

WATER CONTROL MANUAL

ALAMO DAM AND LAKE BILL WILLIAMS RIVER BASIN, ARIZONA

TABLE OF CONTENTS

PERTINENT DATA	inside front cover
TITLE PAGE	i
AERIAL PHOTOGRAPH OF ALAMO DAM AND LAKE	ii
NOTICE TO USERS OF THIS MANUAL	iii
EMERGENCY REGULATION ASSISTANCE PROCEDURES	iii
FIGURES	ix
PHOTOS	x
TABLES	xi
PLATES	xii
LIST OF EXHIBITS	xiv
ABBREVIATIONS USED	xv
CONVERSION FACTORS FROM ENGLISH TO METRIC	xvi

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
I - INTRODUCTION		
1-01.	Authorization	I-1
1-02.	Purpose and Scope	I-1
1-03.	Related Manuals and Reports	I-2
1-04.	Project Owner	I-2
1-05.	Operating Agency	I-2
1-06.	Regulating Agencies	I-2

II - DESCRIPTION OF PROJECT

2-01.	Location	II-1
2-02.	Purpose	II-1
	a. Flood Control	II-1
	b. Hydropower Generation	II-1
	c. Water Conservation and Supply	II-1
	d. Recreation	II-2
	e. Fish and Wildlife Benefits	II-2
	f. Water Quality	II-2
2-03.	Physical Components	II-2
	a. Dam	II-2

b.	Spillway.....	II-3
c.	Outlet Works.....	II-3
d.	Reservoir	II-4
2-04.	Related Control Facilities	II-5
2-05.	Real Estate Acquisition	II-5
2-06.	Public Facilities	II-5

III - HISTORY OF PROJECT

3-01.	Authorization.....	III-1
3-02.	Planning and Design.....	III-1
3-03.	Construction	III-2
3-04.	Related Projects	III-2
	a. Glen Canyon Dam	III-3
	b. Hoover Dam	III-3
	c. Davis Dam	III-4
	d. Parker Dam.....	III-5
3-05.	Modifications to Regulations	III-5
	a. Change in Recreation Pool Elevation.....	III-6
	b. Above-Normal Runoff.....	III-6
	c. Modification to Recreational Facilities	III-7
	d. Southern Bald Eagles	III-7
3-06.	Principal Regulation Problems	III-8
	a. Erosion.....	III-8
	b. Cavitation	III-8
	c. Downstream River Crossings	III-8
	d. Hydrogen-Sulfide	III-8

IV - WATERSHED CHARACTERISTICS

4-01.	General Characteristics.....	IV-1
4-02.	Topography.....	IV-2
4-03.	Geology and Soils.....	IV-2
4-04.	Sediment	IV-5
4-05.	Climate.....	IV-5
	a. Temperature.....	IV-6
	b. Precipitation.....	IV-6
	(1) General Winter Storms	IV-7
	(2) General Summer Storms.....	IV-7
	(3) Local Thunderstorms	IV-7
	c. Snow	IV-8
	d. Evaporation	IV-8
	e. Wind	IV-9
4-06.	Storms and Floods	IV-9
	a. Early Storms and Floods.....	IV-11

b.	Storm and Flood of 6-9 February 1937	IV-12
c.	Storm and Flood of 26 February - 5 March 1938	IV-12
d.	Storm and Flood of 3-8 September 1939	IV-12
e.	Storm and Flood of 27-30 August 1951	IV-13
f.	Storm and Flood of 28 February – 3 March 1978	IV-13
g.	Storm and Flood of 17-19 December 1978	IV-14
h.	Storm and Flood of 28-30 January 1980	IV-14
i.	Storm and Flood of 13-22 February 1980	IV-14
j.	Storm and Flood of 27 February – 4 March 1983	IV-15
k.	Storm and Flood of 8 January – 28 February 1993	IV-15
4-07.	Runoff Characteristics	IV-16
4-08.	Water Quality	IV-17
4-09.	Channel and Floodway Characteristics	IV-18
4-10.	Upstream Structures	IV-20
4-11.	Related Structures.....	IV-20
4-12.	Economic Data	IV-20
	a. Population.....	IV-20
	b. Industry.....	IV-21
	c. Flood Benefits.....	IV-22

