REPORT OF COLORADO RIVER COMMISSION OF ARIZONA

1931-1932

Marble Gorge Dam Site. Mile 4.5

ACKNOWLEDGMENT

We desire to acknowledge the valuable assistance we have been given in preparing this report by many Arizona citizens who have extended courtesies to our field and office workers. In particular we are indebted to:

Senator H. F. Ashurst, for securing information from Federal Departments.

The faculty of the University of Arizona, for general assistance, including library facilities.

Drs. A. A. Stoyanow and E. D. Wilson of the University for Geological investigations.

Dean P. S. Burgess for data on agriculture and Prof. G. E. P. Smith for data on water duty, etc.

J. B. Tenney, Geologist, Bureau Mines, University of Arizona.

Harry A. Clark, Smelter Manager and Harry M. Lavender, Mining Supt. of the Phelps Dodge Corporation.

Robert M. Tally, General Manager and C. E. Mills, Assistant Mine Superintendent, United Verde Copper Company, for cost data on shafts, tunnels, etc.

The management of the Verde Power and Irrigation District, The Roosevelt Irrigation District, Arizona Water Conservation District, Maricopa County Municipal Water Conservation District, Maricopa County Southern Water Conservation District and San Carlos Project for maps and information concerning their projects.

Porter J. Preston of the Bureau of Reclamation for the opportunity to train soil investigators with his field, laboratory and office forces.

Grace Sparks, Secretary, Prescott Chamber of Commerce for information concerning power consumption in the mining industry.

Harry A. Stewart, Maricopa County Agent, for the use of equipment and data on methods of soil improvement, etc.

White and Miller, contractors, Tucson, for general cost data, etc.

The engineering and soil investigating forces who have loyally endured many hardships and adverse weather conditions, inspired by the expectancy of participating in the creation of a greater state of Arizona.

E. C. LaRue, former engineer of U. S. G. S. participated in the investigation of the Verde Dams and B. F. Jakobsen of Los Angeles made the estimates for dams and power plants.

Wm. H. Bartlett assisted in the investigation of Verde Dam sites.

L. C. Lashmet assisted on the computations for steel siphons and penstocks.

PURPOSE

The purpose of this report is to answer the questions that naturally arise in the minds of individuals or a court as to the feasibility of the irrigation of Arizona lands by the use of the waters of the Colorado River and its tributaries. Some of these questions are:

What is the amount of land that can be irrigated?

Where is it located?

What is the ability of the soil to produce commercial crops?

What is the best means of bringing water to the land?

How much is the approximate cost per acre?

How can Arizona projects be financed?

When our Commission entered on its duties no one could answer these questions. We have endeavored to do so as economically as possible. We do not claim the data secured is equal to that obtainable by the usual expenditure of from $ .50 to $1.00 per acre on preliminary investigation of irrigation projects, but assert that it is sufficient to show that Arizona has over 2,700,000 additional acres of good land that can be irrigated by gravity, that the cost of its irrigation would not be prohibitive, and that simultaneous industrial and commercial development would result in Arizona becoming one of the great states of the Union.

We have also endeavored to explain the growth and evil effect of federal bureaucratic control of the greater part of this state, the menace in the impending Mexican Treaty, the injustice done Arizona by the national government and our hope of a new deal.

We believe that the various resolutions, acts and appropriations of the Arizona Legislatures, the opposition of our Congressional delegation to the passage of the Boulder Dam Act, the suit by the Attorney General in the Supreme Court, and the public declaration of the Chief Executive are notices to the world that this state does not acquiesce in the acts of the Secretary of Interior and other federal officials pertaining to the water and power resources of the Colorado River, and that it may never be justly said that Arizona has slept on her rights.

In addition, we allege that this report is an act of due diligence, in an endeavor to maintain the filings, appropriations and all the legal rights of the State of Arizona and its citizens to the waters of the Colorado River.

SCOPE OF THE WORK

Field work performed in order to obtain information for this report includes a geological investigation from Glenn Canyon to the mouth of Oak Creek.*

A reconnaissance survey was made of 120 miles of the Verde River and ravine cross sections taken at ten dam sites.

Topographic surveys for 752 miles of canal lines were run to determine the limiting lines of the lands that could be reached by gravity flow.

On 362 additional miles of canals located beyond control points the costs were estimated.

Section line extensions were run in unsurveyed areas for a total of 170 miles.

Approximately 8,000 miles of section lines were traversed. Holes were drilled to a depth of five feet to obtain soil samples, and 15,300 laboratory tests for salt content and soil texture were made in the soil classifications of 3,500,000 acres.

Office work on maps, profiles, etc. was completed as fast as field data was secured, and computations for quantities and estimates have been made in time for insertion in this report. Much of the area covered has not been sectionized, nor are topographic sheets available, and existing maps of the state were found to be considerably in error in the location of mountains, rivers, etc.

Federal topographic surveys cost about 5c per acre. Sectionizing costs about six cents per acre, and the field work for U. S. Bureau of soil surveys cost from two to three cents per acre, or a total of fourteen cents per acre

* A report on the area covered is in our files. It may be included in a University of Arizona publication.

to secure the preliminary information that is desirable in estimating costs for reclamation project. Investigations for irrigation projects by the United States Reclamation Service cost from 50c to $1.00 per acre. On the large areas in Arizona it would have been too expensive to secure the engineering details that are sometimes obtained by the Federal Engineers and soil investigators, but the work done has permitted estimates of quantities far closer than prices can be calculated for construction work at this time.

OMISSIONS

We had hoped to include in our map of Yuma County the soil survey made by the Reclamation Bureau below the 600 foot contour sea level datum. The survey of this section of the State was made at the request of our commission, and done under authority of Paragraph 15 of the Boulder Dam Act. The field work was completed in June, and the maps should be available shortly. One sheet received, covering the government soil examination in Maricopa County has been added to our map. Advance information furnished by Mr. Porter J. Preston is that out of 1,066,439 gross acres examined some 622,252 or 60% are arable.

There are approximately 100,000 additional acres between the 600 and 700 foot levels that fringe the area surveyed by the government on which soil surveys have not been made. This work can be done better after the government maps are obtained. Probably from 50,000 to 60,000 acres of this area will be found arable.

Presumably the Reclamation Bureau will investigate soil conditions and irrigation possibilities on the Colorado River Indian Reservation, and the valleys of Cottonwood, Mohave, Blankenship, Bouse, Posa, Cibola, Chemehuevis, etc. adjacent to the river. These, with the Yuma Valley and Lower Mesa, total about 280,000 acres of arable land.

During the past summer United States Reclamation forces examined some 210,000 acres in the valleys of the Virgin, Kanab and Paria. Of this, 150,000 acres are in Arizona.

Governor Hunt has requested that the portion of Arizona in the Navajo Indian Reservation, in the Valley of the Chinlee, etc. that drains an area of some 4,500,000 acres in the so-called Upper Basin be examined at the same time the other tributary valleys of the San Juan in Colorado, New Mexico and Utah are investigated. This information is essential prior to any compact discussions by the Upper Basin States which include Arizona.

We have not examined the irrigation possibilities in the Little Colorado Basin nor that of the Bill Williams. The latter flows into the main Colorado above the proposed dam at Parker.

No estimates have been made of the amount of land that can be irrigated by pumping Colorado River water beyond the limits of the gravity canals nor of the irrigation that would result from pumping local ground water if cheap power were available.

PRESENT FEDERAL ACTIVITY

Porter J. Preston, Planning Engineer for the United States Reclamation Service, is now engaged in an investigation of the possibilities of irrigation of all of the Basin States, except California, which has already been taken care of with the $165,000,000 federal appropriation for the Hoover Dam, Power Plant and Highline Canal to the Imperial and Coachella Valleys. He has made soil examinations on over a million acres in the Gila Valley, and on the Yuma Mesa, and has run preliminary canal lines, which indicate that the tunnel through the Trigo Mountains can be considerably shortened on the Parker-Gila project. On the contrary, he advises that the proposal of the Metropolitan Water District to construct the Parker Dam, some twelve miles further up stream than originally planned, would add to the canal costs some $22,000,000. The government report should determine whether some 900,000 acres of land should be irrigated from the vicinity of Parker, as proposed by Arizona Engineering Commission, of 1923; or pumping from the Laguna or proposed Imperial Dam, as suggested by the Colorado River Commission in 1927, or if they should be included in the Colorado-Verde project. Federal Reclamation forces are now working in the vicinity of Parker, Arizona.

The State of Arizona and the Federal Government jointly expended about $70,000.00 for topographic surveys in the Lower Gila Valley in 1926-27, and the Bureau of Reclamation has expended approximately $60,000.00 for soil surveys, etc., in this State out of the $250,000.00 authorized in the Boulder Dam Act.

PREVIOUS PLANS

R. M. Stine, in September, 1920, suggested water diversion by a canal from the Boulder Reservoir, for use on Arizona land. Later this project was studied by R. H. Williams, and changed to the Highline Canal plan. In 1921, Mr. H. E. Blake considered a plan to reclaim a large part of the Gila Valley by a 650 foot pump lift. G. E. P. Smith early suggested pumping from a dam near Cocopah point. In 1923, the Arizona Engineering Commission, composed of E. C. LaRue, P. J. Preston and H. E. Turner, reported on the Parker Gila project. It included a dam to elevation 457 feet sea level datum six miles above Parker—eighty seven miles of canal to Lighthouse Rock, 200 feet pump lift to elevation 610, then a sixteen mile tunnel through the Trigo Mountains, twenty miles of canal, diverging through a six mile tunnel under the Muggins Mountains, and a five mile siphon to Dome, etc; also a north side canal to a point eight miles east of the Maricopa-Yuma line. They estimated the construction to cost $107,400,000 for 640,000 acres, or $168.00 per acre, with an operation and maintenance cost of $5.82 per acre. This Commission also planned on irrigating 287,000 acres of land in Arizona, adjoining the Colorado River, including the Yuma-Parker-Mohave projects, etc. or a total for Arizona of 927,000 acres.

As an alternate to the Parker-Gila project of 640,000 acres the Commission considered:

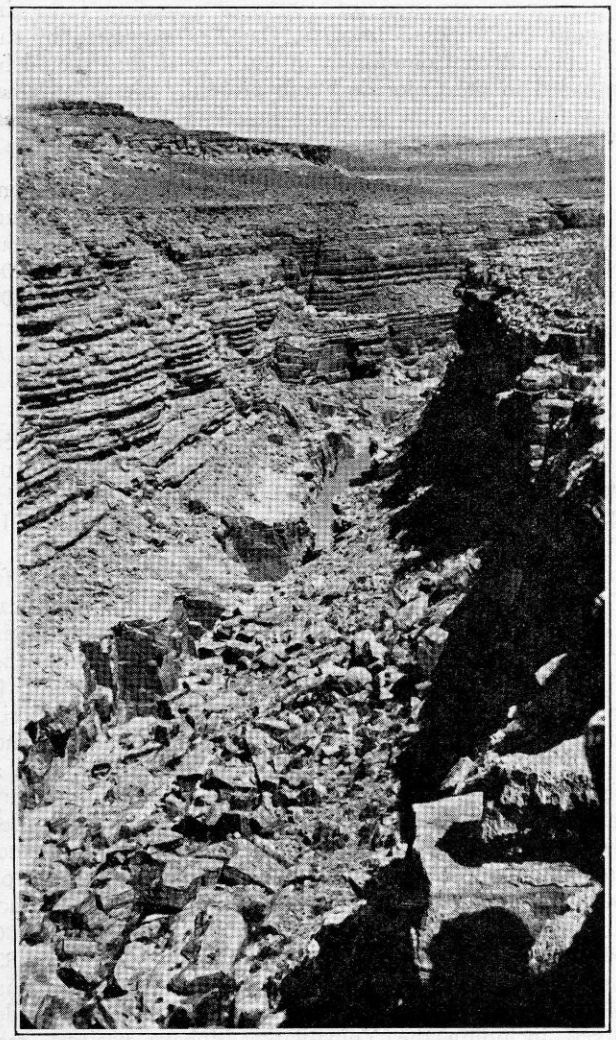
A—The suggestion of Mr. Blake for a dam at Boulder to elevation 1,235 feet (It is now being built to 1,232 feet) with canals to carry water to the Bouse Valley at elevation 970 feet and the Gila Valley at elevation 685 feet.

B—The construction of a dam at Boulder to elevation 1,350 feet with tunnels and canals to the Williams River. Their estimate was $607,000,000 for 2,000,000 acres.

C—A modification of Plan "B" with a 460 foot dam on the Williams River.

D—A modification of Plan C with the dam at Spencer or Bridge Canyon, with a 92 mile tunnel to the Williams river and a 22 mile tunnel to Bouse Valley. This plan proposed the irrigation of 2,000,000 acres at an estimated cost of $480,000,000 less $30,000,000 chargeable to to power, or at the unit cost of $225.00 per acre.

E—A dam in the Colorado River below Lees Ferry, with a 90 mile tunnel to the Verde. This plan was later advocated by C. C. Tillotson.



Coconino Dam Site—Mile 48, Little Colorado

F—A dam at Glen Canyon, with a 50 mile tunnel to the Little Colorado, and a 90 mile tunnel to the Verde.

At the Conference of the Governors, etc. of the Colorado River Basin States, at Denver, in 1927, the Colorado River Commission proposed a plan of pumping from the Laguna Dam to lands in the Gila Valley, including approximately 1,100,000 acres below the 600 foot contour. The maximum lift was 450 feet, and the average 260 feet. This plan would have provided cheap first costs, and the opportunity to develop the land as agricultural demand justified.

SOIL SURVEYS

While it has long been known that it is possible to irrigate millions of acres in Arizona, the arability of this land has been a matter of dispute. Our survey covered some 3,500,000 acres. Township plats have been prepared on a scale of two inches to the mile. These are colored to show the various classifications. The texture of the soil at various depths, and the soluble and insoluble salt contents, are noted as well as topographic features. The Reclamation Department has examined 1,200,000 additional acres, so that information has been obtained in the last two years, covering some 4,700,000 acres, of which some 2,800,000 acres are arable. Much additional arable land is available for irrigation by low pumping lifts if water can be obtained.

Soil classification may be made according to many standards. We adopted that of the Bureau of Reclamation, in order that the areas that can be successfully tilled in Arizona may be compared with those of the other Western States. Various crops prefer acid, neutral or alkaline soil. Leaching of land containing excess soluble salts or chemical reaction on insoluble salts will reclaim lands we have classified as non irrigable. Enhanced value may justify the leveling of lands rejected because of rough topography. *For these reasons the figures given as to arable areas are minimum.* Some soils have been excluded, regardless of the fact that they support heavy desert growth, because they are shallow and are underlain with impermeable clay or caliche strata, or have other disadvantages as to drainage and would water-log if subject to irrigation.

We have been extremely conservative in our soil classification and held to the standards of the Reclamation Service, even where crops are now being successfully cultivated on soils that would be subject to rejection. The yellow areas on the index maps that are marked "a" designate marginal areas that should not yield as great a return as the lands designated class 1 and 2, because of salt contents, or will require larger outlays for leveling than are now considered economical.

The first indication of soil fertility is the present desert growth. Subsurface investigations disclose the possibility of the cultivation of domesticated plants with deeper root systems and are mostly necessary to check surface indications. They usually result in rejection of land appearing good rather than in proving the land better than indicated by surface conditions. In order to keep field examiners quickly advised of salt content in the soil samples taken, the necessary laboratory work was done in camps, and sometimes at night, so that classifications could be made while on the areas in question, and check holes could be put down where necessary.

No attempt was made to secure the exact soil condition on each forty acre tract as the information we desired was the approximate percentage of the various classes

ARIZONA COLORADO RIVER COMMISSION

COLORADO - VERDE PROJECT

INDEX SOIL MAP

OF

LAND IN YUMA COUNTY

1932

ARABLE LAND CLASS 1

ARABLE LAND CLASS 2

MARGINAL LAND CLASS 6A

A

NON-ARABLE LAND CLASS 6

SCALE IN MILES

0 5 10 15 20

YUMA CO

MARICOPA CO.

PIMA CO

YAVAPAI CO

MOHAVE CO

YUMA CO

COLORADO RIVER

WILLIAMS RIVER

GILA RIVER

UNITED STATES
MEXICO

PARKER

EHRENBURG

SWANSEA

BOUSE

WENDEN

SALOME

VICKSBURG

A.T. & S.F. R.R.

McDOWELL PASS TO WEST

GRAVITY TO VICKSBURG

ONE MI.

COURTHOUSE ROCK

EAGLE TAIL LINE

COYOTE PEAK

GRAVITY TO MOTTEBACH AND PALOMAS VALLEYS

HYDER

HORN

KOFA

S.P.R.R.

GROWLER

AZTEC

MUSINA

KIM

PEMBROKE

COLFRED

ROLL

WELLTON

GILA WATER EXTENSION CANAL

TO WEST

GILA RIVER CANAL LINE

LAGUNA DAM

YUMA

WILLCUTS

ARABY

FORTUNA

GADSDEN

T 11 S

T 15

R 11 W

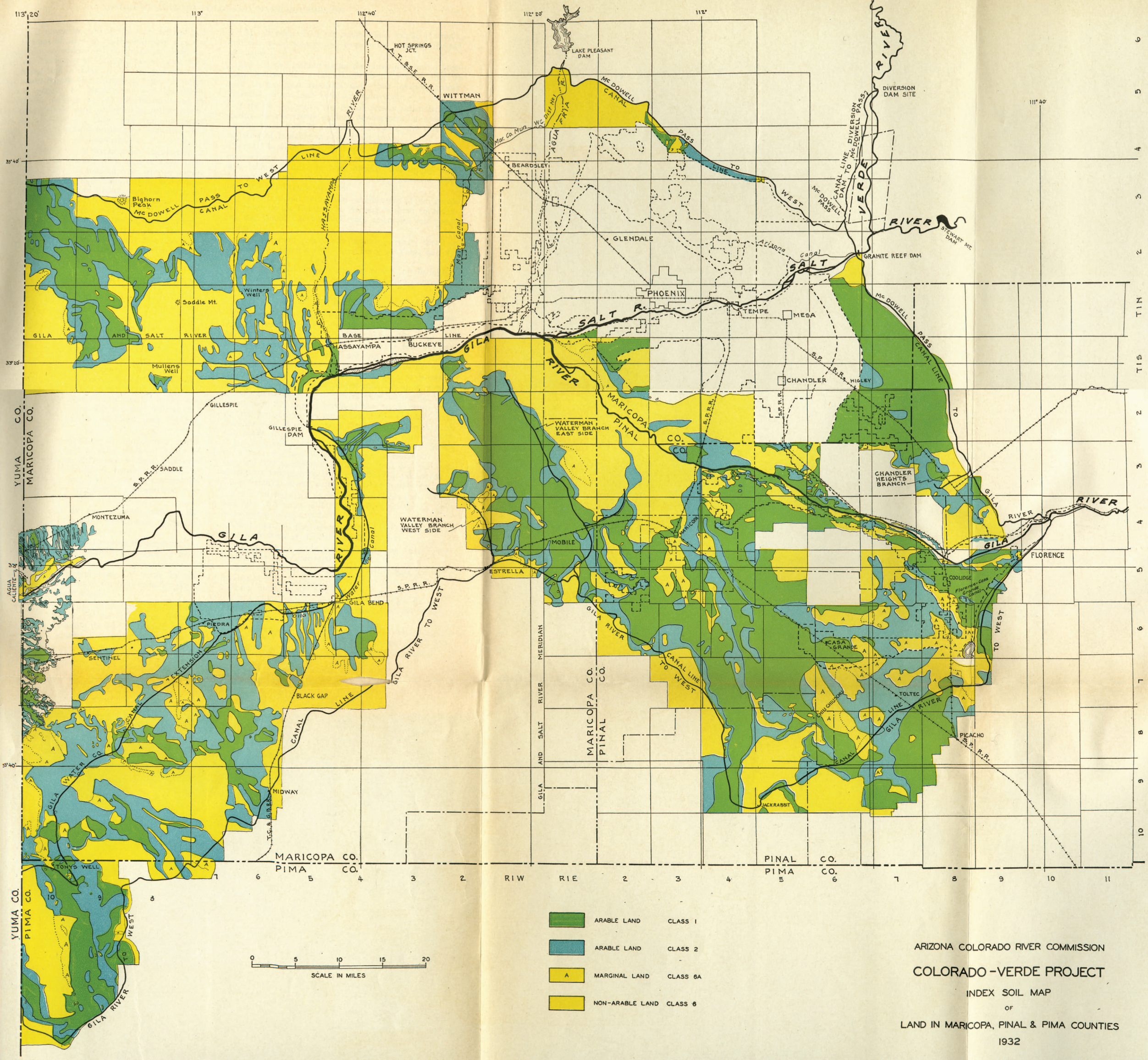
GILA AND SALT RIVER BASE LINE

114° 00'

113° 20'

33°30'

34°00'



ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

INDEX SOIL MAP

OF

LAND IN MARICOPA, PINAL & PIMA COUNTIES

1932

of land in each township, and the cost of detailed soil surveys on millions of acres of land would have been too great. Originally we endeavored to obtain soil field experts from the University of Arizona, but as none were available, through the courtesy of Mr. P. J. Preston of the United States Bureau of Reclamation, former manager of the Yuma project, we placed men with his forces. They studied the methods of soil classification used by the Reclamation Service until permitted to make classification for the Government. They were then transferred to our work, and by gradually breaking in additional men a competent field force was organized.

Soil classification prior to Reclamation construction is a comparatively recent practice. The areas of some existing projects have had to be reduced from fifty to seventy per cent, because of poor soils. Soils that do not require treatment can obviously stand higher costs for water. At present the selling prices of land bears little relation to the soil classification. Where a single years leaching will change soil from No. 2 to No. 1 the difference in value is obviously the cost of the season's treatment. The same conditions exist for other classifications. Likewise, comparatively expensive leveling of land near mountains might be more than justified if citrus is to be planted.

REASONS FOR COLORADO-VERDE PLAN

The plan of irrigating Arizona land with waters of the Colorado River herein submitted was chosen for the following reasons.

(1) It will insure an absolutely dependable supply of water for existing Arizona projects.

(2) It provides for a gravity flow instead of pumping; permitting the saving of hydro-electric power for industrial and commercial development. While low commodity prices, high interest costs and increased efficiency have caused steam and diesel power costs to approach those of hydro, an inevitable readjustment of money and commodity prices will insure that the best hydroelectric developments will be cheaper producers than the best steam or diesel plants.

(3) It will create abundance of cheap power in the central portion of the state at many different locations, insuring non-interruption of service without expensive standby plants, provide for short transmission lines at low altitudes, reducing cost and losses in transmission and freedom from storm damages. This power would be cheaper than that from the Hoover Dam.

(4) It will assist in the mineral development of the state, and provide existing mines with better opportunities to compete with other producers.

(5) It will permit of manufacturing development, insuring a variety of business activity and create a more self sustaining commonwealth.

(6) It will insure several reuses of water by the greater difference in elevation of the land to be irrigated, thus providing a *high* water duty.

(7) It will allow the use of the flow of the Salt, Gila, Verde, Agua Fria, etc. for the peak water demands of summer irrigation, reducing the size of tunnels, canals, etc. to 60% of the capacity they would have to be if serving the land direct.

(8) It will reduce the number and length of canals, and also avoid seepage and evaporation losses by the use of tunnels.

(9) It will include within the canal lines such a great body of land that a limited allotment of water may be used on the most favorable soils, thus insuring greater financial return from each acre cultivated.

(10) It wil permit the use of present urban facilities during the necessarily gradual development of areas adjoining those now in cultivation, reducing the difficulty and cost of bringing in new desert areas.

(11) It would provide ample water to release whatever amount of the Gila could be used in its Upper Valleys, including those in New Mexico, and supply water for approximately 100,000 acres now in projects for which no water is otherwise available.

(12) It would permit the development of the potential power in the Colorado in Arizona, without encumbering the Grand Canyon Park with reservoirs and power plants.

13) It would reduce the distance of water travel in evaporating channels from Lees Ferry to Yuma and the Imperial Valley by about 50%.

(14) It would permit cheaper power installations at more accessible sites than those in the Grand Canyon.

PLAN

This plan of development for Central and Southwest Arizona provides for a 438 foot dam at the head of Marble Gorge, just above the steel arch bridge near Lees Ferry, to raise the water to elevation 3,543 feet and later to 3,600 feet above sea level, securing a storage reservoir of 16,000,000 acre feet capacity, for a pressure tunnel with a 28 foot inside diameter 46.4 miles in length to the Little Colorado River at ten miles from its mouth, for the construction of a dam at mile ten on the Little Colorado to the same elevation as that on the main river, for the use of the canyon of the Little Colorado as a canal to mile nineteen, for a pressure tunnel with a 28 foot inside diameter, 97.8 miles in length from the Little Colorado to the mouth of Oak Creek on the Verde River, for a dam at Camp Verde Dam site to elevation 3,145 feet, and later to elevation 3,200 feet, for a diversion dam seventy six feet high on the Verde River a mile north of Camp Creek to divert water at elevation 1,610 feet;

For a ten thousand second foot canal from the Diversion Site 16.4 miles to McDowell Pass, which can later be increased in capacity by lining;

For a canal to the westward from McDowell Pass to serve land north of the Salt and Gila Rivers;

For siphons or grade reservoirs, crossing Cave Creek, Hassayampa and Centennial;

For a canal southward from McDowell Pass 3.8 miles to Granite Reef Dam;

For a siphon across Salt River;

For a canal from Granite Reef to the Gila River;

For a siphon across the Gila River into the Florence Canal;

For the enlarging and extending of the Florence Casa Grande Canal westward to serve land south of the Gila River in Pinal, Maricopa, Pima and Yuma Counties;

For penstocks at Granite Reef for a three hundred foot drop;

For the enlargement and extension or the construction of a new canal from Gillespie Dam south and westward to serve land south of the Gila River below the 730 foot level;

For a similar parallel canal on the north side of the Gila River;

For the installation of eight dams and power plants in the Verde River as the market for power warrants;

For the erection of power plants on the canals as later justified.

Reservoir

The elevation of the regulating reservoir on the Verde River largely controls the selection of the storage reservoir on the Colorado

The dam site at the highway bridge below Lee's Ferry is made the basis of this report, because the canyon walls are much narrower than at Glenn No. 1 or No. 2 sites, it is more accessible and construction materials are available.

A short distance up and down stream from this site the canyon is wider and the foundation materials are poorer. Competing sites are at least nine miles up stream and twenty miles below.

This site was drilled by the Arizona Colorado River Commission in 1927. A favorable geological report was made by Dr. Ransome of California Institute of Technology. The foundation rock has been tested and found capable of resisting the pressure at the base of a high dam. The dam was designed by B. F. Jakobsen in 1927, and then estimated to cost $19,000,000.

If the depth to bed rock can be decreased by dynamiting the rapids at Badger and Soap Creeks below the site, the costs can be reduced. As the river at this point practically parallels the line of the tunnel to the Little Colorado, the service tunnel could be used for stream diversion during construction. The construction of the Hoover Dam below will warrant the risk of cheaper temporary coffer dam construction than originally planned.

Tunnels

The tunnel from the Colorado River to the Little Colorado could be shortened by 25.4 miles by constructing a dam at mile forty instead of at mile five. Good dam sites apparently exist at this alternate location, but the river is about 260 feet lower. If the river fill above bed rock is similar to that at the Marble Gorge and Hoover sites, a dam at this alternate site would have to be about 800 feet in height from bottom of foundation to bring the crest to the elevation necessary to give equal flow through the main tunnel. As this height is some hundred feet higher than the Hoover Dam, which has been subject to criticism, it is considered better to base this report on a smaller dam and a longer tunnel, but dam sites in the vicinity of mile 35 to 45 on the main river should be examined prior to deciding on any particular site. As these sites are very inaccessible; the trip from the canyon brink to the top of the lower gorge being arduous, and the only practical approach to the river proper being by boat, these investigations will be expensive.

The tunnel from the Colorado River to the Little Colorado is all in stratified rock. The various strata that will be encountered are shown on the geological sections prepared by Prof. Stoyanow of the University of Arizona; most of the field work having been done by Walter Thomas. These strata are broken by few faults, and should provide the least complications possible to secure in long tunnel excavations. Shafts have been calculated at intervals that will permit of the completion of the tunnels in from five to six years.

The tunnel from the Little Colorado to the Verde will be mostly in Yavapai shist, with probable occasional intrusions of granite. The alternate location to the west of Kendrick Peak and Slate Mountain is recommended by the Geologists in order to avoid laccoliths and broken formation. Water problems should be small in the tunnel, with the possible exception in the Verde formation on the southern end, and thru a portion of the redwall limestone in the vicinity of mile 90. The pilot tunnel is figured to be separated from the main bore, and connected at 2,000 foot intervals to permit attacking the main heading at numerous points. The pilot tunnel can later be enlarged and lined to carry additional water.

The dam in the Little Colorado at mile ten is needed to secure the flood flow of that stream. The reservoir will have a small capacity, but excess water could be diverted northward to the Glenn Reservoir and southward to the Camp Verde reservoir through the tunnels. As the hydraulic gradient would result in the surface of the water in the Little Colorado Reservoir being about 130 feet lower than the Glenn Reservoir the rate of flash floods would be automatic. Some thousand second feet of water would be obtained from the Little Colorado River here, including the flow from Blue Springs.

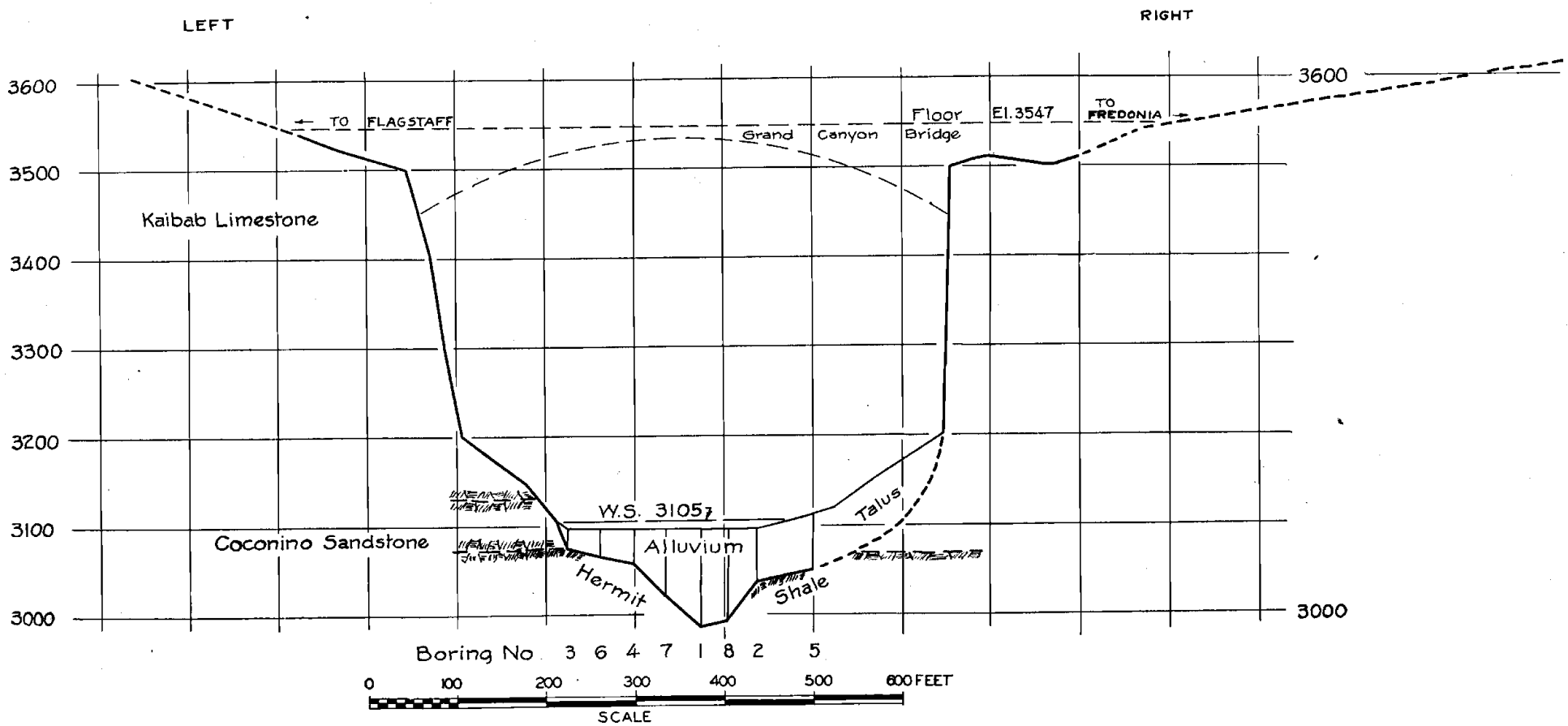
Subsequently a 6.5 mile tunnel could be constructed from mile 10 on the Little Colorado to mile 66.5 on the Main Colorado River, and the upper tunnel capacity increased to Marble Gorge. This would permit the installation of 799,000 horse power at mile 66.5 at a cost of $46,447,000 or $58.00 per h.p. with a production cost of 1.18 mills per kwh.

As an alternate to the dam at mile ten a dam estimated to cost $75,000.00 could be installed at the Coconino site at mile 47.5 on the Little Colorado and 4,800 h.p. developed for $100,000.00 which could be used for tunnel construction purposes.

