ITED STATES
.T OF THE INTERIOR
Stewart L. Udall, Secretary

BUREAU OF RECLAMATION
Floyd E. Dominy, Commissioner

PACIFIC SOUTHWEST WATER PLAN

SUPPLEMENTAL INFORMATION REPORT ON MARBLE CANYON PROJECT, ARIZONA

January 1964

UNITED STATES
DEPARTMENT OF THE INTERIOR
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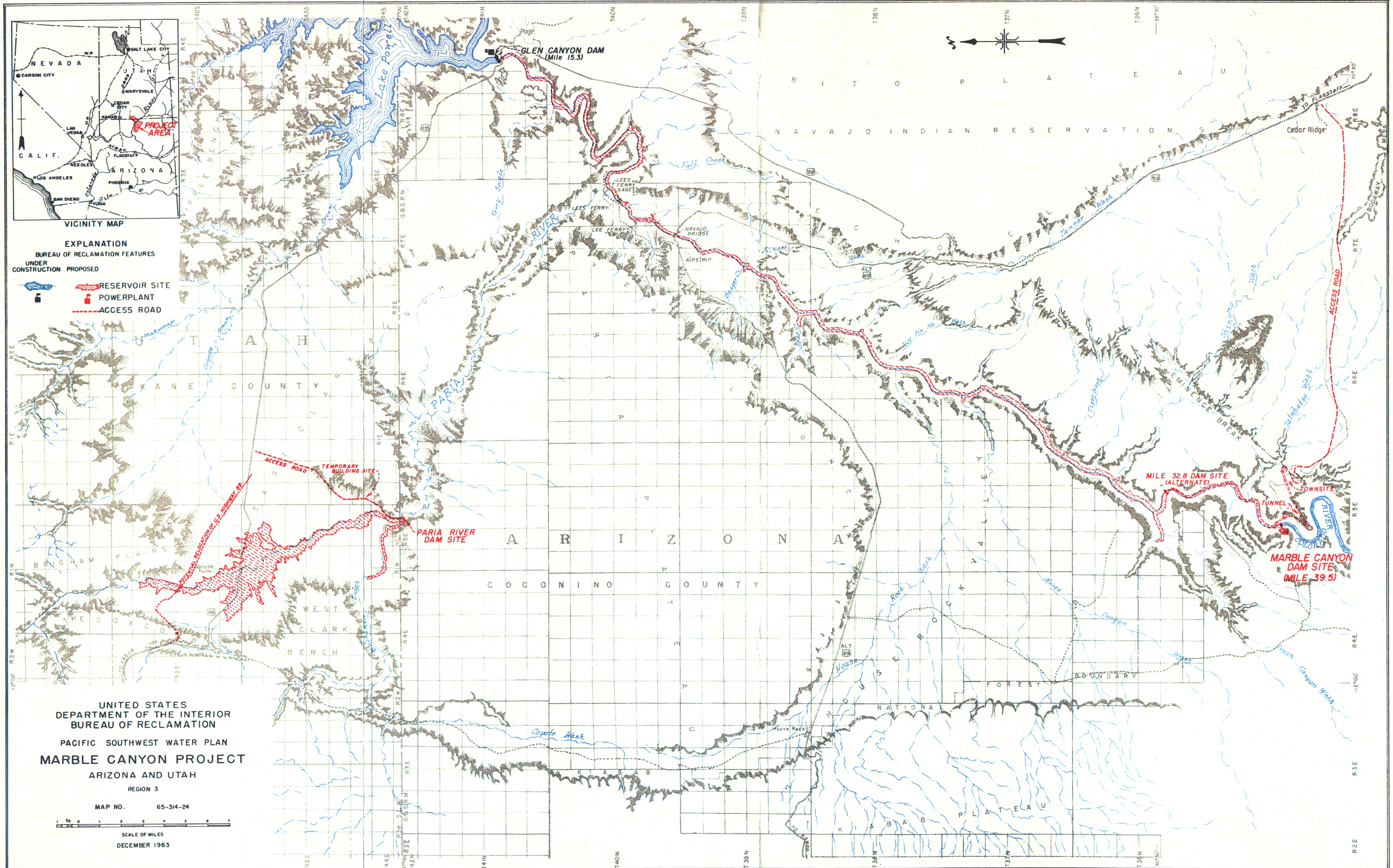
Interior-Reclamation
Boulder City, Nevada

ERRATA SHEET

PACIFIC SOUTHWEST WATER PLAN
SUPPLEMENTAL INFORMATION REPORT
MARBLE CANYON PROJECT

Change Capital Costs on Summary Sheet 3 for the Paria Dam and Reservoir from $10,670,000 to $10,760,000.



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

PACIFIC SOUTHWEST WATER PLAN

MARBLE CANYON PROJECT

ARIZONA AND UTAH

REGION 3

MAP NO. 65-314-24

SCALE OF MILES

DECEMBER 1963

INTERIOR-RECLAMATION, BOULDER CITY, NEVADA

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INTRODUCTION

The Marble Canyon Project, as shown on Drawing No. 65-314-24, is an integral part of the Pacific Southwest Water Plan. This comprehensive plan for the coordinated development and augmentation of the water resources of the Lower Colorado River Basin and southern California provides for the conservation of existing water supplies within the Lower Colorado River Basin, the importation of water from areas of surplus, and the interchange of water between basins.

The electrical output of the Marble Canyon Powerplant will be integrated with generation from other Federal hydroelectric powerplants on the Colorado River. It would be used to supply peaking power and energy to the commercial electrical load in the power market area and a portion of the water project pumping load in the Pacific Southwest Water Plan.

The Marble Canyon Project plan, as presented in this report, is a feasible plan for the development of the hydroelectric powerhead potential of the Colorado River from the northern boundary of the Grand Canyon National Park to Glen Canyon Dam, one of the two remaining undeveloped reaches of the Lower Colorado River. In addition to Marble Canyon Dam and Powerplant, project features would include the power transmission system, the Paria River Dam and Reservoir, and community and construction facilities incidental to the project. Recreation features would be included and provision made for fish and wildlife enhancement facilities.

SUMMARY

Project

Marble Canyon, Lower Colorado River, Arizona

Location

On the Colorado River in north-central Coconino County, Arizona, 55 miles downstream from Glen Canyon Dam and 12.5 miles upstream from the north boundary of Grand Canyon National Park.

Need

The Marble Canyon Project would provide urgently needed peaking generating capacity for the commercial electrical load in Arizona, southern California, and southern Nevada.

Provide energy for a portion of the water project pumping load in the Pacific Southwest Water Plan.

Provide surplus revenues which, in combination with similar revenues from other existing and potential hydroelectric power-generating facilities, would be used for financial assistance in developing urgently needed additional water supplies for the water-deficient Pacific Southwest.

Features

Marble Canyon Dam, Reservoir, and Powerplant, transmission facilities, Paria Dam and Reservoir, and required access and operational facilities. The 310-foot-high, thin-arch concrete Marble Canyon Dam would create a reservoir with a capacity of 363,000 acre-feet. The 600,000-kilowatt powerplant would consist of four 150,000-kilowatt generating units and would annually generate an average of 2,308,000,000 kilowatt-hours based on the 100-year period of analysis. Recreation and fish and wildlife enhancement facilities would be provided.

Plan of Operation

The Marble Canyon Powerplant would utilize the Glen Canyon Reservoir cyclic regulation of Colorado River flows. The daily Glen Canyon power water releases would be reregulated as required by Marble Canyon Reservoir to meet the operational plan of the Marble Canyon Powerplant. The Paria Dam and Reservoir would retain the major portion of the sediment load of the Paria River, thereby preventing its deposition in Marble Canyon Reservoir and reducing its effect upon the Glen Canyon Powerplant tailwater elevation.

Capital Costs	
Marble Canyon Dam and Reservoir	$ 64,944,000
Marble Canyon Powerplant	79,104,000
Transmission Facilities	81,000,000
Paria Dam and Reservoir	10,670,000
Fish and Wildlife	1,500,000
Recreation Facilities	1,346,000
Total	$238,654,000
Annual Benefits	
Power	$ 17,174,000
Recreation	315,000
Fish and Wildlife	360,000
Area Redevelopment	145,000
Total	$ 17,994,000
Annual Equivalent Federal Costs	
100-Year Period of Analysis	$ 10,487,000
Benefit-Cost Ratio	1.7 to 1.0

C H A P T E R I

T H E

P O W E R

M A R K E T

CHAPTER I - THE POWER MARKET

The potential market for Marble Canyon Project power, as shown on Drawing No. 65-314-25, consists of the region designated by the Federal Power Commission as the "Lower Colorado River Basin Power Market Area." The power requirements of the area will include, in addition to domestic and industrial demands, a portion of the electrical energy for the operation of water conveyance facilities of the Pacific Southwest Water Plan.

Physiography

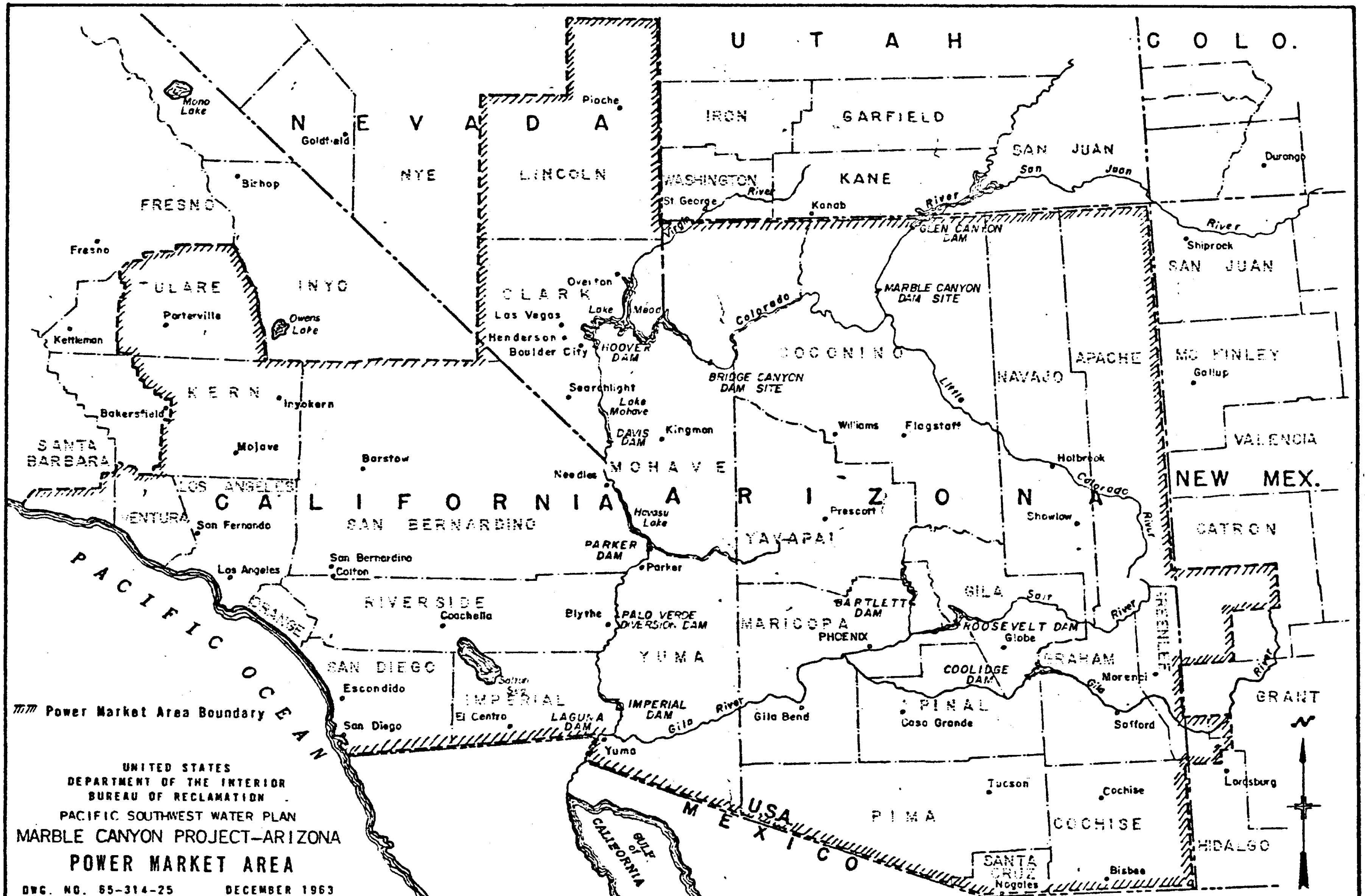
The entire area is drained by the Colorado River, with the exception of the coastal area of southern California, the inland basins of California and Nevada, and small basins in Arizona which drain into Mexico.

The area is characterized by a wide variation of land elevations ranging from over 12,000 feet in Arizona to sea level and below in southern California. East of the mountains which border the coastal area in California are closed drainage basins extending into Nevada, separated by low mountain ranges. The southwestern section of Arizona, at elevations generally less than 2,000 feet, is predominantly a desert, while the north and east sections are mountainous with high plateaus.

Average temperatures vary generally with the precipitation pattern. The low precipitation areas, averaging as little as 2 inches annually, are primarily desert and have the highest temperatures which can range up to 115 degrees during the long summers. The higher precipitation areas, which receive up to 30 but average about 10 inches annually, are generally in the higher mountains where winter temperatures may be in the below-zero range. Southern California, influenced by the ocean winds, has the most moderate climate in the area throughout the year.

Population

The population of the area which could be served by the Marble Canyon Project has increased overall by about 48 percent in the 1950 to 1960 period. In the period from April 1960 to July 1962, this trend continued, and projections of future population by many entities, both private and Government, indicate that this trend is expected to continue, if not increase. The number of seasonal visitors to the area is also increasing. The electrical energy consumption is not only expected to keep pace with the population growth, but to accelerate as additional electrical mechanisms are developed for domestic and industrial uses. The population of the area, based on official 1960 U.S. Bureau of Census data, was approximately 10,670,000, and is



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
PACIFIC SOUTHWEST WATER PLAN
MARBLE CANYON PROJECT—ARIZONA
POWER MARKET AREA

DWG. NO. 65-314-25 DECEMBER 1963

expected to approach 20,000,000 by 1980, by which time all of Marble Canyon power would be absorbed.

Population distribution is extremely unbalanced, with a large majority being concentrated in a few metropolitan areas. The Los Angeles vicinity alone contained about 67 percent of the people in the area in 1960. Five metropolitan areas--Los Angeles, San Diego, and San Bernardino in California, and Phoenix and Tucson in Arizona--accounted for over 95 percent of the total population.

The 1960 census, as presented in the following tabulation, attests the unusual population increase that has occurred in the metropolitan areas since 1950.

Metropolitan Area	1950 Population	1960 Population	Increase
Los Angeles-Long Beach	4,367,911	6,742,696	56%
San Diego	556,808	1,033,011	85%
San Bernardino-Riverside-Ontario	451,688	809,782	80%
Phoenix	331,770	663,510	100%
Tucson	141,216	265,660	88%
Clark County, Nevada	48,289	127,016	165%

Economy

The region has experienced steadily increasing prosperity in recent years. Manufacturing and aero-space allied industries continue to flourish in Arizona and southern California, with the Los Angeles area now ranking third among the Nation's industrial areas. Agriculture and mining, the original economic bases, are next to manufacturing in income production. Military installations also contribute much to the general economic base. The influx of people to the area, both permanent and transient, continues to increase, and providing the necessary services for these people is an increasingly important factor in the general economy.

