dam site is the Salt River's second largest tributary (the Verde River is the largest) and drains an area of approximately 1,000 square miles. The Salt River watershed is shown in Plate 2-1.

**4-02 Topography.** There are three major rivers in the central section of Arizona, namely: 1) the Verde River which flows southward out of the Chino Valley, 2) the Salt River which flows westward from the confluence of the White and Black Rivers, and 3) the Gila River which flows westward along the southern boundary of the section. Runoff

from these rivers is for most part retained in reservoirs, the largest of which is Modified Roosevelt Dam on the Salt River.

The watershed above Modified Roosevelt Dam is extremely irregular and rugged. Here, the topography consists mainly of isolated mountain ranges cut by steep-walled canyons and gorges. Streams and creeks are numerous; however, most of them carry water only after a period of abundant rainfall and/or during periods of snowmelt.

Among the many mountains of the central section of Arizona are the Juniper and Santa Maria Mountains, located on the west side of the Chino Valley, the Prescott (Sierra Prieta) and Bradshaw Mountains, south of Prescott, the Black Hills, west of Jerome, the Mazatzal Mountains, between the Verde River and Tonto Creek, the Sierra Ancha Mountains north of Modified Roosevelt Dam, and the Pinal Mountains south of Miami. Most of these ranges have a north-south orientation and rise to heights of 7,500 feet or more. The elevation at the mouth of the Salt River is 1,000 feet while some of its headwaters exceed 10,000 feet in altitude, Baldy Peak being the highest is at elevation 11,590 feet. The Salt River's main tributary is the Verde River which joins the Salt River 3 miles above Granite Reef Diversion Dam. Tonto Creek, another main tributary joins the Salt River at the dam site. Above Modified Roosevelt Dam, the topography is nearly all of a rough, mountainous character. The Salt River heads westward from the confluence of the Black and White Rivers in the eastern mountains of Arizona.

**4-03 Geology and Soils.** Modified Roosevelt Dam and reservoir is located in the Tonto Valley between the Mazatzal Mountains and the Sierra Ancha. The area is in the Mountain Region of the Transition Zone Physiographic Province, noted for its numerous narrow and deep canyons and washes. Outcroppings of rock in the region are primarily older Precambrian granitic and metamorphic basement rocks and overlying younger Precambrian and Paleozoic sedimentary rocks. The Tonto Basin is an asymmetrical graben formed during a period of widespread block faulting in the late Cenozoic known as the Basin and Range disturbance. More localized faulting and shearing are believed to have been caused by the Precambrian intrusion of igneous sills and by pre-Basin and Range tectonic events.

The dam is located in a narrow canyon of the upper Salt River. The foundation of the dam consists generally of three Precambrian rock units of the Mescal and Dripping

Spring Formations. The uppermost unit within the foundation is the M1 dolomite, which is moderately hard to hard, and slightly to moderately fractured. The M1 dolomite forms the upper abutments of the dam and the foundation of the new thrust blocks.

Three faults exist in the immediate foundation area of the dam. The faults are pre-Quaternary and are not likely to be activated by earthquakes in the region. Two of the faults in the foundation area are minor features which extend beneath the dam and are of no consequence to the modification design. The third fault has significant offset and thickness and transects the left abutment, subparallel to the Salt River canyon, just outside the footprint of the dam. This fault lies to the left of the left spillway chute and thrust block excavation and is crossed by the top of dam access tunnel in the area of the Apache trail.

**4-04 Sediment.** Most of the streams of the southwest carry a considerable quantity of solid matter which causes sediment build up in channels and reservoirs. This is true of the Rio Grande, Colorado, Pecos, and Gila Rivers. There is also silt in the waters of the Salt River, but it is not as abundant as in the streams mentioned. The basin above Modified Roosevelt Dam lies in large part in high timbered country, and includes the White Mountain Apache Indian Reservation. The reservation is almost entirely covered with forest and grass. The basin of Tonto Creek, and a few other tributaries, however, are closely pastured and deliver some silt during sudden floods.

Table 4-1a shows the dates and results of sediments surveys done at Theodore Roosevelt reservoir. The original survey was done in May 1909. This survey resulted in a total reservoir surface area of 17,826 acres at elevation 2136 feet (the top of the original spillway gates). The 1909 survey calculations resulted in a reservoir capacity of 1,539,499 ac-ft at elevation 2136 feet. Table 4-1a also shows the difference in storage between surveys, the average annual sediment accumulation and the average sediment inflow for periods between the surveys. The latest survey was done in April 1995. Table 4-1b shows a summary of the results of this survey. The most recent area capacity table and curves are based on the April 1995 survey and can be found in Exhibit C and Plate 2-8 of this water control manual, respectively.

**4-05 Climate.** The climate is arid throughout most of the State of Arizona, and high evapotranspiration reduces the availability of surface water resources. Throughout the state, average annual precipitation varies widely both geographically and seasonally. In general, however, two seasons of precipitation are common. The summer season, particularly July and August, is the wettest, and precipitation occurs as intense thunderstorms of short duration. The second wet season is December through mid-March. At the higher altitudes, much of the winter precipitation falls as snow, which contributes large amounts of spring runoff. May and June are the driest months.

**a. Temperature.** Temperatures vary greatly across the State of Arizona. For example, in January, average daily temperatures range from between 20 °F and 25 °F on the Kaibab Plateau and in the San Francisco Mountains to about 55 °F along the lower Gila River; while in July, the same regions record average daily temperatures close to 55 °F and 95 °F, respectively. These large variations result mainly from differences in elevation, although latitude also plays an important role, especially in winter when stations in the northeast section are almost ten degrees colder than those at a similar elevation in the southeast section. In summer, average daily temperatures change with elevation rather uniformly throughout the state, from the middle nineties below 500 feet to the high fifties above 8,000 feet, corresponding to a decrease of temperature with height of about 1 °F per 235 feet. Thus, in summer the 9,000 foot peaks in the southeast section are between 25 and 30 degrees cooler than the surrounding desert valleys. Winters in the northeast and plateau sections of Arizona (which include portions of the Upper Salt River watershed above Modified Roosevelt Dam) can be bitterly cold, particularly at elevations above 7,000 feet.

Tables 4-2a, b, c, and d show climatological summaries at four NWS stations in the area, namely: 1) Alpine, 2) McNary, 3) Roosevelt 1 WNW, and 3) Whiteriver. These tables list, among other items, the mean daily maximum and minimum temperature and the recorded highest and lowest temperatures for each month of the year at each of the four stations.

**b. Precipitation.** Plate 4-2 shows the schematic picture of the distribution of the average annual precipitation over Arizona. Roughly half of Arizona averages less than 10 inches of precipitation a year. However, certain regions in the plateau, central and southeast sections of the state (regions that include the drainage area above Modified Roosevelt Dam) average more than 25 inches of precipitation a year. Although not

shown in the plate, there are isolated points in the state which receive more than thirty inches of precipitation per year. These include some of the higher peaks and also exposed locations at lower elevations on the windward (southern and western) side of the mountains in the central section of the state. In some years a few stations may report more than 46 inches of precipitation, but such occurrences are rare. Precipitation at higher elevations in the Salt River Basin, and in other arid zones may or may not be reflected in runoff, especially if snowmelt proceeds slowly, or if rains are relatively gentle and soils are unsaturated. However, high intensity rainfall, rapid snowmelt, or a combination of both, almost invariably result in some level of flooding.

Tables 4-2a, b, c, and d list the mean and maximum monthly and annual precipitation, as well as the maximum mean and maximum daily precipitation for each month of the year, for each of the four climatological stations in the Salt River drainage area. Plate 4-3 shows the historic annual precipitation at Roosevelt, Arizona from 1931 to 1994.

**c. Snow.** Certain regions of Arizona receive a considerable amount of snow during the colder months. More than seventy five percent of the winter precipitation falls as snow in the higher parts of the plateau section, notably on the Kaibab Plateau and in the San Francisco and White Mountains. These areas typically get between eight and eleven feet of snow annually. During unusual cold and wet periods, more than 100 inches may fall in a single month. Except for the plateau section, there are only a few isolated spots in the state that can expect to receive more than four to five inches of snow during a normal season. These include practically all the mountain ranges rising above 7,000 feet in the northwest, central, and southeast sections of the state. A large fraction of water in the state's many storage reservoirs is derived from melting snow from these mountains.

From the early 1910's to the early 1970's, there were only three months characterized by relatively heavy, continuous, and widespread snowfall in Arizona. In the worst of these, January 1949, the average amount of snowfall over the state, 14.8 in, was four times greater than normal. January 1937 was also a snowy month, particularly in the central portions of the state. McNary, for example, received more than 70 inches. In December 1967, snowfall averaged 13.7 inches, with the greatest amounts in the plateau and northeast sections. Sixteen stations recorded more than 50 inches of snow during the month.

**d. Evaporation.** In 1915, the U.S. Weather Bureau (today known as the National Weather Service - NWS) established a network of stations around the country to measure evaporation of water from what is known as the Weather Bureau Class A pan. The first such station to be established was at Modified Roosevelt Dam site. Pan evaporation rates in Arizona range from an estimated 42 inches per year at Fort Valley, north of Flagstaff, to 154 inches per year at Davis Dam. Most values, however, lie between 80 and 105 inches per year. Corresponding lake or reservoir evaporation falls in the range 55 to 75 inches per year.

Table 4-3a shows monthly and annual mean evaporation data for three NWS stations, namely: 1) McNary, 2) Roosevelt 1 WNW, and 3) Whiteriver. Evaporation amounts are given in inches per month or year and wind speeds in miles per month or year.

**e. Wind.** Wind data for the State of Arizona is limited, existing in quantity only for the NWS's airport offices at Winslow, Flagstaff, Prescott, Tucson, Phoenix, and Yuma. Phoenix, the closest station to Modified Roosevelt Dam, has a good mountain-valley circulation with the wind usually blowing from the east down the Salt River at night and from the west up the river in the afternoon. Southeast winds are quite common in the late morning, during the transition period between downvalley and upvalley winds. Because wind speeds at Phoenix are normally light, average values never exceeding 8.3 miles per hour, the constancy of wind direction is relatively low, reaching 60 percent or more only in the morning hours of the cooler months. Despite the low average wind speeds, Phoenix holds the official record for the strongest wind gust ever reported in the state. A speed of 75 miles per hour was reached during a thunderstorm on the afternoon of September 18, 1950. The highest daytime windspeeds at Phoenix are reported in the spring. At night, the strongest winds occur in midsummer.

#### **4-06 Storms and Floods.**

**a. Storm Types.** The major portion of the annual rainfall in Arizona is divided between two distinct rainy seasons, the winter season extending from December to March, and the summer season from June until the early part of September. Recorded rainfall indicates that there are three dissimilar types of rainstorms occurring in the state, namely: 1) general winter storms, 2) general summer storms, and 3) local storms.

**1. General Winter Storms.** Storms of this type move inland from the north Pacific Ocean, spreading general light to moderate precipitation over large areas. Although they can occur any time from late October through May, they are most common and generally heaviest from December through early March. These storms frequently last several days and may occur in series with only slight breaks between storms. They usually reflect orographic effects to a great degree, so the mountains of central Arizona often receive from four to ten times as much precipitation from winter storms as do the desert areas near Phoenix. Snow frequently falls in the mountains above 6,000 feet, and occasionally falls at elevations below 3,000 feet. Despite the normal low intensities of precipitation during general winter storms, the large areal extent and the relatively long duration of these storms, sometimes combined with snowmelt from the mountains, can produce substantial volumes of runoff and high peak discharges on the larger rivers of the region.

**2. General Summer Storms.** Storms of this type normally result from a flow of a warm and very moist tropical air into the region from the southeast or south, including the Gulf of California (Sea of Cortez), the Tropical Pacific Ocean south of Baja California, and, to a slight extent, the Gulf of Mexico. Such storms over Arizona are often associated with tropical storms or hurricanes. General summer storms can occur any time from late June through early October. They usually last from one to three days and generally consist of numerous locally heavy storm cells embedded in more widespread, generally light to moderate rain. Like their general winter counterparts, they usually reflect orographic influence, with higher mountains often receiving from three to eight times as much precipitation as do most of the desert areas. Some of the late September and October general storms can show characteristics of both the summer and winter types. The areal extent and duration of general summer storms are usually somewhat less than those of general winter storms, but intensities may be higher. Because infiltration rates are normally higher during the summer than during the winter, runoff volumes are usually lower than the winter events, but the peak flows on intermediate-sized streams may be higher.

**3. Local Storms.** Local storms consist of heavy downpours of rain over relatively small areas (up to about 300 square miles) for short periods of time (up to 7 hours). They are usually accompanied by lightning and thunder, and are often referred to as “thunderstorms” or “cloudbursts”. They can occur at anytime of the year, but are most prevalent and most intense during the summer months, July to September, when

tropical moisture frequently invades Arizona from out of the south and southeast. During the latter part of the summer season, they are often larger, longer in duration, and more apt to be associated with general summer storms. Runoff from local storms is usually of a high peak, low-volume type, affecting mostly the smaller creeks and washes, and is characterized by a rapid rising and receding hydrograph. They can result in serious flash floods, sometimes with loss of life and serious local property damage.

**b. Storms and Floods.** Little is known about the storms and floods in the State of Arizona prior to the late 1800s. Rainfall records and/or historical accounts indicate that sizeable floods occurred on numerous occasions during the early to mid- 1800s. Brief descriptions of several significant events that occurred in central Arizona from as early as the 1890s to the recent times are presented below:

**1. Storms and Floods of 16-28 February 1891.** The floods of late February 1891 were severe on several central Arizona rivers. The February 1891 precipitation totals included 5.96 inches at Prescott, 4.81 inches at Granite Reef Diversion Dam, 3.90 inches at Peoria, and 3.60 inches at Tempe. Virtually all the month's total rain fell in two periods: 16-19 and 22-23 February. The average rainfall depth over the Gila River drainage area above Gillespie Dam during the period 16-23 February is estimated to have been about 4 inches, and the relatively few records available indicate that rainfall and runoff anomalies were greater in central Arizona basins than in the southern parts of the Gila drainage. During the latter part of the first storm and throughout the second, snow, which had fallen in the early portions of the first storm and earlier, melted and combined with the heavy rainfall to produce severe flooding on the major central Arizona rivers. On 25 February the Salt River just downstream of the Verde River confluence reached a stage of 18 feet - 2 inches; the USGS estimated the peak discharge to be 300,000 cfs.

**2. The Storms and Floods of January 1916.** The month of January 1916 produced some of the worst flooding in the history of Arizona. Conditions leading to these floods began in December 1915, when several cold storms dropped heavy snow on the central Arizona mountains. The storm at the end of the month was especially heavy, and the snow level dropped to as low as 3,000 feet. Scattered light precipitation fell 6-11 January 1916, followed by two very heavy storm periods on 14-21 and 25-30 January. The storms of January 1916 swept into southern California from out of the northwest, then curved eastward across Arizona, bringing alternately cool, Pacific air from the west of Canada and warm, tropical air from the southwest of Baja California. Snow levels

during the storms rose to well above 9,000 feet. at times but briefly lowered near the end of each storm period to below 5,000 feet. Throughout most of central Arizona, precipitation during the first storm period was generally heavier by about 50 percent than that during the second storm period. Rainfall over the Agua Fria drainage area above the site of Lake Pleasant from 15 to 19 January 1916 ranged from 3.85 inches at Walnut Grove and 3.98 inches at Prescott to 6.37 inches at Ashdale Ranger Station and approximately 7.5 inches over the mountains east of the river. Nearly 11 inches fell in the Mazatzal Mountains above Modified Roosevelt Dam. Because the ground was saturated from December 1915 storms and the 6-11 January 1916 storm, conditions for maximum runoff were favorable when the late January 1916 storms hit. The heavy rainfall from these storms combined with rapid snowmelt to produce some of the worst floods of record on many Arizona streams.

**3. The Storm and Flood of 16-20 December 1978.** On 16 and 17 December 1978, an upper-level low pressure center west of Baja California combined with a deep low pressure trough dropping southward from the Gulf of Alaska. The circulation around the resulting system brought great quantities of tropical moisture from the equatorial Pacific Ocean northward into Arizona, triggering heavy rainfall throughout most of the state. Total precipitation in central Arizona ranged from less than 2 inches south of Phoenix to 9-10 inches over the higher mountains. Because the major reservoirs had large storages that were carried over from the unusually wet 1977-78 season and the heavy rainfall in November 1978, they filled rapidly during the early stages of the 16-20 December 1978 runoff. Large releases on the Salt and Agua Fria Rivers were necessary before this storm inflow had significantly subsided. The USGS estimated the flow in the Salt River at the Jointhead Dam location in Phoenix reached 140,000 cfs on 19 December.

**4. Storms and Floods of 13-22 February 1980.** The 1979-1980 winter rainfall season was characterized by several series of low latitude storms that moved into Arizona from the west and southwest (similar to those of 1978). The heaviest and most concentrated series occurred from the 13 through 22 February 1980, when six warm, heavy storms moved across the state in rapid succession, bringing unprecedented 10-day rainfall to many areas. Total central Arizona precipitation during the storm period of 13-22 February ranged from less than 2 inches in areas south and west of Phoenix to more than 13 inches in several of the higher mountain regions. Much of the Salt, Verde, and Agua Fria River drainages above the major reservoirs received more than 7 inches. The

USGS estimated the peak discharge in the Salt River at the Jointhead Dam location in Phoenix reached 170,000 cfs on 16 February.

**5. The Storms and Floods of January and February 1993.** From late December 1992 through February 1993, a series of winter storms produced record breaking amounts of precipitation and severe weather across Arizona. At this time the state was in its third consecutive year of above average precipitation, upper watersheds were saturated, and record breaking snowpacks were recorded statewide. Heavy rains in January, estimated at 520 percent of normal, combined with the rapid melting of the snowpack, caused intense runoff, flooding streams and rivers throughout the state. The 15 day period of heavy rain and high flood stages in early January 1993 was one of the most damaging and extensive wet winter periods witnessed in recent times. February 1993 storms followed after a brief respite, bringing precipitation of 400 percent above normal for the month. Streams and rivers statewide, still partially full from January runoff, experienced additional flows for a period of up to 10 days in February. In some areas of the state, the additional runoff caused flooding in areas not affected by the January storms. The peak discharge in the Salt River at Granite Reef Diversion Dam was estimated by the SRP to be 125,000 cfs.

**4-07 Runoff Characteristics.** The Salt River receives water from the mountains to the north and east of the desert proper. Precipitation at higher elevations in the Salt River Basin, as in other arid zones may or may not be reflected in immediate runoff, especially if snow melt proceeds slowly, or if rains are relatively gentle and soils are unsaturated. However, high intensity rainfall, rapid snow melt, or combination of both, almost invariably result in significant runoff.

From its headwaters to Modified Roosevelt Dam, the flow in the upper Salt River is perennial. This flow is controlled by a series of four dams and reservoirs (including Modified Roosevelt Dam) built during the period from 1905 to 1930. Downstream of the reservoir system, streamflow is dependent on releases from the dams. The Salt River contributes an average of seven to ten times the volume of water to the reservoir system as does Tonto Creek. Granite Reef Diversion Dam, located 3 miles downstream of the Salt River and Verde River confluence, and approximately 25 miles east of Phoenix, diverts the entire normal release from of the Verde and Salt River reservoirs for irrigation

of approximately 250,000 acres in the Salt River Valley and for municipal use by the City of Phoenix and other municipalities in the valley.

Plate 4-4 graphically shows the historic annual peak inflow to Modified Roosevelt Dam from 1891 to 1993. Table 4-4 is a tabulation of this data.

**4-08. Water Quality.** There are three USGS water quality stations that provide data that are used to characterize the Theodore Roosevelt Lake water. The station Tonto Creek above Gun Creek, near Roosevelt Arizona is located upstream of Theodore Roosevelt Lake on Tonto Creek and is designated as Station 09499000. The station on the Salt River near Roosevelt, Arizona is located just upstream of Theodore Roosevelt Lake on the Salt River, and is designated as Station 09498500. Station 09502000, also known as Salt River below Stewart Mountain Dam, Arizona, is located on the Salt River downstream of Stewart Mountain Dam.

The data collected at the USGS stations includes pH, specific conductance, temperature (air and water), chemical oxygen demand, coliform, hardness, inorganic salts, alkalinity, solids, nitrogen, phosphorus, and suspended sediment. Organic carbon and phenol concentrations are collected at the Station 09498500. Turbidity, streptococci, and trace metals data are collected at Station 09502000. Chemical oxygen demand data is collected at stations 09498500, and 09499000. Some of the data are collected monthly, and some quarterly and can be obtained from the annual USGS publication entitled "Water Resources Data".

**4-09 Channel and Floodway Characteristics.** Modified Roosevelt Dam which is an integral part of the Salt River system of storage reservoirs, is located east of Phoenix and provides flood control, municipal and irrigation water, and hydropower for central Arizona. Other dams in the Salt River system include Horse Mesa Dam, Mormon Flat Dam, and Stewart Mountain Dam. The reservoir system forms a continuous chain of lakes approximately 60 miles long. Downstream of these reservoirs, Granite Reef Diversion Dam diverts water from the reservoir system (including Horseshoe Dam and Bartlett Dam on the Verde River) into a system of distribution canals.

Downstream of Granite Reef Diversion Dam, the Salt River flows through a metropolitan area, which includes the City of Phoenix and its surrounding suburbs. At the city of Avondale, the Salt River flows into the Gila River. Downstream of the Salt River and Gila River confluence, the Gila River flows through the agricultural region of Maricopa County. Manning "n" values from Granite Reef Diversion Dam to Gillespie Dam vary from 0.028 to 0.150. The average slopes of the Gila River and Salt River from their headwaters to their mouths are 13 and 25 feet per mile, respectively. The average slope of the Salt River from Granite Reef Diversion Dam to its confluence with the Gila River is 9 feet per mile, and the average slope of the Gila River from the Salt River to Gillespie Dam is about 5.5 feet per mile.

Table 4-5 shows the “limiting channel capacities” of the Salt and Gila Rivers from Granite Reef Diversion Dam on the Salt River downstream to Gillespie Dam on the Gila River. The “limiting channel capacity”, in this case, is defined as the maximum channel capacity before a breakout occurs within a specified channel reach. Resulting breakouts shown on the table, however, do not necessarily cause damages to the adjacent flood plain area. Plate 4-5 shows the bridge crossing capacities downstream of Granite Reef Diversion Dam to Gillespie Dam.

**4-10. Upstream Structures.** There are twenty-six reservoirs in the Salt River watershed upstream of Modified Roosevelt Dam having a combined storage capacity of approximately 45,000 ac-ft. The failure of one or more of the upstream dams will have a negligible effect on Modified Roosevelt Dam.

**4-11. Downstream Structures.** The major projects located in the Salt, Verde and Gila River systems that directly or indirectly affect the regulation of Modified Roosevelt Dam are discussed as follows:

**a. The Salt River Project Reservoir System.** The Salt River Project reservoir system in central Arizona provides a major part of the water supply for much of the metropolitan Phoenix area. Hydroelectric power is also generated by the reservoirs on the Salt River. The reservoir system comprises six reservoirs on the Salt and Verde Rivers, including Modified Roosevelt Dam, and a diversion dam located 3 miles downstream of the Salt River and Verde River confluence. A combined watershed of

more than 13,000 square miles drains to these reservoirs. Modified Roosevelt Dam is the oldest and has the largest reservoir storage. The other dams in the system are:

**1. Horse Mesa Dam (Apache Lake)** - is a concrete thin arch dam located on the Salt River downstream of Modified Roosevelt Dam. Horse Mesa Dam was constructed by SRP from 1924 to 1927. It is operated by the SRP for irrigation and power generation. The dam has a drainage area of 5,935 square miles, and the reservoir has a total storage capacity of 245,000 ac-ft.

**2. Mormon Flat Dam (Canyon Lake)** - is a concrete thin arch dam located on the Salt River downstream of Horse Mesa Dam. Mormon Flat Dam was completed in 1926. The dam has a drainage area of 6,095 square miles and a total reservoir storage of 58,000 ac-ft. Mormon Flat Dam is operated by the SRP for irrigation and power generation purposes.

**3. Stewart Mountain Dam (Saguaro Lake)** - is a concrete thin arch structure located downstream of Mormon Flat Dam. The dam was completed in 1930. Stewart Mountain Dam is operated by the SRP to supply municipal and irrigation water to the Phoenix area. The dam has a drainage area of 6,221 square miles and the reservoir has a total capacity of 70,000 ac-ft. Stewart Mountain Dam was modified between 1988 and 1992 for dam safety purposes.

**4. Horseshoe Dam (Horseshoe Lake)** - is an earthen rockfill structure located on the Verde River 58 miles northeast of Phoenix. The dam was originally constructed by Phelps-Dodge Corporation between 1944 and 1946. Horseshoe Dam has a drainage area of approximately 5,657 square miles and is operated by the SRP for irrigation purposes. In 1993, the dam was modified by the USBR for dam safety purposes. The modified dam has a structural height of 202 feet and a total reservoir capacity of approximately 131,000 ac-ft.

**5. Bartlett Dam (Bartlett Lake)** - is a concrete multiple arch dam originally constructed by the USBR between 1936 and 1939 to provide additional storage capacity for the SRP and the Salt River Indian Community. Bartlett Dam has a drainage area of 5,851 square miles. In 1994, the modification of Bartlett Dam for dam safety purposes began. The modified dam has a structural height of 308.5 feet, and a maximum reservoir capacity of 249,700 ac-ft including

surcharge storage (total reservoir capacity for active conservation remains unchanged at approximately 178,000 ac-ft). The modified dam has a maximum spillway capacity of 546,400 cfs and outlet works capacity of 2,600 cfs. The modification of Bartlett dam was completed in the latter part of 1996.

**6. Granite Reef Diversion Dam** - is located 3 miles downstream of the Salt River and Verde River confluence. The dam is used to divert water from the storage system into a network of distribution canals. It has essentially no storage capacity.

**b. Other Projects.** Other projects on the Gila River system that directly or indirectly influence the operation of Modified Roosevelt Dam include the following:

**1. Painted Rock Dam** - was built by the COE for flood control purposes. Completed in 1960, Painted Rock Dam is located on the Gila River, approximately 126 miles from its confluence with the Colorado River. Painted Rock Dam has a drainage area of 50,800 square miles and its reservoir has a total capacity of approximately 2.5 million ac-ft.

**2. Coolidge Dam (San Carlos Lake)** - is a multiple dome reinforced concrete dam, originally constructed between January 1927 and November 1928 as part of the San Carlos Irrigation Project. The dam is located approximately 90 miles east of Phoenix in Gila and Pinal Counties. The dam has a drainage area of approximately 12,900 square miles. It is owned and operated by the Bureau of Indian Affairs for irrigation and power generation purposes. Beginning in 1992, the dam underwent modifications for dam safety purposes. The dam has a structural height of 251 feet, and the reservoir has a total storage capacity of 1,100,000 ac-ft at spillway crest.

**3. New Waddell Dam (Lake Pleasant)** - is an earthfill dam located on the Agua Fria River, approximately 35 miles northwest of Phoenix. The dam is owned by the USBR and is maintained and operated by the Central Arizona Water District for irrigation purposes. The dam has a drainage area of 1,459 square miles. The original dam was constructed in 1927 as part of an extensive effort to develop the scarce water resources of Central Arizona. Originally named Lake Pleasant Dam, the project was the largest multiple arch dam in the

world upon its completion. In 1985, construction of a new dam called New Waddell Dam began. The construction of New Waddell Dam included the breaching of the original dam. The new dam is located approximately one-half mile downstream of the original dam. The dam is operated to store Agua Fria River runoff, and provides incidental flood protection. It has a total storage capacity of 1,108,000 ac-ft.

**4-12 Economic Data.** The area that directly benefits from Modified Roosevelt Dam includes the Salt River Project System, the Phoenix Metropolitan area, three Indian reservations, and the agricultural region of Maricopa County located along the Gila and Salt Rivers. These areas contain over 50 percent of Arizona's total population.

**a. Population.** Phoenix and Maricopa County are the largest city and county in the State of Arizona. This region has experienced intensive growth over the past forty-five years. The cities in the suburbs of Phoenix such as Tempe, Chandler, Mesa, and Scottsdale have all experienced this intensive population growth. The Indian reservations of Fort McDowell, Salt River, and Gila River had some population growth; however, compared with the total population, it is small.

The population of Maricopa County has increased by 64 percent since the 1970's, from the 1970 population of 1,297,000 to 2,132,975 in 1990. The population is projected to grow to 2,801,000 by the year 2000 representing an increase of 668,025. The growth is supported by commercial and industrial developments. Maricopa County is expected to shift from an agricultural to a major industrial region.

The metropolitan Phoenix area has a population density close to 2,411 per square mile compared to a county density of 240 per square mile. The City of Tempe is home of the Arizona State University and has the highest population density of 3,598 per square mile. The metropolitan Phoenix area includes downtown Phoenix, interstate highways, and the Sky Harbor International Airport.

A list of population by city in Maricopa County is shown on Table 4-6a. The population data for 1990 was taken from the U.S. Census of 1990. The population data for 1978 was taken from the Salt-Gila Flood Control Study of 1980. The suburban cities

have increased their populations more than the city of Phoenix since 1978. In Chandler and Scottsdale, population rose by 277 percent and 53 percent, respectively since 1978.

The agricultural regions and the Indian reservations are sparsely populated and some areas are uninhabited.

**b. Agriculture.** Maricopa County's economy started in the 1870s with farmers diverting water from the Salt River and Gila River to support agriculture in the region. Agriculture has been the impetus for the development of the county's economy during the past century. In the past thirty years, however, the industrialization of the metropolitan Phoenix area reduced the amount of agricultural land. The total value of agricultural products in Maricopa County actually decreased from \$689,537,000 in 1990 to \$589,387,000 in 1993. In addition, the number of cattle farms decreased from 181 in 1990 to 166 in 1993. Yet, Maricopa County is still a major agricultural region in the US, producing diverse crops, including wheat, barley, corn, hay, lettuce, cauliflower, broccoli, melons, potatoes, fruits, wool, and livestock including pork and beef, and other by-products. A detailed list of the total production of agricultural products grown in the county is found on Table 4-6b.

**c. Industry.** Maricopa County is a major economic center in the southwest. The county's dry climate has attracted businesses from different parts of the country. Throughout the 1980s major corporations in the service industry located their headquarters in the county. Leading sectors in the economy are manufacturing, services, retail trade, and tourism. Major products include aircraft parts, chemicals, leather goods, air conditioning equipment, and industrial products. Among Maricopa County's largest corporations are Motorola, Sperry, and Garrett Turbine.

The county per capita income of \$18,468 is the highest of any county in Arizona. The total non-farm income was in excess of \$26B in 1991. The county's total value of non-residential construction was more than \$420M in 1991. Table 4-6c lists the percentages of labor force in Maricopa County.

The county's transportation system is vital to its strong economy. The county had well over 1.7 million vehicles driving on 2,954 miles of public road in 1987. The transportation of goods was aided by 348 motor freight carriers and three rail carriers. The Phoenix Sky Harbor International Airport serves air travelers and freight.

**d. Flood Damages.** The report entitled "Study for Flood Control Alternatives for Cliff Dam", dated October 1988 was used for the determination of flood benefits for Modified Roosevelt Dam. The study reflects recent changes to the Salt and Gila Rivers, including: 1) channel clearing on the Gila River from 91st Avenue to Bullard Avenue, 2) new levees (35th Avenue to 51st Avenue, and 113th Avenue to 123rd Avenue), 3) two new bridges (7th Avenue and the I-10), 4) channel excavation and filling associated land with new industrial developments through metropolitan Phoenix, and 5) the Tempe Channel from Mill Avenue to the I-10.

The total acres that will be inundated in the area downstream of Modified Roosevelt Dam by selected flow magnitudes are listed in Table 4-6d. From Granite Reef Dam to the Phoenix International Raceway (PIR), the area includes residential development from the suburbs and relatively undeveloped land on indian reservations. In the Phoenix area, the floodplain includes a highly developed area of residential, industrial, and commercial uses. Along the Gila River (downstream of the PIR), the flood plain includes scattered residential and industrial uses and considerable agricultural areas.

**Table 4-1a**  
**Sediment Surveys and Results**  
**Modified Roosevelt Dam Water Control Manual**

Date of Survey	Period Between Surveys (yrs)	Storage Capacity* (ac-ft)	Difference Between Surveys (ac-ft)	Average Annual Sediment Accumulation for Period (ac-ft/sq-mi/yr)**	Sediment Inflow (ac-ft/yr)
MAY 1909	(Original)	1,530,499	(n/a)	(n/a)	(n/a)
DEC 1914	5.7	1,495,460	35,039	1.054	6,147
OCT 1916	1.8	1,460,150	35,310	3.365	19,616
SEP 1925	8.9	1,425,813	34,337	0.662	3,858
JAN 1935	9.3	1,418,013	7,800	0.144	839
JAN 1939	4.0	1,398,430	19,583	0.840	4,896
JAN 1946	7.0	1,381,580	16,850	0.413	2,407
SEP 1981	35.7	1,336,734	44,846	0.215	1,256
APR 1995	13.5	1,348,314	(see ***)	(see ***)	(see ***)
TOTAL (1909-1985)***	72.4	(n/a)	193,765	0.459	2,676

\* Up to elevation 2136 ft, m.s.l. (the top of the original spillway gates).

\*\* Computation based on a drainage area of 5,830 sq-mi.

\*\*\* The increased intensity of the bathymetric survey (used for the 1995 survey) along with the increased map detail, resulted in lower sediment deposit estimates for 1995 when compared to the 1981 survey results. Data used in this table (except for the 1995 survey results) was taken from source 3 below. Apr 1995 survey data was taken from source 4 below.

- SOURCES:**
1. *Hydrology Report - Gila River and Tributaries, Central Arizona Water Control Study, May 1982.*
  2. *Theodore Roosevelt Dam Modifications and New Roosevelt Power Plant - Engineering Specifications Design Data, Arizona Project Office, USBR, April 1987.*
  3. *Theodore Roosevelt Lake, 1981 Sedimentation Survey, Denver, CO, USBR, Sep 1982.*
  4. *Theodore Roosevelt Reservoir, 1995 Sedimentation Survey, Denver CO, USBR, May 1996*

**Table 4-1b**  
**Summary of 1995 Survey and Sediment Distribution Computations**  
**Modified Roosevelt Dam Water Control Manual**

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Elevation ft	Original area acres	Original Capacity ac-ft	1995 Area acres	1995 Capacity ac-ft	Computed Sediment Volume ac-ft	Percent of Computed Sediment (%)
2220			32,221	3,496,484		
2210			30,614	3,182,584		
2200			29,053	2,884,154		
2190			27,402	2,601,879		
2180			25,753	2,336,067		
2170			24,163	2,086,387		
2160			22,723	1,852,129		
2150			21,351	1,631,622		
2140			19,746	1,425,957		
2136	17,785	1,530,499	19,075	1,348,314	182,185	100
2130	17,203	1,425,512	18,000	1,237,049	188,463	103.5
2120	16,177	1,258,547	16,356	1,065,544	193,003	105.9
2110	15,095	1,102,215	14,831	909,867	192,348	105.6
2100	14,104	956,455	13,579	767,887	188,568	103.5
2090	13,247	819,272	12,194	638,669	180,603	99.1
2080	11,939	693,315	10,769	524,050	169,265	92.9
2070	10,638	580,590	9,396	423,232	157,358	86.4
2060	9,482	479,928	7,979	336,245	143,683	78.9
2050	8,262	391,207	6,714	262,987	128,220	70.4
2040	7,106	314,623	5,581	202,025	112,598	61.8
2030	6,216	248,009	4,954	149,442	98,567	54.1
2020	5,286	190,334	4,273	103,035	87,229	47.9
2010	4,264	142,903	3,440	64,357	78,546	43.1
2000	3,544	103,787	2,198	36,147	67,640	37.1
1990	2,744	72,347	1,211	19,850	52,497	28.8
1980	1,859	48,867	927	9,120	39,747	21.8
1970	1,428	31,935	551	1,850	30,085	16.5
1960	1,020	19,743			19,743	10.8
1950	677	11,328			11,328	6.2
1940	419	5,893			5,893	3.2
1930	227	2,735			2,735	1.5
1920	117	1,059			1,059	0.6
1910	52	211			211	0.1
1902	0	0			0	0.0

*Explanation of Columns:*

- (1) Elevation of reservoir water surface
- (2) Original reservoir surface area. Roosevelt Dam was modified, which raised the top of dam elevation to 2218 ft.
- (3) Original reservoir capacity. The modification increased the capacity to 3,432,408 ac-ft.
- (4) Reservoir surface area determined from 1995 survey
- (5) Reservoir capacity taken from 1995 survey
- (6) Accumulated sediment volume= (3) - (5)
- (7) Meas. sediment expressed as a % of total measured sediment.

Source: Theodore Roosevelt Reservoir, 1995 Sedimentation Survey, USBR, May 1996

**Table 4-2a**  
**Climatological Summary at Alpine, Arizona**  
**Modified Roosevelt Dam Water Control Manual**

ALPINE

MEAN PERIOD 1941 - 1970

EXTREMES FOR PERIOD 1931 - 1972

LATITUDE 33° 51'

LONGITUDE 109° 08'

0159

ELEVATION 8050 ft

Month	Temperature (°F)							Mean Degree days**	Precipitation Totals (in)					Estimated Mean Rel. Humidity (percent)		Mean Number of Days				Month		
	Means			Extremes					Mean	Greatest Daily	Year	Snow, Sleet, Hail			0600 MST	1800 MST	Precip. .10 in or more	Temperatures				
	Daily Max.	Daily Min.	Monthl y	Record Highest	Year	Record Lowest	Year					Mean	Max. Monthl y	Year				0600 MST	1800 MST		Max.	
															90° and above	32° and below		32° and below	0° and below			
(A)	27	27	27	35		35		18	30	37		28	37			29	20	21	19	21	(A)	
JAN	45.8	10.4	28.1	72	1967	-30	1971	1111	1.49	2.00	1949	14.8	78.4	1949	68	62	5	0	2	31	7	JAN
FEB	47.3	12.6	30.3	72	1967	-28	1948	978	0.96	1.33	1937	11.6	43.1	1948	69	59	5	0	1	28	4	FEB
MAR	50.8	16.9	33.9	72	1971	-25	1948	942	1.13	1.60	1954	11.6	36.3	1948	64	53	5	0	1	30	1	MAR
APR	60.4	22.1	41.3	79	1962*	-6	1949	704	0.58	1.70	1939	2.8	11.6	1949	55	43	3	0	0	27	+	APR
MAY	68.6	27.0	47.8	85	1956*	8	1950	512	0.42	0.68	1957	0.5	5.0	1969*	53	36	2	0	0	24	0	MAY
JUN	77.3	34.6	56.0	92	1955*	13	1971	252	0.78	2.00	1937	0.1	2.0	1945	56	36	3	+	0	10	0	JUN
JUL	78.6	44.1	61.4	91	1958*	29	1941	106	3.43	1.66	1957	T	T	1952*	74	68	12	+	0	+	0	JUL
AUG	75.8	42.9	59.4	88	1958	29	1954*	162	3.95	2.25	1969	T	T	1954*	84	73	12	0	0	+	0	AUG
SEP	73.0	35.0	54.0	87	1950*	17	1955*	317	2.19	2.23	1941	T	T	1949*	76	57	7	0	0	12	0	SEP
OCT	65.0	26.7	45.9	82	1965	5	1949*	575	1.91	2.83	1962	0.5	14.0	1961	66	54	5	0	0	26	0	OCT
NOV	54.8	16.4	35.6	77	1944	-18	1952	862	0.91	2.00	1931	4.7	36.0	1931	62	58	3	0	+	29	1	NOV
DEC	48.4	11.8	30.1	72	1958	-28	1949	1050	1.58	1.95	1967	13.7	63.0	1967	69	63	4	0	1	31	3	DEC
YEAR	62.2	25.0	43.6	92	JUN 1955*	-30	JAN 1971	7571	19.33	2.83	OCT 1962	60.3	78.4	JAN 1949	66	55		+	5	248	16	YEAR

Key To Symbols:

\* record equaled in earlier dates, months, or years.

(A) average length of record, years.

+ less than one hour.

> amount accumulated in following monthly total.

\*\* base for degree day data is 65 degrees Fahrenheit.

T trace, an amount too small to measure.

M average temperature missing on one through nine days during the month.

E estimated.

SOURCE: Arizona Climate, 1931 - 1972, Sellers and Hill

**Table 4-2b**  
**Climatological Summary at McNary, Arizona**  
**Modified Roosevelt Dam Water Control Manual**

MCNARY

MEAN PERIOD 1941 - 1970

EXTREMES FOR PERIOD 1933 - 1972

LATITUDE 34° 04'

LONGITUDE 109° 51'

ELEVATION 7320 ft

5412

Month	Temperature (°F)								Mean Degree days**	Precipitation Totals (in)					Estimated Mean Rel. Humidity (percent)		Mean Number of Days				Month	
	Means			Extremes						Mean	Greatest Daily	Year	Snow, Sleet, Hail			Precip. .10 in or more	Temperatures					
	Daily Max.	Daily Min.	Monthl y	Record Highest	Year	Record Lowest	Year	Mean					Max. Monthl y	Year	Max.		Min.					
															90° and above		32° and below	32° and below	0° and below			
(A)	29	30	29	38		38	18	30	38		29	37			29	22	22	22	22	(A)		
JAN	44.3	16.0	30.2	67	1969	-23	1949	1060	2.29	2.95	1952	21.2	70.5	1937	60	62	6	0	4	30	3	JAN
FEB	46.1	18.1	32.1	69	1963*	-18	1939	931	1.69	2.00	1937	18.0	52.0	1948	64	67	5	0	3	28	2	FEB
MAR	50.0	21.7	35.9	74	1971	-13	1951	894	2.53	4.41	1954	22.1	54.0	1952	61	56	6	0	1	29	1	MAR
APR	50.7	27.9	43.8	80	1962*	0	1949	631	1.30	1.18	1935	7.3	27.6	1941	54	51	4	0	+	23	+	APR
MAY	69.0	33.8	51.4	89	1952	8	1950	399	0.56	1.45	1937	0.9	11.0	1969	49	43	2	0	0	13	0	MAY
JUN	78.1	40.7	59.4	93	1937	20	1950	153	0.58	1.41	1955	T	1.0	1945	54	50	2	1	0	3	0	JUN
JUL	80.5	49.1	64.8	94	1971*	30	1935	41	3.45	1.55	1961	T	T	1954*	72	74	11	1	0	0	0	JUL
AUG	77.5	48.1	62.8	91	1962*	32	1956	75	3.95	2.40	1951	T	T	1954*	75	72	12	+	0	+	0	AUG
SEP	74.4	41.6	58.0	89	1948	21	1945	206	2.15	2.65	1970	T	T	1961*	69	63	6	0	0	2	0	SEP
OCT	65.6	32.6	49.1	83	1972	6	1971	475	2.08	2.78	1959	2.4	27.0	1971	62	61	4	0	0	17	0	OCT
NOV	53.6	23.4	38.5	73	1967	-3	1952*	785	1.57	2.00	1965	8.4	38.5	1952	55	57	4	0	1	27	+	NOV
DEC	46.5	18.2	32.4	70	1950	-18	1945	999	2.75	4.43	1967	21.8	61.0	1967	63	65	5	0	3	30	1	DEC
YEAR	62.1	30.9	46.5	94	JUL 1971*	-23	JAN 1949	6649	24.90	4.43	DEC 1967	102.1	70.5	JAN 1937	62	60	67	2	12	202	7	YEAR

Key To Symbols:

\* record equaled in earlier dates, months, or years.