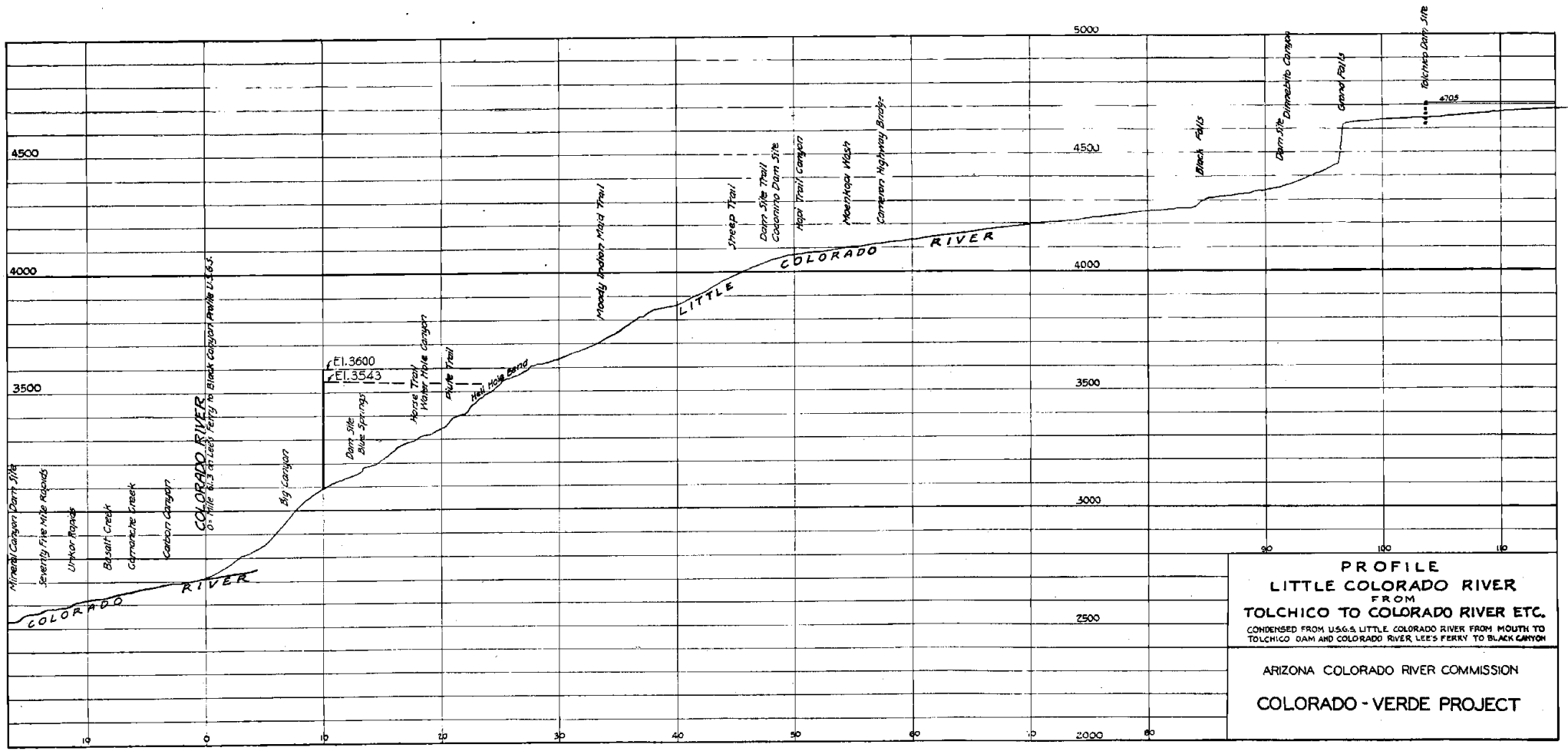
The water from the Coconino dam could be dropped down the canyon of the Little Colorado and into the tunnel. The total length of tunnel would have to be increased by five miles in place of the nine miles of river channel between mile 10 and 19 on the Little Colorado. The alternate plan would be approximately $1,500,000 cheaper, but it would preclude the capture of the water from Blue Springs, which is approximately half of the flow of the Little Colorado River.

Verde Dam

The Verde Dam in addition to acting as a storage reservoir for Verde flood waters would become a regulating reservoir permitting continuous flow through the tunnels, which can be reduced in capacity accordingly to about 60% of what they otherwise would need to be.



DAM SITE
NEAR
GRAND CANYON BRIDGE
850' ABOVE BRIDGE
4.4 MI BELOW LEE'S FERRY

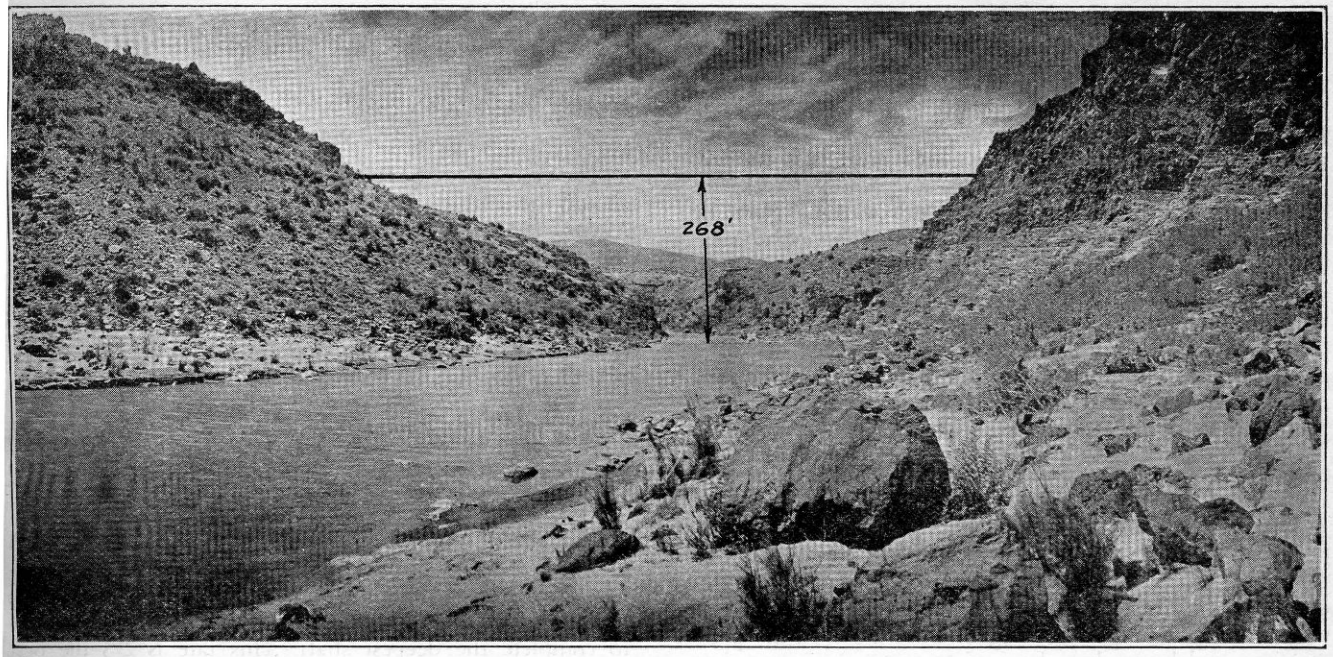


PROFILE
LITTLE COLORADO RIVER
FROM
TOLCHICO TO COLORADO RIVER ETC.

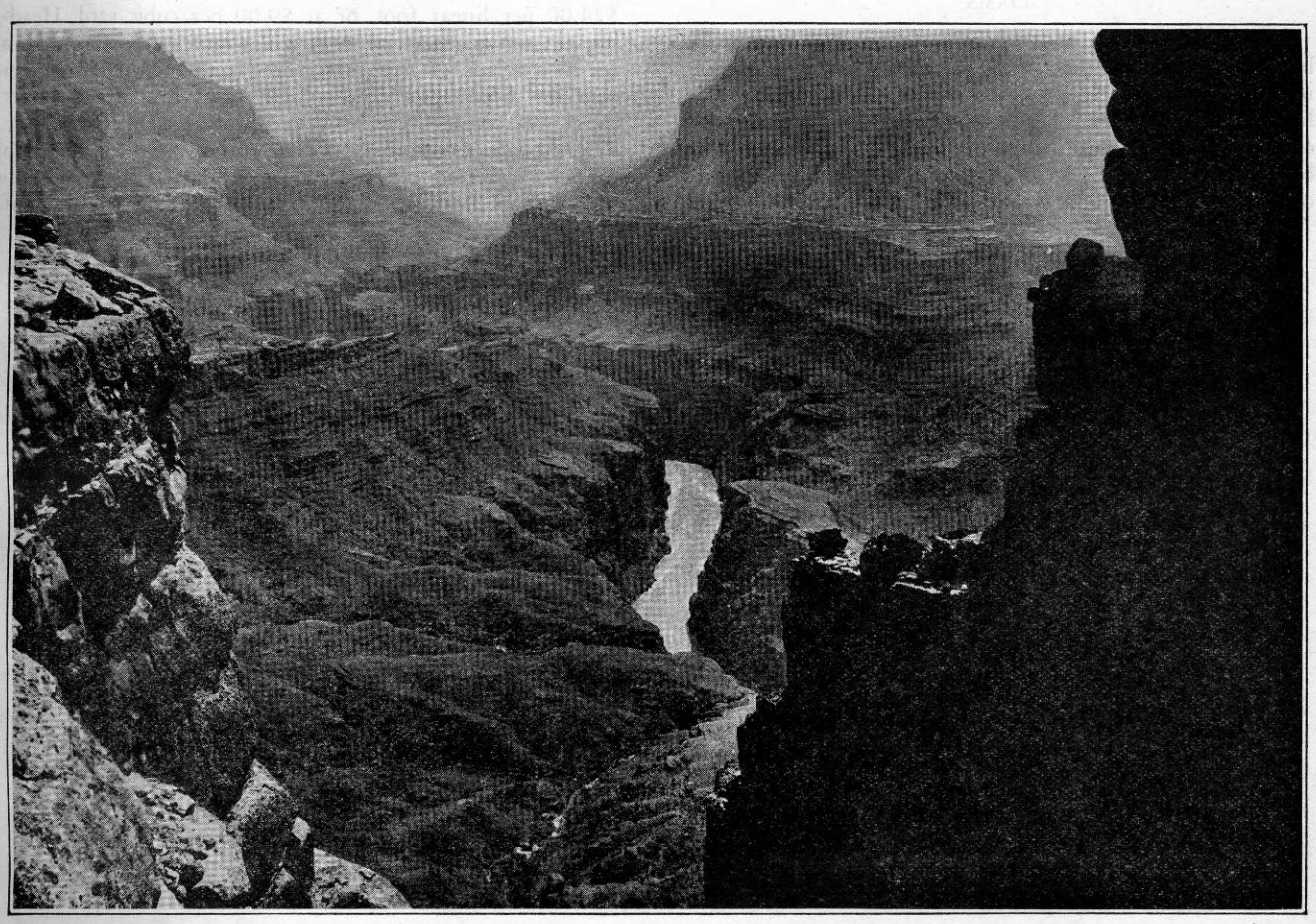
CONDENSED FROM U.S.G.S. LITTLE COLORADO RIVER FROM MOUTH TO TOLCHICO DAM AND COLORADO RIVER LEE'S FERRY TO BLACK CANYON

ARIZONA COLORADO RIVER COMMISSION

COLORADO - VERDE PROJECT



Camp Verde Dam Site—Mile 102



Mile 38 Colorado River. Top Red Wall 3600' Top Canon 6000'

The Verde Reservoir will contain 950,000 acre feet with a dam constructed to elevation 3,145, and approximately 2,000,000 acre feet when built to 3,200. As the tunnel would be able to supply peak water demands in the early period of irrigation development the cost of raising the dam the last 55 feet can be postponed until it is needed.

The dams between Camp Verde and Camp Creek can be installed as rapidly as power demands warrant. None of these dams are high, and the sites drilled have had relatively shallow foundations. If the Verde Dam is constructed first their flood hazard will be small. The sites are suitable to multiple arch designs, although rock fill dam backed with finer material might be cheaper in a few instances. The estimates have been prepared for multiple arches and the foundations that are undrilled presumed to be similar to those examined.

COST ESTIMATES

The price of labor obviously is the basis of all construction costs. No one can determine what the prevailing price for labor will be during the five to six year period required to construct the Colorado-Verde project. The figures used in this report are higher than those of the present time, and lower than those of 1928-29. Sufficient data has been obtained to permit others to make their own estimates. Our estimates were made as follows:

Dams

The estimate used for the Marble Gorge Dam was made by LaRue and Jakobsen in 1927. In the latter's opinion, in view of the safety provided by the Hoover Reservoir, higher stresses would be permissible, and with cheaper construction costs this structure should be contracted now below the estimate. The estimates for the dam at mile 10 on the Little Colorado is based on reconnaissant investigation. At this site the river runs approximately on bed rock. The low water flow is very small and the flood hazard negligible.

Shafts

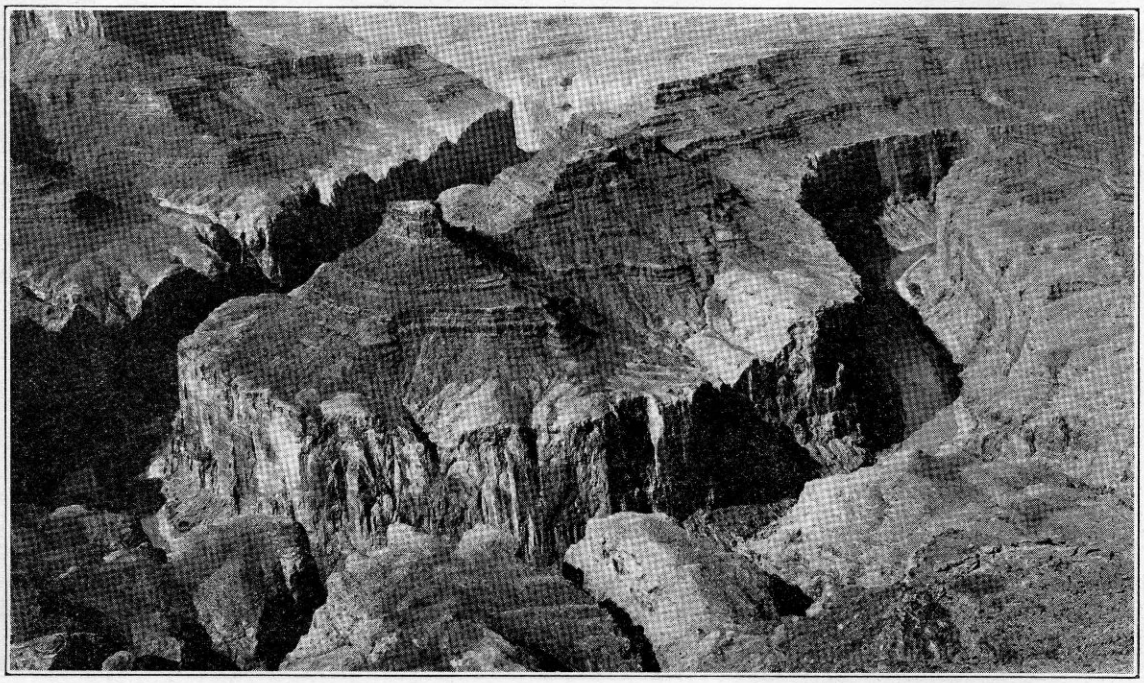
The estimated $110.00 per foot for sinking shafts, should be ample—Bulletin 357 U. S. D. C. Bureau of Mines, 1932, Shaft Sinking Practices and Costs—includes the following representative shafts:

Company	Date	Depth	Kind of Rock	Size	Cost per ft.
Magma Copper	1925-28	0 -2531′	Sedimentary	8′x21′	$104.50
Cal. & Ariz.	1929-30	0 -1720′	Diorite	6-6 x16	56.62
Chief Con. Utah	1921	20′-1385′	Rhyolite & Limestone	6-6 x18 -6	57.71
Lick Hughes, Ontario		1516′-3000	Porphyry	6-4 x21 -4	96.34
United Verde No. 5	1930	3150′-3509′	Quartz Porphyry	7-8 x19 -4	101.09
Van Dyke Shaft No. 1	1921	0′-1692′	Conglomerate & Shist	6′x11′	81.27

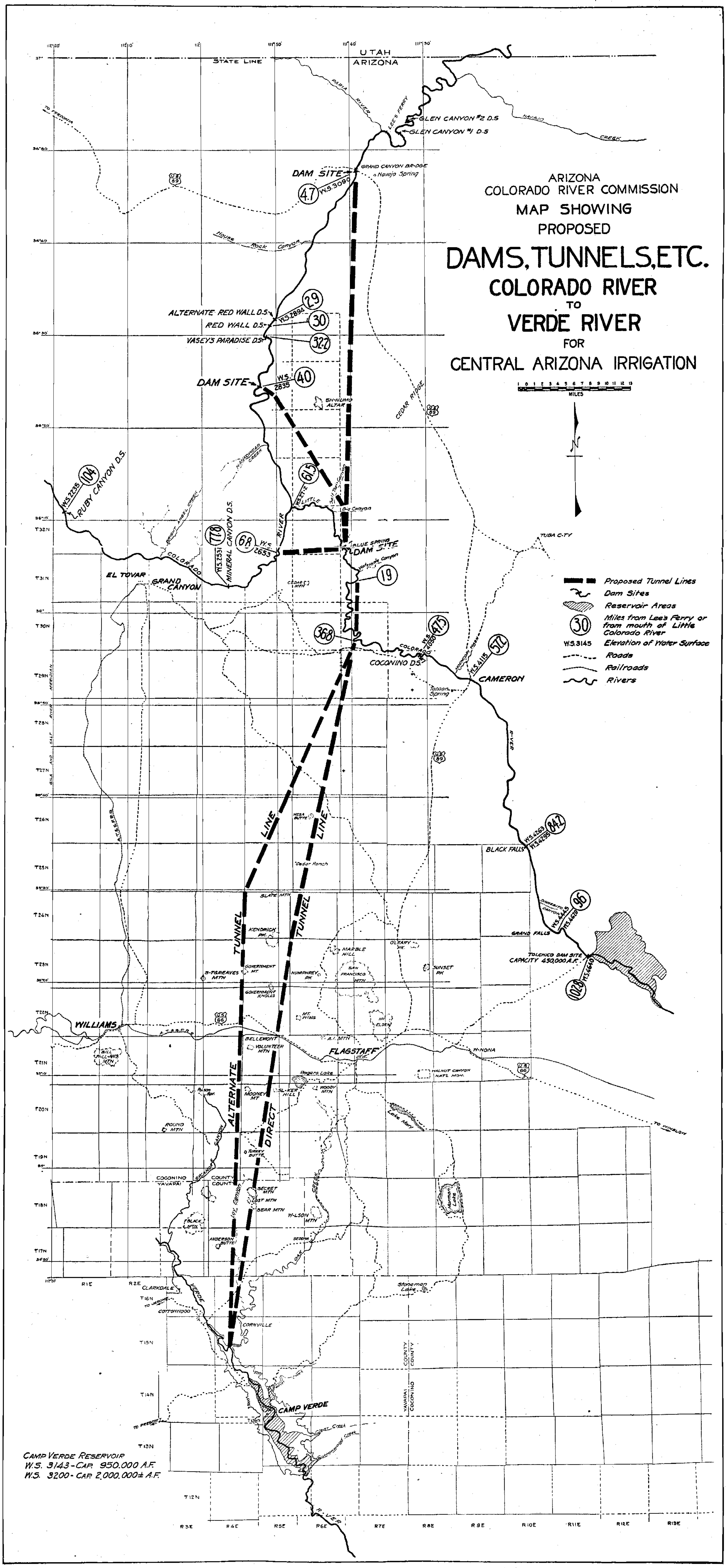
The shafts have been estimated 50 feet below tunnel grade in order to provide drainage, etc. in the pilot headings. An average of eight or nine feet per day should be secured which would require approximately sixteen months to complete the deepest shaft. This rate is 2/3 the best speed attained in shaft sinking.

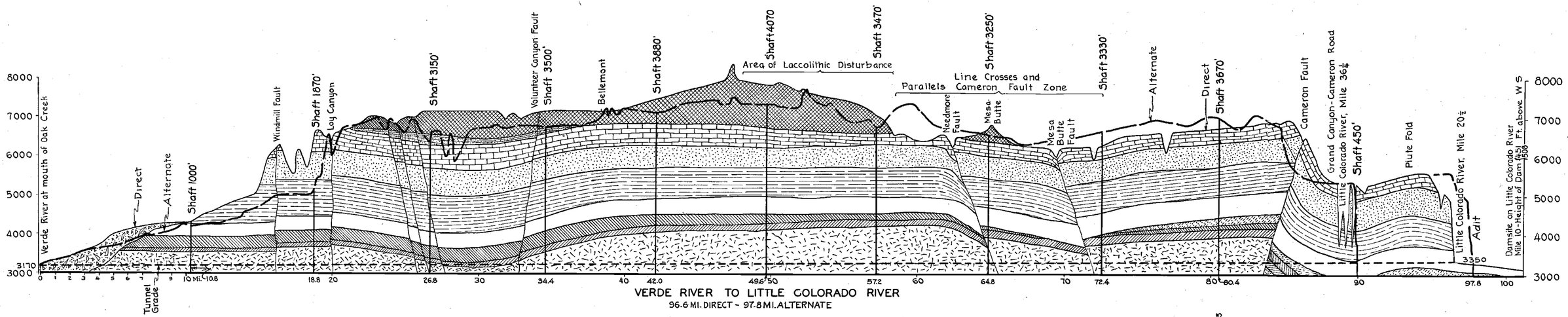
Pilot Tunnel Headings

Pilot headings of 8-ft.x9-ft. have been estimated at $24.00 per linear foot, or at $9.00 per cubic yard. Headings in similar material in Arizona mines are being driven for two thirds of this price, or $16.00 per ft. Seven per cent has been added to the length of headings to cover the cross connections between pilot and main heading. These connections are sufficient to insure that the main tunnel excavation can proceed as rapidly as the pilot tunnel. Tunnel headings have been advanced at the rate of



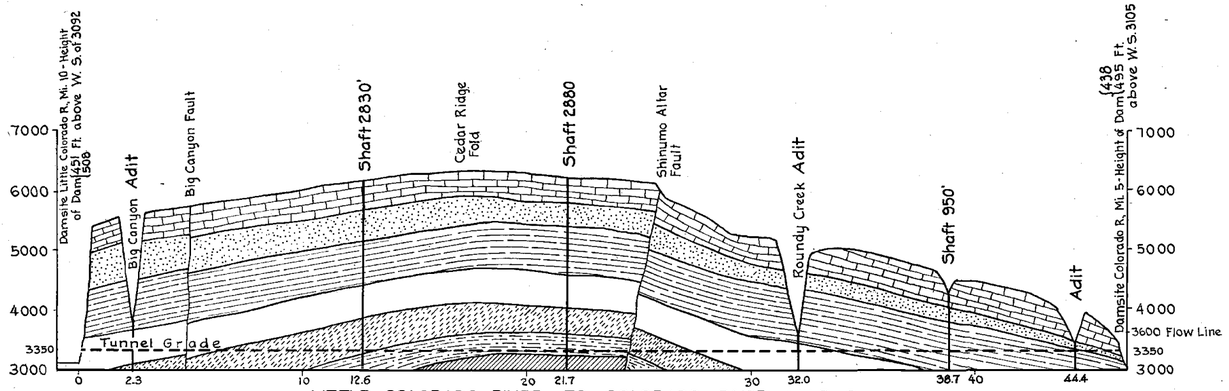
Big Bend—Mile 44, Colorado River. Top of vertical Red Wall Limestone Elev. 3600′


ARIZONA
COLORADO RIVER COMMISSION
MAP SHOWING
PROPOSED
DAMS, TUNNELS, ETC.
COLORADO RIVER
TO
VERDE RIVER
FOR
CENTRAL ARIZONA IRRIGATION
MILES
Proposed Tunnel Lines
Dam Sites
Reservoir Areas
Miles from Lee's Ferry or from mouth of Little Colorado River
W.S. 3145 Elevation of Water Surface
Roads
Railroads
Rivers
UTAH
ARIZONA
STATE LINE
GLEN CANYON #2 D.S
GLEN CANYON #1 D.S
DAM SITE
W.S. 3090
4.7
ALTERNATE RED WALL D.S.
RED WALL D.S.
VASEY'S PARADISE D.S.
W.S. 2894
29
30
32.2
DAM SITE
W.S. 2835
40
61.5
W.S. 2653
68
BLUE SPRING DAM SITE
19
368
W.S. 2235
104
RUBY CANYON D.S.
W.S. 2531
77.8
MINERAL CANYON D.S.
EL TOVAR
GRAND CANYON
COLORADO
RIVER
COCONINO D.S.
47.5
W.S. 4115
57.2
CAMERON
BLACK FALLS
W.S. 4263
84.2
96
GRAND FALLS
TOLCHICO DAM SITE
CAPACITY 450,000 A.F.
102.8
TUBA CITY
CEDAR RIDGE
TUNNEL LINE
TUNNEL LINE
ALTERNATE
DIRECT
WILLIAMS
FLAGSTAFF
WINONA
TO WINSLOW
COCONINO COUNTY
YAVAPAI COUNTY
CLARKDALE
COTTONWOOD
CORNVILLE
VERDE
CAMP VERDE
TO PRESCOTT
Camp Verde Reservoir
W.S. 3143 - Cap. 950,000 A.F.
W.S. 3200 - Cap. 2,000,000± A.F.



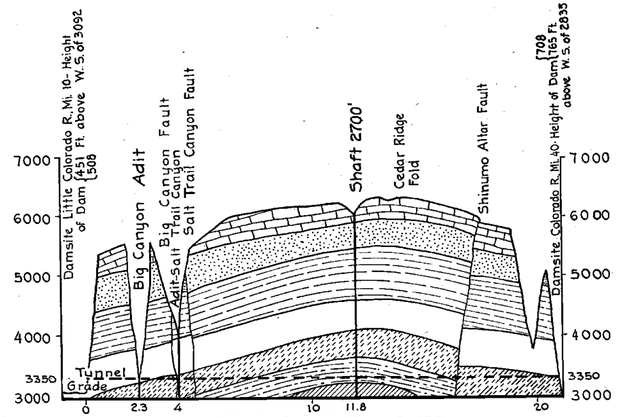
VERDE RIVER TO LITTLE COLORADO RIVER

96.6 MI. DIRECT ~ 97.8 MI. ALTERNATE



LITTLE COLORADO RIVER TO COLORADO RIVER MILE 5

46.4 MI.



LITTLE COLORADO RIVER

TO COLORADO RIVER MILE 40

21.0 MI.

Prepared under the direction of
Dr. A.A. Stoyanow, Prof. of Geology,
University of Arizona

- Verde Formation
- Volcanic Rocks
- Moenkopi Formation
- Kaibab Limestone
- Coconino Sandstone
- Supai Formation
- Redwall Limestone
- Devonian Limestone
- Muav Limestone
- Bright Angel Shale
- Tapeats Sandstone
- Schist

ARIZONA COLORADO RIVER COMMISSION

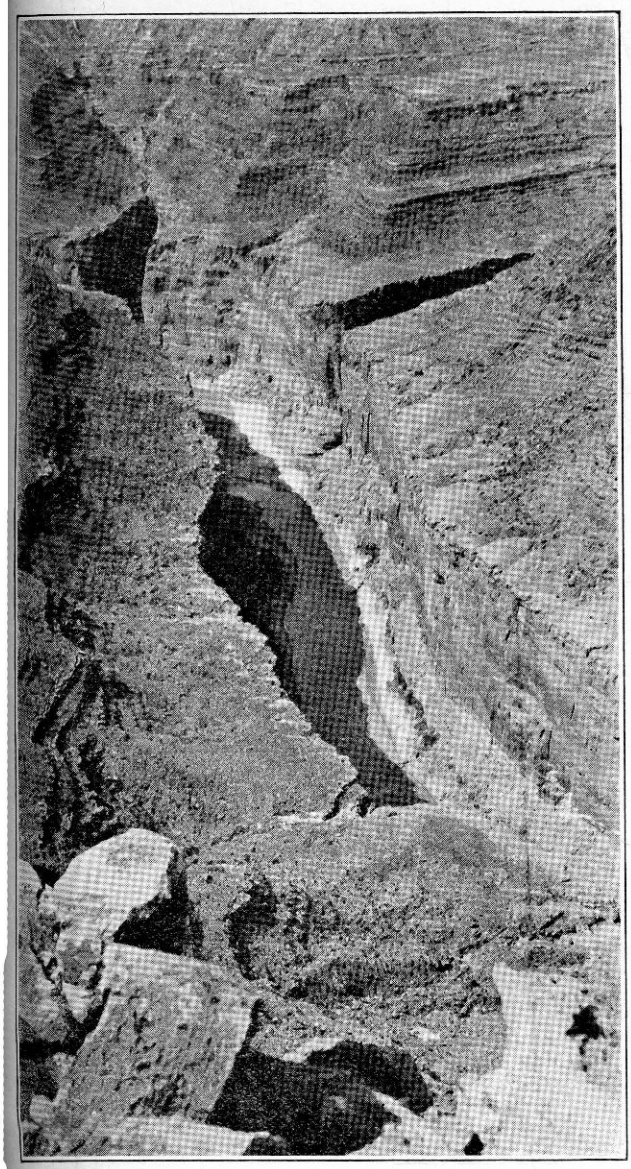
COLORADO-VERDE PROJECT

SECTIONS

ALONG PROPOSED TUNNELS

SHOWING

GEOLOGIC STRUCTURE



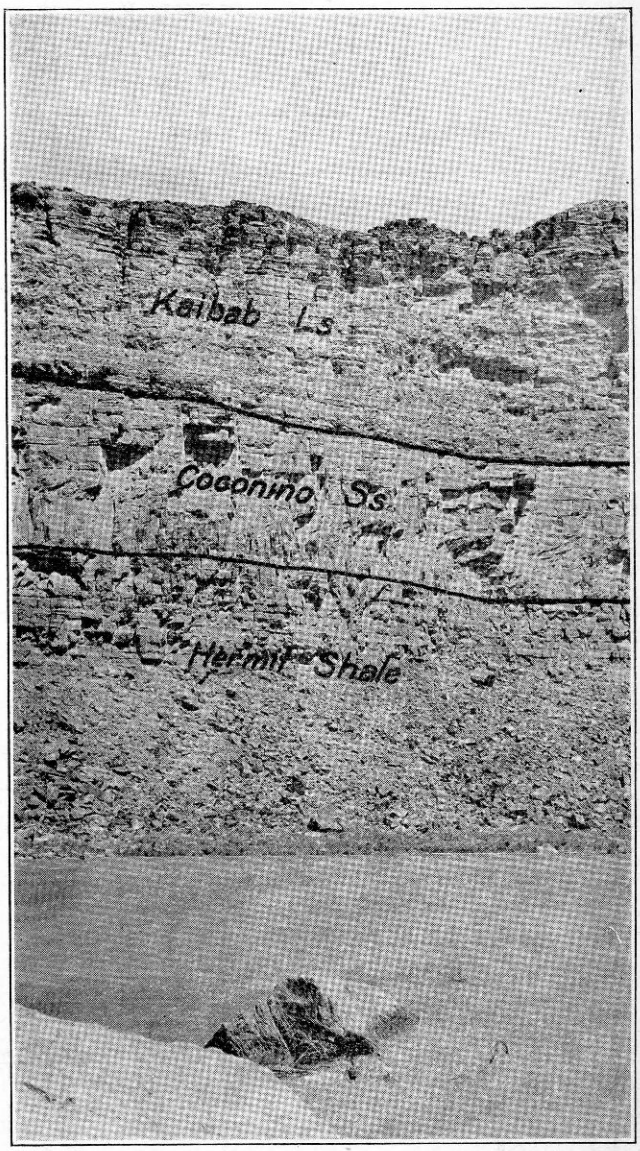
Mile 40, Colorado River
Inner Gorge is in Redwall Limestone

two miles per year. At a speed of 1¼ miles per year in the heading, the tunnels could be excavated in three years after the shafts were completed.