V - DATA COLLECTION AND COMMUNICATIONS NETWORK

5-01.	Hydrometeorological Stations	V-1
a.	Facilities.....	V-1
b.	Reporting	V-4
	(1) Manual	V-4
	(2) The Geostationary Operational Environmental Satellite (GOES) Telemetry System.....	V-4
	(3) Automated Local Evaluation in Real-Time (ALERT) System.....	V-5
	(4) Weather Data	V-5
c.	Maintenance.....	V-6
d.	Cooperative Stream Gage Program	V-6
5-02.	Water Quality Reporting	V-6
a.	Facilities.....	V-6
b.	Reporting	V-7
c.	Maintenance.....	V-8
5-03.	Sediment Stations	V-8
a.	Facilities.....	V-8
b.	Reporting	V-8
c.	Maintenance.....	V-8

5-04. Recording Hydrologic Data.....	V-9
5-05. Communication Network	V-10
a. Commercial Telephones	V-10
b. FM Radio Transceiver.....	V-10
5-06. Communication with Project.....	V-10
a. Between ROC and Alamo Dam.....	V-10
b. Between Alamo Dam and Others.....	V-11
c. Between ROC and Others	V-11
5-07. Project Reporting Instructions.....	V-12
5-08. Warnings.....	V-13

VI - HYDROLOGIC FORECASTS

6-01. General	VI-1
a. Role of the Corps of Engineers	VI-1
b. Role of Other Agencies.....	VI-1
6-02. Flood Condition Forecasts.....	VI-2
6-03. Conservation Purpose Forecasts.....	VI-2
6-04. Long Range Forecasts	VI-2
6-05. Drought Forecasts	VI-3

VII - WATER CONTROL PLAN

7-01. General Objectives	VII-1
7-02. Operational Constraints	VII-1
a. Lower Colorado River	VII-1
b. Channel Capacity	VII-2
c. Streambed Crossings	VII-2
d. Hydrogen-Sulfide in Outlet Works Gate Chamber	VII-2
7-03. Overall Plan for Water Control	VII-2
a. Bill Williams River Corridor	
Technical Committee	VII-3
b. Alamo Lake Feasibility Study	VII-4
c. Adopted Operation Plan	VII-4
7-04. Standing Instructions	VII-5
7-05. Flood Control.....	VII-5
7-06. Recreation.....	VII-6
7-07. Water Quality	VII-7
7-08. Fish and Wildlife	VII-7
a. Riparian Releases	VII-7
b. Fisheries.....	VII-8
c. Wildlife	VII-8
7-09. Water Conservation	VII-9
7-10. Hydroelectric Power	VII-9

7-11. Navigation Operation	VII-9
7-12. Drought Contingency Plans.....	VII-9
7-13. Flood Emergency Action Plan.....	VII-10
7-14. Water Rights	VII-10
7-15. Inspection and Maintenance	VII-10
a. Monthly Gate Exercise	VII-10
b. Outlet Tunnel Inspection and Maintenance Operation.....	VII-11
(1) Lower Portion of Outlet Tunnel	VII-11
(2) Upper Portion of Outlet Tunnel	VII-11
7-16. Deviation from Normal Regulation.....	VII-12
7-17. Rate of Release Change.....	VII-23

VIII - EFFECTS OF WATER CONTROL PLAN

8-01. General	VIII-1
8-02. Flood Control.....	VIII-1
a. Spillway Design Flood	VIII-1
b. Standard Project Flood – Original.....	VIII-1
c. Standard project Flood – Revised.....	VIII-2
d. Probable Maximum Flood.....	VIII-2
e. Threshold Flood.....	VIII-3
f. Other Floods.....	VIII-4
8-03. Recreation.....	VIII-4
8-04. Water Quality	VIII-4
8-05. Fish and Wildlife	VIII-5
8-06. Water Supply	VIII-5
8-07. Hydroelectric Power	VIII-6
8-08. Navigation	VIII-6
8-09. Drought Contingency Plan	VIII-6
8-10. Flood Emergency Action Plan.....	VIII-7
8-11. Frequencies.....	VIII-7
a. Inflow Frequency.....	VIII-8
b. Elevation Frequency	VIII-8
c. Outflow Frequency	VIII-8
d. Elevation-Duration-Frequency	VIII-8
8-12. Other Studies	VIII-8

IX - WATER CONTROL MANAGEMENT

9-01.	Responsibilities and Organization	IX-1
a.	Corps of Engineers	IX-1
b.	Other Federal Agencies	IX-1
c.	State and County Agencies.....	IX-2
d.	Private Organizations	IX-2
9-02.	Interagency Coordination	IX-2
a.	Local Press and Corps of Engineers Bulletins	IX-2
b.	National Weather Service.....	IX-2
c.	U.S. Geological Survey (USGS)	IX-3
d.	U.S. International Boundary and Water Commission (IBWC).....	IX-3
e.	U.S. Bureau of Reclamation	IX-3
f.	U.S. Fish and Wildlife Service (USFWS).....	IX-3
g.	U.S. Bureau of Land Management (BLM).....	IX-4
h.	Arizona State parks Board.....	IX-4
i.	Arizona Game and Fish Department	IX-4
9-03.	Interagency Agreements	IX-4
9-04.	Commissions, River Authorities, Compacts, and Committees.....	IX-4
9-05.	Non-Federal Hydropower.....	IX-4
9-06.	Reports.....	IX-5