Resources

The region has long been an important mineral-producing area, and there is a continuing development of reserves. Arizona leads the Nation in the production of copper, but lesser quantities of many other minerals are produced in the area. California's now declining oil production ranks third in the Nation, and exploration for new reserves continues throughout the region. In addition to lumber production, some of the large timber reserves in Arizona are used in the production of fiber for paper pulp. With the prevailing moderate winter temperatures, and with water for irrigation, the desert soils are highly productive, but adequate water supplies are not available even to permanently sustain the presently irrigated acreage.

Problems and Needs

The basic problem of this dynamic growth area is that of obtaining adequate supplemental water supplies to sustain the present economy and provide for future growth of population and industry. In the past, water was usually obtainable by simple gravity diversion or shallow pump lift in sufficient quantities to provide water needs. This condition was relatively short lived, and long-term holdover storage reservoirs and high pump lift projects later became necessary to regulate and distribute waters to the farms and growing communities. The end of this era is now fast approaching, as the physical limits of local water supplies have been reached in many areas. No longer can a development request and receive water by merely demonstrating the need and the ability to pay.

Historically, most water development projects of the area were basically for agricultural consumption, with municipal, industrial, power, recreation, and other aspects being secondary or incidental participants. Today, this cycle is reversing as urban developments throughout the West are demanding water supplies which, in many cases, can only be obtained by condemning agricultural water rights, but in many areas the water quantities are limited. Coincident with the growing water demands are demands for ever-increasing quantities of electrical energy for domestic and industrial use and for the pumping of water.

Peaking power and energy requirements now demand a high percentage of present installed capacity, especially for the areas that have been developed within desert regions. This demand arose with the now widespread use of air-conditioning equipment in home and industry. The irrigation pumping requirement in central Arizona adds to the summer load. It is probable that, as urbanization spreads over presently irrigated lands, the relatively constant summer irrigation pumping load will give way to more pronounced peaks as the pumps are converted to supply irregular municipal and industrial water requirements.

The peaking energy requirements of the southern California area, with a moderate climate, are of greater magnitude than the desert areas, owing to the larger demand. The daily duration is somewhat shorter at certain times of the year, but there is need for an adequate peaking energy supply in this area as well as in the desert areas.

Present Development and Requirements

Present power developments in the Lower Colorado River Basin market area range from hydroelectric and fuel-burning plants, serving the metropolitan areas in southern California and south-central Arizona, to local powerplants serving the smaller towns and communities.

The principal suppliers of energy in the California portion of the market area are the cities of Los Angeles, Burbank, Glendale, and Pasadena; the Southern California Edison Company; the San Diego Gas and Electric Company; the California Electric Power Company; Imperial Irrigation District; and the Bureau of Reclamation. The energy is produced at several hydroelectric plants within or near the market area, in addition to large steamplants located near the load centers. Hoover, Davis, and Parker Powerplants on the Colorado River form one of the major sources of supply. Hoover Dam Powerplant is operated for the Bureau of Reclamation by the city of Los Angeles and the Southern California Edison Company, and Parker Dam and Davis Dam Powerplants by the Bureau of Reclamation. The cities of Pasadena, Burbank, and Glendale operate municipally owned steam and hydroelectric plants, and the Imperial Irrigation District owns and operates steam and hydroelectric plants and distributes energy in the Imperial and Coachella Valleys. Most of the power systems of these agencies are interconnected, but integration of their operations is, in some cases, limited by existing facilities.

In Arizona, the principal agencies generating and distributing electric power are the Salt River Project Agricultural Improvement and Power District; the Arizona Public Service Company; the Tucson Gas, Electric Light and Power Company; Citizens Utilities Company; Arizona Electric Power Cooperative; the Bureau of Indian Affairs; and the Arizona Power Authority.

In general, these agencies serve the more densely populated areas in the south-central part of the State. The Bureau of Reclamation, by virtue of the power delivered from Hoover, Davis, and Parker Powerplants, is a large producer of electric energy utilized in the State.

In southern Nevada, Clark and Lincoln Counties and the Atomic Commission's testing facilities in Nye County are supplied from the Nevada Power Company's Clark Steamplant, the Parker-Davis Project, and the Hoover Powerplant. The major operating agencies for this area are the Colorado River Commission of Nevada, Amargosa Electric Cooperative, the Nevada Power Company, the Lincoln County Power District, the California-Pacific Utilities Company, the Bureau of Reclamation, and the city of Boulder City.

Some of the foregoing utilities are purchasing electrical power from the Bureau of Reclamation as preference customers under the Reclamation Project Act of 1939, and it is anticipated that they would purchase additional power and energy to meet growing demands.

Transmission lines of sufficient capacity for present loads extend from Hoover, Davis, and Parker Powerplants to the load centers.

The installed generating capacity in the area was about 11,700,000 kilowatts as of December 31, 1962. Additional installed capacity of about 3,700,000 kilowatts was planned for construction after 1962, some of which is now either in service or under construction. Planning since 1962 will have anticipated some of the additional capacity needed for the period beyond 1965.

The consumption of electric energy in the metropolitan areas of Los Angeles County, San Diego, and south-central Arizona continues to increase tremendously as during World War II and the immediate postwar years. Continuous installation of power generation facilities has been required to meet population influx and "space-age" requirements. Additional large installations will be necessary to meet the ever-increasing demands.

The growth of industrial activity and increase in population during the 1950-1960 period was reflected by an increase in energy requirements of 27.4 billion kilowatt-hours, from 16.7 billion kilowatt-hours to 44.1 billion kilowatt-hours. During this period, the peakload of the market area increased from 3,100,000 kilowatts to 7,800,000 kilowatts. The 1961 increase was about $1\frac{1}{2}$ times the average annual increase of the 1950-1960 period. During this year, the energy requirements increased about 3 billion kilowatt-hours to 47 billion kilowatt-hours and the peak demand increased 600,000 kilowatts to about 8,400,000 kilowatts. To meet the 1950-1961 increased demand of 5,300,000 kilowatts and to provide reserve capacity, the principal energy-producing agencies increased their installed capacity by 6,131,000 kilowatts.

The Nevada electrical load is characterized by a winter heating peak and the Arizona load by a summer air-conditioning and irrigation pumping peak. The industrial demands are not of sufficient magnitude to materially flatten the peaks. California, with a large year-round industrial demand, has only a minor peak which occurs during the winter. The market area, as a whole, has a minor winter peak which is only 1 percent higher than the summer peak demand.

In the summer of 1961, only about 50 percent, or 4,200,000 kilowatts, of the maximum demand of 8,400,000 kilowatts was required throughout the 24-hour day. At this time, 15 percent of the maximum demand, or 1,260,000 kilowatts, was required for only 57 hours during a week--about 10 percent, or 840,000 kilowatts, was required for only 41 hours a week. These periods of maximum demand occur in the 5 days, Monday through Friday, each week. Portions of the peakload demands of these periods are being provided by noncontinuous operating hydroelectric plants.

Future Power Requirements

According to Federal Power Commission estimates, the electrical requirements for 1970 and 1980, which do not include project pumping, and as presented in the following tabulation, will be 93 billions of kilowatt-hours and 172 billions of kilowatt-hours, respectively, with peakload demands of 17,000,000 kilowatts and 31,000,000 kilowatts.

	Estimated annual energy requirements (Millions of Kilowatt-Hours)			Estimated peak demand (Thousands of Kilowatts)	Estimated 1/ required installed capacity (Thousands of Kilowatts)
	Load	Load Increase			
		Incremental Increase	Accumulative Total		
1950	16,713			3,085	-
1960	44,135	27,422	27,422	7,790	-
1970	93,009	48,874	76,296	17,000	19,500
1975	127,200	34,191	110,487	23,000	26,400
1980	171,534	44,334	154,821	31,000	35,700

1/ Includes 15 percent reserve capacity needed to meet peak demand.

As previously stated, additional future installations will continue to be planned well in advance of need so construction can be completed in time to meet the ever-increasing demands. In addition to that projected for domestic and industrial uses, electrical power will be required for conveying imported and transferred water supplies.

Installed generation capacity as of 1962, and that planned for construction after that year, amounts to 15,400,000 kilowatts. Generation to meet the projected 1975 domestic and industrial requirements is estimated to be 26,400,000 kilowatts. Disregarding the capacity that might be needed by project water supply pumping plants, the 600,000-kilowatt capacity of the Marble Canyon Powerplant could readily be absorbed by the market area as it would constitute only about 5.5 percent of the capacity installation of 11,000,000 kilowatts that will be needed to meet the projected 1975 domestic and industrial requirement of 26,400,000 kilowatts.

C H A P T E R   I I

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CHAPTER II - PLAN OF DEVELOPMENT

The development of the Marble Canyon Project would include the construction of Marble Canyon Dam and Powerplant, transmission facilities, the Paria River Dam, and other related features. Owing to the inaccessibility of the inner gorge, the initial activity would be the construction of access roads and of community facilities for the workers and their families at the Marble Canyon Dam site. The construction of the dam, powerplant, transmission system, and the Paria River Dam would follow in sequence. Drawing No. 65-314-24 shows the locations of the Marble Canyon and Paria River features. The Paria River sediment-retention dam would alleviate the sediment problem at Marble Canyon Reservoir for over 100 years.

Climatological Factors

Precipitation at the Marble and Paria Dam sites and on the adjacent plateaus averages about 7 inches a year, most of which occurs in the form of short-duration cloudbursts during July and August. May and June are usually the driest months of the year. Snowfall at the damsites is infrequent and light, averaging about 10 inches annually. However, at Flagstaff, Arizona, the nearest railhead which is about 100 miles south, the annual snowfall averages 68 inches.

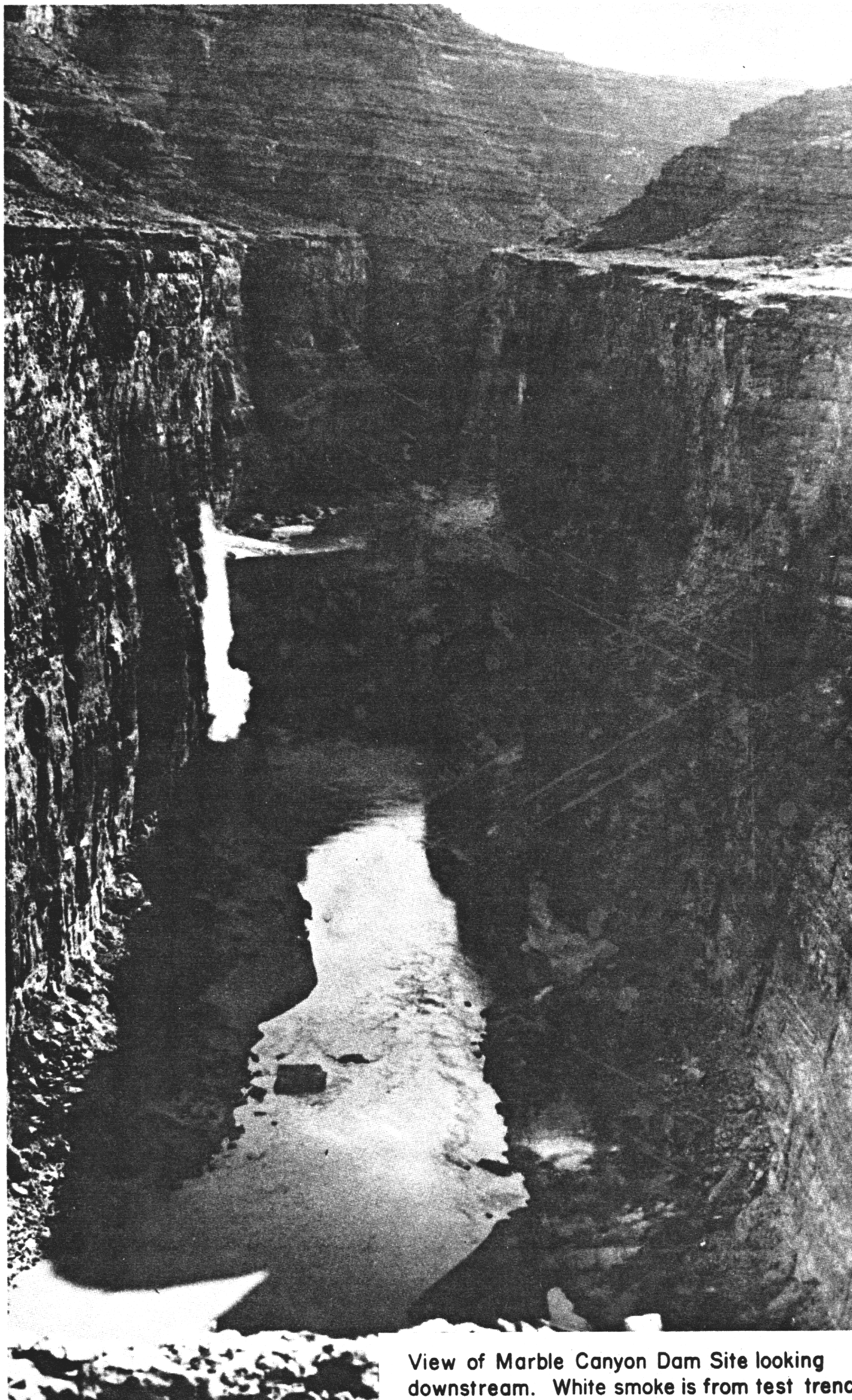
Temperatures adjacent to the damsites range from a low of 12 degrees to a high of 117 degrees Fahrenheit. On the plateau the temperatures average 14 degrees less than those on the inner gorge rim of Marble Canyon Dam site.

Winds on the plateaus may on occasion reach high velocities, particularly in the winter and spring months.

Settlement and Economy

The Colorado River, through the Marble Canyon reach, is the northern boundary of the Navajo Indian Reservation. The area, on both sides of the Colorado and Paria Rivers, is sparsely settled. Thin soil and inadequate rainfall limit livestock grazing potential; hence, the area has a deserted appearance.

Local industry is relatively minor, consisting of sheep raising by the Navajo Indians, a few cattle ranches, and a few trading posts along the highways. The city of Page, at Glen Canyon Dam, is the only community along this reach of the river. The personnel required for construction activities would not be available from the permanent population of the area.



View of Marble Canyon Dam Site looking downstream. White smoke is from test trench blast. PX - 43 - 221.

Marble Canyon Facilities

Water supply and powerplant operation--The water supply available for operation of the Marble Canyon Powerplant would consist of controlled releases and spills from the Glen Canyon Reservoir, the flow of the Paria River, and minor contributions from other drainage areas between Glen Canyon and Marble Canyon Dams. Glen Canyon Dam and Powerplant, a unit of the Colorado River Storage Project about 55 miles upstream from the Marble Canyon Dam site, is nearing completion.