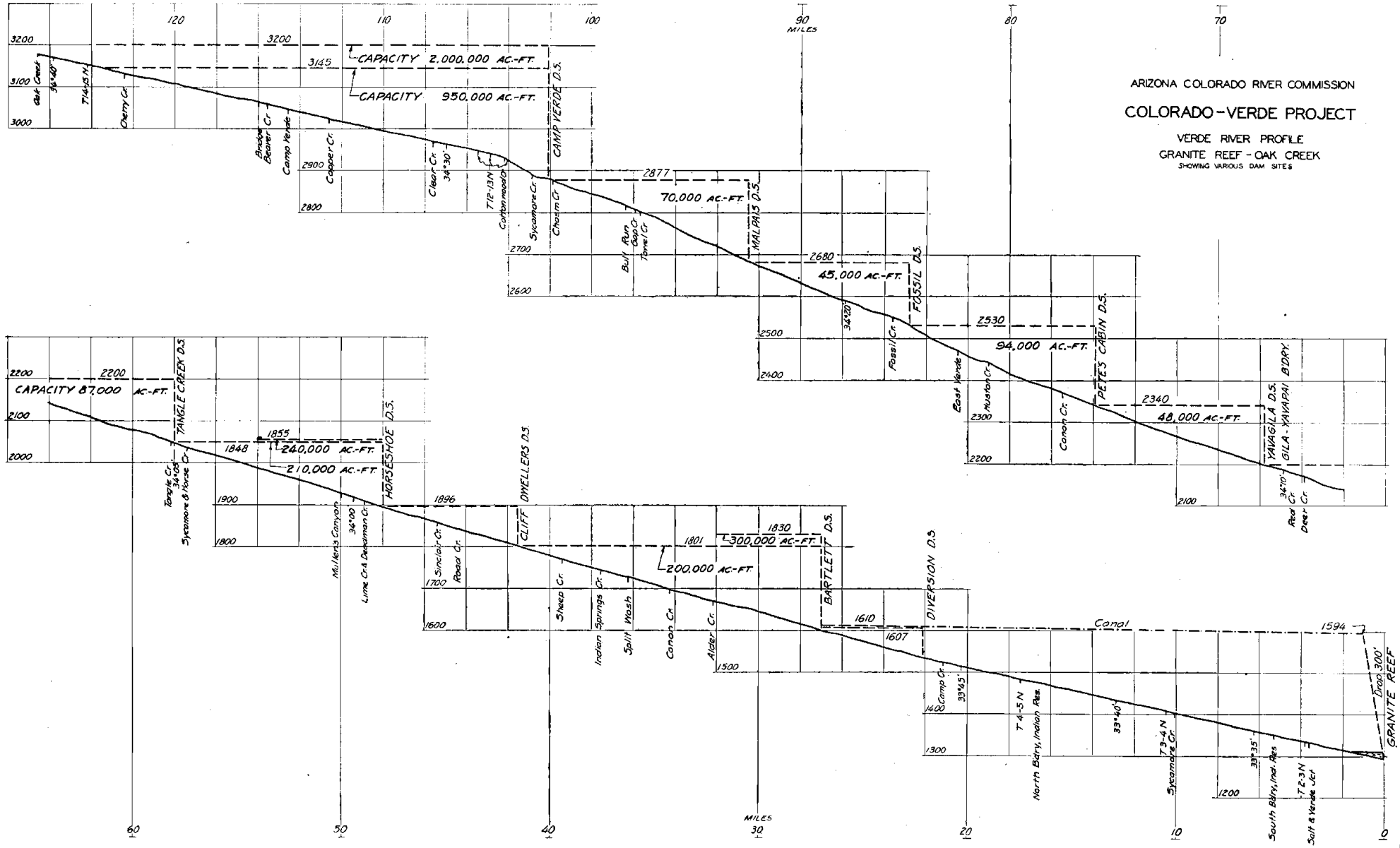
Tunnel enlargements have been estimated at $4.00 per cu. yd. or approximately $1.80 per ton. Ore has been mined from deep workings in Arizona mines for half this figure. Excavation in the three-quarter mile Hoover tunnels is reported to have been done for $1.69 per cu. yd. including $1.39 for excavation and loading and 30 cents for hauling and disposing. The Hoover tunnels were so large that the excavation was similar to quarrying or surface rock work, rather than tunneling. Hard rock excavation in thorough highway cuts several years ago was estimated at $1.50 per yard. Current estimates are $ .60 and contracts are being let considerably under this latter figure. The tunnels on the Colorado-Verde project are twice the size of standard railroad or highway tunnels. They are so long, and the rock conditions are so favorable that new records for speed and economy should be established on their construction. Underground tramming and hoisting costs should average about 50 cents per yard, and $3.50 should easily cover the excavation costs with faces thirty feet in diameter. The shafts should be completed prior to the letting of tunnel contracts in order that the engineers and contractors may know what conditions they will encounter. Had more information regarding the rock been available at Hoover, the bids would no doubt have been cheaper. As it was, the profits were extremely excessive.

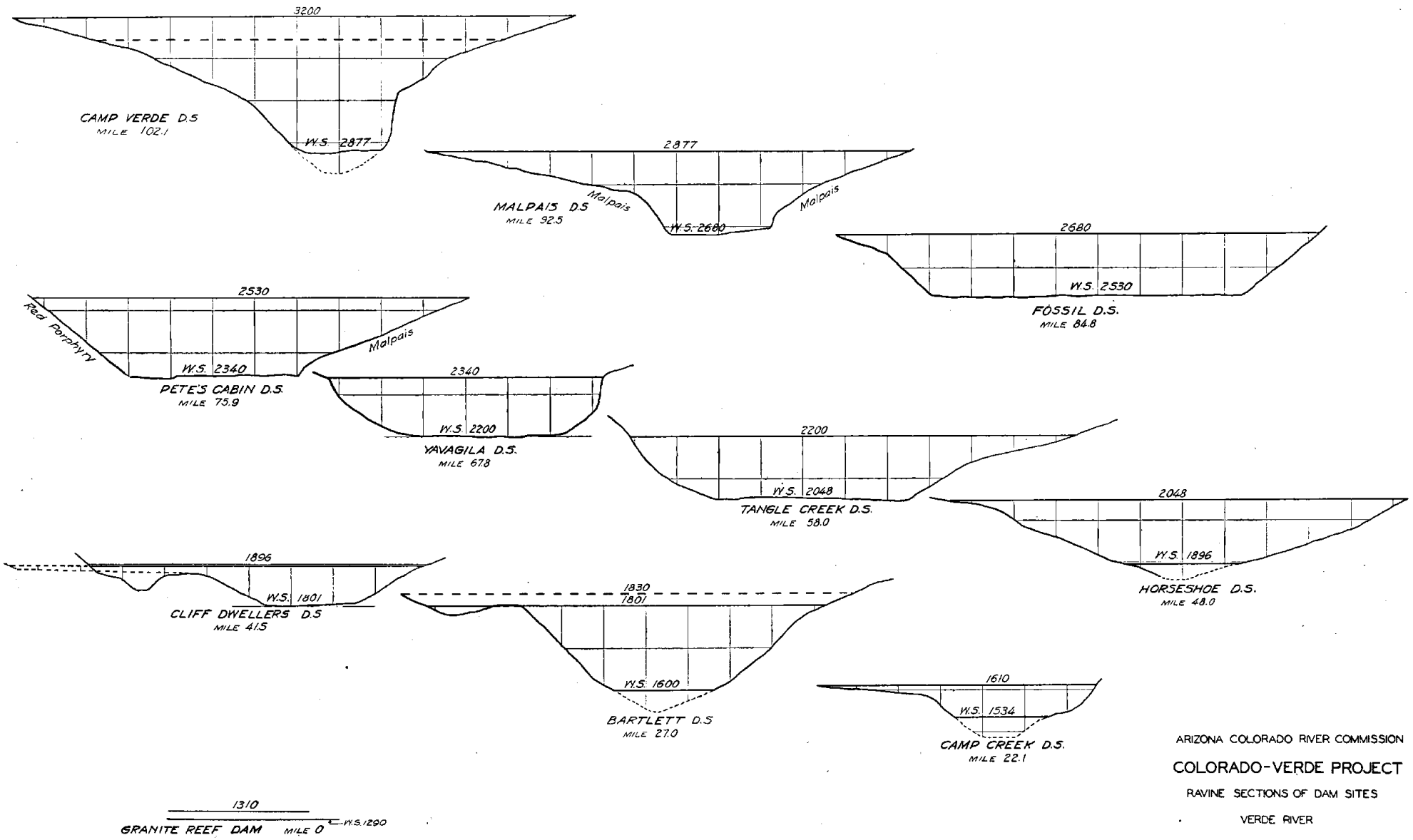
Tunnel Lining

It is probable that concrete lining will not be necessary on many miles of the Colorado Verde tunnels until the entire capacity is needed for power or agricultural purposes. Unlined tunnels have approximately half the capacity of lined ones. Our estimates, however, include lin-



Rock Strata, Mile 8 Colorado River
A dam at the Lees Ferry Bridge would have its foundations in material similar to that in the vertical wall.


ARIZONA COLORADO RIVER COMMISSION
COLORADO-VERDE PROJECT
VERDE RIVER PROFILE
GRANITE REEF - OAK CREEK
SHOWING VARIOUS DAM SITES
MILES
CAPACITY 2,000,000 AC.-FT.
CAPACITY 950,000 AC.-FT.
CAMP VERDE D.S.
70,000 AC.-FT.
MALPAIS D.S.
45,000 AC.-FT.
FOSSIL D.S.
94,000 AC.-FT.
PETE'S CABIN D.S.
48,000 AC.-FT.
YAVAGILA D.S.
GILA - YAVAPAI BDRY.
CAPACITY 87,000 AC.-FT.
TANGLE CREEK D.S.
240,000 AC.-FT.
210,000 AC.-FT.
HORSESHOE D.S.
CLIFF DWELLERS D.S.
200,000 AC.-FT.
300,000 AC.-FT.
BARTLETT D.S.
DIVERSION D.S.
Canal
GRANITE REEF
Oak Creek
Cherry Cr.
Beaver Cr.
Camp Verde
Copper Cr.
Clear Cr.
Cottonwood Cr.
Sycamore Cr.
Chasm Cr.
Bull Run
Deep Cr.
Tonel Cr.
Fossil Cr.
East Verde
Huston Cr.
Canon Cr.
Rock Cr.
Deer Cr.
Tangle Cr.
Sycamore & Horse Cr.
Millers Canyon
Lime Cr. & Dekeman Cr.
Sinclair Cr.
Road Cr.
Sheep Cr.
Indian Springs Cr.
Split Wash
Canon Cr.
Alder Cr.
Camp Cr.
North Bary, Indian Res.
Sycamore Cr.
South Bary, Ind. Res.
Salt & Verde Jct.



ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

RAVINE SECTIONS OF DAM SITES

VERDE RIVER

Contact between Coconino Sand Stone and Hermit Shale in Marble Gorge. "A" shows hard rock exposed by dynamite. "B" weathered rock surface. This material is similar to that of foundations at Marble Gorge Dam Site.

ings throughout, with concrete estimated at $12.00 per cu. yd. The length of the tunnels warrants the use of movable steel form, insuring cheap placing of concrete. The quantities involved command low bids for cement. Coarse aggregate will be available from crushed tunnel spoil. Sand is the only material that will be expensive to import or manufacture.

Verde River Dams

Multiple Arch type of Dams will be cheaper at most of the sites on the Verde River than the Rock fill type, especially as they reduce the length of penstocks and permit the incorporation of power plants. If standard size arches are adopted, the steel forms may be used at several sites, reducing equipment costs. Tentative buttress centers of fifty feet were calculated, and the concrete estimated at $15.00 per cu. yd. The foundations of the undrilled sites were assumed to be of the same depth, etc. as the ones that have been investigated. If the Camp Verde Dam is constructed first, the flood hazard on the lower dams will be largely eliminated.

Canals

Most of the canal's location is in earth. Excavation has been estimated at 10 cents per yard. Modern machinery can handle earth in the large quantities involved for from six to seven cents. The sections in mixed earth and rock have been estimated at 60 cents per cu. yd. The canal sections are several times the size of railroad and highway cuts, so these figures are conservative. Some of the rock sections of canals have been estimated as lined with Gunite at 10 cents per sq. ft. The Arizona mines have been guniting to prevent fire and rock slackening at a cost of about 9 cents. The earth sections are not calculated for lining, but when additional water is required these sections can be lined, and with reduced friction, lower free boards and increased velocity, their capacity can be doubled. These canal figures can be reduced approximately 10% if projects on the Gila, Salt, Agua Fria, etc. are used for standby water storage for the peak demands of summer irrigation.

Power

The estimates for power installation have been made by Mr. B. F. Jakobsen after securing the latest quotations from the manufacturers of hydro-electric power equipment. No estimates for transmission lines have been made, as the power market is yet to be developed. Power would be available at numerous sites on a north and south line 250 miles in length that bisects the state. As much of the power would be taken off to the east and west, and the power installed as needed, power movement will vary in direction.

An arbitrary figure of two mills per kwh has been used as the price at the switch board. This is the same price as Hoover power, but as Arizona power users are much closer to the Colorado-Verde projects than they or coast users are to the Hoover Dam, shorter transmission lines will result, with less cost and power loss, giving Arizona power users as low prices as it is possible to secure anywhere in the world.

The estimates on power installation have been made on a 60% load factor in accordance with average conditions elsewhere.

The use of power in the production and reduction of ores would be at a much higher load factor than 60%, so that plant installation and operations costs would be materially reduced for this portion of power consumed.

Also the selling price of peak demand power could be increased from the estimated rate of two mills per kwh without noticeably adding to the retail price of power when distributed.

VERDE RIVER POWER DEVELOPMENT

Dam	Head	Installed Horsepower	Power House Cost	Type of Dam	Cost of Dam	Total Cost
Malpais	195	177,000	$ 3,260,000	Multiple Arch	$1,272,000	$ 4,532,000
Bartlett	189	171,500	3,175,000	Single Arch	1,510,000	4,685,000
Pete's Cabin	188	171,000	3,250,000	Multiple Arch	1,720,000	4,970,000
Yavagila	138	125,500	3,010,000	Multiple Arch	750,000	3,760,000
Horseshoe	150	136,400	3,000,000	Multiple Arch	1,240,000	4,240,000
Tangle Creek	150	136,400	3,000,000	Multiple Arch	1,400,000	4,400,000
Fossil Creek	148	134,500	2,960,000	Multiple Arch	1,593,000	4,553,000
Cliff Dwellers	93	84,500	2,700,000	Multiple Arch	350,000	3,050,000
		1,136,800	$24,355,000		$9,835,000	$34,190,000
Roads						500,000
						$34,690,000

Q=6,000 Sec. ft.

Installed Horsepower	1,136,800	Annual Cost	$2,896,050
Firm Horsepower	682,080	Sale Price at 2 mills	$8,920,000
KWH per annum	4,460,000,000	Net Annual Return	$6,023,950
		Net Annual Return, per KWH	1.351 mills

COST ESTIMATE COLORADO-VERDE CANALS

SET-UP NO. 1

Acreage 1,217,664
Miles Canals 547
Canal capacity at Diversion Dam 10,000 sec. ft.

Earth excavation	54,226,230	cy	at 10c	$ 5,422,623
Rock and Caliche excavation	5,477,138	cy	at 60c	3,286,283
Concrete Lining	14,125,604	sf	at 10c	1,412,560
Horseshoe Tunnels				
R....15.2	1,550	lf	at $190	294,500
R....10.4	2,000	lf	at 110	220,000
R.... 8.85	2,000	lf	at 90	180,000
R.... 7.55	550	lf	at 80	44,000
R.... 3.9	1,600	lf	at 35	56,000
R.... 6.8	1,044	lf	at 65	67,860
Agua Fria Siphon	4,900	lf		700,000
Salt River Siphon	9,590	lf		792,000
Salt River Penstocks	6,700	lf		1,380,000
Siphon South of Salt River	2,850	lf		151,000
Hassayampa Crossing	4,700	lf		375,000
R. R. and Hwy. Crossings and Turnouts				330,000
			Total	$14,711,826

SETUP NO. 2

Acreage 2,314,000
Miles Canals 881.4
Canal capacity at Diversion Dam 19,775 sec. ft.

Earth excavation	120,027,324	cy	at 10c	$12,002,708
Roch and Caliche excavation	11,495,068	cy	at 60c	6,897,041
Concrete lining	23,757,589	sf	at 10c	2,375,759
Horseshoe Tunnels				
R....10.4	2,000	lf	at $110	220,000
R.... 8.85	2,000	lf	at 90	180,000
R.... 7.55	550	lf	at 80	44,000
R.... 3.9	1,600	lf	at 35	56,000
R....14.8	1,044	lf	at 175	182,700
Agua Fria Siphon	4,900	lf		700,000
Salt River Siphon	9,590	lf		4,490,700
Salt River Penstocks	6,700	lf		1,380,000
Siphon South of Salt River	2,850	lf		859,500
Hassayampa Crossing	4,700	lf		375,000
Gila River Siphon	2,872	lf		440,000
R. R. and Hwy. Crossings and Turnouts				400,000
			Total	$30,653,408

SUMMARIES

Numerous summaries of cost estimates can be made depending upon how many acres are to be irrigated and how much power is to be developed, etc. On the opposite page we have made five tentative set ups. These figures are based on four per cent interest and one per cent amortization to repay the principal in 41 years. Summary No. 1 is based on no power sales and about 50% irrigation. While a million acres of land can not be brought into cultivation in a short period, we believe that power demand would inevitably increase with population growth, and power sales offset delayed receipts from agriculture.

Summary No. 2 is similar to No. 1 but with power sales of 40% of the potential demand of Arizona, with power development at the cheapest points of installation.

Summary No. 3 is similar to No. 2 but with power sales for complete potential demands with development of the power sites on the Verde River.

Summary No. 4 is similar to No. 3 with additional power production at Mile 66.5 on the Colorado River.

Summary No. 5 is based on the irrigation of about double the acreage in the other summaries, and additional power plant installation for the greater supply of water.

In none of these estimates are included the areas in the valleys adjacent to the Colorado River nor the Verde River project proper, which may be financed before the Colorado-Verde project.

The inclusion of the Verde project would increase the acreage, water supply and power and thus decrease the cost per acre foot of water.

It is believed that federal funds should be obtained on a self-liquidating project at 4% interest. However, if Arizona farmers should be able to secure federal money under the same terms as those in the Imperial and Coachella Valleys, the cost of water would be as follows:

	Summary No. 1 Cost per Acre-ft.	Summary No. 2 Cost per Acre-ft.	Summary No. 3 Income per Acre-ft.
1st 5 years	1.10	.14 (income)	2.08
Next 10 years	1.55	.33	1.52
Next 25 years	2.00	.81	.95

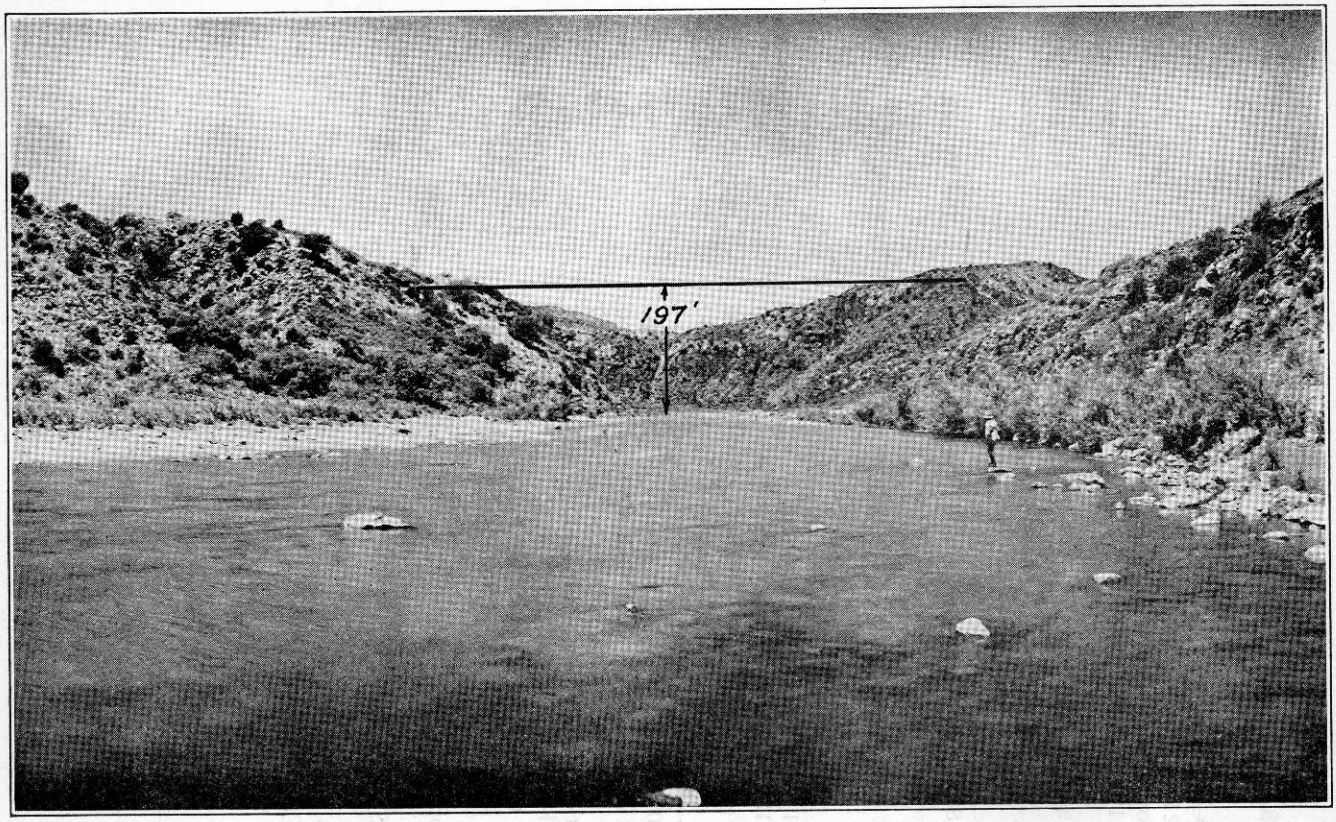
Summaries 4 and 5 would also show an income per acre-ft.

SUMMARY OF COSTS — COLORADO-VERDE PROJECT

	No. 1 Q=6000 s.f. 1,217,664 Ac. Low Dams	No. 2 Q=6000 s.f. 1,217,664 Ac. Low Dams	No. 3 Q=6000 s.f. 1,217,664 Ac. High Dams	No. 4 Q=6000 s.f. 1,217,664 Ac. High Dams	No. 5 Q=12,000 s.f. 2,314,000 Ac. High Dams
Marble Gorge Dam, Mile 5, Colorado, 438′-495′	$ 19,000,000	$ 19,000,000	$ 21,000,000	$ 21,000,000	$ 21,000,000
Marble Gorge Power, 400,000 I.H.P., 500,000 I.H.P.	.....	4,800,000	6,000,000	.....	.....
Tunnel, Mile 5, Colorado to Mile 10, Little Colorado	41,904,000	41,904,000	41,904,000	75,311,000	75,311,000
Dam, Mile 10, Little Colorado, 451′-508′	6,000,000	6,000,000	7,500,000	7,500,000	7,500,000
Tunnel, Mile 10, Little Colorado to Mile 66.5, Colorado	.....	.....	.....	5,870,000	.....
Power, Mile 66.5, Colorado, 799,000 I.H.P.	.....	.....	.....	9,590,000	.....
Tunnel, Mile 19, Little Colorado to Verde River	88,323,000	88,323,000	88,323,000	88,323,000	158,737,000
Shafts and Elevators	4,357,000	4,357,000	4,357,000	4,357,000	4,357,000
Camp Verde Dam 268′-323′	2,800,000	2,800,000	3,785,000	3,785,000	3,785,000
Camp Verde Power 209,000 I.H.P., 268,000 I.H.P.	.....	3,500,000	4,020,000	4,020,000	8,040,000
Camp Creek Diversion Dam	325,000	325,000	325,000	325,000	325,000
Power at Granite Reef 172,000 I.H.P.	.....	2,780,000	2,780,000	2,780,000	2,780,000
Main Canal System	13,000,000	14,712,000	14,712,000	14,712,000	30,654,000
Lateral System (to each 80 acres)	18,265,000	18,265,000	18,265,000	18,265,000	34,710,000
Verde River Power (see tabulation)	.....	.....	34,690,000	34,690,000	59,045,000
Highway Construction	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
TOTALS	$195,174,000	$207,966,000	$248,861,000	$291,728,000	$407,444,000
Installed Horsepower	.....	781,000	2,076,800	2,375,800	2,981,600
Firm Horsepower	.....	468,600	1,246,080	1,425,480	1,788,960
KWH per Annum	.....	3,064,644,000	8,149,363,200	9,322,639,200	11,699,798,400
Annual cost	$ 13,637,390	$ 14,838,670	$ 18,164,320	$ 21,119,340	$ 29,997,460
Sale price per Annum, at 2 mills per KWH	.....	$ 6,129,288	$ 16,298,726	$ 18,645,278	$ 23,399,597
Net cost per Annum	$ 13,637,390	$ 8,709,382	$ 1,865,894	$ 2,474,062	$ 6,597,863
Net cost per Annum per acre-foot, first 40 years	$ 3.10	$ 1.98	$0.42	$0.56	$0.75
Net cost per Annum per acre-foot, after 40 years	$ 0.67	Profit $0.61	Profit $2.65	Profit $3.06	Profit $1.76

ANNUAL COST

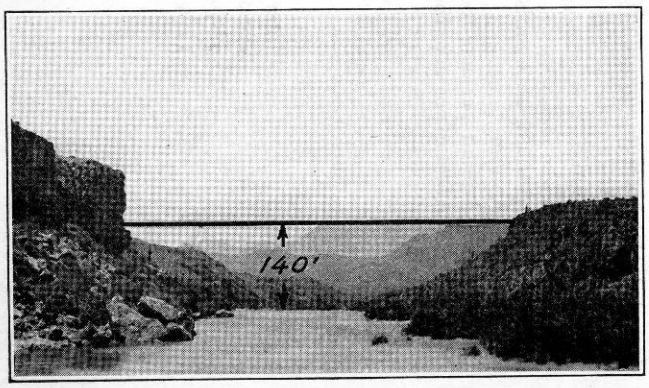
	Dams, Tunnels Shafts	Other Items	Interest during Construction
Interest	4%	4%	4%
Amort.	1%	1%	1%
Dep. & O & M	1%	4%	
Totals	6%	9%	5%



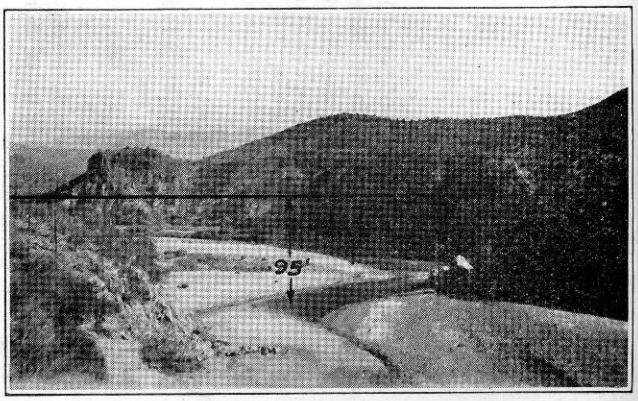
Malpais Dam Site. Verde River Mile 92

RELATIVE

The irrigation of Arizona lands by the use of the water of the Colorado River is not a small or cheap proposition. The total costs are staggering, but so is the acreage that can be irrigated, the power that can be developed and the growth and prosperity that can be brought to the state. The unit costs are not high. They are less than those of many projects built and contemplated. The irrigation of a large acreage in Arizona is a project comparable with the Columbia, which is estimated at $376,631,000.00 to produce 1,400,000 commercial horsepower and irrigate 1,200,000 acres by a pump lift of 370 feet. With the project estimated to cost $360,000,000.00 for transferring the surplus water of the Sacramento River to the Valley of the San Juaquin. With the six million acre extension of the Aswan project on the Nile by England, now being constructed in the face of a temporary surplus of farm projects. We believe that the development of Arizona power and irrigation is much more feasible than any of these projects, and that it is entitled to *equal consideration.* A comparison of the Colorado-Verde project shows that, while it involves costs similar to those of the Metropolitan Water District, it would give returns many times as favorable. In this connection it should be remembered that Los Angeles has in the Owens Valley-Mono Lake region a source of better and cheaper water than from the Colorado River, and that they will not need any of the latter for over twenty years, and probably not the whole amount for seventy five or one hundred years.



Yavagila Dam Site—Mile 68 Verde River



Cliff Dwellers Dam Site—Mile 42, Verde River

It will require over eight million additional population at 120 gal. per capita per day to consume in domestic use the 1,500 sec. ft. of water that it is proposed to pump 1,600 ft. over the coast mountain range to the vicinity of Los Angeles, but it will only require 30,000 farm units of forty acres each, or say an additional population of 120,000 to occupy a million two hundred thousand acres of Arizona land. If Los Angeles expects to use Colorado River water for agricultural purposes an acre in California producing crops for shipment to New York, Chicago, Philadelphia or Detroit can stand no higher water costs than an acre in Arizona.

Those who condemn the 144 miles of tunnel on the Colorado-Verde project should consider that there are 104 miles of tunnel on the revised plan for the 267 miles of Metropolitan Aqueduct from Parker to the reservoirs, twenty-five miles outside of Los Angeles, and nearly as many additional miles of concrete conduits, pipes and siphons.

A comparison of the figures given in the final report of the Metropolitan Water District Board of Review with those of the Colorado-Verde project, with interest estimated at 4¾% and excluding the cost of distribution in California beyond their terminal reservoirs and in Arizona beyond the main canals; shows that without any power at all the costs for water on the Arizona project would be but 11% of the cost of water to California during the amortization period, and after the amortization period but 8%.

If the Colorado-Verde project could sell a small part of their power the water cost would be but 6% of that of the Metropolitan District during amortization, and after amortization would become a profit.

	Metropolitan Water District	Colo-Verde	Colo-Verde
Cost of Project	$ 194,364,000	$176,909,000	$ 189,731,000
Water Obtained acre ft.	1,100,000	4,400,000	4,400,000
Kwh Produced	314,770,000	0	3,065,000,000
Kwh used in pumping	2,533,200,000	0	0
Cost per acre ft. for 40 yrs.	26.66	3.09	1.63
Cost per acre ft. after 40 yrs.	6.56	.50	Income .98

At present Los Angeles charges the San Fernando Valley lands $9.80 per acre foot for water, and it has been suggested that Colorado River water that will cost $26.66 per acre foot to take to the coastal plain be temporarily sold to irrigation projects at $10.00 per acre foot.

FINANCING

A decade ago one of the large power companies applied to the Federal Government to construct a storage reservoir and power plant at Glenn Canyon to be followed later by complete hydro-electric development of the river by a series of dams, etc. Later the State of Arizona applied for a license for several sites. Both the state and the corporation, which would have paid taxes to the State of Arizona, were refused permits, the government itself going into the power business, using the expected receipts as the credit for financing irrigation projects and city water works for the State of California. Since the Federal Government has entered the power business, it is improbable that Arizona or any private agency would care to compete with the Government, in view of the kind of competition that would exist with the practically unlimited funds at the disposal of the Nation.

A united group of mining companies might have raised the funds to develop cheap power for their mines in Arizona if their business had continued profitable, and had the mining interest not made so many foreign investments in the last decade, but at present it would appear that the only immediate hope of irrigation and hydro-electric development in Arizona is for the Federal Government to advance the funds necessary. This is particularly so as long as the Federal Government continues to hold large areas in the state that if owned by the state would constitute assets upon which it might obtain credit at low rates of interest.

If the same generous terms were extended to the people of Arizona, that were given to California by the Federal Government, repayment of a loan would be easy. The Secretary of Interior has contracted with the farmers of the Imperial and Coachella Valleys for the repayment of one per cent of the principal of their canal loan during each of the first five years, two per cent per year for the next ten years and three per cent for the remaining twenty-five years; all without interest. The inability at the present time of California Cities and water districts to finance their projects independent of government aid should silence the criticism that we can not immediately finance the development of Arizona.

ECONOMIC

The Colorado-Verde project would require a lot of labor for construction, but the workers who have been idle in Arizona during this depression have lost more hours of employment than would be required to construct this project. Somehow these workers have existed, but Arizona as a social unit has extravagantly neglected to secure what their work could have created. As a state we lost the additional wealth "that might have been," that could have provided the credit for their wages, and the farm units upon which a part of our national surplus of industrial workers could have been self sustaining.

The population of the United States doubled in the last forty-one years. Arizona's population doubled in nineteen years. Our population will continue to grow if we develop the resources within our state that can sustain population.

The previous generation had the foresight, courage and ability to conquer the western deserts. If we have not lost these attributes progress will continue.

PARKER DAM

Perhaps the next subject to engage the attention of Arizona will be the construction of a dam in the vicinity of Parker. No provision is made for this structure in the Boulder Dam Act, but it is desired by the Metropolitan Water District of Southern California to create a desilting basin, to furnish 40,000 horse power for pumping and to reduce the pumping lift across the coast mountain range. The district has figured on 78 feet less lift from a reservoir than from the river and as they have estimated each foot of elevation eliminated worth $80,000 this saving in pump lift would be worth $6,240,000.

Two sites near Parker have been considered; one about 6 and the other 18 miles above Parker. The upper site

is narrower and is preferred by the District. The canyon between the two sites is rugged and an 8,000 sec. ft. canal between the sites has been estimated by the Reclamation Bureau to cost over $22,000,000, which would be prohibitive. The lower site is at the end of the canyon section and could be used as a diversion dam for a canal to some 120,000 acres of land on the Indian Reservation and perhaps to the Parker Gila Project. A canal could also be constructed from the lower site to the Palo Verde mesa so this lower site would be valuable for both Arizona and California, and for irrigation as well as for power and city water works. Should this reservoir be constructed for the exclusive benefit of the Metropolitan District, California should stand the evaporation loss from its surface. The Metropolitan Water District has planned the postponement of the construction of a Parker Dam until the river silt load is reduced. Governor Hunt wrote the following letter regarding this subject to the chairman of the Federal Power Commission.

Mr. Geo. Otis Smith, Jan. 13, 1931.
Chairman, Federal Power Commission,
Washington, D. C.

Dear Sir:

Your letter of January 1, requesting comments or objections to the applications of the Metropolitan Water District of Southern California for a preliminary permit for the construction of a dam and power plant near Parker, received.

It is impossible for me to comment on this question specifically as no application has been received by the state of Arizona for this project.