(A) average length of record, years.

+ less than one hour.

> amount accumulated in following monthly total.

\*\* base for degree day data is 65 degrees Fahrenheit.

T trace, an amount too small to measure.

M average temperature missing on one through nine days during the month.

E estimated.

SOURCE: Arizona Climate, 1931 - 1972, Sellers and Hill

**Table 4-2c**  
**Climatological Summary at Roosevelt 1 WNW, Arizona**  
**Modified Roosevelt Dam Water Control Manual**

ROOSEVELT 1 WNW

MEAN PERIOD 1941 - 1970

EXTREMES FOR PERIOD 1931 - 1972

LATITUDE 33° 40'

LONGITUDE 111° 09'

7281

ELEVATION 2205 ft

Month	Temperature (°F)								Mean Degree days**	Precipitation Totals (in)						Estimated Mean Rel. Humidity (percent)		Mean Number of Days				Month	
	Means			Extremes						Mean	Greatest Daily	Year	Snow, Sleet, Hail			0600 MST	1800 MST	Precip. .10 in or more	Temperatures				
	Daily Max.	Daily Min.	Monthl y	Record Highest	Year	Record Lowest	Year	Mean					Max. Monthl y	Year	90° and above				32° and below	32° and below	0° and below		
																							Max.
(A)	30	30	30	42		42		16	30	25		23	25				23	23	22	22	22	(A)	
JAN	58.9	37.0	48.0	80	1951	19	1963	527	1.78	1.58	1957	T	T	1960*	55	48	4	0	0	7	0	JAN	
FEB	65.6	39.9	52.3	87	1951	23	1933	362	1.11	1.51	1965	0.0	0.0		56	43	3	0	0	3	0	FEB	
MAR	69.7	44.2	57.0	92	1966	27	1971	240	1.56	2.62	1954	0.5	12.1	1951	48	36	3	+	0	1	0	MAR	
APR	79.5	52.3	65.9	100	1949	34	1933	69	0.61	1.05	1952	0.0	0.0		37	28	2	3	0	0	0	APR	
MAY	89.0	60.9	75.0	110	1958	38	1968	8	0.24	0.53	1969	0.0	0.0		32	22	1	17	0	0	0	MAY	
JUN	98.2	69.3	83.8	113	1970*	52	1961	0	0.25	1.33	1955	0.0	0.0		30	23	1	28	0	0	0	JUN	
JUL	102.1	75.9	89.0	116	1949	57	1946	0	1.30	2.1.	1967	0.0	0.0		43	34	4	30	0	0	0	JUL	
AUG	99.3	73.6	86.5	113	1964	58	1964	0	1.93	2.23	1963	0.0	0.0		58	43	5	30	0	0	0	AUG	
SEP	95.4	68.2	81.8	115	1950	45	1945	0	1.43	2.44	1940	0.0	0.0		51	38	2	25	0	0	0	SEP	
OCT	84.2	57.4	70.8	100	1961*	34	1971	23	0.97	4.00	1959	0.0	0.0		47	41	2	9	0	0	0	OCT	
NOV	70.7	45.3	57.7	90	1950	23	1969	232	0.95	1.63	1968	0.0	0.0		47	44	2	+	0	1	0	NOV	
DEC	60.1	38.7	49.4	79	1958	25	1968*	483	2.02	2.60	1965	T	T	1967	56	51	4	0	+	5	0	DEC	
YEAR	80.9	55.2	68.1	116	JUL 1949	19	JAN 1963	1944	14.15	4.00	OCT 1959	0.5		MAR 1951	46	38	33	142	+	17	0	YEAR	

**Key To Symbols:**

- \* record equaled in earlier dates, months, or years.
- (A) average length of record, years.
- + less than one hour.
- > amount accumulated in following monthly total.

- \*\* base for degree day data is 65 degrees Fahrenheit.
- T trace, an amount too small to measure.
- M average temperature missing on one through nine days during the month.
- E estimated.

**SOURCE: Arizona Climate, 1931 - 1972, Sellers and Hill**

**Table 4-2d**  
**Climatological Summary at Whiteriver, Arizona**  
**Modified Roosevelt Dam Water Control Manual**

WHITERIVER

MEAN PERIOD 1941 - 1970

EXTREMES FOR PERIOD 1931 - 1972

LATITUDE 33° 50'

LONGITUDE 109° 58'

ELEVATION 5280 ft

0159

Month	Temperature (°F)								Mean Degree days**	Precipitation Totals (in)					Estimated Mean Rel. Humidity (percent)		Mean Number of Days				Month		
	Means			Extremes						Mean	Greatest Daily	Year	Snow, Sleet, Hail			0600 MST	1800 MST	Precip. .10 in or more	Temperatures				
	Daily Max.	Daily Min.	Monthl y	Record Highest	Year	Record Lowest	Year	Mean					Max. Monthl y	Year	90° and above				32° and below	32° and below		0° and below	
																							Max.
(A)	30	30	30	35		35		16	30	32		29	35				29	23	22	22	22	(A)	
JAN	52.7	22.0	37.4	75	1950	-13	1949	851	1.47	2.39	1956	5.9	27.9	1960									JAN
FEB	56.2	25.1	40.7	78	1963*	-6	1948	693	1.06	0.97	1963	304	13.5	1956									FEB
MAR	59.9	29.5	44.7	80	1943*	5	1953	624	1.59	2.00	1954	407	35.5	1952									MAR
APR	69.1	36.1	52.6	90	1943	15	1945	392	0.74	0.85	1968	0.4	3.0	1941									APR
MAY	78.7	43.5	61.1	98	1942	22	1953	158	0.33	0.99	1947	0.1	1.5	1950									MAY
JUN	88.4	51.1	69.8	102	1950*	33	1950*	20	0.45	1.67	1954	0.0	.0										JUN
JUL	91.5	58.9	75.2	106	1958*	46	1931	0	2.59	1.74	1961	T	T	1954*									JUL
AUG	88.1	57.3	72.7	101	1960*	42	1941	1	3.49	2.25	1961	T	T	1955									AUG
SEP	84.8	51.6	68.2	101	1948	31	1961	31	1.72	2.25	1958	0.0	0.0										SEP
OCT	75.2	40.8	58.0	93	1950	17	1970	228	1.37	2.91	1972	0.2	4.2										OCT
NOV	63.3	29.4	46.4	82	1949	-7	1931	553	1.01	1.73	1940	0.8	14.2										NOV
DEC	54.9	23.4	39.2	79	1942	-6	1968	787	1.53	1.30	1965	5.5	20.1										DEC
YEAR	71.9	39.1	55.5	106	JUL 1958*	-13	JAN 1949	4338	17.35	2.91	OCT 1972	21.0	35.5	MAR 1952									YEAR

Key To Symbols:

- \* record equaled in earlier dates, months, or years.
- (A) average length of record, years.
- + less than one hour.
- > amount accumulated in following monthly total.

- \*\* base for degree day data is 65 degrees Fahrenheit.
- T trace, an amount too small to measure.
- M average temperature missing on one through nine days during the month.
- E estimated.

SOURCE: Arizona Climate, 1931 - 1972, Sellers and Hill

**TABLE 4-3**  
**Evaporation and Total Wind Movement at Selected Stations**  
**Modified Roosevelt Dam Water Control Manual**

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
EVAPORATION (INCHES) AT McNARY, ARIZONA													
1968					8.58	9.67	7.29	5.24	5.50	4.94	2.80		
1969					7.79	8.83	5.95	6.11	5.13	5.01			
1970					8.53	8.77	6.91	5.16	4.98	3.16			
1971					8.10	8.51	7.30	5.44	4.99				
1972					8.55	6.68	7.55	6.18	4.41	2.75			
1973						7.19	7.09	5.68	6.19				
AVG.					8.31	8.28	7.02	5.64		3.96	2.80		
TOTAL WIND MOVEMENT (MILES) AT McNARY, ARIZONA													
1968					1544	944	496	344	525	621	830		
1969					857	598	472	362	299	758			
1970					1232	930	589	438	505	565			
1971					1122	761	585	439	537				
1972					707	317	311	273	184	246			
1973						607	215	360	453	548			
AVG.					1092	693	445	369	417		830		
EVAPORATION (INCHES) AT ROOSEVELT 1 WNW, ARIZONA													
1963	1.87	3.60	6.19	8.38	12.95	15.22	17.23	10.36	8.32	6.65	3.15	2.14	96.08
1964	2.57	4.08	5.77	9.32	13.50	15.20	14.54	11.51	10.13	7.79	3.56	2.13	100.10
1965	2.17	3.30	5.08	7.39	11.71	14.06	14.47	14.41	10.19	7.40	3.55	1.61	95.34
1966	2.03	3.11	5.34	9.15	14.40	15.15	15.64	13.61	9.17	6.19	3.62	2.20	99.61
1967	2.17	4.36	6.57	8.75	11.91	14.92	14.56	12.65	10.58	8.22	3.89	2.47	101.05
1968	2.36	3.82	4.86	7.90	12.47	15.25	13.89	10.87	10.54	6.87	3.46	2.32	94.61
1969	1.98	2.93	5.20	9.17	11.56	15.57	14.13	12.01	9.86	7.09	3.64	2.08	95.22
1970	2.48	3.67	5.76	8.86	13.78	16.19	15.12	12.28	9.37	6.24	3.76	1.73	99.24
1971		4.63	7.41	10.15	12.95	15.68	17.29	10.97	10.34	5.79	2.73	1.73	
1972	2.30	4.03	8.29	10.47	13.49	14.35	16.77	12.99	10.45	5.36		4.32	
1973	1.99	2.45	4.23	7.33	10.59	13.58	13.55	12.50	10.85				
AVG.	2.19	3.63	5.88	8.81	12.66	15.02	15.18	12.20	9.98	6.76	3.48	2.27	90.06
TOTAL WIND MOVEMENT (MILES) AT ROOSEVELT 1 WNW, ARIZONA													
1963	923	843	1899	2470	1426	2484	2500	1050	700	910	980	770	16955
1964	1260	1780	2110	2560	2790	2630	2530	2600	2090	1350	1190	1120	24010
1965	1040	1240	1610	1790	2280	2180	2040	2480	1830	1180	790	1220	19680
1966	1375	1486	1392	1927	2097	2083	2315	2248	1269	1222	951	1211	19576
1967	965	1434	1870	2535	2560	3170	2778	2272	2227	1581	1232	2382	25006
1968	1393	1325	1530	2207	2196	2035	2392	1649	1446	1143	1306	1481	20103
1969	1010	1115	1920	2215	1734	2816	2415	1903	1677	1786	1868	1198	21657
1970	1196	1326	2104	2372	2044	2560	2319	1934	1708	1484	1033	715	20795
1971	891	1839	1984	2553	2842	2549	2876	2440	1595	1442	841	1432	23284
1972	1067	1150	1839	2160	2335	2157	2689	2118	1715	1223		1310	
1973	1261	1008	1293	1769	1550	1528	1803	1686	1278				
AVG.	1126	1322	1777	2233	2169	2381	2423	2035	1594	1332		1284	20808
EVAPORATION (INCHES) AT WHITERIVER, ARIZONA													
1967											3.99		
1968					4.86	6.63	10.58	12.88	9.48	7.48	8.72	7.06	3.56
1969		3.43			4.88	9.22	9.72	12.95	10.39	8.26	7.63	6.13	2.98
1970					4.36	7.57	11.93	13.12	10.31	8.79	7.98	5.52	4.60
1971					7.32	9.08	11.12	13.12	10.55	7.09	7.72	3.82	3.12
1972					7.72	9.96	11.78	10.75	11.04	8.82	7.68	4.28	2.50
1973					8.55	6.96	8.32	9.80	9.51	8.65	9.34		
AVG.		3.43			5.91	8.24	10.58	12.10	10.21	8.18	8.18	5.63	3.46
TOTAL WIND MOVEMENT (MILES) AT WHITERIVER, ARIZONA													
1967											1811		
1968					2236	2378	2283	2263	1970	1740	2020	1958	1694
1969		1910			2307	2507	1910	2405	1929	1578	1705	2032	1771
1970					2258	2294	2434	2025	1277	1506	1911	2011	1968
1971					2731	2448	2420	2148	1159	1159	1032	1312	1394
1972					2355	2349	2137	1823	1628	1391	1461	1353	1402
1973						2108	1431	1091	1211	1352	1431		
AVG.		1910			2377	2347	2102	1959	1603	1454	1593	1733	1673

SOURCE: ARIZONA CLIMATE 1931 - 1972, SELLERS AND HILL, REVISED-2ND EDITION.

**Table 4-4  
Historic Annual Peak Inflow to Roosevelt Lake  
Modified Roosevelt Dam Water Control Manual**

Year	Peak Inflow <sup>1</sup> (cfs)	Year	Peak Inflow <sup>1</sup> (cfs)	Year	Peak Inflow <sup>1</sup> (cfs)	Year	Peak Inflow <sup>1</sup> (cfs)
1889	27500	1916	128870	1943	29050	1970	57690
1890	105000	1917	42590	1944	4940	1971	13870
1891	194340	1918	12590	1945	6470	1972	34230
1892	8000	1919	26350	1946	20240	1973	83760
1893	29000	1920	102000	1947	8020	1974	4710
1894	1900	1921	27750	1948	6570	1975	13340
1895	70000	1922	24140	1949	19120	1976	40200
1896	18000	1923	24550	1950	6450	1977	11030
1897	27000	1924	75000	1951	51300	1978	155000
1898	10800	1925	10130	1952	142780	1979	152300
1899	13000	1926	44650	1953	5770	1980	142130
1900	8000	1927	61000	1954	47820	1981	5130
1901	5500	1928	4840	1955	17400	1982	24680
1902	14900	1929	17530	1956	2680	1983	35910
1903	14000	1930	13730	1957	19070	1984	67100
1904	27000	1931	35860	1958	30620	1985	58150
1905	68000	1932	69770	1959	16830	1986	16710
1906	145000	1933	5370	1960	95200	1987	10150
1907	50100	1934	6450	1961	14280	1988	30880
1908	46000	1935	17290	1962	9840	1989	8030
1909	46000	1936	17090	1963	43110	1990	7260
1910	M.D. <sup>2</sup>	1937	112100	1964	13900	1991	106380
1911	M.D. <sup>2</sup>	1938	40790	1965	24970	1992	29510
1912	M.D. <sup>2</sup>	1939	10230	1966	88000	1993	194000
1913	M.D. <sup>2</sup>	1940	4980	1967	11190	Footnotes: 1. From entire drainage area. 2. M.D. - Missing data.  Source: Section 7 Study For Modified Roosevelt Dam, Arizona - Hydrologic Evaluation of Water Control Plans Salt River Project to Gila River at Gillespie Dam - March 1996	
1914	15940	1941	144180	1968	25660		
1915	73780	1942	6210	1969	16780		

**TABLE 4-5**  
**Limiting Channel Capacities<sup>1</sup> for Salt River and Gila River**  
**(From Gillespie Dam to Granite Reef Dam)**  
**Modified Roosevelt Dam Water Control Manual**

Channel Capacity Reach miles above the Colorado-Gila River Confluence)	Limiting Channel Capacity <sup>1</sup> (in specified reach) (cfs)	First Breakout <sup>2</sup> Location Station	
		Left Bank	Right Bank
<b>Gillespie Dam</b>			
166.60 - 167.52	10,000	167.52	
167.52 - 168.20	10,000		167.62
168.20 - 168.63	6,000		168.63
168.63 - 169.80	30,000	169.07	
169.80 - 169.89	5,000	169.84	
169.89 - 173.28	10,000		172.79
173.28 - 173.65	5,000	173.37	
173.65 - 175.17	12,000	174.47	
175.17 - 175.45	6,000		175.25
175.45 - 176.30	20,000		175.53
176.30 - 178.55	8,000		177.58
178.55 - 179.11	50,000	178.77	178.77
179.11 - 179.34	6,000		179.20
179.34 - 180.02	20,000		179.91
<b>HWY 85 Bridge</b>	245,000		
180.02 - 180.06	20,000		180.05
180.06 - 180.29	20,000		180.18
180.29 - 181.72	50,000	180.94	
181.72 - 182.20	30,000		181.99
182.20 - 182.83	50,000		182.56
182.83 - 183.02	30,000		182.92
183.02 - 183.18	80,000		183.11
183.18 - 183.32	90,000		183.31
183.32 - 183.45	80,000		183.39
183.45 - 185.19	130,000		185.00
185.19 - 185.85	90,000		185.71
185.85 - 186.26	70,000		186.00
186.26 - 187.30	90,000		186.55
187.30 - 188.06	70,000	187.45	
<b>Tuthill Bridge</b>	200,000		
188.06 - 189.05	180,000		188.81
189.05 - 189.39	50,000		189.12
189.39 - 190.00	30,000		189.68
190.00 - 191.16	70,000	190.40	
191.16 - 191.67	50,000	191.36	
191.67 - 192.64	30,000		191.94
192.64 - 192.73	90,000		192.69
192.73 - 193.46	130,000		192.97
193.46 - 193.58	90,000	193.54	
193.58 - 194.20	200,000		193.86
<b>Estrella Pkwy Bridge</b>	220,000		
194.20 - 194.61	130,000	194.30	
194.61 - 195.15	180,000		194.81

Table 4-5 continued...

Channel Capacity Reach miles above the Colorado-Gila River Confluence)	Limiting Channel Capacity <sup>1</sup> (in specified reach) (cfs)	First Breakout <sup>2</sup> Location Station	
		Left Bank	Right Bank
<b>Bullard Rd Bridge</b>	220,000		
195.15 - 195.75	90,000		195.38
195.75 - 196.08	50,000		195.94
196.08 - 196.53	90,000		196.32
196.53 - 198.13	70,000	197.54	
198.13 - 198.26	90,000	197.54	
<b>El Mirage Rd Dip Crossing</b>	5,000		
198.26 - 199.30	90,000	199.30	
<b>115th Ave Dip Crossing</b>	5,000		
199.30 - 199.35	90,000	199.30	
199.35 - 199.61	180,000		199.61
199.61 - 200.10	25,000	199.72	
200.10 - 201.14	80,000		200.20
201.14 - 202.18	100,000		201.43
202.18 - 202.29	50,000	202.29	
<b>91st Ave Dip Crossing</b>	5,000		
202.29 - 202.33	50,000	202.29	
202.33 - 202.77	170,000	202.59	
202.77 - 203.70	100,000	202.90	
203.70 - 204.42	200,000	204.25	
204.42 - 204.60	100,000	204.53	
204.60 - 205.90	30,000	204.97	
<b>67th Ave Dip Crossing</b>	5,000		
205.90 - 205.95	30,000	204.97	
205.95 - 206.32	100,000		206.03
206.32 - 206.67	50,000	206.60	
206.67 - 207.07	130,000	207.07	
207.07 - 207.30	50,000		207.27
207.30 - 207.48	130,000		207.32
<b>51st Avenue Bridge</b>	200,000		
207.48 - 207.52	130,000	207.48	207.48
207.52 - 207.63	50,000	207.53	
207.63 - 207.90	130,000	207.63	
207.90 - 208.72	170,000		208.19
208.82 - 209.55	50,000		208.96
<b>35th Avenue Bridge</b>	105,000		
209.55 - 210.26	50,000	210.17	
210.26 - 210.39	170,000		210.26
210.39 - 210.52	170,000		210.46
210.52 - 210.59	100,000		210.57
210.59 - 210.71	80,000	210.64	
210.71 - 211.06	130,000		210.95
211.06 - 211.45	200,000	211.41	
211.45 - 211.54	170,000	211.52	
<b>19th Avenue Bridge</b>	180,000		
211.54 - 211.65	170,000		211.63
211.65 - 211.95	50,000		211.71

Table 4-5 continued...

Channel Capacity Reach miles above the Colorado-Gila River Confluence)	Limiting Channel Capacity <sup>1</sup> (in specified reach) (cfs)	First Breakout <sup>2</sup> Location Station	
		Left Bank	Right Bank
211.95 - 212.15	100,000		212.08
212.15 - 212.67	200,000	212.18	
<b>7th Avenue Bridge</b>	200,000		
212.67 - 212.97	200,000		212.67
212.97 - 213.26	170,000		213.22
<b>Central Avenue Bridge</b>	180,000		
213.26 - 213.29	170,000		213.28
213.29 - 213.48	130,000	213.34	
213.48 - 213.74	170,000	213.48	
<b>7th Avenue Bridge</b>	200,000		
213.74 - 213.78	170,000	213.74	
213.78 - 213.91	130,000	213.86	
213.91 - 214.14	170,000	214.05	
214.14 - 214.78	200,000	214.23	
<b>16th Street Bridge</b>	180,000		
214.78 - 215.18	200,000	215.18	
215.18 - 215.36	125,000	215.27	
215.36 - 215.82	200,000	215.57	215.57
<b>24th Street Bridge</b>	180,000		
215.82 - 216.12	200,000		
216.12 - 216.50	150,000	216.23	
<b>Freeway 10 Bridge</b>	215,000		
216.50 - 216.87	150,000		216.62
216.87 - 216.95	300,000		216.92
216.95 - 217.48	300,000		217.48
217.48 - 219.02	260,000	Channel Modified	
<b>Hohokam Expwy Bridge</b>	289,000		
219.02 - 220.05	260,000	Channel Modified	
<b>Priest Drive Bridge</b>	289,000		
220.05 - 221.06	260,000	Channel Modified	
<b>Southern Pac. R.Road Bridge</b>	250,000		
221.06 - 221.26	260,000	Channel Modified	
<b>Mill Avenue</b>	250,000		
221.26 - 222.09	260,000	Channel Modified	
<b>Rural Road Bridge</b>	250,000		
222.09 - 223.10	260,000	Channel Modified	
<b>McClintock Drive Bridge</b>	250,000		
223.10 - 224.15	260,000	Channel Modified	
224.15 - 224.57	50,000		224.24
224.57 - 224.80	150,000		224.71
224.80 - 225.22	100,000	225.10	
225.22 - 225.28	150,000	225.28	
225.28 - 226.50	260,000	226.23	
<b>Alma School Road Bridge</b>	190,000		
226.50 - 226.99	260,000	226.89	
<b>McKellips Rd Dip Crossing</b>	5,000		
226.99 - 227.38		226.89	

Table 4-5 continued...

Channel Capacity Reach miles above the Colorado-Gila River Confluence)	Limiting Channel Capacity <sup>1</sup> (in specified reach) (cfs)	First Breakout <sup>2</sup> Location Station	
		Left Bank	Right Bank
227.38 - 227.61	40,000	227.56	
<b>Country Club Road Bridge</b>	180,000		
227.61 - 228.11	40,000		227.87
228.11 - 228.20	10,000	228.17	
228.20 - 228.63	260,000		228.63
228.63 - 229.34	40,000	229.30	
229.34 - 229.91	180,000		229.68
229.91 - 230.10	20,000		230.09
230.10 - 230.84	40,000		230.47
230.84 - 231.60	120,000	231.41	
<b>Gilbert Road Bridge</b>	70,000		
231.60 - 232.03	120,000		231.88
232.03 - 232.97	40,000		232.36
232.97 - 233.44	80,000		233.41
233.87 - 234.76	180,000		233.95
234.76 - 235.07	80,000	234.91	
235.07 - 235.68	40,000	235.57	
235.68 - 236.04	80,000		235.76
236.04 - 236.77	180,000	236.53	
236.77 - 237.50	60,000	237.00	
<b>Granite Reef Dam</b>			

NOTES: 1. Limiting Channel Capacity - maximum capacity before first breakout occurs within channel reach.  
2. Breakouts listed do not necessarily cause damage to the adjacent flood plain area.

SOURCE: 1. Hydraulic Study - Modified Roosevelt Dam - by Baker Engineering for Corps of Engineers - 1994.

**Table 4-6a**  
**Population of Cities**  
**Maricopa County, Arizona**  
**Modified Roosevelt Dam Water Control Manual**

City	Population	
	1978 <sup>1</sup>	1990 <sup>2</sup>
Avondale	7,130	16,169
Buckeye	2,900	5,038
Chandler	24,000	90,533
Goodyear	2,745	6,258
Guadalupe	4,300	5,458
Mesa	130,000	288,000
Phoenix	725,000	983,403
Scottsdale	85,070	130,069
Tempe	106,675	142,139

Notes: 1. From the Salt-Gila River Flood Control Study - 1980.  
2. U.S. Census of 1990.

**Table 4-6b**  
**Total Value of Crop Production in 1993**  
**Maricopa County, Arizona**  
**Modified Roosevelt Dam Water Control Manual**

Type	Production
Cotton	344, 800 Bales
Wheat	78,330 Tons
Barley	32,160 Tons
Corn	2,100 Tons

**Table 4-6c**  
**Percentages of Labor Force**  
**Maricopa County, Arizona**  
**Modified Roosevelt Dam Water Control Manual**

<b>Type of Industry</b>	<b>Percentage</b>
Construction	7%
Manufacturing	15%
Transportation and Utilities	5%
Retail Trade	19%
Wholesale Trade	6%
Services	34%
Government	14%

**Table 4-6d**  
**Downstream Areas Flooded by Selected Discharges <sup>1</sup>**  
**Granite Reef Diversion Dam to Gillespie Dam**  
**Modified Roosevelt Dam Water Control Manual**

<b>Discharge (in cfs)</b>	<b>Area Flooded (in acres)</b>
55,000	30,000
80,000	35,000
110,000	38,000
195,000	54,000
245,000	60,000
270,000	73,000
360,000	78,000

Note: 1) Taken from "Study for Flood Control Alternatives to Cliff Dam".

## V - DATA COLLECTION AND COMMUNICATION NETWORK

### 5-01 Hydrometeorological Stations.

a. **Facilities.** Precipitation, stream flow, and reservoir water surface elevation data are collected and monitored from gages located throughout Arizona including the Gila River and Salt River watersheds. Plate 5-1 shows the location of hydrometeorological gages located within Salt River watershed above Granite Reef Diversion Dam (excluding the Verde River watershed). Table 5-1a lists hydrometeorological gages by name and the type of information collected at each station located within the Salt River Basin and adjacent watersheds. The SRP collects hydrometeorological information using the following:

1. **The SRP River Gage System (RGS).** The Salt River Project River Gage System is a system of eight gaging stations on the Salt and Verde Rivers, and Tonto Creek. The system is owned by the SRP and operated in coordination with the USGS. Table 5-1.b lists the stream gaging stations in the Salt and Verde watersheds including the eight stations in the RGS system.
2. **The Lake Level Telemetry System (LLTS).** The lake Level Telemetry System is a system of automatic sensors that measure the lake elevation at each storage reservoir operated by the SRP.
3. **The Snow Telemetry System (SNOTEL).** The SNOTEL which is operated by the U.S. Department of Agriculture, National Resource Conservation Service, is made up of automatic sensors at 15 strategic locations in the mountainous areas of the Salt River and Verde River watersheds. In addition to precipitation data, the SNOTEL system also collects snow water and air temperature data. Table 5-1c lists SNOTEL sites located within and adjacent to the Salt River watershed.
4. **The Geostationary Operational Environmental Satellite (GOES) Telemetry System.** The GOES telemetry system is a system of remote stream gaging stations in the Salt, Verde, and Tonto watersheds operated by USGS in cooperation with the SRP and other government entities.

**5. The Device for Automatic Remote Data Collection (DARC).** The DARC is a statewide system of precipitation gaging stations and three river gaging stations operated by the NWS.

**b. Reporting.**

**1. The SRP River Gage System (RGS).** The RGS gages are normally set to report automatically every two hours or at a different time interval as necessary. In addition, they can be polled manually anytime, or set to report whenever specified thresholds are reached. The RGS data is transmitted via FM radio frequency.

**2. The Lake Level Telemetry System (LLTS).** The LLTS gages are normally set to report at a time interval specified by SRP. In addition, the gages can be polled manually anytime, or set to report whenever specified thresholds are reached. The LLTS data is transmitted via microwave to readouts located in the SRP office. In case the LLTS system becomes inoperative, backup communication systems can be used to allow direct contact with the dam tenders for each SRP dam.

**3. The Geostationary Operational Environmental Satellite (GOES) Telemetry System.** The data is transmitted to one of two GOES satellites, then to a ground station. The data is collected at fifteen minute intervals and transmitted every four hours. Data is transmitted at fifteen-minute intervals for stations at which data exceeds a predetermined emergency threshold. The SRP receives data via an on-site Direct Readout Ground Station. The GOES satellite also transmits imagery data. The SRP utilizes its own earth station to receive weather satellite images every half hour from the GOES-7 satellite. Visible, infra-red and water vapor images with coverage ranging from hemispheric to regional to state are available to the SRP operational groups via the SRP computer network for video display or hard copy prints.

**c. Maintenance.** Each operating agency is responsible for the maintenance of its own gages and/or telemetry radio or microwave equipment.

## 5-02 Water Quality Stations.

**a. Facilities.** There are three USGS water quality stations that provide data that are used to characterize the Theodore Roosevelt Lake water. The station "Tonto Creek above Gun Creek, near Roosevelt, Az" is located upstream of Theodore Roosevelt Lake on Tonto Creek and is designated as USGS station no. 09499000. The station "Salt River near Roosevelt, Az" is located just upstream of Theodore Roosevelt Lake on the Salt River, and is designated as USGS station no. 09498500. Station 09502000 also known as "Salt River below Stewart Mountain Dam, Az" is located on the Salt River Downstream of Stewart Mountain Dam.

**b. Reporting.** The data collected at the USGS stations includes pH, specific conductance, temperature (air and water), chemical oxygen demand, coliform, hardness, inorganic salts, alkalinity, solids, nitrogen, phosphorus, and suspended sediment. Organic carbon and phenols concentrations have been collected at the Station 09498500. Turbidity, streptococci, and trace metals have been collected at Station 09502000. Chemical oxygen has been collected at stations 09498500, and 09499000. Some of the data are collected monthly and some quarterly and can be obtained from the USGS annual publication entitled "Water Resources Data".

**c. Maintenance.** The USGS has maintenance responsibilities with respect to water quality stations.

## 5-03 Sediment Stations.

**a. Facilities.** A layout of the sedimentation range system composed of seventy- two sedimentation range lines and markers were established during the construction of the original Theodore Roosevelt Dam. During the reservoir survey in September 1981, forty-eight of the initial markers had to be reset. The latest resevoir survey was done in April 1995.

**b. Reporting.** Raw sedimentation data and calculations resulting from the reservoir surveys, including the latest survey, are available at the USBR and the SRP offices. The USBR publishes a report documenting the results of sedimentation surveys. Table 4-1a lists the sediments surveys and results since the construction of the dam. Table 4-1b lists

the summary of the 1995 survey and sediment distribution computations. Information in these tables was taken from a USBR reports entitled "Theodore Roosevelt Lake, 1981 Sedimentation Survey, USBR Sep 1982", and "Theodore Roosevelt Reservoir, 1995 Sedimentation Survey, USBR, May 1996." Exhibit C contains the area and storage capacity tables of the reservoir.

**c. Maintenance.** The USBR has maintenance responsibilities with respect to sediment stations.

**5-04 Recording Hydrologic Data.** Each agency maintains records of its own data. The NWS Data are archived at the NOAA, National Climatic Data Center in Asheville, North Carolina. Precipitation and other data are published monthly by the National Climatic Data Center in Climatological Data and Hourly Precipitation Data.

During flood operations, personnel in the EOC at SRP maintain a three-ring binder notebook which is subdivided in sections, and contains, but is not limited to, the following: operational status reports, river flow reports, individual communication logs, memos, weather advisories, and satellite pictures. The following forms are also used by the SRP for recording information and data: 1) Salt River Project - Information Log (see Figure 5-1), 2) Lotus spreadsheet- "Salt System, Gate/Valve Position and Reservoir Operation Releases (see Figure 5-2), and 3) Salt River Project - Verde System, Gate/Valve Position and Release Log (see Figure 5-3).

**5-05 Communication Network.** The SRP's EOC communicates with its project offices through regular telephone lines. However, SRP maintains backup radio communication systems with emergency backup power connecting its main office with all of its project offices. These systems can be used to communicate with project offices in the event telephone communication is not possible.

**5-06 Communication with the Project Offices.** When water delivery releases are exceeded, the SRP's Power Dispatch Office (PDO) is the communication center through which operational control of dams on the Salt River, excluding Granite Reef Diversion Dam, is exercised. Communication between this office and the dam operators is

accomplished via telephone. Backup radio communication systems are used in the event that telephone communication is not available.

**5-07 Project Reporting Instructions.** The operation of Modified Roosevelt Dam during flood events is a responsibility of the SRP. Instructions to the dam tenders and other project information are contained in the SRP's Standing Operating Procedures (SOP) for Modified Roosevelt Dam. A Copy of the SOP is available at the SRP corporate headquarters.

**5-08 Warnings.** The responsibility for issuing all weather watches and warnings and all flood and flash flood watches and warnings rests with the NWS. Local state, county and city emergency management officials are responsible for issuing any public warnings regarding unusual overflows, evacuations, unsafe roads or bridges, toxic spills, etc. During flood operations, SRP informs public, municipal, and agency officials regarding emergency conditions and the SRP actions and plans.

**Table 5-1a**  
**Hydrometeorological Stations**  
**Within and the Salt River Basin and Adjacent Watersheds**

STATION NAME	WATERSHED	STAGE	PRECIP
Agua Fria - Mayer	Agua Fria	Y	Y
Agua Fria - Rock Springs	Agua Fria	Y	Y
Ashfork	Verde	N	Y
Baghdad	Bill Williams	N	Y
Mar-M	Verde	N	Y
Bartlett Lake	Verde	Y	N
Big Sandy River - Wikieup	Bill Williams	Y	Y
Black River - Pumps	Salt	Y	Y
Black River - Ft. Apache	Salt	Y	N
Blue Ridge Reservoir	Little Colorado	Y	Y
Blue River - Clifton	Gila	Y	N
Bonita Creek - Morenci	Gila	Y	Y
Buck Springs - Pinetop	Salt	N	Y
Burro Creek - Baghdad	Bill Williams	Y	Y
Camp Wood	Verde	N	Y
Carrizo Creek - Show Low	Salt	Y	Y
Cave Creek - Cottonwood	Agua Fria	Y	Y
Cherry Creek - Globe	Salt	Y	Y
Chevelon Creek	Little Colorado	Y	Y
Childs	Verde	N	Y
Cibecue Creek	Salt	Y	Y
Crook Trail	Verde	N	Y
Dry Beaver Creek	Verde	Y	Y
Eagle Creek - Morenci	Gila	Y	Y
East Fork White River	Salt	Y	N
East Verde Childs	Verde	Y	Y
East Verde Diversion - Pine	Verde	Y	Y
Fish Creek	Salt	N	Y
Flagstaff Airport	Verde	N	Y
Forestdale Creek Diversion	Salt	Y	Y
Gisela	Salt	N	Y
Globe	Salt	N	Y
Hannagan Meadow	Salt	N	Y
Happy Jack Ranger Station	Verde	N	Y
Hassayampa River - Morristown	Hassayampa	Y	Y
Horseshoe Lake	Verde	Y	N

TABLE 5-1a CONTINUED...

STATION NAME	WATERSHED	STAGE	PRECIP
Humbug Creek - Castle Spring	Agua Fria	Y	Y
J.D. Cabin - Williams	Verde	N	Y
Lakeside Ranger Station	Little Colorado	N	Y
Lookout Wash - Kingman	Bill Williams	N	Y
Lyman Lake Spillway	Little Colorado	Y	Y
Montezuma Castle National Monument	Verde	N	Y
New River - Rock Springs	Agua Fria	Y	Y
North Fork Thomas Creek	Salt	N	Y
Oak Creek - Sedona	Verde	Y	Y
Oak Creek - Cornville	Verde	Y	N
Pinal Creek	Salt	Y	N
Pleasant Valley Ranger Station	Salt	N	Y
Salt River Canyon	Salt	Y	Y
Salt River Below Stewart Mountain	Salt	Y	Y
Salt River - Roosevelt	Salt	Y	Y
San Carlos Reservoir	Gila	Y	N
San Francisco River - Clifton	Gila	Y	Y
San Francisco River - Glenwood NM	Gila	Y	Y
Santa Maria River - Baghdad	Bill Williams	Y	Y
Skull Valley Wash - Prescott	Bill Williams	N	Y
Sun Flower	Verde	N	Y
Sycamore Creek	Verde	Y	Y
Tonto Creek - Roosevelt	Salt	Y	Y
Tonto Fish Hatchery	Salt	N	Y
Verde River - Scottsdale	Verde	Y	N
Verde River Below Bartlett Dam	Verde	Y	N
Verde River Below Tangle Creek	Verde	Y	Y
Verde River Below East River	Verde	Y	Y
Verde River Below Camp Verde	Verde	Y	N
Verde River - Clarkdale	Verde	Y	Y
Verde River - Paulden	Verde	Y	Y
West Clear Creek	Verde	Y	N
Wet Beaver Creek - Rimrock	Verde	Y	Y
Wet Bottom Creek	Verde	Y	Y
White River - Ft. Apache	Salt	Y	Y
Wikieup	Bill Williams	N	Y
Willow Creek Diversion	Salt	Y	N

**Table 5-1b  
Stream Gaging Stations  
Within Salt River and Verde River Watersheds**

Station Name	Watershed	Drainage Area (sq. mi.)	Max. Discharge	
			(cfs)	Date
1. Verde - Paulden.	Verde	2707	23,200	2-20-93
2. Verde - Clarkdale	Verde	3503	53,200	2-20-93
3. Oak Creek - Sedona	Verde	233	23,200	2-19-93
4. Dry Beaver Creek	Verde	142	26,600	9-5-70
5. Wet Beaver Creek	Verde	111	16,000	1-8-93
6. Verde River below Camp Verde <sup>1</sup>	Verde	5024	40,900	2-20-93
7. West Clear Creek	Verde	241	24,800	1-8-93
8. East Verde River	Verde	331	23,500	9-5-70
9. Verde River Below East River <sup>1</sup>	Verde	5623	110,000	3-3-38
10. Verde below Tangle Creek <sup>1</sup>	Verde	5858	145,000	1-8-93
11. Verde River Below Bartlett <sup>1</sup>	Verde	6161	110,000	1-8-93
12. Sycamore Creek	Verde	164	24,200	9-5-70
13. Verde below Beeline Bridge <sup>1</sup>	Verde	6615	127,000	1-8-93
14. Salt River Below Stewart Mt.	Salt	6232	75,200	2-15-80
15. Tonto Creek <sup>1</sup>	Salt	675	72,500	1-8-93
16. Salt near Roosevelt <sup>1</sup>	Salt	4306	143,000	1-8-93
17. Cherry Creek	Salt	200	15,700	1-17-79
18. Cibique Creek	Salt	295	22,200	9-2-77
19. Salt River Canyon <sup>1</sup>	Salt	2849	76,600	1-8-93
20. Carrizo Creek	Salt	439	23,000	12-30-65
21. Black River Near Ft. Apache	Salt	1232	40,200	12-18-78
22. White River Near Ft. Apache	Salt	632	14,600	12-18-78
23. East Fork White River	Salt	39	2,700	10-1-83
24. Black River Pumps	Salt	560	17,900	10-19-72

FOOTNOTE: 1. Included in the SRP's River Gage System (RGS).

**Table 5-1.c**  
**Snow Telemetry (SNOTEL) Sites**  
**Within and Adjacent to**  
**Modified Roosevelt Dam Watershed**

STATION NAME	Watershed
Baker Butte	Verde
Baldy	Salt
Beaverhead	Salt
Buck Spring	Salt
Coronado Trail	Salt
Fry	Verde
Hannagan Meadow	Salt
Heber	Salt
Maverick Fork	Salt
Mormon Mountain	Verde
Promontory	Salt
Sugar Loaf	Verde
Whitehorse Lake	Verde
Wildcat	Salt
Workman Creek	Salt



2/4/87 1315

R O D O S E V E L T	Lake Elevation	2130
	Unit (Turbine)	ON
	RCW Valve #1	10X OPEN
	RCW Valve #2	10X OPEN
	RCW Valve #3	10X OPEN
	RCW Valve #4	10X OPEN
	Spillgate #1	CLOSED
	Spillgate #2	CLOSED
	Spillgate #3	CLOSED
	Spillgate #4	CLOSED
H O R S E M E S A	Lake Elevation	1908
	Unit #1, 2, 3 (Turbine)	ON
	Unit #4 (Turbine)	ON
	Tunnel Gate	CLOSED
	Spillgate #1	CLOSED
	Spillgate #2	CLOSED
	Spillgate #3	CLOSED
	Spillgate #4	CLOSED
	Spillgate #5	CLOSED
	Spillgate #8	CLOSED
Spillgate #7	CLOSED	
Spillgate #8	CLOSED	
Spillgate #9	CLOSED	

M O R M O N F L A T	Lake Elevation	1856
	Unit #1, (Turbine)	ON
	Unit #2, (Turbine)	ON
	Spillgate #1	CLOSED
	Spillgate #2	CLOSED
	Lake Elevation	1523
	Unit (Turbine)	ON
	Fixed Cone Valve	CLOSED
	SERVICE SPILLWAY	
S T E W A R T M O U N T A I N	Spillgate #1	CLOSED
	Spillgate #2	CLOSED
	Spillgate #3	CLOSED
	Spillgate #4	CLOSED
	Spillgate #5	CLOSED
	Spillgate #8	CLOSED
	Spillgate #7	CLOSED
	Spillgate #8	CLOSED
	Spillgate #9	CLOSED
	AUXILIARY SPILLWAY	
S T W M T N	Spillgate #10	CLOSED
	Spillgate #11	CLOSED
	Spillgate #12	CLOSED
	Spillgate #13	CLOSED

2/4/87 1315

R O S E V E L T	Lake Elevation	2130
	Unit Flow	2,000
	North Spillway	800
	South Spillway	0
	Total Spillway	0
Total Release		2,800
H O R S E M E S A	Lake Elevation	1908
	Unit #1, 2, 3 Flow	1,000
	Unit #4 Flow	6,000
	Tunnel Gate	0
	South Spillway	0
M O R M O N F L A T	North Spillway	0
	Total Spillway	0
	Total Release	7,000
	Lake Elevation	1856
	Unit #1 Flow	1,500
S T W M T N	Unit #2 Flow	5,000
	Spillgate #1	0
	Spillgate #2	0
	Total Spillway	0
	Total Release	6,500
S T W M T N	Lake Elevation	1523
	Unit Flow	1,000
	Fixed Cone Valve	0
	Total Serv. Spillway	0
	Total Aux. Spillway	0
Total Release		1,000

Figure 5-2. Salt River Project - Lotus Spreadsheet - Salt System Gate/Valve Position and Release Log

SRP

E.O.C. - VERDE SYSTEM

OUTLET WORKS STATUS & RELEASE LOG

PAGE \_\_\_\_\_ OF \_\_\_\_\_  
DATE \_\_\_\_\_

1ST SHIFT \_\_\_\_\_ 2ND SHIFT \_\_\_\_\_ 3RD SHIFT \_\_\_\_\_  
0800 - 1800                      1800 - 2400                      2400 - 0800

(RECORD STATUS AT BEGINNING OF EACH SHIFT AND  
CHANGES IN STATUS DURING A SHIFT)

		OUTLET WORKS STATUS							
		CALL	CONFIRM	CALL	CONFIRM	CALL	CONFIRM	CALL	CONFIRM
TIME		SITE		SITE		SITE		SITE	
B	LAKE ELEVATION								
A	UPPER FIXED CONE VALVE								
R	LOWER FIXED CONE VALVE								
T	SERVICE SPILLWAY GATE 1								
L	SERVICE SPILLWAY GATE 2								
E	SERVICE SPILLWAY GATE 3								
T	AUX SPLWY FUSE-PLUG 1								
	AUX SPLWY FUSE-PLUG 2								
	AUX SPLWY FUSE-PLUG 3								
H	LAKE ELEVATION								
O	CYLINDER VALVE								
R	SERVICE SPILLWAY GATE 1								
S	SERVICE SPILLWAY GATE 2								
E	SERVICE SPILLWAY GATE 3								
S	AUX SPLWY FUSE-PLUG 1								
H	AUX SPLWY FUSE-PLUG 2								
O	AUX SPLWY FUSE-PLUG 3								
E									

COMMENTS: \_\_\_\_\_  
\_\_\_\_\_

Figure 5-3a. Salt River Project - Verde System, Gate/Valve Position and Release Log - Page 1 of 2

SRP  
E.O.C. - VERDE SYSTEM  
OUTLET WORKS STATUS & RELEASE LOG

PAGE \_\_\_\_\_ OF \_\_\_\_\_  
DATE \_\_\_\_\_

1ST SHIFT \_\_\_\_\_ 2ND SHIFT \_\_\_\_\_ 3RD SHIFT \_\_\_\_\_  
0800 - 1600      1600 - 2400      2400 - 0800

(RECORD STATUS AT BEGINNING OF EACH SHIFT AND  
CHANGES IN STATUS DURING A SHIFT)

	RELEASES							
	CALL SITE	CONFIRM	CALL SITE	CONFIRM	CALL SITE	CONFIRM	CALL SITE	CONFIRM
TIME								
TOTAL VALVE								
TOTAL SERVICE SPILLWAY								
TOTAL AUXILIARY SPILLWAY								
TOTAL RELEASE								
TOTAL VALVE								
TOTAL SERVICE SPILLWAY								
TOTAL AUXILIARY SPILLWAY								
TOTAL RELEASE								

COMMENTS: \_\_\_\_\_  
\_\_\_\_\_

**Figure 5-3b. Salt River Project - Verde System, Gate/Valve Position and Release Log - Page 2 of 2**

## VI - HYDROLOGIC FORECASTS

### 6-01 General.

a. **Role of the Corps of Engineers.** The COE does not prepare formal published hydrologic forecasts for Modified Roosevelt Dam.