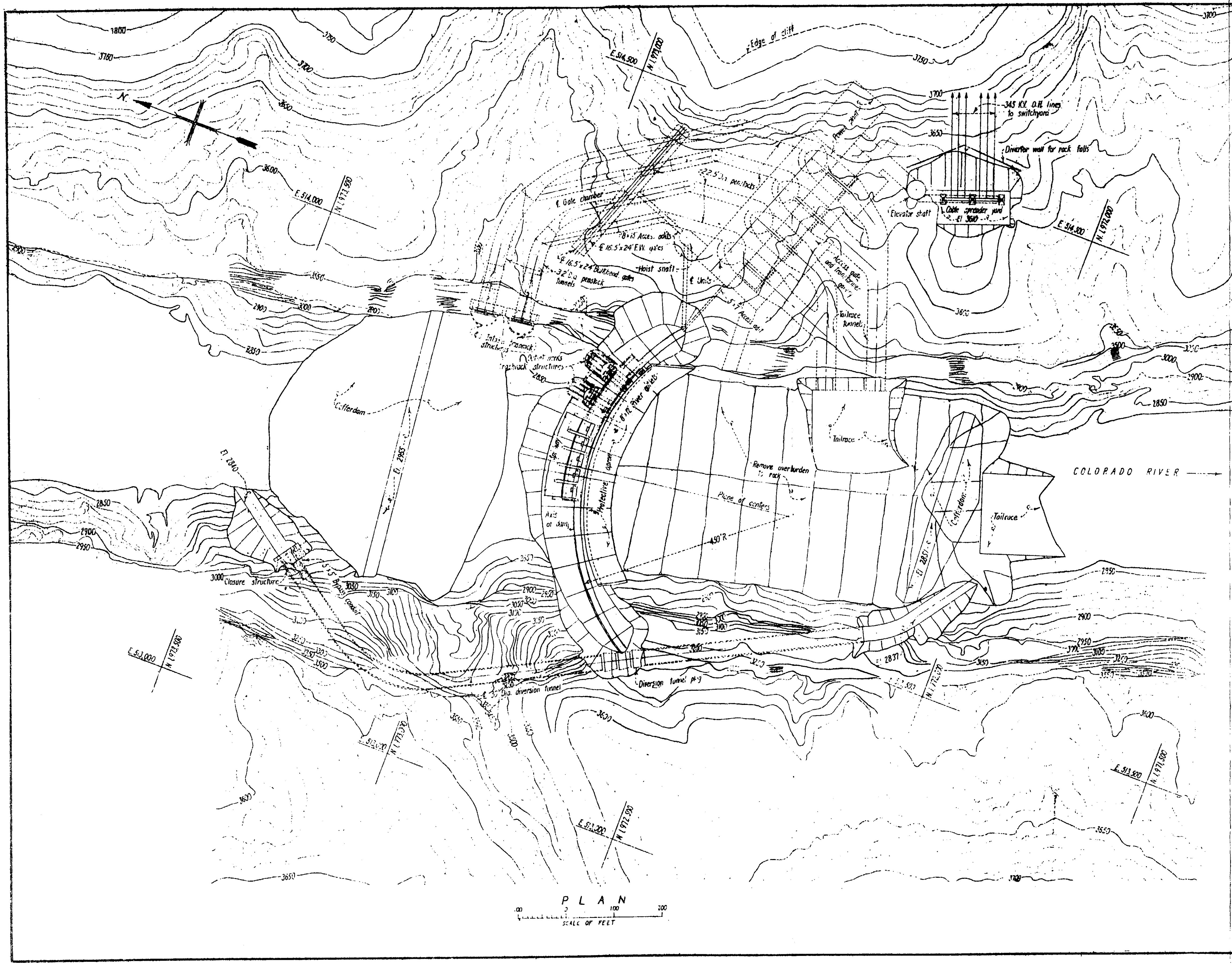
Glen Canyon Dam, the principal storage feature of the Upper Colorado River Storage Project, will provide cyclic regulation of the flows of the Colorado River and will assure that the delivery of water to the Lower Basin is in compliance with the Colorado River Compact, which apportions the waters of the Colorado River system between the Upper and Lower Basins. For the purpose of the operation studies, inflow to the Marble Canyon Reservoir was considered to consist entirely of releases from the Glen Canyon Reservoir. Accretions below Glen Canyon Dam, evaporation, and other losses were not included in the operations study, since the quantities involved are minor and compensatory and the net effect would be insignificant.

The primary functions of Marble Canyon Dam and Reservoir would be to develop head for the powerplant and to provide the small amount of storage needed for weekly reregulation of the Glen Canyon releases. The maximum height of water in the reservoir is limited by the upstream location of the Glen Canyon Dam and Powerplant.

The backwater of Marble Canyon Reservoir would encroach on the tailwater of the Glen Canyon Powerplant, and for short periods affect that plant's capacity capability. The additional power benefits that would be obtained by the Marble Canyon Powerplant, owing to the additional powerhead obtained by this encroachment, would exceed the power benefits lost at the Glen Canyon Powerplant.

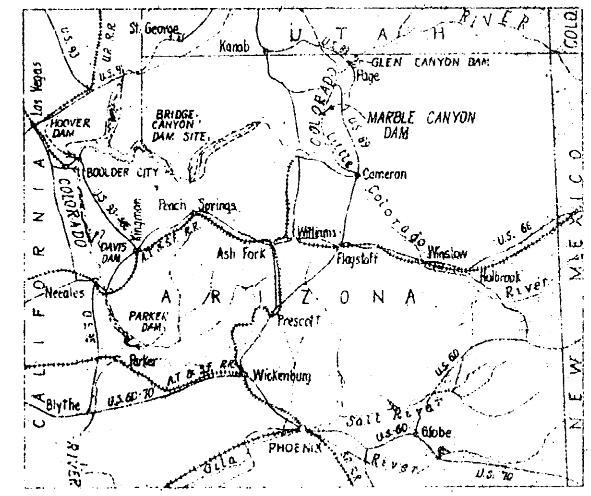
Marble Canyon Reservoir would have a capacity of 363,000 acre-feet, with a normal water surface elevation of 3,140 feet. The surcharge pool, with a maximum water surface elevation of 3,145 feet, would have a capacity of 17,000 acre-feet. Thirty-seven thousand acre-feet of active storage would be required for the weekly regulation of Glen Canyon releases. This regulation would require a maximum drawdown of about 10 feet of the Marble Canyon Reservoir water surface to elevation 3,130 feet. The area capacity curves for the reservoir are shown on Drawing No. 788-D-21.

The hydraulic capacity of the Marble Canyon Powerplant would be the same as that of the Glen Canyon Powerplant; therefore, the maximum Marble Canyon Powerplant power water releases would be the same as those of the Glen Canyon Powerplant. The estimated releases and spills from the Glen Canyon and Marble Canyon Reservoirs for the period 1975-2024 will average 10,550,000 acre-feet annually, of which an



PLAN

SCALE OF FEET



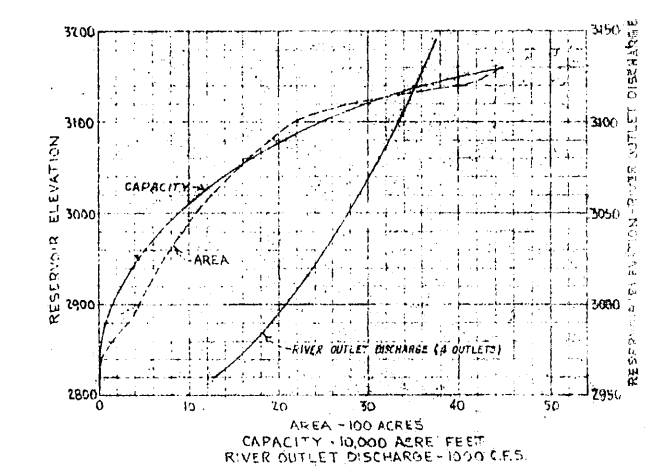
LOCATION MAP

RESERVOIR STORAGE ALLOCATIONS

PURPOSE	ELEVATION	STORAGE - A.F.
Surcharge	3140 - 3145 (Max. W.S.)	20,000
Active conservation	3126 - 3140	30,000
Inactive	2930 - 3126	283,000
Dead	Streambed (El. 2820±) to El. 2930	30,000
	Total reservoir capacity - 363,000	

Max. spillway capacity .... 264,800 C.F.S.
Max. outlet capacity .... 37,500 C.F.S.
Power plant capacity (1 unit @ 7,700 c.f.s.) .... 7,700 C.F.S.
310,000 C.F.S.

The inflow design flood is based on a peak discharge of 310,000 c.f.s.



AREA, CAPACITY, AND OUTLET DISCHARGE CURVES

UNITED STATES
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BUREAU OF RECLAMATION
MARBLE CANYON PROJECT - ARIZONA

MARBLE CANYON DAM AND POWER PLANT
MILE 39.5
600,000 K.W. POWERPLANT
FEASIBILITY ESTIMATE DRAWING

DRAWN ..... SUBMITTED .....
TRACED ..... RECOMMENDED .....
CHECKED ..... APPROVED ..... CHIEF ENGINEER
DENVER, COLORADO, DECEMBER 4, 1963 SHEET 1 OF 2 788-D-21

average of 700,000 acre-feet represents spill. This water supply is based upon the recurrence of Colorado River flow corresponding to the period 1906-1959, after making appropriate deductions for future water uses within the Upper Colorado River Basin above Glen Canyon Dam.

The installed capacity of the Marble Canyon Powerplant would be 600,000 kilowatts, with an average operating head of 295 feet. The average annual generation would be 2,308,000,000 kilowatt-hours, of which 2,123,000,000 kilowatt-hours could be delivered to the load centers for the 100-year period of analysis.

The Marble Canyon Powerplant operations would be integrated hydrologically and electrically with the proposed Bridge Canyon Powerplant and with the other Lower Colorado River Powerplants and the Glen Canyon Powerplant to obtain maximum power benefits. This integration would be obtained by coordinated reservoir operation and interties of transmission facilities.

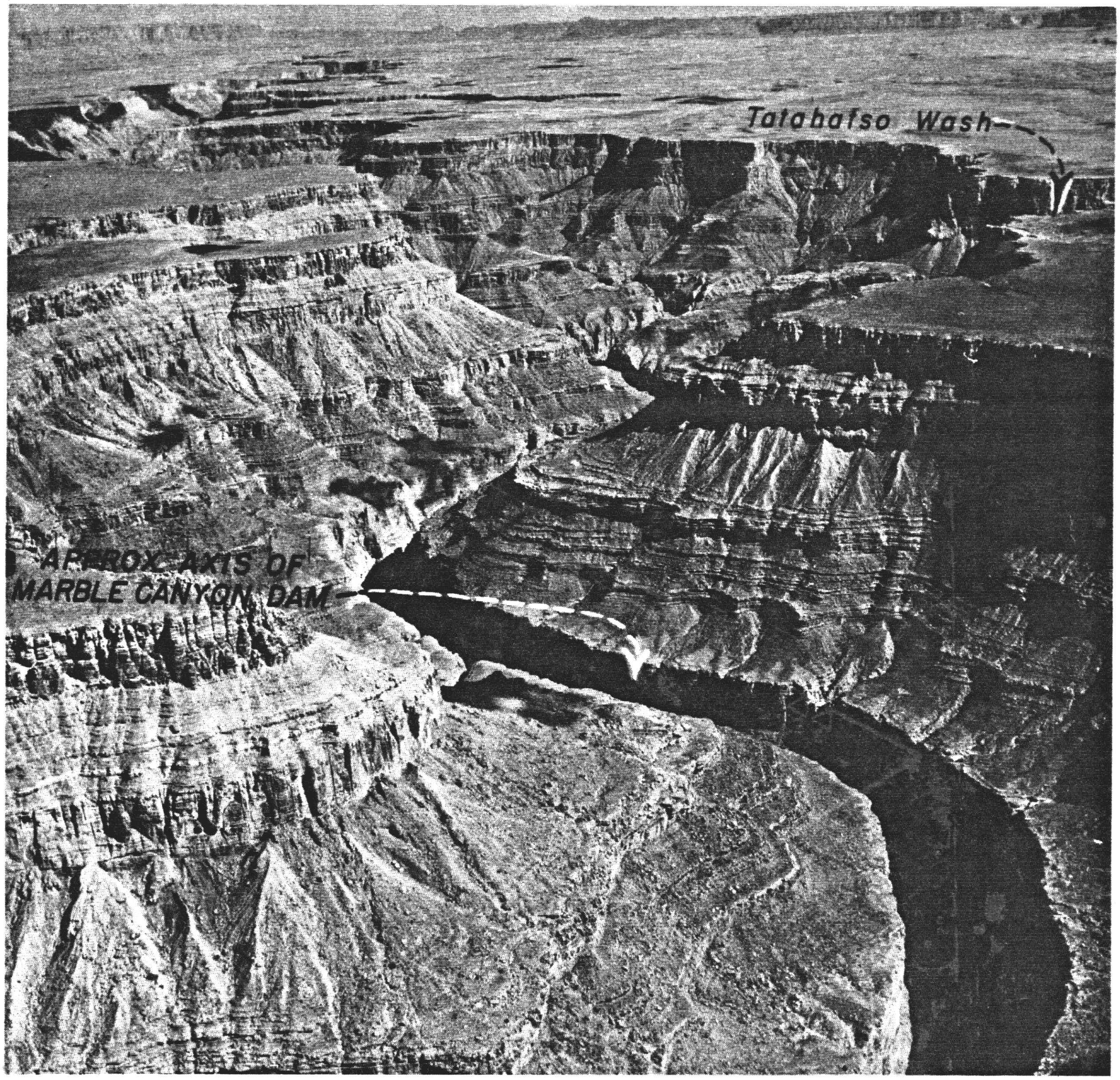
The dam--Marble Canyon, at the damsite, is about 6,000 feet wide and 3,000 feet deep. The Marble Canyon Dam and Powerplant would be located entirely within the inner gorge, which is about 700 feet deep and 400 feet wide. The general plan and section for Marble Canyon Dam are shown on Drawing Nos. 788-D-21 and 22. The dam would be a thin, concrete-arch structure, with a crest length of approximately 750 feet at elevation 3,150 feet. It would have a structural height of 415 feet, of which 105 feet would be below the streambed.

The spillway and river outlet works would have a combined capacity of 302,300 cubic feet of water per second, which is in addition to the 30,800 cubic-feet-per-second capacity of the powerplant turbines.