Chapter 102 Arizona Session Laws of 1929, require the approval of the State Engineer of the plans, specifications, etc. for dams.

Chapter 81 Arizona Civil Code 1928, the state water code provide that all applications for irrigation and power projects are to be made to the State Water Commissioner.

Paragraph 3385 in this chapter provides that applications involving more than 25,000 horse power may not be granted without the consent of the state legislature.

The Arizona legislature today convened for a regular session of sixty days.

The supreme court also today set March 9th as the time for the hearing of arguments on the motion to dismiss the suit of Arizona against the Secretary of the Interior and California, Colorado, Nevada, New Mexico, Utah and Wyoming. This suit involves the constitutionality of the six state compact and the Boulder Dam Act.

It is probable that Arizona will oppose all applications for reservoirs on the Colorado River until this suit is settled or until a seven state agreement is executed dividing the water and power of this stream.

You write that the proposed reservoir would store 717,000 acre feet. May I suggest that if a dam at Parker were constructed immediately it would be filled with silt from the 100,000 to 140,000 acre feet carried each year by the river before a storage dam above could be completed even if the upper dam is not delayed.

It has been the desire of the people of Arizona that the Parker site would be used for a reregulation reservoir to adjust power flow to irrigation demand. The silting of this reservoir site would of course ruin it for such a purpose.

The primary construction of a storage reservoir in the upper pottions of the river would tend to deepen the channel below as the clear water from such a desilting reservoir again picked up a silt burden. This would reduce the depth to bed rock foundations for subsequently built lower dams and thus reduce their cost.

This has been the idea of Arizona men who are familiat with our silt carrying western streams. We are still hopeful that a comprehensive plan of development for the entire river can be adopted.

Thanking you for the infotmation furnished in your letter I beg to remain,

G. W. P. HUNT,

Recently the Reclamation Bureau advised that the Secretary of Interior had approved a contract for the construction of a dam at the Upper Site; that the Metropolitan District was to furnish the funds for the construction, by securing a loan from the Reconstruction Finance Corporation and that the power to be generated was to be divided equally between the Disttict and the Bureau of Reclamation. Senator Ashurst has been unable to secure a copy of this contract which should be of interest to Arizona.

MEXICAN TREATY

Commissioners appointed by the United States and Mexico were authorized by Congress March 3, 1927 to investigate an equitable division of the waters of the Colorado, Rio Grande and Tia Juana. Their report was printed as House Document 359. The International Water Commission is continuing its studies preliminary to a treaty. Secretary of Intetior R. L. Wilbur has contracted to deliver over 5,320,000 acre feet of Colorado Rivet water to California. Mr. Dwight Morrow, when Ambassador to Mexico, is reported to have expressed the belief that Mexico was entitled to half of the water stored in the Hoover Reservoir. If he voiced the opinion of the State Department and a treaty is negotiated accordingly with Mexico, and the contracts made by the Secretary of Interior are valid there will be no watet available for Arizona irrigation. The following correspondence covers this subject.

July 24, 1931.

Senator Carl Hayden,
Washington, D. C.

Dear Senator:

In an endeavor to avoid Arizona again being placed in the position of having to make a delayed opposition to a developed program on the Colorado River, we wish to suggest to you the probability that Arizona's interest may be greatly jeopardized in the pending treaty with Mexico. We believe that it would be fairer to all concerned, and more conducive to international and interstate comity to preclude the signing of an unfair treaty than to defeat its ratification by the United States Senate.

Pursuant to Act of Congress, approved March 3, 1924, President Coolidge appointed a Commission to investigate an equitable international division of the waters of the Rio Grande. By Congressional Act March 3, 1927, this commission was authorized to include the Colorado and Tia Juana Rivers in its study. On August 26, 1927 the seven Governors of the Colorado River Basin States requested President Coolidge to notify Mexico that the

United States intended to use all the additional waters made available by storage works in the United States. They also requested he increase the membership of his Commission to include residents of the Colorado Basin. This was not done.

Arizona secured an amendment to the Swing Johnson Bill in Section 1, providing for the exclusive use within the United States of all the water stored in the Boulder Reservoir. Senator Johnson, however, secured an amendment in Section 20 of this Act, which may have nullified the provisions of Section 1. His amendments lend credence to the report that he had agreed to trade United States Colorado River water to Mexico in exchange for Mexican Rio Grande tributary water, in return for Texas support for his bill.

The report of the American Section of the International Water Commission, United States and Mexico, printed as House Document No. 359, indicates clearly that Mexico expects to secure a large quantity of water from the Hoover Reservoir, and is endeavoring to set up facts on which to base such a demand, as an equitable division.

While our commissioners have so far suggested that Mexico be limited to the use of 750,000 acre feet, this report contains many dangerous unrefuted statements to support an excessive Mexican allotment. On pages 7, 64 and 71 Mexico demands that American hydro-electric power be sold in Mexico at prices identical with those in the United States. Our Commissioners have accepted this idea, which in the case of the Boulder Dam means that tax free power would be available for Mexico, to insure the feasibility of irrigation by pumping for 579,300 additional acres.

On page 91 of this report Mexico's possible irrigable acreage has been greatly increased from about 200,000 acres, now irrigated, to a total of 1,961,900, while the irrigable lands in the United States have been greatly minimized. Present Central Arizona irrigation from the Gila, all areas in the lower Colorado Basin in New Mexico and Utah and the Little Colorado acreages have been omitted from the Commission's estimate of United States lands.

On page 68 Mr. Delph Carpenter, Water Commissioner of Colorado, is quoted, through the United States Geological Survey, as stating the Upper Basin needs but 5,720,000 acre feet, instead of the seven and a half million acre feet provided in the Santa Fe Compact. We are in receipt of a letter from Mr. Carpenter, dated June 30, 1931, in which he unequivocally denies this statement, and insists that the Upper Basin will require all of its allotment.

The Supreme Court's decision indicates Arizona is not subject to the Santa Fe Compact, with its provision of a sixteen million acre feet United States limitation on the use of water until 1963. Presumably the entire Basin is not limited by Section 8 (A) of the Boulder Dam Act, if Congress could not constitutionally limit Arizona.

The Arizona original resistence and the Supreme Court decision have, therefore, cancelled the automatic gift to Mexico of five million acre feet of water, as provided in the Swing-Johnson Bill. While the actions, of the six states, in approving a six instead of a seven state compact, Congress, in passing the Boulder Dam Act, and the Supreme Court, in declaring the Colorado River navigable, may delay and discourage Arizona development, nothing so far has occurred which can not be adjusted, but if a treaty is consummated, giving a large amount of water to Mexico, the interest of Arizona, as well as all of the other Basin States, will be seriously hurt, for which reason we respectfully suggest that opposition to such a treaty be immediately organized in the United States Senate.

Very sincerely yours,

COLORADO RIVER COMMISSION OF ARIZONA,
GEO. W. P. HUNT,
Chairman.

DEPARTMENT OF STATE
WASHINGTON

September 29, 1931

George W. P. Hunt,
Chair. Ariz. Colo. River Com.,
Phoenix, Arizona.

My dear Governor Hunt:

I have received your letter of September 9, 1931, with which you enclosed a copy of a letter dated July 24, 1931, addressed to the Honorable Carl Hayden, United States Senate, by the Colorado River Commission of Arizona, in which reference is made to the probability that the interests of the State of Arizona may be jeopardized in pending treaty negotiations between the United States and Mexico, concerning the waters of the Colorado River.

There are at present no treaty negotiations in progress between the United States and Mexico with reference to the distribution of the waters of the Colorado River. You may rest assured that when the question arises the legitimate interests of this country and its citizens will command our fullest attention and care. The problem of an adjustment between the United States and Mexico on the Colorado River is inevitably bound up with a somewhat similar situation on the Rio Grande River. A position taken on either river, a principle invoked or a condition which must be met will certainly affect the other. If the United States asserts in the case of the Colorado River that it is entitled to the exclusive use of the waters which originate in its own territory, it must face the application of the same principle on the Rio Grande for example. Other suggested principles have a similar dual bearing. On both rivers the people of this country have important investments and, perhaps, even greater hopes for future development. In approaching the problem on the Colorado River I trust that both you and the people of Arizona will, on the one hand, accept my statement that we are thoroughly appreciative of the national interests involved and, on the other hand, be ready to recognize that in some of the broader aspects the rivers must be considered together and not as isolated problems.

I may say for your information that the American Section of the International Water Commission, in cooperation with representatives of Mexico, is continuing its studies of the Lower Rio Grande and the Lower Colorado and Tia Juana Rivers, in accordance with the provisions of the Act of Congress approved March 3, 1927, to which Act reference is made in your letter to Senator Hayden.

Sincerely yours,
HENRY L. STIMSON.

October 9, 1931.

Hon. Henry L. Stimson,
Secretary of State,
Washington, D. C.

Dear Mr. Stimson:

I much appreciate your letter of September 29, and assurance that the interest of this country and its citizens will have your fullest attention and care, in case of a treaty between the United States and Mexico regarding the use of Colorado River water.

I am anxious that, even in the preliminary discussions of such a treaty *"now in progress"* by the International Water Commission, the interests of Arizona and the Colorado River Basin States be not subordinated to that of other sections of our country. This same concern induced all the Governors of the Colorado River Basin States at Denver in 1927 to request local representation on a special commission for the Colorado River, or on the International Water Commission; also that Mexico be notified that that nation could not hope to secure water of the Colorado, made available by storage in the United States. I consider that Congress endeavored to carry out this latter provision in Section 1 of Boulder Dam Act.

While the opinion prevails in these seven states that Mexico is not legally entitled to any water of the Colorado River, I am unaware of any disposition on the part of any of our states to assert that 'the United States shall have exclusive use of all the waters of the Colorado River that originate on United States soil', by denying Mexican citizens the use of the amount of the normal flow of the river which they now enjoy. Therefore, in my opinion, there will be no objection on the part of the Colorado Basin States to a treaty awarding 750,000 acre feet of United States Colorado River water to Mexico, *provided that nation will award equal compensating quantities of water originating in her territory to American lands served from the Rio Grande, etc.*

The people of our section believe that water power is a natural resource, which should be developed for the benefit of the communities adjacent to such resources, so you can understand our alarm at the acquiescence of the American members to the claim of the Mexican members of the International Water Commission, that power developed in our states should be sold to Mexican citizens at the same price it is sold to Americans, i. e. perhaps tax free.

If there were enough water in the Colorado River to irrigate all the lands within its basin the diversion of water to irrigate the coastal plain would not have occasioned such opposition as has occurred, but an additional paper transfer of the water resources of the Colorado Basin to the Basin of the Lower Rio Grande River, by means of an International treaty, will probably occasion more extensive resistence and ill feeling, as the decision of the Supreme Court, determining that Arizona is not bound by the Colorado River Compact, will compel other states to share with Arizona the losses due to an excessive award to Mexico.

As the Colorado River Basin, which may be hurt by a treaty, is not represented on the International Water Commission, while other sections, which might be benefited by a treaty, trading resources, are represented, I feel that I should convey to you some of the sentiments of this part of the Southwest, in the hope of reducing the differences between states, which are arising from the efforts of one section of our country to secure the resources of another.

Very respectfully,
GEO. W. P. HUNT,
Governor.

Federal Aid

While the Mexican states of Sonora and Lower California, as well as Texas, would benefit by a trade of Colorado for Rio Grande water, the states of Chihuahua, Coahuila, Nuevo Leon and Tamaulipas, like Arizona, would suffer a reduction of development, and they will probably oppose the trade. Sonora and now Lower California in Mexico, like California, in the United States, have had the advantage of having their citizens in high Federal positions, where they could favor their states, with Federal appropriations, etc.

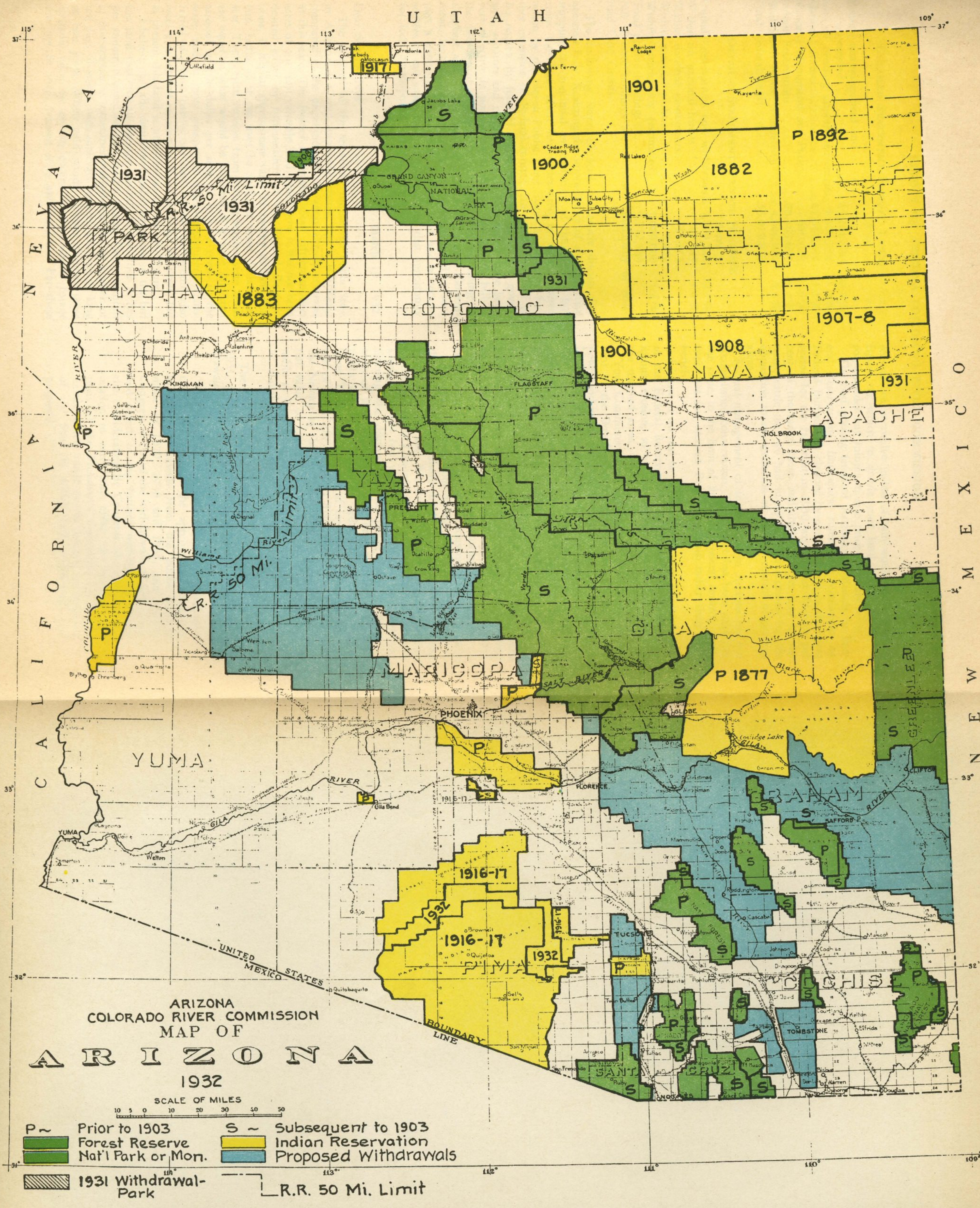
Future Friction

An exchange of Colorado for Rio Grande water would provide a source of future international friction. Those familiar with irrigation affairs know that compacts, agreements, rules, edicts, etc., difficult as they are to secure, are more difficult to execute; that they are not needed during wet years but are extremely hard to enforce during droughts, especially between different sections or states. Upper water users are inclined to preserve their crops rather than their agreements and later pay for the damage done when slow court procedure can compell them. If the farmers of the lower valley lands in each nation have to await recourse by international adjustment, which is slower than judicial action, and depend upon international agreements (sometimes found to be scraps of paper) for compensation, periods of droughts would be much more destructive to lower water users than if each nation retained and administered its own water on its own soil.

LAND WITHDRAWALS

The map on the opposite page shows in colors the relative amount of Arizona territory that is included in Federal Withdrawals or Reservations and the additional amount that it is proposed to include in National Forests or Parks. To these colored areas in the charge of Federal Bureaus would be added any public lands that are proposed to be placed in Federal Grazing Districts by a bill before the Public Lands Committee of the House of Representatives. The dates on the map show the progressive encroachment of Federal Bureaucratic control. The following tabulation of the status of the Land of Arizona, as of March 14, 1931, was secured by Senator Ashurst from Commissioner Moore of the General Land Office. Additional Federal Withdrawals & Reservations have been made since that date.

1.	Area of state	72,931,840 acres	100 %
2.	Land granted State	10,539,236 acres	14.5
3.	Federal lands	53,019,870 acres	72.6
4.	Private holdings	9,372,734 acres	12.9



UTAH
NEVADA
CALIFORNIA
NEW MEXICO
MOHAVE
COCONINO
NAVAJO
APACHE
YAVAPAI
MARICOPA
GILA
GREENLEE
GRAHAM
YUMA
PIMA
COCHISE
SANTA CRUZ
PHOENIX
FLAGSTAFF
KINGMAN
HOLBROOK
PRESCOTT
GLOBE
FLORENCE
TUCSON
TOMBSTONE
YUMA
GRAND CANYON NATIONAL PARK
R.R. 50 Mi. Limit
UNITED STATES MEXICO BOUNDARY LINE
ARIZONA
COLORADO RIVER COMMISSION
MAP OF
ARIZONA
1932
SCALE OF MILES
P ~ Prior to 1903
S ~ Subsequent to 1903
Forest Reserve
Indian Reservation
Nat'l Park or Mon.
Proposed Withdrawals
1931 Withdrawal-Park
R.R. 50 Mi. Limit

DETAILED STATEMENT FEDERAL LANDS

	Acres	
Vacant, unappropriated and unreserved	15,180,880	20.7%
Area of pending unperfected entries..	1,345,200	1.7%
National forests	11,371,341	15.5%
National Monuments and Parks	659,429	.9%
Indian Reservations	20,463,020	28.4%
Withdrawn lands (estimated)	4,000,000	5.4%
Total Federal lands	53,019,870	

DETAILED STATEMENT: PRIVATE HOLDINGS

	Acres	
Outside reservations and withdrawals	7,609,722	10.4%
Within the national forests	747,447	1.0%
Within national monuments	13,113	
Within national parks	2,452	
Within withdrawals (estimated)	1,000,000	1.4%
Total private holdings	9,372,734	

NB. Private holdings are composed principally of Railroad Land Grants.

The following letter, editorial and article discuss this question fully. Realizing the impossibility of a single state stopping the continual encroachment of the Federal Bureaus Governor Hunt has endeavored to secure united action by the eleven Public Land States against any further extension of Federal control. An article prepared at his request by John H. Page, and sent to various governors, senators and congressmen, is reported to have been very effective in postponing action on the grazing bill in the last session of Congress. Complaint is increasing in the East against the mounting costs of Federal Government. In the West we are not only being taxed to support a growing Bureaucracy, but the land and water resources of our states are being so handled that opportunity for local development is being strangled.

March 19, 1932.

Dear Senator Nye:

The disposal of the remaining unreserved public land in Arizona is a very important matter, but it is trifling compared to the disposition of the areas already reserved in this state. The former represents about fifteen million acres of our least valuable land. Until now it has not been desired either by homesteaders or for Federal Reservations. It has an approximate value of twenty million dollars. Little of it can ever be sold for three dollars per acre. The present receipts from leasing similar state lands are equal to what would be obtained if it were sold and assessed at one dollar per acre. If it were given to the state, and in more prosperous times subsequently transferred to private parties our state school fund would also receive in interest an amount about equal to the taxes, but at present this land is unsalable at nearly any figure.

I believe that the depreciated value proposed in the bill for land that has an average rainfall of but four inches per annum is based on too small a figure. Desert rainfall of this amount is sometimes precipitated during a week or ten days of storm, with intervals between rains of as long as two years. When cold windy weather follows these sporadic rains no growth occurs. Semi-occasional forage can not be used, because it is undependable. For these reasons ten or twelve inches of rain would make a fairer figure on which to divide your land classifications, if you consider any minimum sale price necessary.

The best grazing lands of Arizona are already in Federal Reservations. Impractical rules and regulations by Federal Bureaus are claimed by our stockmen as the main reason for the fact that in 1930 we had but fifty-six per cent of the range sheep and thirty-five per cent of the range cattle that we had in 1918. This accounts for the opposition to any extension of Federal control of grazing areas.

Federal management of forest areas in Arizona has not accomplished conservation. The timber has been sold just the same, to the limit of demands. Federal control, therefore, has but secured Federal revenue rather than local benefit.

I know of no real or practical work that has been done in the Federal Reservations of Arizona to protect them against erosion, so we can anticipate none by extending the reserved areas.

Your Committee is no doubt familiar with the provisions of the Boulder Dam Act, that transferred Arizona power and water resources to California. I will not discuss it, except to say that eighty-three per cent of the fall in the river to be developed at the Hoover site occurs in Arizona, and seventeen per cent in Nevada. Therefore, the absorbtion by the Federal Government of sixty two and one half per cent of the net profits (if there are to be any) from this construction results in its being taken exclusively from this state. If Arizona were permitted to tax this project the same as Maryland taxes the interstate hydro development at Conowingo we would receive a million three hundred thousand dollars annually.

Arizona possesses four times the potential power in the Colorado River above the Hoover Dam flow line that there is at this site. We heretofore have looked forward to this power as a source of future growth and taxation. During the last few years, while Congress has been considering the disposal of the public lands, millions of acres of land in Arizona have been withdrawn from the public domain by Executive order, and placed in reservations. Today the Secretary of Interior is in temporary control of all of the Colorado River power in Arizona from the Nevada to the Utah line. This power, with a potential value of one billion dollars, is fifty times as valuable as the unreserved and unappropriated areas of public domain in this state.

The Conference of Governors at Portland in October, 1931 passed the following resolution regarding withdrawals:

> "RESOLVED That the Western Governor's Conference opposes the approval by Congress of the withdrawals from the public domain made in 1929, 1930 and 1931, and request Congress to cancel the withdrawals of said years, and object to any further withdrawals during the consideration by Congress of proposed legislation to carry into effect the recommendations of the President's Committee on Public Lands, unless made on the request or approval of the State in which such withdrawals are proposed."

We sincetely hope that you will comply with theit tequest.

The importation of Aftican coppet and long staple cotton ptecludes this state ftom using the natutal tesoutces now available fot out people.

The Fedetal Buteaus have tutned out patk ateas ovet fot exploitation by monopolies in contol of ttanspottation, housing and metchandizing. Indian Resetvations ate being extended without wattant of inctease in tesident population. The ttansfet of land and watet powet sites to the Indians with theit subsequent lease fot Indian tevenue itstead of state taxation is compelling the citizens of Atizona to assume mote than out shate of the national obligation to the Indian peoples.

Unless yout Committee and Congtess can secute out people the petmission to use theit initiative and enetgy in developing the tesoutces of this state, we not only will be unable to assist in dissipating the ptesent deptession, but we will have no hope of being able in the futute to make of this state the gteat commonwealth it was destined to be befote Fedetal intetfetence hobbled out activity.

It appeats to me that if the membets of yout Committee will but look at the enclosed maps, showing the ptesent and ptoposed Fedetal Resetve ateas in Atizona, no additional atgument will be necessaty to convince you that out patticulat lack of ptospetity is due to conditions not in out contol, but imposed on us by the Fedetal Govetnment.

Very sincetely youts,

GEO. W. P. HUNT,
Govetnot.

Hon. Getald P. Nye,
Chaitman Public Lands Committee,
Senate Office Building,
Washington, D. C.

EDITORIAL—GRAHAM GUARDIAN, MARCH 3, 1932

REACHING OUT AGAIN

The fedetal buteaus ate teaching out again.

Ptess news ftom Washington btings infotmation that a tepott by Hetbett J. Hagetman, Special Indian Commissionet, tecommends that thtee hundted thousand additional actes of land be withdtawn in Atizona to inctease Navajo Indian Resetvations, also a like amount in New Mexico, and fifty thousand actes in Utah.

Half of Atizona is alteady in fedetal tesetvations, and seventy-thtee pet cent of out land is owned ot contolled by the fedetal govetnment, and administeted by edicts of the Washington buteaus. With 28.4 pet cent of out atea in Indian teservations, Atizona has had thtee times as much land taken fot this putpose as any othet westetn state. Atizona Indians have 435 actes pet capita, while the atea of ptivate lands, including millions of actes given to the tailtoads, would allow but 24 actes pet capita fot the temaindet of out population.

We should considet the tespective tacial incteases of population, and ptovide fot the one hundted and twenty million othet people in the United States, as well as fot the one-thitd million Indians.

In his tecent book "Consetvation" Sectetaty Wilbut tecommends intet-mattiage with the whites as the way to pteserve the Indian stock. Appatently he assays the tole of a match maket, and is ttying to ptovide latget doweties in otdet to expedite such unions.

Should congtess apptove the withdtawals of land in the Atizona Sttip, exchanges of land ftom fotest to Indian tesetvations in the vicinity of Shinumo Altat, the cteation of the fedetal Buffalo ptesetves, etc., the Sectetaty of the Intetiot will have secuted complete contol of the Colotado tivet thtough Atizona ftom the Nevada to the Utah line, including potential watet powet fout times as gteat as that of the Boulder Dam ptoject.

The ptoposed extension of the San Catlos tesetvation of two hundted thousand actes would include Gila tivet watet power below the Coolidge Dam. The powet sites on the Little Colotado and the Uppet Salt tivet ate alteady controlled by the Indian depattment, as well as the soutces of supply of domestic watet fot Phoenix and Tucson, the latgest cities in out state.

If the Indians ate to mingle with the whites, as the sectetaty tecommends, thete is no need to inctease the size of theit tesetvations.

If the United States is to give the temaindet of the public lands to the states, as the Sectetary advocates, it is inconsistent fot him to be constantly ttying to enlatge the fedetal tesetvations.

The sectetaty talks decenttalization of govetnment, while seeking to expand his contolled ateas.

The Indians tepotted by the Indian Depattment to own ovet a billion dollats of assets, ot a per capita wealth of thtee thousand dollats, ate largely in a condition of povetty. They ate like stock holdets of a cotpotation whose management is absotbing its tevenues.

The congtessional delegations ftom the westetn states should unite in opposing all futthet withdtawals of public land, and secute the cancellation of those tempotatily withdtawn.

We now have fotest teservations without ttees, Indian resetvations without Indians, and latge patk ateas destitute of natutal atttactions.

If it is advisable to make some adjustment of tesetvation boundaties it can be done aftet the gtowth of the federal buteaus has been checked. Buteauctacy cannot be decteased by incteasing its activities.

PUBLIC LANDS

By THOMAS MADDOCK

Deliveted at Govetnots' Confetence, Pottland, Otegon, Octobet 28, 1931

The public land question is oldet than the nation. Desite fot mote tettitoty caused the wats between England, Ftance and Spain that followed the discovety of Ametica. Aftet the wats the Colonists quatteled ovet the contol of lands located fat beyond theit settlements.

The pledge of state lands to the nation provided the security upon which Hamilton established out credit, as well as settled the ovetlapping claims of the states to the tettitoty west of the Alleghaney Mountains.

The gift of public lands to the tailtoads enabled them to finance the consttuction of out gteat ttanscontinental systems, and the possession of undeveloped tesoutces in the public lands has been a large factot in maintaining ptices of the United States bonds duting wat petiods.

The desire to own and control lands is innate in the human race. Most of the wars and conquests of the world have resulted from land hunger. The French Revolution and the Irish question revolved around control of lands. Germany started the World War to secure more land for a place for her people in the sun. The present Japanese invasion of China is to procure more land, and the few Bolshevics of Russia are able to control the great mass of that nation, because during the revolution the peasants obtained possession of the lands they had for years been tilling, and are afraid that under another government they might be returned to the former large proprietors. Our Indian and Mexican wars were over land, also the sheep and cattle wars of our west.

As the land question is not new it is easy to find historical comparisons for the different views on land control.

Not only George III believed the lands of the colonies should be controlled for the benefit of the mother country, but the farmers and merchants of England felt that they were entitled to exploit the colonies discovered and established under the British flag. Then, as now, those in charge of the government, believed the colonists or settlers incapable of self government. Unfortunately the Revolution transferred rather than altered this feeling. Tide water men and women could not appreciate the independent views of the transmountain people. Just as those who fled to America for religious freedom persecuted and even killed those who came later with contrary beliefs, each group of people who succeed to the control of government appear desirous to rule their own affairs, and, in addition, to supervise those of the Hinterland.

The history of how settlers of the proposed State of Franklin and Kentucky were deprived, by those in authority in Virginia and North Carolina, of the lands they had acquired by blood and toil is not as cheerful reading as the way the settlers of Vermont successfully defied the world, including the courts, to take from those who conquered the wilderness the fruits of their victory.

We must recognize the common inclination of mankind to meddle in and supervise the affairs of his brother. Those of us in the west who resent the control of western natural resources by a distant national government perhaps are not disturbed by this same government's control of the affairs of the people of Cuba, Haiti, Nicaragua and the Philippines. We only resent the guardianship of ourselves.

The states, not our nation, won their individual independence, and took from England the land of the colonies. The transfer of this land to the Federal Government was a pledge or a security to strengthen the finance of the new nation until the Revolutionary War debts were paid. The Federal Government was intended to be merely the trustee of the lands, to sell them to settlers. Ninety nine years ago, in 1832, the Public Land Committee of the United States Senate reported as follows:

> "The public debt being now paid, the public lands are entirely released from the pledge they were under to that object, and are free to receive a new and liberal destination for the relief of the States in which they lie."

> "The speedy extinction of the Federal title within their limits is necessary to the independence of the new States, to their equality with the older States, to the development of their resources, to the subjection of their soil to taxation, cultivation, and settlement, and to the proper enjoyment of their jurisdiction and sovereignty."

> "The ramified machinery of the Land Office Department and the ownership of so much soil extends the patronage and authority of the General Government into the heart and corners of the new States and subjects their policy to the danger of a foreign and powerful influence."

Remember this statement was made by men but one generation removed from those who transferred the lands from the states to the nation, and also long after the purchase of Louisiana, which put additional lands in the control of the Federal Government.

Our frequent wars, and the creation thereby of new debts postponed the returns of the lands to the states, but in Buchanan's administration Congress passed a law receding the public lands to the individual states. This President, who is generally believed not to have been one of our greatest, vetoed the Act of Congress, stating that the Federal Government was a trustee of these lands, and should administer them for the benefit of the states wherein they lay. Abraham Lincoln stated the fact of the trusteeship on the passage of the Homestead Law, which gave rather than sold land to actual settlers.

The Civil War again increased the national debt, and made it advisable for the national government to retain every possible resource. Later when the war debt was largely cancelled and a surplus existed in the treasury the government loaned about $30,000,000.00 to the eastern and central states, to assist them in paying their debts. These subsidies were never repaid. Today, at compound interest, they would amount to hundreds of millions of dollars, so perhaps the eastern portion of our nation has been repaid their tax expenditures in conquering the west.

In the early days it may have been good policy for the nation to administer the public lands. The frontier state governments were new, and the short occupancy of the lands had not yet given the people of the new commonwealths the stable and honest governments that come with a love of the home lands. Certainly today, after several generations have lived in them, the people of the western states possess state pride, and are as much inclined to honestly and wisely administer the resources of these states as any outsider or carpet bagger can ever be.

Mishandling of lands by state officials today would result in their removal from office, and the cancellation of any fraudulent transaction. Theoretically it is equally possible to change national officials who mis-handle public lands, but practically it is very difficult. Those interested in public lands are relatively few in number, and the question of land administration cannot compete for national interest with questions like the tariff, prohibition, national finance, unemployment, international debts and even religion. The public land question may be para-

mount to the people of the few western states, but if the Federal Government continues to administer those lands they will be controlled by men elected to office by reason of their presumed positions on other issues.

We are inclined to look upon our government as having been without material change since its creation. This is untrue. Real power in government, regardless of constitution and laws, lies in the hands of men strong enough to take and keep it. We have had Presidents of the United States who were virtual dictators, but men in other positions have also bossed this country. Speakers of the House of Representative, like Tzar Reid and Joe Cannon, Chairmen of the House Appropriation Committee and the Senate Finance Committee have temporarily dominated our affairs. A strong Chief Justice of the Supreme Court, Marshall, who presumed to tell Congress what laws it could pass or not pass, has been the real power in our country.

Today this power is in the hands of the Federal Bureaus, with the director of the budget looming as a possible contender for power. How can it be otherwise when 11,078 laws and resolutions were introduced in the final Session of the 71st Congress? What member of Congress could have studied these measures and the 43,599 pages of Committee Hearings regarding them? How many read the 13,336 pages of the Congressional Record of the debates on the Bills that got by the committees? How can the members of Congress be advised regarding the innumerable matters on which they are called to vote? They cannot. So, instead of being governed by laws, we are rapidly being ruled by Bureau rules and regulations.

How can the President select the 600,000 Federal employees who execute the law and their own rules and regulations which the courts have decided have all the power of laws? How can the ten heads of the departments, with an average employee list of 60,000, personally select their subordinates?

The real government of America is changing. Power is shifting, without constitutional changes, theoretically to Congress, but actually to the Bureaus. It is now a question as to whether public lands shall be administered by officials chosen by the people, who have an opportunity to know their abilities and duties, or whether they will be selected by some one else, selected by some others, selected by the President. The last selection is removed four or five steps from the original source of authority.