Quantitative Precipitation Forecasts (QPF) for the Gila River Basin are obtained by the COE from a private meteorological firm under contract with the LAD. These are used in determining the potential for significant runoff into the LAD's Painted Rock Dam located on the lower Gila River.

b. **Role of the Salt River Project.** SRP meteorologists, in cooperation with the Phoenix NWS office, produce a 24-hour average quantitative precipitation forecast (QPF) for the Salt-Verde watershed. This QPF is used by SRP hydrologists to develop runoff predictions.

Through special agreements with the NWS and the National Severe Storm Laboratory (NSSL), the SRP has access to precipitation and velocity data from the WSR-88D Doppler weather radar (NEXRAD) installed at the Williams Gateway Airport. SRP forecasters also use weather maps and alphanumeric data from the NWS through WSI, a dial-up weather data vendor, the NWS DIFAX weather map service (via communication satellite), and the Internet.

Historical precipitation and stream flow data for Modified Roosevelt Dam are available from the SRP, as well as from the NWS and USGS.

**6-02 Flood Condition Forecasts.** The SRP's CLEMM Runoff Model (named after its developer) forecasts storm runoff from the Salt, Tonto and Verde watersheds and constructs hydrographs from those forecasts. Input parameters to the model are: 1) initial soil moisture conditions, 2) initial snow level, 3) forecasted precipitation and snow levels for the storm duration, and 4) current stream base flow. The model output is a six-hourly runoff hydrograph, peak inflow and volumetric calculations.

The NWS Colorado Basin River Forecast Center, located in Salt Lake City, Utah, operates computer programs that model the Salt and Verde watersheds and predict streamflow runoff from short duration storms. The NWSRFS model predicts the peak flow rate and timing of an event based on antecedent soil moisture conditions and the forecasted precipitation. A portion of the model helps predict total runoff from snow melt and from rain-on-snow events. Plate 6-1 illustrates the methodology NWS uses in river forecasts and flood predictions.

Outputs from the CLEMM and NWSRFS are used by the SRP as input to a HEC-5 reservoir routing model. The HEC-5 reservoir routing model calculates reservoir outflows, storage and elevation in time steps selected by the user.

**6-03 Conservation Purpose Forecasts.** The Salt River Project Simulation Model (SRPSIM) is a program developed in 1979 and updated in 1982 by the USBR. The SRPSIM is currently maintained and updated by the SRP which uses it to study impacts of varying water demands on reservoir operations and resulting surface water supplies. Since SRPSIM utilizes a monthly time step, it cannot be used for flood operations.

**6-04 Long Range Forecasts.** The NWS has implemented an extended range of forecasting procedures for the watersheds in Arizona to provide an estimate of inflows into the major water resources projects including Modified Roosevelt Dam. The procedure uses the NWS Extended Streamflow Prediction (ESP) program. The ESP program uses conceptual hydrologic/hydraulic models to predict future streamflows using current river, soil moisture, and snowpack conditions, along with historic hydrological and meteorological data. The ESP program is useful in predicting water supply and drought conditions, as well as in predicting floodflows. Plate 6-2 illustrates the methodology the NWS uses in the ESP.

## VII - WATER CONTROL PLAN

**7-01 General Objectives.** The passage of Reclamation Safety of Dams Act (PL 95-578) authorized the modification of Theodore Roosevelt Dam consistent with the objectives of the Central Arizona Water Control Study (CAWCS). Although the primary objective of the selected CAWCS alternative is to improve water conservation, it was also intended to provide other project purposes and benefits, including flood control and dam safety. The water control plan presented in this document and shown on the water control diagram (Plate 7-1) was developed for the regulation of Modified Roosevelt Dam for flood control purposes. The formulation of the water control plan is documented in a COE report entitled “Section 7 Study for Modified Roosevelt Dam, Arizona (Theodore Roosevelt Dam) - Hydrologic Evaluation of Water Control Plans - Salt River Project to Gila River at Gillespie Dam”, dated March 1996. Flood control release ranges shown in the diagram (Part 1 of Plate 7-1) were developed in order to minimize downstream flood damages along the Salt and Gila Rivers including the SRP System, the metropolitan Phoenix area, and other downstream communities. In addition, this plan was designed to provide incidental production of hydropower by the SRP during flood operations. Also, the overall water control plan was expanded to outline the operation for dam safety purposes at elevations above the flood control pool (Part 2 of Plate 7-1).

Although beyond the scope of the water control plan, other project purposes and benefits derived from the dam, including water supply, are discussed briefly in this manual (see Chapter 7 and Chapter 8).

**7-02 Major Constraints.** Major constraints to the regulation of Modified Roosevelt Dam for flood control, including the development of the water control plan, are discussed as follows:

**a. Top of Flood Control Pool.** Starting from the top of the new water conservation pool (WSE 2151 feet), a reservoir volume of 557,000<sup>1</sup> ac-ft established the top of the flood control pool at elevation 2175 feet. The water control plan presented in this

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1. The 1995 reservoir survey, which was done after the formulation of the water control plan, shows the reservoir volume between WSE 2151 feet and WSE 2175 feet to be 556,196 ac-ft. Exhibit C of this water control manual contains the Area-Capacity Table based on the 1995 reservoir survey.

document was developed with the constraint that the maximum water surface elevation resulting from a flood with a magnitude equal to that of the SPF (see section 8-02.b of this manual) should not exceed elevation 2175 feet (the top of flood control pool).

**b. Top of Dam.** During the design phase of Modified Roosevelt Dam, the top of dam was determined by the USBR to be at elevation 2218 feet. The water control plan presented in this manual was developed with the purpose of preventing the possibility of overtopping the dam during a flood event of a magnitude equal to that of the Probable Maximum Flood (PMF, see section 8-02.a of this manual). The releases shown on Part 1 and Part 2 of the water control diagram shown on Plate 7-1 ensure that the resulting maximum water surface elevation at Modified Roosevelt Dam during the routing of the PMF would not exceed WSE 2218 feet, thus preventing the possibility of overtopping the modified dam. In order to provide the necessary freeboard, a 4.5 foot-high concrete parapet wall along the upstream side of the dam crest was incorporated in the design.

**c. Environmental Requirement (20-Day Evacuation Period).** Previous environmental studies and reports for a modified dam concluded that a 10 to 20 day evacuation period of the flood control space would not require additional mitigation already undertaken by the USBR for the overall CAP project. To comply with this requirement, the water control plan presented in this manual ensures that the flood pool will be drawn down to WSE 2151 feet, the top of the water conservation pool, within 20 days of the beginning of the (single event) reservoir design flood (SPF). The release ranges in the water control plan during the falling stages were designed to meet the 20-day evacuation constraint.

**d. Hydropower Generation.** Although the storage volume of Modified Roosevelt Dam from WSE 2151 feet to WSE 2175 feet is dedicated for flood control purposes only, the development of the water control plan presented in this manual considered making maximum use of water in the flood control pool for power generation. Therefore, flood control releases in the early stages of a flood event are limited to the system hydropower generation capacities. In addition, this also prevents or reduces downstream damages while a significant amount of flood control space is still available.

**e. Flood Control Discharge Limitation.** The left spillway structure, when utilized for flood releases can cause damages to the SRP system, specifically the power plant

115Kv switchyard. To prevent damages, the left spillway is to be used only when water surface elevation exceeds the top of the flood control pool (WSE 2175 feet). The limit for flows from the right spillway structure alone, without damages to the power plant access road is 41,000 cfs. The maximum combined outflow from the right spillway (approximately 41,000 cfs), and river outlet works (approximately 10,000 cfs), and the hydroelectric turbine (approximately 2,100 cfs) when the water level is within the flood control pool is 53,100 cfs. The maximum flood control release of 53,100 cfs was established because of these constraints.

**f. Spillway Discharge Limitation.** Inflows greater than 150,000 cfs can result in the overtopping of Horse Mesa Dam and Mormon Flat Dam, both located downstream of Modified Roosevelt Dam. Therefore, in order to prevent this possibility, the spillway discharge from Modified Roosevelt Dam when combined with the downstream tributary flow shall not exceed 150,000 cfs.

**g. Capacities of Downstream Channels and Bridge Crossings.** Plate 4-5 shows the river crossings from Granite Reef Diversion Dam on the Salt River to Gillespie Dam on the Gila River and their capacities. Although damages will result during smaller flows, the majority of the bridges have capacities greater than or equal to 180,000 cfs. A discharge in excess of 180,000 cfs will affect some of these major river crossings and cause major damages. Since these structures are downstream of the Salt River and Verde River confluence, the outflows from Modified Roosevelt Dam were evaluated in conjunction with the outflows from Bartlett Dam which controls the Verde River contribution, as well as the downstream tributary flow. Therefore, when operating Modified Roosevelt Dam for flood control, the Bartlett Dam outflow and local intervening runoff should be monitored so that the combined flow of the Salt and Verde Rivers (measured at the confluence) does not exceed 180,000 cfs.

**h. River Outlet Works (ROW) Limitations.** An important limitation to the use of the ROW during the flood operations is the possibility of damaging the river outlet works gates if operated with the discharge partially, or entirely submerged. In order to minimize the possibility of damaging the gates, the outlet works are to be closed prior to the valve discharges becoming partially submerged. Submergence of the valve discharge will likely occur at WSE 2175 feet.

**i. Structures and Recreational Facilities in the Basin (above El 2175 feet).** The USBR purchased lands and properties located below the reservoir taking line (at elevation 2175 feet and an additional 300 lineal feet); However, there are residential structures and recreational facilities just above the taking line within the surcharge pool. If the flood control pool elevation (WSE 2175 feet) is exceeded, these structures may be inundated by the reservoir impoundment.

**7-03. Overall Plan for Water Control.** The overall objective of the water control plan for the flood pool at Modified Roosevelt Dam is the minimization of downstream flood damages along the Salt and Gila Rivers, including the SRP (Salt River Project) system, the metropolitan Phoenix area, and other downstream communities. The minimization of damaging peak discharges resulting from major flood events including that of the SPF (see section 8-02.b) is accomplished by sequencing releases from Modified Roosevelt Dam so that the resulting flow at the Salt and Verde River confluence (which is a combination of flows from the Salt and Verde Rivers and intervening local runoff) does not exceed 180,000 cfs. In addition, the plan was designed to allow full production of hydropower during flood operations. This incidental hydropower production is accomplished in part by making relatively small releases during the early stages of flood events, or during events with low peak inflows of long duration. Part 1 of the Water Control Diagram on Plate 7-1 illustrates the water control plan for the flood pool at Modified Roosevelt Dam. The plan was also designed to prevent the possibility of overtopping the dam during large floods equal in magnitude to the PMF (see section 8-02.a). Part 1 and part 2 of the Water Control Diagram on Plate 7-1 illustrate the regulation of the dam during these events.

**7-04 Standing Instructions to the Project Operator for Water Control.** Normal operating procedures for Modified Roosevelt Dam are contained in the SRP's "Standing Operating Procedures" (SOP) for Modified Roosevelt and the other projects in the Salt and Verde System. During flood operations, the Chair of the PROP Committee (Project Reservoir Operations Planning Committee) is responsible for the activation of the EOC (Emergency Operations Center). The PROP Committee is responsible for planning reservoir operations and approving a course of action, including gathering information pertaining to conditions with potential for destructive flooding and preparing recommendations for emergency reservoir operation, release status promulgation, and

development or revision of operating criteria. The EOC is located at the Project Administration Building of the SRP. Once the EOC is activated, the Shift Manager assumes operational control of the Salt and Verde Reservoir System through the Power Dispatch Office (PDO) for the dams on the Salt River except Granite Reef Diversion Dam, and the Association Dispatch Center (ADC) for Granite Reef Diversion Dam and the dams on the Verde River.

Instructions to the dam tender at Modified Roosevelt Dam are normally transmitted by the PDO to the dam tender via telephone. However, backup radio communications with emergency power supplies are available, if needed.

**7-05 Flood Control.** The regulation of Modified Roosevelt Dam within the flood pool (WSE 2151 feet - WSE 2175 feet) shown as Part 1 of Plate 7-1 of this document, limits the maximum release from the reservoir to 53,100 cfs. The regulation of the dam above the flood control pool (greater than WSE 2175 feet - Part 2 of Plate 7-1) is limited to a maximum spillway release of 150,000 cfs. The water control plan also attempts to limit the maximum flow at the confluence of the Salt and Verde Rivers to 180,000 cfs at all times, except when the water surface elevation behind Modified Roosevelt Dam exceeds the top of the flood pool (WSE 2175 feet). The procedures in operating the dam within and above the flood control pool are discussed in the following paragraphs.

**a. Within the Flood Pool (WSE 2151 feet - WSE 2175 feet).** As previously stated, the main objective of the water control plan for the flood pool at Modified Roosevelt Dam is to minimize the downstream flood damages along the Salt and Gila Rivers system during large flood events. This is accomplished by reducing the peak discharges resulting from major flood events including that of the SPF. In addition, the water control plan was designed to allow full production of hydropower during the early stages of flood operations. Part 1 of the Water Control Diagram on Plate 7-1 illustrates the water control plan for the flood pool at Modified Roosevelt Dam. Deviations from the release schedule specified in this plan may be required due to emergencies, as defined in section 7-14.a, or to meet the downstream coincident flow restriction at Granite Reef Diversion Dam, as defined in section 7-02.g.

**1. During Rising Stages.** The reservoir release ranges from Modified Roosevelt Dam during the rising stage are discussed below:

(a) **WSE 2151 feet - 2153 feet (1,900 cfs)**. Beginning at the top of the water conservation pool, WSE 2151 feet and up to WSE 2153 feet, a rising pool flood control discharge of 1,900 cfs is specified. A release of this magnitude permits maximum use of floodwater for hydropower production on all Salt River dams, limited by the hydropower generating capacity of Stewart Mountain Dam. At Modified Roosevelt Dam, hydropower production would be accomplished by passing the 1,900 cfs release through the power plant.

(b) **WSE 2153 feet - 2155 feet (2,200 cfs)**. From WSE 2153 feet up to WSE 2155 feet, a rising pool flood control discharge of 2,200 cfs is specified. A release of this magnitude would make it possible to maximize the hydropower production from all hydropower generators on the Salt River, while bypassing only 300 cfs at Stewart Mountain Dam.

(c) **WSE 2155 feet - 2157 feet (6,500 cfs)**. From WSE 2155 feet up to WSE 2157 feet, a rising pool flood control discharge of 6,500 cfs is specified. A release of this magnitude would allow maximum hydropower production from all hydropower generators on the Salt River, while bypassing 4,300 cfs at Modified Roosevelt Dam through the outlet works and 4,600 cfs at Stewart Mountain Dam. This discharge matches the maximum capacity of the generators at Horse Mesa Dam and at Mormon Flat Dam.

(d) **WSE 2157 feet - 2162 feet (12,200 cfs)**. From WSE 2157 feet up to WSE 2162 feet, a rising pool flood control discharge of 12,200 cfs from Modified Roosevelt Dam is indicated by the plan. A discharge of this magnitude matches the maximum release capacity of the outlet works at Modified Roosevelt Dam; therefore, this flow can all be passed from the outlet works, if necessary (i.e., during power generation shutdowns). Hydropower generation throughout the SRP system is still possible in this range.

(e) **WSE 2162 feet - 2172 feet (39,500 cfs)**. From WSE 2162 feet up to WSE 2172 feet, a rising pool flood control discharge of 39,500 cfs is specified. A discharge of this magnitude matches the combined total of the ungated release capacity of the Horse Mesa tunnel with Apache Lake at elevation 1910 feet (33,000 cfs), plus the capacity of the Horse Mesa generators (6,500 cfs).

**(f) WSE 2172 feet - 2175 feet (53,100 cfs).** From WSE 2172 feet up to WSE 2175 feet, a rising pool flood control discharge of 53,100 cfs is specified. A discharge of this magnitude utilizes the right spillway, the outlet works and the hydropower turbines at Modified Roosevelt Dam without causing significant damage to the SRP system. This flow is to be maintained up to WSE 2175 feet, which is the top of the flood control storage.

**2. During Falling Stages.** As mentioned previously, the flood control regulation of Modified Roosevelt Dam includes a 20-day drawdown period in order to meet environmental requirements. As a result, a separate release schedule was developed for use when the reservoir water surface elevation is falling. During the falling stage (also shown on Part 1 of Plate 7-1), the scheduled reservoir releases for some steps are designed to be higher than those of their corresponding (same WSE) releases during the rising stage. These higher releases are necessary in order to meet the 20-day drawdown criteria of the EIS. In the event of another forecasted storm (while regulating under a falling stage from a prior inflow event), higher releases than those specified can be maintained in order to evacuate the pool more rapidly, and create additional reservoir space in preparation for the next inflow event.

It should be noted that the release ranges of the first steps of this plan were intended to fully utilize hydropower generation of the Salt system. However, controlling floods by storing flood water is the only authorized purpose of the flood pool. Therefore, if the water control manager at the SRP office determines that there is a need to make releases higher than those specified in the diagram (including flows that will result in power generation shutdown), the water control manager has the flexibility to do so provided that the maximum discharge at the Salt River and Verde River confluence resulting from this action does not exceed the maximum discharge that would occur at the confluence if the release diagram was followed.

During the falling stages, the water control manager has the flexibility to maintain higher discharges than those specified, even at lower elevations, in order to meet the 20-day evacuation period or to evacuate the pool more rapidly in preparation for another forecasted storm. The maximum release that can be made within the flood pool is limited to 53,100 cfs, unless projections indicate that the water surface elevation will rise above 2175 feet.

**b. Spillway Surchage Pool (WSE 2175 feet - WSE 2218 feet).** The reservoir storage space at Modified Roosevelt Dam above WSE 2175 feet is reserved for use during spillway surcharge. Once the water surface elevation exceeds WSE 2175 feet, dam safety becomes the prime objective. Passing as much water out of the reservoir as possible to assure the safety of Modified Roosevelt Dam and the downstream dams becomes the primary regulation concern. Releases from the dam are no longer coordinated with downstream runoff to limit the flow at the Salt and Verde confluence to 180,000 cfs. The water control diagram shown on Part 2 of Plate 7-1 illustrates the regulation of the dam during this condition. According to the diagram, once the reservoir level exceeds the top of the flood control pool, the total reservoir discharge is increased linearly from 53,100 cfs at WSE 2175 feet, up to 142,000 cfs at WSE 2180 feet (i.e., at WSE 2176 feet, the discharge is 70,880 cfs; at WSE 2177 feet, the discharge is 88,660 cfs, etc). At WSE 2180 feet, the total spillway outflow is 142,000 cfs; if the water surface elevation reaches WSE 2185, the combined spillway outflow is 146,000 cfs; and if the water surface elevation reaches WSE 2187.6 feet, the combined spillway outflow is 150,000 cfs. Flows indicated for elevations above WSE 2175 feet are to be passed through both the left and right spillways. With all gates wide open, the combined outflow of the left and right spillways is 150,000 cfs when the water surface elevation is at WSE 2187.6 feet. Once this elevation is exceeded (even at elevations above WSE 2218 feet), the spillway gates are to be adjusted so as to maintain a maximum of 150,000 cfs.

As previously stated, the maximum discharge from Modified Roosevelt Dam within the spillway surcharge pool (at WSE 2187.6 feet and above) can be as high as 150,000 cfs. However, the combination of spillway flow and local inflow to the reservoirs downstream of Modified Roosevelt Dam is not to exceed this amount (150,000 cfs). Therefore, the water control manager at the Salt River Project can cut back spillway releases if necessary so as not to exceed a total inflow of 150,000 cfs into Apache Lake or into Canyon Lake during spillway flow at Modified Roosevelt Dam.

**7-06 Recreation.** There are existing recreational facilities within and around the Theodore Roosevelt Lake area and other recreational facilities are being planned for future construction. However, Modified Roosevelt Dam is not operated for recreational purposes when the reservoir water surface is within the flood control pool.

**7-07 Water Quality.** This water control plan does not specifically address any water quality concerns. Water quality, however, is monitored by the USGS. The water quality data collected by the USGS can be obtained from various reports published annually by the USGS.

During emergencies, the water control manager can operate Modified Roosevelt Dam to contain pollution spills either in or downstream of Modified Roosevelt Dam and Theodore Roosevelt Lake. This subject is discussed in detail on section 7-14.a. of this water control manual.

**7-08 Fish and Wildlife.** The importance of biological resources has been recognized in several Federal environmental laws, including NEPA, the Fish and Wildlife Coordination Act, and the Endangered Species Act. The first two laws require that the conservation of biological resources, by preventing or minimizing damages, shall receive equal consideration and be coordinated with other features of water resources programs. The Endangered Species Act stipulates that each Federal Agency shall ensure that its actions are not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction of or adverse impacts to critical habitat for such species. These acts also require Federal agencies to coordinate with the U.S. Fish and Wildlife Service and State agencies regarding such matters.

The regulation of Modified Roosevelt Dam requires that the flood pool be evacuated within a 20 day time period from the beginning of the (single event) design flood. This requirement will minimize the impact of the flood pool on riparian habitats located within the reservoir.

**7-09 Water Supply.** As previously mentioned, the modification of Theodore Roosevelt Dam was authorized as part of the CAWCS recommended project of which the main objective is water supply. As a result, the modifications to the dam resulted in an increase of reservoir storage allocated for water supply (from WSE 2136 feet to WSE 2151 feet, or approximately an additional 305,000 ac-ft). This increase includes dead storage. The water control plan presented in this manual, however, is limited to the flood control regulation of the dam, thus it does not cover the project regulation for water supply.

**7-10 Hydropower.** Although the storage volume of Modified Roosevelt Dam from WSE 2151 feet to WSE 2175 feet is dedicated for flood control purposes only, the development of the water control plan presented in this manual considered making the maximum use of water in the flood control pool for power generation. Therefore, flood control releases in the early stages of a flood event are limited to the system hydropower generation capacities. These releases were determined not only to limit downstream runoff to the minimum when significant flood control space is still available, but also to gain the maximum benefits derived from incidental hydropower generating capacity of the SRP system.

**7-11 Navigation.** Navigation is not a project purpose for Modified Roosevelt Dam.

**7-12 Drought Contingency Plan.** The dam is regulated for water conservation up to WSE 2151 feet. Above 2151 feet, the reservoir space is dedicated for flood control and dam safety purposes. The COE's ETL 1110-2-335 entitled "Development of Drought Contingency Plans" requires every Corps of Engineers water control project with the potential for providing useful service during times of drought to have a drought contingency plan (DCP) in place. However, since Modified Roosevelt Dam is a Section 7 dam, a DCP is not required.

**7-13 Flood Emergency Action Plans.** The SRP's Emergency Reservoir Operating Procedure (SRP-160) outlines different responsibilities and procedures within the organization during flood emergencies. In addition, SRP publishes the Standing Operating Procedures (SOP) outlining the operation of SRP projects, including Modified Roosevelt Dam during flood emergencies. The SOP for Modified Roosevelt Dam reflects the current water control plan presented in this water control manual. A copy of the SOP is available at the SRP office.

**7-14 Deviation from Normal Regulation.** There may be instances when it is necessary for the regulation of Modified Roosevelt Dam to deviate from the established flood

control plan described in this chapter. Prior approval of deviations is required from the COE through the LAD, except for emergencies as described in paragraph 7-14.a below.

**a. Emergencies.** Emergencies may include, but are not limited to, drownings, accidents, chemical spills, and failure of operational facilities. Necessary action should be taken immediately to contend with emergencies. In any action taken, assessment of the situation by the water control manager at the SRP should rely on his/her knowledge of the dangers involved. The COE must be informed of any deviations due to emergencies as soon as practical. Emergency deviations do not require prior approval by the COE, but coordination with the COE must be made as soon as practical.

**b. Unplanned Minor Deviations.** Instances arise periodically which require minor deviations from the normal regulation of the reservoir. Construction activities are the primary source of these deviations. Downstream maintenance of culverts and channel sections are another reason for minor regulation changes. Each request is analyzed on its own merits. Consideration is given to the potential of flooding and possible alternative measures. Prior approval for these minor deviations must be obtained from the COE. Flood control, environmental and legal ramifications will be addressed and evaluated prior to the COE's approval of this type of deviation.

**c. Planned Deviations.** There are planned instances which require deviations from normal regulation. Each condition will be judged on its own merits. Prior approval for this type of deviation must be obtained from the COE. Flood control, environmental and legal ramifications will be addressed and evaluated prior to COE's approval of this type of deviation. Requests for planned deviations must be coordinated through the Reservoir Regulation Section of the LAD. As per the MEMORANDUM FOR Commander, Los Angeles District, from the Division Commander dated March 20, 1991:

*“All planned deviations from approved water control plans for reservoir projects within the South Pacific Division must be coordinated with the Coastal Engineering and Water Management Division at CESPD. Approval must be given prior to implementation of the deviation.”*

(NOTE: The Corps' South Pacific Division was later reorganized and the Coastal Engineering and Water Management Division was renamed as the Directorate of Engineering and Technical Services.)

Names and telephone numbers of contact persons at the COE are listed in the LAD publication entitled “Instructions for Reservoir Operations Center Personnel” (a.k.a. the

“Orange Book”). The LAD issues an updated version of the “Orange Book” in the early part of each water year.

**7-15 Rate of Release Change.** Plate 7-1 illustrates the water control plan for Modified Roosevelt Dam. The diagram shows a specified release for a given reservoir elevation range. During high releases, bank erosion of the downstream channel is not anticipated to be a major concern since the Salt River downstream of Modified Roosevelt Dam enters a series of reservoirs; Therefore, the regulation of Modified Roosevelt Dam does not require limits on the rate at which releases are changed. Releases can be increased or decreased as specified in the water control plan without such restrictions.

As previously stated, during large flood events, the plan allows the flexibility to release discharges greater than specified in the diagram provided that the maximum discharge at the Salt and Verde River confluence resulting from this action does not exceed the resulting maximum discharge at the same location if the water control diagram was followed. During this process, however, it is advisable to make release adjustments in increments based on the flow magnitudes specified in the diagram. This is illustrated in the following example:

**EXAMPLE:**

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**SCENARIO:**

1. The reservoir water surface elevation is at 2161.5 feet and the dam is operated according to schedule (outflow of 12,200 cfs).
2. It has been continuously raining and a series of major storms are forecasted to cause the reservoir water surface elevation to exceed WSE 2172 feet.
3. The water control manager at SRP decides to increase outflows to more than what the schedule specifies.

**RECOMMENDED ACTION:**

1. At this stage, a maximum release of up to 53,100 cfs can be made from the dam. However, increasing the outflow from 12,200 cfs to 53,100 cfs should be done in two steps: 1) increase the outflow to 39,500 cfs and maintain for a reasonable time period, and then 2) increase the outflow to 53,100 cfs.
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## VIII - EFFECT OF WATER CONTROL PLAN

**8-01 General.** The water control plan presented in this manual provides a guideline to the water control manager at the SRP in regulating Modified Roosevelt Dam when the reservoir water surface reaches the flood control storage pool (WSE 2151 feet). Part 1 of the Water Control Diagram shown on Plate 7-1 was developed in order to provide flood control benefits by minimizing downstream discharges during large flood events. This plan was selected from three other alternative plans because it also provides the best mix of (as compared with the other three): 1) minimizing damaging releases within the SRP system, 2) minimizing the frequency of exceeding the top of the flood control pool, 3) maximizing operational flexibility, and 4) maximizing hydropower generation during flood control regulation. Part 1 and Part 2 of the Water Control Diagram were developed in order to prevent the possibility of overtopping the dam during large flood events up to and including the PMF. The regulation of the dam during these conditions limits the discharge from the dam up to a maximum spillway flow of 150,000 cfs in order to prevent the possibility of overtopping other downstream dams, namely Horse Mesa Dam and Mormon Flat Dam. Although intended mainly for flood control purposes, the releases indicated in the plan were also selected based upon consideration of other factors including other project benefits, environmental issues, design and physical limitations of Modified Roosevelt Dam and the downstream dams and facilities, and the downstream channel capacities of the Salt River and Gila River. In addition, the plan also allows the flexibility to make releases higher than indicated by the Water Control Diagram provided that the maximum downstream discharge (measured at the Salt and Verde confluence) resulting from this action does not exceed the resulting maximum downstream discharge if the reservoir was operated according to the diagram.

**8-02 Flood Control.** The modification of Theodore Roosevelt Dam includes a approximately a 557,000<sup>1</sup> ac-ft reservoir space dedicated for flood control measured from from WSE 2151 feet to WSE 2175 feet. The water control plan presented in this manual was developed to control: 1) the SPF without exceeding a maximum water surface

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1. The 1995 reservoir survey, which was done after the formulation of the water control plan, shows the reservoir volume between WSE 2151 feet and WSE 2175 feet to be 556,196 ac-ft. Exhibit C of this water control manual contains the Area-Capacity Table based on the 1995 reservoir survey.

elevation of 2175 feet, with a maximum release of 53,100 cfs, and 2) the PMF without exceeding a maximum water surface elevation of 2218 feet, with a maximum spillway discharge of 150,000 cfs. These two design floods and the routings of historical flood events are discussed in the following paragraphs:

**a. Probable Maximum Flood (PMF).** The USBR's design criteria requires that Modified Roosevelt Dam safely pass a design flood called the Inflow Design Flood (IDF). During the design phase of the modification project, the IDF was chosen to be equal to the PMF. The decision to equate the IDF to the PMF is contained in the USBR's Technical Memorandum No. TR 222-1. Paragraph 4, page 2 of the said memorandum, referring to the original Theodore Roosevelt Dam, states:

*“In the modification process report and its amendment, the IDF was equated to the feasibility level PMF based upon the incremental flood damage analysis. In the amendment to the modification report, the first stage of failure occurred at the 35 percent level of the feasibility PMF peak inflow or 235,000 cfs. This first stage failure consists of complete loss of the spillway gates and piers on both abutments. The threshold of the second failure begins at the fifty percent level of the feasibility PMF peak inflow or 340,000 cfs. This mode of failure consists of the additional loss of 50 feet of the dam at each abutment. The revised PMF has a larger volume than the feasibility PMF which means that the same level of outflow will occur for the new PMF at a lower percentage of the flood. Therefore, the incremental damages will be greater at a given percentages of the flood. In other words, the probability of incurring a given damage has increased with the revised PMF. This leads to the conclusion that equating the IDF to the revised PMF is even more justified now than it was during the feasibility studies, upon which the modification report is based.”*

The PMF is the flood that can be expected from the most severe combination of meteorological and hydrologic conditions reasonably possible in the region. PMF, as the name implies, is an estimate of the upper bound of flood potential for a drainage area. During the feasibility phase of the modification project, a summer PMF and a winter PMF were developed by the USBR for the watershed above Modified Roosevelt Dam. The winter PMF was found to cause the highest maximum reservoir water surface and thus was chosen to be critical for the feasibility design of the modified dam. This PMF has a peak inflow of 678,200 cfs and a 17-day volume of 2,550,000 ac-ft. In 1986, due to a change in methodology of determining the Probable Maximum Storm (PMS) values, a new winter PMF was recalculated for the modified dam. This winter rain-on-snow PMF was developed based on estimates provided by the National Weather Service Hydrometeorological Reports. The new winter PMF which was used in the final design has a peak flow of 654,000 cfs and a 16-day volume of 3,020,000 ac-ft.

The updated PMF was derived from the USBR's density compaction method for determining runoff from rain-on-snow and the unit hydrograph method for determining the magnitude and distribution of the runoff related to time. The drainage basin was divided into five subbasins for the hydrologic analyses. An average dimensionless graph from the analyses of three separate flood events, Salt River near Roosevelt, Verde River near Tangle Creek, and the Tonto Creek above Gun Creek, was used in the unit hydrograph derivation.

The Probable Maximum Precipitation (PMP) for the winter-type occurrence was determined for each of the 5 subbasins and varied from 12.69 inches to 9.40 inches in 72 hours. An antecedent winter storm, which was assumed to occur 48 hours prior to the PMP, was also employed. This antecedent storm was based on the December 12-20, 1967 storm and varied in depth from 6.55 inches to 9.45 inches for the 8-day period. The precipitation excesses from the rain-on-snow computations were obtained by subtracting a constant loss rate of 0.10 inches per hour. The subbasin hydrographs were determined by applying the appropriate unit hydrograph to the rainfall excesses and then adding base flow. The base flow was estimated to be 0.10 cfs per sq. mi. at hour zero of the storm sequence to 2.53 cfs per sq. mi. at hour 72 and thereafter. The hydrographs for the three upstream subbasins were routed downstream by the Tatum method of successive averages and combined with the other two subbasin hydrographs, which flow directly into the reservoir.

Plate 8-1 shows the routing hydrograph for the PMF (or IDF) at Modified Roosevelt Dam using the water control plan presented in this manual. In this routing, the water surface at the beginning of the design flood is at elevation 2151 feet (top of the water conservation pool). The plate shows a maximum water surface elevation of 2217.60 feet on the 5th day of the flood event, a maximum inflow of 654,000 cfs which occurs on the 3rd day, and a maximum discharge of 150,000 cfs for approximately 8 days.

**b. Standard Project Flood (SPF).** The SPF represents the flood that would result from the most severe combination of meteorologic and hydrologic conditions considered reasonably characteristic of the geographical area. The SPF is normally larger than any past recorded flood in the area and would be exceeded in magnitude only on rare occasions. The SPF, therefore constitutes a standard for design or redesign that would provide a high degree of flood protection.

The derivation of the component of the SPF for the watershed above Modified Roosevelt Dam is contained in a LAD report entitled "Interim Report on Survey For Flood Control, Gila and Salt Rivers, Gillespie Dam to McDowell Dam Site, Arizona", dated December 4, 1957. The inflow hydrograph for the watershed above Modified Roosevelt Dam is a component of the SPF for the watershed above a then proposed dam, named McDowell Dam. McDowell Dam was at the time proposed below the Salt and Verde River confluence approximately 3 miles above Granite Reef Diversion Dam. Second paragraph of page 1-10 of the said report states the following:

*"...The Standard Project Flood on Salt River between the mouth and Verde River has been synthesized on the basis of the assumed occurrence of a storm equivalent to the 1938 storm and the 1916 storms centered (approximately 20 miles northeast and 80 miles northwest, respectively, of actual occurrence) over the area above the proposed McDowell Dam site."*

The report states further:

*"Determination of the magnitude of the storms that would be equivalent to the 1916 and 1938 storms but would have a critical centering to the northwest and northeast, respectively was accomplished by: (a) expressing the actual rainfall amounts in the 1916 and 1938 storms as percentages of the mean rainfall amounts for the period of October through May, (b) constructing isopercentual maps based on those percentages, and (c) shifting the isopercentual lines to such a position over the basin as would result in more critical amounts of rainfall over the drainage area above the respective concentration points. Use of the mean precipitation for the months of October through May as a base for determining project-storm precipitation is considered warranted in view of the fact that most precipitation in those months in Arizona results from storms of the general winter type, and thus such mean seasonal precipitation is an indication of the effects of basin topography on precipitation in general storms..."*

The determination of the SPF resulting from both centerings was summarized in the CAWCS report entitled "Gila River and Tributaries, Central Arizona Water Control Study", dated May 1982, as follows:

*"a. SPF Computation. The standard project floods for both centerings were computed in several identical steps as follows:*

- (1) effective rainfall (para. 3-03) for each subarea was calculated by application of the 1957 loss rate (para 3-02) to the standard project storm precipitation totals.*
- (2) unit graphs for each subarea were determined as discussed in para 3-04;*
- (3) flood hydrographs for each subarea were determined by inputting effective rainfall to LADFHP (Los Angeles District Flood Hydrograph Package - a computer simulation model developed by LAD), which combines computed unit graphs with effective rainfall to determine subarea hydrographs;*

*(4) the respective subarea component flood hydrographs were input to HEC-5, the reservoir operation program, wherein all reservoir routing, channel routing, hydrograph combination, and percolation losses were taken into account (para. 3-05 and 3-06)."*

3rd paragraph of page 1-13 of the 1957 report read :

*"...Computation of the Standard Project Flood for Salt River from its mouth to McDowell Dam site, made in like manner, resulted in two alternative standard project floods. The 1938 storm transposed resulted in highest peak discharge and the 1916 storm transposed resulted in largest volume flood. In order to have one standard project flood for Salt River to simplify investigations and planning, the rainfall pattern for the Verde River area, over which both the 1938 and 1916 storms were assumed centered, was adjusted to give higher intensities for the maximum 6- and 12-hour periods so that the resulting flood at McDowell Dam site would have the same peak as the one based on the 1938 storm transposed and the same volume as the one based on the 1916 storm transposed..."*

The computation of the SPF component for the watershed above Modified Roosevelt Dam has a peak inflow of 184,700 cfs occurring on the 5th day of the flood event. Plate 8-2 shows the routing of this SPF component using the water control plan presented in this manual. The routing resulted in a maximum water surface elevation of 2174.58 feet on the 10th hour of the 7th day of the event, and maximum flood control release of 53,100 cfs for two days.

**c. Other Floods.** In order to test the adequacy of the water control plan during its development, selected historical floods and frequency floods were routed using the plan. Table 8-1 shows the peak values at Modified Roosevelt Dam from the routings of the selected historical floods with the resulting peak discharges at the Salt River and Verde River confluence (designated as peak discharges at Granite Reef Diversion Dam). Table 8-2 shows the peak values at Modified Roosevelt Dam from frequency floods when routed using the water control plan. Plate 8-3 shows the resulting selected annual peak discharges (simulated using the water control plan) at Granite Reef Diversion Dam compared with the annual peak discharges under without project conditions. Plate nos. 8-4a., 8-4b, 8-4c, 8-4d and 8-4e show the selected historical floods routed using the water control plan. Plates nos. 8-5a, 8-5b, and 8-5c show the 100-yr, 200-yr, and 500-yr frequency floods routed using the water control plan.

**8-03 Recreation.** Recreation issues of the overall CAP project (including at Modified Roosevelt Dam) are addressed in the USBR's report entitled "Stage III Report Addendum, Central Arizona Project, Appendix C", and dated March 1984. The modification of Theodore Roosevelt Dam results in a vast increase in recreational potential. New, upgraded roads resulted from the modification, all recreation facilities affected by the modification project will be replaced, and additional facilities will be constructed to enhance visitor activities. However, the regulation of the project above elevation 2151 ft. does not include recreation. Therefore, none of the recreational facilities depend upon runoff impounded behind the dam, and no flood control releases are made from the dam for downstream recreational purposes. The effects of the dam and its operation upon recreational activities within the reservoir are by necessity all negative; that is, some of the facilities, (existing and proposed) may be flooded by the impoundment of water behind the dam for flood control purposes.

**8-04 Water Quality.** The USBR's Final Environmental Impact Statement for the CAP project reported that overall, a modified Theodore Roosevelt Dam or a New Theodore Roosevelt Dam, would have an insignificant effect on water quality. Therefore, the regulation of the dam for flood control purposes which requires the temporary impoundment of excess flood waters in the flood control pool does not have a significant effect on water quality.

**8-05 Fish and Wildlife.** The water control plan for Modified Roosevelt Dam results in temporary impoundment of flood waters within the flood control pool (above WSE 2151 ft). Previous environmental studies concluded that riparian habitats within the specified reservoir space will not be adversely affected as long as the flood pool is evacuated within 20 days. Therefore, the water control plan includes a 20-day evacuation requirement in order to minimize the impact of the regulation to the riparian habitats. The flood control releases indicated in the water control plan during the recession side were determined in order to meet the 20-day evacuation requirement.

**8-06 Water Conservation.** The modification of Theodore Roosevelt Dam results in additional capabilities for water conservation, including an increase of 272,500 ac-ft of storage reserved for water supply and dead storage. Although the water control plan

presented in this manual does not directly take into account water conservation purposes, at each flood event prior the water control plan going into affect, the reservoir's water conservation pool has to be filled to maximum capacity. At the end of each flood event, flood control regulation terminates at the top of the water supply pool. Therefore, the flood control regulation of the dam has a positive effect on water conservation.

**8-07 Hydropower.** The release ranges shown in the Water Control Diagram shown on Plate 7-1 were determined taking the hydropower capabilities of the SRP system into consideration; the water control plan's initial ranges of releases were designed to fully utilize the hydropower generation capacity of the system. Therefore, the flood control regulation of Modified Roosevelt Dam has a positive effect on hydropower generation.

**8-08 Navigation.** Modified Roosevelt Dam is not regulated for navigation purposes.

**8-09 Drought Contingency Plan.** A drought contingency plan for Modified Roosevelt Dam is not required.

**8-10 Flood Emergency Action Plan.** The SRP's Emergency Reservoir Operating Procedures (SRP-160) and Standing Operating Procedures for Modified Roosevelt Dam provide guidance to SRP personnel during flood emergencies. Copies of these publications are available through the SRP.

**8-11. Frequencies.** The development of the water control plan for Modified Roosevelt Dam is documented in the draft report entitled "Section 7 Study for Modified Roosevelt Dam, Arizona, Hydrologic Evaluation of Water Control Plans, Salt River Project to Gila River at Gillespie Dam", dated March 1996. This report was developed by the COE, and copies are also available at the SRP and the USBR offices. The following plates which show anticipated results of the water control plan were taken from the said report: 1) Plate 8-6 which presents the elevation frequency curve for Modified Roosevelt Dam when operated in accordance with the water control plan, 2) Plate 8-7 which shows a comparison of the without project peak discharge frequency (developed during the

CAWCS) to the peak discharge frequency for the water control plan, and 3) Plate 8-8 which shows the peak outflow frequency curve for Modified Roosevelt Dam when operated in accordance with the water control plan.