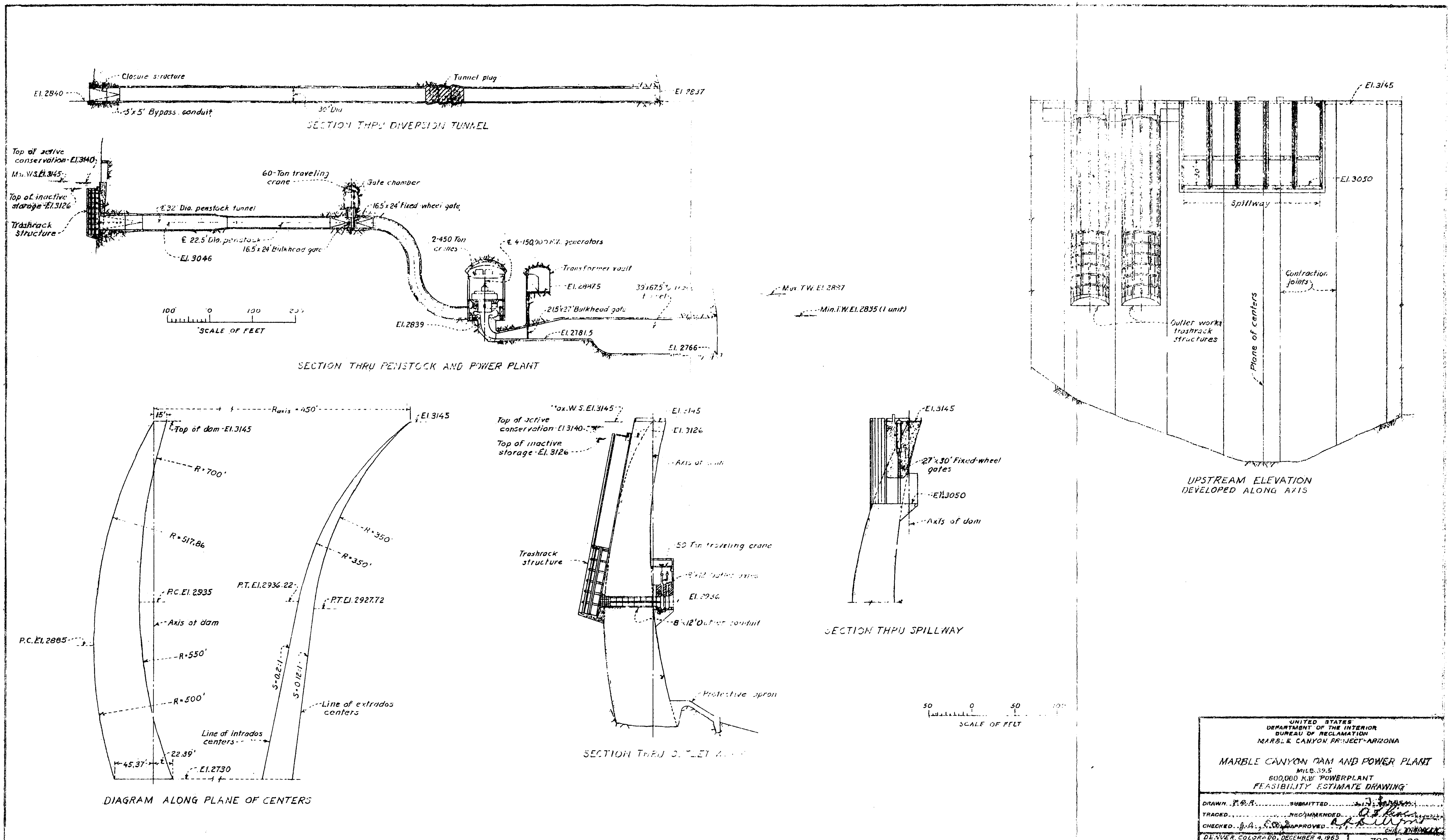
The spillway would consist of five 27- by 30-foot openings through the dam at elevation 3,050 feet. Flood discharges up to a maximum of 264,800 cubic feet per second would be controlled by five fixed wheel gates. The spillway releases would cascade down the outer face of the dam into a stilling pool at the toe of the dam. River outlet capacity, totaling 37,500 cubic feet per second, would be provided by four 8- by 12-foot fixed wheel gated openings through the dam at elevation 2,936 feet. Outlet releases would also cascade down the outer face of the dam into a stilling pool.

A single detached 30-foot-diameter diversion tunnel with a capacity of 35,000 cubic feet per second, located around the right abutment of the dam, would convey the Glen Canyon Reservoir releases and tributary flows around the construction site. The tunnel would be permanently plugged upon completion of the dam and powerplant.

The powerplant--A 600,000 kilowatt powerplant, consisting of four 150,000-kilowatt units, would be located underground immediately downstream from the left abutment of the dam as shown on Drawing



VIEW LOOKING UPSTREAM AT MARBLE CANYON DAM SITE. R3AO - 208



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MARBLE CANYON PROJECT - ARIZONA

MARBLE CANYON DAM AND POWER PLANT
MILE 39.5
600,000 K.W. POWERPLANT
FEASIBILITY ESTIMATE DRAWING

DRAWN P.G.R. SUBMITTED
TRACED RECOMMENDED
CHECKED APPROVED
CHIEF ENGINEER

DENVER, COLORADO, DECEMBER 4, 1963
SHEET 8 OF 8
788-D-22

Nos. 788-D-20 and 21. The underground room would be excavated in the solid rock of the left wall of the inner gorge of Marble Canyon. Four 22.5-foot-diameter penstock tunnels leading from two 32-foot-diameter entrance tunnels would convey a maximum flow of 30,800 cubic feet per second of water to four 213,000-horsepower turbines.

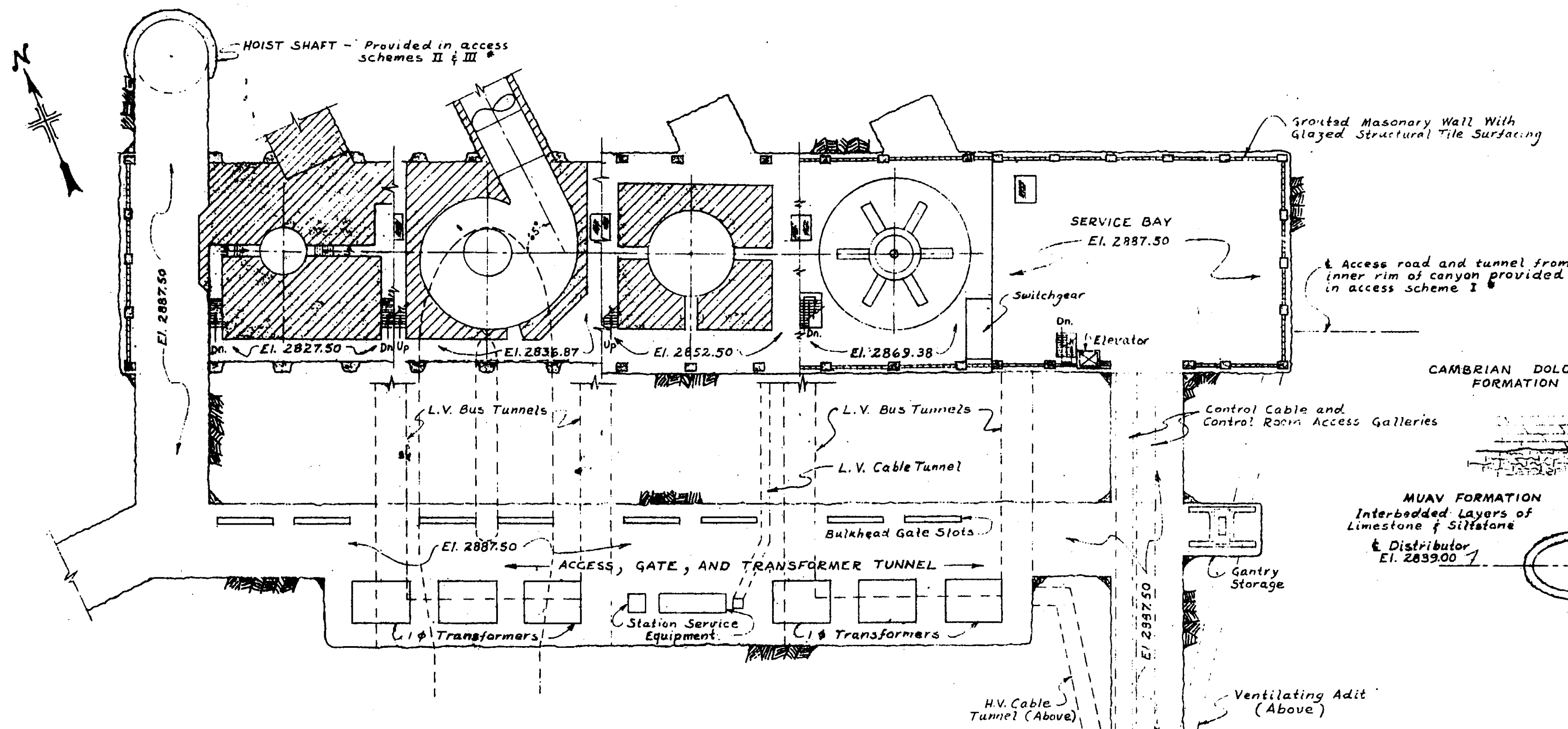
Geology--Geological conditions at the damsite are favorable for the construction of a concrete dam and an underground powerplant. The Colorado River has formed a narrow, steep-sided inner gorge in hard, resistant formations.

Explorations consisted of 35 drill holes ranging in depth from 53 feet to 435 feet, for a combined total of 5,480 feet, and two test drifts, 100 feet and 75 feet long, excavated into the left and right abutments, respectively. Drawing Nos. 788-300-39 and 40 show geological sections of the lower gorge at the damsite.

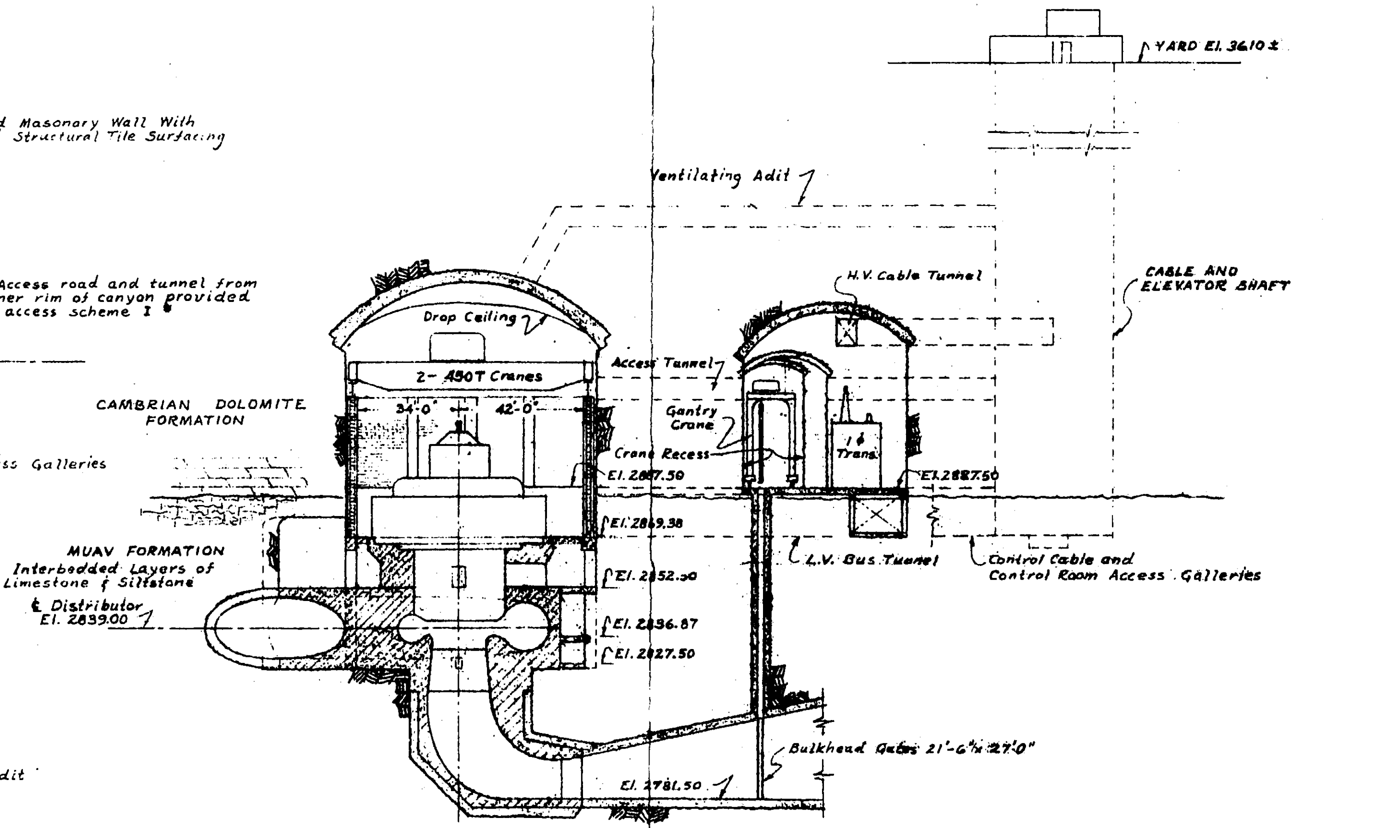
The dam would be imbedded in three geologic formations. The upper part of the abutments would be in massive Redwall limestone and the middle portions in hard Cambrian dolomite and dolomitic limestone. The lower part of the abutments and the dam foundation would be in the silty limestone Mauv formation. Over 400 feet of the Mauv formation would lie between the base of the dam and the top of the soft and incompetent Bright Angel shale. The powerplant and penstock tunnel excavation would be in the dolomitic limestone and in the Mauv formations. The diversion tunnel would be in only the Mauv formation.

Access facilities--The isolated location of the project and the deep canyon in which the dam would be located present a difficult access situation that would require solution before any but token activity could proceed at the damsite. The damsite is located about 86 airline miles north of Flagstaff, Arizona, and within the deep rugged gorge of the Colorado River. The river is approximately 3,000 feet below the surrounding plateau area. At present the plateau above the damsite is accessible from Flagstaff by motor vehicle. The distance, via U.S. Highway 89, from the railroad terminal yard developed for the Glen Canyon Project, about 5 miles east of Flagstaff, to the turnoff near Cedar Ridge is approximately 88 miles. The remaining 21 miles across the relatively level plateau country is over an unimproved road which provides satisfactory access for any type of vehicle in fair weather, but during occasional wet periods, four-wheel-drive vehicles may experience difficulty. U.S. Highway 89 from Flagstaff, which was improved to accommodate Glen Canyon Dam construction traffic, would be adequate for Marble Canyon construction traffic.

