III - HISTORY OF PROJECT

3-01. <u>Authorization</u>

Alamo Dam was constructed under authorization of the Flood Control Act of 22 December 1944 (Public Law 534, 78th Congress, 2nd Session). The project was recommended for approval by the Chief of Engineers in his report dated 11 April 1944, published as a part of the project document (House Document No. 625, 78th Congress, 2nd Session). The project was authorized for flood control, water conservation, and recreational purposes.

Subsequent legislation under Section 301(b)(1) of the Water Resources Development Act of 1996 (Public Law 104-303) authorized Alamo Dam to be operated for fish and wildlife benefits upstream and downstream from the dam.

3-02. <u>Planning and Design</u>

The initial planning for Alamo Dam is documented in a 15 January 1941 report by the District Engineer, Los Angeles District. The report recommended a flood control dam be constructed at the Alamo site. The report also recommended that features be included in the dam and reservoir to meet future water conservation and power developments, as well as changes in flood control requirements.

After formal authorization, various hydrologic, topographic, and geologic studies were conducted from 1946 through 1963. Although the primary purpose of Alamo Dam and Lake was for flood control, the Corps entered into an agreement with the U.S. Bureau of Reclamation (USBR) for the latter to assess the water conservation and hydropower potential of the project. In a November 1961 report, the USBR concluded that there was water conservation potential, but no feasible hydropower potential. Hydropower generation was determined to have potential for the National Economic Development (NED) plan under some operating scenarios. However, a final analysis in the 1964 GDM indicated that hydropower generation would be operational too infrequently and thus would not be economically justified. As a result, although authorized, hydropower generation has never been implemented.

The original design concept was a concrete arch dam with an overflow spillway located in the center of the structure. However, following a re-study in the early 1960's, the final design was changed to an earthfill dam with a detached spillway in the right abutment, as presented in the April 1964 General Design Memorandum No. 3.

3-03. Construction

Preliminary construction at Alamo Dam began in July 1963. Access road construction began in October 1963 and was completed in October 1964. The dam and appurtenant works were started in March 1965 and completed in July 1968. Operations commenced 15 July 1968 and Alamo Lake reached the top of the original recreation pool elevation of 1046 feet (318.8 m) on 2 March 1970.

3-04. Related Projects

The regulation of Alamo Dam is closely coordinated with the regulation of dams on the lower Colorado River. The lower Colorado River Dams include those owned and operated by the USBR, as well as dams operated by other agencies. The USBR office in Boulder City, Nevada, is responsible for regulation of the lower Colorado River system by means of its lower Colorado River dams and through coordination with facilities, such as Alamo Dam, on tributaries to the Colorado River. Plate 3-01 is a schematic of the lower Colorado River system, showing the location of all dams, USGS operated stream gages, and listing the channel and levee capacity of the Colorado River main stem.
The USBR dams that Alamo Dam operations are coordinated with are described in the following paragraphs.

a. Glen Canyon Dam. Glen Canyon Dam is on the Colorado River in north-central Arizona, about 15 miles (24.1 Km) upstream of Lee Ferry and 12 river miles (19.3 m) downstream of the Arizona-Utah state line. The dam, completed in 1964, has a structural height of 710 feet (216.4 m), a crest length of 1,560 feet (475.5 m), and contains 4,901,000 cubic yards (3,747,083 cubic meters) of concrete. Lake Powell, the reservoir impounded by the dam, has a total storage capacity of 27,000,000 acre-feet (3,330,401 ha-m), extends 186 miles (299.3 Km) up the Colorado River, has 1900 miles (3,057.8 Km) of shoreline, and is the 2nd largest reservoir in the country. The reservoir provides the long-term regulatory storage needed to permit the states of the Upper Colorado River Basin to use their apportioned water and still meet their flow obligations at Lee Ferry, Arizona, under the terms of the 1922 Compact of the Colorado River. The powerplant provides the principal portion of the electrical energy generated by the Colorado River Storage Project. Surplus revenue from the sale of this energy helps the Upper Basin States to repay the costs of the project as authorized by Congress in 1956. The powerplant has eight generating units providing a total generating capacity of 1,042,000 kilowatts. Water is conveyed from the reservoir to the turbines through eight 15-foot diameter penstocks embedded within the dam. Four river outlet conduits are located near the left abutment of the dam to release water for downstream commitments when the powerplant is not in operation and to assist in making releases during floods. The conduits, each having a diameter of 96 inches (243.8 cm), have a total capacity of 15,000 cfs (424.8 cms) with releases controlled by 96-inch (243.8 cm) diameter hollow jet valves. One spillway is provided on each abutment of the dam to make releases during large floods. Discharges from each spillway are controlled by two 40- by 52.5-foot (12.2m x 16m) radial gates in each intake structure providing a total spillway discharge capacity of 276,000 cfs (7,815.5 cms).

b. Hoover Dam. Hoover Dam is on the Colorado River between Arizona and Nevada, about 7 miles (11.3 Km) northeast of Boulder City, Nevada. The dam, completed in 1936, has a structural height of 726 feet (221.3 m), a crest length of 1,232 feet (375.5 m), and contains 4,400,000 cubic yards (3,364,041 cubic meters) of concrete. Lake Mead, the reservoir impounded by the dam, has a total storage capacity of