**Table 8-1**  
**Simulation Results Using the Water Control Plan**  
**Selected Historical Floods**

<b>Simulated Date</b>	<b>Peak WSE at Modified Roosevelt Dam (ft., m.s.l.)</b>	<b>Peak Discharge at Modified Roosevelt Dam (cfs)</b>	<b>Peak Discharge at Granite Reef Diversion Dam (cfs)</b>
February 1891	2172.86	53,100	199,000
April 1905	2157.95	37,500	63,500
January 1916	2165.30	39,500	109,000
February 1920	2159.60	39,500	111,000
March 1941	2161.01	3,950	91,100
December 1979	2157.65	29,600	49,300
February 1980	2162.60	39,500	130,000

**TABLE 8-2**  
**Simulation Results Using the Water Control Plan**  
**Frequency Floods**

<b>Flood Frequency</b>	<b>Modified Roosevelt Dam Peak Inflow (cfs)</b>	<b>Modified Roosevelt Dam Peak Discharge (cfs)</b>	<b>Modified Roosevelt Dam Peak W.S.E. (ft., m.s.l.)</b>
500-yr	300,000	105,000	2178
200-yr	255,000	53,100	2173
100-yr	225,000	39,500	2168
50-yr	190,000	39,500	2164
20-yr	140,000	39,500	2159
10-yr	100,000	12,200	2155
5-yr	62,000	5,500	2151

*SOURCE: Section 7 Study For Modified Roosevelt Dam, Arizona  
 Hydrologic Evaluation of Water Control Plans  
 Salt River Project to Gila River at Gillespie Dam  
 U.S. Army Corps of Engineers, Los Angeles District, March 1996*

## IX - WATER CONTROL MANAGEMENT

### 9-01 Responsibilities and Organization.

a. **Corps of Engineers (COE).** The role of the COE in the regulation of Modified Roosevelt Dam is based on Section 7 of the Flood Control Act of 1944, which reads in part:

*“Hereinafter it shall be the duty of the Secretary of War to prescribe regulations for the use of storage allocated for flood control or navigation at all reservoirs constructed wholly or in part with Federal funds provided on the basis of such purposes, and the operation of any such project shall be in accordance with such regulations..”*

Rules and regulations published in "The Federal Register", July 1, 1993 Edition, under Title 33, Chapter 11, part 208, provide for the revision of water control plans *"to reflect changed conditions that come to bear upon flood control and navigation.."*. These regulations are reprinted in Exhibit B of this manual.

In practice, the COE's role has mainly consisted of developing flood control operating criteria and regulations and monitoring flood conditions and compliance with flood control regulations. The COE is available for consultation on flood-related operations. Deviations from water control plan require COE approval.

Exhibit A of this manual contains agreements between the COE and the USBR, namely: 1) the Interagency Agreement No. 2-AA-32-01390, 2) Letter of Understanding, and 3) Water Control Agreement. The COE chain of command and related telephone numbers are shown in Plate 9-1.

b. **U.S. Bureau of Reclamation (USBR).** The USBR owns Modified Roosevelt Dam and other related projects in the Salt River System.

The Lower Colorado Region of the USBR is ultimately responsible for the construction, operation and maintenance of Modified Roosevelt Dam. The offices of the Lower Colorado Region are located in Boulder City, Nevada. The USBR's Phoenix Area Office, an element of the Lower Colorado Region is located in Phoenix, Arizona.

c. **Salt River Project (SRP).** The SRP is responsible for the operation and maintenance of Modified Roosevelt Dam, pursuant to the 1917 contract with the USBR. The SRP office is located in Phoenix, Arizona.

**9-02 Interagency Coordination.** The U.S. Army Corps of Engineers coordinates with other Federal, State, County, and local organizations concerning the water control operations of its projects and Section 7 Dams.

a. **Local Press Bulletins.** The Public Affairs Office of the Corps of Engineers, LAD (after coordination with the USBR), coordinates with the local press regarding floods and other aspects of project operation. This is accomplished through both telephone and in-person interviews and occasional issuance of press releases. It should be noted that the COE does not issue flood watches or warnings, or other status reports or forecasts to the general public. The Lower Colorado Region of the USBR, and the SRP coordinate with the local press regarding floods and other aspects of project operation.

b. **National Weather Service (NWS).** The NWS has the responsibility for issuing flood watches and warnings to the public. The COE, USBR, and SRP utilize NWS data to aid in real-time flood control operations. Both real-time and post-event data is shared by the agencies.

c. **U.S. Geological Survey (USGS).** The U.S. Geological Survey cooperates with several agencies in the lower Colorado River Basin in the operation of stream gaging stations. The USGS maintains and services many of the stations under contract with other agencies. Data from many of the gages are published annually by the USGS in its Water Supply Papers.

d. **U. S. Fish and Wildlife Service (USFWS).** In accordance with the Endangered Species Act of 1973 (PL 93-205) and the Fish and Wildlife Coordination Act (PL 85-624) the COE coordinates with the U.S. Fish and Wildlife Service regarding environmental impacts at COE projects including Section 7 dams.

### **9-03 Interagency Agreements.**

**a. Interagency Agreement No. 2-AA-32-01390.** The COE and the USBR entered Interagency Agreement No. 2-AA-32-01390 on 12 February 1992 for the purpose of performing flood control related studies such as economic, hydraulic, hydrologic and operational analyses and where needed, and development of a water control plan, agreement and/or operating manual for particular features of the Central Arizona Project (CAP) being constructed at the time. Modified Roosevelt Dam was one of the features of the CAP for which hydrologic and economic analyses were required in developing the water control plan, agreement and manual. A copy of this agreement can be found in Exhibit A.

**b. Letter of Understanding (LOU).** The COE and the USBR entered into an agreement called a Letter of Understanding which outlines the responsibility of each agency in the flood control regulation of Modified Roosevelt Dam. A copy of this agreement can be found in Exhibit A.

**c. Water Control Agreement (WCA).** The USBR, the COE and the SRP entered into a Water Control Agreement that details the operation of Modified Roosevelt Dam for flood control. A copy of this agreement can be found in Exhibit A of this water control manual.

**9-04 Commissions, River Authorities, Compacts, and Committees.** Modified Roosevelt Dam is operated and maintained by the Salt River Project (SRP) which represents all the water users subscribed to the Salt River Valley Water Users Association.

**9-05 Reports.** Reports and manuals relevant to the original Theodore Roosevelt Dam and Modified Roosevelt Dam, including the Standing Operating Procedures (SOP) for Modified Roosevelt Dam are available in the USBR and the SRP offices.

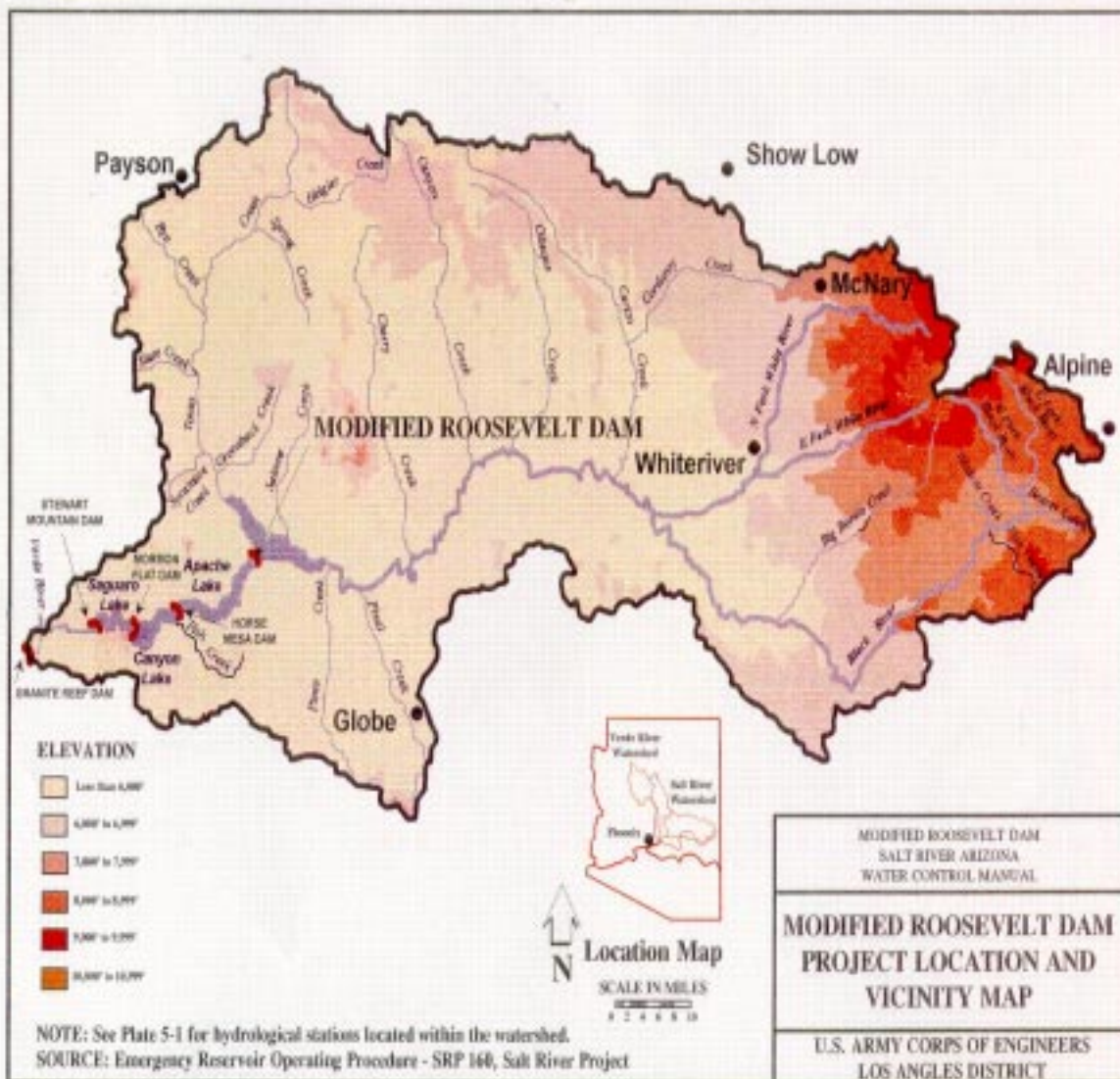
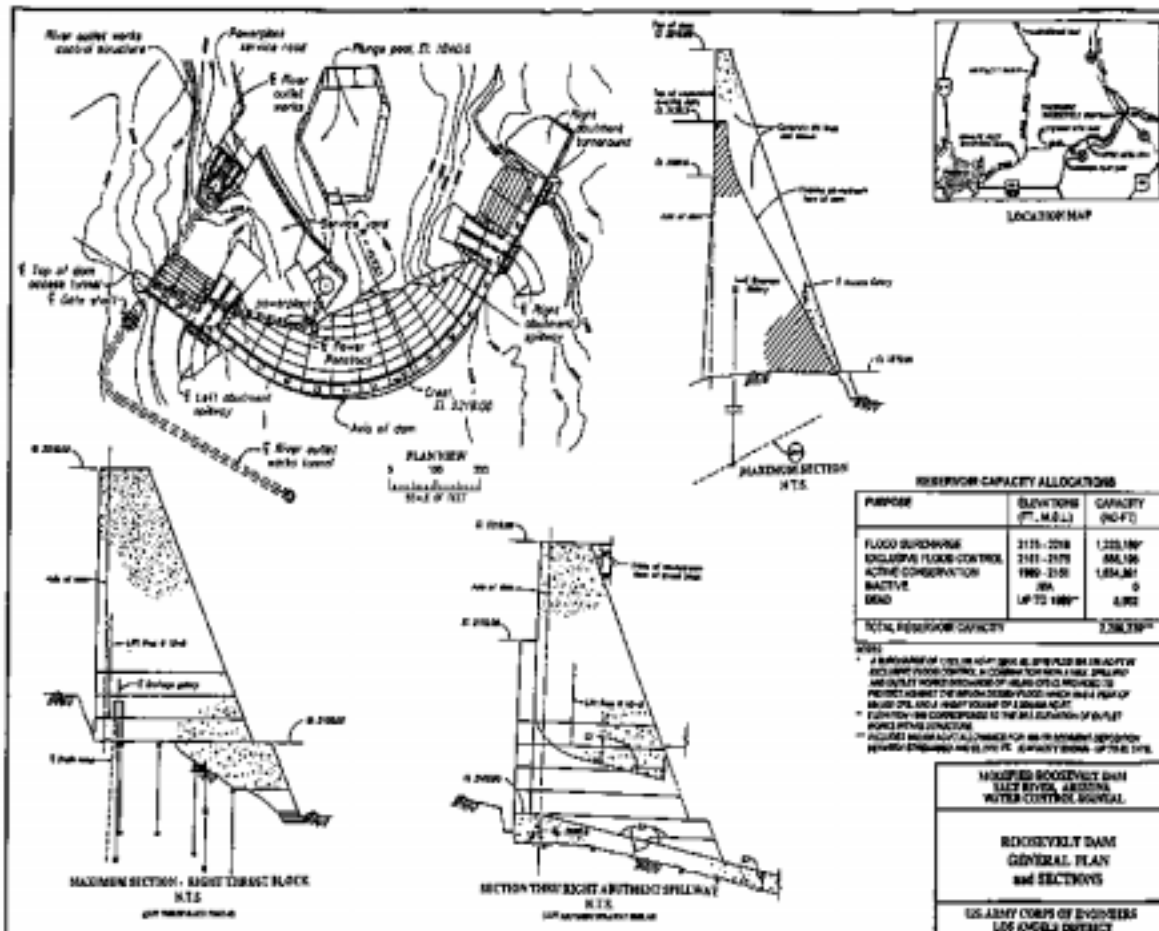


Plate 2-1



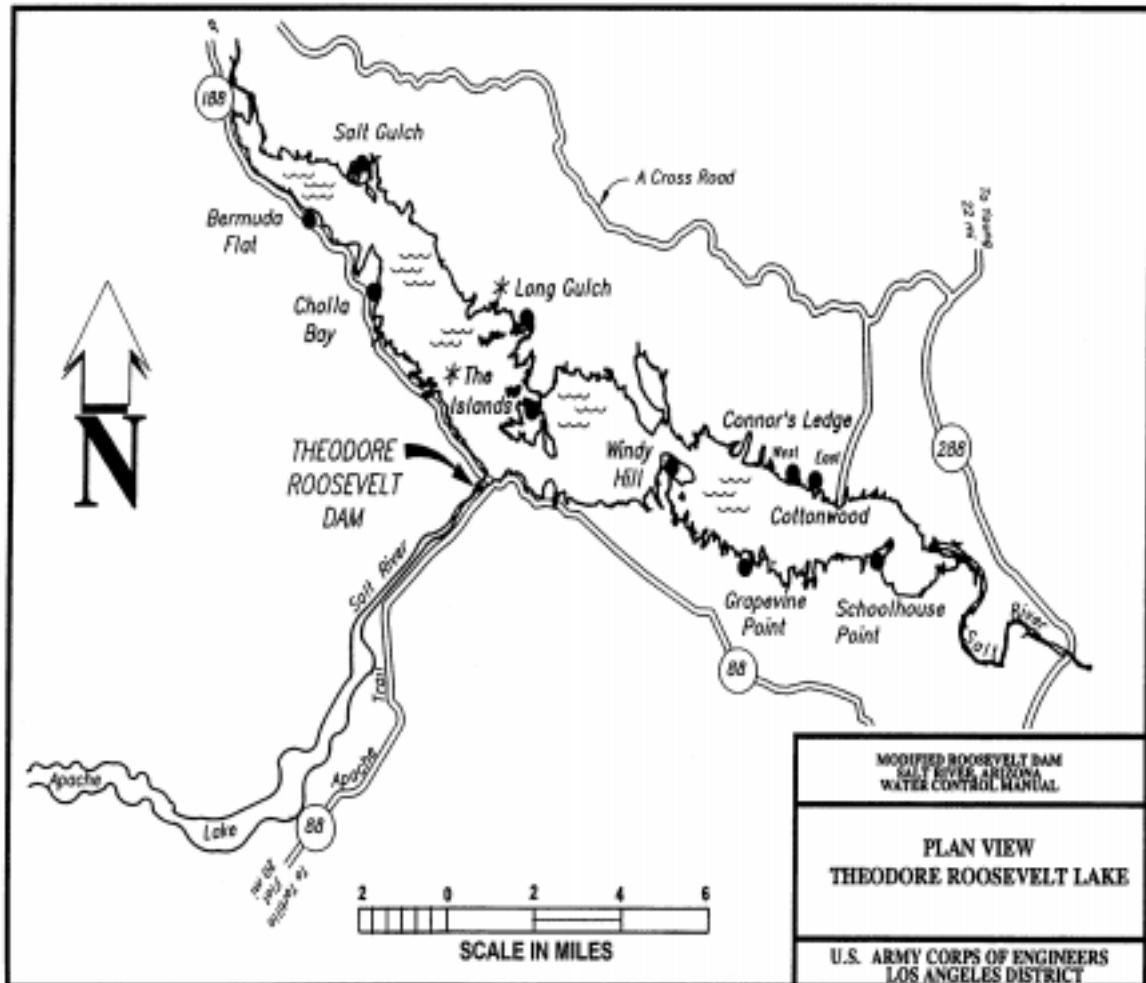
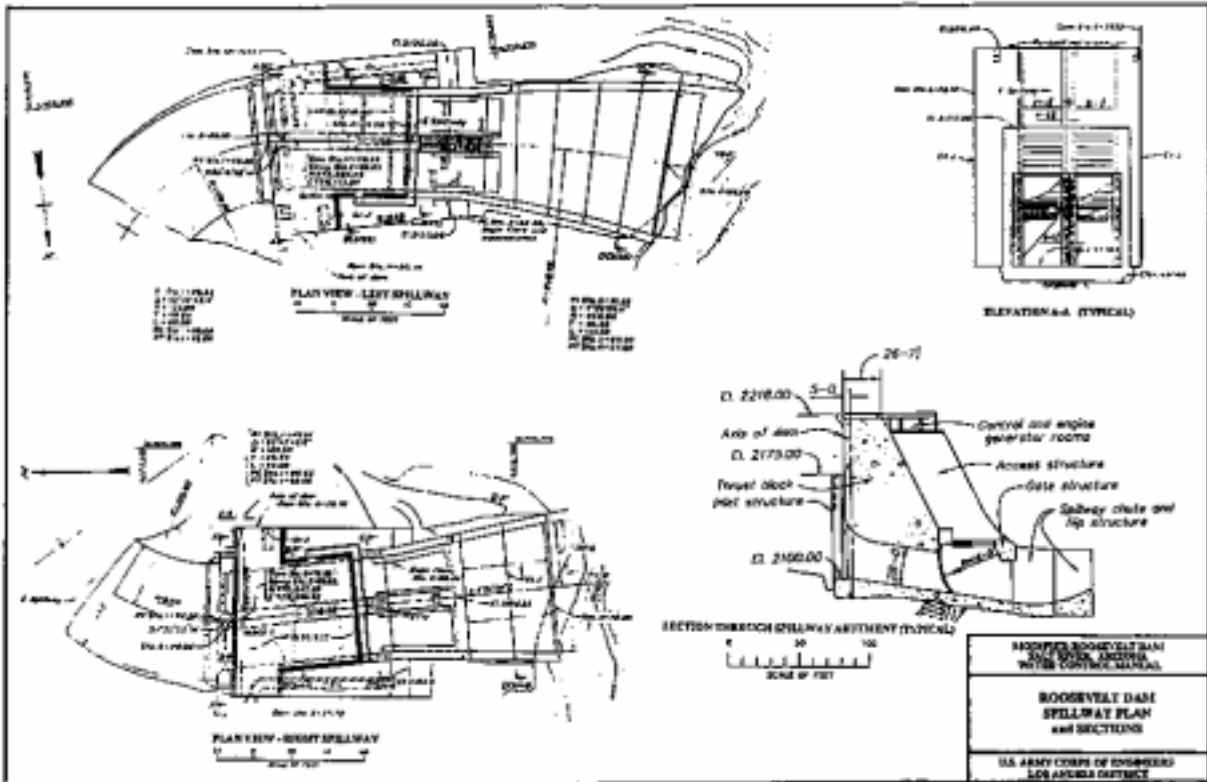


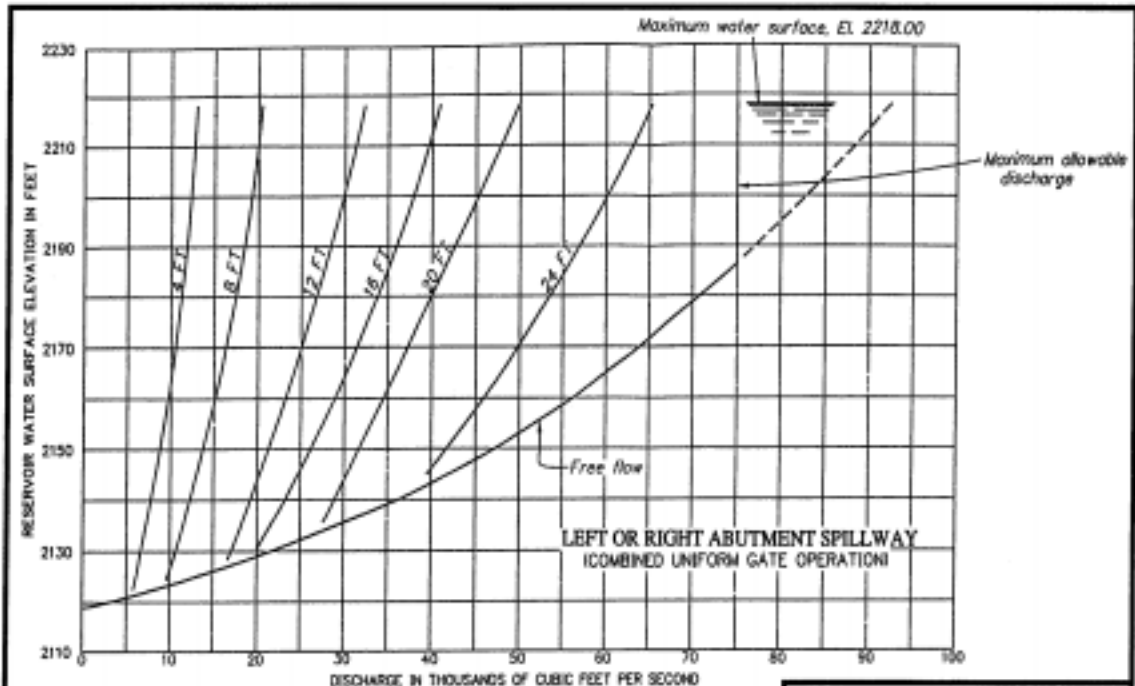
PLATE 2-3



MODIFIED ROOSEVELT DAM  
 SOUTHWEST ARIZONA  
 WHITE CONTRACT, 1914-15

**ROOSEVELT DAM  
 SPILLWAY PLAN  
 AND SECTIONS**

U.S. ARMY CORPS OF ENGINEERS  
 LOS ANGELES DISTRICT



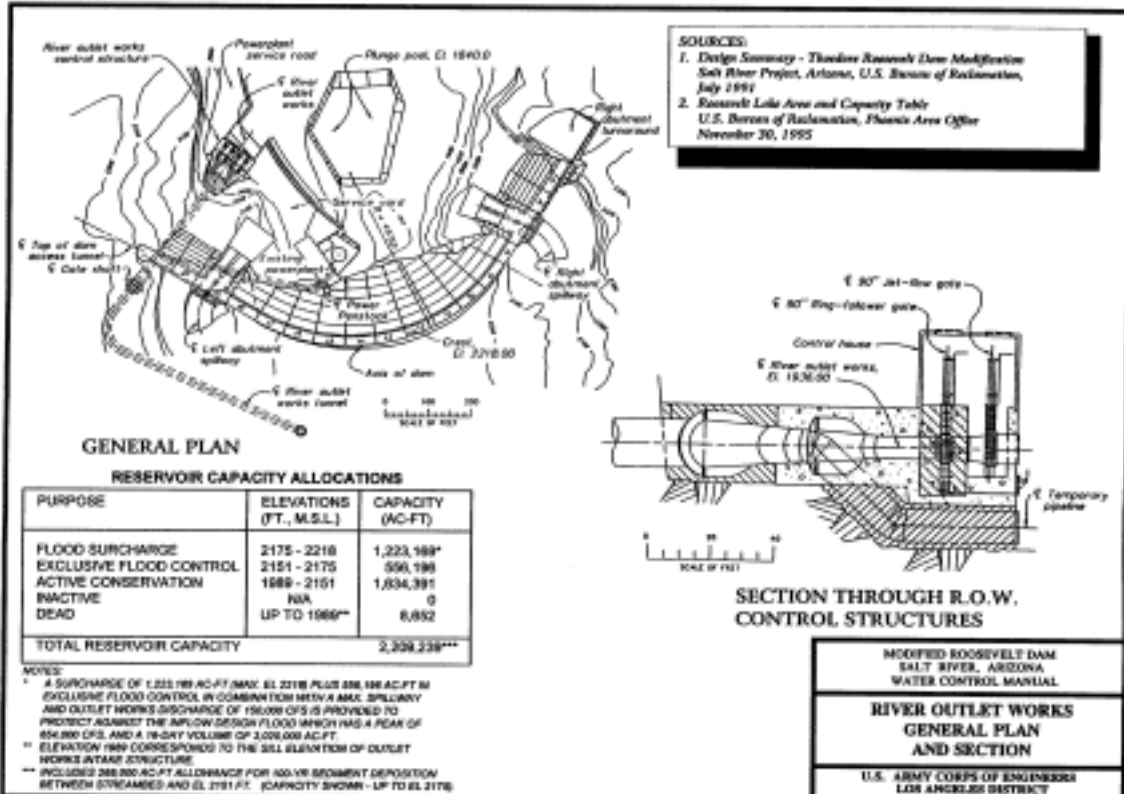
- NOTES:**
1. The curves are for various gate openings for 21'x36' radial gates. Gate openings are measured normal to spillway slopes.
  2. The curves are applicable for either left abutment or right abutment spillway.
  3. Spillway sill is at elevation 2190 ft, m.s.l. However, approach channel invert is at higher elevation (approx. 219.78 ft) therefore, spillway flow starts above 219.75 ft.

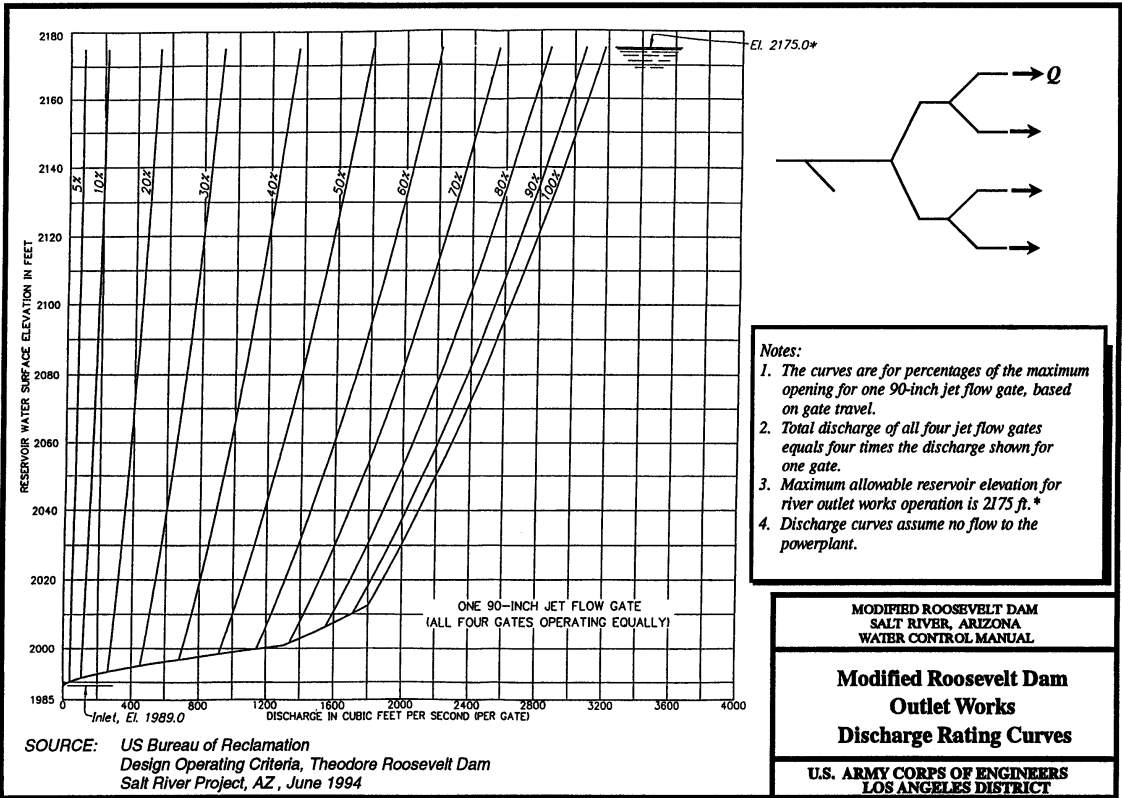
**SOURCE:** US Bureau of Reclamation  
 Design Operating Criteria, Theodore Roosevelt Dam  
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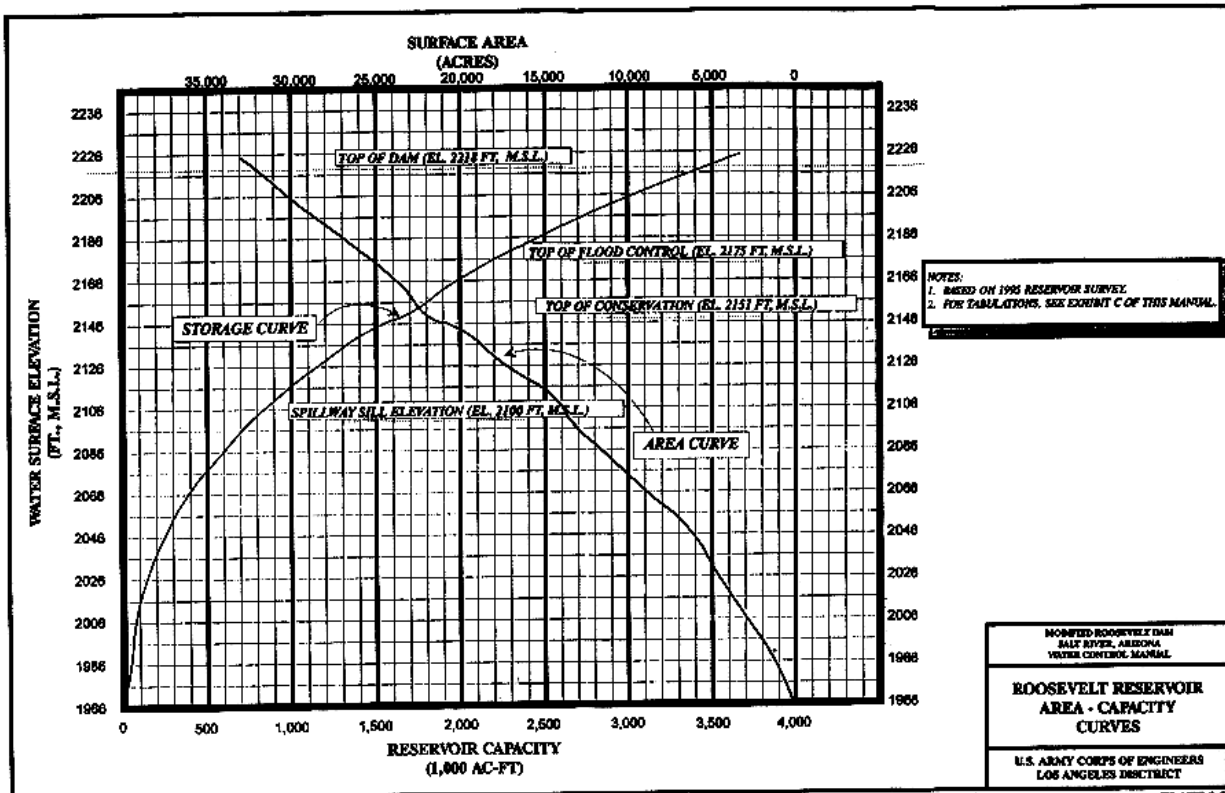
MODIFIED ROOSEVELT DAM  
 SALT RIVER, ARIZONA  
 WATER CONTROL MANUAL

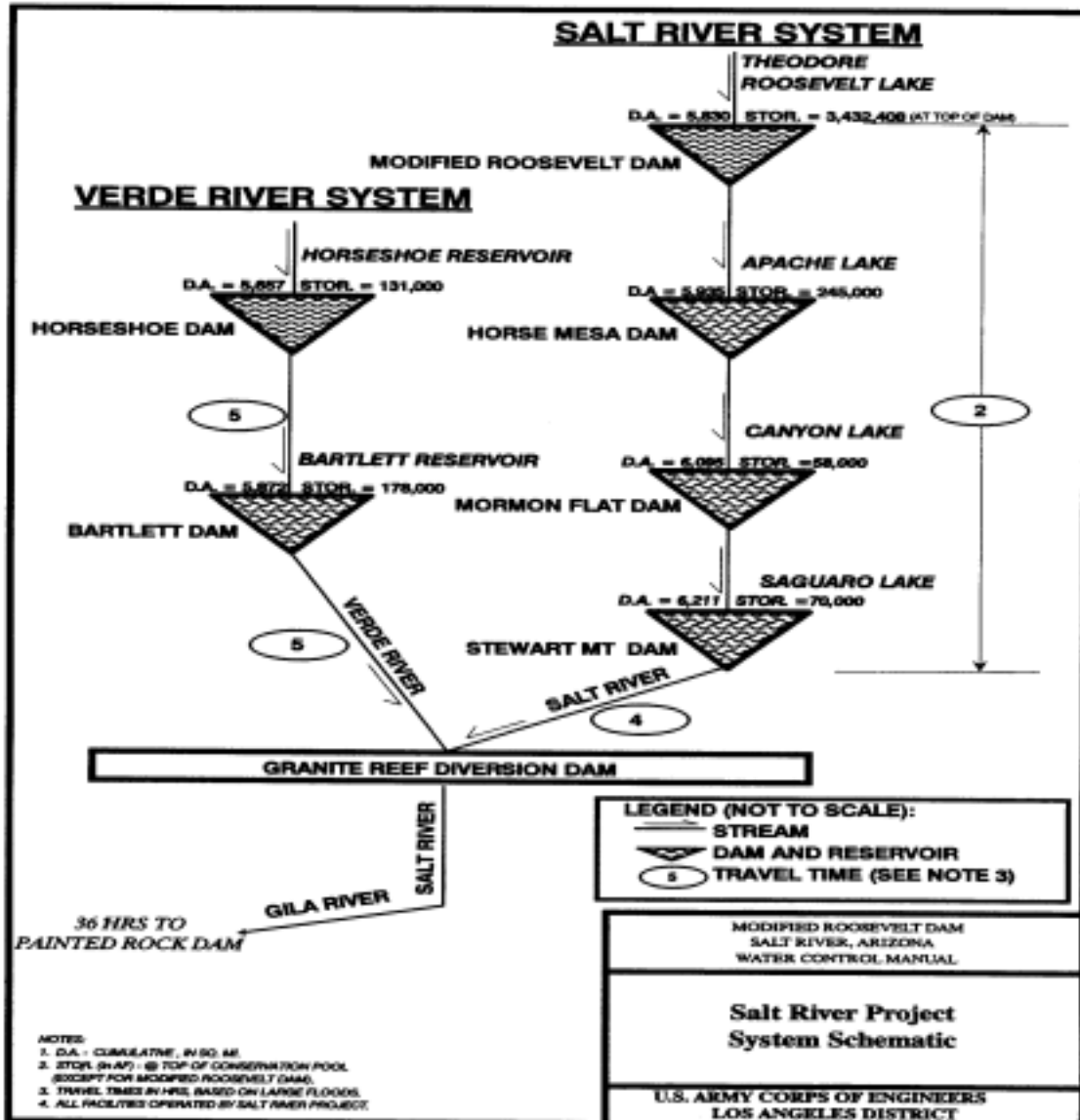
**Modified Roosevelt Dam  
 Spillway Structure  
 Discharge Rating Curve**  
 (FOR EITHER LEFT OR RIGHT ABUTMENT SPILLWAY)

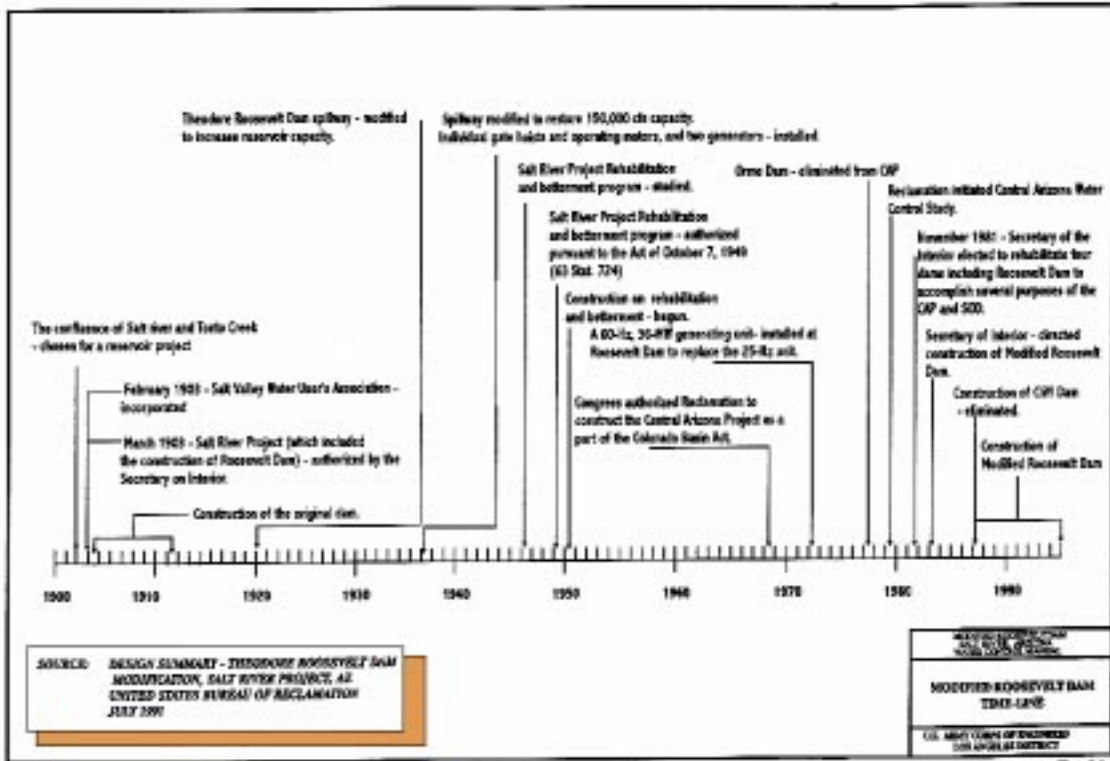
U.S. ARMY CORPS OF ENGINEERS  
 LOS ANGELES DISTRICT





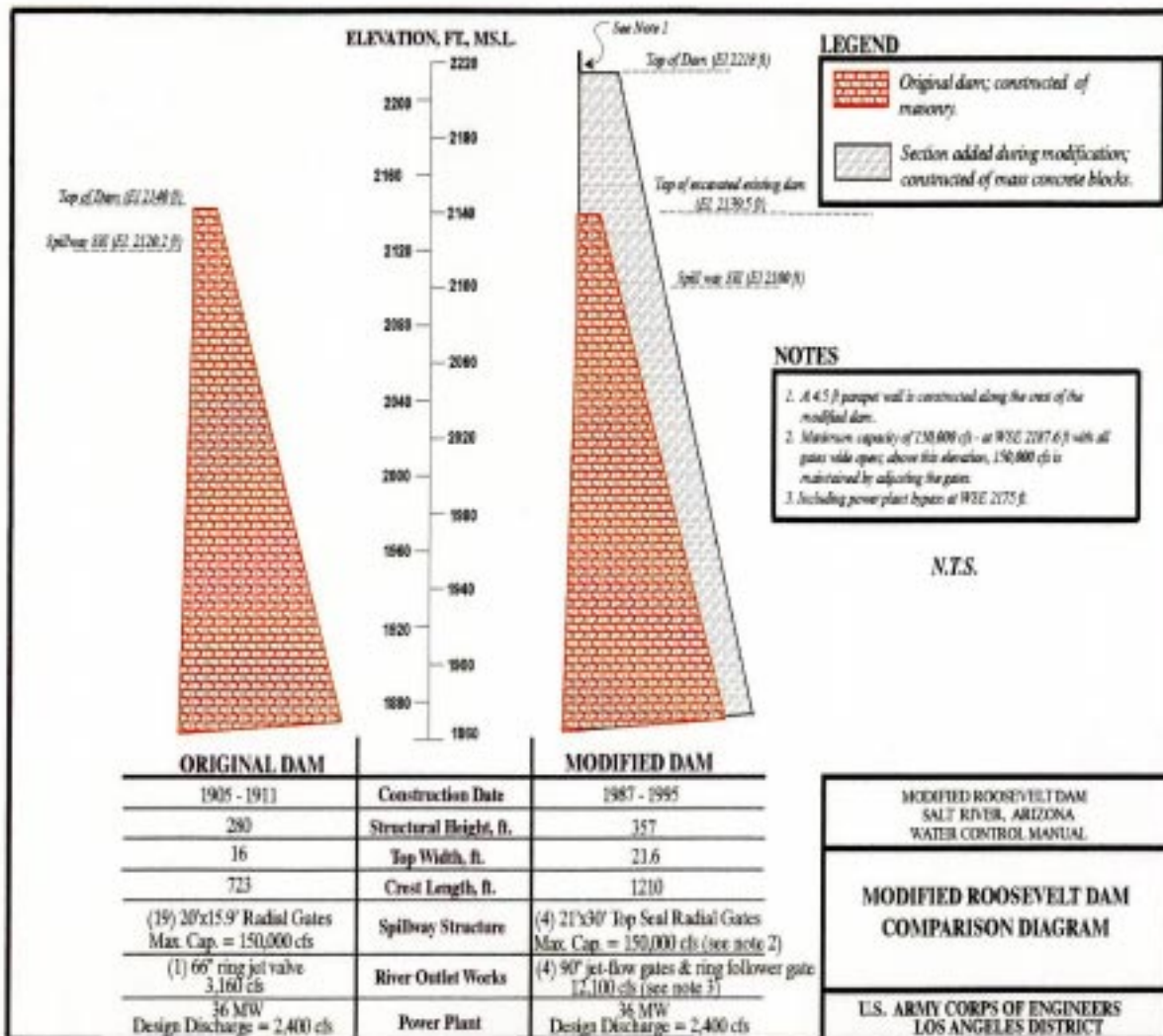






SOURCE: DESIGN SUMMARY - THEODORE ROOSEVELT DAM MODIFICATION, SALT RIVER PROJECT, AZ UNITED STATES BUREAU OF RECLAMATION JULY 1991