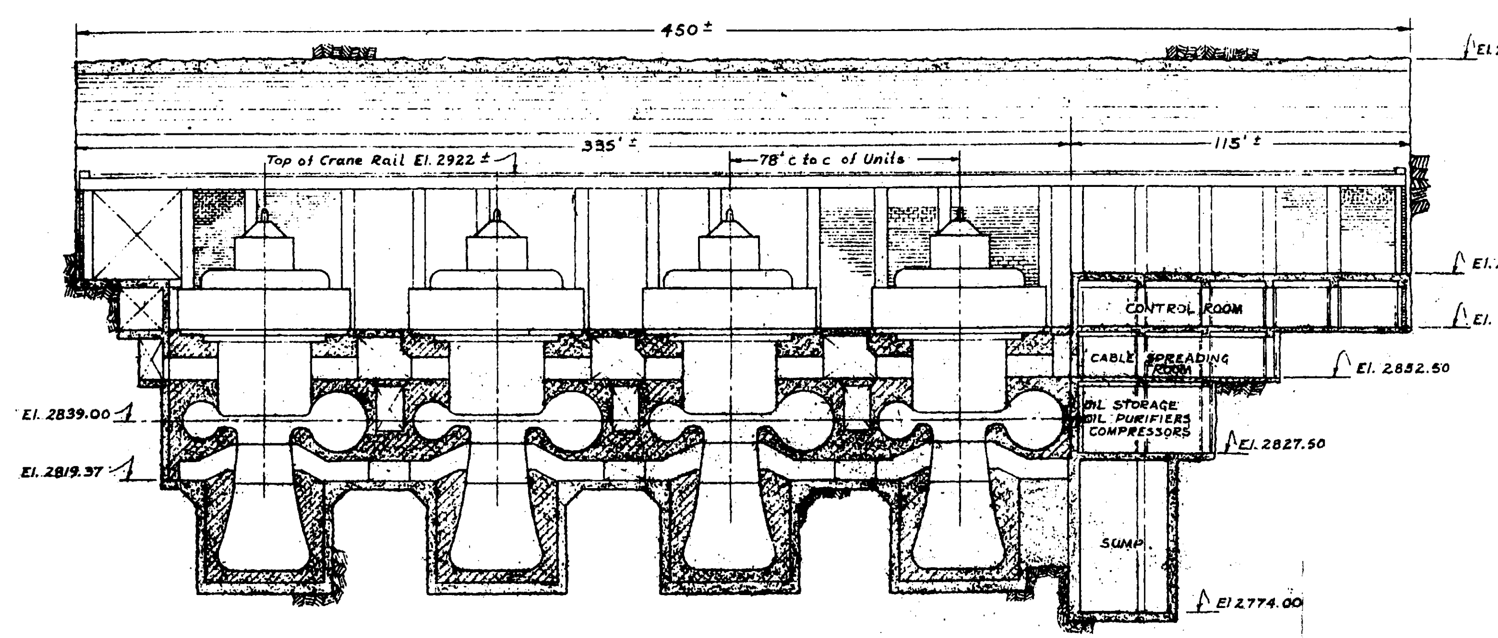
The construction of the 21-mile permanent access highway across the plateau from Cedar Ridge on Highway 89 to the townsite on Tatahatso Point would not involve any unusual construction problems. On the relatively flat plateau, existing or newly bladed roads would provide ready access to any section, permitting construction of the permanent highway to proceed simultaneously on a number of sections. Drawing No. 65-314-24 shows the locations of the access roads.



PLAN



TRANSVERSE SECTION



LONGITUDINAL SECTION

UNIT DATA

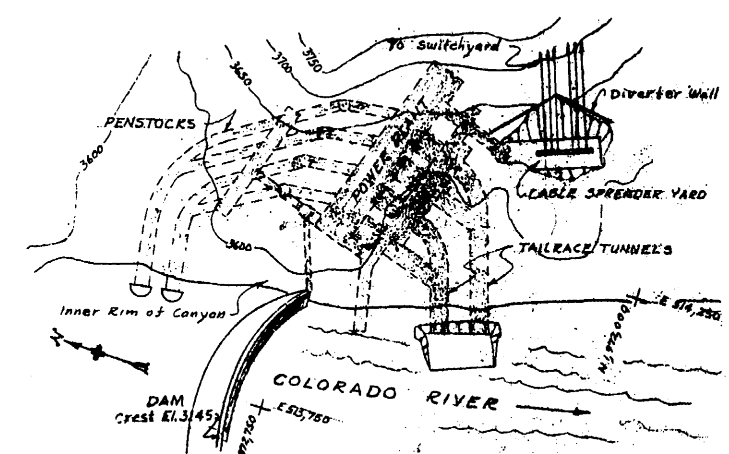
4 UNITS @ 150 MW EACH .... 600 MW
RATED HEAD .... 280 FT.
SPEED .... 100 RPM
Q - PER UNIT .... 7,700 CFS

NOTES

All excavated surfaces between elevations 2819 and 2885 to be lined with a 2 inch thickness of pneumatically applied concrete reinforced with woven wire mesh to prevent air slaking of the siltstone layers of the Muav Formation. Surfaces below El. 2819 should be coated with asphalt or similar material as temporary protection pending placement of first stage concrete.

* Access facilities schemes as outlined in speedletter to Regional Director from ACCE dated September 6, 1962.

10 0 50
Scale of Feet



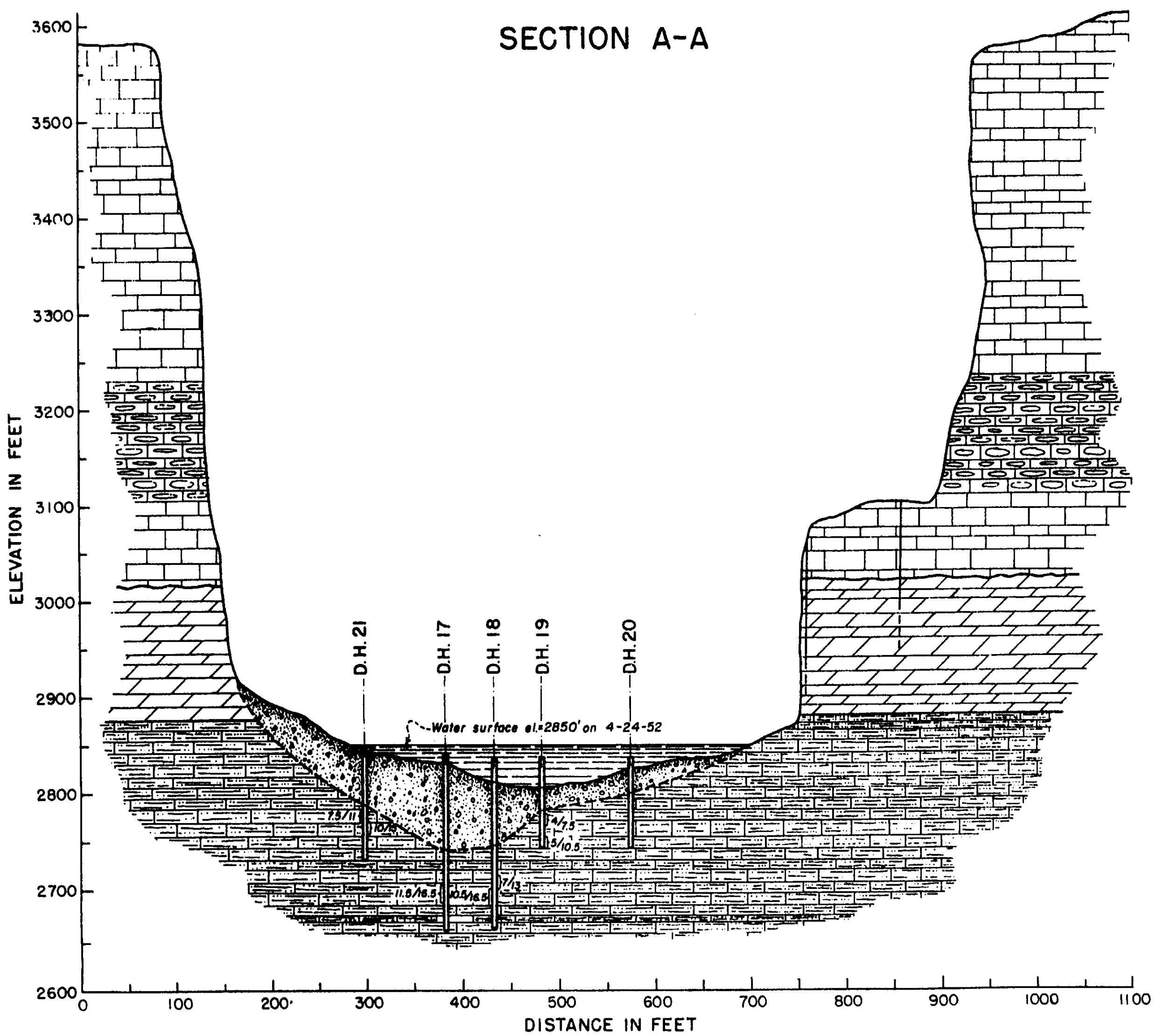
GENERAL PLAN OF SITE
SCALE 1" ≈ 200'

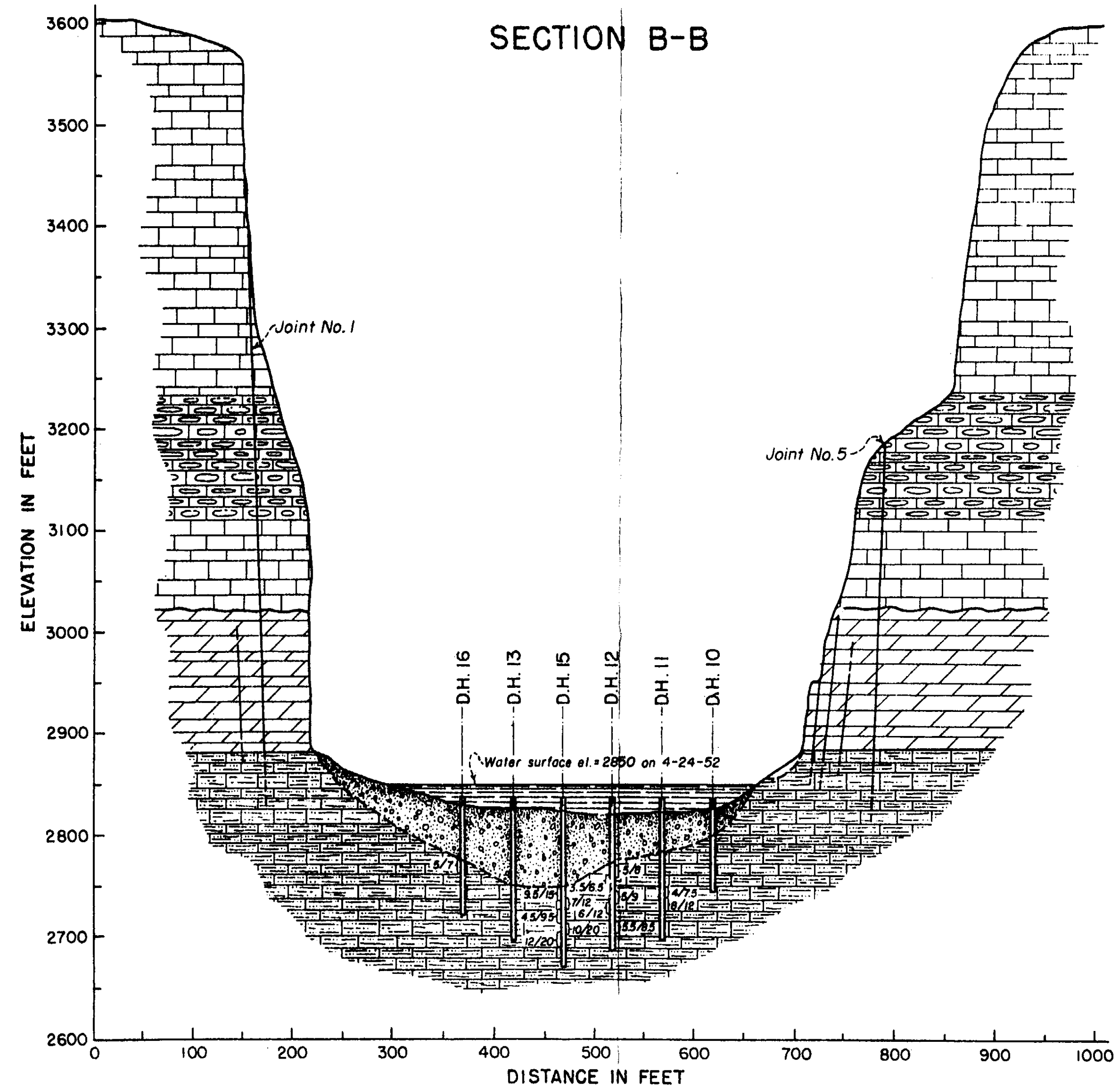
ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MARBLE CANYON PROJECT - ARIZONA
MARBLE CANYON POWER PLANT
RIVER MILE 39.5 SITE
CAPACITY 600 MW
FEASIBILITY ESTIMATE
PLANT LAYOUT

DRAWN .... SUBMITTED ....
TRACED .... RECOMMENDED ....
CHECKED .... APPROVED ....
DENVER, COLORADO OCT. 15, 1963 788-D-20

INTERIOR-RECLAMATION, BOULDER CITY, NEVADA





EXPLANATION

- Talus
- River fill (sand, gravel, and boulders)
- Supai formation
- Massive limestone } Redwall formation
- Cherty limestone } Redwall formation
- Temple Butte formation
- Cambrian dolomite formation
- Muav formation
- 5/8 — Loss in gpm. at 50 lbs. per sq inch / Loss in gpm. at 125 lbs. per sq. inch

REFERENCE DRAWINGS

Geologic Map.........788-300-38

50 0 100 200 300
SCALE OF FEET

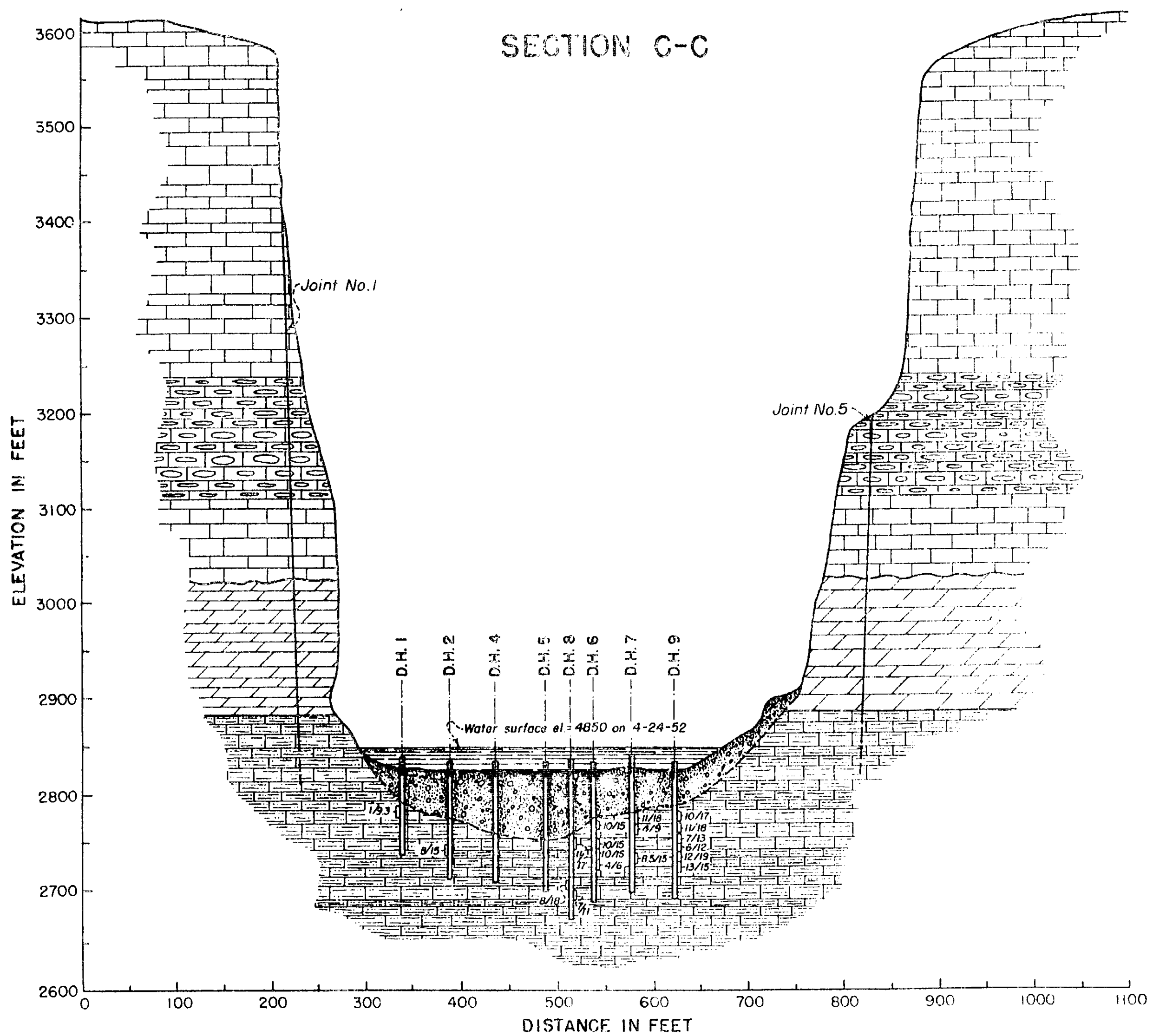
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MARBLE CANYON PROJECT-ARIZONA