Our population is now 25 times as large as when administered by our first President, but the number of our Federal employees is 4,500 times as great. The average American today maintains 180 times as much Federal supervision as had our forefathers. The load is too heavy, and the situation gets worse instead of better. The army of civil employees is 150,000 larger than it was just prior to the great war. The present depression has caused a demand for economy in government, but instead of abolishing useless boards and commissions the last years saw an increase of 8,000 Federal employees in the City of Washington alone. Apparently, without having formally adopted the British dole system, we are competing with her in feeding a larger and larger number of nonproducers. However, our selection of those helped with government funds are not those most in need of assistance.

Two dangerous results can be anticipated from the extension of the Federal Government into the affairs of our people, besides that of excessive cost. One is the loss of an initiative in our citizens that heretofore has had the admiration of the world. The other is that Bu reaus tend to be self perpetuating.

Theoretically the President appoints Federal Officials, but in return Federal Officials practically insure a President his renomination or the choice of his successor. As it is hard to fire one's supporters the circle is complete. If voting were not wisely prohibited in the District of Columbia, where many of the Federal employees live, they would cast approximately as many votes for President as the total in six of our public land states, but our national officials influence a much greater number of voters.

The legislative and executive leaders of both political parties have long realized the ill effect of the increasing number of Federal employees, but they have been unable to do anything to remedy the situation. They have been powerless to adjust and consolidate overlapping Bureau activities. There is probably no greater service the public land states could render the nation at this time than to reduce or stop the increase of Federal employees.

It is no longer a question as to whether the State Legislatures or Congress will be the real judge of legislation. Measures introduced into Congress are not immediately considered by that deliberate body, as was originally intended and once done. They are printed and referred to the heads of the Executive Departments, by whom they are referred to Bureau heads, who in turn submit them through channels to some obscure clerk who is presumed to know about the subject. His approval or disapproval when countersigned by those in higher authority determines the fate of 95 per cent of the Bills submitted. Only measures of great national interest can arouse Congress to act contrary to the recommendations of the Bureaus. The Bureaus exert much influence in the appointment of members of Congress to the various committees that will consider the Bills in which they are interested. They can help or hurt members of Congress in their districts by the expenditures of national funds. When an administration has a large majority in the House of Representatives the power and influence of a new Congressman is insignificant. While the Bureaus frequently control the House Members they sometimes in return provide jobs for "lame duck" Congressmen who have been active in their behalf.

The Senators, with more clerical assistance to make investigations, still retain some independence, but the Bureaus are usually successful in securing their desires against the opposition of the few Senators whose states are concerned in the matter at issue. The director of the budget has become about the only Governor on the Bureau's machinery. During the last administration he frequently denied Bureaus' proposed expenditure, including items as small as a hundred dollars that did not meet his approval, stating that they were not in accord with the economic program of the President. A strong man in this position may become another temporary boss of our na-

tion, especially if we continue to centralize authority in Washington.

We are a queer people. Our nation was formed shortly after the struggle between the British Parliament and the Crown had resulted in victory for the legislative bodies and their control of expenditures. The constitution framers, knowing their history, insisted upon the House of Representatives as the body closest to the people, retaining the right to initiate appropriation. Today we have the budget prepared by an appointee of the Executive, just like the King's Minister one time prepared the King's levy, but under the name of budget we fail to see that we have merely gone back to old conditions once thought so bad that a few heads fell before it was decided that the representatives of the people should handle their purse strings.

The Bureaus long since realized that they can not govern the country from Washington. They have located headquarters in various districts, which sometimes conform with the state lines, so if our drift towards nationalism continues and state government becomes impotent, and our governors are limited to social duties we will at least have some real government available for local inspection.

It is said that if we had a perfect government for a generation we would lose the ability to govern ourselves with the death of the perfect officials. Danger from this source does not seem imminent, but we may lose the power of self government if we continue to increase the functions of Federal employees who are above and beyond the reach of indignant voters. A business depression may cause the change of administrations, but under civil service the Bureaus' power would probably continue the same as they have in the past. Business panics are depressing. Revolutions are mussy and disturbing, so we should find some other way to return government to the people.

Congress for thirty years has tried to pass a Public Land Grazing Bill. In 1925 hearings were held all over the west. A Bill was prepared, but defeated. The Bureaus opposed its passage, unless they were left with complete control of the public domain.

Elected officials are answerable to the Courts. The Tax Assessor who values your property, the County Commissioner or City Councilman who condemns your property for public purposes, the Sheriff or the Policeman that arrest you must meet you as an equal in our Courts, and justify their actions. A Jury of your peers decides your case, but the Federal Official in charge of Forest, Park and Indian Reservation is a member of a Bureau that makes rules and regulations. He enforces them as his fancy dictates, and is Policeman, Prosecuting Attorney, Judge, Jury and Executioner within his domain. This is a strange procedure in a nation which started out by dividing government into three distinct branches, Legislative, Executive and Judicial.

The government reservations of the west include the best lands. The Indian Reservations were selected either by the Indian themselves occupying these lands or by those anxious to preserve their interest. These lands are better than the average. Their size has been increased much fastr than the growth of the Indian population they support. The Forest Reservations, representing the best watered areas of the semi-desert west, are in government control. We see much propraganda regarding the benefit of Federal Forest administration, but for actual result, according to Senator Oddie "The Forest Service is reforesting something like 35,000 acres a year as against numbers of millions of acres that are denuded of forests by fires, insect pests and lumbering." The Parks, including the most beautiful portions of our states, taken by the Federal Government, have been handed over to monopolistic exploitation by large companies.

Additional land is being purchased or exchanged by the government to be put in these Reservations. It seems strange that our Constitution that requires the consent of the states for the purchase of land "for the erection of forts, magazines, arsenals, dock yards and other needful buildings," which we all admit are necessary for the public defense, would permit the alienation of land from private owners for minor purposes without state consent. If the Constitution did not give either the states or the nation the power to destroy each other it appears wrong that the gradual strangulation of a state by the elimination of its taxable property should be possible by the Federal Bureaus.

The Bureaus are seeking to control the waters of the western streams, although most of our land is valueless without water, and those who control the water can control the land with it.

Federal Commissions are struggling to obtain control of the hydro-electric power of the west. Millions of acres recently have been withdrawn in Arizona that contain potential water power; the ultimate value of which equals the entire present assessed valuation of property in the state.

Indian Reservations have been extended in Arizona and Utah to include water power sites and when these are developed the Indian Department, as in the past, will demand payment for the use of these sites. There is no logical reason why this generation of Indians should be supported by the western users of electricity even if the government does feel it is under obligations to support the Indians.

Half of the present Forest Reservation lands do not include areas with merchantable timber, but they are far more valuable for grazing purposes. Unable to get their Grazing Bill through Congress, the Bureaus are indirectly trying to extend their power and control by having lands added to the Forest areas that contain no timber. The excuse is protection of the watersheds. If this is for the benefit of cities must the Federal Government, created by the states, intercede to protect the cities, which are a like creation of the same agency? If for land reclamation, can not our irrigation states handle irrigation problems, including watershed protection as well as the Federal Government?

Only one-third of the seven and one-half million acres of Forest Reserve in Utah is really timbered, but the Forest Bureau proposes to add two and one-half million additional acres to that which they now control. Present Indian Reservations in Arizona have an area of about nineteen and one-half million acres. Three hundred thousand additional acres are proposed. The National Forests now include eleven and one-half million acres, of which only about three-eighths is timbered, but three

million seven hundred thousand acres of non-timbered land is proposed to be added by the National Forester, who at least temporarily has reduced the eight million seven hundred thousand acres which the District Forester thought should be added to his sphere of influence. National Parks and Military Reservations included seven hundred thousand acres before the recent addition of one million eight hundred thousand acres. A total of about forty-three per cent of Arizona is now in Reservations, and if the Bureaus are successful in their plans this will be increased to about 58 per cent or an area equal to that of the State of Washington. If the Federal Government reserves the control of all the mineral including coal and oil, of the lumber, power, water and grazing lands of the west, the transfer of the remaining worthless lands to the states would be of benefit only to the Bureaus that might thereby issue more modest statistics on Federal encroachment.

It is futile to criticise without suggesting a remedy. This nation today is ruled by organized minorities. That we do not like this system of government is no reason why we should not use it if it is our only recourse. Bureaus can not exist without appropriations. The Representatives from the western states are comparatively too few in number, and perhaps too anxious to have the Bureaus expend funds in their districts to offset much hope of curbing the Bureaus, but the eleven public land states have twenty-two Senators and the Senate must approve all Bureau appropriations. A little group of about half this number have been the balance of power in the United States Senate for the last decade. If fifteen or twenty of the western Senators will unite on any fair policy for the local control of western lands they can insure its adoption.

The Governors of the western states possess the most powerful peace time weapon, publicity. If you gentlemen will unite on a policy of resistence to further Federal encroachment, and the curtailment of present superfluous activity by the Federal Government in affairs that should be handled by officials answerable to the people at the polls, and will arouse the citizens of your commonwealth your Senators will be glad to carry out the wishes of your people, and the control of the lands and resources of your states will be vested where they were intended to be, in the hands of those without whose adjacent residency they would be worthless. Lands and resources have always been obtained or retained by fighting. Human nature has not changed. If the West desires to control its own resources it must fight to do so.

WATER LAW

Recent decisions of the United States Supreme Court indicate that the Riparian law of the Eastern and the Appropriation law of the Western states have both been discarded in interstate water suits, and that each case submitted to the courts will be judged on its opinion of the equities involved. Governor Hunt, in response to a request of the Governor of Pennsylvania, submitted the following ideas on the tendency of the courts to supplant law by opinion.

August 17, 1932.

Dear Governor Pinchot:

I appreciate your inquiry as to my suggestions for a law to clarify the interstate water situation. It appears to me that a Constitutional Amendment rather than a Congressional Act would be required.

The Constitution does not mention, among the powers given Congress, the control of irrigation water and hydro-electric power. The Supreme Court has repeatedly said Congressional control of rivers is limited to navigation, but if water and power control originally vested in the states is denied the Federal Government by the reserve clause of the Constitution it would appear that this same reservation exists against the judicial as well as the legislative branch, and that the Federal Court should not constitute itself a paternal authority to divide water, etc. between the states, as it personally thinks most equitable in each individual case.

As the states have no allegiance to intangible and impotent international laws, the recent assertion, that the court is following these in its water decisions, does not appear to be justified. In other words, the Supreme Court should determine what laws apply, and their meaning, but not legislate or create laws regarding subjects neither delegated nor implied to the Federal authority.

Constitutional amendments and interstate compacts provide methods of handling provision omitted from the Constitution. Therefore, there is no need for small appointed courts to originate laws, and I think that they have assumed too much authority in setting aside the old appropriation laws of the West and the Riparian Laws of the East by their recent decisions assertedly based on equity.

It is generally admitted that during the first Century of our history the courts construed our Constitution much more literally than at present, and that lately (no doubt in response to a popular opinion) they have given decisions that have increased the power of the national government at the expense of the states. The growing popular opposition to the extension of Federal Bureaucracy may reverse this tendency, but it appears to me that it would be safer if our Nation depended on changing our National Constitution by amendment, rather than by changing the personnel and the opinions of the members of the court.

In the Hoover Dam case the Supreme Court announced a legal fiction in saying it took judicial notice that the Colorado River was a navigable stream. Had they tried the Arizona-California case and taken evidence, it would have shown there has been no navigation for several decades. The court could have taken notice that Congress subordinated navigation to other uses on the Colorado River in approving the Santa Fe Compact and Boulder Dam Act. Confidence of the people and the states in the courts is hurt when they use technicalities to deprive communities of their resources.

This National Administration, as far as it relates to water control, is composed of men from California. Their endeavor to transfer billions of valuable Arizona resources to their California constituents is provincial, and demonstrates the necessity of the Constitutional guarantees that should supplant the surrendered rights of the states to armed defense against aggression.

In the Colorado River case the administration is trying to do the same as if it had prohibited taxation to Pennsylvania and Maryland on your interstate project at Con-

owingo on the Susquehana, and then sold the powet exttemely cheap to an outside state like New Jetsey.

I think that the states should have the same tight to tax watet powet that Pennsylvania has to tax het anthtacite coal befote expottation. If the Hoovet Dam site was taxed, as Matyland taxes the intetstate powet at Conowingo, Atizona would secute yeatly one million and a half in taxation. Atizona is despetately in need of this tevenue.

I fully tealize the supetiot necessity of watet fot domestic putposes ovet that of ittigation, also that it would be uneconomical and un-Ametican to desttoy wealth by dtying up ptesent cultivated land in one state in otdet to bting in new land in anothet, but I tesent the subtetfuge by which ptesent watet necessities ate used to give one state a monopoly on all futute development.

As watet is ftom ten to one hundted times as valuable for domestic putposes as fot ittigation cettainly cities in need can pay for it. I doubt that the Fedetal Govetnment is justified in subsidizing city watet wotks of Los Angeles out of the Fedetal Ttеasuty, but I am cettain that it is unfait to divett Atizona tesoutces fot such subsidizing.

If the watet tesoutces of the states, including powet, ate to be disposed of by the National Govetnment, we can but expect each gtoup of officials who tempotatily conttol the Nation, to, human-like, give the lion's shate to theit ftiends, ot to those possessing the gteatet political powets that may secute theit re-election.

Out local ptoblems may seem temote ftom you and yout people, but ptecedents ate being cteated hete that will be of vital concetn in the division of the watet and powet of yout eastetn intetstate stteams. On this account, I believe that this is a national question, and that yout intetest in this mattet is watranted.

Vety sincetely youts,

GEO. W. P. HUNT,

Govetnot.

Hon. Giffotd Pinchot,
Govetnot of Pennsylvania,
Hattisbutg, Pennsylvania.

Gibbon in his "Decline and Fall of the Roman Empite" said "The disctetion of the judge is the fitst engine of tytanny. The laws of a ftee people should fotesee and detetmine evety question that may ptobably atise in the exetcise of powet and the ttansactions of industry." In othet wotds, the tules of the game should be agteed upon befote the catds ate delt.

HOOVER DAM MISTAKE

Ftom Glenn Canyon to the Hoovet Resetvoit the Colotado Rivet has a fall of 2300 feet. Complete tivet development could tesult in ovet 6,000,000 H.P. being installed on this section of the tivet if stotage is cteated at ot above Glenn Canyon. Without such stotage powet development is uneconomical.

The fedetal engineets ate depending upon up stteam stotage to teduce the filling by silt of the Hoovet Resetvoit and to teduce the amount of tesetve capacity needed fot flood conttol so that powet output can be maintained by incteasing the head on the tutbines as the stteam flow is decteased by additional ittigation in the upper basin states. Evety comptehensive plan of tivet development tequites uppet stotage, but when this uppet stotage is secuted not ovet 2,500,000 acte feet of ittigation stotage will be needed in the lowet tivet to adjust continuous powet flow to seasonal ittigation demand.

The ptoposed Hoovet Resetvoit will contain 30,500,000 acte feet. When uppet stotage is eventually secuted, 28,000,000 acte feet of this stotage will be sutplusage. Ftom the gteat atea of the tesetvoit, each yeat thete will be wasted unnecessatily by evapotation about 700,000 acte feet of watet. This is about the same amount of watet now used on the Salt Tivet Ptoject. It is two thitds of the amount the Mettopolitan Watet Disttict of Los Angeles is spending $300,000,000 to take to the coastal plain so the loss may be compatatively figuted at Two Hundted Million Dollats.

With this useless waste of watet some 60,000 hotse powet will also be lost, wotth ftom Twelve to Eighteen Million Dollats.

As a powet ptoject the gteat capacity of the Hoovet Resetvoit will be a handicap instead of a benefit aftet stotage is secuted in the uppet pottions of the stteam as following an extended dtougth it will tequite sevetal seasons to tefill.

It would have been cheapet and safet to have built a 220 foot dam at the Hoovet site and a 365 foot dam at Gtand Wash than to build the entire 585 foot sttuctute at Hoovet.

The two sttuctutes would have ptovided sufficient immediate flood conttol.

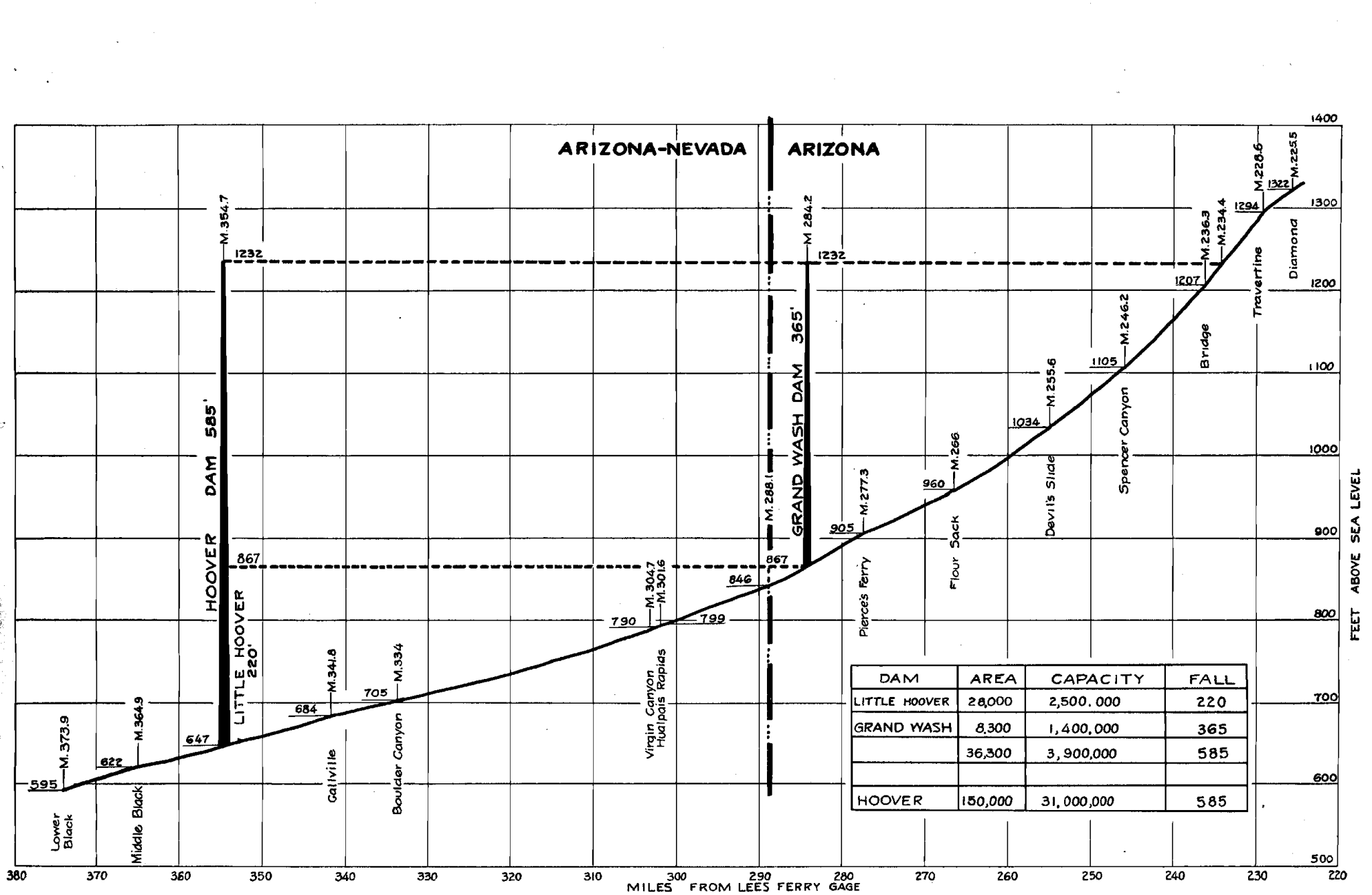
A bettet plan yet would be to build the Hoovet Dam ftom 250 to 275 feet high and to build the dam at Matble Gotge just below the Glenn Canyon. These two sttuctutes would cost less than the Hoovet Dam and would fit into a comptehensive plan of complete tivet development.

When we need all of out powet and watet it will pay to install the Gtand Wash Dam in the Hoovet Resetvoit to save the excess evapotation but it would save millions of dollats if the height of the Hoovet Dam wete teduced now.

Some opposition to the $300,000,000 Mettopolitan Aqueduct is gtowing in Los Angeles. Membets of the City Council have ctiticized it in theit meetings and in the ptess.

They contend that Owens Tivet watet is bettet, cheapet to secute and in sufficient quantity to ptovide fot the needs of at least the next two decades, that the people of Los Angeles can not affotd to subsidize new agticultute by paying $26.66 pet acte foot fot pumping watet ftom the Colotado River to sell it to ittigation ptojects fot $10.00 pet acte foot.

Should Los Angeles postpone the building of the aqueduct, thete will be no immediate sale fot 60% of the powet ftom Hoovet Dam. As a high dam at this location is not needed fot flood ot silt conttol not fot tegulation fot ittigation ot navigation but solely fot possible powet putposes the probable postponement of powet demands wattants a change in the height of this dam. Such teduction in height could still be made without much sactifice of wotk alteady done and at gteat future financial benefit.

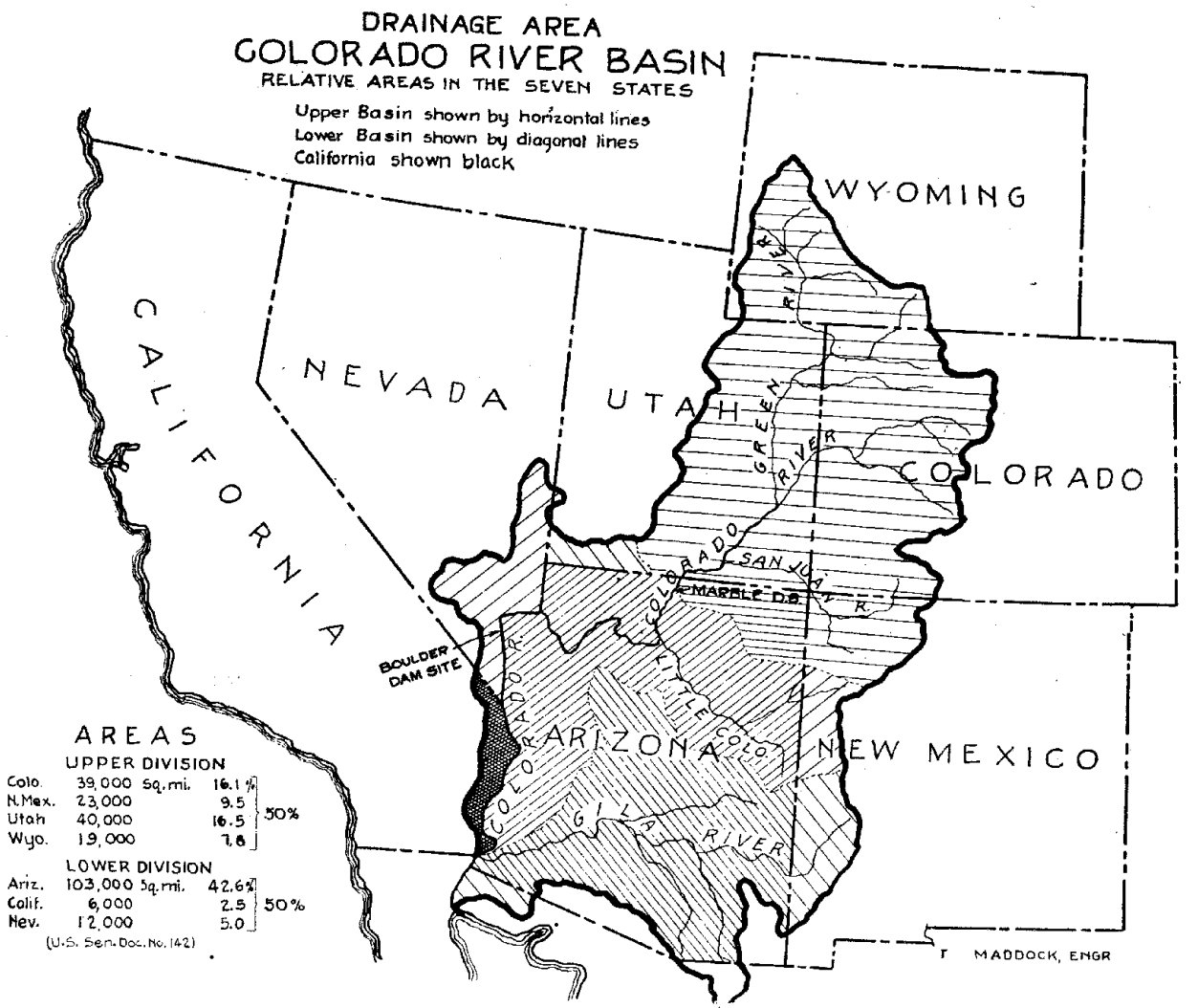


DAM	AREA	CAPACITY	FALL
LITTLE HOOVER	28,000	2,500.000	220
GRAND WASH	8,300	1,400,000	365
	36,300	3,900,000	585
HOOVER	150,000	31,000,000	585

FACTS ARIZONANS SHOULD KNOW

The belief in Arizona that the present national administration and the other Basin States have been antagonistic to Arizona and partial to California has the following facts for justification:

1. Irrigation projects and dam sites desired by California were investigated by Federal authorities.	Projects and dam sites in Arizona were not investigated by Federal authorities even when Arizona offered to pay the cost.
2. Three Cabinet members, composing the Federal power Commission, opposed the Boulder Project.	Two died, the third, recanted, became Hoover's campaign manager, and received an honorary degree from a California university.
3. E. C. LaRue, hydraulic engineer, principal investigator of the Colorado River for the United States G. S., opposed the Boulder project.	He was eliminated from government service. Other government engineers were silenced.
4. The governors of the Upper Basin States with their advisers, at Denver in 1927, unanimously endorsed a specific water division among the states; a limitation on waters to be allotted Mexico; the right of states to tax hydro-electric water power.	A majority of the Senators and Congressmen of the Upper Basin States in 1928 voted for the Boulder Dam Act, which is devoid of these provisions.
5. The Boulder Dam Act exempts California irrigation from any payment for the storage and delivery of water.	The Boulder Dam Act enables the Secretary of Interior to charge Arizona projects for storage whatever he sees fit.
6. The Boulder Dam Act provides that power plants and revenue therefrom in California can become owned by California Districts.	The Boulder Dam Act provides that power plants and the revenue therefrom in Arizona shall be owned by the Federal Government forever.
7. The Boulder Dam Act does not interfere with state control of a single California stream or power plant.	The Boulder Dam Act purporting to construct one reservoir, power plant, and canal, if constitutional, controls all the water and power in all Arizona streams for all purposes.
8. The Senatorial compromise that resulted in stopping the filibuster against the passage of the Boulder Dam Act contemplated California securing about 5,000,000 acre feet of Colorado River water.	Jokers in the Act permit California to claim over 7,500,000 acre feet of water out of the 8,500,000 acre feet the Lower Basin is permitted to use.
9. The Boulder Dam Act passed Congress on the representation of the California delegation that water for the coastal plain was to be limited to domestic use.	The first session of the California Legislature, succeeding the passage of the Boulder Dam Act amended the Metropolitan Water District law so that water can be sold for irrigation use.
10. The Boulder Dam Act was passed on the representation that California would finance the aqueduct and transmission lines necessary to guarantee the contracts providing for the repayment of government expenditures at Hoover Dam.	The Metropolitan Water District is securing funds from the Reconstruction Finance Corporation for California Dams, Power Plants, Canals, Transmission Lines and City Water Works.
11. The Boulder Dam Act was passed on the representation of its proponents that power sale prices should be sufficient to insure repayment of federal expenditures in forty years.	The power contracts provide that after ten years the price of power shall depend on the cost of transmission to Southern California and the price there of competing power regardless of the debt to the government.
12. The Boulder Dam Act passed Congress on the representation of the Secretary of Interior that a charge of three mills per kwh would be made for Hoover Dam Power.	The Secretary of Interior has contracted power at approximately two mills per kwh.
13. The President's Colorado Review Board recommended that the Secretary of Interior's tentative charge for storing water be increased.	The Secretary of Interior contracted to store water for the Metropolitan Water District for less than this tentative price.
14. Coal and oil royalties of 37½% of the *gross* receipts go to states in which these sources of power are developed on Federal lands.	The Boulder Dam Act provides that the States of Arizona and Nevada are to receive a royalty on hydro-electric power of but 37½% of the *net* receipts for but the forty year amortization period, and the Secretary of Interior has contracted power at so small a price that any net receipts are improbable.



There is three and one-half times as much potential water power in California alone as in the entire Colorado River basin.

There are more people living within the Colorado River basin and dependent on its waters in Arizona than in the other six states combined.

Arizona has seventeen times the area possessed by California within the Colorado River basin. Arizona has twice the good land that can be irrigated by feasible gravity flow from the Colorado River and its tributaries as California.

By the rules of justice, equity and economics, Arizona should receive more from the Colorado River development than California. Political influence alone has occasioned the attempted delivery to California of the lion's share of the waters and power of the Colorado River.

The total ultimate area irrigable from the Colorado River and its tributaries in Arizona, including existing projects, gravity projects herein proposed, areas below proposed canals subject to soil reclamation, pumping projects from proposed canals and local sources of water if cheap power is obtainable, total approximately four and one-half million acres. See fact 22 on opposite page.

15. Candidate Hoover in 1928 advised Arizona that he favored state taxation of Colorado River power plants.

President Hoover neglected to provide for state taxation in the Hoover Dam power contracts.

16. The Boulder Dam Act provides "That the States of Arizona, California and Nevada shall be given equal opportunity as applicants for power."

The Secretary of Interior contracted to sell 64% of the firm, and all of the cheap dump power to his California constituents.

17. The $165,000,000.00, authorized in the Boulder Dam Act for California, has been appropriated by Congress as needed.

The funds authorized in the Boulder Dam Act for the investigation of projects in Arizona have not been appropriated.

18. The Secretary of Interior has contracted the sale of power to California cities, districts and power companies.

The sovereign states of Arizona and Nevada alone and not their subdivisions or corporations may purchase power.

19. The Secretary of Interior has given small cities in California unlimited time in which to take power allotted to them.

Power not taken by Arizona within fifteen years after it is available is subject to reduction of allotment.

20. The Secretary of Interior disregarded the provision in the Boulder Dam Act that no money could be expended until a state's compact was approved and expended $385,000.00 on California's canal survey.

The Secretary of Interior failed to report on the survey of the Parker-Gila project on December 10, 1931 as instructed in the Boulder Dam Act.

21. United States Treaty Commissioners have agreed that Mexico shall receive power produced in the United States at the same price as American consumers.

The Secretary of Interior provided in the California canal contract that the Yuma Arizona project should pay 10% profit to California districts producing power.

22. The Mexican Treaty Commissioner in the report of the International Water Commission H. D. 359, 71st Congress, gives Mexico's irrigable area as 1,961,000 acres.

The American Commissioner reported Arizona's ultimate irrigable area as 890,900. He omitted all present irrigation from the Salt River, Gila, Little Colorado, etc.

23. During this depression the Federal Government has provided $365,000,000 for California development.

The Phoenix Federal Building, for which funds were available July 1, 1930, is still a hole in the ground.

The facts that the Secretary of Interior advertised and let the contracts for the Hoover Dam before the Supreme Court decided Arizona's suit to prevent his action, that the Supreme Court decision was based on "navigation" that does not exist, that the House of Representatives did not even read the Boulder Dam Bill after it had been completely amended by the Senate, that the Secretary of Interior since the passage of this act has endeavored to place all the water power sites in Arizona under Federal control; contribute to the belief that this state is being unjustly treated by the Federal Government.

ARIZONA'S HANDICAPS

Several causes have contributed to the ill success that Arizona has had in endeavoring to retain her resources for the benefit of her own people.

Arizona citizens were not advised as to the possibilities of development in this state. A majority of our leaders and sources of news dissemination early discredited Arizona possibilities, and have naturally slowly and reluctantly changed their early attitude. Most of our people have been busy with their own affairs, while many thought our projects too large, or the obstacles insurmountable.

Arizona's prospects for additional irrigation development were handicapped by the agricultural depression that occurred before the general depression diminished the prospective immediate domestic water and power needs of Southern California.

The forces in Southern California desirous of diverting our resources to their own enrichment were better financed and organized. They succeeded in placing Arizona in a false position before Congress and the country at large.

California had two advocates in the Cabinet of President Coolidge, and in the Hoover administration has had her citizens in key positions to secure whatever they desired. Besides the presidency her citizens occupied the positions of Secretary of Interior, Commissioner of Reclamation and Executive Secretary of the Federal Power Commission. California was the only state in the Colorado Basin that had citizens on the Mexican Treaty Commission, and by a trade with Texas they secured the support of the Congressman from the Texas district interested who was the minority leader and later the Speaker of the House of Representatives.

Had the late election continued the present national administration, there would have been little hope for any early relief for Arizona and the administration might have proceeded so far that it would have been nearly impossible for the courts to remedy the situation just as the President can so handle foreign affairs that war becomes inevitable regardless of the constitutional restriction that Congress alone may declare war. Following the decision of the Supreme Court in the Arizona vs. California case, it appeared untimely to continue to seek redress at Washington, but advisable to get ready for later action. It now would seem that immediately after March 4, 1933, Arizona should resume her efforts before a more impartial administration.