APPROVED FOR THE PROJECT BY THE BUREAU OF RECLAMATION  
 MODIFIED ROOSEVELT DAM  
 TIER-1/2  
 U.S. ARMY CORPS OF ENGINEERS  
 DENVER DISTRICT



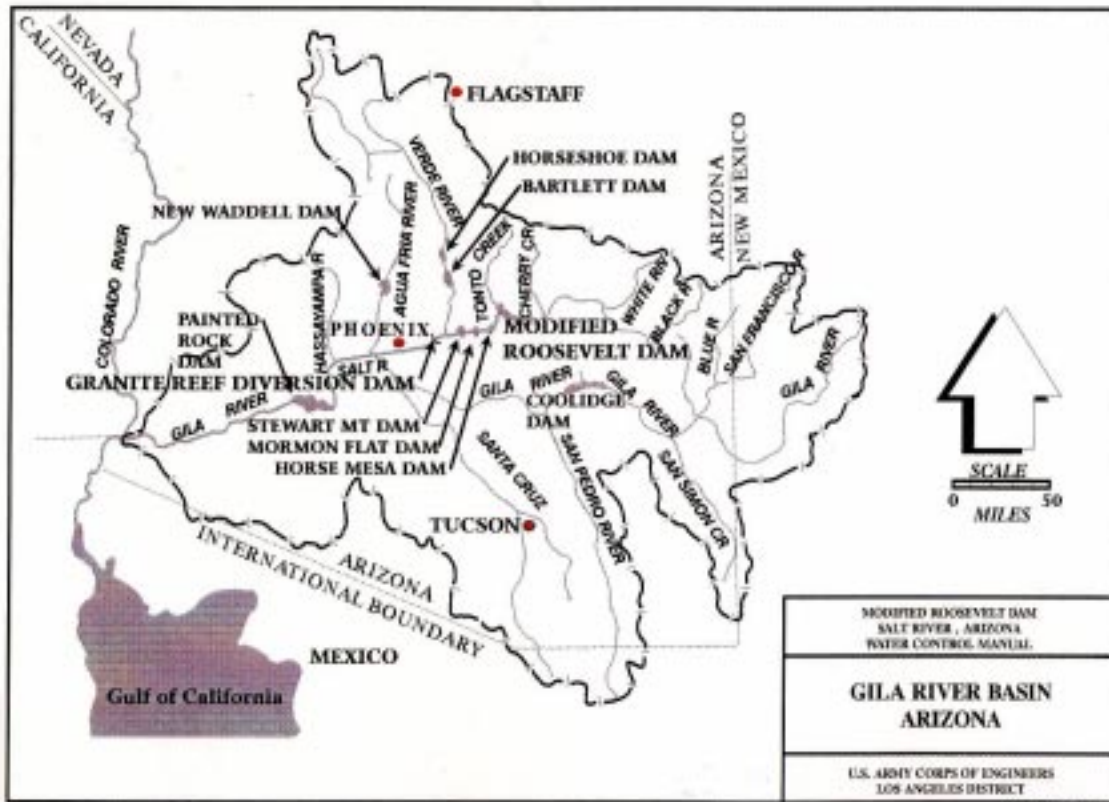
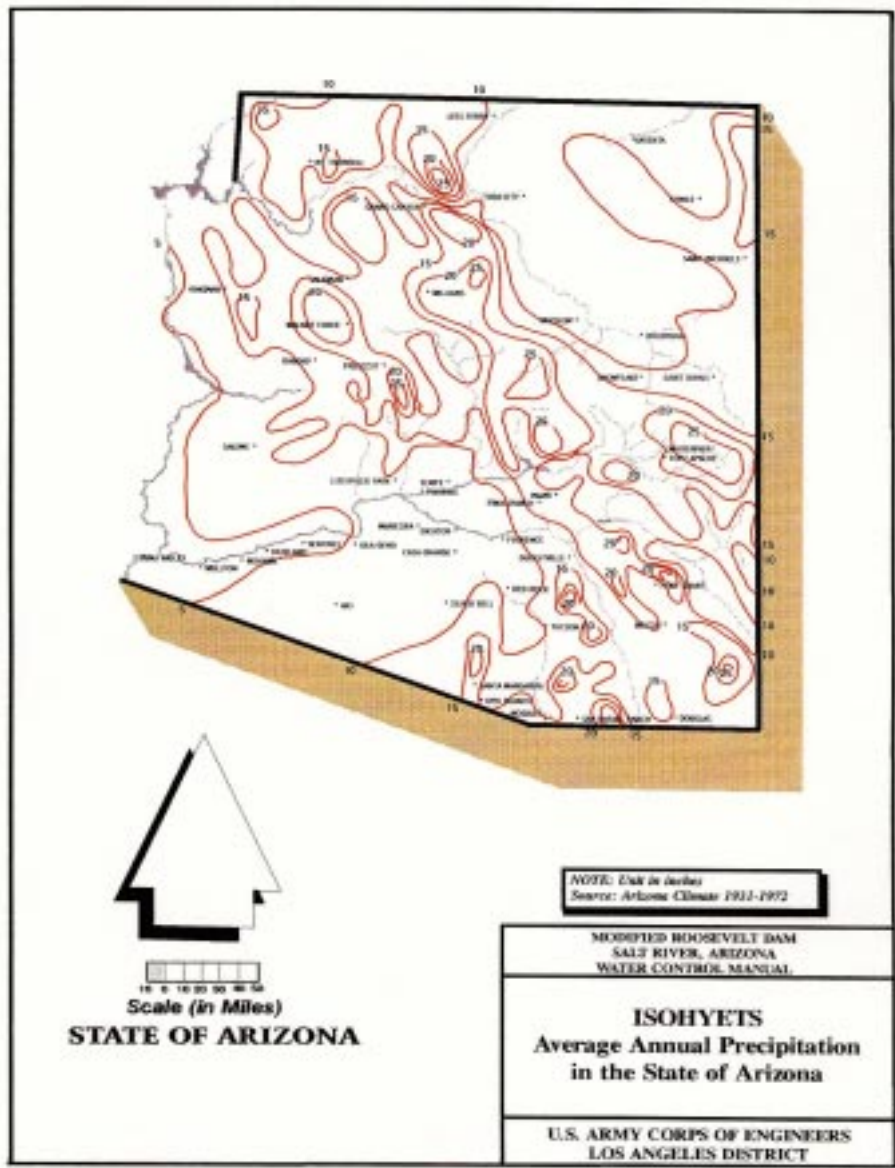


PLATE 4-1



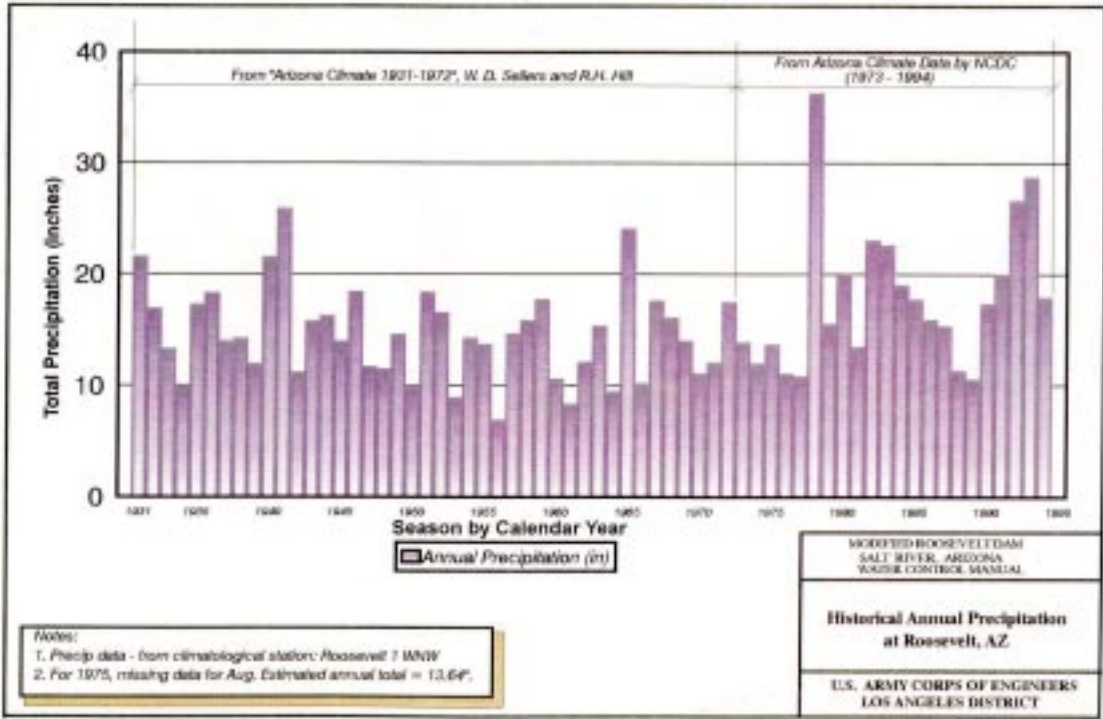
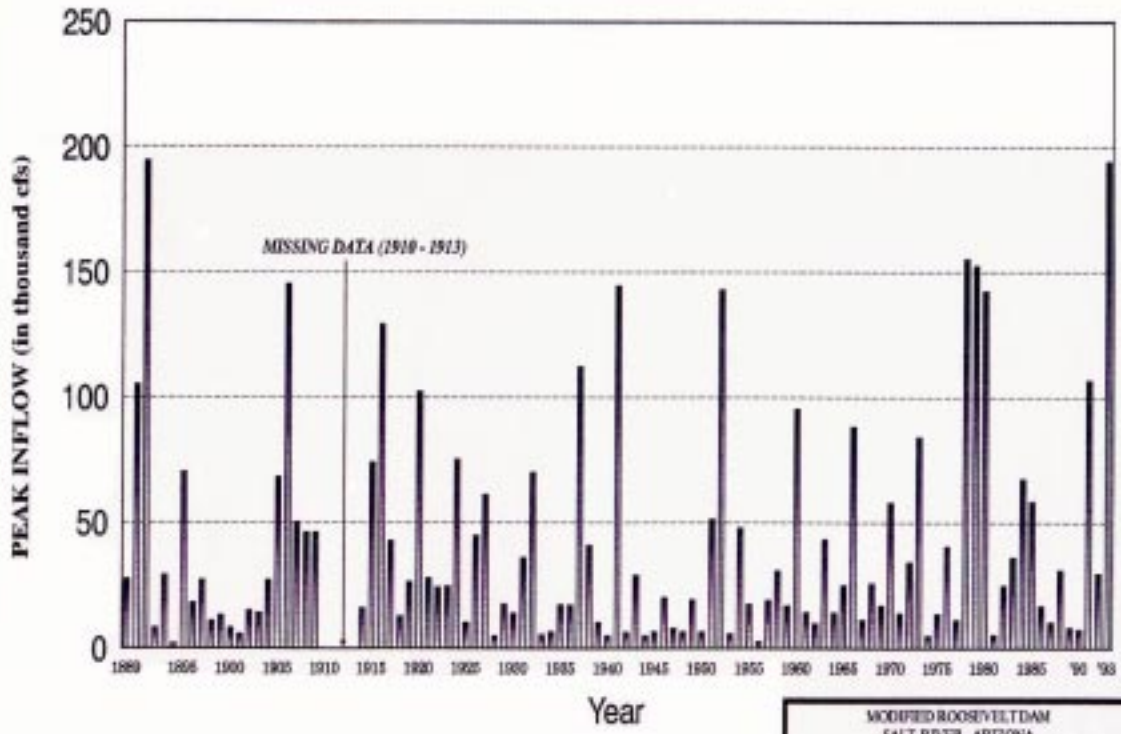
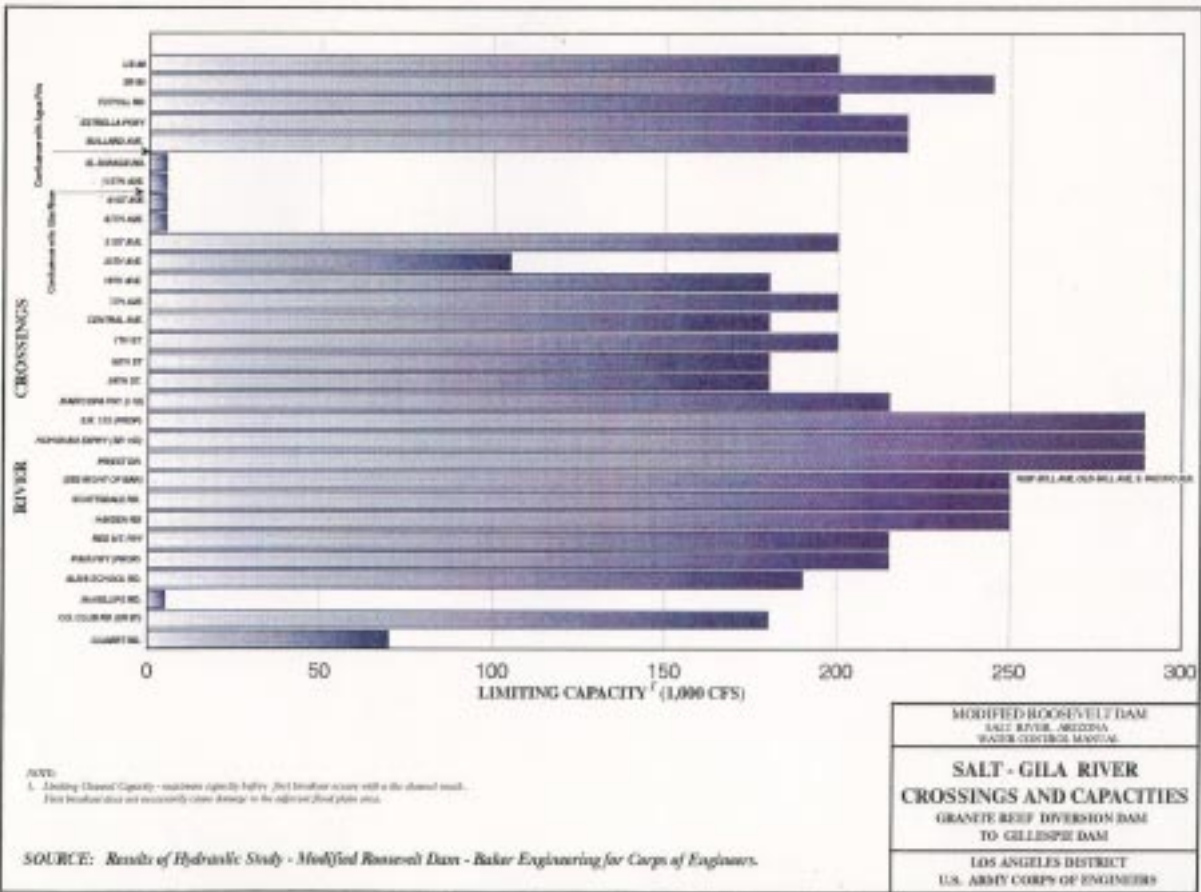


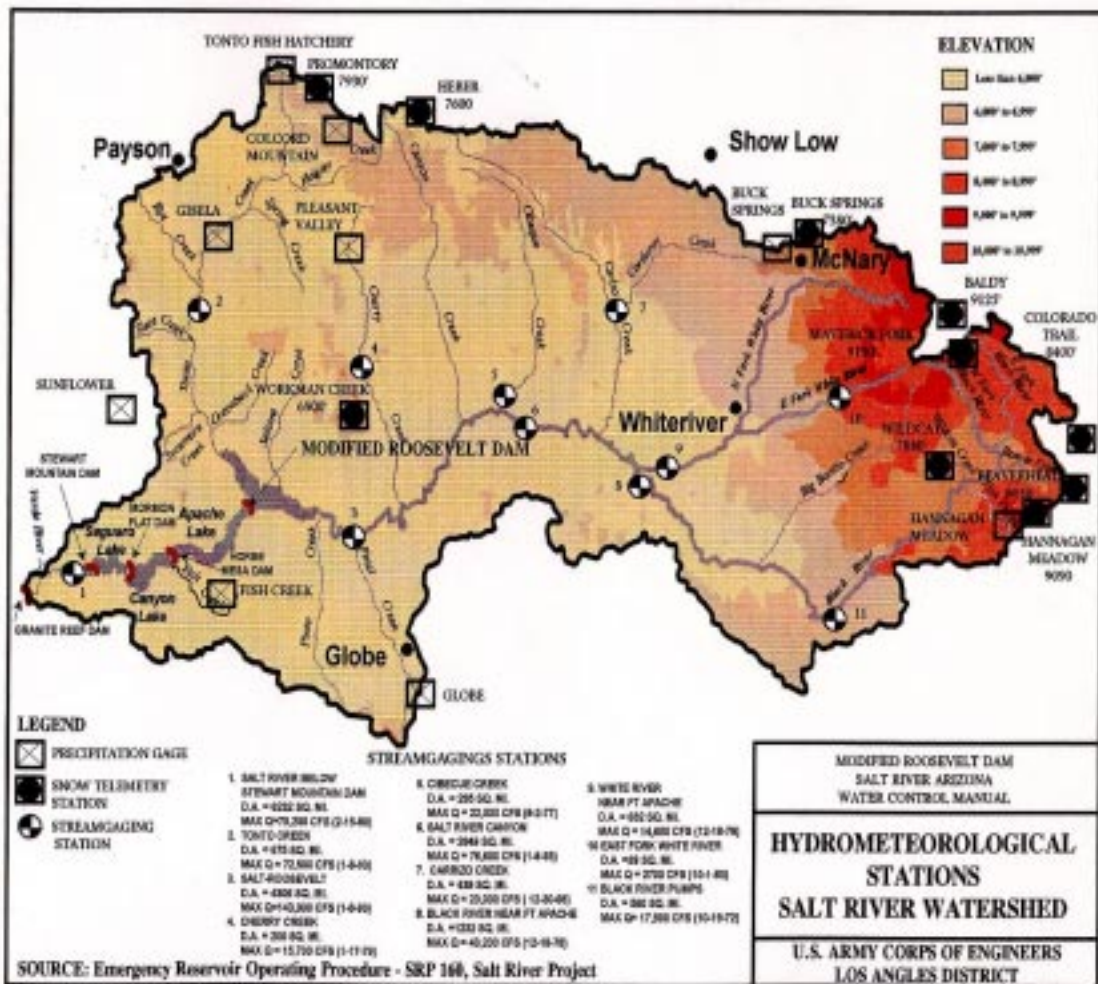
PLATE 4-3



Source: Section 7 Study for Modified Roosevelt Dam, Arizona  
 Hydrologic Evaluation of Water Control Plans  
 Salt River Project to Gila River at Gillespie Dam, Sep. 1995

MODIFIED ROOSEVELT DAM SALT RIVER, ARIZONA WATER CONTROL MANUAL
<b>ANNUAL PEAK INFLOW          TO          MODIFIED ROOSEVELT DAM          1889 - 1993</b>
U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT





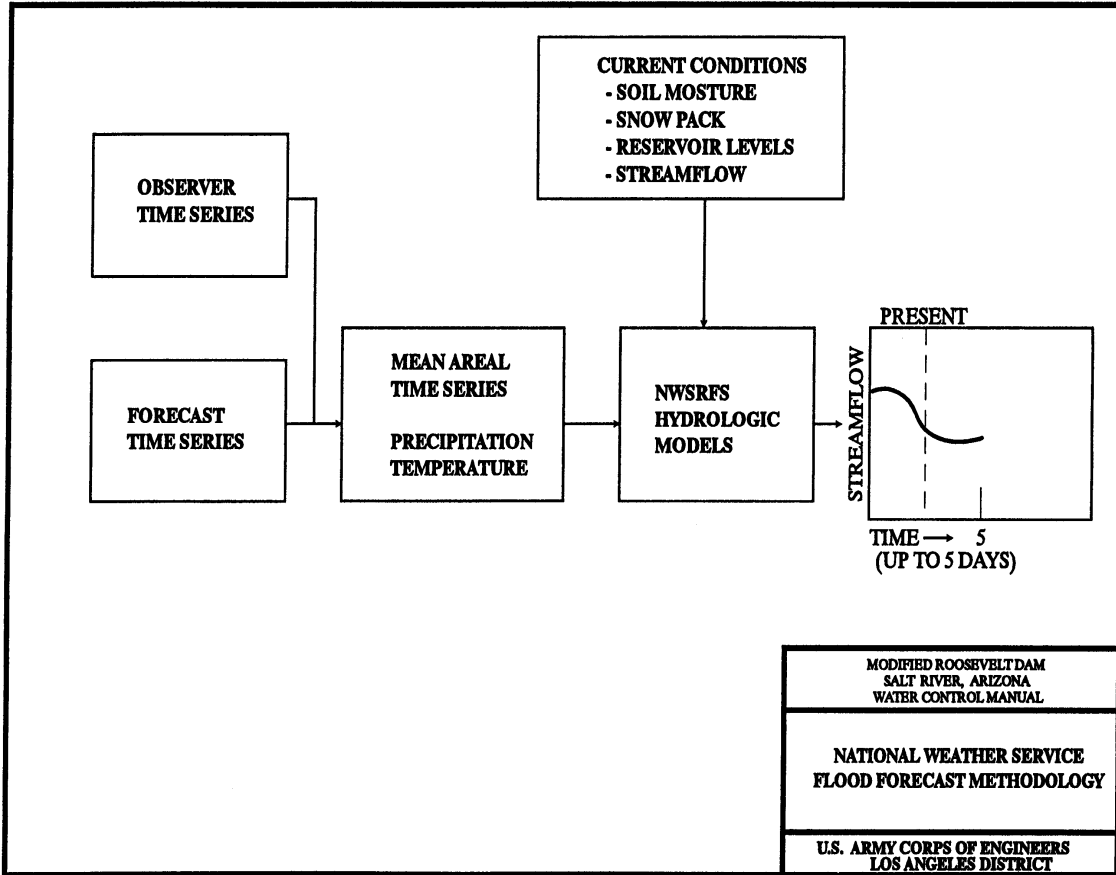


PLATE 6-1

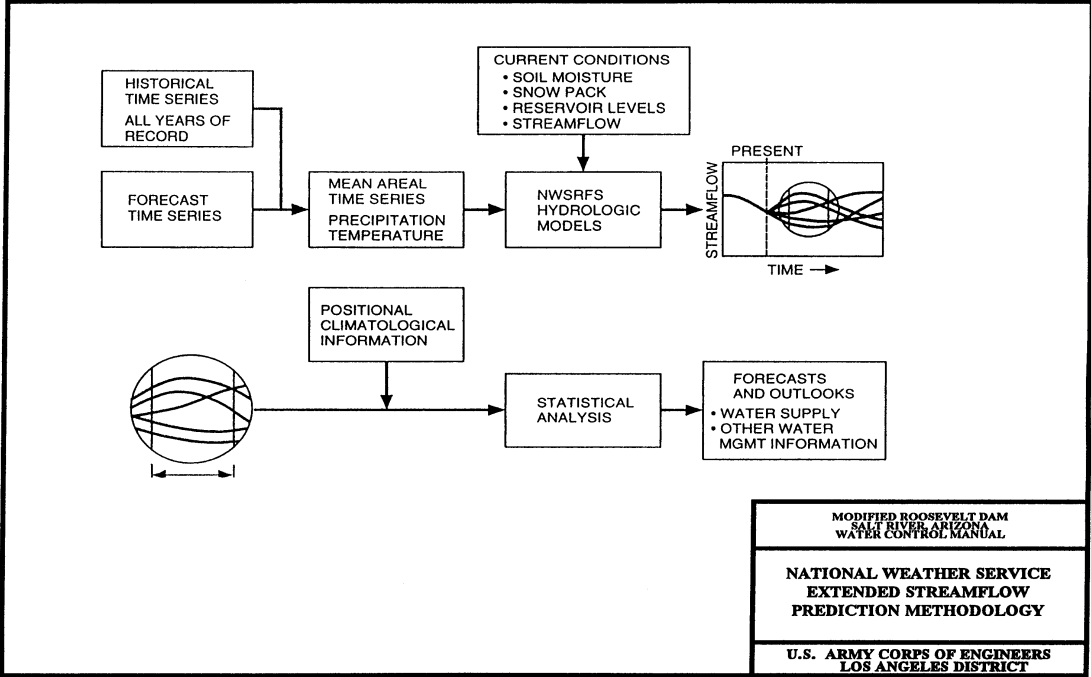
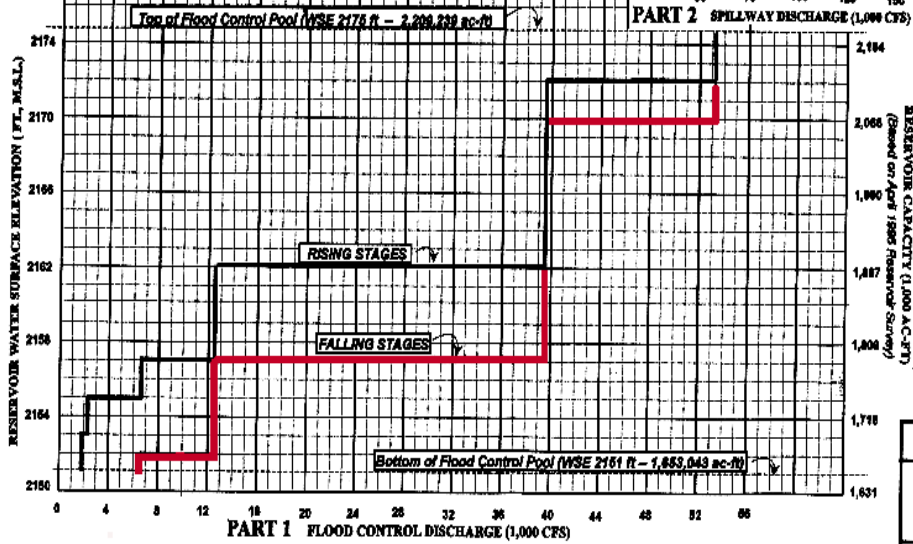
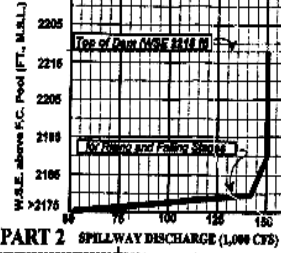


PLATE 6-2

# MODIFIED ROOSEVELT DAM WATER CONTROL DIAGRAM

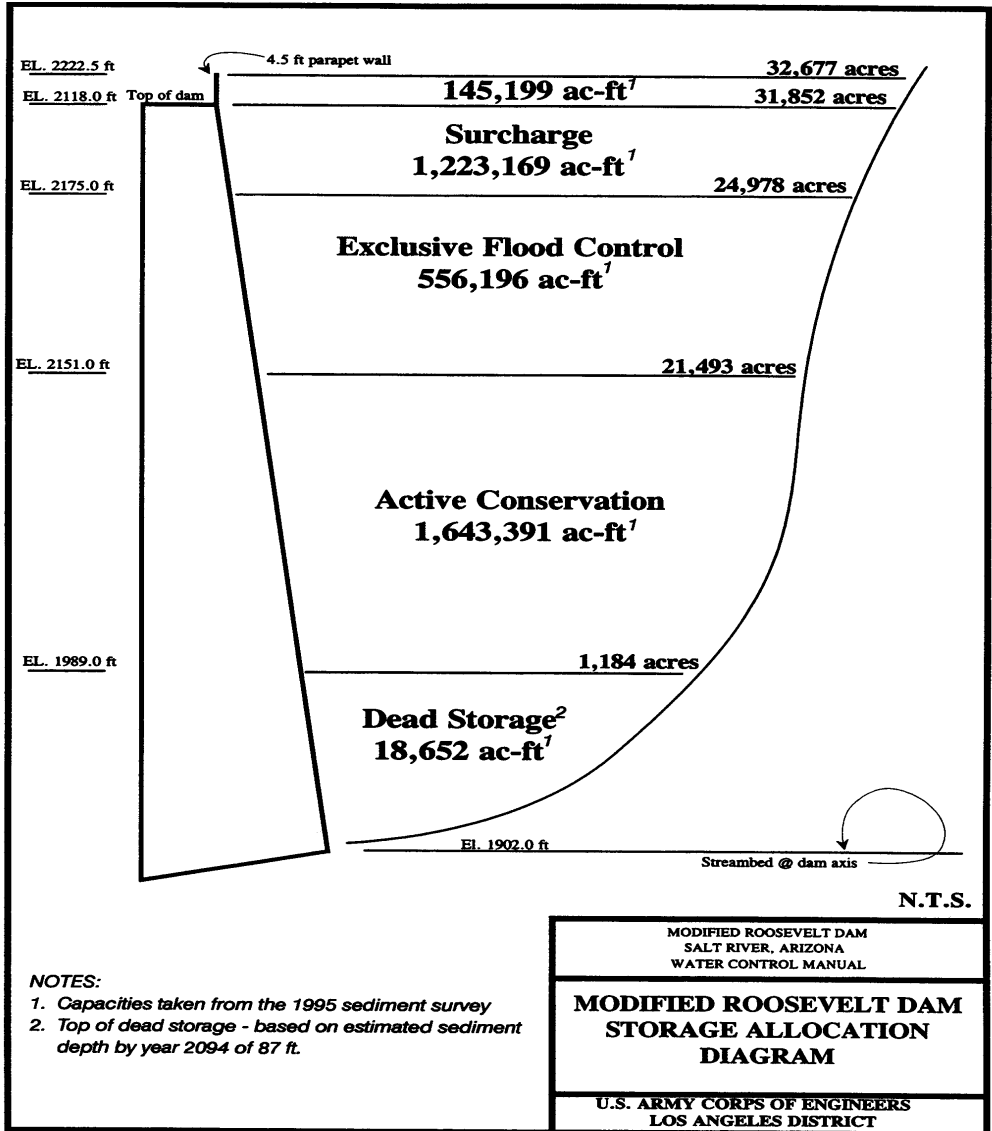
**NOTES:**

1. Max. discharge within the flood pool (WSE 2161 ft. - WSE 2176 ft.) is 65,180 cfs.
2. For elevations greater than WSE 2176 ft. follow spillway discharge diagram.
3. When WSE exceeds 2218 ft. maintain spillway flow at 150,000 cfs.
4. Rising and falling stages - refers to trend of WSE, not the inflow hydrograph.
5. When WSE is between 2161 ft. - 2176 ft. the combination of Modified Roosevelt Dam outflow and the downstream runoff should not exceed 140,000 cfs at Granite Reef Dam.
6. During rising stages, higher releases can be made provided that d/s constraints are not exceeded.
7. During falling stages, do not reduce to a scheduled discharge if inflow is greater than that discharge value.
8. During transition from rising to falling stage, increase releases if required to meet drawdown duration requirements. Flood pool must be evacuated within 28 days of the beginning of a single design flood (any event with max. pool elevation within the flood pool). In order to accomplish this, in general, the falling stage schedule should be followed.



MODIFIED ROOSEVELT DAM RIVER, ARIZONA WATER CONTROL MANUAL
<b>MODIFIED ROOSEVELT DAM                  WATER CONTROL DIAGRAM</b>
U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT

Plate 7-1



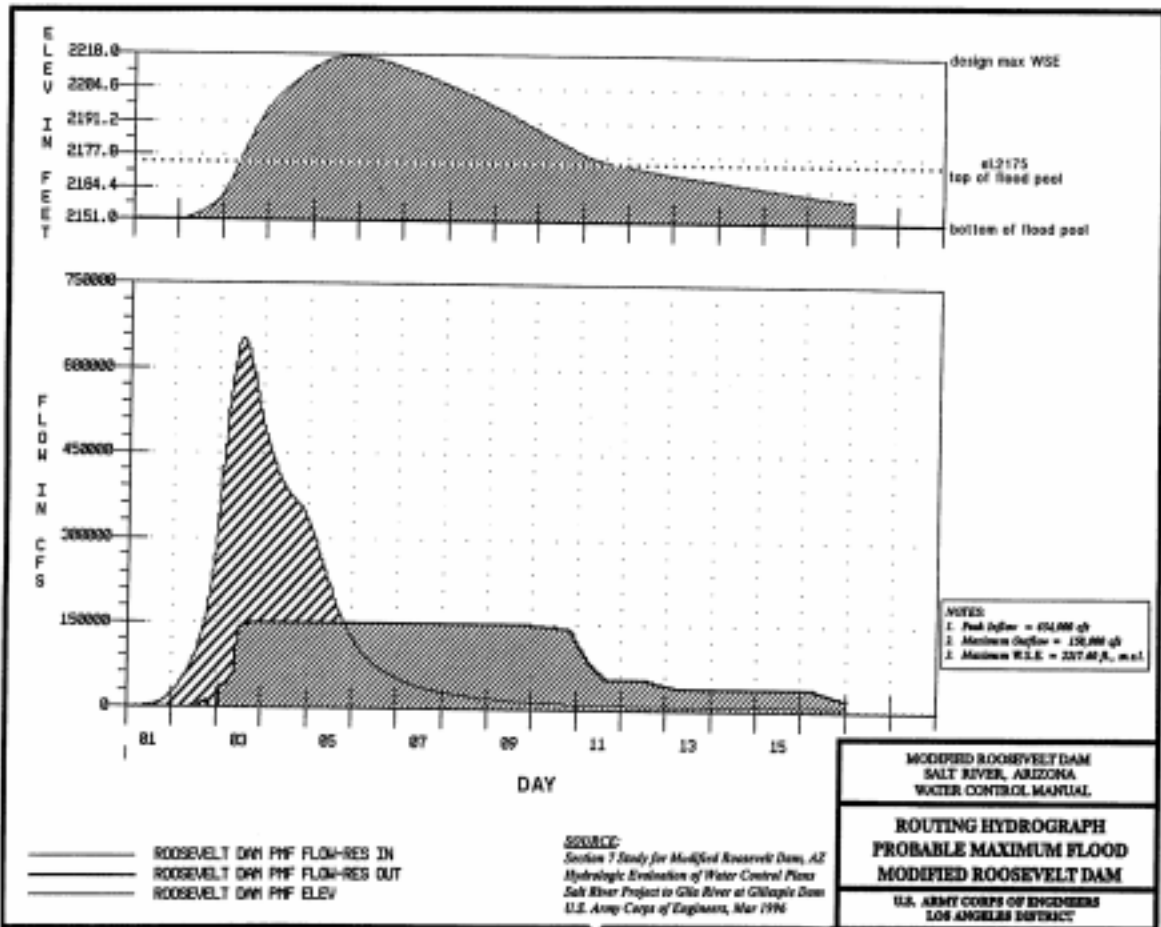


PLATE 8-1

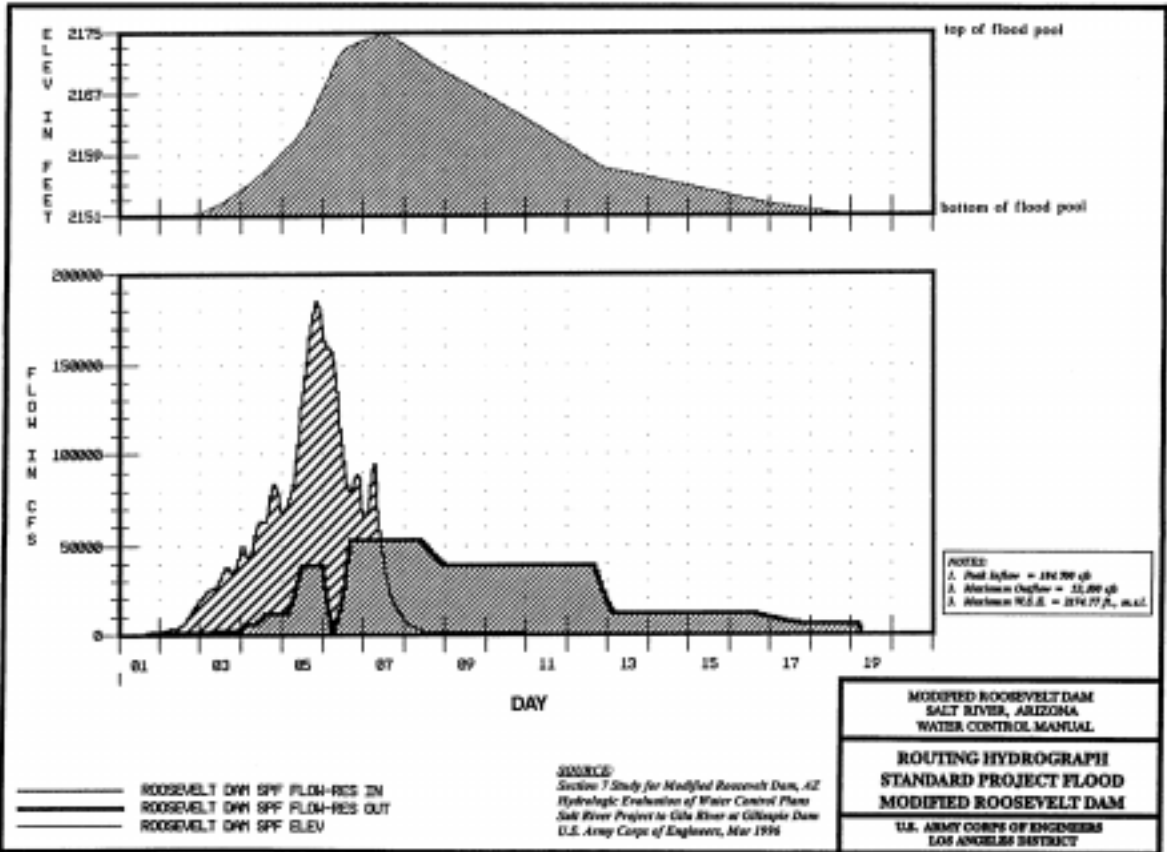


PLATE 8-2

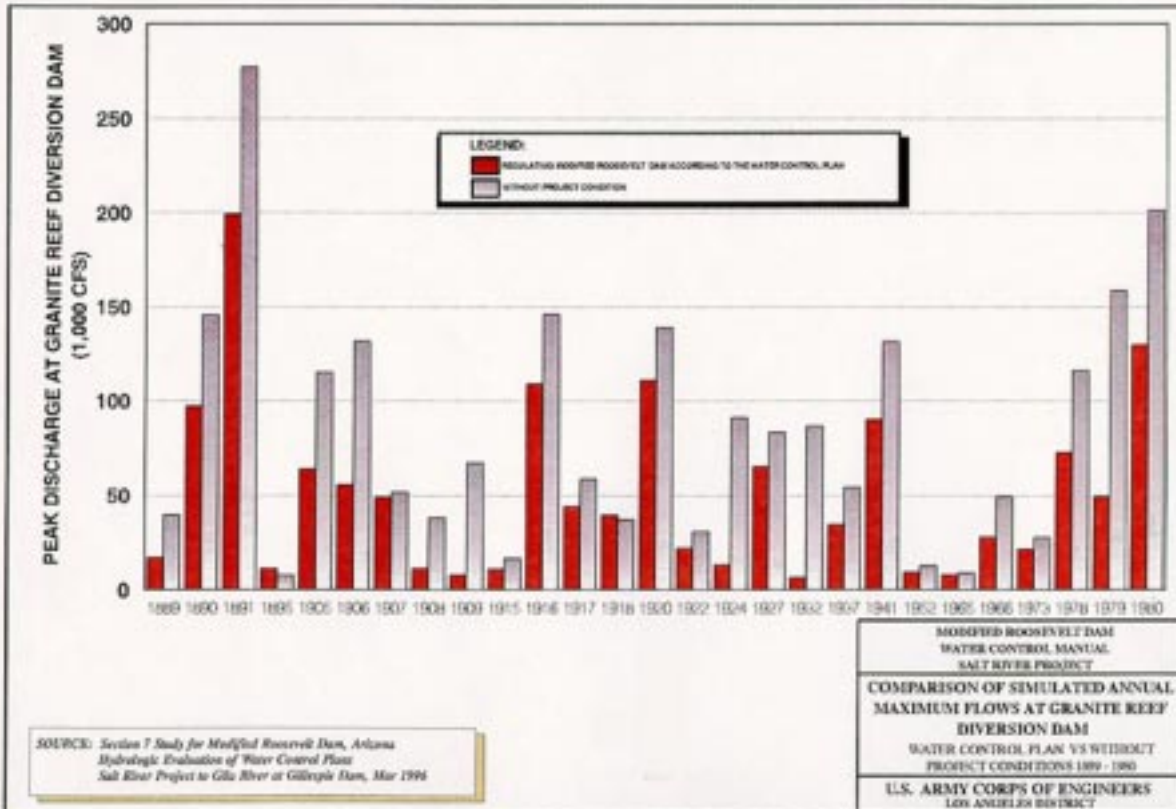
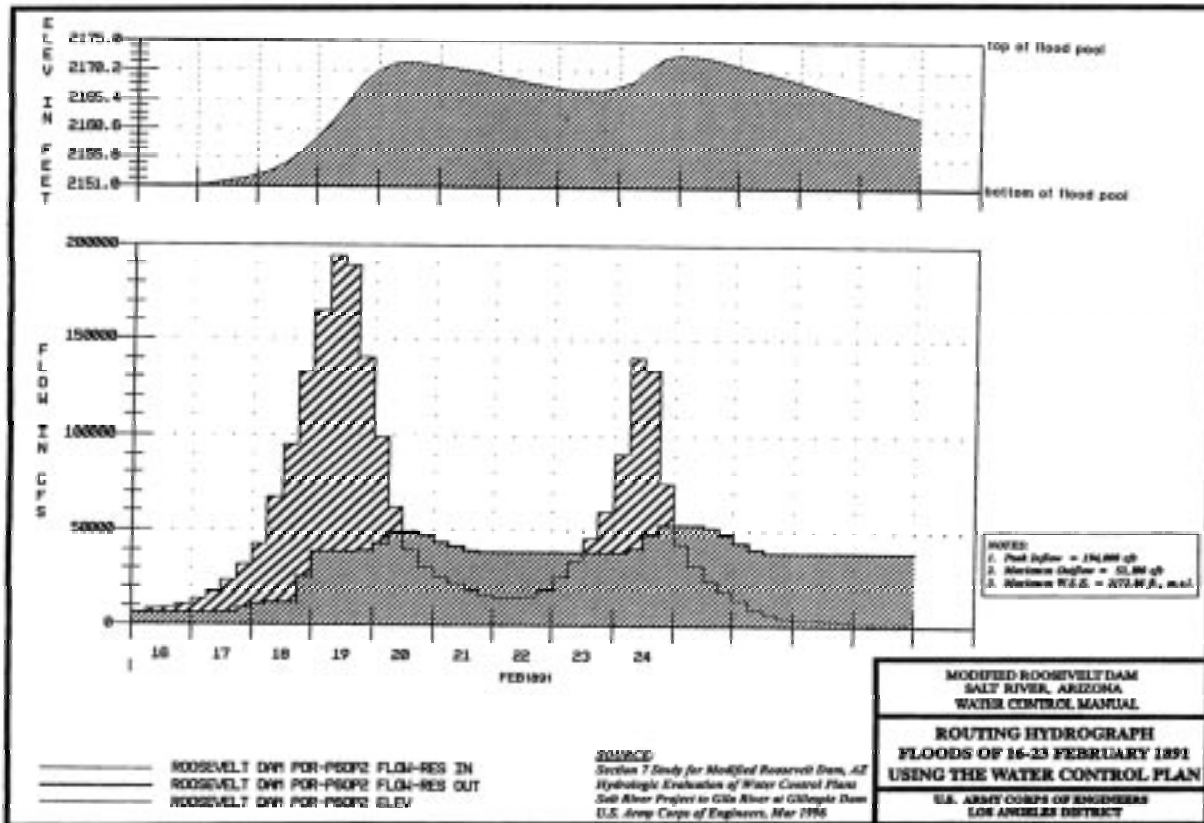