28,537,000 acre-feet (3,519,987 ha-m), extends 115 miles (185 Km) up the Colorado River, and has 550 miles (885 Km) of shoreline. The dam and reservoir provide flood control, water supply for irrigation and municipal use, power generation, and recreation. The powerplant is one of the major electrical generating facilities in the southwestern United States. The powerplant has 19 generating units providing a total generating capacity of 1,434,000 kilowatts. Water is conveyed from the reservoir to the turbines through 13-foot (3.9 m) diameter penstocks connecting to 30-foot (9.1 m) diameter steel pipes located within the old diversion tunnels inside of each abutment of the dam. River outlet conduits continue downstream from the penstocks in each abutment of the dam to release water for downstream commitments when the powerplant is not in operation and to assist in making releases during floods. One spillway is provided within each abutment of the dam to make releases during large floods. Discharges are controlled by four 16- by 100-foot (4.9m x 30.5m) drum gates in each intake structure providing a combined discharge capability of 130,000 cfs (3,681.2 cms) for each spillway tunnel.

c. <u>Davis Dam</u>. Davis Dam spans the Colorado River in Pyramid Canyon, 67 miles (107.8 Km) downstream from Hoover Dam and 88 miles (141.6 Km) upstream from Parker Dam. The Dam provides re-regulation of the Colorado River below Hoover Dam and facilitates water delivery beyond the boundary of the United States, as required by treaty with Mexico. The Mexican Treaty of 1944 required the United States to construct Davis Dam for regulation of water to be delivered to Mexico. The Dam also provides for production and transmission of electrical energy, contributes to flood control, irrigation and municipal water supplies, navigation improvement, recreation, and wild waterfowl protection and related conservation purposes. Davis Dam, rising 200 feet (6.7 m) above the lowest point of the foundation and about 140 feet above the level of the river, is a zoned earthfill structure with concrete spillway, intake structure, and powerplant. The dam has a crest length of 1,600 feet (487.7 m), and a top width of 50 feet (15.2 m). The reservoir, Lake Mohave, has a total storage capacity of 1,818,300 acre-feet (224,284 ha-m), and, at high-water stages, extends 67 miles (107.8 Km) upstream to the tailrace of the Hoover Powerplant.

d. Parker Dam. Parker Dam is located on the Colorado River, approximately 16 miles (25.7 Km) northeast of Parker, Arizona and 155 miles (249.5 Km) downstream from Hoover Dam, in a short section of gorge cut through low-lying hills. It is a gravity-arch dam with a structural height of 320 feet (97.5 m), a crest length of 856 feet (260.9 m) at elevation 455 feet (138.7 m), and provides water storage and power production. The reservoir formed by the dam, Lake Havasu, stores water for municipal and industrial use by southern California and by the Central Arizona Project. With a reservoir elevation of 450 feet (137.2 m) and a tailwater elevation of 366 feet (155.6 m), Parker Dam has a differential hydrostatic load of 84 feet. The spillway consists of five 50- by 50-foot (15.2m x 15.2m) Stoney gates located across the top of the dam above elevation 400 feet (121.9 m). The gates are placed between hollow piers that contain the gate guides and hold the gate hoist structure. The five bay gate-hoist structure rises 63 feet (19.2 m) above the top of the dam.

Releases from Alamo Dam that are large enough to enter Lake Havasu, are coordinated with the USBR to obtain maximum benefits. These benefits include water supply, power generation, and incidental flood control (if releases are made within the water conservation pool).

3-05. Modifications to Regulations

The original regulations for Alamo Dam and Lake were based on a plan developed in General Design Memorandum No. 3. These regulations are described in the paragraphs below.

(1) A recreation pool was designated from streambed up to elevation 1046 feet (318.8 m). The downstream release from the recreation pool was stipulated as outflow-equal-to-inflow up to a maximum of 10 cfs (0.28 cms), to meet water rights requirements.

(2) A water conservation pool was designated from elevation 1046 feet (318.8 m) to elevation 1160.4 feet (353.7 m). Releases in the water conservation pool were to be a maximum of 2,000 cfs (56.6 cms).

(3) A flood control pool was designated from elevation 1160.4 feet (353.7 m) to elevation 1235 feet (376.4 m). Releases from the flood control pool were to be held to a maximum of 7,000 cfs (198.2 cms), which was considered to be the non-damaging channel capacity of the Bill Williams River downstream.