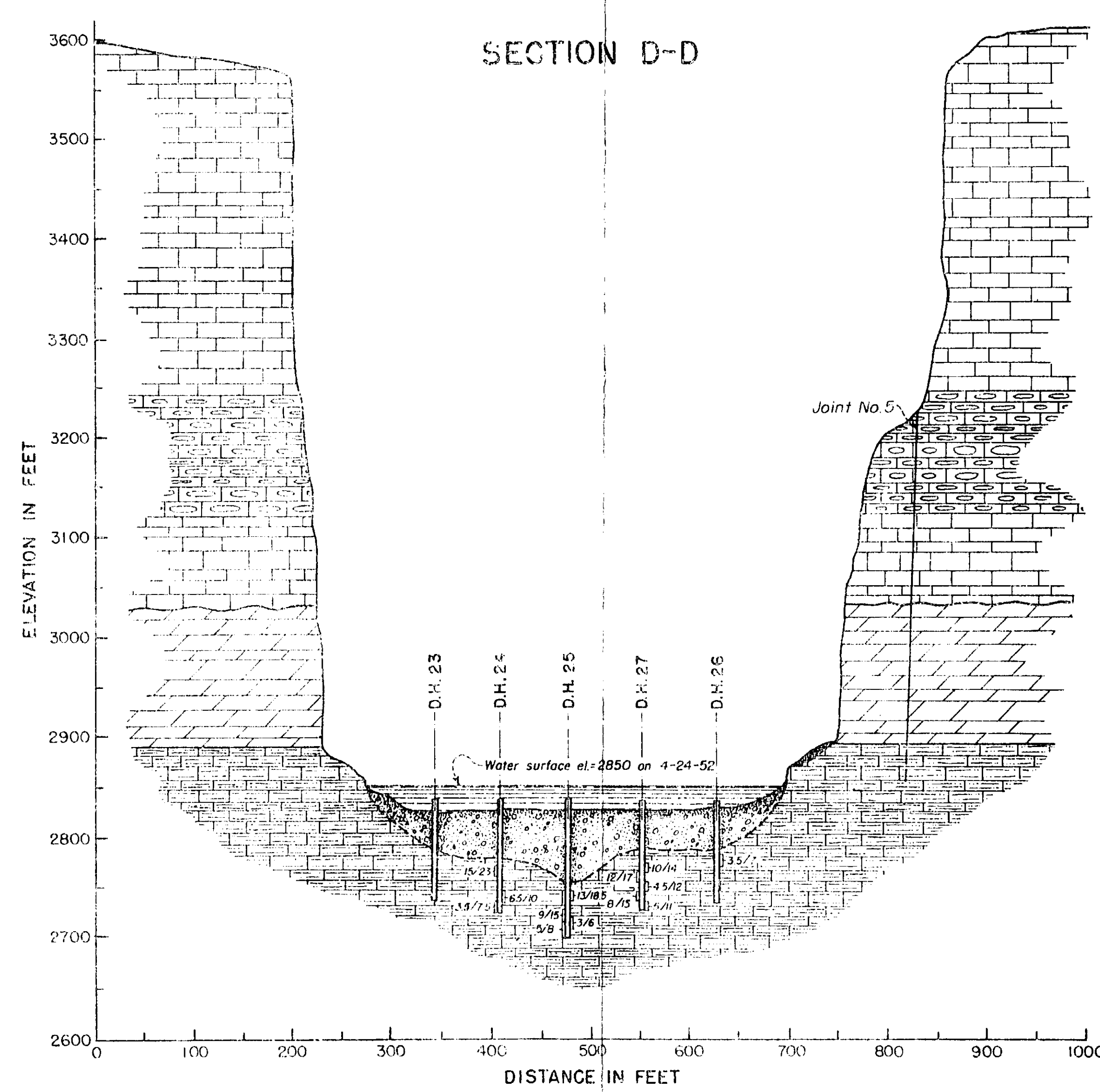
GEOLOGIC SECTIONS AA AND BB

MARBLE CANYON MILE 39.5 DAM SITE

DRAWN: G.D.L. SUBMITTED:
TRACED: R.S.W. RECOMMENDED:
CHECKED: APPROVED:
BOULDER CITY, NEV. 2-24-53 SHEET 2 OF 5 | 788-300-39

INTERIOR-RECLAMATION, BOULDER CITY, NEVADA





EXPLANATION

- Talus
- River fill (sand, gravel, and boulders)
- Supai formation
- Massive limestone } Redwall formation
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- Temple Butte formation
- Cambrian dolomite formation
- Muav formation
- 5/8 — Loss in gpm at 50 lbs. per sq. inch / Loss in gpm at 125 lbs. per sq. inch

REFERENCE DRAWINGS

Geologic Map........788-300-38

50 0 100 200 300
SCALE OF FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MARBLE CANYON PROJECT-ARIZONA

GEOLOGIC SECTIONS CC AND DD

MARBLE CANYON MILE 39.5 DAM SITE

DRAWN: G.B.J. SUBMITTED:
TRACED: H.S.W. RECOMMENDED:
CHECKED: APPROVED:
BOULDER CITY, NEV. 2-24-53 SHEET 3 OF 5 788-300-40

INTERIOR-RECLAMATION, BOULDER CITY, NEVADA

Owing to space limitations, only minor shops and equipment storage, together with aggregate stockpiling, could be provided on the rim of the inner gorge. Administration, major fabrication plants, and warehouses would need to be located on the plateau adjacent to the top of the outer rim of the canyon. Therefore, the capacity and dependability, as well as costs of the access facilities from the outer rim to the top of the inner gorge, are of major importance. Alternative cableway and inclined railway systems were studied previous to the selection of the road plan. The selected road plan would consist of two tunnels, totaling 2.9 miles in length, and 2.2 miles of open roadway traversing the rugged walls of Marble Canyon. The road would descend about 1,600 feet in its 5.1-mile length.

On-site construction access to the river could be provided by the installation of the usual construction cableway system extending across the top of the inner gorge. The powerplant hoist shaft shown on Drawing No. 788-D-21 would also provide access to the powerplant and dam construction areas. The hoist shaft and powerplant elevators would also provide access to all parts of the dam and powerplant for operational and maintenance operations.

Community facilities--Owing to the remoteness of the Marble Canyon construction site, it would be necessary to establish a townsite with all community facilities for the employees and their families. An area on Tatahatso Point, about 1 mile from the rim of the canyon, would be suitable for the townsite. The site is located adjacent to the access road and convenient for the construction of the necessary service facilities. Water supplies would be pumped from the Colorado River and filtered for domestic use. Electrical power could be obtained from the system used to supply that needed for construction operations.

Construction materials--There are no natural sand and gravel deposits in the immediate vicinity of the damsite. The Redwall limestone, comprising the upper part of the inner gorge along the construction area, would be processed for concrete aggregate. Adequate room is available along the left side of the top of the inner gorge upstream of the construction area for quarrying, processing, and storage operations. This material would not be available until the access road to the inner gorge was completed. Therefore, less desirable aggregate would be used for earlier features, such as access roads, townsite facilities, and some construction facilities. Material suitable for these purposes could be obtained from the Shinarump conglomerate capping Bodaway Mesa, one end of which is located along the access road about 7 miles west of Cedar Ridge.

Transmission system--Transmission lines will be constructed from the Marble Canyon Powerplant to the load centers in the power market area and integrated with other plants on the Colorado River for maximum utilization of the hydroelectric power potential. The transmission lines would interconnect Marble Canyon Powerplant with the load centers, the Parker-Davis and Colorado River Storage Project transmission system, and the Havasu Pumping Plants. Switching stations and substations would also be built to provide for line sectionalizing, interconnection with existing Bureau transmission systems, and delivery of power and energy at the load centers.

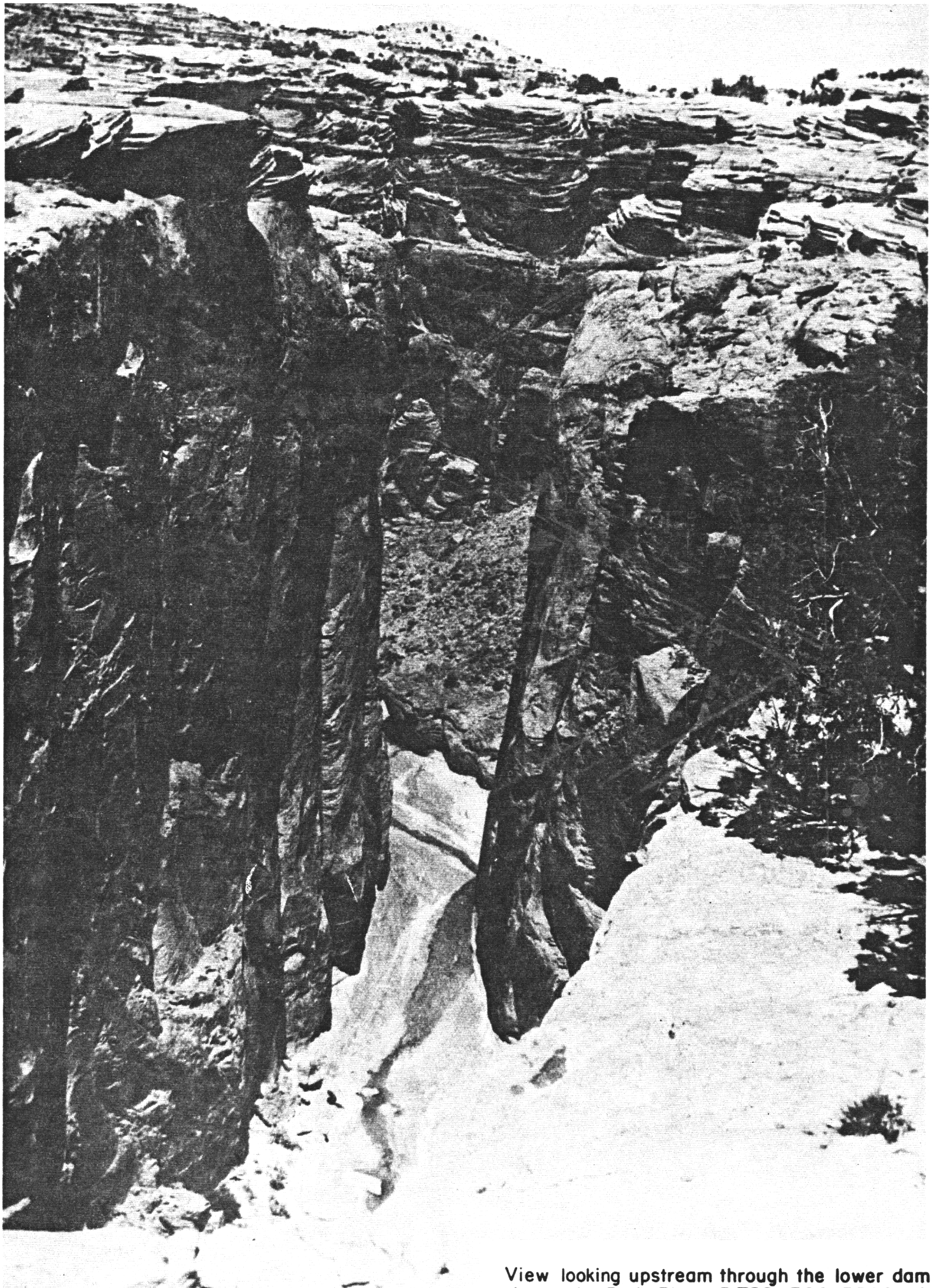
Rights-of-way--The Marble Canyon Dam and Reservoir site is in the Marble Canyon and Glen Canyon gorges of the Colorado River in an area of arid desertland in northern Arizona. The land on the eastern side of the river is in the Navajo Indian Reservation, and on the western side of the river the area is public land. All of the reservoir area has been withdrawn either under powersite reservations or Reclamation withdrawals. An exception to the above is 160 acres of patented land, known as the "Old Lee Homestead," lying at the mouth of the Paria River. The property was at one time well improved, and some of the buildings have been well maintained and are in excellent condition. A cemetery is located at the northwest corner of the irrigated land. A portion of the patented land is presently being developed by the National Park Service as a part of the Glen Canyon National Recreation Area.

The Marble Canyon Reservoir, the campsite, and access roads will not affect any patented land other than the "Old Lee Homestead." Rights-of-way over the Navajo Indian Reservation would need to be acquired by negotiations with the Navajo Indians prior to the start of construction.

A reservoir water surface, rising to elevation 3145, will necessitate relocating the stream gages now located on the Paria River near its mouth and on the Colorado River at Lees Ferry. The Paria River gage could be moved up that stream without difficulty. The measurement of Glen Canyon Reservoir releases may require special instrumentation of Glen Canyon Powerplant turbine penstocks, river outlet, and spillways. The gage measurements will be used to determine the releases that will be required from Glen Canyon Reservoir to fulfill the terms of the Colorado River Compact. Relocation of these gages will require the concurrence of the seven Colorado River Basin States.

Paria River Dam and Reservoir

The need--The Glen Canyon Dam will remove essentially all of the sediment from the Colorado River originating upstream from the dam. However, between the Glen Canyon and the Marble Canyon Dam sites, there is a sediment contribution to the Colorado River estimated to average 5,100 acre-feet annually. Of this amount, it is estimated that the Paria River contributes about 4,475 acre-feet annually. The Paria River enters the Colorado at Lees Ferry, about 15 miles downstream from Glen Canyon Dam site and about 40 miles upstream from the Marble Canyon site.



View looking upstream through the lower dam site on the Paria River. P 788-300-3502-10.