PLATE 8-3



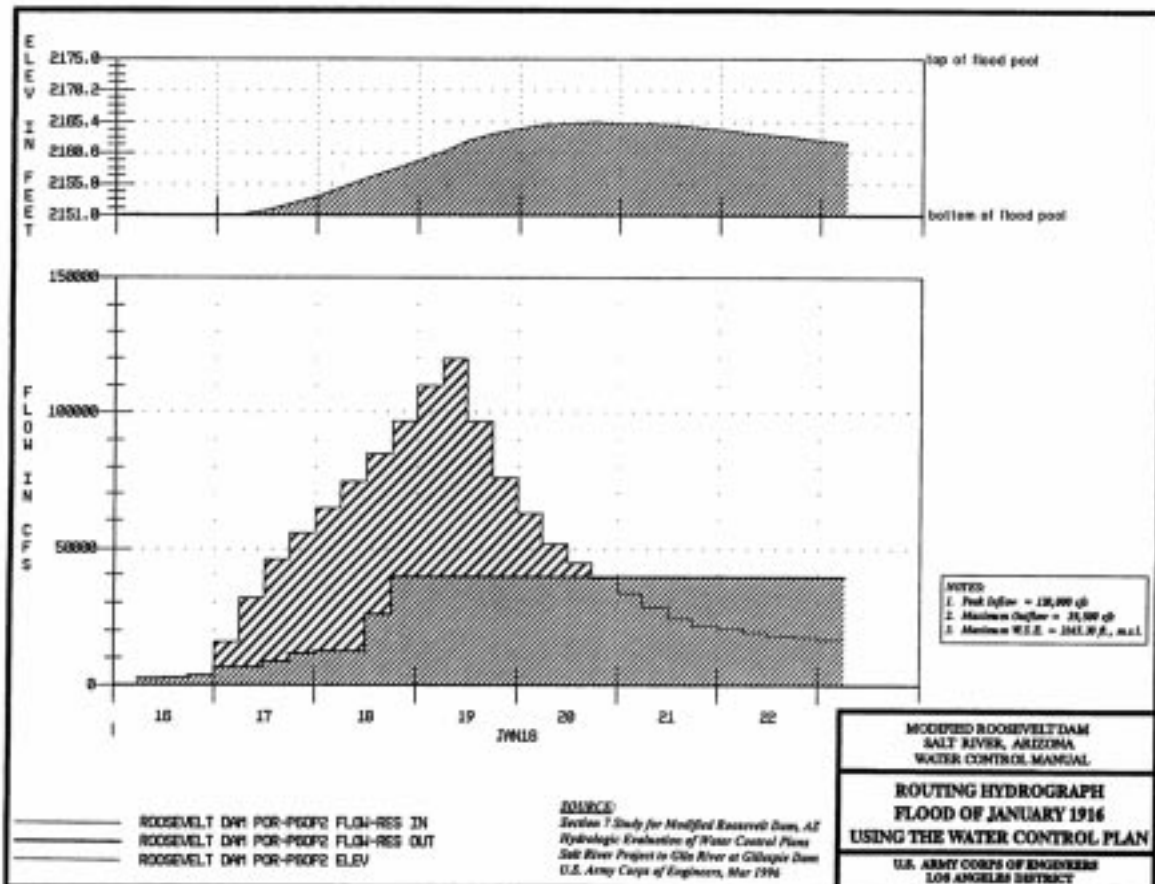
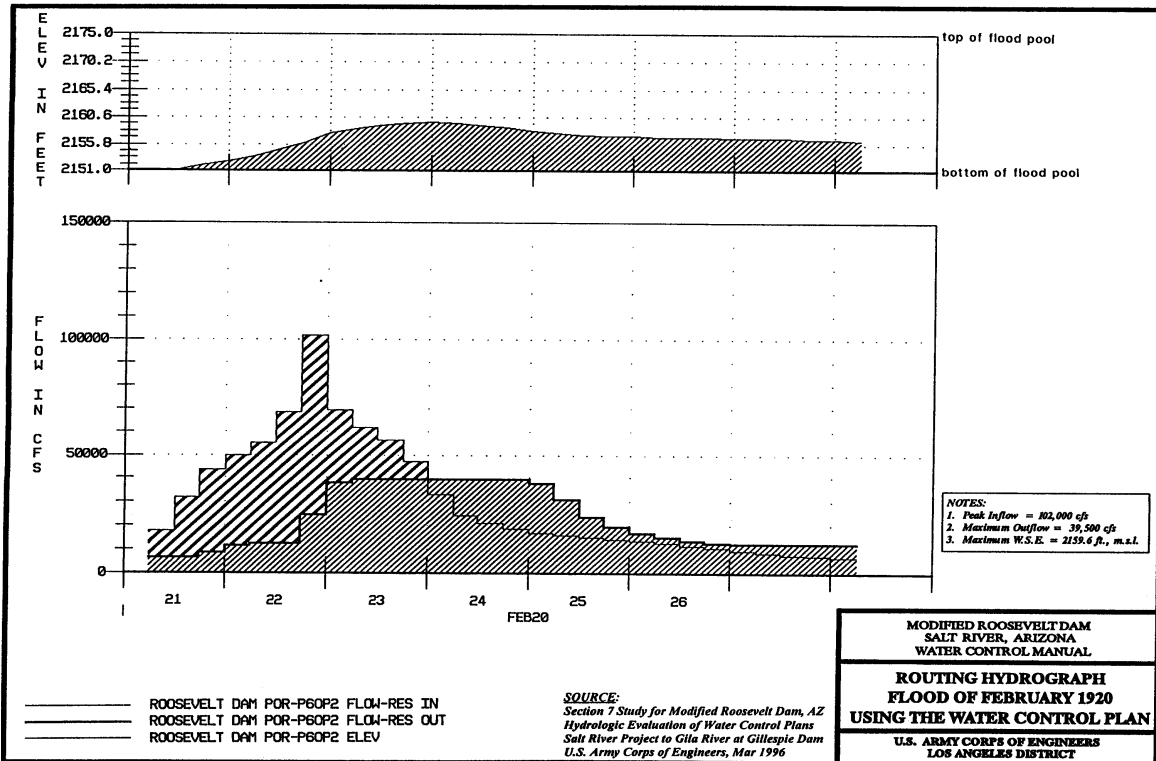
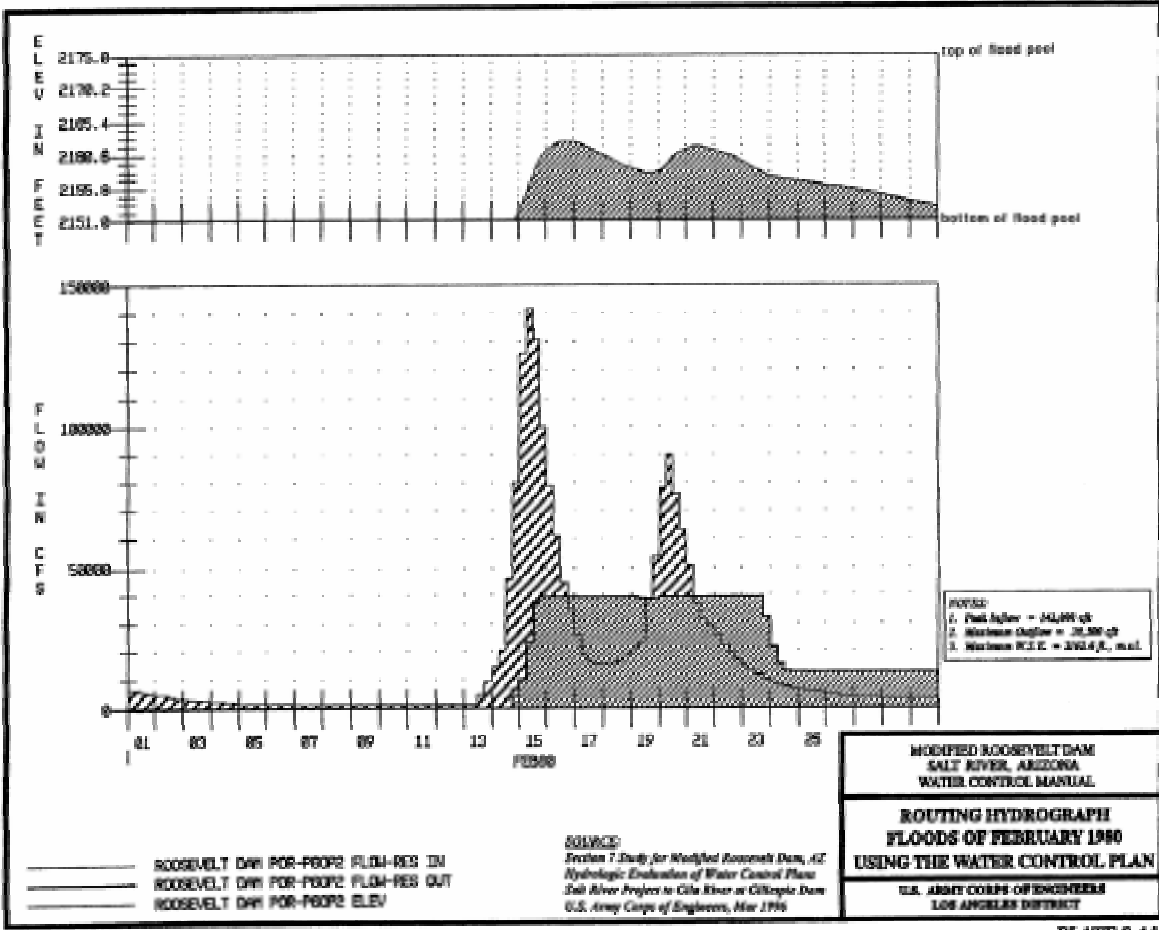
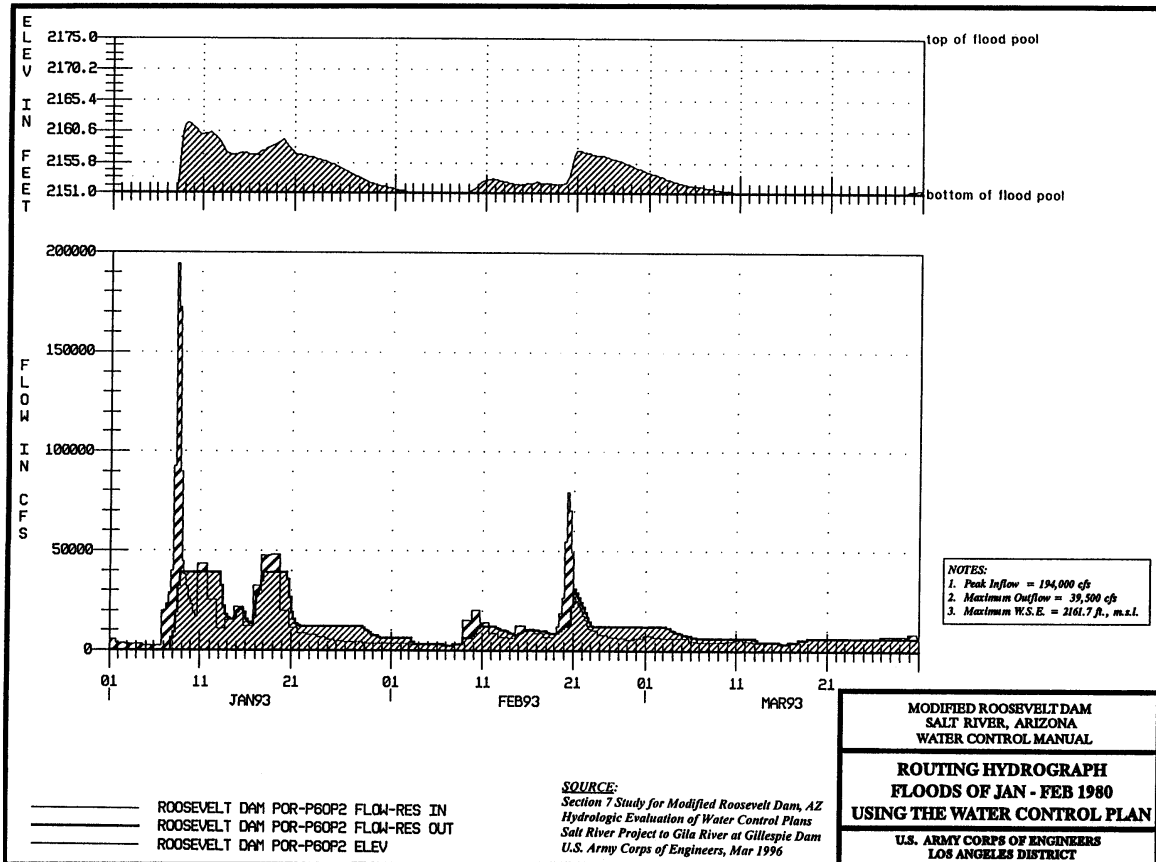
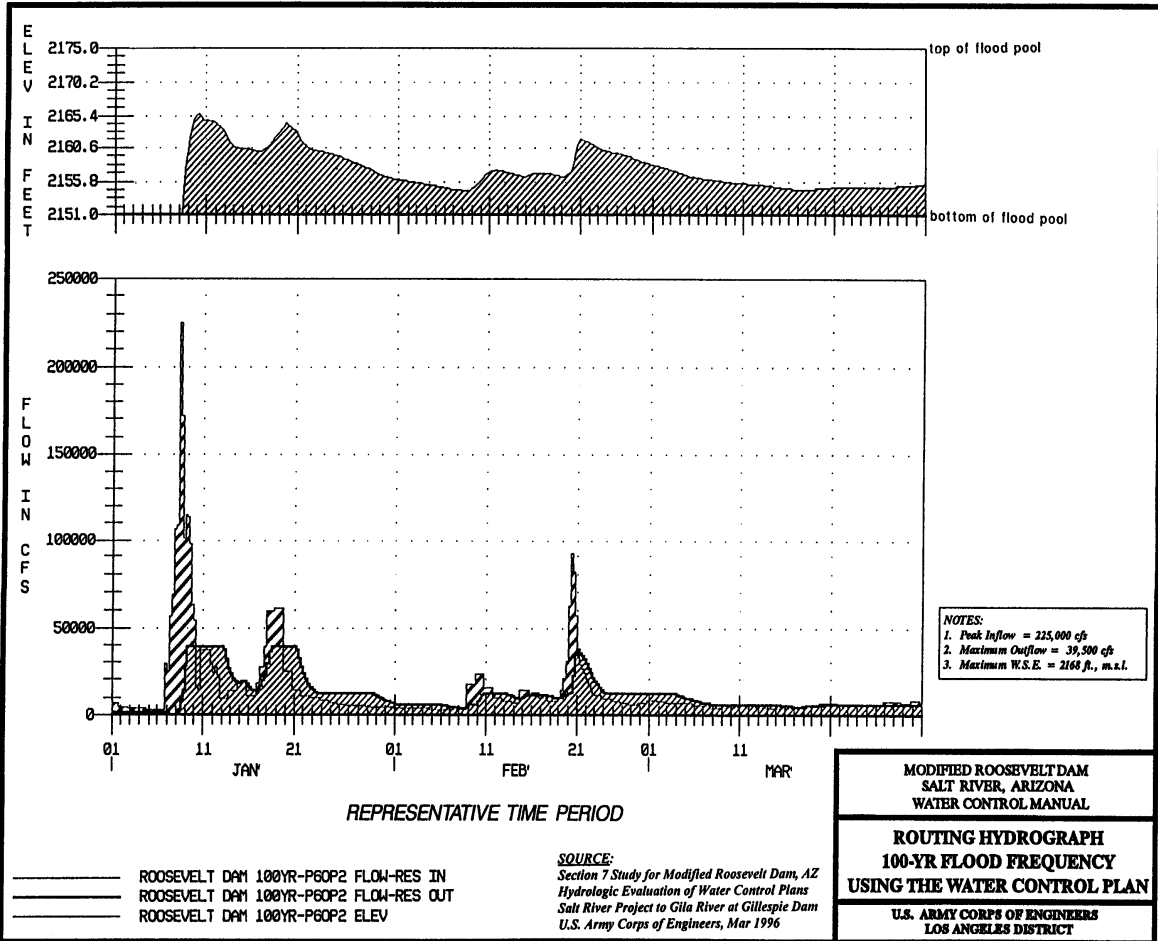


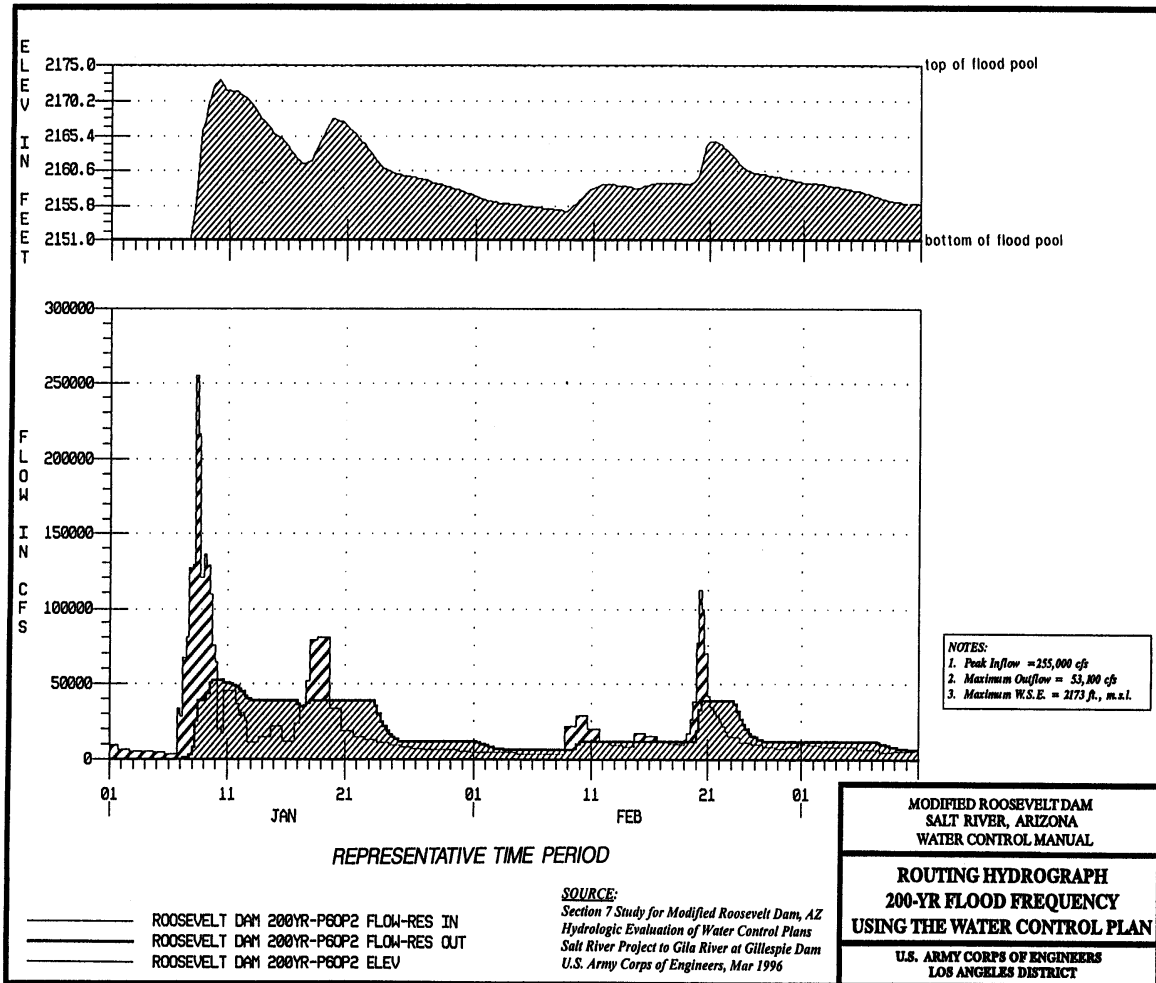
PLATE 8-4b

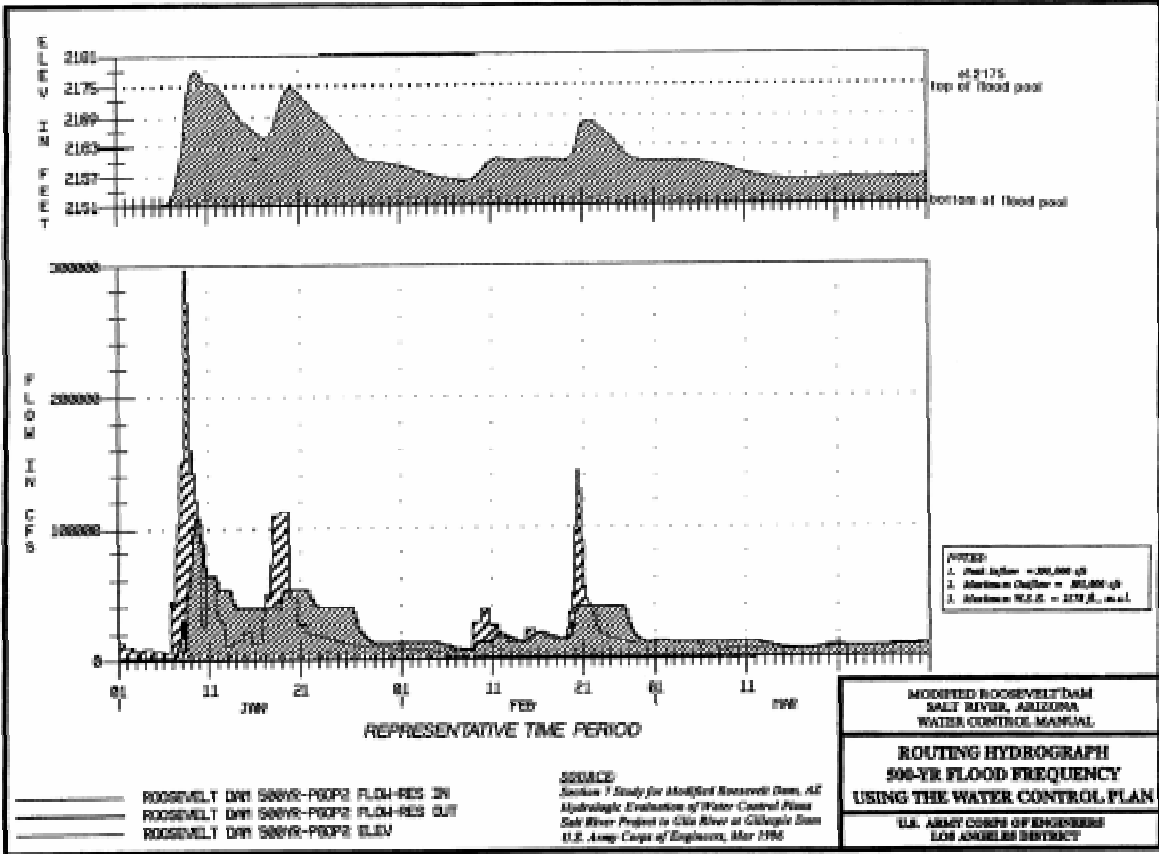


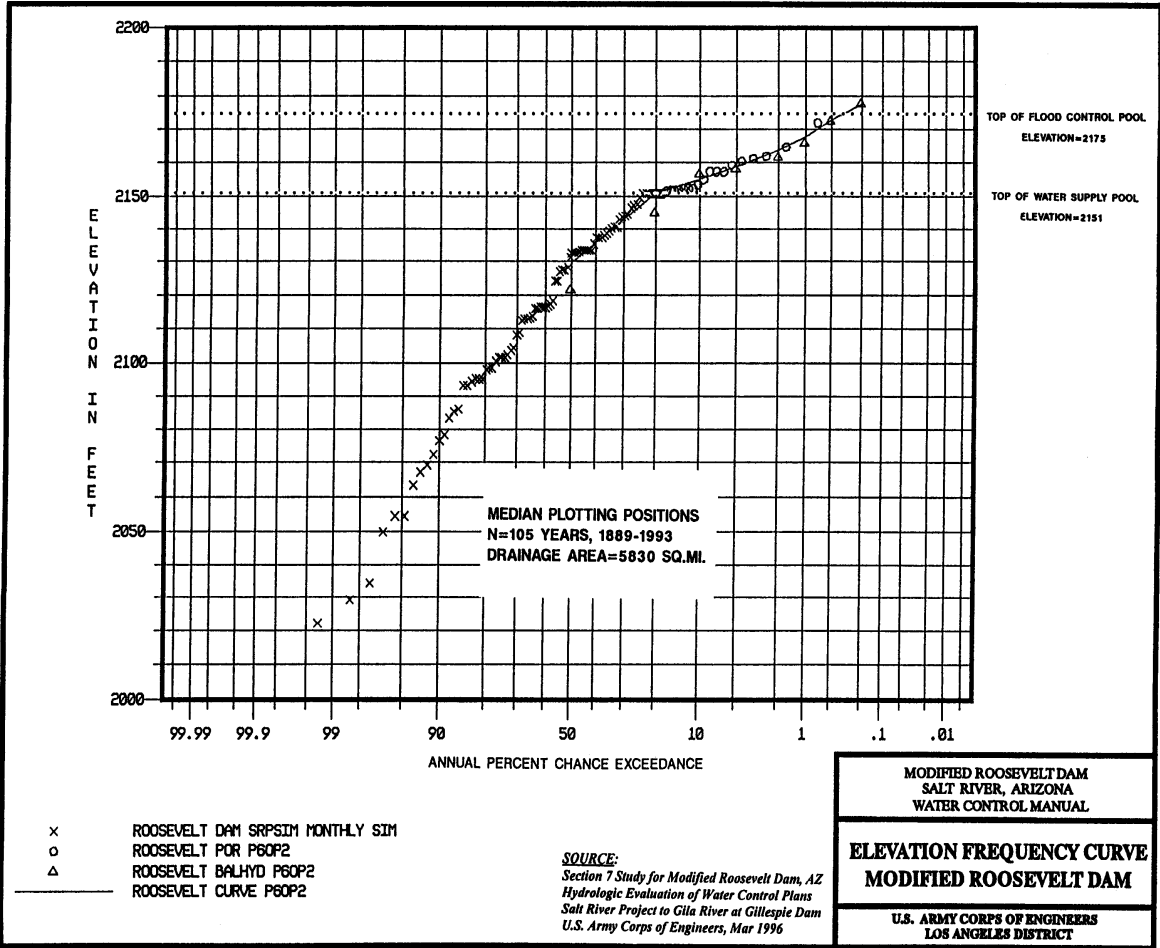












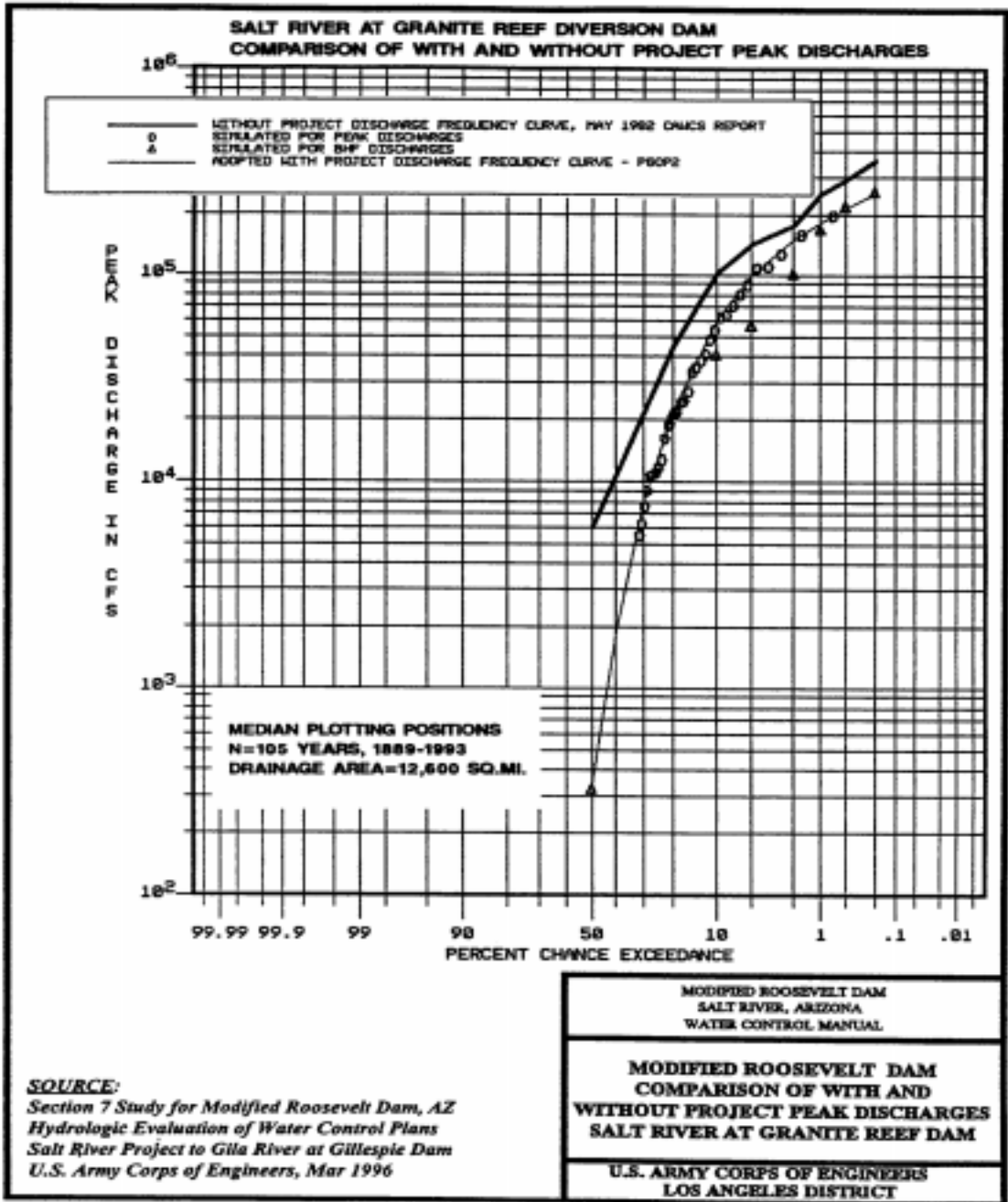
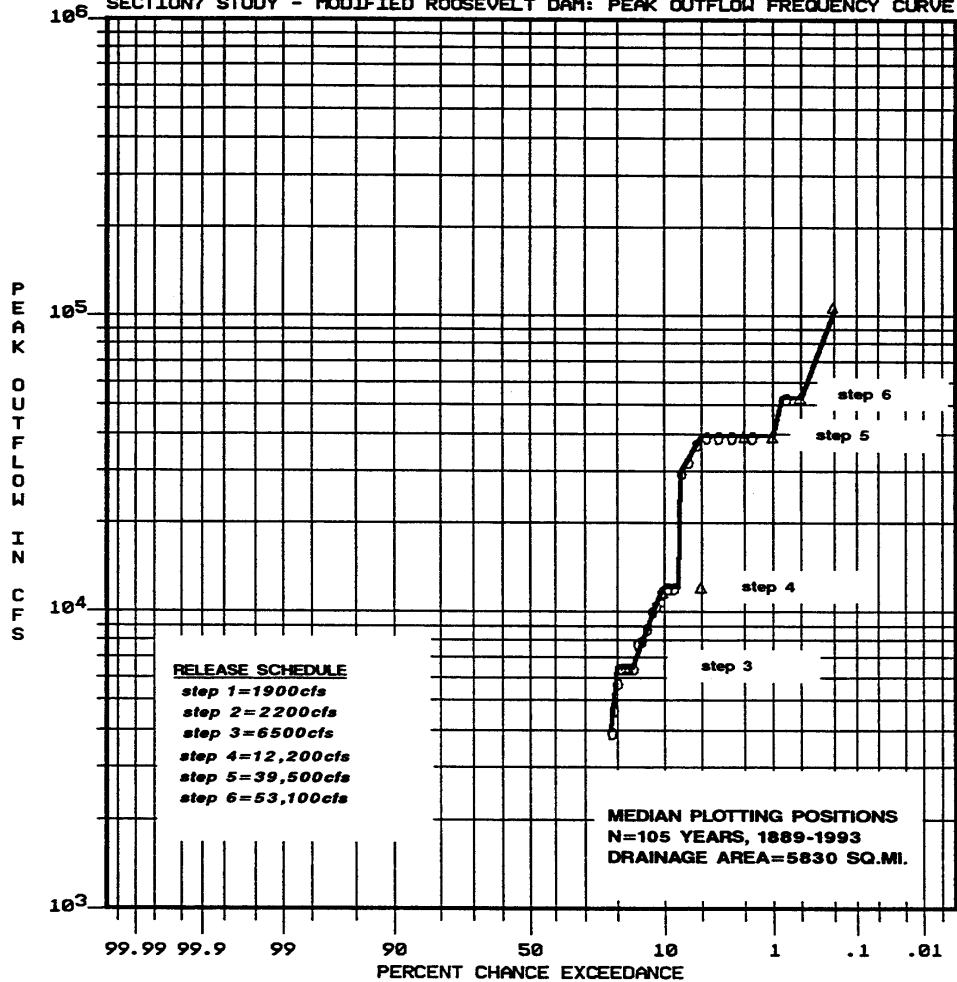


PLATE 8-7

SECTION 7 STUDY - MODIFIED ROOSEVELT DAM: PEAK OUTFLOW FREQUENCY CURVE



— ROOSEVELT SMOOTH CURVE  
 O ROOSEVELT PQR P6QP2  
 Δ ROOSEVELT PEAK P6QP2

MODIFIED ROOSEVELT DAM  
 SALT RIVER, ARIZONA  
 WATER CONTROL MANUAL

**MODIFIED ROOSEVELT DAM  
 PEAK OUTFLOW  
 FREQUENCY CURVE**

U.S. ARMY CORPS OF ENGINEERS  
 LOS ANGELES DISTRICT

**SOURCE:**  
 Section 7 Study for Modified Roosevelt Dam, AZ  
 Hydrologic Evaluation of Water Control Plans  
 Salt River Project to Gila River at Gillespie Dam  
 U.S. Army Corps of Engineers, Mar 1996

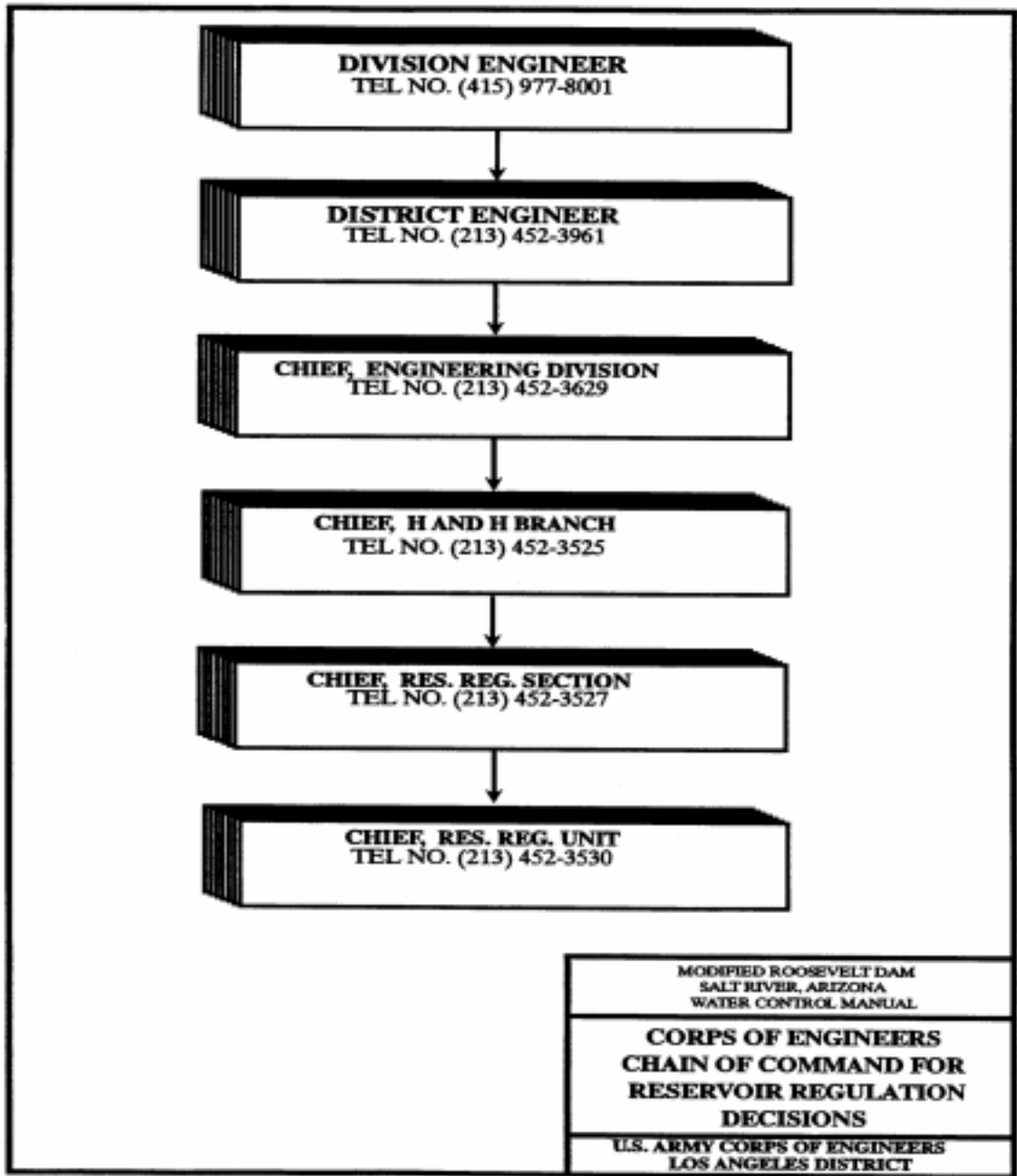


PLATE 9-1

EXHIBIT A  
FLOOD CONTROL REGULATIONS

MODIFIED ROOSEVELT DAM  
WATER CONTROL MANUAL  
SALT AND GILA RIVERS

**September 1997**

PREPARED BY:  
U.S. ARMY CORPS OF ENGINEERS  
LOS ANGELES DISTRICT  
RESERVOIR REGULATION SECTION

INTERAGENCY AGREEMENT

1. Interagency Agreement Number <u>1-AA-32-01390</u>	2. Effective Date <u>See Block 14.</u>	3. Requisition Number <u>1-0700-0032-00025</u>
4. Issued by: Code: <u>500</u> Bureau of Reclamation, APO Acquisition and Assistance Division P.O. Box 9980 Phoenix, AZ 85068	5. Administered by: Code: <u>800</u> Arizona Projects Office	
6. Recipient Name and Address Los Angeles District US Army Corps of Engineers PO Box 2711; Los Angeles CA 90053-2325	7. Project Office Code: <u>450</u> Arizona Projects Office Water and Lands Division Water Resources Branch	
8. Accounting & Appropriation Data 092-0344-1030-001-92-0-0 (Roosevelt) Cost Ctr: <u>22A1390</u> Obj. Cls. <u>253G</u>	11. Payment to be made by: Code <u>D-2322</u> Bureau of Reclamation P.O. Box 25045 Lakewood CO 80235-0045	
9. Total Estimated Amount \$ <u>700,000</u> Total Obligated Funds \$ <u>52,000</u> Pre-Incurred Costs (Paid) \$ <u>22,000</u> FY 92 \$\$ - for New Work: \$ <u>30,000</u>		
10. Authority: <u>43 USC § 391;</u> <u>43 USC § 485; 43 USC § 1521; the</u> <u>Flood Control Act of 1944; and the</u> <u>Economy Act of 1992 (11 USC § 1525)</u>		
12. Description Flood Control Related Economic, Hydraulic, Hydrologic and Operational Studies for Features of the Central Arizona Project (CAP)		
This Interagency Agreement consists of the following: SECTION I Reclamation Responsibilities SECTION II Corps Responsibilities SECTION III Special Provisions		
13. Acceptance of this Interagency Agreement in accordance with the terms and conditions contained herein is hereby made on behalf of the United States of America, U. S. Army Corps of Engineers By: <u>Charles S. Thomas</u> <u>23 Jan 92</u> Signature Date Charles S. Thomas Typed Name Colonel, Corps of Engineers Title: <u>District Engineer</u>	14. Acceptance of this Interagency Agreement in accordance with the terms and conditions contained herein is hereby made on behalf of the United States of America, Bureau of Reclamation. By: <u>Dennis E. Schrader</u> Signature Date Dennis E. Schrader Typed Name Title: <u>Project Manager</u>	
	By: <u>Carol L. Harris</u> Signature Date Carol L. Harris Typed Name Title: <u>Contracting Officer</u>	

INTERAGENCY AGREEMENT NO. 2-AA-32-01390  
 BETWEEN THE  
 LOS ANGELES DISTRICT OFFICE  
 UNITED STATES ARMY CORPS OF ENGINEERS  
 AND  
 ARIZONA PROJECTS OFFICE  
 LOWER COLORADO REGION  
 BUREAU OF RECLAMATION  
 UNITED STATES DEPARTMENT OF INTERIOR  
  
 FOR FLOOD CONTROL RELATED STUDIES  
  
 FOR FEATURES OF THE CENTRAL ARIZONA PROJECT

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Interagency Agreement No. 2-AA-32-01390

INTERAGENCY AGREEMENT

BETWEEN THE

LOS ANGELES DISTRICT OFFICE  
UNITED STATES ARMY CORPS OF ENGINEERS

AND

ARIZONA PROJECTS OFFICE  
LOWER COLORADO REGION  
BUREAU OF RECLAMATION  
UNITED STATES DEPARTMENT OF INTERIOR

FOR FLOOD CONTROL RELATED STUDIES

FOR FEATURES OF THE CENTRAL ARIZONA PROJECT

THIS INTERAGENCY AGREEMENT is entered into this 12<sup>th</sup> day of February, 1991, by and between the Bureau of Reclamation, Lower Colorado Region, Arizona Projects Office, United States Department of the Interior, hereinafter referred to as "Reclamation," and the U.S. Army Corps of Engineers, Los Angeles District, hereinafter referred to as "Corps," pursuant to the Act of Congress approved June 17, 1902 (32 Stat. 388, 43 U.S.C. § 391), the Reclamation Projects Act of August 4, 1939 (53 Stat. 1187, 43 U.S.C. § 485); the Colorado River Basin Act of 1968 (Pub. L. 90-537; 82 Stat. 855, 43 U.S.C. § 1521); the Flood Control Act of 1944 (58 Stat. 534); and the Economy Act of June 30, 1930, as amended (21 U.S.C. § 1535).

PURPOSE

This agreement is for the purpose of performing flood control related studies such as economic, hydraulic, hydrologic and operational analyses and, where needed, development of a water control plan, agreement, and/or operating manual for particular features of the Central Arizona Project (CAP) being constructed by Reclamation, in accordance with Section 7 of the Flood Control Act of 1944.