After completion of Alamo Dam, a number of issues arose that have resulted in significant changes to the aforementioned operating regulations. These issues are described in the sections herein.

a. Change in Recreation Pool Elevation. Approximately 6 years after operations began, the Arizona Game and Fish Department requested that the top of the recreation pool elevation be increased from 1046 feet (318.8 m) to 1066 feet (324.9 m), which has since, by agreement, been revised to 1070 feet (326.1 m). The Corps agreed to the request after determining that the increase would not have an adverse impact upon the flood control capability of the reservoir. The request was formally approved 8 July 1981 by the Arizona Department of Water Resources, which also determined that the increase would not adversely impact existing water rights.

b. Above-Normal Runoff. During the period 1978-1980, the entire Colorado River basin experienced several significant flood events generating above-normal runoff. The runoff peaked in 1980 (calendar year) when the total flow volume entering Mexico (at the Northern International Boundary) was 6,934,000 acre-feet (855,296 ha-m), or 260 percent of the 1950-80 average. Inflows into Alamo Lake also peaked in 1980 with an annual total of 503,148 acre-feet (60,062 ha-m) or 456 per cent of the normal annual volume. During this period, Alamo Lake reached the highest historic elevation of 1207.33 feet (368.0 m) and the peak release from Alamo Dam of 3,900 cfs (110.4 cms) was the highest of record until 1993.

In order to alleviate flooding on the lower Colorado River, a multi-agency meeting was convened 28 March 1980 to discuss what appropriate measures should be taken. A decision was made whereby the Corps would gradually lower the elevation in Alamo Lake to 1110 feet (338.3 m), and then maintain that elevation as long as conditions warranted. The 1110-foot (338.3 m) elevation was chosen because it was determined to be an optimal value for flood control, water supply and recreational interests. The elevation was maintained as a result of subsequent high run-off years that lasted into the mid-1980's.

c. Modification to Recreational Facilities. Although the 1110-foot (383.3 m) elevation described in the above section was never formally authorized as a permanent change to operations, local interests in and around the lake had to modify their operations as a result of the higher impoundment. Arizona State Parks (ASP) was obliged to replace boat launch ramps and other recreational facilities inundated by the higher lake elevation. The ASP proceeded to construct boat launch ramps and other facilities that were designed for usage at this elevation. The new facilities, coupled with the higher lake elevation, increased annual recreational usage because of greater lake surface area. ASP has planned expansion of the recreational facilities around the lake based upon continued maintenance of the lake being around the 1110-foot (383.3 m) elevation.

d. Southern Bald Eagles. In early 1980's a pair of Southern Bald Eagles were discovered nesting in a partially inundated tree within the upper reaches of the Alamo Lake (Photo 3-01). Subsequently, another pair was discovered nesting in the canyon wall downstream from the dam. Occupation of the two nests prompted the USFWS to request that the lake elevation remain within the range of 1100-1135 feet (335.3 – 345.9 m) for the preservation of the eagles. The Bill Williams River Corridor Steering Committee addressed management needs for the bald eagle in development of the recommended plan, which was subsequently analyzed through the Alamo Lake, Arizona Feasibility Study and Environmental Impact Statement.

3-06. Principal Regulation Problems

Although Alamo Dam has never spilled, there have been several problems associated with operations. These problems are summarized in the sections below.

a. Erosion. In the spring of 1980, a release of about 2,500 cfs (70.8 cms) resulted in an erosive eddy effect downstream of the outlet works, which in turn, caused scouring of random fill adjacent to the toe of the dam. As a consequence of this occurrence, scouring is now monitored during high releases.

b. Cavitation. Cavitation and abrasion have occurred on the service gates and service gate seals when these gates were set at openings of one-half foot or less to regulate discharges. The cavitation and abrasion ultimately resulted in leakage of as much as 13 cfs (0.37 cms) through the gate-gate seal contact when the gates were fully closed. Although the gates and gate seals were repaired and the leakage stopped, modified regulations prevent the service gates from being set at an opening of less than a half-foot (0.15 m).

c. Downstream River Crossings. Although no significant damage has occurred from releases less than 2,000 cfs (56.6 cms), releases in the 300-500 cfs (8.5 – 13.2 cms) range have made crossing the Bill Williams River virtually impossible at key locations downstream from Alamo Dam. As a consequence the Corps is required to notify a number of local agencies and citizens prior to making releases that equal or exceed the aforementioned ranges.

d. Hydrogen-Sulfide. During the summer and early fall, Alamo Lake stratifies, resulting in an anoxic hypolimnion. The anoxic conditions cause the generation of hydrogen-sulfide (H_2S) as a dissolved gas in the hypolimnic water. The H_2S escapes from the dissolved state as water is released through the outlet works. When the releases being made are low-flow through the butterfly valve, the gas tends to permeate into the outlet works gate chamber and gate shaft. The H_2S gas is potentially lethal and, consequently, operating personnel cannot enter the chamber or shaft if high concentrations are present. The result is that a change in the release from the butterfly valve (which can only be operated from within the chamber) may have to be delayed until the H_2S dissipates. In addition, the H_2S tends to be corrosive to the electrical equipment in the chamber and shaft.

Photo 3-01. Partially inundated tree in upper reaches of Alamo Lake (lake elevation 1097.95 feet (334.7 m), 27 October 1987). Example of a tree where Southern Bald Eagles have nested within the lake.

Photo 3-02. High-pressure gasline across Bill Williams River 13.5 miles below Alamo Dam.

Photo 3-03. Bill Williams River National Wildlife Refuge, showing stands of cottonwood trees.