Owing to the small capacity of the Marble Canyon Reservoir and to the fact that it would extend upstream to the tailwater of Glen Canyon Dam, this inflow of sediment becomes important from the standpoint of the prospective life of usable reservoir capacity. The accumulation of sediment in Marble Canyon Reservoir also would affect the tailwater elevations and production of power at the Glen Canyon Powerplant, and decrease the usefulness of the recreational facilities presently being constructed at Lees Ferry.

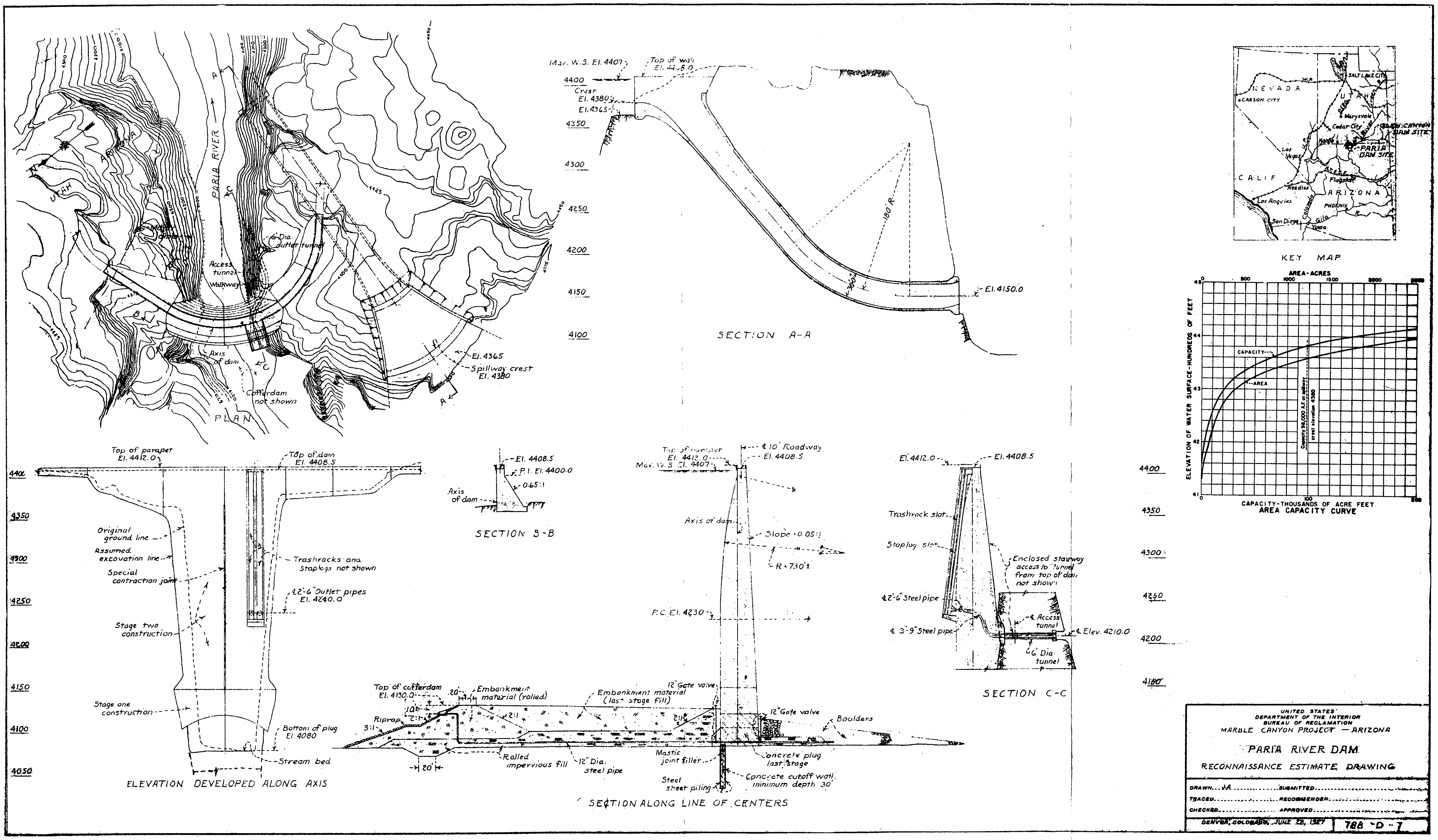
Paria Dam and Reservoir would curtail this detrimental deposition of sediment by storing the major portion of the Paria River's sediment load. The reservoir would store 235,000 acre-feet of sediments which otherwise would be deposited in Marble Canyon Reservoir.

The dam--The Paria River Dam site would be located in a gorge section of the Paria River, about 23 miles above its confluence with the Colorado River, and immediately downstream from the junction of Buckskin Gulch. The location, as shown on Drawing No. 65-314-24, is at the Utah-Arizona boundary line in the rugged terrain typical of that section of the country. The type of dam would be a concrete-arch plug in the inner gorge, flanked by curved gravity-type sections at the abutments which flatten out from the gorge. Drawing No. 788-D-7 shows the dam section and the area and capacity curves. The top of the dam, elevation 4408.5, would be about 328 feet above streambed. The bottom width of the gorge is about 70 feet. The nearly vertical sidewalls result in an increase in width to only about 120 feet at the top of the inner gorge. A total of 50,000 cubic yards of concrete is estimated for the dam and gravity sections, and another 17,110 cubic yards for the closure plug, spillway crest and walls, outlet structures, and other related features.

The spillway would have a curved uncontrolled crest converging into a tunnel discharging through the right abutment. The spillway would be designed so that an inflow design flood of 96,000 c.f.s. could be safely passed through the spillway and outlet pipes combined.

The proposed outlet works consist of a drop inlet structure protected by trashracks and controlled with stoplog overflow weir crests. The logs would be placed in slots in the structure, by means of handling equipment, to a level just above the top of the retained sediment pool of the reservoir. Their function would be to release normal flows and small floods at a rate slow enough to permit optimum sediment disposal into the reservoir, but with a retention rate to minimize reservoir water evaporation. The two drop inlet units are carried through the dam and converge into a pipe in a discharge tunnel through the right abutment rock. Access for inspection and maintenance of the outlet works would be provided.

Geology--The Paria River Dam site lies in a narrow slot-like gorge cut into Jurassic Navajo sandstone. The Navajo formation is a massive,

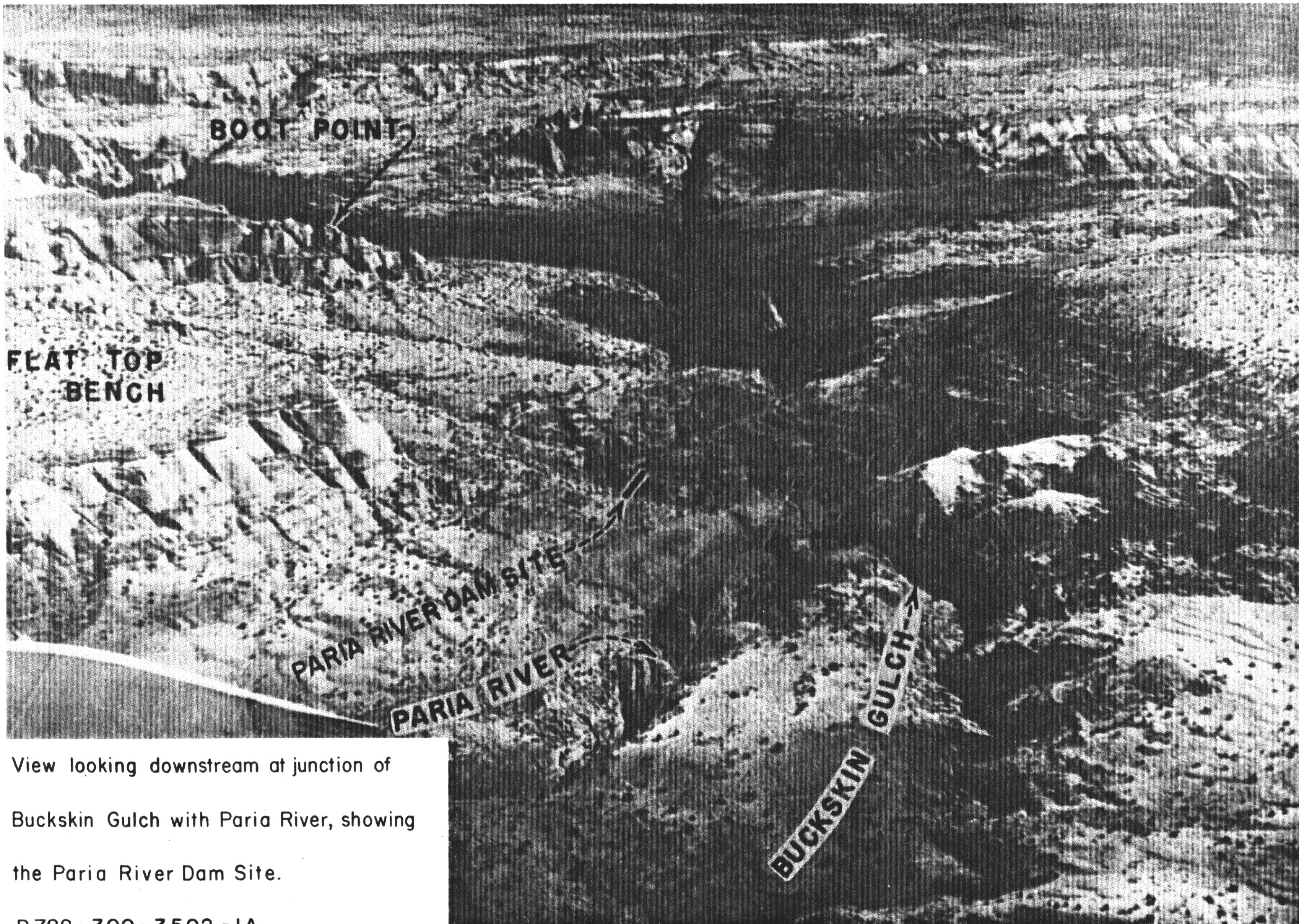


UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MARBLE CANYON PROJECT — ARIZONA

PARIA RIVER DAM

RECONNAISSANCE ESTIMATE DRAWING

DRAWN ...J.R.......... SUBMITTED ....
TRACED .... RECOMMENDED ....
CHECKED .... APPROVED ....
DENVER, COLORADO, JUNE 28, 1947 | 788-D-7



View looking downstream at junction of Buckskin Gulch with Paria River, showing the Paria River Dam Site.

P 788-300-3502-1A.

strongly cross-bedded, medium- to fine-grained sandstone made up essentially of quartz grains. The rock is only moderately hard and is not strongly cemented, yet stands in nearly vertical walls. It is relatively porous, but water will not move rapidly through it owing to the small size of the intergrain voids. This rock is the same formation and comparable to the rock at the Glen Canyon site. The extensive test data on the physical character and behavior of the rock at Glen Canyon are believed applicable to the rock at the Paria River Dam site. The upper part of the reservoir is an erosional valley cut out of the Corral shale and Entrada sandstone. There are no roads in the vicinity of the damsite, and at present access is difficult. No drilling has been done at the damsite, but channel conditions indicate the depth of fill in the stream channel to be from 60 to 100 feet. A detailed foundation exploration program will be required before final designs are prepared.

The preliminary studies do not reveal any geologic defects of any consequence at the damsite. The Navajo sandstone is considered competent for the proposed dam.

Access facilities and relocation of U.S. Highway 89--The damsite is about 33 miles via U.S. Highway 89 from the nearest town and trucking terminal at Page, Arizona. Construction of about 8.1 miles of road across the relatively flat, but sandy, plateau from the State highway to the damsite would be required. At the damsite, the precipitous nature of the narrow canyon would make roadway construction from the rim to the streambed impracticable. Men and materials could easily be lowered to the work by cableways or hoists, with some use of ladders and stairways, as the dam approaches completion.

As a result of sediment deposition and the resulting backwater effects, there would be encroachment upon U.S. Highway 89 in the Paria River Valley. Based on maintaining the standards and approximate length of the existing highway, the relocation would be about 10.7 miles in length, including a 1,000-foot tunnel through Cockscomb Ridge.

Construction materials--A reconnaissance investigation indicated that suitable construction materials are not abundant locally. The best source of concrete aggregate appears to be the deposit on Wahweep Creek, which was developed and used for the construction of Glen Canyon Dam. The haul distance would be about 23 miles. Material suitable for road and highway construction may be available where the highway relocation crosses the Paria River.

Community facilities--Housing would not be provided for Federal employees at the damsite. Owing to the short 2-year construction period and the costs involved in providing utilities and educational facilities at the damsite, it would be more economical to provide transportation from Page for the employees. Page, which is located near Glen Canyon Dam, 33 miles southeasterly via U.S. Highway 89, is expected to have a permanent population of about 3,500 after the departure of Glen Canyon construction employees.

Only those facilities associated with on-job construction management--a material-testing laboratory and building for inspectors--would be located at Paria Dam site. General administration offices and transportation facilities would be located in existing buildings in Page.

Rights-of-way-- The reservoir would occupy private, State, and public domain desert valley lands presently being used for livestock operations. The only rights-of-way that would need to be purchased consist of 760 acres of patented lands, as rights-of-way are reserved on the State lands and the necessary public domain lands are under Reclamation withdrawal.

Estimated Costs

Construction costs--The estimated capital cost of the Marble Canyon Project, on the basis of October 1963 prices, is $238,654,000. This total includes contingencies, engineering, general expenses, land and rights, relocation of existing property, and construction and recreational facilities. The following tabulation presents a summary of the costs:

Marble Canyon Dam and Reservoir	$ 37,079,000
Marble Canyon Powerplant	79,104,000
Marble Canyon Access Road	21,300,000
Marble Canyon Headquarters	6,565,000
Transmission Facilities	81,000,000
Fish and Wildlife Facilities	1,500,000
Recreation Facilities	1,346,000
Total	$227,894,000
Paria River Dam and Reservoir	10,760,000
Project Total	$238,654,000

A more detailed cost summary is presented in table 1.