Modified Roosevelt Dam is one such feature of CAP for which Reclamation has a requirement for hydrologic and economic analysis to develop a water control plan, agreement, and manual. The work for Modified Roosevelt Dam is to be accomplished in two phases. First, Reclamation will reimburse the Corps for development of a scope of work, schedule, and cost estimate for the plan, agreement, and manual, in coordination with Reclamation. When the scope of work, schedule, and cost estimate have been developed and agreed to, this Interagency Agreement will be modified and Reclamation will obligate funds to reimburse the Corps for accomplishment of the work necessary to update the flood control benefits and develop the water control plan, agreement, and manual for Roosevelt Dam.

Interagency Agreement No. 2-AA-32-01390

New Waddell Dam is another component of Plan 6 Regulatory Storage Division of the CAP for which Reclamation requires hydrologic and incidental flood control benefits analysis. New Waddell Dam is being constructed across the Agua Fria River in Maricopa County, Arizona. Its operation will essentially control the flows of the Agua Fria River and will reduce flooding below the dam.

Other features of CAP which provide flood control, such as the Paradise Valley detention dikes, may require similar flood control related studies.

I. RECLAMATION RESPONSIBILITIES

Reclamation agrees to:

- I.A. Reimburse the Corps on a quarterly basis for actual costs incurred for work performed after execution of this agreement. Reimbursable costs shall not exceed \$30,000.00 for work performed after November 18, 1991, for the development of a scope of work, schedule, and cost estimate for updating the flood control benefits and developing the water control plan, agreement, and manual for Roosevelt Dam.
- I.B. Coordinate with the Corps and meet as needed to review the progress of work and deliverables under this agreement and to provide direction to the Corps relative to Reclamation's needs.
- I.C. Provide the Corps with written requests for specific flood control related studies for New Waddell Dam, Paradise Valley Detention Dikes, or other CAP features as required. Review each scope of work, cost estimate and schedule proposed by the Corps in response to a work request by Reclamation, and hold discussions with the Corps as required to reach agreement.
- I.D. After each specific scope of work, schedule, and cost estimate have been developed and agreed upon, modify this agreement to include the scope of work and funds necessary to perform the specific study requested.
- I.E. Notify the Corps when they need to establish a separate account in their financial system to identify costs separately for work on each new study incorporated by modification to this agreement.

II. CORPS RESPONSIBILITIES

The Corps agrees to:

II.A. MODIFIED ROOSEVELT DAM WATER CONTROL PLAN, AGREEMENT AND MANUAL

- II.A.1. Develop a scope of work, schedule, and cost estimate for updating the flood control benefits and developing the water control plan, agreement, and manual for Modified Roosevelt Dam, in coordination with Reclamation, by December 31, 1991.

Interagency Agreement No. 2-AA-32-01390

II.A.2. After the scope of work, schedule, and cost estimate specified in II.A.2 have been developed and agreed upon with Reclamation, and if the agreement is modified pursuant to I.D above, perform the work necessary to update the flood control benefits and develop the water control agreement, plan, and manual for Modified Roosevelt Dam.

II.B. OTHER FLOOD CONTROL RELATED STUDIES

Perform flood control related studies for features, including economic, hydraulic, hydrologic and/or operational analyses as specified in bilateral, per I.C. above.

II.C. STUDY MANAGEMENT AND INTERAGENCY AGREEMENT ADMINISTRATION

II.C.1. STUDY MANAGEMENT. As requested by Reclamation for specific studies, develop scope, schedule, and cost for a requested study; negotiate with Reclamation toward reaching agreement on a modification establishing the costs and scope of work; perform other study management tasks as required. For each study conducted under this agreement, prepare a Final Report according to the specifications detailed in the scope of work for the study. When requested by Reclamation, establish a separate account to identify specific costs for work on each new study incorporated by modification to this agreement. If the Corps subcontracts for any portion of this work, provide Reclamation copies of relevant invoices from the subcontractor. Upon request by Reclamation, provide backup information in support of invoices.

II.C.2. TECHNICAL COORDINATION. Coordinate with Reclamation to discuss the scope, progress, and results of work under this agreement. Coordinate with other organizations as needed for specific studies, such as the Flood Control District of Maricopa County.

II.C.3. BILLING PROCEDURES. The Corps shall provide Reclamation with a properly executed Standard Form 1081 as a basis for each reimbursement payment by Reclamation. The SF 1081 shall include a breakdown of the type of costs incurred and the time frame in which costs were incurred.

For payment authorization, the SF-1081 should be sent to:

Bureau of Reclamation  
Attention: APO-804  
P.O. Box 9980  
Phoenix, AZ 85068

Interagency Agreement No. 2-AA-32-01390

Billings shall specify the feature of GAP for which the work was performed, and use accounting information designated for that specific work. If this agreement is modified to add funds for studies for features other than Roosevelt Dam, the appropriate accounting information will be included in such modification.

The following Reclamation accounting information should be referenced in each submittal of costs for Modified Roosevelt Dam work:

Appropriation Symbol	14X4079.1
Agreement Number	2-AA-32-01390
Cost Authority	092-0344-1030-001-92-0-0
Cost Center	32A1390
Object Code	253G

III. SPECIAL PROVISIONS

It is mutually agreed:

- III.A. NOTIFICATION TO PROCEED. The Corps shall not perform tasks under this agreement until given specific written notification to proceed on those tasks by Reclamation. Such notification to proceed shall include the amount of funds presently available under the agreement for reimbursement of costs incurred in performance of those specific tasks.
- III.B. TERM OF THE AGREEMENT. The term of this agreement shall be from the last date of the signing of this agreement until September 30, 1998. All work will be accomplished by then and the final billing submitted to Reclamation by then.
- III.C. MODIFICATIONS. This agreement may be modified by amendment duly executed by authorized officials of Reclamation and the Corps.
- III.D. AVAILABILITY OF FUNDS. The performance of any obligation or the expenditure of any funds by the Government under this agreement is contingent upon the necessary appropriations and funds being allocated and made available for the work required hereunder. Nothing in this agreement shall be construed as delegating the recipient or Reclamation to expend money in excess of appropriations authorized by law and administratively allocated for this work.

Interagency Agreement No. 2-AA-32-01390

The estimated availability of funds is as follows:

For Work Performed Prior to October 1, 1990  
\$22,000.00 (previously obligated, already reimbursed)

For Work Performed After November 18, 1991  
Fiscal Year 1992: \$30,000.00

Estimates of funds available for future Fiscal Years will be included when the agreement is modified, pursuant to provision I.C above, to include the work necessary to develop the water control plan, agreement, and manual for Modified Roosevelt Dam.

- III.E. DATE OF INCURRENCE OF COSTS. The Corps shall be entitled to reimbursement of costs incurred, in an amount not to exceed \$5,000, on or after November 18, 1991, and before execution of this agreement, which if incurred after this agreement had been entered into, would have been reimbursable under the provisions of the agreement.
- III.F. REIMBURSABLE COSTS. Payments made for work under this agreement include (1) \$22,000 already paid to the Corps by Reclamation, per Reclamation's letter dated February 23, 1990, for costs incurred prior to October 1, 1990 and (2) reimbursement for actual costs not to exceed \$30,000 for work performed after November 18, 1991, and prior to any modifications.
- III.G. OFFICIALS NOT TO BENEFIT. No member of Congress, or resident Commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom.
- III.H. MEET AND CONFER. The parties agree to meet and confer as necessary to resolve interagency differences with respect to the implementation of this agreement.

LETTER OF UNDERSTANDING (LOU) BETWEEN  
THE BUREAU OF RECLAMATION AND THE CORPS OF ENGINEERS

Subject: Flood Control Regulations at Modified Roosevelt Dam - Roosevelt Lake, Salt River, Arizona

1. Purpose: This letter of understanding defines the general provisions under which the Bureau of Reclamation (hereinafter called the "Bureau") is to operate the Modified Roosevelt Project in compliance with Section 7 of the 1944 Flood Control Act, as stipulated by flood control procedures developed by the Corps of Engineers (hereinafter called the "Corps").

2. Responsibilities.


a. Bureau. The Bureau shall be responsible for compliance with the following:

- (1) Section 208.11 Title 33, Code of Federal Regulations, dated July 1, 1987.
- (2) Water Control Agreement for Modified Roosevelt Dam & Lake, Salt River, Arizona.
- (3) The Water Control Plan for Flood Control contained in the Water Control Manual for Modified Roosevelt Dam.

b. Corps. The Corps shall be responsible for preparing and updating the Water Control Plan and Manual for Flood Control, and for oversight and consultation in insuring that the regulations referred to in section 2.a.(1) above are properly implemented in compliance with Section 7 of the Flood Control Act approved 22 December 1944 (58 Stat. 890; 33 U.S.C. 709).

3. Requirements for Compliance. After approval by the Bureau and the Corps, the Bureau shall be required to implement the Water Control Plan for Flood Control in its entirety, as well as pertinent sections of the regulations referred to in paragraph 2.a.(1). Advanced approval by the District Engineer, Los Angeles District, Corps of Engineers, or his duly authorized representative, is required prior to any deviation from the Water Control Plan for Flood Control, except in emergency situations as defined in the Plan.

The responsibilities and requirements for compliance  
are agreed to and understood.

  
\_\_\_\_\_  
J. RICHARD CAPKA  
Brigadier General, U.S. Army  
Division Engineer

  
\_\_\_\_\_  
ROBERT W. JOHNSON  
Regional Director,  
Lower Colorado Region  
Bureau of Reclamation

5 NOV 96

(date)

2/5/96

(date)

WATER CONTROL AGREEMENT (WCA)  
AMONG THE BUREAU OF RECLAMATION (USBR),  
THE SALT RIVER PROJECT AGRICULTURAL IMPROVEMENT AND POWER DISTRICT (SRP),  
AND THE CORPS OF ENGINEERS (COE)

WHEREAS, the SRP currently operates and maintains Theodore Roosevelt Dam (hereinafter Modified Roosevelt Dam) on the Salt River in Arizona, pursuant to agreements with the USBR and the Salt River Valley Water User's Association, dated September 6, 1917 and March 22, 1937, as amended on February 28, 1944, and September 12, 1949, AND;

WHEREAS, as provided in the above referenced agreement dated September 6, 1917, the USBR holds title to Modified Roosevelt Dam in accordance with the Reclamation Act of June 17, 1902, as amended, AND;

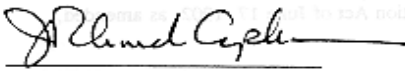
WHEREAS, Congress authorized USBR to construct the Central Arizona Project (CAP), as part of the Colorado River Basin Act of 1968, for the purposes of water conservation and flood control, and as a result of the Central Arizona Water Control Study (CAWCS) and the Reclamation Safety of Dams Act of 1978, flood control became a designated feature of Modified Roosevelt Dam, AND;

WHEREAS, as contained in Section 7 of the Flood Control Act of 1944 (58 Stat. 890, 33 U.S.C. 709), the COE is responsible to prescribe regulations for the use of storage allocated for flood control at all reservoirs constructed wholly or in part with Federal funds.

In consideration of the above recitals, the parties hereto agree as follows:

1. SRP shall operate Modified Roosevelt Dam in a manner consistent with this Agreement which includes the water control diagram (Exhibit A); the Water Control Plan (Chapter 7) contained in the Water Control Manual for Modified Roosevelt Dam; Section 7 of the Flood Control Act of 1944; 33 CFR 208.11; and in all other respects, with federal reclamation law and SRP's contractual obligations referenced herein.
2. The parties intend that this Agreement be supplementary and complementary to the agreements of September 6, 1917 and March 22, 1937, referenced herein, and is not intended to amend such agreements.
3. SRP shall procure current basic hydrological data, make determinations of the magnitude of downstream discharges on the Verde, Salt and Gila Rivers, and make calculations of permissible releases from the reservoir as required to accomplish the flood control objectives prescribed in the water control manual.
4. USBR shall install a stream gaging station to reliably measure the combined flow of the Salt River and Verde River as required by the water control plan contained in the Modified Roosevelt Dam Water Control Manual. Maintenance of the gaging station shall be the responsibility of the SRP.
5. The USBR and SRP shall keep the District Engineer, Los Angeles District, of the COE, advised of hydrological conditions, the status of the SRP reservoir facilities, and other operating information which affect the flood control operation.

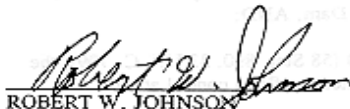
6. Modification of the Water Control Plan contained in the Modified Roosevelt Dam Water Control Manual may be made from time to time as deemed necessary by the parties of this agreement. Each such revision shall be effective on the date a new Water Control Agreement is signed.
7. Flood control regulations are subject to temporary modification, if found necessary in time of emergency. Request for, and action on, such modifications shall be made by any available means of communication, to the Los Angeles District Engineer, COE or his duly appointed representative, and the action requested shall be confirmed in writing with justification for the action on the same day as the action. Any deviations from the approved Water Control Plan other than for emergencies, as stated above, shall be approved by the COE prior to the action being taken. The request for deviation shall be made by SRP after consultation with the USBR.



J. RICHARD CAPKA  
Brigadier General, U.S. Army  
Division Engineer

5 NOV 96

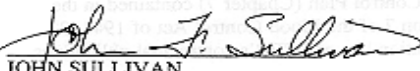
Date



ROBERT W. JOHNSON  
Regional Director,  
Lower Colorado Region  
Bureau of Reclamation

2/5/96

Date



JOHN SULLIVAN  
Associate General Manager,  
Water Group  
Salt River Project Agricultural  
Improvement and Power District

1/3/96

Date

APPROVED TO FORM  
BY   
DATE 1/3/96



EXHIBIT B  
CODE OF FEDERAL REGULATIONS  
Title 33, Part 208.11

MODIFIED ROOSEVELT DAM  
WATER CONTROL MANUAL  
SALT AND GILA RIVERS

**September 1997**

PREPARED BY:  
U.S. ARMY CORPS OF ENGINEERS  
LOS ANGELES DISTRICT  
RESERVOIR REGULATION SECTION









LIST OF PROJECTS—Continued  
 (All-Cost projects with Corps Reimbursement Requirements)

Project Name C&A No.	State	County	Stream	Project Type	Storage 1000 AF	Firm Flow 10 CFS		Firm Flow 10 CFS		Firm Flow 10 CFS		Firm Flow 10 CFS	Firm Flow 10 CFS
						Min	Max	Min	Max	Min	Max		
Allen Canyon Dam & Res.	CA	Alameda	Truba R.	DR	10.7	1985.0	1983.0	7084	8996	FERC No. 1074-1		USBR	
Almond Dam & Res.	CA	Alameda	Truba R.	DR	10.7	1985.0	1983.0	7084	8996	FERC No. 1074-1		USBR	
Almond Dam & Res. (cont.)	CA	Alameda	Truba R.	DR	10.7	1985.0	1983.0	7084	8996	FERC No. 1074-1		USBR	
Almond Dam & Res. (cont.)	CA	Alameda	Truba R.	DR	10.7	1985.0	1983.0	7084	8996	FERC No. 1074-1		USBR	
Almond Dam & Res. (cont.)	CA	Alameda	Truba R.	DR	10.7	1985.0	1983.0	7084	8996	FERC No. 1074-1		USBR	

111

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Allen Dam & Res.	CA	Alameda	Truba R.	DR	10.7	1985.0	1983.0	7084	8996	FERC No. 1074-1		USBR
Almond Dam & Res.	CA	Alameda	Truba R.	DR	10.7	1985.0	1983.0	7084	8996	FERC No. 1074-1		USBR
Almond Dam & Res. (cont.)	CA	Alameda	Truba R.	DR	10.7	1985.0	1983.0	7084	8996	FERC No. 1074-1		USBR
Almond Dam & Res. (cont.)	CA	Alameda	Truba R.	DR	10.7	1985.0	1983.0	7084	8996	FERC No. 1074-1		USBR
Almond Dam & Res. (cont.)	CA	Alameda	Truba R.	DR	10.7	1985.0	1983.0	7084	8996	FERC No. 1074-1		USBR

5208.11

33 CFR Ch. II (7-1-04 Edition)

Office of Engineering, Dept. of the Army, DOD

5208.11

EXHIBIT B  
 Modified Roosevelt Dam Water Control Manual





**EXHIBIT C**  
**AREA - STORAGE CAPACITY TABLES**

**MODIFIED ROOSEVELT DAM**  
**WATER CONTROL MANUAL**  
**SALT AND GILA RIVERS**

SEPTEMBER 1997

PREPARED BY:  
U.S. ARMY CORPS OF ENGINEERS  
LOS ANGELES DISTRICT  
RESERVOIR REGULATION SECTION

## MODIFIED ROOSEVELT DAM - AREA TABLE

April 1995 Reservoir Survey  
Source: Phoenix Area Office - USBR

THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1963	0	0	0	0	0	1	1	1	1	1
1964	1	17	32	48	63	79	95	110	126	141
1965	157	165	173	181	189	196	204	212	220	228
1966	236	244	252	259	267	275	283	291	299	307
1967	315	322	330	338	346	354	362	370	378	386
1968	393	401	409	417	425	433	441	449	456	464
1969	472	480	488	496	504	512	519	527	535	543
1970	551	554	558	561	564	567	571	574	577	581
1971	584	587	590	594	597	600	603	607	610	613
1972	617	620	623	626	630	633	636	640	643	646
1973	649	653	656	659	663	666	669	672	676	679
1974	682	685	689	692	695	699	702	705	708	712
1975	715	719	723	728	732	736	740	745	749	753
1976	757	762	766	770	774	779	783	787	791	796
1977	800	804	808	813	817	821	825	829	834	838
1978	842	846	851	855	859	863	868	872	876	880
1979	885	889	893	897	902	906	910	914	919	923
1980	927	930	933	936	939	942	945	948	951	954
1981	957	960	963	966	969	972	975	978	981	984
1982	987	990	993	996	999	1002	1005	1008	1011	1014
1983	1017	1020	1023	1026	1029	1032	1035	1038	1041	1044
1984	1047	1050	1053	1056	1059	1062	1065	1068	1071	1074
1985	1077	1080	1082	1085	1088	1090	1093	1096	1098	1101
1986	1104	1106	1109	1112	1115	1117	1120	1123	1125	1128
1987	1131	1133	1136	1139	1141	1144	1147	1149	1152	1155
1988	1157	1160	1163	1165	1168	1171	1173	1176	1179	1182
1989	1184	1187	1190	1192	1195	1198	1200	1203	1206	1208

**MODIFIED ROOSEVELT DAM - AREA TABLE**

April 1995 Reservoir Survey

Source: Phoenix Area Office - USBR

THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1990	1211	1218	1225	1232	1239	1245	1252	1259	1266	1273
1991	1280	1287	1294	1300	1307	1314	1321	1328	1335	1342
1992	1349	1355	1362	1369	1376	1383	1390	1397	1404	1411
1993	1417	1424	1431	1438	1445	1452	1459	1466	1472	1479
1994	1486	1493	1500	1507	1514	1521	1527	1534	1541	1548
1995	1555	1568	1581	1594	1606	1619	1632	1645	1658	1671
1996	1684	1696	1709	1722	1735	1748	1761	1774	1786	1799
1997	1812	1825	1838	1851	1864	1876	1889	1902	1915	1928
1998	1941	1954	1967	1979	1992	2005	2018	2031	2044	2057
1999	2069	2082	2095	2108	2121	2134	2147	2159	2172	2185
2000	2198	2211	2223	2236	2248	2261	2273	2286	2298	2311
2001	2323	2336	2348	2361	2373	2386	2398	2412	2423	2436
2002	2448	2461	2473	2486	2498	2511	2523	2536	2548	2561
2003	2573	2586	2598	2611	2623	2636	2648	2661	2673	2686
2004	2698	2711	2723	2736	2748	2761	2773	2786	2798	2811
2005	2823	2835	2848	2860	2872	2885	2897	2909	2922	2934
2006	2946	2959	2971	2983	2996	3008	3020	3033	3045	3057
2007	3070	3082	3094	3107	3119	3132	3144	3156	3169	3181
2008	3193	3206	3218	3230	3243	3255	3267	3280	3292	3304
2009	3317	3329	3341	3354	3366	3378	3391	3403	3415	3428
2010	3440	3449	3458	3466	3475	3484	3493	3501	3510	3519
2011	3528	3537	3545	3554	3563	3572	3580	3589	3598	3607
2012	3616	3624	3633	3642	3651	3660	3668	3677	3686	3695
2013	3703	3712	3721	3730	3739	3747	3756	3765	3774	3782
2014	3791	3800	3809	3818	3826	3835	3844	3853	3861	3870
2015	3879	3887	3895	3903	3911	3918	3926	3934	3942	3950
2016	3958	3966	3974	3981	3989	3997	4005	4013	4021	4029
2017	4037	4044	4052	4060	4068	4076	4084	4092	4100	4108
2018	4115	4123	4131	4139	4147	4155	4163	4171	4178	4186
2019	4194	4202	4210	4218	4226	4234	4241	4249	4257	4265

# MODIFIED ROOSEVELT DAM - AREA TABLE

April 1995 Reservoir Survey  
Source: Phoenix Area Office - USBR

THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2020	4273	4281	4289	4297	4305	4313	4320	4328	4336	4344
2021	4352	4360	4368	4376	4384	4392	4399	4407	4415	4423
2022	4431	4439	4447	4455	4463	4471	4478	4486	4494	4502
2023	4510	4518	4526	4534	4542	4550	4557	4565	4573	4581
2024	4589	4597	4605	4613	4621	4629	4636	4644	4652	4660
2025	4668	4674	4679	4685	4691	4697	4702	4708	4714	4719
2026	4725	4731	4737	4742	4748	4754	4760	4765	4771	4777
2027	4782	4788	4794	4800	4805	4811	4817	4822	4828	4834
2028	4840	4845	4851	4857	4862	4868	4874	4880	4885	4891
2029	4897	4903	4908	4914	4920	4925	4931	4937	4943	4948
2030	4954	4960	4966	4972	4978	4984	4989	4995	5001	5007
2031	5013	5019	5025	5031	5037	5043	5048	5054	5060	5066
2032	5072	5078	5084	5090	5096	5102	5107	5113	5119	5125
2033	5131	5137	5143	5149	5155	5160	5166	5172	5178	5184
2034	5190	5196	5202	5208	5214	5219	5225	5231	5237	5243
2035	5249	5256	5262	5269	5276	5282	5289	5295	5302	5309
2036	5315	5322	5329	5335	5342	5349	5355	5362	5369	5375
2037	5382	5388	5395	5402	5408	5415	5422	5428	5435	5442
2038	5448	5455	5461	5468	5475	5481	5488	5495	5501	5508
2039	5515	5521	5528	5535	5541	5548	5554	5561	5568	5574
2040	5581	5590	5600	5609	5618	5627	5637	5646	5655	5665
2041	5674	5683	5692	5702	5711	5720	5729	5739	5748	5757
2042	5767	5776	5785	5794	5804	5813	5822	5832	5841	5850
2043	5859	5869	5878	5887	5897	5906	5915	5924	5934	5943
2044	5952	5961	5971	5980	5989	5999	6008	6017	6026	6036
2045	6045	6058	6072	6085	6099	6112	6125	6139	6152	6165
2046	6179	6192	6206	6219	6232	6246	6259	6272	6286	6299
2047	6313	6326	6339	6353	6366	6380	6393	6406	6420	6433
2048	6446	6460	6473	6487	6500	6513	6527	6540	6553	6567
2049	6580	6594	6607	6620	6634	6647	6660	6674	6687	6701

**MODIFIED ROOSEVELT DAM - AREA TABLE**

April 1995 Reservoir Survey  
Source: Phoenix Area Office - USBR

THE AREA TABLE IS IN ACRES

THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2050	6714	6726	6738	6749	6761	6773	6785	6797	6809	6820
2051	6832	6844	6856	6868	6879	6891	6903	6915	6927	6939
2052	6950	6962	6974	6986	6998	7010	7021	7033	7045	7057
2053	7069	7080	7092	7104	7116	7128	7140	7151	7163	7175
2054	7187	7199	7210	7222	7234	7246	7258	7270	7281	7293
2055	7305	7318	7332	7345	7359	7372	7386	7399	7413	7426
2056	7440	7453	7467	7480	7494	7507	7521	7534	7548	7561
2057	7575	7588	7602	7615	7629	7642	7655	7669	7682	7696
2058	7709	7723	7736	7750	7763	7777	7790	7804	7817	7831
2059	7844	7858	7871	7885	7898	7912	7925	7939	7952	7966
2060	7979	7994	8008	8023	8037	8052	8067	8081	8096	Sill
2061	8125	8140	8154	8169	8184	8198	8213	8228	8242	8257
2062	8271	8286	8301	8315	8330	8344	8359	8374	8388	8403
2063	8418	8432	8447	8461	8476	8491	8505	8520	8535	8549
2064	8564	8578	8593	8608	8622	8637	8652	8666	8681	8695
2065	8710	8724	8738	8751	8765	8779	8793	8806	8820	8834
2066	8847	8861	8875	8889	8902	8916	8930	8943	8957	8971
2067	8985	8998	9012	9026	9039	9053	9067	9080	9094	9108
2068	9122	9135	9149	9163	9176	9190	9204	9218	9231	9245
2069	9259	9272	9286	9300	9314	9327	9341	9355	9368	9382
2070	9396	9410	9423	9437	9451	9464	9478	9492	9505	9519
2071	9533	9547	9560	9574	9588	9601	9615	9629	9643	9656
2072	9670	9684	9697	9711	9725	9739	9752	9766	9780	9793
2073	9807	9821	9835	9848	9862	9876	9889	9903	9917	9931
2074	9944	9958	9972	9985	9999	10013	10026	10040	10054	10068
2075	10081	10095	10109	10122	10136	10150	10164	10177	10191	10205
2076	10219	10232	10246	10260	10274	10287	10301	10315	10329	10342
2077	10356	10370	10384	10397	10411	10425	10439	10453	10466	10480
2078	10494	10508	10521	10535	10549	10563	10576	10590	10604	10618
2079	10631	10645	10659	10673	10686	10700	10714	10728	10741	10755

# MODIFIED ROOSEVELT DAM - AREA TABLE

April 1995 Reservoir Survey  
Source:,Phocnix Area Office - USBR

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ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2080	10769	10782	10794	10807	10820	10833	10845	10858	10871	10884
2081	10896	10909	10922	10935	10947	10960	10973	10986	10998	11011
2082	11024	11037	11049	11062	11075	11088	11100	11113	11126	11138
2083	11151	11164	11177	11189	11202	11215	11228	11240	11253	11266
2084	11279	11291	11304	11317	11330	11342	11355	11368	11381	11393
2085	11406	11425	11445	11464	11484	11503	11522	11542	11561	11581
2086	11600	11619	11639	11658	11678	11697	11716	11736	11755	11775
2087	11794	11807	11821	11834	11847	11861	11874	11887	11901	11914
2088	11927	11941	11954	11967	11981	11994	12007	12021	12034	12047
2089	12061	12074	12087	12101	12114	12127	12141	12154	12167	12181
2090	12194	12209	12225	12240	12255	12270	12286	12301	12316	12331
2091	12347	12362	12377	12392	12408	12423	12438	12453	12469	12484
2092	12499	12514	12530	12545	12560	12575	12591	12606	12621	12637
2093	12652	12667	12682	12698	12713	12728	12743	12759	12774	12789
2094	12804	12820	12835	12850	12865	12881	12896	12911	12926	12942
2095	12957	12969	12982	12994	13007	13019	13032	13044	13057	13069
2096	13081	13094	13106	13119	13131	13144	13156	13168	13181	13193
2097	13206	13218	13231	13243	13256	13268	13280	13293	13305	13318
2098	13330	13343	13355	13368	13380	13392	13405	13417	13430	13442
2099	13455	13467	13479	13492	13504	13517	13529	13542	13554	13567
2100	13579	13591	13603	13616	13628	13640	13652	13665	13677	13689
2101	13701	13714	13726	13738	13750	13763	13775	13787	13799	13812
2102	13824	13836	13848	13861	13873	13885	13897	13909	13922	13934
2103	13946	13958	13971	13983	13995	14007	14020	14032	14044	14056
2104	14069	14081	14093	14105	14118	14130	14142	14154	14167	14179
2105	14191	14204	14217	14229	14242	14255	14268	14281	14293	14306
2106	14319	14332	14345	14357	14370	14383	14396	14409	14421	14434
2107	14447	14460	14473	14485	14498	14511	14524	14537	14549	14562
2108	14575	14588	14601	14613	14626	14639	14652	14665	14677	14690
2109	14703	14716	14729	14741	14754	14767	14780	14793	14805	14818

**MODIFIED ROOSEVELT DAM - AREA TABLE**

April 1995 Reservoir Survey  
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ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2110	14831	14845	14859	14874	14888	14902	14916	14931	14945	14959
2111	14973	14987	15002	15016	15030	15044	15059	15073	15087	15101
2112	15115	15130	15144	15158	15172	15186	15201	15215	15229	15243
2113	15258	15272	15286	15300	15314	15329	15343	15357	15371	15386
2114	15400	15414	15428	15442	15457	15471	15485	15499	15514	15528
2115	15542	15558	15575	15591	15607	15623	15640	15656	15672	15689
2116	15705	15721	15737	15754	15770	15786	15802	15819	15835	15851
2117	15868	15884	15900	15916	15933	15949	15965	15982	15998	16014
2118	16030	16047	16063	16079	16096	16112	16128	16144	16161	16177
2119	16193	16209	16226	16242	16258	16275	16291	16307	16323	16340
2120	16356	16371	16387	16402	16417	16433	16448	16463	16479	16494
2121	16509	16525	16540	16555	16571	16586	16601	16617	16632	16647
2122	16663	16678	16693	16709	16724	16740	16755	16770	16786	16801
2123	16816	16832	16847	16862	16878	16893	16908	16924	16939	16954
2124	16970	16985	17000	17016	17031	17046	17062	17077	17092	17108
2125	17123	17141	17158	17176	17193	17211	17228	17246	17263	17281
2126	17298	17316	17333	17351	17369	17386	17404	17421	17439	17456
2127	17474	17491	17509	17526	17544	17562	17579	17597	17614	17632
2128	17649	17667	17684	17702	17719	17737	17754	17772	17790	17807
2129	17825	17842	17860	17877	17895	17912	17930	17947	17965	17982
2130	18000	18018	18036	18055	18073	18091	18109	18127	18145	18164
2131	18182	18200	18218	18236	18255	18273	18291	18309	18327	18345
2132	18364	18382	18400	18418	18436	18455	18473	18491	18509	18527
2133	18545	18564	18582	18600	18618	18636	18654	18673	18691	18709
2134	18727	18745	18764	18782	18800	18818	18836	18854	18873	18891
2135	18909	18925	18941	18958	18975	18992	19008	19025	19042	19059
2136	19075	19092	19109	19126	19142	19159	19176	19193	19209	19226
2137	19243	19260	19276	19293	19310	19327	19344	19360	19377	19394
2138	19411	19427	19444	19461	19478	19494	19511	19528	19545	19561
2139	19578	19595	19612	19628	19645	19662	19679	19695	19712	19729

**MODIFIED ROOSEVELT DAM - AREA TABLE**

April 1995 Reservoir Survey

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THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2140	19746	19763	19779	19796	19813	19830	19846	19863	19880	19897
2141	19913	19930	19947	19964	19980	19997	20014	20031	20047	20064
2142	20081	20098	20114	20131	20148	20165	20182	20198	20215	20232
2143	20249	20265	20282	20299	20316	20332	20349	20366	20383	20399
2144	20416	20433	20450	20466	20483	20500	20517	20533	20550	20567
2145	20584	20600	20616	20631	20646	20662	20677	20692	20708	20723
2146	20738	20754	20769	20784	20799	20815	20830	20845	20861	20876
2147	20891	20907	20922	20937	20953	20968	20983	20999	21014	21029
2148	21045	21060	21075	21091	21106	21121	21137	21152	21167	21182
2149	21198	21213	21228	21244	21259	21274	21290	21305	21320	21336
2150	21351	21365	21379	21394	21408	21422	21436	21450	21464	21479
2151	21493	21507	21521	21535	21550	21564	21578	21592	21606	21620
2152	21635	21649	21663	21677	21691	21706	21720	21734	21748	21762
2153	21776	21791	21805	21819	21833	21847	21861	21876	21890	21904
2154	21918	21932	21947	21961	21975	21989	22003	22017	22032	22046
2155	22060	22073	22087	22100	22114	22127	22141	22154	22168	22181
2156	22194	22208	22221	22235	22248	22262	22275	22288	22302	22315
2157	22329	22342	22356	22369	22383	22396	22409	22423	22436	22450
2158	22463	22477	22490	22504	22517	22530	22544	22557	22571	22584
2159	22598	22611	22624	22638	22651	22665	22678	22692	22705	22719
2160	22732	22745	22759	22772	22786	22799	22813	22826	22840	22853
2161	22866	22880	22893	22907	22920	22934	22947	22960	22974	22987
2162	23001	23014	23028	23041	23055	23068	23081	23095	23108	23122
2163	23135	23149	23162	23176	23189	23202	23216	23229	23243	23256
2164	23270	23283	23296	23310	23323	23337	23350	23364	23377	23391
2165	23404	23419	23434	23450	23465	23480	23495	23510	23525	23541
2166	23556	23571	23586	23601	23617	23632	23647	23662	23677	23692
2167	23708	23723	23738	23753	23768	23783	23799	23814	23829	23844
2168	23859	23875	23890	23905	23920	23935	23950	23966	23981	23996
2169	24011	24026	24042	24057	24072	24087	24102	24117	24133	24148

## MODIFIED ROOSEVELT DAM - AREA TABLE

April 1995 Reservoir Survey  
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THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2170	24163	24179	24196	24212	24228	24244	24261	24277	24293	24310
2171	24326	24342	24359	24375	24391	24407	24424	24440	24456	24473
2172	24489	24505	24522	24538	24554	24570	24587	24603	24619	24636
2173	24652	24668	24685	24701	24717	24733	24750	24766	24782	24799
2174	24815	24831	24848	24864	24880	24896	24913	24929	24945	24962
2175	24978	24994	25009	25025	25040	25056	25071	25087	25102	25118
2176	25133	25149	25164	25180	25195	25211	25226	25242	25257	25273
2177	25288	25304	25319	25335	25350	25366	25381	25397	25412	25428
2178	25443	25458	25474	25489	25505	25520	25536	25551	25567	25582
2179	25598	25613	25629	25644	25660	25675	25691	25706	25722	25737
2180	25753	25770	25786	25803	25820	25836	25853	25869	25886	25903
2181	25919	25936	25953	25969	25986	26003	26019	26036	26053	26069
2182	26086	26102	26119	26136	26152	26169	26186	26202	26219	26236
2183	26252	26269	26285	26302	26319	26335	26352	26369	26385	26402
2184	26419	26435	26452	26469	26485	26502	26518	26535	26552	26568
2185	26585	26601	26618	26634	26650	26667	26683	26699	26716	26732
2186	26748	26765	26781	26797	26814	26830	26846	26863	26879	26895
2187	26912	26928	26944	26961	26977	26994	27010	27026	27043	27059
2188	27075	27092	27108	27124	27141	27157	27173	27190	27206	27222
2189	27239	27255	27271	27288	27304	27320	27337	27353	27369	27386
2190	27402	27418	27434	27451	27467	27484	27500	27517	27534	27550
2191	27567	27583	27600	27616	27633	27649	27666	27682	27699	27715
2192	27732	27748	27765	27781	27798	27814	27831	27847	27864	27880
2193	27897	27914	27930	27947	27963	27980	27996	28013	28029	28046
2194	28062	28079	28095	28112	28128	28145	28161	28178	28194	28211
2195	28227	28244	28260	28277	28293	28310	28327	28343	28360	28376
2196	28393	28409	28426	28442	28459	28475	28492	28508	28525	28541
2197	28558	28574	28591	28607	28624	28640	28657	28673	28690	28706
2198	28723	28740	28756	28773	28789	28806	28822	28839	28855	28872
2199	28888	28905	28921	28938	28954	28971	28987	29004	29020	29037



**MODIFIED ROOSEVELT DAM - CAPACITY TABLE**

April 1995 Reservoir Survey  
Source: Phoenix Area Office, USBR

THE CAPACITY TABLE IS IN ACRE-FEET

THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1963	0	0	0	0	0	0	0	0	0	0
1964	1	1	4	8	13	21	29	39	51	65
1965	80	96	112	130	149	168	188	209	230	253
1966	276	300	325	350	377	404	432	460	490	520
1967	551	583	616	649	683	718	754	791	828	866
1968	905	945	985	1027	1069	1112	1155	1200	1245	1291
1969	1338	1386	1434	1483	1533	1584	1635	1688	1741	1795
1970	1850	1905	1960	2016	2073	2129	2186	2243	2301	2359
1971	2417	2475	2534	2594	2653	2713	2773	2834	2894	2956
1972	3017	3079	3141	3204	3266	3330	3393	3457	3521	3585
1973	3650	3715	3781	3846	3912	3979	4046	4113	4180	4248
1974	4316	4384	4453	4522	4591	4661	4731	4801	4672	4943
1975	5015	5086	5158	5231	5304	5377	5451	5525	5600	5675
1976	5751	5827	5903	5980	6057	6135	6213	6291	6370	6450
1977	6529	6609	6690	6771	6853	6935	7017	7100	7183	7266
1978	7350	7435	7520	7605	7691	7777	7863	7950	8038	8125
1979	8214	8302	8391	8481	8571	8661	8752	8843	8935	9027
1980	9120	9212	9306	9399	9493	9587	9681	9776	9871	9966
1981	10062	10157	10254	10350	10447	10544	10641	10739	10837	10935
1982	11034	11132	11232	11331	11431	11531	11631	11732	11833	11934
1983	12036	12137	12240	12342	12445	12548	12651	12755	12859	12963
1984	13068	13172	13278	13383	13489	13595	13701	13808	13915	14022
1985	14130	14237	14345	14454	14562	14671	14781	14890	15000	15110
1986	15220	15330	15441	15552	15664	15775	15887	15999	16112	16224
1987	16337	16450	16564	16677	16791	16906	17020	17135	17250	17365
1988	17481	17597	17713	17830	17946	18063	18180	18298	18416	18534
1989	18652	18770	18889	19008	19128	19247	19367	19487	19608	19729

**MODIFIED ROOSEVELT DAM - CAPACITY TABLE**

April 1995 Reservoir Survey

Source: Phoenix Area Office, USBR.