RECOMMENDATIONS

The decision of the Supreme Court that the Federal Government possessed the power to construct the Hoover Dam for the purpose of facilitating commerce on the *navigable* Colorado River settled that question alone.

The court refused to yet consider the division of the water and power of the river among the states or the right of the states to impose taxes upon hydro-electric power plants or their output or on transmission lines. The court's statement that the rights of the State of Arizona were unimpaired indicates that the contracts for the delivery of 5,320,000 acre feet of water, and two thirds of the power at the Hoover Dam, to California by the Secretary of Interior, may be without legal warrant.

The treaty in process of negotiation with Mexico includes an allotment of Colorado River water to that nation. The total of the demands for water of the various states in the Colorado River exceeds the supply and any of the states may petition the Supreme Court for an equitable division of the river at any time.

The withdrawals by the president of millions of acres of land in Arizona have been neither approved nor cancelled by congress.

There is a movement in the eastern part of the United States to stop all reclamation in the West and to expedite repayments to the Government and a counter-organization among the western states opposing this movement with which Arizona should unite.

These matters necessitate attention by some active agency of this State.

We, therefore, recommend the continuance of a Colorado River Commission, and that its efforts be directed to apprising the incoming national administration of the injustice done Arizona, and to having it corrected, to preparing for resistance to any treaty awarding a large amount of water to Mexico and to assembling and compiling data that will establish in court Arizona's claim to an equitable share of the benefits accruing from the development of the Colorado River.

Any service that the members of this Commission can do for Governor Moeur, a succeeding Commission, or any other agency created to retain for our citizens, Arizona's resources of land, water and power, will be gladly performed.

G. W. P. HUNT
HOMER WOOD
SAMUEL L. PATTEE
THOMAS MADDOCK

FINANCIAL STATEMENT 1931-1932

Received

Balance Appropriation Chap. 104, Sub. 70 Laws 1929	$ 7,369.96
Appropriation, 1931	100,000.00
	$107,369.96

Expended

Legal (Attorney General, etc.)	1,772.98	
Office (stenographer, telephone, telegraph, postage, etc.)	3,979.62	
Commission (Expenses for travel, etc.)	1,037.50	
Engineering, surveys, plans & estimates	46,075.01	
Withdrawals	1,431.71	
Geological	2,130.05	
Soil Survey (3,500,000 acres)	16,365.16	
Power Demand investigation	655.69	
Plates, etchings and half tones	1,000.52	
		74,448.24
Balance		$ 32,811.72

Outstanding

Ben N. Webber (salary)	$100.00
Mtn. States T. & T. Dec.	7.50
Arizona Printers (for printing report)	

APPENDIX
MINERAL RESOURCES

As there is no immediate market in Arizona for the entire amount of hydro-electric power that would be developed in conjunction with the irrigation of Arizona projects and as the sale of this power is essential in order to reduce irrigation water charges to an amount that would attract private capital, if public funds are unobtainable, we have had a preliminary survey made of the possibilities of increasing power use in the State. A similar but more extensive study of the same kind was made by the federal government on the Columbia basin project.

Preliminary Report

MINERAL RESOURCES SURVEY OF ARIZONA

With Reference to Electrical Power Demand
for
Arizona Colorado River Commission

BENJ. N. WEBBER, M.S., Geologist

Summary

Power Demand of the Mineral Industries.

Actual Demand

Normal Power Demand (Based on installed capacity only. Exclusive of Power sold by S. R. V. W. U. A. and Central Ariz. Power Co. and waste heat installations.)	121,345 H.P.

Potential Demand

Probable

Expansion of copper leaching	75,000 H.P.
Refining and recasting copper	29,055
Electrolytic zinc	42,000
Lead refining	804
White lead	1,147
Ferroalloys:	
Ferrosilicon	25,000
Ferromanganese	17,733
Ferrotungsten	441
Electrolytic iron	330,700
Limes and cements	42,977
Total 'probable' demand	564,857 H.P.
Total 'actual and probable' demand	686,202 H.P.

Possible

Electrolytic zinc	42,000 H.P.
Ferroalloys:	
Ferromanganese	17,733
Ferrovanadium	469
Electrothermic iron and steel	146,067
Magnesium:	253,260
	287,790
Alternate process and	279,860
Raw material figures	314,390
Total possible demand:	
Maximum	520,695 H.P.
Minimum	459,565
Total potential demand:	
Maximum	1,085,552
Minimum	1,024,422
Total actual and potential demand:	
Maximum	1,206,809
Minimum	1,145,767

INTRODUCTION

The primary object of this survey is to consider the mineral resources of the state in relation to their actual and potential demand for electric power. The actual power demand resolves itself into an investigation of the installed power capacity of the mineral industries. The problem of potential demand is a function of the following considerations: (1) The availability of raw materials and their quality, quantity and composition. These are essentially functions of the geological occurrance. (2) Mining methods. (3) Beneficiation methods with particular emphasis on the application of electrical processes. (4) Relative costs. The satisfactory solution of the problem depends on a careful and complete consideration of the above involved factors. Due to the exigencies of time, this report is of a preliminary or reconnaissance nature and these factors were only considered in sufficient detail to indicate the results.

Electric power at average efficiency costing two mills per K.W.H. is equivalent to available coals at $3.50 per ton or coke at $9.50 per ton, for simple heating operations of a non-chemical nature. Therefore power is substituted for fuels in such operations and enters into the total calculations of horsepower demand.

The writer is indebted to E. D. Gardner, Supervising Engineer of the Southwest Experiment Station of the U. S. Bureau of Mines, who kindly reviewed this report. The Arizona Bureau of Mines extended the courtesy of the use of their library and the faculty of the University of Arizona, College of Mines made helpful suggestions.

ACTUAL POWER DEMAND OF THE MINERAL INDUSTRIES

Actual power demand is herein calculated on the basis of installed horsepower, less the amount of power generated by waste heat installations. The following does not take into consideration the power purchased by mining

corporations from the S. R. V. W. U. A. and includes only major mining or beneficiation operations.

Average power consumption of present mining and milling practice approaches 22 K.W.H. per ton of ore. Two mills is less than one-fourth the published cost of power to the major mining companies. Power at this figure would result in lowering copper costs approximately 0.7 cents per pound on 1% ore.

Operation	Capacity H. P.	Plant
Gila Copper Sulphide Cons, Christmas	1,350	Diesel
P. D. Smelter, Douglas	7,000	Waste heat boilers
P. D. Concentrator, Warren	6,000	Diesel
Old Dominion, Globe	2,500	Oil fired steam
Ariz. Commercial, Globe	800	" " "
Inspiration Cons., Miami	39,000	" " "
Miami Copper Co., Miami	21,000	" " "
Nevada Cons., Ray and Hayden	19,500	Coal " "
United Verde, Jerome	8,500	Waste heat boilers
United Verde Ext., Jerome	3,700	" " "
P. D. Junction shaft, Bisbee	1,450	Oil fired steam
New Cornelia, Ajo	20,000	" " "
P. D., Morenci	5,000	Waste heat boilers
	5,000	Diesel
Magma Cons., Superior	1,750	Oil fired steam
Arizona Bagdad Co., Bagdad	975	Diesel
Clara A. S. & R., Swansea	1,000	Oil fired steam
Superior and Boston, Globe	1,000	Coal fired steam
Total Installed ..Capacity	145,525	
Total Capacity, Waste heat installations	24,200	
Installed Capacity Less waste heat installations	121,325	

This figure, 121,325 horsepower, closely approaches the amount of power demanded by the mining industry of the state, which is amenable to replacement by hydro-electric power at a lower rate than the present cost of generation. The average published cost of power of the major mining companies is 9.1 mills per K.W.H.

This quantity, 121,325 H.P., may also be considered as stand by capacity, already installed, by any hydro-electric development capable of absorbing this market.

Potential Power Demand

SECTION 1. PROBABLE DEMAND

LEACHING OF COPPER ORES

As a probable consumer of large amounts of electrical power, the beneficiation of copper ores by leaching methods is of first order importance. The process is growing in use and in the number of methods of which, the most efficient depend on the expenditure of about 1.75 K.W.H. of electrical energy per pound of copper produced.

Great Importance of Copper Industry

Copper is, and probably will continue to be, the chief mineral product of Arizona. Approximately 50% of the domestic production and 25% of the world production is mined in Arizona. Under normal conditions eight copper smelters and over thirty milling plants are active in the state. Published copper ore reserves of nominally commercial grade exceed 550 million tons and ore bodies undoubtedly exist, data on which have never been made public.

Of the total copper production of Arizona, 93% is the product of ten mines; 50% of the total production is from low grade disseminated ores requiring concentration previous to smelting. Since the copper mining industry is of a centralized nature, the application of power to beneficiation processes would not introduce a complicated transmission problem.

Leaching Processes

Leaching the copper content of an ore by the use of solvents and recovery of the copper, chemically as cement copper or electrolytically as cathode copper, is a process with a wide range of possibilities both in regard to reagents and methods of application.

A brief outline of leaching applications and methods follow: (1) Leaching in place. This consists of circulating solvents through a broken or fractured but unmined ore body, recovery of the solvents carrying the copper in solution and precipitation of the contained copper. This method is most feasible where the gangue or barren portion of the ore body consists of chemically inert material which will not react with the solvents used. This method has been successfully used on quartzyte ore bodies in Utah and resulted in a very low cost.

This method of leaching will undoubtedly come into use in Arizona for the recovery of copper from marginal ore after the principal ore bodies of the large operations are exhausted.

(2) Heap leaching. In this method the ore is mined and placed in heaps so that free circulation of air and solvents is possible. This is an accepted metallurgic method but is applicable only to large tonnages as a long time is necessary to complete the process. Leaching heaps at Rio Tinto, Spain aggregate 20 million tons and seven to nine years are required to bring the extraction up to 80 to 85 per cent of the contained copper. Heap leaching has been practiced at Bisbee and Jerome. The lowest cost copper ever produced at Bisbee was by this method.

(3) Confined leaching. This method consists of subjecting the copper bearing material, ground to appropriate size, to the action of solvents in tanks and precipitating the copper from the resulting solution.

(4) Controlled roasting of chalcopyrite ores and concentrates to produce a calcine with a highly soluble copper content and a minimum of soluble impurities. This is followed by agitation of the calcine with sulphuric acid which produces a copper sulphate solution. From this solution the copper is precipitated electrolytically. This is a recent development and is reported to be successful at the Bagdad, Arizona, plant of the Arizona Bagdad Copper Company.(1)

The first two methods are largely used on oxidized copper ores. The third method on oxidized or mixed oxide and sulphide ores and the fourth method only on sulphide ores, principally chalcopyrite. Milling processes prior to leaching may be adjusted to facilitate leaching operations. In some cases a middling product may be leached and a concentrate roasted and then leached. Therefore there hardly remains a copper occurrance that is not amenable to some type of leaching operation.

A large number of solvents have been developed. Sulphuric acid is the usual solvent as it is commonly cheaply obtained from sulphide ores near at hand. Ammonia and ammonium carbonate are used on some types of ores. Ferric salts are solvents of the copper oxides and chalcocite. Hydrochloric acid is an excellent leaching agent but its use is restricted by its cost. Sulphur dioxide and sulphurous acid are in successful use at Miami, Arizona.

Precipitants used do not cover as wide a range as solvents, only two are commercially successful, scrap iron and the electric current. Precipitation of copper on scrap iron produces a product known as cement copper which may be as low as 60% copper and requires further refining to remove impurities. Electrolytic precipitation of the copper from solution has a twofold advantage over the scrap iron method; (1) The product of electrolytic deposition is cathode copper of a high degree of purity and needs no further refining. (2) Deposition by electrolysis regenerates the solvent so that it may be re-used and results in substantial savings in costs.

(1) Baroch, C.D., Eng. and Min. Jour., Nov. 30, 1929. Also paper read before the Ariz. Mining Congress, Prescott meeting.

Future of Leaching Processes

Leaching of copper ores, as a method of beneficiation, is increasing. In 1929, 16.77% of the copper ore beneficiated in Arizona was so treated. The success of the Inspiration plant in treating mixed sulphide and oxide ores, with a successsively higher sulphide content and with continuously higher sulphide extraction has been outstanding. In 1929 oxide extraction was reported as 96% and sulphide extraction as 84%. The operation of the Bagdad plant in leaching roasted chalcopyrite concentration products is reported as satisfactory. The amount of copper ore treated by leaching in Arizona in 1929 showed a 5% increase over the amount leached in 1928. Leaching will undoubtedly continue to so increase. The increasing use of the process would be tremendously stimulated by the development of cheap power and it seems reasonable that with the development of cheap power, the larger portion of Arizona ores and concentrates would be so treated.

Application of leaching methods to copper ores and concentrates is only limited by the fact that as yet no satisfactory means have been devised to recover precious metals from material leached. This becomes a disadvantage in certain instances but the bulk of the copper ores of Arizona do not contain sufficient precious metal to warrant its recovery. Therefore 50% of the Arizona copper production is considered amenable to leaching.

Seventy-five Thousand H.P. Eventual Demand

The average copper production of Arizona over the ten-year period ending in 1929, less the amount of copper produced as cathode copper from leaching operations already established, is 551 million pounds per annum. The average current consumption of electrolysis of leaching solutions is 1.75 K.W.H. per pound of copper. The average annual production, 551 million pounds, would require 149,550 horsepower. If 50% of this production were the product of leaching operations, 75,000 installed horsepower would be necessary. Considering the expanding trend of leaching operations, it seems reasonable that the latter figure will be reached eventually. If cheap hydro-electric power is developed this period of time will be greatly shortened.

COPPER REFINING AND RECASTING

The expansion of leaching methods to eventually handle 50% of the Arizona copper output would leave a residue of 275 million pounds per annum to be pyrometallurgically

smelted to blister copper. The electrolytic refination of this quantity of copper would necessitate a refinery of the same size as the Maurer plant of the A. S. & R.

Copper Refining

Power represents one-half of the tank room costs of electrolytic refining. At two mills per K.W.H., power costs would be 0.8 mills per pound of copper refined. Present power costs at refining centers are approximately 2 mills per pound of copper. This indicates that with power available at 2 mills per K.W.H., or one-half of the present average cost to the industry, local electrolytic refining should be probable. Including overhead power and conversion loss, refining requires 0.38 K.W.H. per pound of copper. Refining 275 million pounds per year would require 16,273 constant horsepower.

Practically all of the copper of commerce passes through the cathode stage, either as the product of leaching operations or of electrolytic refining of smelter products. Cathode sheets are recast to ingots, cakes, wire bars, etc., to facilitate handling and meet the demands of the trade.

Recasting Refined Copper

Recasting is simply a melting and molding process. Care must be taken to prevent the formation of cuprous oxide, or if it is formed, to remove it by reduction with carbon. The latter process is unsatisfactory as it evolves gases that are absorbed by the molten copper. Control of cuprous oxide is greatly facilitated by the use of an electric furnace in the recasting operation. (T.A.I.M.E. 1914.)

Fuel costs of the reverberatory furnace are approximately 0.2 mill per pound of copper recast. The electric recasting furnace consumes approximately 0.15 K.W.H. per pound of copper. With a rate of 2 mills per K.W.H., electrothermic recasting costs would be 0.3 mill per pound of copper. The technical advantages of the electric furnace are believed to offset the slight difference in cost.

With cheap power available, it is probable that all or a substantial part of the cathode copper produced locally might be recast at the point of production. In order to recast the total average copper production of Arizona, 12,818 H.P. would be required.

Conclusions

Power necessary to electrolytically refine 50% of the copper production of Arizona and to recast the total production of cathode copper, from both leaching and refining operations, would be 29,055 H.P.

ZINC AND LEAD

Zinc Occurrence

Zinc is an important mineral resource of Arizona. It has not been mined to any extent, due to the long haul to the nearest zinc smelters. Zinc, in Arizona, occurs largely in the complex ores wherein zinc sulphide is associated with the sulphides of lead, copper and iron in an ore containing appreciable amounts of the precious metals, gold and silver. The occurrence of zinc in ores of copper and lead has retarded the development of these metals as its presence complicates smelting. Penalties are charged by smelters proportional to the zinc content of the ore. This, together with non-payment for zinc, often renders a zinc bearing copper or lead ore uncommercial.

Zinc, copper and lead sulphides may be separated from a complex ore by the process of differential flotation. This renders the copper and lead concentrates marketable but the absence of a market for the zinc concentrates militates against the commercial development of an ore body. The zinc concentrates often contain appreciable amounts of the precious metals. If this is the case, these values are lost unless the zinc concentrate is further refined. A local zinc refinery would insure the production of substantial amounts of lead, copper, silver and gold as well as zinc.

The refining of zinc ores containing appreciable amounts of the precious metals is an electrolytic process and if the zinc resources of the state were developed, a heavy consumption of electric power would be necessary.

Arizona Zinc Resources

The zinc resources of a single Arizona mining district are indicated in a paper presented by Oliver C. Ralston, Research Director of the United Verde Copper Co., at the St. Louis meeting of the American Zinc Institute. Mr. Ralston states that the Jerome district contains a large tonnage of zinc ore. That, altho the United Verde is developed to a depth of 3,000 feet and a new shaft will shortly go to 5,000 feet, development is incomplete and reserves are unknown but, "there will apparently be a greater tonnage of zinc ore than of copper ore. "The United Verde is credited with a copper production from 1888 to 1924 of 1,111,-971,696 pounds of copper. (Lindgren, U.S.G.S. Bull. 872.)

The potential zinc production of Arizona is approximately as follows:

District	County	Potential production In tons of zinc per day
*Cerbat	Mohave	75
†Bradshaw	Yavapai	90
*Dragoon	Cochise	12
*Patagonia	Santa Cruz	53

*Sierrita	Pima	37
*Oro Blanco	Pima and Santa Cruz	22
†Superior	Pinal	20
†Eureka	Yavapai	35
		344

*From data by Arizona Bureau of Mines, 1927.
†Estimated.

This production would be in the form of concentrates about 50% zinc, the product of the differential flotation of complex lead, copper, zinc ores.

A slight indication of the zinc potentialities of Arizona is given by the accepted geologic hypothesis, that the zinc sulphides paragenetically precede the copper sulphides where the two occur together. Zinc mineralization is therefore the product of a deeper zone than copper. It is possible that the deeper development of other copper mines containing some zinc will show an intensification of the zinc mineralization on the lower levels similar to the United Verde and develop a zinc mineralization comparable to the copper mineralization in the shallower zone.

Electrolytic Zinc Reduction

The electrolytic method is the most satisfactory for the production of zinc from ores or concentrates that contain values in the precious metals. The process is a post war development and is in use at several large plants in the western U. S. The process consists of three steps; (1) The concentrate or ore is roasted to reduce the zinc sulphide to zinc sulphate and zinc oxide. (2) The zinc is leached from this calcine by the solvent action of sulphuric acid. (3) The zinc is precipitated from solution and the acid regenerated by an electric current, (electrolysis).

Conclusions

Tabulation of the zinc resources of the state indicate a potential production of 344 tons of zinc per day. At least 200 tons of this would be available on the establishment of a zinc refinery of this capacity. The electrolytic production of zinc requires an average of 1.5 K.W.H. per pound of zinc. Therefore a plant with a capacity of 200 tons per day would require 33,500 H.P. for electrolysis alone. Conversion loss and overhead power would bring the total to 42,000 H.P.

The erection of an electrolytic zinc plant in Arizona is inevitable. The development of cheap power would accelerate its installation. The probable initial capacity of such a plant is 200 tons, requiring 42,000 horsepower. The remaining potential zinc production of 144 tons per day will be considered in calculations for an additional 200 ton plant.

LEAD RESOURCES OF ARIZONA

The average lead production of Arizona for the five-year period ending in 1929 was 19,487,067 pounds of lead per year. Of this production, 35% was from lead zinc ore and 65% was from lead or copper-lead ore. This figure, 65% of the production or 12,670,000 pounds, represents lead production, not dependent on the production of zinc.

The zinc production, outlined in the section on electrolytic zinc, would almost entirely be derived from the differential flotation of complex ores containing copper and lead as well as zinc. The proportions of zinc, lead and copper in a complex ore vary through a wide range but the average ratio is about one lead to two zinc. A production of 200 tons of zinc per day would be accompanied by 100 tons of lead. This amount plus the quantity derived from non zinc bearing ores would bring the total to 84,670,000 pounds of lead per year.

Smelting capacity for this amount of lead already exists at Douglas and Humboldt. Lead smelting is a pyrometallurgic process and requires only a nominal amount of power which is usually generated by waste heat boilers.

Electrolytic Lead Refining

Two lead refining processes are in general use; The Parkes process, a fire method, and the Betts process, an electrolytic method. The Betts process is in use at points where power costs are moderate as at Trail, B. C., and elsewhere. With power at 2 mills the Betts process would undoubtedly be the most advantageous.

The Betts process is essentially as follows: Cast lead anodes are suspended in an electrolyte consisting of a fluosilicic acid solution. The lead is dissolved from the anode by the solution and deposited on the cathode by the electric current, impurities remain in the slime from the solution. The power consumed in this operation is 0.05 .W.H. per pound of lead produced.

Conclusions

With zinc refining facilities available, the production of over 75,000,000 pounds of lead per year would be eminent. The electrolytic refining of this quantity of lead would require 670 H.P., conversion loss and overhead power would bring the total power required to 804 installed horsepower.

Electrolytic White Lead

One of the most satisfactory and valuable pigments is the basic carbonate of lead. This is an electro-metallurgical product requiring considerable power for its production. Either fire refined lead of high purity or ordinary

electrolytic lead may be used for the producduction of basic carbonate. The lead resources of Arizona are more than adequate for the production of large amounts of lead pigments. Cheap power would establish a combination of resources which would make Arizona a favored locality for the production of pigments, at least in the quantity consumed by the Pacific coast and Orient.

The following electrolytic process for the production of basic carbonate is in successful use.(1) An electrolytic cell with a diaphragm, an iron cathode and a lead anode is used. The electrolyte on the anode side of the diaphragm (anolyte) contains sodium acetate and sodium carbonate and the solution on the cathode side of the diaphragm (catholyte) contains the same salts in different concentration. On the application of the electric current, the lead is dissolved electrolytically as lead acetate and is immediately precipitated as basic lead carbonate by the reaction with sodium carbonate. The concentration of sodium carbonate is maintained on the anode side of the diaphragm by the passage of the ionized salt through the diaphragm. The anode consisting of basic lead carbonate is filtered and marketed.

A plant capable of producing ten tons of basic carbonate per day would require 1,147 H.P.

LIMES AND CEMENTS

Cement Materials

The raw material of the lime of commerce is limestone of high purity, essentially calcium carbonate. The presence of magnesium carbonate, silica, alumina and iron are deleterious if present in sufficient amount.

The raw materials of cement are, limestone, argillaceous material such as clay, shale or slate, and gypsum. The presence of argillaceous material and silica in limestone and of calcium carbonate in clay, shale or slate; allows the mixture of material to be adjusted somewhat to the analysis of the raw materials in order to produce a cement which consists of 75% calcium carbonate, 20% of silica, alumina and iron and not over 5% of impurities. The ratios of silica to alumina and of carbonates to insoluble must also be definite quantities. The ratio of silica to alumina and iron must be greater than 2.5 and less than 3.5. The ratio of carbonates to insoluble must be between three and four.(2) Pure material is therefore not essential to the production of cement provided that the ingredients exist of such composition that the mix may be calibrated to produce a cement of the desired analysis.

(1) Bowman, R.G., T.A.I.M.E. 1926.
(2) Eckel, Limes Cements and Plasters.

Limestone Resources of Arizona

Lime has been made successfully at a number of points in Arizona, notably at Cedar Glade, Nelson and Perkinsville in the north central part of the state and at Forrest Station near Douglas. The Perkinsville deposit is the Redwall limestone of Mississippian age and contains an almost unlimited tonnage of pure limestone. This deposit furnished flux to the United Verde Extension smelter, containing 98% calcium carbonate.(3)

Other than the deposits mentioned, limestone of sufficient purity is probably more than adequately distributed throughout the Paleozoic formations of both northern and southern Arizona.

Local Sources of Cement Materials

The raw materials required for cement production are also widely distributed. The Arizona Bureau of Mines reports limestones and shales of the proper analysis near Superior, Ariz.(4) It is significant that the Riverside Cement Co. controls 1,200 acres of limestone and asociated rocks near Winkleman, Arizona. Relatively pure limestones are abundant in north-central Arizona. The deposits from which commercial lime is made have been already mentioned. Clays for argillaceous material are also abundant particularly in the Verde valley. Gypsum which is used only in small amounts occurs in quantity in the Verde lake beds of Tertiary age as well as material of remarkable purity in the Harrisburg member of the Kaibab limestone of Permian age. Natural pozzuolanic material is widely distributed over the southwestern half of the state in the form of volcanic tuff. Tuff of the proper alumina silica ratio may be used in the production of cement as basic slags are used as well as in the production of Pozzuolan cement. Tuff has proved an excellent light weight aggregate material. The Los Angeles aqueduct consisted of 50% pozzuolanic material as light weight aggregate.

Electric Power in Mining and Calcining Limestone

Lime. The electric calcination of lime is not practiced at present but since the operation is simply dependant on temperature its use is only a matter of costs. A 100,000 ton per year lime plant, using power as calcination fuel, thermic requirements would be 21,248 H.P. Overhead power and the power necessary to mine the requisite limestone would bring the total to 21,461 H.P.

Electric power at a thermic efficiency of 80% reduces the fuel cost well below that ob-

(3) Hanson, Mayer, Yavapai Magazine, Jan. 1930
(4) Arizona Bureau of Mines, Unpublished data.

tainable with Gallup coal. Lime materials are relatively scarce on the Pacific coast and this market is open to Arizona lime whose closest competitor would be Nevada lime calcined with Utah coal. The fines from a lime plant, if sold to an adjacent cement plant, would also result in lowering costs.

Power in Cement; Mining and Calcination

Cement. A 375-ton per day cement plant (about equivalent to a 2,000 standard barrel plant) requires 450 tons of limestone, 150 tons of argillaceous material and ten tons of gypsum per day. The thermal requirements of this quantity of cement is equivalent to 17,705 H.P. overhead power and the power necessary to mine the required raw materials would bring the total to 21,516 H.P.

Conclusion

If power at two mills per .W.H. were available, the combined probable power requirements of limes and cement will be 42,977 H.P.

ELECTROTHERMIC PRODUCTION OF THE FERROALLOYS

The ferroalloys of silicon, tungsten and manganese are essential ingredients of special steels and are of interest because the necessary raw materials for their production exists locally and the general methods of production are electrothermic, requiring large amounts of electric power.

Locally Available Iron Deposits

All of these alloys require iron as an essential common ingredient. There are five sources of iron available, (1) The Canyon Creek iron deposit, (2) The Seligman deposit, (3) Fierro, N. M. deposit, (4) Ferriferous portions of the Yavapai schist and (5) Electrolytic iron produced from leaching by-product pyrite.

Ferrosilicon

The raw material used in the production of this alloy is silica (silicon dioxide). This may be used in the form of sand, quartzyte or vein quartz of required purity. Vein quartz is the preferred raw material. This is abundant throughout central Arizona.

The product of the electric furnace is usually 15% silicon or over but lower grade material can be made if demand justifies. Power at 2 mills per K.W.H. should justify a production of 32,700 tons of ferrosilicon per annum which would require 25,000 horsepower. This amount is approximately 12% of the annual consumption of ferrosilicon in the U. S.

Ferromanganese

The raw material of this alloy is manganese ore or concentrates of 35% manganese or over. The production of manganese ores in Arizona during war conditions, the only time a market has existed, was equivalent to 7,600 tons of metallic manganese. Furness, I. C. No. 6034, U. S. Bureau of Mines, estimates the low grade ores of Arizona, subject to beneficiation, to be capable of yielding concentrates equivalent to 8,300 tons of the metal per year. These figures were based on a long haul to markets. Also the beneficiation of manganese has made great progress since these figures were published. The production of concentrates would be substantially stimulated by the presence of a local market and improvement in milling and leaching methods would make lower grade ore available. A 25% increase in the production of concentrates would bring the total manganese available to 10,375 tons per year. In addition to the above the low grade sedimentary ores of the Alamo-Signal district have recently attracted attention. These ores are sedimentary manganese oxides and therefore promise a large reserve. The tenor is low, about 8.5% manganese. Beneficiation by sulphur dioxide leaching is contemplated and the district is considered capable of a potential production of concentrates equivalent to 25,000 tons of manganese per annum. The potential manganese production of the state totals 35,375 tons of metallic manganese per year.

Half of this amount is considered as probable production and its conversion to 76% ferromanganese would require 17,733 H.P. Since this is approximately 5% of the ferromanganese production of the U. S. there would be little question of its marketability, probably the Pacific coast and Orient would consume this amount.

Ferrotungsten

The tungsten resources of Arizona appear adequate although little definite data is available due to the fact that economic conditions have permitted little mining as the market is far removed.

The Boriana mine in Mojave county is a producer of tungsten ore, the product being consumed by the owners, the Stoody Rod Co. The Quijas mine in Cochise county is equipped to produce 35 tons of hubnerite (manganese tungstate) concentrates per day. Scheelite (calcium tungstate ore) has also been shipped from several localities in Cochise county. Considerable wolframite (tungstate of manganese and iron) has been reported in the Tip Top and Eureka districts. Hand cobbed scheelite was shipped from northern Sonora during the war. There is little doubt that if a local market existed, adequate supplies of tungsten ores would be forthcoming.

There are several chemical methods of producing tungsten salts. The electric furnace produces an alloy suitable for steel makers requirements. The present domestic production of ferrotungsten is almost entirely from imported ores. The electrothermic production of ferrotungsten containing 70% tungsten requires 7,600 K.W.H. per ton. A yearly production of 281 tons of ferro, 12% of the domestic consumption, would require 441 H.P.

Local Importance of Ferromanganese

The heaviest ferroalloy demand of the steel industry is for ferromanganese. Large amounts of ferrosilicon are also required but the necessary raw material is widely distributed. Manganese ores are not wide spread in distribution and the ferromanganese industry if established would have the double advantage of raw material close at hand as well as cheap power.

Conclusions

Estimated raw material costs with power at 2 mills per K.W.H. indicate that Arizona could compete in the production of these alloys on favorable terms, at present current prices.

Potential probable power consumption of the ferroalloy industry would be 43,174 H.P.

ELECTROLYTIC IRON AND SULPHUR FROM SULPHIDE ORES

Iron produced by electrolysis is practically chemically pure iron and is used in specialized industries where its improved malleability, ductility and electrical properties are an advantage. Seamless tubing of very thin walls may be directly produced by using a special type of cathode. Electrolytic iron has almost the same ease of working as copper or brass.

Electrolytic Iron From Sulphide Ores

The Perin process leaches the iron from pyrite or pyrrotite ores by use of an acid solution and the iron is precipitated electrolytically. The process is direct, pyrite (iron disulphide) ore or concentrates may be directly converted to pure iron and sulphur; there are no waste products since sulphur as well as any precious metals present may be recovered as well as iron.

Pyrite as a Source of Iron

Pyrite is a mineral that almost universally accompanies copper minerals as well as those of lead and zinc and the precious metals. In concentrating these minerals by the flotation process it is necessary to "drop out' a large portion of the pyrite as a worthless gangue (waste) mineral. A certain amount of iron is necessary in pyro-metallurgic smelting operations to form both slag and matte. In spite of this, pyrite is so abundant a constituent of copper and other ores that thousands of tons are disposed in tailings every year. Inevitable increase in the use of the leaching process as a method of beneficiating copper ore will result in more pyrite being wasted than is the case at present as iron required in smelting operations will be less.

Pyrite as a By-Product of the Arizona Copper Industry

In Arizona, pyrite may be considered as a by-product that is wasted although it must be mined and to a certain extent concentrated in order to recover the other minerals. No figures are at hand concerning the amount of pyrite mined as a constituent of other ores and discarded. However, one of the larger mining companies has been working on the problem of leaching pyrite and recovering iron and sulphur and have adopted a tentative estimate of the production of 700 tons of iron per day. On this basis an estimate of 1,500 tons of iron per day as a by-product of the copper industry of the state seem conservative.

Conclusions

The power requirements of electrolytic iron are 2 K.W.H. per pound of iron. Therefore 330,700 horsepower would be required.

By-product raw materials and power at 2 mills per K.W.H. would probably entrench this industry against more favorably situated sources of iron and sulphur.

Potential Power Demand

SECTION 2. POSSIBLE DEMAND

MAGNESIUM

Magnesium is now the lightest metal employed for purposes of engineering construction. The last few years it has been rapidly increasing in use throughout the industrial field. In Germany the metal is of first rate importance and is an active competitor of aluminum. Production of magnesium in the U. S., although still small, has increased over 300% in the last decade.

Magnesium, Field of Use and Competitive Metals

The important development of the metal lies in the use of the ultra light magnesium alloys as structural metals. The transportation industries are a large field for such material. The outstanding property of magnesium and the magnesium alloys is their extreme lightness. Increasing world wide interest in magnesium

and its alloys is due to their low cost per unit volume.

COMPARISON OF UNIT VOLUME COSTS (1)

Metal	Cost per cubic foot
Nickel	$200
Tin	100
Copper	40
Aluminum	38
Magnesium	30
Lead	25
Zinc	15
Iron	5

Beryllium is almost as light as magnesium but does not occur in sufficient quantities to be considered an engineering material. The geology of the beryllium minerals is such that the possibility of finding them in any concentration is remote.