TABLE OF CONTENTS (Continued)

FIGURES

<u>Figure No.</u>	<u>Title</u>
9-01.	Flood Control Basin Operation Report
9-02.	Rainfall Record
9-03.	Reservoir Operation Report
9-04.	Record of Data from Digital Recorders
9-05.	Reservoir Computations
9-06.	Record of Calls

PHOTOS

<u>Photo No.</u>	<u>Title</u>	<u>Page</u>
2-01	Downstream face of Alamo.....	II-6
2-02	Upstream face of Alamo Dam.....	II-6
2-03	Upstream end of Spillway	II-7
2-04	Spillway channel looking upstream, showing concrete spillway crest block.....	II-7
2-05	Gully (arrow) through which spillway flows discharge before rejoining Bill Williams River channel.....	II-8
2-06	Bill Williams River channel immediately downstream from Alamo Dam	II-8
2-07	Aerial View of Alamo Lake	II-9
3-01	Partially inundated tree in upper reaches of Alamo Lake	III-10
3-02	High-pressure gasline across Bill Williams River 13.5 miles below Alamo Dam	III-10
3-03	Bill Williams River National Wildlife Refuge, showing stands of cottonwood trees.....	III-11
4-01	Big Sandy River basin.....	IV-25
4-02	Santa Maria River basin	IV-25
4-03	Segment of Bill Williams River between Lincoln Ranch and Planet Ranch.....	IV-26
5-01	Evaporation Pan at Alamo Lake.....	V-14
5-02	Alamo Dam Control House	V-14

TABLE OF CONTENTS (Continued)

TABLES

<u>Table No.</u>	<u>Title</u>	<u>Page</u>
1-01	Related Manuals and Reports.....	I-4
2-01	Alamo Lake Capacity Table.....	T2-1
2-02	Alamo Lake Area Table	T2-7
4-01	Climatological Summary.....	T4-1
4-02	Evaporation at Alamo Dam, Arizona	IV-8
4-03	Recorded Annual Peak Discharges at Alamo Dam Site.....	IV-10
4-03a.	Alamo Dam and Lake – Cumulative Annual Damages Prevented	IV-11
4-04	Peak Discharges from 3-8 September 1939 Storm	IV-13
4-04a	Annual Average Inflow to Alamo Lake	IV-16
4-05	Spillway Flow Travel Times Downstream of Alamo Dam.....	IV-19
4-06	Dams on Lower Colorado River Below Parker.....	IV-20
4-07a	Population Data for Alamo Dam Watershed and Downstream.....	IV-21
4-07b	Agricultural Data for Alamo Dam (1997).....	IV-22
4-07c	Unemployment Rate and Number People Employed by Sector	IV-22
4-08	Discharge-Damage Data Below Alamo Dam.....	IV-23
5-01	Bill Williams Basin Precipitation, Streamflow, and Evaporation Stations.....	V-2
5-02	Bill Williams Basin Precipitation, Streamflow and Evaporation Stations.....	V-3
5-03	Alamo Lake Water Quality Monitoring Schedule	V-7
7-01	Recommended Spring Flush Characteristics.....	VII-12
9-01	Reports Prepared Annually by Corps of Engineers Los Angeles District.....	IX-6
9-02	Chain of Command for Reservoir Operations Decisions	IX-7

TABLE OF CONTENTS (Continued)