THE CAPACITY TABLE IS IN ACRE-FEET

THE ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1990	19850	19971	20093	20216	20339	20464	20588	20714	20840	20967
1991	21095	21223	21352	21482	21612	21743	21875	22008	22141	22275
1992	22409	22544	22680	22817	22954	23092	23231	23370	23510	23651
1993	23792	23934	24077	24220	24365	24509	24655	24801	24948	25096
1994	25244	25393	25543	25693	25844	25996	26148	26301	26455	26609
1995	26765	26921	27078	27237	27397	27558	27721	27885	28050	28216
1996	28384	28553	28723	28895	29068	29242	29417	29594	29772	29951
1997	30132	30314	30497	30681	30867	31054	31242	31432	31623	31815
1998	32008	32203	32399	32596	32795	32995	33196	33398	33602	33807
1999	34013	34221	34430	34640	34851	35064	35278	35493	35710	35928
2000	36147	36367	36589	36812	37036	37262	37488	37716	37945	38176
2001	38408	38640	38875	39110	39347	39585	39824	40064	40306	40549
2002	40793	41038	41285	41533	41782	42033	42284	42537	42791	43047
2003	43304	43561	43821	44081	44343	44606	44870	45135	45402	45670
2004	45939	46209	46481	46754	47028	47304	47580	47858	48137	48418
2005	48700	48982	49267	49552	49839	50126	50416	50706	50997	51290
2006	51584	51879	52176	52474	52773	53073	53374	53677	53981	54286
2007	54592	54900	55209	55519	55830	56143	56456	56771	57088	57405
2008	57724	58044	58365	58687	59011	59336	59662	59989	60318	60648
2009	60979	61311	61644	61979	62315	62652	62991	63331	63671	64014
2010	64357	64701	65047	65393	65740	66088	66437	66787	67137	67489
2011	67841	68194	68548	68903	69259	69616	69973	70332	70691	71051
2012	71413	71775	72137	72501	72866	73231	73598	73965	74333	74702
2013	75072	75443	75815	76187	76560	76935	77310	77686	78063	78441
2014	78819	79199	79579	79961	80343	80726	81110	81495	81880	82267
2015	82655	83043	83432	83822	84212	84604	84996	85389	85783	86178
2016	86573	86969	87366	87764	88162	88562	88962	89363	89764	90167
2017	90570	90974	91379	91785	92191	92598	93006	93415	93825	94235
2018	94646	95058	95471	95884	96299	96714	97130	97546	97964	98382
2019	98801	99221	99641	100063	100485	100908	101332	101756	102181	102608

**MODIFIED ROOSEVELT DAM - CAPACITY TABLE**

April 1995 Reservoir Survey  
Source: Phoenix Area Office, USBR

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ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2020	103035	103462	103891	104320	104750	105181	105613	106045	106478	106912
2021	107347	107783	108219	108656	109094	109533	109972	110413	110854	111296
2022	111739	112182	112626	113071	113517	113964	114411	114860	115309	115758
2023	116209	116660	117113	117566	118019	118474	118929	119385	119842	120300
2024	120759	121218	121678	122139	122600	123063	123526	123990	124455	124921
2025	125387	125854	126322	126790	127259	127728	128198	128669	129140	129611
2026	130084	130556	131030	131504	131978	132453	132929	133405	133882	134359
2027	134837	135316	135795	136275	136755	137236	137717	138199	138682	139165
2028	139648	140133	140617	141103	141589	142075	142562	143050	143538	144027
2029	144517	145007	145497	145988	146480	146972	147465	147958	148452	148947
2030	149442	149938	150434	150931	151428	151926	152425	152924	153424	153925
2031	154426	154927	155429	155932	156435	156939	157444	157949	158455	158961
2032	159468	159976	160484	160992	161502	162011	162522	163033	163544	164057
2033	164570	165083	165597	166111	166627	167142	167659	168176	168693	169211
2034	169730	170249	170769	171290	171811	172332	172855	173377	173901	174425
2035	174950	175475	176001	176527	177054	177582	178111	178640	179170	179701
2036	180232	180764	181296	181829	182363	182898	183433	183969	184505	185042
2037	185580	186119	186658	187198	187738	188280	188821	189364	189907	190451
2038	190995	191540	192086	192633	193180	193728	194276	194825	195375	195926
2039	196477	197028	197581	198134	198688	199242	199797	200353	200910	201467
2040	202025	202583	203143	203703	204264	204827	205390	205954	206519	207085
2041	207652	208220	208789	209358	209929	210500	211073	211646	212221	212796
2042	213372	213949	214527	215106	215686	216267	216849	217431	218015	218600
2043	219185	219772	220359	220947	221536	222126	222717	223309	223902	224496
2044	225091	225687	226283	226881	227479	228079	228679	229280	229882	230485
2045	231090	231695	232301	232909	233518	234129	234741	235354	235968	236584
2046	237201	237820	238440	239061	239684	240308	240933	241559	242187	242817
2047	243447	244079	244712	245347	245983	246620	247259	247899	248540	249183
2048	249827	250472	251119	251767	252416	253067	253719	254372	255027	255683
2049	256340	256999	257659	258320	258983	259647	260312	260979	261647	262316

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ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2050	262987	263659	264332	265007	265682	266359	267037	267716	268396	269077
2051	269760	270444	271129	271815	272502	273191	273881	274572	275264	275957
2052	276651	277347	278044	278742	279441	280141	280843	281546	282250	282955
2053	283661	284368	285077	285787	286498	287210	287923	288638	289354	290071
2054	290789	291508	292228	292950	293673	294397	295122	295848	296576	297305
2055	298035	298766	299498	300232	300967	301704	302442	303181	303922	304664
2056	305407	306152	306898	307645	308394	309144	309895	310648	311402	312157
2057	312914	313672	314432	315193	315955	316718	317483	318249	319017	319786
2058	320556	321328	322101	322875	323651	324428	325206	325986	326767	327549
2059	328333	329118	329904	330692	331481	332272	333064	333857	334651	335447
2060	336245	337043	337843	338645	339448	340252	341058	341866	342674	343485
2061	344297	345110	345925	346741	347558	348377	349198	350020	350844	351669
2062	352495	353323	354152	354983	355815	356649	357484	358321	359159	359998
2063	360839	361682	362526	363371	364218	365066	365916	366768	367620	368474
2064	369330	370187	371046	371906	372767	373630	374495	375361	376228	377097
2065	377967	378838	379712	380586	381462	382339	383218	384098	384979	385862
2066	386746	387631	388518	389406	390296	391186	392079	392972	393867	394764
2067	395662	396561	397461	398363	399266	400171	401077	401984	402893	403803
2068	404715	405627	406542	407457	408374	409293	410212	411133	412056	412980
2069	413905	414831	415759	416689	417619	418551	419485	420419	421356	422293
2070	423232	424172	425114	426057	427001	427947	428894	429843	430793	431744
2071	432696	433650	434606	435562	436521	437480	438441	439403	440367	441332
2072	442298	443266	444235	445205	446177	447150	448125	449100	450078	451056
2073	452036	453018	454001	454985	455970	456957	457945	458935	459926	460918
2074	461912	462907	463904	464901	465901	466901	467903	468907	469911	470917
2075	471925	472933	473943	474955	475968	476982	477998	479015	480033	481053
2076	482074	483097	484121	485146	486173	487201	488230	489261	490293	491327
2077	492362	493398	494436	495475	496515	497557	498600	499645	500691	501738
2078	502787	503837	504888	505941	506995	508051	509108	510166	511226	512287
2079	513349	514413	515478	516545	517613	518682	519753	520825	521898	522973

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ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2080	524050	525127	526206	527286	528367	529450	530534	531619	532706	533793
2081	534882	535973	537064	538157	539251	540346	541443	542541	543640	544741
2082	545842	546945	548050	549155	550262	551370	552480	553590	554702	555815
2083	556930	558046	559163	560281	561401	562521	563643	564767	565892	567018
2084	568145	569273	570403	571534	572666	573800	574935	576071	577208	578347
2085	579487	580629	581772	582918	584065	585214	586366	587519	588674	589831
2086	590990	592151	593314	594479	595646	596814	597985	599158	600332	601509
2087	602687	603867	605048	606231	607415	608601	609787	610975	612165	613356
2088	614548	615741	616936	618132	619329	620528	621728	622929	624132	625336
2089	626542	627748	628956	630166	631377	632589	633802	635017	636233	637450
2090	638669	639889	641111	642334	643559	644785	646013	647242	648473	649705
2091	650939	652175	653412	654650	655890	657132	658375	659619	660865	662113
2092	663362	664613	665865	667119	668374	669631	670889	672149	673410	674673
2093	675938	677204	678471	679740	681011	682283	683556	684831	686108	687386
2094	688666	689947	691230	692514	693800	695087	696376	697666	698958	700252
2095	701547	702843	704140	705439	706739	708041	709343	710647	711952	713258
2096	714566	715874	717184	718496	719808	721122	722437	723753	725071	726389
2097	727709	729031	730353	731677	733002	734328	735655	736984	738314	739645
2098	740977	742311	743646	744982	746319	747658	748998	750339	751681	753025
2099	754370	755716	757063	758412	759762	761113	762465	763818	765173	766529
2100	767887	769245	770605	771966	773328	774691	776056	777422	778789	780157
2101	781527	782897	784269	785643	787017	788393	789770	791148	792527	793908
2102	795289	796672	798057	799442	800829	802217	803606	804996	806388	807780
2103	809174	810570	811966	813364	814763	816163	817564	818967	820370	821775
2104	823182	824589	825998	827408	828819	830231	831645	833060	834476	835893
2105	837312	838731	840152	841575	842998	844423	845849	847277	848705	850135
2106	851567	852999	854433	855868	857304	858742	860181	861621	863063	864505
2107	865950	867395	868841	870289	871739	873189	874641	876094	877548	879004
2108	880461	881919	883378	884839	886301	887764	889229	890694	892161	893630
2109	895100	896570	898043	899516	900991	902467	903944	905423	906903	908384

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ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2110	909867	911350	912836	914322	915810	917300	918791	920283	921777	923272
2111	924769	926267	927766	929267	930769	932273	933778	935285	936793	938302
2112	939813	941325	942839	944354	945870	947388	948908	950429	951951	953474
2113	954999	956526	958054	959583	961114	962646	964180	965715	967251	968789
2114	970328	971869	973411	974954	976499	978046	979594	981143	982693	984246
2115	985799	987354	988911	990469	992029	993590	995154	996718	998285	999853
2116	1001422	1002994	1004567	1006141	1007717	1009295	1010875	1012456	1014038	1015623
2117	1017209	1018796	1020385	1021976	1023569	1025163	1026758	1028356	1029955	1031555
2118	1033158	1034761	1036367	1037974	1039583	1041193	1042805	1044419	1046034	1047651
2119	1049269	1050890	1052511	1054135	1055760	1057386	1059015	1060645	1062276	1063909
2120	1065544	1067180	1068818	1070458	1072099	1073741	1075385	1077031	1078678	1080327
2121	1081977	1083628	1085282	1086936	1088593	1090251	1091910	1093571	1095233	1096897
2122	1098563	1100230	1101898	1103569	1105240	1106913	1108588	1110264	1111942	1113622
2123	1115302	1116985	1118669	1120354	1122041	1123730	1125420	1127111	1128804	1130499
2124	1132195	1133893	1135592	1137293	1138995	1140699	1142405	1144112	1145820	1147530
2125	1149242	1150955	1152670	1154386	1156105	1157825	1159547	1161271	1162996	1164723
2126	1166452	1168183	1169915	1171650	1173386	1175123	1176863	1178604	1180347	1182092
2127	1183838	1185587	1187337	1189088	1190842	1192597	1194354	1196113	1197874	1199636
2128	1201400	1203166	1204933	1206703	1208474	1210246	1212021	1213797	1215575	1217355
2129	1219137	1220920	1222705	1224492	1226281	1228071	1229863	1231657	1233453	1235250
2130	1237049	1238850	1240653	1242457	1244264	1246072	1247882	1249694	1251507	1253323
2131	1255140	1256959	1258780	1260603	1262427	1264254	1266082	1267912	1269744	1271577
2132	1273413	1275250	1277089	1278930	1280773	1282617	1284464	1286312	1288162	1290014
2133	1291867	1293723	1295580	1297439	1299300	1301163	1303027	1304893	1306762	1308632
2134	1310503	1312377	1314253	1316130	1318009	1319890	1321773	1323657	1325543	1327432
2135	1329322	1331214	1333108	1335003	1336899	1338798	1340698	1342599	1344503	1346408
2136	1348314	1350223	1352133	1354044	1355958	1357873	1359790	1361708	1363628	1365550
2137	1367473	1369399	1371325	1373254	1375184	1377116	1379049	1380985	1382921	1384860
2138	1386800	1388742	1390686	1392631	1394578	1396526	1398477	1400429	1402382	1404338
2139	1406295	1408253	1410214	1412176	1414139	1416105	1418072	1420040	1422011	1423983

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ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2140	1425957	1427932	1129909	1431888	1433868	1435850	1437834	1439820	1441807	1443796
2141	1445786	1447778	1449772	1451768	1453765	1455764	1457764	1459767	1461770	1463776
2142	1465783	1467792	1469803	1471815	1473829	1475845	1477862	1479881	1481902	1483924
2143	1485948	1487974	1490001	1492030	1494061	1496093	1498127	1500163	1502201	1504240
2144	1506280	1508323	1510367	1512413	1514460	1516509	1518560	1520613	1522667	1524723
2145	1526780	1528841	1530902	1532964	1535028	1537093	1539160	1541229	1543299	1545370
2146	1547443	1549518	1551594	1553672	1555751	1557831	1559914	1561997	1564083	1566170
2147	1568258	1570348	1572439	1574532	1576627	1578723	1580820	1582919	1585020	1587122
2148	1589226	1591331	1593438	1595546	1597656	1599767	1601880	1603995	1606111	1608228
2149	1610347	1612468	1614590	1616713	1618839	1620965	1623093	1625223	1627354	1629487
2150	1631622	1633757	1635895	1638033	1640173	1642315	1644458	1646602	1648748	1650895
2151	1653043	1655193	1657345	1659498	1661652	1663808	1665965	1668123	1670283	1672444
2152	1614607	1676771	1678937	1681104	1683272	1685442	1687613	1689786	1691960	1694136
2153	1696313	1698491	1700671	1702852	1705035	1707219	1709404	1711591	1713779	1715969
2154	1718160	1720352	1722546	1724742	1726939	1729137	1731336	1733537	1735740	1737944
2155	1740149	1742356	1744564	1746773	1748984	1751196	1753409	1755624	1757840	1760057
2156	1762276	1764496	1766718	1768941	1771165	1773390	1775617	1777845	1780075	1782306
2157	1784538	1786771	1789006	1791243	1793480	1795719	1797959	1800201	1802444	1804688
2158	1806934	1809181	1811429	1813679	1815930	1818182	1820436	1822691	1824947	1827205
2159	1829464	1831725	1833986	1836250	1838514	1840780	1843047	1845316	1847585	1849857
2160	1852129	1854403	1856678	1858955	1861233	1863512	1865792	1868074	1870358	1872642
2161	1874928	1877216	1879504	1881794	1884086	1886378	1888672	1890968	1893264	1895562
2162	1897862	1900163	1902465	1904768	1907073	1909379	1911687	1913995	1916306	1918617
2163	1920930	1923244	1925560	1927876	1930195	1932514	1934835	1937157	1939481	1941806
2164	1944132	1946460	1948789	1951119	1953451	1955784	1958118	1960454	1962791	1965129
2165	1967469	1969810	1972153	1974497	1976843	1979190	1981539	1983889	1986241	1988594
2166	1990949	1993305	1995663	1998023	2000383	2002746	2005110	2007475	2009842	2012211
2167	2014581	2016952	2019325	2021700	2024076	2026453	2028833	2031213	2033595	2035979
2168	2038364	2040751	2043139	2045529	2047920	2050313	2052707	2055103	2057500	2059899
2169	2062299	2064701	2067105	2069510	2071916	2074324	2076734	2079144	2081557	2083971

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ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
2170	2086387	2088804	2091222	2093643	2096065	2098489	2100914	2103341	2105769	2108199
2171	2110631	2113065	2115500	2117936	2120375	2122815	2125256	2127699	2130144	2132591
2172	2135039	2137488	2139940	2142393	2144847	2147304	2149761	2152221	2154682	2157145
2173	2159609	2162075	2164543	2167012	2169483	2171956	2174430	2176905	2179383	2181862
2174	2184343	2186825	2189309	2191794	2194282	2196770	2199261	2201753	2204247	2206742
2175	2209239	2211738	2214238	2216740	2219243	2221748	2224254	2226762	2229271	2231782
2176	2234295	2236809	2239324	2241842	2244360	2246881	2249402	2251926	2254451	2256977
2177	2259505	2262035	2264566	2267099	2269633	2272169	2274706	2277245	2279785	2282327
2178	2284871	2287416	2289962	2292511	2295060	2297612	2300164	2302719	2305275	2307832
2179	2310391	2312952	2315514	2318078	2320643	2323210	2325778	2328348	2330919	2333492
2180	2336067	2338643	2341221	2343800	2346381	2348964	2351548	2354135	2356722	2359312
2181	2361903	2364496	2367090	2369686	2372284	2374883	2377484	2380087	2382692	2385298
2182	2387905	2390515	2393126	2395739	2398353	2400969	2403587	2406206	2408827	2411450
2183	2414074	2416700	2419328	2421958	2424589	2427221	2429856	2432492	2435129	2437769
2184	2440410	2443053	2445697	2448343	2450991	2453640	2456291	2458944	2461598	2464254
2185	2466912	2469571	2472232	2474894	2477559	2480225	2482892	2485561	2488232	2490904
2186	2493578	2496254	2498931	2501610	2504291	2506973	2509657	2512342	2515029	2517718
2187	2520408	2523100	2525794	2528489	2531186	2533885	2536585	2539287	2541990	2544695
2188	2547402	2550110	2552820	2555532	2558245	2560960	2563676	2566395	2569114	2571836
2189	2574559	2577284	2580010	2582738	2585467	2588199	2590931	2593666	2596402	2599140
2190	2601879	2604621	2607363	2610108	2612853	2615601	2618350	2621101	2623854	2626608
2191	2629364	2632121	2634880	2637641	2640404	2643168	2645933	2648701	2651470	2654241
2192	2657013	2659787	2662563	2665340	2668119	2670899	2673682	2676466	2679251	2682038
2193	2684827	2687618	2690410	2693204	2695999	2698796	2701595	2704396	2707198	2710001
2194	2712807	2715614	2718423	2721233	2724045	2726859	2729674	2732491	2735309	2738130
2195	2740952	2743775	2746600	2749427	2752256	2755086	2757918	2760751	2763586	2766423
2196	2769262	2772102	2774943	2777787	2780632	2783479	2786327	2789177	2792029	2794882
2197	2797737	2800593	2803452	2806312	2809173	2812036	2814901	2817768	2820636	2823506
2198	2826377	2829250	2832125	2835002	2837880	2840759	2843641	2846524	2849408	2852295
2199	2855183	2858072	2860964	2863857	2866751	2869648	2872545	2875445	2878346	2881249



**EXHIBIT D  
RECORD OF PUBLIC MEETING**

**MODIFIED ROOSEVELT DAM  
WATER CONTROL MANUAL  
SALT AND GILA RIVERS**

SEPTEMBER 1997

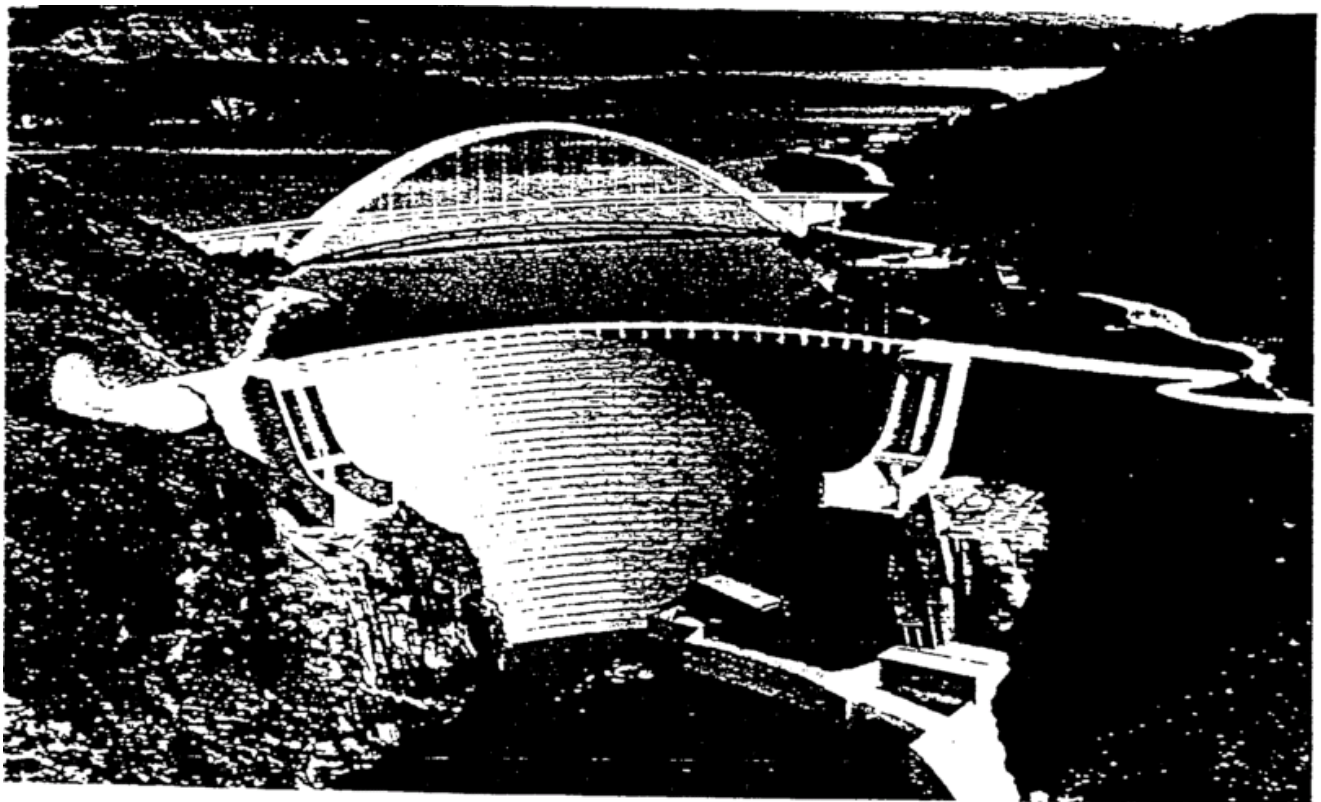
PREPARED BY:  
U.S. ARMY CORPS OF ENGINEERS  
LOS ANGELES DISTRICT  
RESERVOIR REGULATION SECTION

*MEETING SUMMARIES*

*OPEN HOUSE*

*OCTOBER 17 AND 18, 1995*

*Tonto Basin Elementary School  
and  
Flood Control District of Maricopa County*



*MODIFIED ROOSEVELT DAM*

*WATER CONTROL STUDY*

MODIFIED ROOSEVELT DAM WATER CONTROL STUDY  
OPEN HOUSE,  
TONTON BASIN ELEMENTARY SCHOOL  
OCTOBER 17, 1995

AGENCY REPRESENTATIVES

JOE DIXON, STUDY MANAGER, CORPS OF ENGINEERS, PHX OFFICE  
NICK ADELMEYER, HYDRAULIC ENGINEER, CORPS OF ENGINEERS, LAD OFFICE  
BILLY THOMAS, HYDRAULIC ENGINEER, CORPS OF ENGINEERS, LAD OFFICE  
MELVIN MENESES, HYDRAULIC ENGINEER, CORPS OF ENGINEERS, LAD OFFICE  
CHRIS BRECHLER, CIVIL ENGINEER FOR ROOSEVELT DAM, RECLAMATION, PXAO  
BOB MICHAELS, NATURAL RESOURCE SPECIALIST, RECLAMATION, PXAO  
JUNE GIBBONS, PUBLIC INVOLVEMENT PROGRAM MANAGER, RECLAMATION, PXAO

MEETING PARTICIPANTS: See sign-up sheets (Attachment A)

On Tuesday, October 17, 1995, the agency representatives traveled to Punkin Center, Arizona, to conduct the final open house on the Water Control Study. The purpose of the Open House was to provide the public with an opportunity to ask questions about the flood control regulations developed by the Corps of Engineers for Reclamation's Modified Roosevelt Dam. The Water Control Manual is scheduled to be finalized in December 1995 at which point it will then be provided to the dam operator, Salt River Project.

As in the first sessions held when the study was initiated in early 1994, the representatives of the public voiced little-to-no concerns with the manner in which the flood control space at Modified Roosevelt Dam would be regulated. The 35 people who attended the Open House were, however, extremely concerned about the build up of sediment that they predict will occur with the expansion of the new reservoir. It is their perception that the backwater effect -of the reservoir is causing a buildup of sediment which in turn causes Tonto Creek to meander, results in bank erosion, loss of shoreline property, damage to property and a major transportation problem for residents living on the east side of Roosevelt Lake. They believe that Reclamation and the Corps have not taken a serious interest in their flooding problems. Mr. Dixon explained the legislative authorities that are available and advised the group that they should contact their local, county, state, and Federal representatives to determine their willingness to seek legislation that would authorize the Corps to conduct a study to address their flooding concerns. Mr. Dixon explained that to date no requests have been made by any local agencies. Unfortunately, in spite of Mr. Dixon's detailed explanation of the study authorization process, the group felt that the Corps did have authority. They viewed the Corps' regulatory function (I e., 404 Permit process) as a clear demonstration of that authority. Mr. Dixon did his utmost to offer suggestions on ways the local residents could get their local government to address their concerns. Unfortunately, it was the general consensus of the agency representatives that nothing we could say would satisfy their concerns. At best, we were only able to calm the group down to a point where they were no longer enraged, they were simply angry that once again, the Federal government was not to address their flood control needs.

It should be noted that following this Open House, staff from Reclamation conducted an informal meeting amongst Phoenix Area Office staff and the Denver

Office to determine the accuracy of the backwater curves developed for Modified Roosevelt Dam. The analysis performed by Reclamation in 1988 showed that the projected sediment buildup would not have any impact on the area of concern which is upstream of Roosevelt Lake along Tonto Creek. Based on these informal discussions, it was agreed that a more formal meeting should occur with the Denver Office's Hydraulic Engineer in the Sedimentation and River Hydraulics Group to determine if the assumptions made in the 1988 analysis were still valid today and determine the need and costs of performing a reanalysis using 1995 data. This meeting is tentatively scheduled for the first week in November 1995.

Another issue of great concern to the local residents was their belief that there was a lack of public notices of the Open Houses. Everyone who spoke out (and that was virtually all 35 people) said that they did not hear or read anything about the meetings. Some said they heard about it at the local barber shop and just started calling their neighbors to tell them about the meeting. Ms. Gibbons explained that the meeting notices and Press Releases (see Attachments B and C) were mailed to everyone on the study mailing list and the media on Friday, October 6, 1995. and Wednesday October 11th, respectively, which should have given sufficient time for the U.S. Postal Service and the press to make delivery and publish the notices in the Punkin Center area. However, no one claimed to have received the notice or read anything in the papers. Note: Upon return to Phoenix, Ms. Gibbons personally contacted three people whose names appear on the Study mailing list and on the sign up sheet for the October 17th Open House. Each said they received their meeting notice either Thursday or Friday, October 12th or 13th. Ms. Gibbons also contacted Reclamation's Public Affairs Office to confirm distribution of the Press Release to both area newspapers, the Payson Roundup and the Globe Silverbelt. Public Affairs confirmed the Press Release was faxogrammed to both papers on October 11, 1995. We checked the newspapers' schedules for publishing and also confirmed that the Press Releases reached both papers in time for publication prior to the Open Houses. As of this writing, however, we have not been able to confirm whether or not the papers actually published the notices.

Comment forms (Attachment D) were also made available for the participants to complete and either return to the agency representatives at the conclusion of the Open House or mail back to Reclamation's Phoenix Area Office. No Comment Forms were submitted after the Open House, nor, as of this writing, have any Comment Forms been received by the Phoenix Area Office through the Postal Service.

The meeting adjourned at 6:15 pm.

FOLLOWUP NOTATION: Due primarily to the concerns expressed by the Roosevelt area residents at the Open House on October 18, Reclamation is in the process of drafting a Service Agreement with its Technical Service Center (TSC) in Denver. The TSC will evaluate the current reservoir sedimentation condition and the likelihood for future changes in sediment deposition patterns will be undertaken. The recent reservoir survey data and the proposed operating plan for Roosevelt Dam will provide the basis for analysis of backwater effects upstream from the reservoir during floods in the major tributary drainages and will be used to describe historical sedimentation patterns associated with extreme hydrologic events. A final report is scheduled to be available in July 1996.

MODIFIED ROOSEVELT DAM WATER CONTROL STUDY  
OPEN HOUSE  
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY  
OCTOBER 18, 1995

AGENCY REPRESENTATIVES:

JOE DIXON, STUDY MANAGER, CORPS OF ENGINEERS, PHX OFFICE  
NICK ADELMEYER, HYDRAULIC ENGINEER, CORPS OF ENGINEERS, LAD OFFICE  
BILLY THOMAS, HYDRAULIC ENGINEER, CORPS OF ENGINEERS, LAD OFFICE  
MELVIN MENESSA, HYDRAULIC ENGINEER, CORPS OF ENGINEERS, LAD OFFICE  
CHRIS BRECHLER, CIVIL ENGINEER FOR ROOSEVELT DAM, RECLAMATION, PXAO  
LESLIE MEYERS, STUDY MANAGER, RECLAMATION, PXAO  
SANDY ETO, NEPA COMPLIANCE SPECIALIST, RECLAMATION, PXAO  
JUNE GIBBONS, PUBLIC INVOLVEMENT PROGRAM MANAGER, RECLAMATION, PXAO

MEETING PARTICIPANTS: See Attachment E

On Wednesday, October 18th. agency staff conducted the final Open House in the Phoenix metropolitan area. Staff held discussions with 7 people during this session. All seven attendees were representatives of other local agencies, no private citizens attended this session.

No concerns or objections were raised by the attendees with one exception. Mr. Scott Celley of Senator Kyl's office met with Chris Brechler and June Gibbons to discuss the Open House held in Punkin Center. Apparently some of the local residents who attended the meeting the night before had contacted the Senator's office to express their concern with Reclamation and the Corps. They told the Senator's office that: (a) Reclamation did not notify them of the Open House. (b) Reclamation had a hidden agenda, although it was not clear to Mr. Celley what the hidden agenda was, and © they wanted the Federal government to address their flood control needs. Chris Brechler explained to Mr. Celley that Reclamation had already decided to call a meeting to discuss Reclamation's analysis of the backwater effects and the sediment build up along Tonto Creek at it relates to Modified Roosevelt Dam. June Gibbons explained that we would prepare a meeting summary in the form of an Information Paper to report the results of 'he Open Houses back to the public and to tell them that Reclamation has scheduled a meeting to review the previous analysis and determine if further agency action is warranted This seemed to satisfy Mr. Celley.

Comments forms (Attachment F) were also made available for the participants to complete and either return to the agency representatives at the conclusion of the Open House or mail back to Reclamation's Phoenix Area Office. No Comment Forms were submitted after the Open House, nor, as of this writing. have any Comment Forms been received by the Phoenix Area Office through the Postal Service.

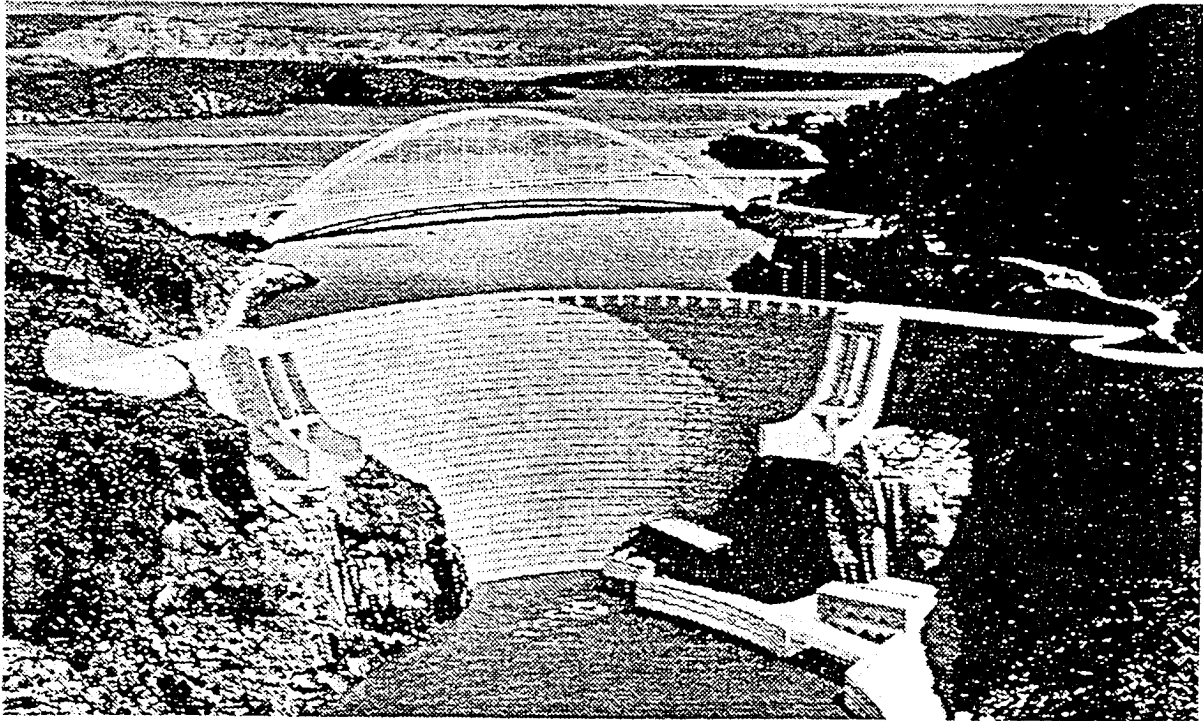
Most attendees left the Open House by 5:30 pm. The meeting adjourned promptly at 6 pm.

*MEETING SUMMARIES*

*OPEN HOUSES*

*JUNE 18 AND 19, 1994*

*Tonto Basin Elementary School  
and  
Flood Control District of Maricopa County*



*MODIFIED ROOSEVELT DAM*

*WATER CONTROL STUDY*

MODIFIED ROOSEVELT DAM WATER CONTROL STUDY  
OPEN HOUSE  
TONTON BASIN ELEMENTARY SCHOOL  
JULY 18, 1994

MEETING PARTICIPANTS:

PAUL LEBRUN, STUDY MANAGER, CORPS OF ENGINEERS, PHX OFFICE  
NICK ADELMEYER, HYDROLOGIST, CORPS OF ENGINEERS, LA DISTRICT OFFICE  
CHRIS BRECHLER, CIVIL ENGINEER FOR ROOSEVELT DAM, RECLAMATION, PAO  
CLIFF SCHLUETTER, STUDY MANAGER, RECLAMATION, PAO  
DAVE NELSON, STUDY ENVIRONMENTAL REPORT WRITER, RECLAMATION, PAO  
PHIL GUERRERO, PUBLIC AFFAIRS OFFICE, RECLAMATION, PAO  
JUNE GIBBONS, PUBLIC INVOLVEMENT PROGRAM MANAGER, RECLAMATION, PAO

On Monday, July 18, 1994, the staff noted above travelled to Punkin Center, Arizona, to conduct an open house on the Water Control Study. The purpose of the Open House was to provide members of the public with an opportunity to examine the various flood control operation concepts and receive an update on the status of the modifications underway at Roosevelt Dam.

Approximately 20 people came to the Open House which was conducted from 4 pm to 7 pm at the Tonto Basin Elementary School cafeteria. They spoke with both Reclamation and Corps staff on an individual basis. They viewed photographs of the modifications underway, the 1993 flooding and associated damages, hydroponic graphs and charts, and a variety of potential concepts for operating the new flood control space at Modified Roosevelt Dam. Some also took the time to watch two videotapes on the history/construction of both the original and modified dam and the 1993 flood. Copies of the handouts are attached. The primary issues expressed to the Federal staff centered around flooding, relocations, and recreation.

Although we suggested that those interested in recreation matters should speak with representatives of the Tonto National Forest, they felt it was important for us to understand their needs and concerns, primarily because they knew that Reclamation was funding the construction of all the recreation facilities associated with Modified Roosevelt Dam. The major recreational concern centered around the fact that at some point in the very near future, those who enjoy shoreline recreation (camping, boating, fishing, etc) will no longer have access to the places they have used since the dam was constructed (Horse Pasture, Orange Peel, etc.) They felt that since these sites will potentially be underwater after completion of the dam modifications, someone (either Reclamation or Forest Service) should mitigate their loss of access by constructing a new area for shoreline recreating.

We explained that we examined the possibility of creating another Horse Pasture or similar site. Our studies showed that such an action would have detrimental environmental impacts on the riparian habitat. They felt that to be "hogwash,"

noting that there's plenty of riparian habitat on the north side of the reservoir that could be protected. They also felt that clearing an area for shoreline recreating would not have a negative impact on the wildlife.

They suggested that wildlife are smarter than we give them credit for. They believe that if we create a new site, the wildlife will find another place, including the north shoreline.

A second issue was discussed amongst members of the staff and several individuals from the Tanto Basin area. They believe that when Roosevelt Dam was constructed 75 years ago, it started an aggradation of the land area along Tanto Creek. They explained that when the dam was built and the reservoir was created, it slowed down the once free flowing Tanto Creek, thereby causing the silt to settle in the Tanto Basin. They believe there has been at least a 22 foot rise in the land surface area and are concerned that the raising of Roosevelt Dam would slow the flows even more and increase the build up of sediment. Additionally, they believe that the 4 homes lost during the 1993 floods were a direct result of the sediment deposits. They also noted that this impact was not and should have been addressed in the Plan 6 EIS and in subsequent EA's. One person completed a Response Form on which he addressed this issue.

The third issue raised by the public related to property owned by a Mr. Lawrence Center and some properties located in the vicinity of Meddler Point (Rock House Farms/Store) (Wheeler and Mercer properties).

Mr. Center owns property at Roosevelt Lake Estates. He is quite dismayed that Reclamation chose not to purchase his property. There were some discrepancies noted by the staff as he discussed his concerns with us. He said that we established the elevation for relocations at 2175. When he spoke with some, he said that although his home is at elevation 2181, his septic system is at a lower elevation and could be subjected to flooding. However he told other staff members that his home is at elevation 2201 and his septic system is at elevation 2181.

Mr. Center is primarily concerned because the top of the dam is at elevation 2218 and there is a slight risk that at some time in the future his home and septic system could be damaged from floodwaters. He also mentioned a neighbor who was in a similar setting. He believes that we relocated the neighbor because he is an SRP employee and that by not relocating him as well, we unfairly discriminated against him. He would really like to see Reclamation buy his property and relocate him.

(Note: I spoke with Stan Seigal, Realty Division Chief on this issue. Stan is aware of Mr. Center's concerns but believes that Mr. Center knows that his property is located several lots away from our relocation boundary and that no further consideration will be given to relocating him. Stan believes that Mr. Center will probably continue to express his concerns with the ever-so-slight hope that we may reconsider our decision. No further action will be taken by our Realty Division on this matter.)

When I first spoke with Mr. Mercer, he told me he thought that our new reservoir elevation map was incorrect because his property (fields) and his neighbor's property (Wheeler) are at elevation 2181, not the 2175 maximum water surface elevation. Our map showed his property being wet at 2175. We then talked more about the situation and we learned that most of the flooding that occurs to his property is a direct result of Salt River runoff as opposed to water from the Roosevelt reservoir. Interestingly enough, Mr. Mercer is not concerned about his fields being flooded. He said that when he gets flooded nothing really gets damaged. As a matter of fact, it simply means that he has one less irrigation to do.

What is bothering him is the fact that representatives from the Phoenix Area Office' Realty Division are no longer talking with him. Apparently the last time he spoke with anyone from Reclamation was last December. At that December meeting, Mr. Gary Patchet told Mr. Mercer that we had three options: 1) buy him out; 2) purchase an easement of the lands that get flooded; or 3) do nothing. Mr. Mercer felt that in the first option, the buyout, we offered him a mere \$1,500 per acre. He felt this was insulting and that others were getting much more from Reclamation buyouts. I agreed/promised Mr. Mercer that I would speak with the Realty Division Chief and have him contact Mr. Mercer as soon as possible. I also told Mr. Mercer that I would follow up on this action. I will contact Mr. Mercer on or about July 29th. If he has not heard from our Realty Division by that time, I will once again contact the Realty Division Chief and request Mr. Mercer be contacted immediately.

(Note: I mentioned Mr. Mercer's concerns to Bruce Ellis, Chief, Environmental Division. Bruce was of the opinion that we were planning to purchase Mr. Mercer's property and use it, to construct a fish farm as part of our Mitigation Program.)

(Note: On July 19th, I met with Stan Seigal, Realty Division Chief. He explained that he is having some difficulties working with the Denver Office and reaching agreement on the appraised value of both properties. He explained that a decision had been made to purchase the land and assured me that he would contact both Mr. Mercer and Mr. Wheeler to inform them of the status of the realty activities.)

(Note: On June 22, 1994, the PAO received a copy of a letter Mr. Wheeler sent to Arizona State Senator Bill Hart requesting the Senator's assistance in settling this issue with Reclamation.)

Overall, the Open House was a success. Many people were genuinely interested in the construction activities and some were extremely impressed by the equipment and technology being used. Although some would have liked to see representatives of the Forest Service present and one person would have preferred a more formal presentation, they enjoyed meeting the new faces from Reclamation and the Corps and were satisfied with the information we presented.

It should be noted that serious consideration was given to determining the appropriate format for meeting with the public. Because no alternative flood operations' have been developed as yet and because the basic conditions under which the flood control space will be operated have been documented in previous

documents (Plan 6 EIS and subsequent EA's), the decision was made to conduct an informal Open House session where people could speak directly with those involved in the Study and the Construction Program. In the Spring/ Summer of 1996, following completion of the draft Water Control Manual, a more formal Public Workshop will be held.

The Open House adjourned promptly at 7 pm.

See List of Attachments on page 6.

MODIFIED ROOSEVELT DAM WATER CONTROL STUDY  
OPEN HOUSE  
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY  
JULY 19, 1994

MEETING PARTICIPANTS:

PAUL LEBRUN, STUDY MANAGER, CORPS OF ENGINEERS, PHX OFFICE  
JOE DIXON, PLANNING CHIEF, CORPS OF ENGINEERS, PHX OFFICE  
NICK ADELMEYER, HYDROLOGIST, CORPS OF ENGINEERS, LA DISTRICT OFFICE  
CHRIS BRECHLER, CIVIL ENGINEER FOR ROOSEVELT DAM, RECLAMATION, PAO  
CLIFF SCHLUETTER, STUDY MANAGER, RECLAMATION, PAO  
DAVE NELSON, STUDY ENVIRONMENTAL REPORT WRITER, RECLAMATION, PAO  
BRUCE ELLIS, CHIEF, ENVIRONMENTAL DIVISION, RECLAMATION, PAO  
PHIL GUERRERO, PUBLIC AFFAIRS OFFICE, RECLAMATION, PAO  
JUNE GIBBONS, PUBLIC INVOLVEMENT PROGRAM MANAGER, RECLAMATION, PAO

This Open House was set up identical to the session conducted on July 18th. Unfortunately, the turnout was extremely low. A total of 12 people entered their names on the sign-up sheet, five were employees of the Flood Control District, one name of a husband and wife from Mesa, and the remainder were local agency representatives. Although there were some discussions amongst the staff and the agency representatives, no issues or concerns were expressed. The couple from Mesa came to find out if the property they own in the Roosevelt Lake area was going to get flooded out. They had not visited their property for over 6 years and were not quite sure of its location. After reviewing a map they brought with them, we determined that their property is located in the upper Tanto Basin in the vicinity of Punkin Center. Once they learned that their property would not be inundated, they expressed their satisfaction and left.

Because no one else showed up between the hours of 5:45 and 6:30, it was agreed that we could begin packing up the exhibits. No one else came and we left the facility at 7 pm.

(Note: The staff members tried to determine why there was such a low turnout at the Phoenix Open House. Some felt that it was probably because there was really no new information being presented and we are simply meeting the commitments previously identified in the Plan 6 EIS and subsequent EA's. Some felt that it may have been due to the manner in which the Arizona Republic misrepresented the purpose of the meeting. However, a notice of the Open House was sent to all on the Study mailing list and all on the mailing list have received a copy of an Information Paper which clearly described the purpose and objectives of the study.)

## List of Attachments

Sign-Up Sheet, July 18, 1994

Response Form from Mr. Ray Anderson

Copy of Letter from Mr. Wheeler To Senator Hart

Sign-Up Sheet, July 19, 1994

Handout on Project Description, Background, Potential Environmental Issues  
and Concerns, and Schedule

March 1994 Information Paper on Modified Roosevelt Dam Water Control Study

July 1994 Open House Public Notice

July 11, 1994 Reclamation's Press Release Announcing Open Houses

Article from July 17, 1994 Edition of Arizona Republic

**EXHIBIT E**  
**CHAIN OF CORRESPONDENCE FOR APPROVAL**  
**OF THE MODIFIED ROOSEVELT DAM**  
**WATER CONTROL MANUAL**

**MODIFIED ROOSEVELT DAM**  
**WATER CONTROL MANUAL**  
**SALT AND GILA RIVERS**

SEPTEMBER 1997

PREPARED BY:  
U.S. ARMY CORPS OF ENGINEERS  
LOS ANGELES DISTRICT  
RESERVOIR REGULATION SECTION

CESPD-ET-EW (CESPL-ED-HR/22 Aug 96) 1st End  
Bigornia/lm/415-977-8102  
SUBJECT: Modified Roosevelt Dam - Water Control Agreement and  
Letter of Understanding

DA, South Pacific Division, Corps of Engineers, 333 Market  
Street, Room 923, San Francisco, CA 94105-2195

21 NOV 1996

FOR Commander, Los Angeles District, ATTN: CESPL-ED

1. The Water Control Manual for Modified Roosevelt Dam (Theodore Roosevelt Dam), Salt and Gila Rivers, Arizona, September 1996, is herein approved. Enclosed are the subject documents signed by the Division Commander. Copies are to be incorporated into the final water control manual. As per 33 CFR Ch. II, Sec. 222.5, App. C, Paragraph 1.f., an original set should be transmitted to the project owner for filing. Another set should be returned to this office (ATTN: CESPD-ET-EW) for transmittal to CECW-EH for promulgation and filing.

2. The District is requested to submit five copies of the final water control manual to this office after completion.

FOR THE COMMANDER:

3 Encls  
1. WCA  
2. LOU  
3. PONS1

  
JACK E. FARLESS  
Chief, Engineering Division



**DEPARTMENT OF THE ARMY**  
LOS ANGELES DISTRICT, CORPS OF ENGINEERS  
P.O. BOX 2711  
LOS ANGELES, CALIFORNIA 90053-2325

REPLY TO  
ATTENTION OF  
CESPL-ED-HR

22 August 1996

MEMORANDUM FOR Commander, South Pacific Division, Attn: CESPED-ED-W

SUBJECT: Modified Roosevelt Dam - Water Control Agreement and Letter of Understanding

1. The purpose of this memorandum is to furnish original copies of the Water Control Agreement (WCA) and the Letter of Understanding (LOU) for Modified Roosevelt Dam for the Commander's signature, in order to complete these agreements. Enclosure 1 contains three originals of the WCA for the regulation of Modified Roosevelt Dam for flood control, and two originals of the LOU which defines the general provisions under which the Bureau of Reclamation (USBR) is to operate project, as outlined in Section 7 of the Flood Control Act of 1944. The WCA requires the signatures of the USBR, the Corps of Engineers (COE), and the Salt River Project (SRP). The SRP and the USBR have accepted and signed the WCA. The LOU has been signed by USBR's Regional Director. In order to complete the necessary paperwork, we request that you sign both agreements and return them to this office, attention: CESPL-ED-HR.
2. A final Environmental Assessment has also been prepared and a joint Finding of No Significant Impact (FONSI) has been signed by both USBR and COE for the flood control space at Modified Roosevelt Dam. Copies of these two documents are enclosed and marked enclosures 2 and 3, respectively.
3. If you have any questions, please contact Melvin Meneses of our Reservoir Regulation Section at (213) 452-3530.

MICHAL R. ROBINSON  
COL, EN  
Commanding

- 3 Encls
1. WCA & LOU
  2. FONSI
  3. EA