Magnesium is two-thirds lighter than aluminum and one-quarter the weight of zinc. Magnesium alloys combine lightness with good strength which are the prime requisites of the transportation industries. All of the magnesium alloys are characterized by a high ratio of fatigue endurance to weight. Some alloys have high thermal properties, others are salt water resisting and all are free from intercrystalline corrosion.

Forty years ago aluminum was a laboratory curiosity, magnesium is well beyond that stage and may be expected to develop along the same lines as aluminum.

MAGNESIUM RESOURCES

The magnesium resources of Arizona are of two types; (1) The naturally occuring mineral dolomite, a double carbonate of magnesium and calcium. (2) Magnesia (magnesium oxide) which may be expected as a by-product of syngenite in the newly developed polyhalite field of New Mexico.

Dolomite resources are indicated by analyses scattered thru the geologic literature of Arizona. In north central Arizona, the Kaibab limestone of Permian age is often variably dolomitic. Six feet of the Kaibab limestone at Base Trail contains 18% magnesia and 39% lime. (Noble, U.S.G.S. Prof. Paper 131) The Kaibab limestone southeast of Flagstaff, magnesium carbonate, 5% and calcium carbonate, 18%, silica 72%. The same limestone at Elden mountain contains calcium carbonate, 52% and magnesium carbonate 24%. These analyses are widely separated and a general reconnaissance of the Kaibab limestone would probably show more dolomitic areas. Sixty three feet of the Muav limestone of Cambrian age is reported as containing 20% magnesia. Ransome (Prof. Paper 98 K., U.S.G.S.) reports the Mescal limestone of Cambrian age to contain 125 feet of dolomite, 15% magnesia. The Martin limestone, Devonian, in the same area contains 300 to 350 feet of dolomite with a magnesia content of 18.65%. The Martin limestone at Bisbee is reported (Bonillas et al, T.A.I.M.E. 1916) to contain 23% magnesia. It is obvious from the above that dolomite is quite widely distributed, arealy and stratigraphically.

The second magnesium resource which might be utilized depends on the production of magnesia as a by-product in the conversion of polyhalite, a naturally occurring salt, to syngenite, a fertilizer. For geologic data on the polyhalite field see Bull. 780 U.S.G.S. The process of reducing polyhalite to syngenite with production of magnesia is worked out in Rept. Inv. No. 3116 U. S. Bureau of Mines.

BENEFICIATION OF MAGNESIUM BEARING MATERIAL

Several methods for the production of metallic magnesium are feasible. (1) The oxide, magnesia, may be reduced by carbon in the electric furnace. The reaction is reversible and control is somewhat delicate. The resulting magnesium is distilled to the required purity. The operation requires 27,000 K.W.H. per ton of magnesium. (2) The anhydrous chloride of magnesium may be broken down by electrolysis and metallic magnesium collected on the cathode. This is the most popular commercial process at present. Power requirements are 17,000 K.W.H. per ton of magnesium. The product is of sufficient purity for use as an alloy base and requires no further refining. (3) The electrolysis of magnesium sulphate is technically feasible but as yet is commercially untried.

The magnesium carbonate may be separated out of dolomite by calcination followed by recirculation of the by-product carbon dioxide thru an aqueous suspension. Insoluble calcium carbonate precipitates out and the magnesium remains in solution as magnesium bicarbonate. Complete separation is then a matter of filtration. Several methods have been patented for the production of magnesium chloride from dolomite. It appears feasible to convert magnesium bicarbonate to the chloride by the use of sodium hydrate and hydrochloric acid in steps. Both of these reagents may be cheaply produced by the electrolysis of halite (sodium chloride) which occurs abundantly in the polyhalite field.

POSSIBLE PRODUCTION

Magnesium production might be expected to reach a figure of 62,000 tons per annum. This was approximately one half of the aluminum production of the U. S. in 1924, considered a normal year.

(1) Mining and Metallurgy, 1932, April.

Magnesium From By-product Magnesia

Production of this quantity by electrothermic methods, reduction of magnesia by carbon in the electric furnace, would require electric power to the extent of 253,260 H.P. If all the magnesia were a by-product of the conversion of polyhalite to syngenite, about a million and one half tons of polyhalite would have to be treated in order to supply the required magnesia. Syngenite is a co-product of the magnesia produced from polyhalite and is used as a potash fertilizer. Treatment of the requisite amount of polyhalite is a possible figure since the domestic consumption of potash salts similar to syngenite exceeds a million tons per year.

Electrolytic methods of producing magnesium from by-product magnesia would require its conversion to the sulphate or chloride. Conversion to the sulphate would be simple as the magnesia is an end product of magnesium sulphate liquors evolved in leaching polyhalite (R. I. 3116 U.S.B.M.)

Utilization of by-product magnesium salts produced in the refining of polyhalite is a phase of the investigation concerning the extraction of potash from polyhalite now under way at the Non Metallic Minerals Experiment Station of the U. S. Bureau of Mines at New Brunswick, N. J. The University of Texas, Bureau of Industrial Chemistry is also working on this problem. Therefore definite information on the production of metallic magnesium from these salts may be forthcoming shortly.

The electrolysis of the anhydrous magnesium chloride is the present largest commercial process for the production of metallic magnesium. The production of 62,000 tons per annum of metallic magnesium by this process would require 159,460 H.P.

Magnesium From Dolomite, Reagent and Power Requirements

The electrolysis of sodium chloride to produce sodium hydrate and chlorine to be converted to hydrochloric acid is a standard commercial process in successful use. If magnesium bicarbonate is converted to the hydrate and thence to the chloride, the reagent requirements would call for the electrolysis of 282,800 tons of halite, at an expenditure of electrical energy equivalent to 120,400 installed horsepower.

To produce this quantity of magnesium from dolomite would require 481,800 tons of dolomite containing 12.8% magnesium (about the average of known analyses of Arizona dolomite). Calcination of this amount by electrothermic methods requires 34,500 horsepower. Mining this tonnage of dolomite requires about 600 additional horsepower.

Power Resume of Magnesium Production Possibilities

Process	Required Electrical Horsepower
(1) Electrothermic magnesium from magnesia	253,260
(2) Electrolytic magnesium from anhydrous magnesium chloride	159,460
(3) Production of necessary reagents, to convert magnesium bicarbonate to magnesium chloride, by electrolysis of halite (sodium chloride)	120,400
(4) The electrothermic calcination of dolomite	34,530

The above is based on a required production of 62,000 tons of metallic magnesium per year.

Figure No. 1 represents the total if all magnesium were derived from by-product magnesia from the refining of polyhalite and were beneficiated electrothermically.

If all the magnesium were derived from dolomite and produced electrothermically; The sum of figures (1) and (4) would be the power required. (287,790 H.P.)

If all the magnesium were the product of the electrolysis of magnesium chloride derived from syngenite by-product magnesia Figures (2) and (3) would represent the power required. (279,860 H.P.)

With dolomite as the source of the magnesium and electrolysis of the chloride, the process used, the total power required would be that of figures (2), (3) and (4) or 314,390 horsepower.

Conversion of available magnesium salts to magnesium chloride is possible by a number of means and any consideration of the power involved in any commercial operation is necessarily highly approximate.

The present price of metallic magnesium is 30-cents per pound and the trend of the price is downward as magnesium enters new fields in competition with aluminum. Approximate figures indicate that the production of magnesium, with power at 2 mills per K.W.H., would be attended by a profit with magnesium at 20-cents per pound.

ELECTROLYTIC ZINC

One, 200 ton per day, electrolytic zinc plant is considered as the probable zinc production capacity of the state. This leaves a balance of 144 tons zinc per day of the estimated potential zinc production.

New Mexico has a large number of zinc and complex ore deposits. The actual zinc produc-

tion of New Mexico in 1929 was equivalent to 115 tons of metallic zinc per day. In addition to this, the zinc resources of Sonora are quite large, altho but slightly developed.

The part of the potential zinc production of Arizona that would not be cared for by one 200 ton zinc refinery plus the actual zinc production of New Mexico totals 259 tons of metallic zinc per day. The production of both New Mexico and Sonora would be drawn to Arizona if the refining capacity existed. Therefore it seems necessary to consider an additional 200 ton zinc plant as a possible development.

This would require 42,000 additional horsepower.

FERROALLOYS

Ferromanganese

The sum of 17,687 tons of manganese was considered as the probable amount of metallic manganese to be converted to ferro-manganese. This leaves a residue of 17,687 tons of the potential manganese production which might also be converted to ferromanganese, the market permitting and cheap power available.

This would require 17,733 additional horsepower.

Ferrovanadium

Vanadium minerals are common constituents of the oxidized ores of copper, zinc and lead thruout the Southwest. The usual occurance is as chloro-vanadates of zinc, lead and copper. These are usually beneficiated, if mined, for the base and precious metal content and little attention is paid to the vanadium and often molybdenum content of these ores. A number of methods have been devised to convert these vanadium and molybdenum minerals into usable salts of these metals.

The production of 35% ferrovanadium requires the expenditure of 6,800 K.W.H. per ton of alloy. 450 tons of ferrovanadium, approximately 25% of the domestic production, should not be beyond the vanadium resources of Arizona. This production per annum would require an installed horsepower of 453 H.P.

IRON AND STEEL

Other than the production of these commodities from by-product material as discussed under electrolytic iron, it may seem a bit far fetched to some, to consider the production of iron and steel in a locality situated as Arizona in regard to the consumption centers of these products.

From a study of the oldest mineralized areas in the wold, in point of discovery and utilization, Dr. Hewett of the U. S. G. S. finds that there is an economic cycle in mineral production dependent on geologic occurance. When several metals are the product of the same metallogenetic epoch, they are developed and utilized in approximately the following order: gold, silver, lead, copper, zinc and iron. It might appear that Arizona is well into the copper stage and that the major development of zinc and iron remain.

Arizona Iron Resources

There are several local sources of iron other than electrolytic iron from sulphide ores. The Seligman iron deposit, the Canyon Creek deposit, estimated by the U. S. G. S. to contain ten million tons of iron ore (Bull. 821C). The Fierro, N. M. deposit and certain portions of the Yavapai schist.

Electrothermic Iron Beneficiation

Electrothermic iron smelting and steel making are entirely feasible and their use depends upon power costs. (Stansfield, The Electric Furnace and Bradley, Metallurgy of Iron and Steel.) The electric steel furnace is conceded advantages providing costs are equal.

Electrothermic iron smelting requires 2,000 K.W.H. per ton of iron, this figure varies according to the composition of the ore. Electrothermic steel requires 600 K.W.H. per ton of steel.

Conclusions

A possible production of 1,000 tons of iron and steel per day would entail a power consumption of 146,067 H.P. Such production is based on the mining and beneficiation of iron ores and does not consider the utilization of electrolytic iron which would be marketed as such.

GENERAL MINING

In addition to the actual, probable and possible power demands of the mineral industries heretofore outlined, there exists a demand in these three phases which is difficult to outline without more or less detailed field work. This demand depends upon the development and utilization of mineral deposits which are either marginal or uncommercial at the present time but which would become commercially profitable if cheap power were available. Electric power is a large and increasing factor in all mining and in most metallurgical operations. The average power required per ton of ore mined approaches 8 K.W.H. per ton. This figure is based on partial electrification. Cheap power would result in a larger figure per ton mined.

There is little doubt, granting normal conditions, that the mineral industries of Arizona will continue to expand for some time to come.

Extensively mineralized mining districts which have been heretofore confined to the exploitation of superficially enriched oxide ores would be able to exploit and beneficiate lower grade primary ores if cheap power were available. Known deposits of the baser metals, copper lead, zinc and manganese would, if rendered commercial by cheap power, be large power consumers. The life of present operating mines would be greatly extended as cheap power would make ore of lower tenor feasible of beneficiation. Cheap power also may make possible the operation of present properties whose cost border on the selling prices, and, with specially cheap power, Arizona's copper production costs might compare with those of countries with specially cheap labor, such as Africa, Chile, etc. There is reason to believe that several very low grade gold deposits in central Arizona might be exploited at a profit if cheap power were available. The potential consumption of a substantial amount of power might be established by a field survey of the large low grade ore resources of the state.

ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

DIVERSION DAM—MC DOWELL PASS

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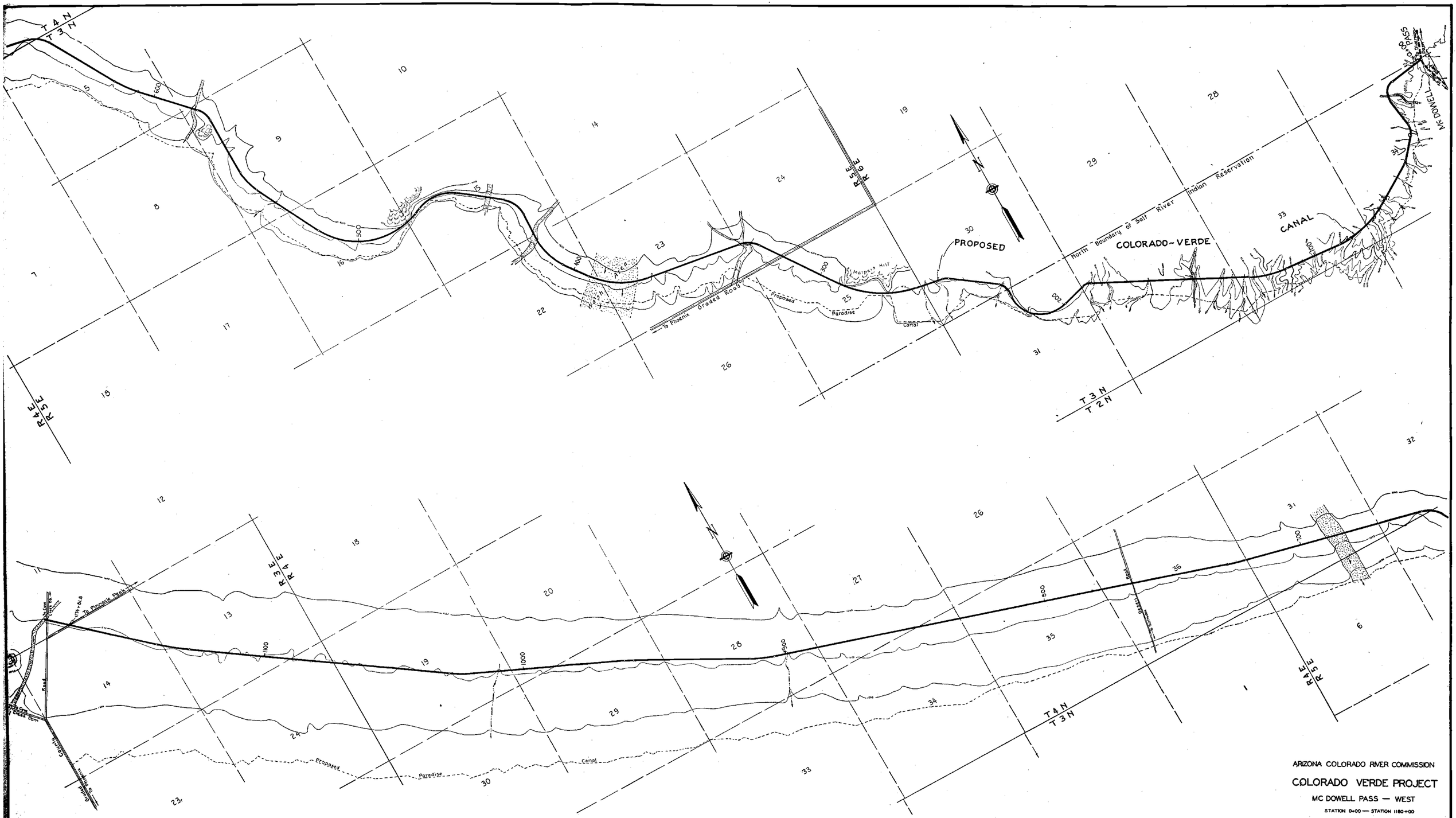

ARIZONA COLORADO RIVER COMMISSION

COLORADO VERDE PROJECT

MC DOWELL PASS — WEST

STATION 0+00 — STATION 1180+00

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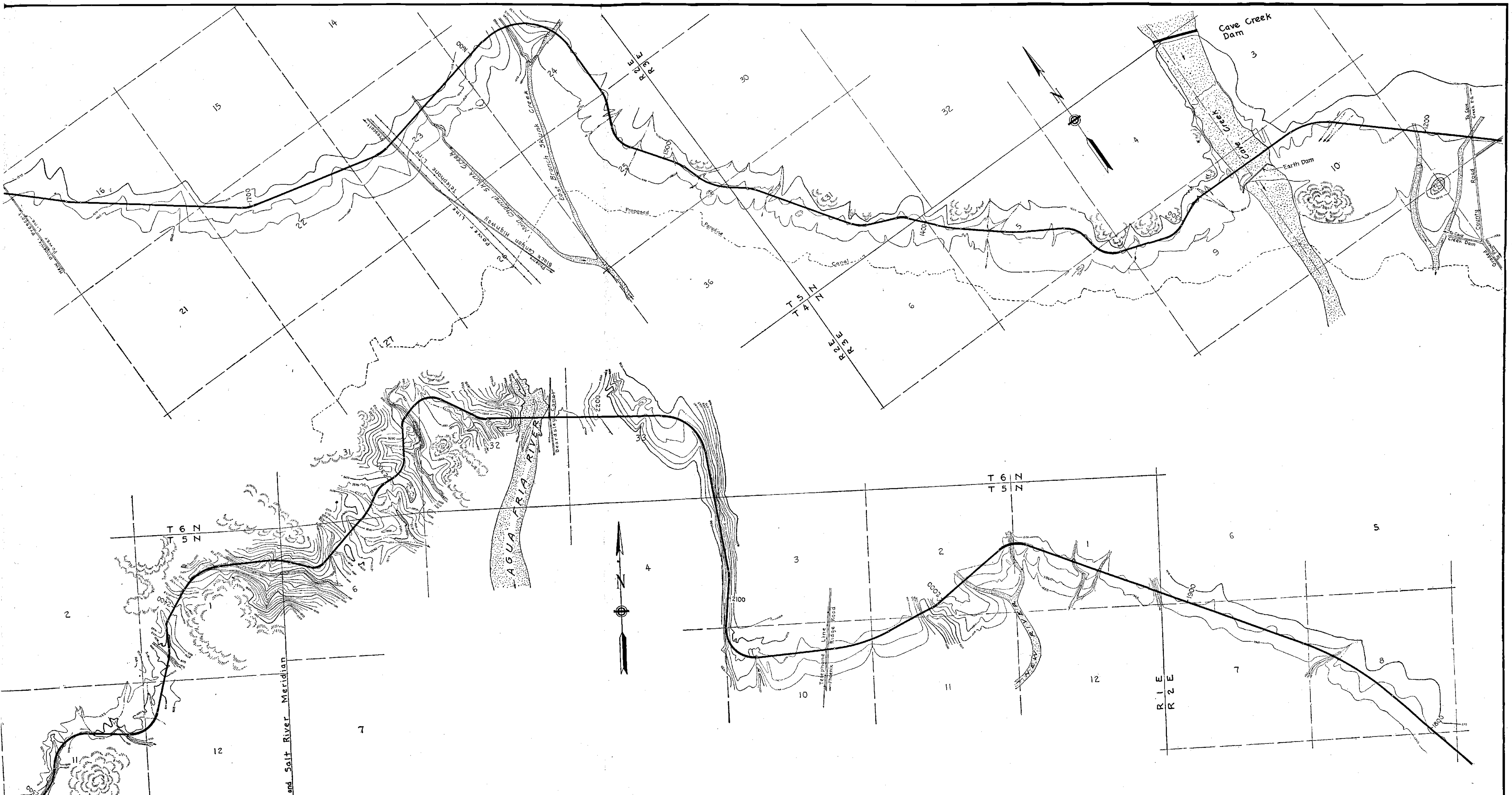

ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

MC DOWELL PASS — WEST

STATION 1180+00 STATION 2500+00

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL AS SHOWN

ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

MC DOWELL PASS — WEST

STATION 2500+00 – STATION 3550+00

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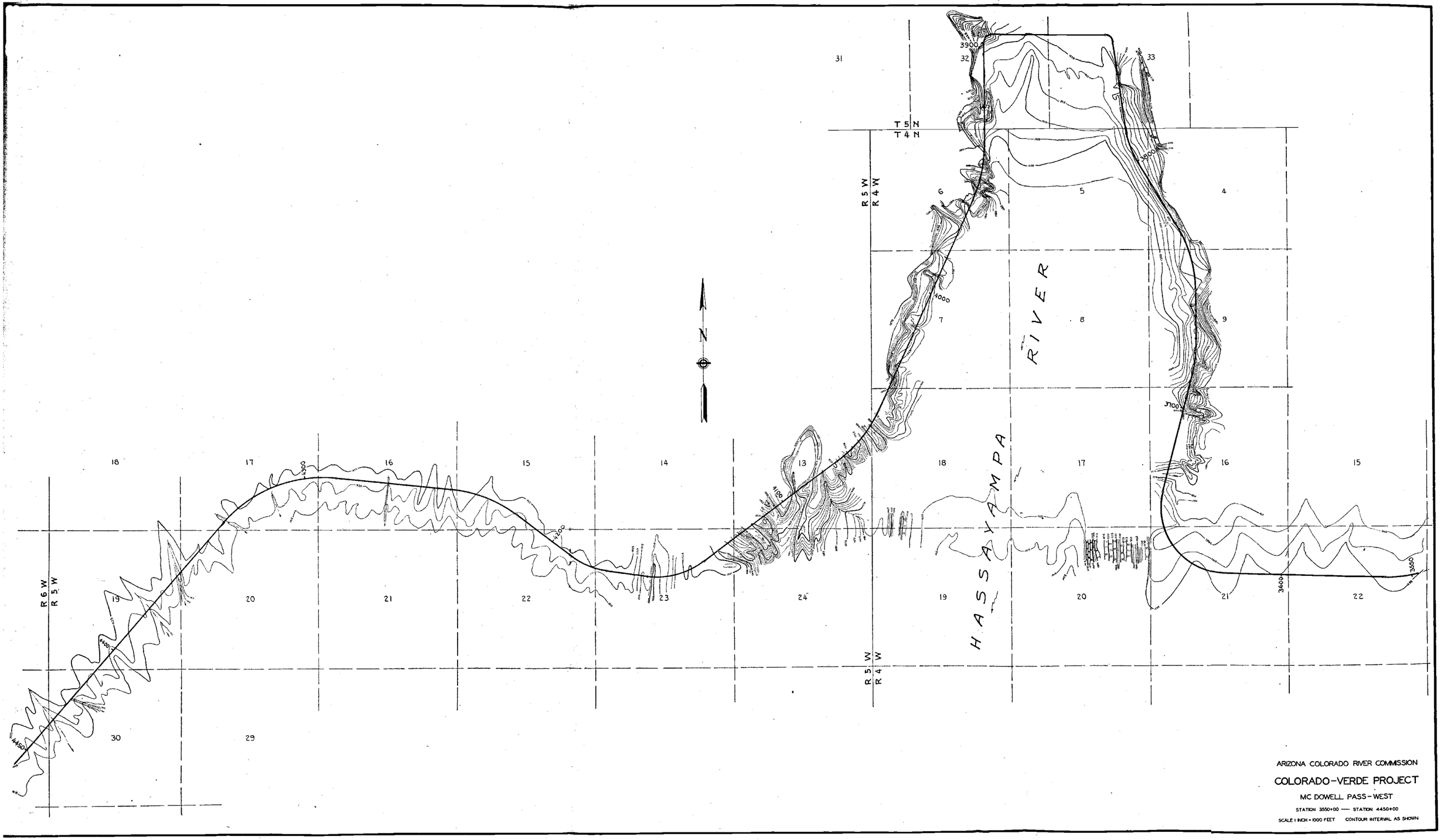


ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

MC DOWELL PASS-WEST

STATION 3550+00 — STATION 4450+00

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL AS SHOWN

BIG HORN MOUNTAINS

UNSURVEYED TOWNSHIP

T 4 N
T 3 N

R 7 W
R 6 W
R 5 W
R 9 W
R 8 W

5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
5600
5500
5400
5300
5200
5100

Rock Ridge
Rock Point

ARIZONA COLORADO RIVER COMMISSION

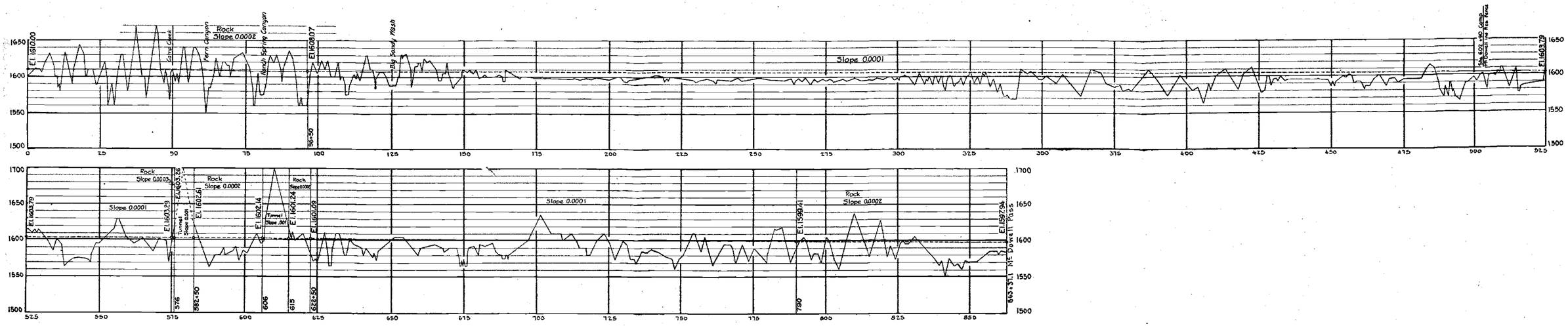
COLORADO-VERDE PROJECT

MC DOWELL PASS - WEST

STATION 445+00 — STATION 565+00

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 5 FEET

T 4 N
T 3 N
R 10 W
R 9 W
R 9 W
R 8 W
T 3 N
T 4 N
T 3 N
R 12 W
R 11 W
R 11 W
R 10 W
BIG HORN PEAK
To Roosevelt
To Hassayampa
U.S.C.&G. Mon. marked Apex 1938.43
El. U.S.El. 1939.19
Frame House
EAGLE TAIL LINE
ARIZONA COLORADO RIVER COMMISSION
COLORADO-VERDE PROJECT
MC DOWELL PASS—WEST
STATION 5650+00 — STATION 671+86.4
SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 5 FEET



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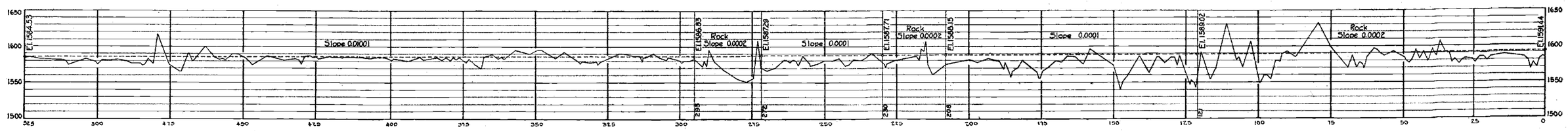
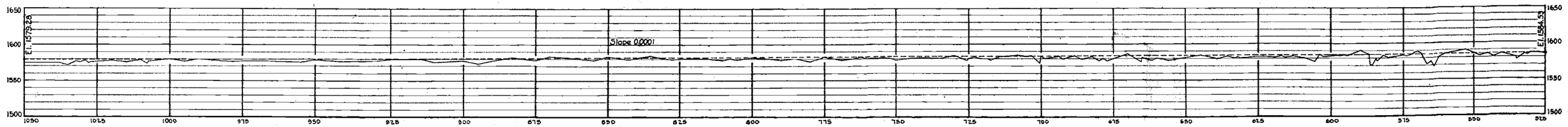
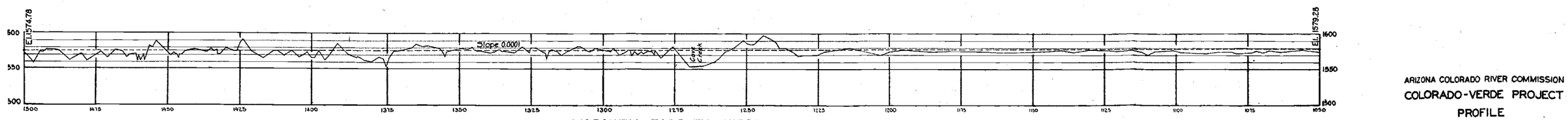






Mc DOWELL PASS TO WEST

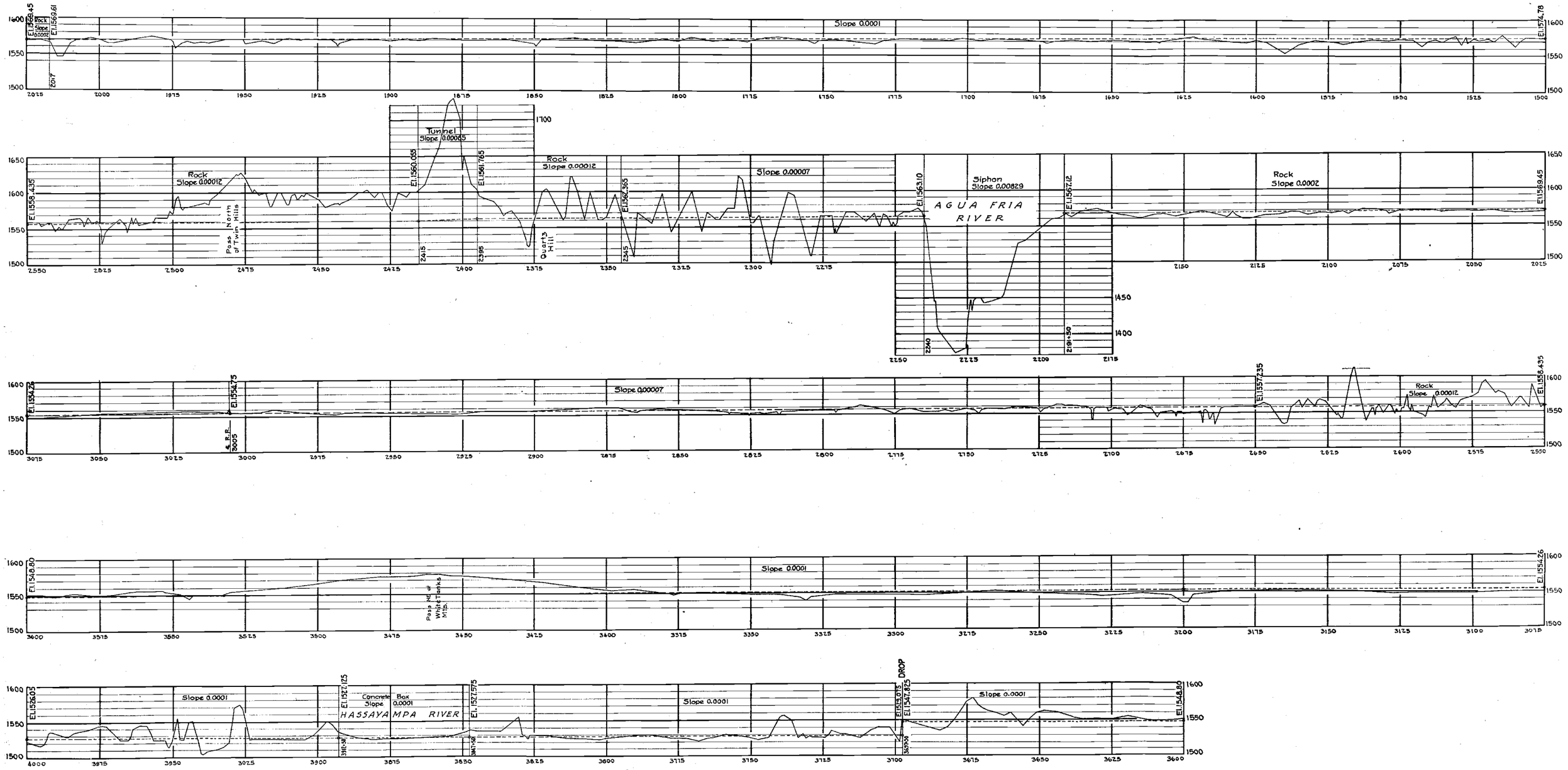
ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