PLATES*

<u>Plate No.</u>	<u>Title</u>
2-01	Colorado River Basin - Location Map
2-01a	Project Location
2-02	General Plan of Embankment
2-03	Embankment and Spillway Profiles and Sections
2-04	Spillway Discharge Curves
2-05	Outlet Works - Plan and Profile
2-06	Outlet Works Transition Gate Chamber and Tunnel Sections
2-07	Outlet Works - General Arrangement - Gates and Control Structure
2-08	Outlet Discharge Curves
2-09	General Plan of Reservoir
2-10	Alamo Reservoir Area-Capacity Curves
2-11	Real Estate - Alamo Reservoir
2-12	Alamo Dam and Lake Recreational Facilities
3-01	Lower Colorado River – Channel Schematic
4-01	Streambed Profiles
4-01a	Topography
4-02	Alamo Lake A-Index Ranges
4-03	Alamo Lake C-Index Ranges
4-04	Isohyets of 90-Year Mean Seasonal Precipitation – 1868 -1957
4-05	Alamo Dam and Lake Flood Routing 28 February - 3 March 1978
4-06	Alamo Dam and Lake Flood Routing 17-19 December 1978
4-07	Alamo Dam and Lake Flood Routing 28-30 January 1980 and 13-22 February 1980
4-08	Alamo Dam and Lake Flood Routing 27 February - 4 March 1983
4-09	Alamo Dam and Lake Flood Routing 8 January – 28 February 1993
4-10	Bill Williams River Channel Schematic
4-11	Damage vs. Discharge Curve
4-12	Lower Colorado River – Areas Subject to Overflow Prior to Construction of Alamo Dam
5-01	Hydrometeorologic Stations
6-01	National Weather Service Flood Forecast Methodology

* All plates are current with respect the date of this Water Control Manual.

TABLE OF CONTENTS (Continued)

<u>Plate No.</u>	<u>Title</u>
6-02	National Weather Service Extended Streamflow Prediction Methodology
7-01	Alamo Lake Storage Allocation Diagram
7-02	Alamo Dam and Lake Reservoir Operation Schedule
8-01	Spillway Design Flood Routing
8-02	Revised Standard Project Flood Routing
8-02a	Revised December Probable Maximum Flood Routing
8-03	Threshold Flood Routing (Current Water Control Plan)
8-04	Alamo Dam and Lake 28 February – 3 March 1978 Flood Routing (Current Water Control Plan)
8-05	Alamo Dam and Lake 17 – 19 December 1978 Flood Routing (Current Water Control Plan)
8-06	Alamo Dam and Lake 29 – 30 January and 13 – 22 February 1980 Flood Routing (Current Water Control Plan)
8-07	Alamo Dam and Lake 27 February – 4 March 1983 Flood Routing (Current Water Control Plan)
8-08	Alamo Dam and Lake 8 January – 28 February 1993 Flood Routing (Current Water Control Plan)
8-09	Risk Assessment Inflow Volume Frequency Curves
8-09a	50-year Balanced Hydrograph
8-09b	Peak Annual Inflow Frequency
8-10	Reservoir Stage Frequency and Outflow Frequency Relations for Current Water Control Plan
8-11	Elevation – Duration Frequency Curve

LIST OF EXHIBITS

<u>Exhibit No.</u>	<u>Subject</u>
A	Standing Instructions to Project Operator for Water Control
B	Pertinent Data for Other Dams Affecting Alamo Dam and Lake Operation
C	Record of Decision -- Alamo Lake B- La Paz and Mohave Counties, Arizona
D	Biological Assessment B – Alamo Lake B - Alamo Lake Re-operation Project B – La Paz and Mohave Counties, Arizona -- August 1998
E	Guidance on preparation of Deviations from Approved Water Control Plans (CESPD R 1110-2-8)
F	District Certification for Approval of the Water Control Manual

TABLE OF CONTENTS (Continued)

ABBREVIATIONS USED IN WATER CONTROL MANUAL

ac-ft	acre-feet
AGF	Arizona Department of Game and Fish
ASP	Arizona State Parks Department
BLM	U.S. Bureau of Land Management
BWRCTC	Bill Williams River Corridor Technical Committee
cm	centimeter
cfs	cubic feet per second
cms	cubic meter per second
DCP	Data Collection Platform
ESP	Extended Streamflow Prediction
FCBOR	Flood Control Basin Operation Report
GOES	Geostationary Observational Environmental Platform
ha	Hectare
ha-m	Hectare meter
m	meter
NGVD	National Geodetic Vertical Datum (English Units)
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
NWSRFS	National Weather Service River Forecast Center
PMF	Probable Maximum Flood
RESCAL	Reservoir Calculation program
ROC	Reservoir Operations Center
SPF	Standard Project Flood
SPL	Los Angeles District, U.S. Army Corps of Engineers
SSMA	Sacramento Soil Moisture Accounting
STORET	Storage and Retrieval Program
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCM	Water Control Manual

TABLE OF CONTENTS (Continued)

CONVERSION FACTORS FROM ENGLISH TO METRIC UNITS

1 inch.....	2.54 centimeters
1 foot	0.3049 meter
1 mile	1.609 kilometers
1 cubic foot	0.0283 cubic meter
1 acre.....	0.4047 hectare
1 acre-foot.....	0.1233482 hectare meter
1 square mile (640 acres).....	2.59 square kilometers
1 cubic foot/second	0.028317 cubic meter/second