7-1720
(6-62)
Bureau of Reclamation

BASIC ESTIMATE DC-I SUMMARY

Prepared by Phoenix Development Office

PROJECT MARBLE CANYON
Date of Estimate October 24, 1963
Prices as of October 1963
Sheet 1 of 1 sheets

Previous Estimate
Prices as of ____

PROPERTY CLASS	IDENTI-FICATION	ACCOUNT	PROPERTY DESCRIPTION	LABOR AND MATERIALS BY CONTRACTOR COST	MATERIALS AND EQUIPMENT BY GOVERNMENT COST	LABOR BY GOVERNMENT FORCES COST	FIELD COST PROPERTY ACCOUNT	TOTAL FIELD COST IDENTIFIED PROPERTY	SERVICE FACILITIES IDENTIFIED PROPERTY	INVEST'GNS ENGR'G. AND OTHER COST IDENTIFIED PROPERTY	TOTAL COST IDENTIFIED PROPERTY	TOTAL COST PROPERTY CLASS	Previous Estimate TOTAL COST IDENTIFIED PROPERTY
1			2	3	4	5	6	7	8	9	10	11	12
01			RESERVOIRS AND DAMS									69,049,000	
	01		MARBLE CANYON DAM					47,979,000		10,400,000	58,379,000		
		30	Lands and Rights	219,000			219,000						
		35	Dam	27,990,000	2,730,000		30,720,000						
		50	Roads, Railroads, and Bridges	17,040,000			17,040,000						
	02		PARIA DAM					8,781,000		1,889,000	10,670,000		
		30	Lands and Rights	300,000			300,000						
		31	Relocation of Existing Facilities Highway U.S. 89	3,370,000			3,370,000						
		35	Dam	4,625,000			4,625,000						
		50	Roads, Railroads, and Bridges	486,000			486,000						
11			POWERPLANTS - HYDRO									79,104,000	
	01		MARBLE CANYON POWERPLANT - 600,000 kw.					65,920,000		13,184,000	79,104,000		
		33	Structures and Improvements	17,755,000	235,000		17,990,000						
		36	Waterways	12,660,000	3,120,000		15,780,000						
		41	Turbines and Generators	16,410,000	6,310,000		22,720,000						
		48	Accessory Electric Equipment	580,000	2,720,000		3,300,000						
		49	Miscellaneous Equipment	100,000	900,000		1,000,000						
		50	Roads, Railroads, and Bridges	4,120,000	1,010,000		5,130,000						
13			TRANSMISSION LINES, SWITCHYARDS, AND SUBSTATIONS									1/ 81,000,000	
	01		MARBLE CANYON TRANSMISSION SYSTEM	67,500,000				67,500,000		13,500,000	81,000,000		
15			GENERAL PROPERTY									2,846,000	
	01		RECREATIONAL FACILITIES	1,122,000				1,122,000		224,000	1,346,000		
	02		FISH AND WILDLIFE	1,250,000				1,250,000		250,000	1,500,000		
GL	130		SERVICE FACILITIES					5,324,000		1,331,000	6,655,000	6,655,000	
	01		Marble Canyon Construction Camp	5,252,000			5,252,000						
	02		Paria Construction Buildings	72,000			72,000						
			TOTALS	180,851,000	17,025,000			197,876,000		40,778,000		238,654,000	

1/ Total cost transmission lines based on 600,000 kw. Powerplant at $135 per kw.

TABLE 1

Construction program and schedule--The proposed construction, as presented in table 2, contemplates a preconstruction period of 6 months and an actual construction period of 7 years. Initial contracts would be for construction of the Marble Canyon access road and construction camp, followed by the Marble Canyon Dam and Powerplant. The Marble Canyon transmission system and Paria Dam and access road would be the final major contracts awarded. Initial reservoir storage would be in the fifth year of construction, with initial power generation the latter part of the following year.

Operation, maintenance, and replacement costs--Annual costs consist of those required for operation and maintenance, including administrative and general expenses, and those associated with replacement of equipment. The following tabulation presents a summary of the annual costs of the principal features of the project. The annual costs for Paria River Dam allow for periodic inspections, routine maintenance, and placing of the outlet stoplogs as required.

Feature	Operation and Maintenance	Replacement	Total
Marble Canyon Dam and Headquarters	$100,000	$ 12,000	$ 112,000
Marble Canyon Powerplant	336,000	115,000	451,000
Marble Canyon Transmission System	-	-	1,215,000 1/
Marble Canyon Access Road	19,000	0	19,000
Marble Canyon Recreation Facilities	100,000	37,000	137,000
Paria Dam and Access Road	5,000	0	5,000
Subtotal			$1,939,000
Energy Purchase			391,000
Total annual costs			$2,330,000

1/ Consists of operation, maintenance, and replacement costs.

TABLE 2

LEGEND: Types of Activity

Preconstruction — Construction

LINE NO.	CLASS AND ACCOUNT	PROGRAM ITEM	QUANTITY	UNIT	ESTIMATED TOTAL	TOTAL TO JUNE 30, 1965	FISCAL YEARS 1	2	3	4	5	6	7	BALANCE TO COMPLETE	ESTIMATED COMPLETION DATE	LINE NO.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1		Power Development - Hydro.	600,000	kw.												1
2																2
3																3
4		CONSTRUCTION PROGRAM														4
5																5
6	01.01	Marble Canyon Dam and Reservoir	363,000	a.f.	37,079,000	155,000	1,000,000	2,000,000	10,000,000	10,000,000	9,000,000	4,924,000				6
7	01.01.50	Marble Canyon Access Road			21,300,000	90,000	7,000,000	14,210,000								7
8	10.02	Paria Dam and Access Facilities			10,670,000	43,000				500,000	2,170,000	4,000,000	3,957,000			8
9	11.01	Marble Canyon Powerplant	600,000	kw.	79,104,000	369,000	1,000,000	2,000,000	9,000,000	18,000,000	18,000,000	18,000,000	12,735,000			9
10	13.01	Transmission System	115 to 345	kv.	81,000,000	395,000		1,000,000	2,000,000	18,000,000	21,000,000	20,000,000	18,605,000			10
11	GL 130.01	Marble Canyon Construction Camp			6,565,000	28,000	1,000,000	2,500,000	3,037,000							11
12	GL 130.02	Paria Construction Buildings			90,000	1,000				9,000	80,000					12
13	15.01	Recreational Facilities			1,346,000	-						46,000	1,300,000			13
14	15.02	Fish and Wildlife Facilities			1,500,000	-					500,000	1,000,000				14
15																15
16		TOTAL CONSTRUCTION COST			238,654,000	1,081,000	10,000,000	21,710,000	24,037,000	46,509,000	50,750,000	47,970,000	36,597,000			16
17																17
18		TOTAL PROJECT COST			238,654,000	1,081,000										18
19		Consolidated Expenditures and Credits			-166,000	-166,000										19
20		TOTAL EXPENDITURES			238,488,000	915,000										20
21																21
22		TOTAL OBLIGATION			238,438,000	915,000	10,000,000	21,710,000	24,037,000	46,509,000	50,750,000	47,970,000	36,597,000			22
23																23
24																24
25																25
26																26
27																27
28																28
29																29
30																30
31																31
32																32
33																33

Notes:

Recommended: ______ (Operating Office Head) ______ (Date)

Recommended: ______ (Regional Director) ______ (Date)

Recommended: ______ (Chief, Div. of PC & F) ______ (Date)

Approved: ______ (Commissioner) ______ (Date)

Revised: ______ (Date) SHEET ___ OF ___ SHEETS

Form PF-2 — UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION — AUG. 1961

CONTROL SCHEDULE

MARBLE CANYON PROJECT

Phoenix, Arizona (OFFICE) — December 9, 1963 (DATE) — 3 (REGION)

☐ GENERAL INVESTIGATIONS ☐ LOAN PROGRAM ■ CONSTRUCTION ☐ OTHER

GPO 848874

C H A P T E R   I I I

E C O N O M I C

A N A L Y S I S

CHAPTER III - ECONOMIC ANALYSIS

Economic Justification

The Marble Canyon Project would provide several different types of benefits to the economy and well-being of the Pacific Southwest area. The nature of these benefits and the method by which they were derived are described in the following paragraphs. Derivation of the other major elements required in showing economic justification--the project's cost--has been described in a preceding chapter.

Power Benefits

Benefits accruing from the production of commercial power were determined as costs of producing similar-type power at the lowest-cost alternative source. It was assumed that the most likely alternative source would be steam-electric plants located near load centers in the Lower Colorado River Basin power market area. The lowest-cost source in the area, according to information available from the Federal Power Commission, would be publicly owned non-Federal, gas-fired steamplants in the Phoenix and Los Angeles areas. The cost of energy produced at such plants was used as the basis for an estimate of alternative costs at the various load centers. On this basis, the average annual equivalent value of this cost was estimated to be $17,359,000, which was used as annual benefits for the power produced at Marble Canyon Powerplant. This value includes an item of $391,000 which represents the annual cost of purchasing power to firm the on-peak generation of the Marble Canyon power as developed in the Pacific Southwest Water Plan.

Irrigation and Municipal and Industrial Water Supply Benefits

Irrigation water supplies would not be developed by the Marble Canyon Project, as the Marble Canyon Reservoir is operated primarily for power production and the Paria Reservoir for sediment retention. Seasonal regulation of the Colorado River flows is provided by Glen Canyon Reservoir.

Adverse Power Effects

The backwater of the Marble Canyon Reservoir would encroach slightly on the tailwater of the Glen Canyon Powerplant which would have an adverse effect on the production of electrical energy at Glen Canyon. The annual loss of revenue to the Upper Colorado River Basin Fund resulting from the reduction in generation of electrical power and energy at Glen Canyon Powerplant would be about $185,000. However, the additional powerhead that would be made available for the Marble Canyon Powerplant by this encroachment would result in additional Marble Canyon revenues averaging about $350,000 annually. This potential loss of revenue to the Colorado River Storage Project has been considered as a debit to the Marble Canyon Project and, as such, has been deducted from Marble Canyon annual benefits. Deduction of the $185,000 from the total annual benefits of $17,359,000 leaves a net annual benefit of $17,174,000 accruing to Marble Canyon Project.

Recreation Benefits

The National Park Service has prepared a report on recreational use and development for the Marble Canyon Project. The National Park Service is presently constructing recreation facilities at Lees Ferry as a part of the Glen Canyon National Recreation Area. That agency estimates that, owing to the additional boating area and possible scenic boat trips through the gorge of Marble Canyon, construction of the Marble Canyon Project would provide additional annual recreation benefits of $315,000. These annual benefits would accrue from recreational visits of 100,000 persons, with a visitor-day value of $0.52, 50,000 scenic sightseers with a value of $5 per waterborne sightseer, and 25,000 days of camping with a visitor-day value of $0.50.

Fish and Wildlife Benefits

The project would provide for fish and wildlife conservation. The Bureau of Sport Fisheries and Wildlife, which is preparing a report on the project's effect on fishing and wildlife aspects, furnished the following information.

Marble Canyon Reservoir will provide fishing of good quality in a region of the United States where a longstanding shortage of fishing waters is being compounded by phenomenal growth of both local population and the number of visitors seeking recreational facilities. It is manifestly desirable that full advantage be gained from the reservoir's sports-fishing potential. The surface area created by the reservoir would, according to the Bureau of Sport Fisheries and Wildlife, create about 120,000 fisherman-days, with a benefit value of $360,000 annually.

Area Redevelopment Benefits

Marble Canyon Project would be constructed on the Navajo Indian Reservation, a designated redevelopment area. It is assumed that unemployed reservation labor would be utilized, wherever possible, in the construction, operation, and maintenance of the project, including the operation of the recreational facilities.

Estimates of the amount of Indian labor that would be utilized in the construction, operation, and maintenance of the project were based on employment records of the Glen Canyon Unit of the Colorado River Storage Project. The annual area redevelopment benefits accruing from the construction and operation of the Marble Canyon Project are estimated as follows:

Construction	$107,000
Operation	38,000
Total Annual	$145,000

Effect on Public Health

The Public Health Service, Department of Health, Education and Welfare, prepared a report on the effects of the Marble Canyon Project on the public health. The report states that the project will not affect the quality of the water of the Colorado River and that, with proper management, the reservoir will not create a mosquito problem. Therefore, no benefits are assignable to the public health aspects.

Effect on Mining and Minerals

A report by the Bureau of Mines states that there are not any known mineral deposits of commercial value within the reservoir area. Therefore, no benefits are assignable to mining and minerals.

Benefit and Cost Summaries

The following tabulation presents a summary of the annual benefit values; also the total of these benefits derived for a 100-year period of analysis, using an interest rate of 3 percent:

Purpose	Annual Benefits
Power	$17,174,000
Fish and Wildlife	360,000
Recreation	315,000
Area Redevelopment	145,000
Total	$17,994,000

The derivation of the average annual costs from the estimated construction costs and annual operational costs of the project facilities is presented in table 3.

Benefit-Cost Analysis

The total annual benefits of $17,994,000 accruing from the project exceed the total annual costs of $10,487,000 for the 100-year period of analysis, at a ratio of 1.7 to 1.0.

Table 3

Derivation of Average Annual Project Costs

Marble Canyon Project

	100-Year Period of Analysis
Construction Costs 1/	$237,573,000
Interest During Construction 2/	20,174,000
Total Federal Costs	$257,747,000
Average Annual Equivalent Costs 3 percent interest 100-year period	$ 8,157,000
Annual Operation, Maintenance, and Replacement Costs 3/	2,330,000
Total Average Annual Project Costs	$ 10,487,000

1/ Excludes $166,000 of nonreimbursable and $915,000 of reimbursable investigation costs.

2/ Interest during construction computed at 3 percent.

3/ Also includes annual operation, maintenance, and replacement cost of recreation facilities and cost of purchased energy.

CHAPTER IV - ALTERNATIVE PLANS

General

In the process of formulating the plan for the Marble Canyon Project, numerous alternative plans and damsites were studied. Some of these studies were in considerable detail, and some were reconnaissance in nature. It is believed that all practical alternatives have been considered, and that the selected plan will best fulfill the overall plan of development for the Lower Colorado River.

From the earliest plans for the development of the Colorado River, it was conclusive that the construction of a dam in the Marble Canyon would be necessary for maximum utilization of the potential powerhead available in the reach of the river extending from the north boundary of Grand Canyon National Park to Glen Canyon Dam.

In 1945, the first studies by the Bureau of Reclamation began with an examination of topographic maps and geographic surveys prepared by the U.S. Geological Survey in 1923. From these investigations it was decided that the reach of Marble Canyon, extending from Mile 29 to Mile 45 (measurement from Lee Ferry Gage), would be the one most likely to have suitable damsites which would fit into the overall plan of development of the Colorado River.

Damsite Selection

Marble Canyon Dam--Several alternative damsites were considered along the river reach from Mile 29 to Mile 45. Reconnaissance field investigations resulted in the selection of possible damsites at Miles 29.9, 32.4, 32.8, 37.5, and 39.5. Profiles and geologic sections of these river sites were made, and from these data preliminary engineering studies eliminated the sites at Miles 29.9 and 32.4. Studies of the remaining sites, Miles 32.8, 37.5, and 39.5, all indicated foundation materials suitable for a concrete dam. The Mile 37.5 site was considered inferior because of a badly eroded joint system behind the left abutment, and was, therefore, eliminated from further field studies.

During a 4-year period, from 1950 to 1953, both field and office investigations were conducted at Miles 32.8 and 39.5. Extensive drilling and mapping of both sites, as well as reconnaissance estimates prepared by the Chief Engineer's office, revealed both sites to be suitable for a concrete dam.

Further economic and engineering studies resulted in the selection of the Mile 39.5 site. A dam at Mile 39.5 would develop approximately 30 feet more powerhead, and provide about 114,000 acre-feet more storage capacity than could be obtained from a similar dam at Mile 32.8. This additional powerhead and reservoir capacity would create approximately $3,000,000 more annual power benefits, with no decrease in the project's benefit-cost ratio.

Alternate sediment-retention damsite--Reconnaissance field studies were made of several possible locations of a sediment-retention dam on the Paria River and its tributaries before a final site was selected. The Paria River site was selected because studies indicated that the cost of obtaining adequate sediment storage capacity by the construction of a dam at this site would be less than that of dams located at other sites.