PROFILE

DIVERSION DAM TO McDOWELL PASS
STATION 0+00 TO 863+37.1

McDOWELL PASS TO WEST
STATION 0+00 TO 1500



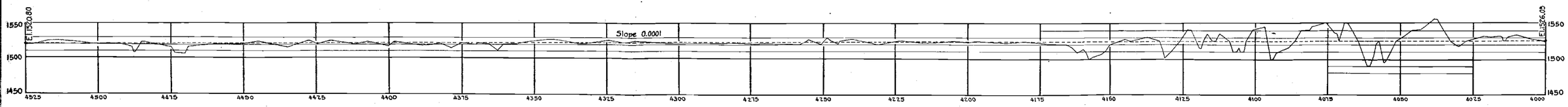
ARIZONA COLORADO RIVER COMMISSION

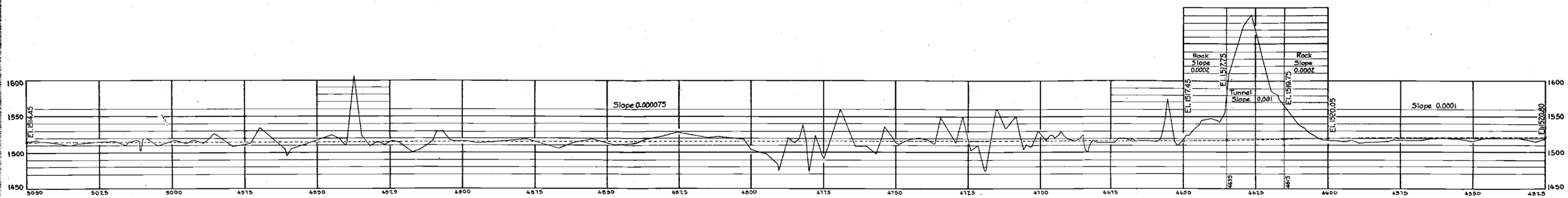
COLORADO-VERDE PROJECT

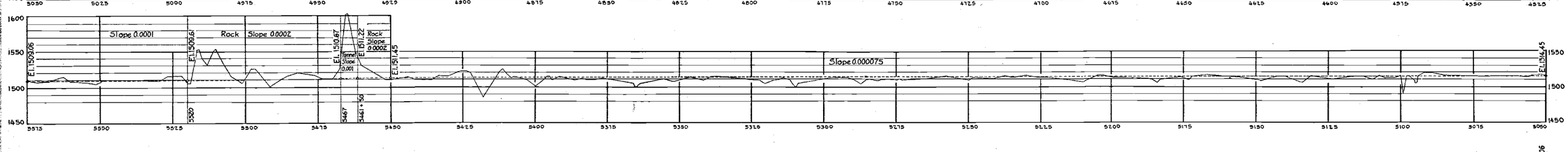
PROFILE

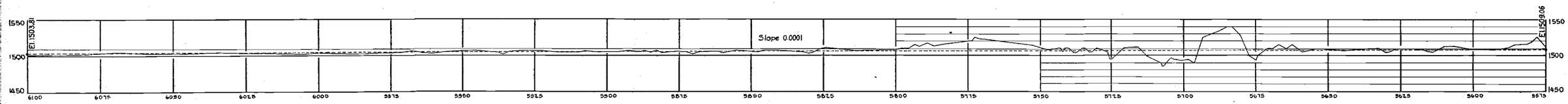
McDOWELL PASS TO WEST

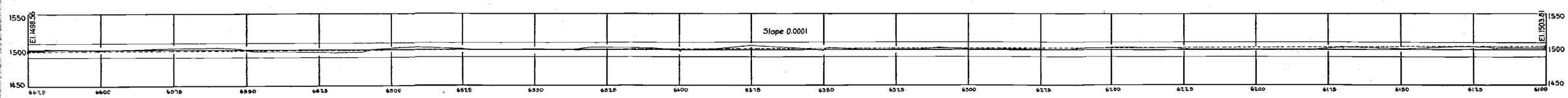
STATION 1500 TO 4000

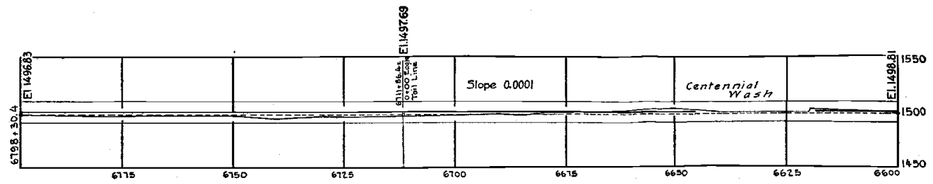












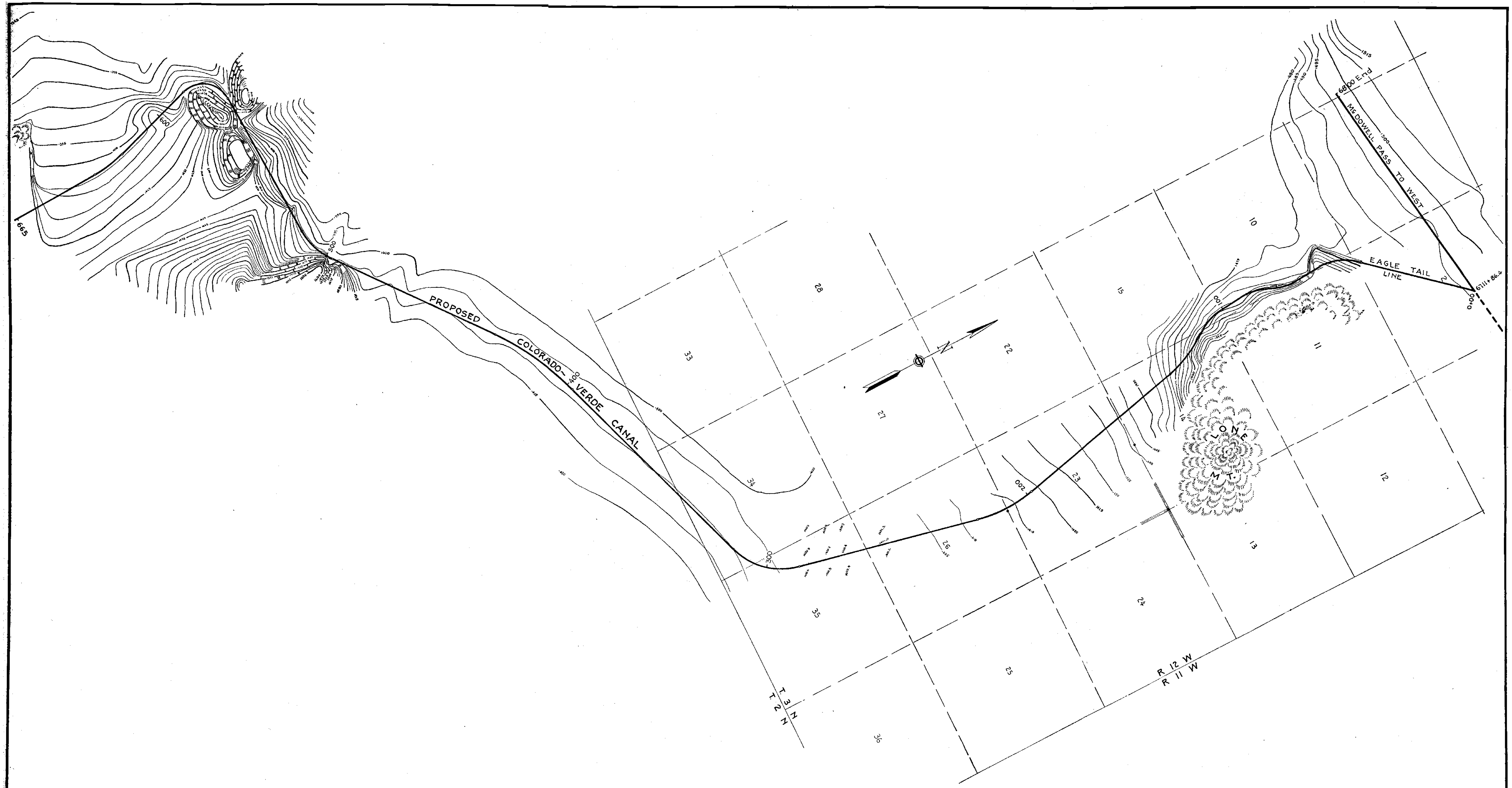
ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

PROFILE

McDOWELL PASS TO WEST

STATION 4000 TO 6798 + 30.4 END



ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

EAGLE TAIL BRANCH

STATION 0+00 —— STATION 665+00

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 5 FEET

UNSURVEYED TOWNSHIP

PROPOSED COLORADO-VERDE CANAL

1795+05.5
End Eagle Tail Line

Eagle Tail Line

T 2 N
T 1 N

R 13 W
R 14 W

UNSURVEYED TOWNSHIP

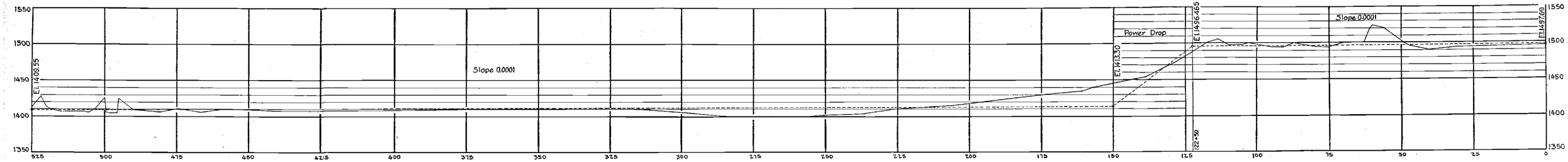
ARIZONA COLORADO RIVER COMMISSION

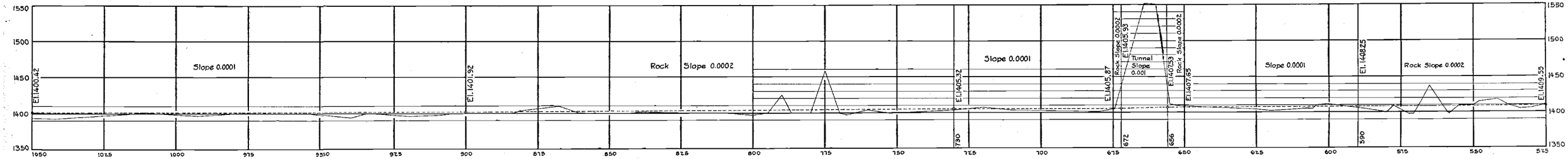
COLORADO-VERDE PROJECT

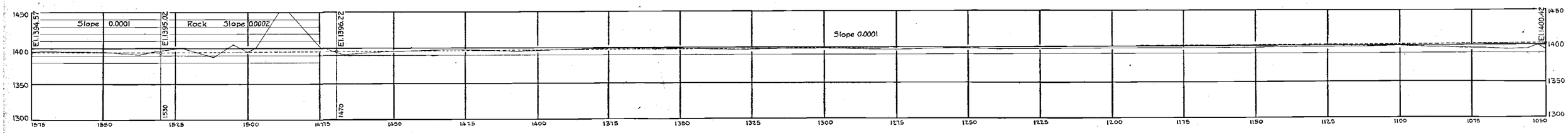
EAGLE TAIL BRANCH

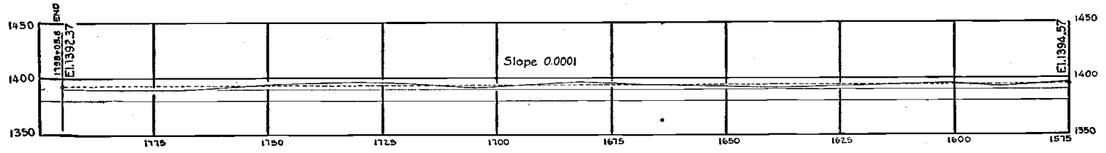
STATION 665+00 — STATION 1795+05.5, END

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 5 FEET









ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

PROFILE

EAGLE TAIL LINE

STATION 0+00 TO 17+95 + 05.5 END

ARIZONA COLORADO RIVER COMMISSION

COLORADO–VERDE PROJECT

MC DOWELL PASS — GILA RIVER

STATION 0+00 — STATION 1580+00

SCALE: INCH = 1000 FEET CONTOUR INTERVAL 25 FEET

ARIZONA COLORADO RIVER COMMISSION

COLORADO–VERDE PROJECT

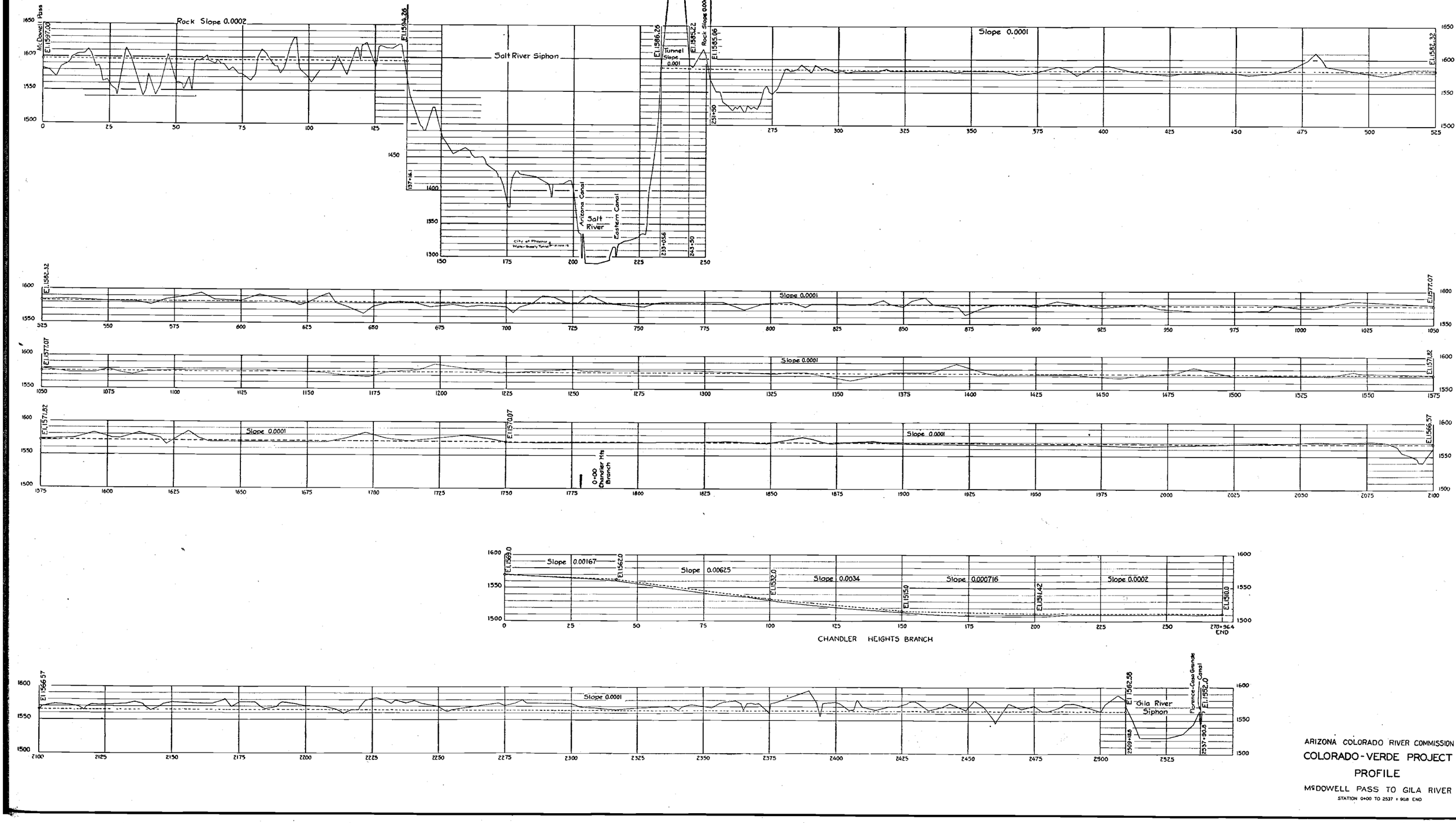
MC DOWELL PASS — GILA RIVER

STATION 1580+00 — STATION 2537+90.8 END

CHANDLER HEIGHTS BRANCH

STATION 0+00 — STATION 270+96.4

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL AS SHOWN



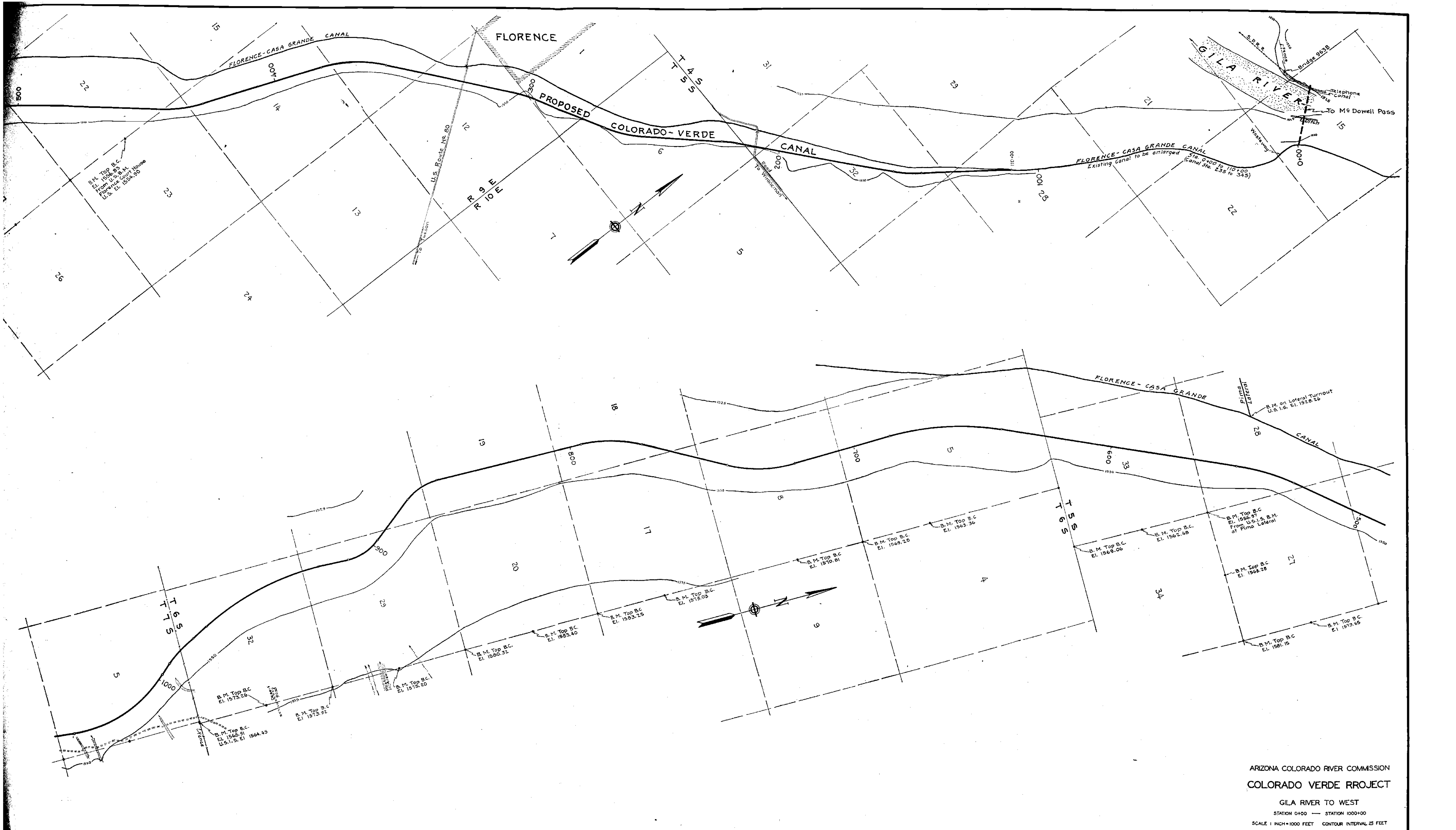
ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

PROFILE

McDOWELL PASS TO GILA RIVER

STATION 0+00 TO 2537 + 90.8 END



ARIZONA COLORADO RIVER COMMISSION

COLORADO VERDE RROJECT

GILA RIVER TO WEST

STATION 0+00 — STATION 1000+00

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 25 FEET

ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

GILA RIVER TO WEST

STATION 1000+00 —— STATION 2000+00

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 5 FEET

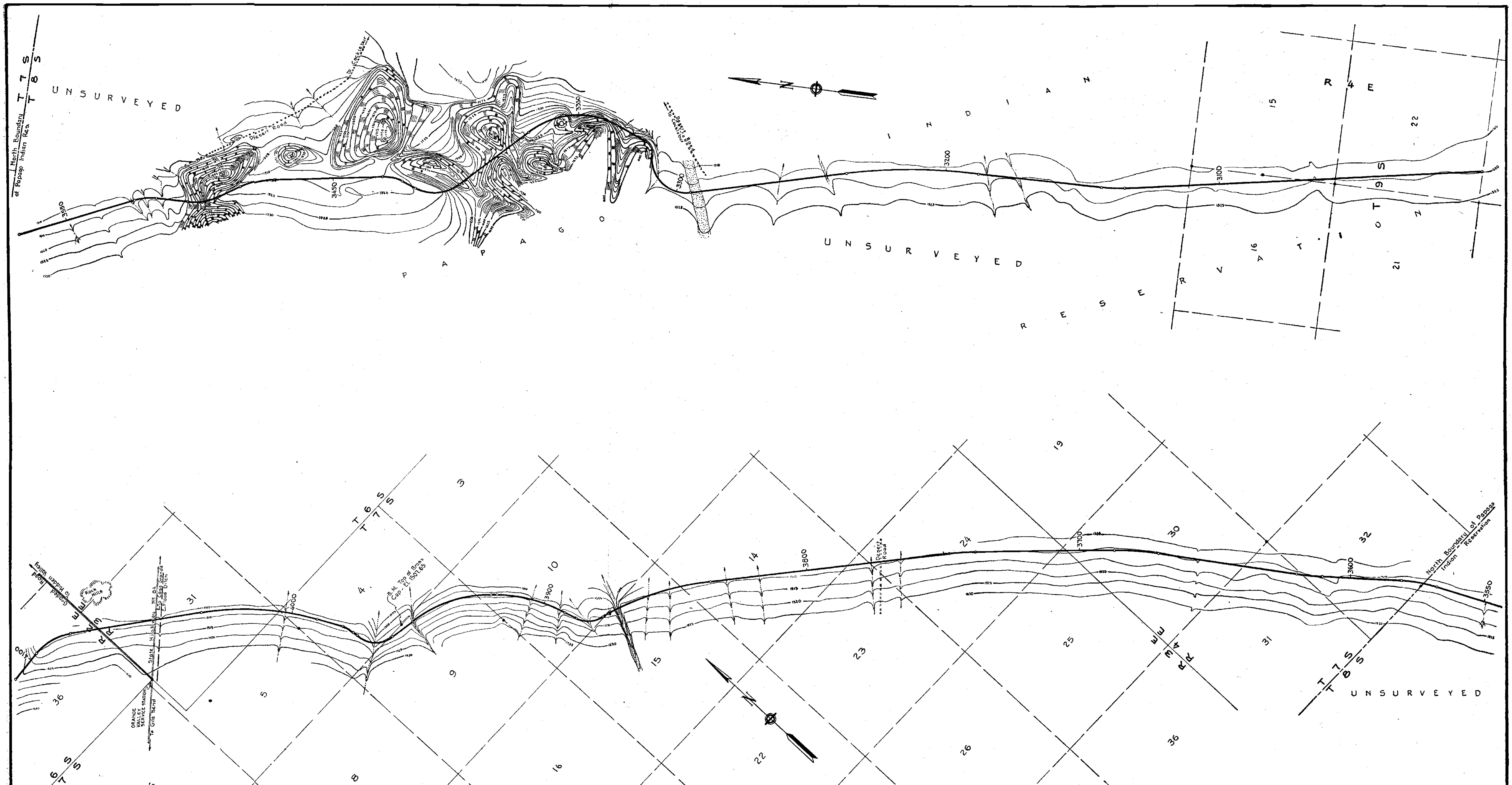
ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

GILA RIVER TO WEST

STATION 2000+00 — STATION 3010+00

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 5 FEET



ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

GILA RIVER TO WEST

STATION 3010+00 — STATION 4100+00

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 5 FEET

ARIZONA COLORADO RIVER COMMISSION

COLORADO VERDE PROJECT

GILA RIVER TO WEST

STATION 4100+00 —— STATION 5220+00

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 5 FEET

Mountain Range

Pole Line

Branch to West Side of Waterman Valley

M. P. 816

Telephone

Telephone Line

ESTRELLA

SLOAN

Highway

Rocky Mountain Range

25

36

T 4 S

R 4 W

R 3 W

U N S U R V E Y E D

Hills

Hills

Mts.

ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

GILA RIVER TO WEST

STATION 5220+00——STATION 6350+00

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 5 FEET

ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

GILA RIVER TO WEST

STATION 6350 —— STATION 7880

SCALE 1 INCH = 1000 FT CONTOUR INTERVAL AS SHOWN


ARIZONA COLORADO RIVER COMMISSION
COLORADO-VERDE PROJECT
GILA RIVER TO WEST
STATION 7880 —— STATION 9550
SCALE 1 INCH = 1000 FT   CONTOUR INTERVAL AS SHOWN
CHILDS MTS.
Bluffs
Road Sign Two Roads to Ajo
To Tonys Well
To Three Mile Well and Ajo
Telephone Line
GROWLER PEAK
8500
8300
8200
8100
8000
7900
7880
8900
9100
9150
9000
8800
8700
8600
9400
9300
9200
9500
9550

ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

GILA RIVER TO WEST

STATION 9550 —— STATION 10940

SCALE 1 INCH = 1000 FT CONTOUR INTERVAL AS SHOWN

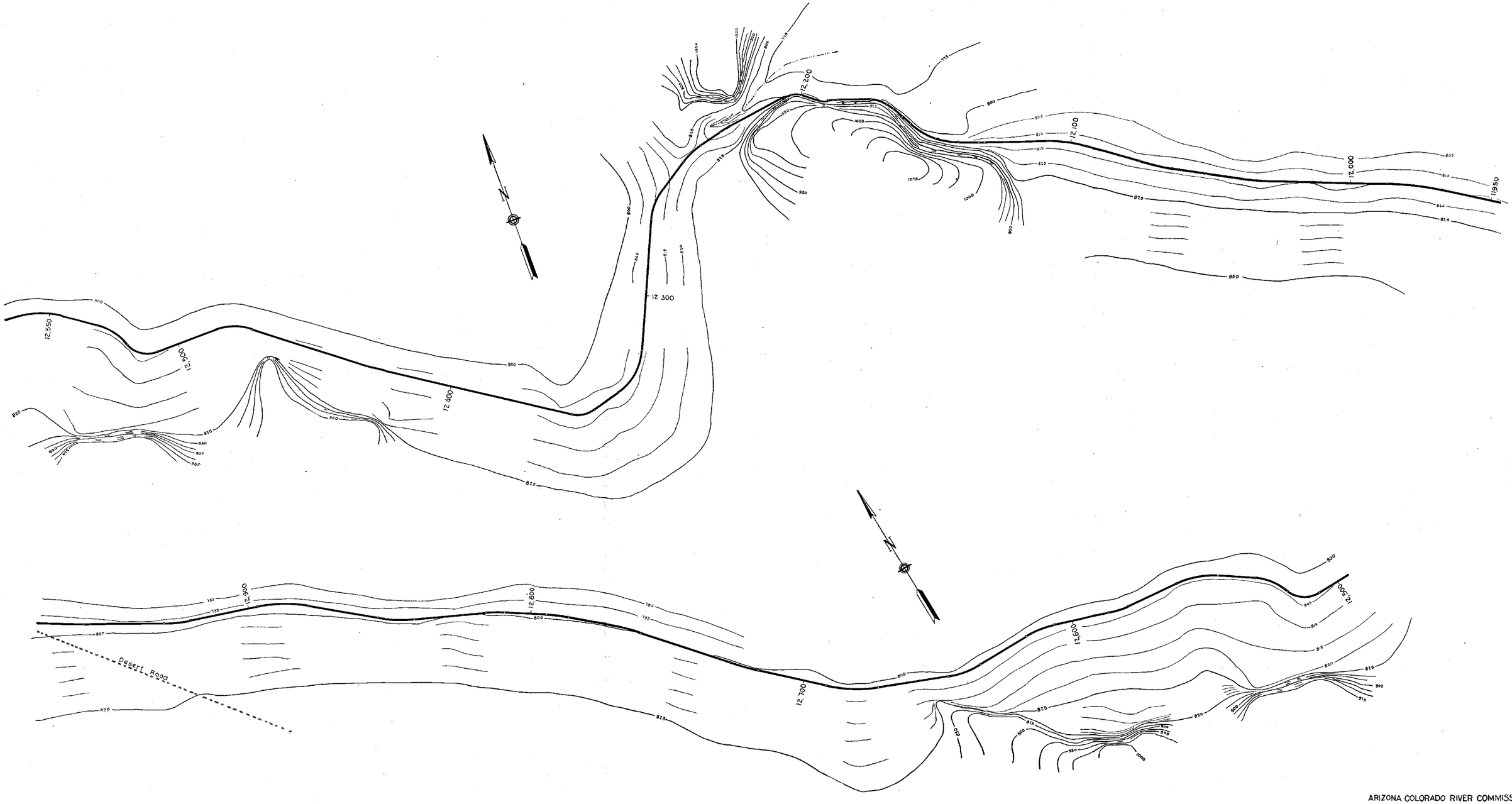
ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

GILA RIVER TO WEST

STATION 10940 — STATION 11950

SCALE 1 INCH = 1000 FT CONTOUR INTERVAL AS SHOWN



ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

GILA RIVER TO WEST

STATION 11,950 —— STATION 12,900

SCALE 1 INCH = 1000 FT CONTOUR INTERVAL AS SHOWN

PROPOSED COLORADO-VERDE CANAL

13,400

13,300

13,200

13,100

13,000

12,900

Desert Road

N

R 16 W
R 17 W

T 9 S
T 10 S

36

U.S.G.S. B.M.
Top of B.C.
El. 664.30
(U.S. El. 660.50)

Road

13+44+59.3 End

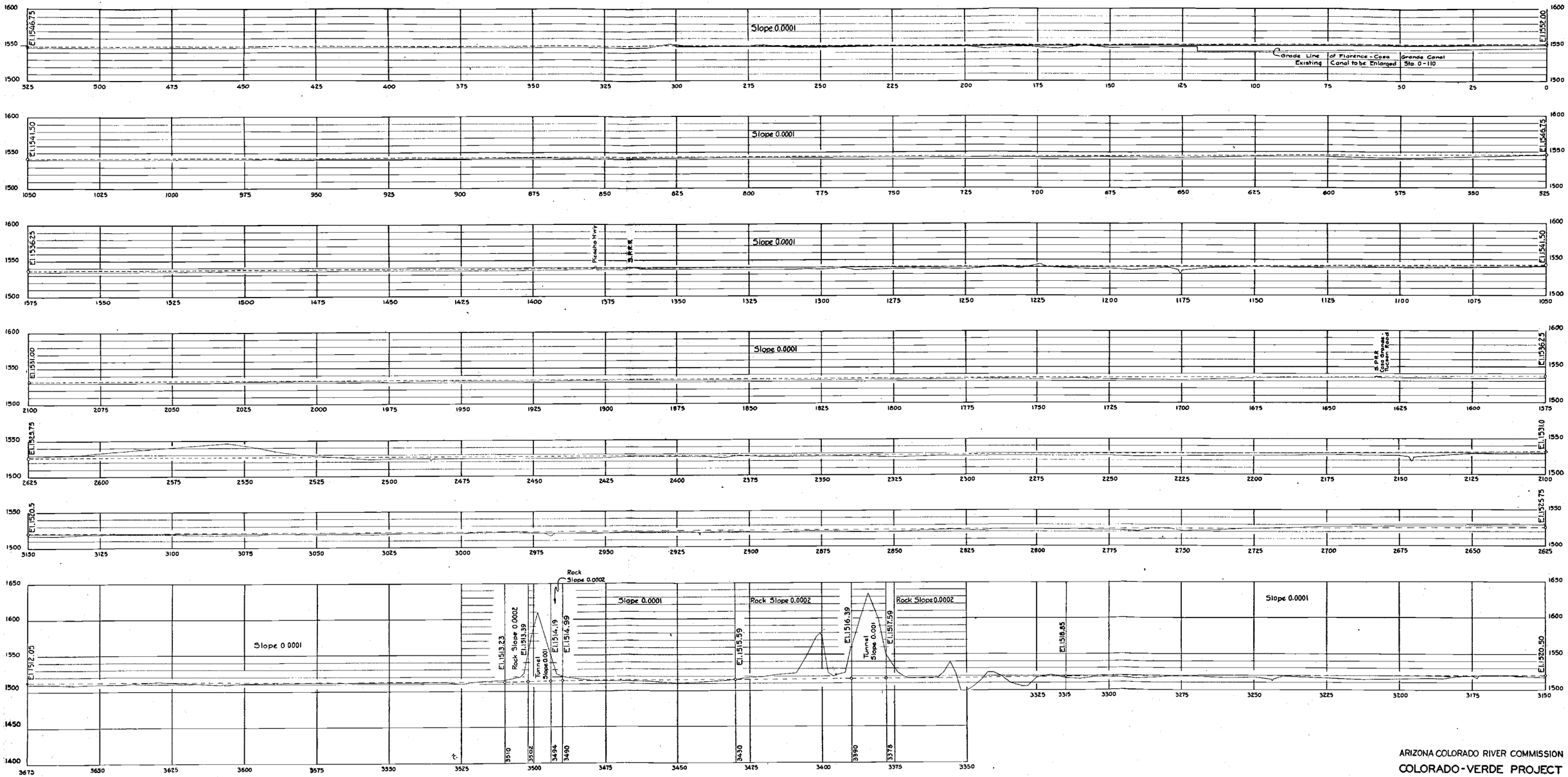
ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

GILA RIVER TO WEST

STATION 12,900 — STATION 13.445 + 94.3 END

SCALE 1 INCH = 1000 FT CONTOUR INTERVAL 25 FEET



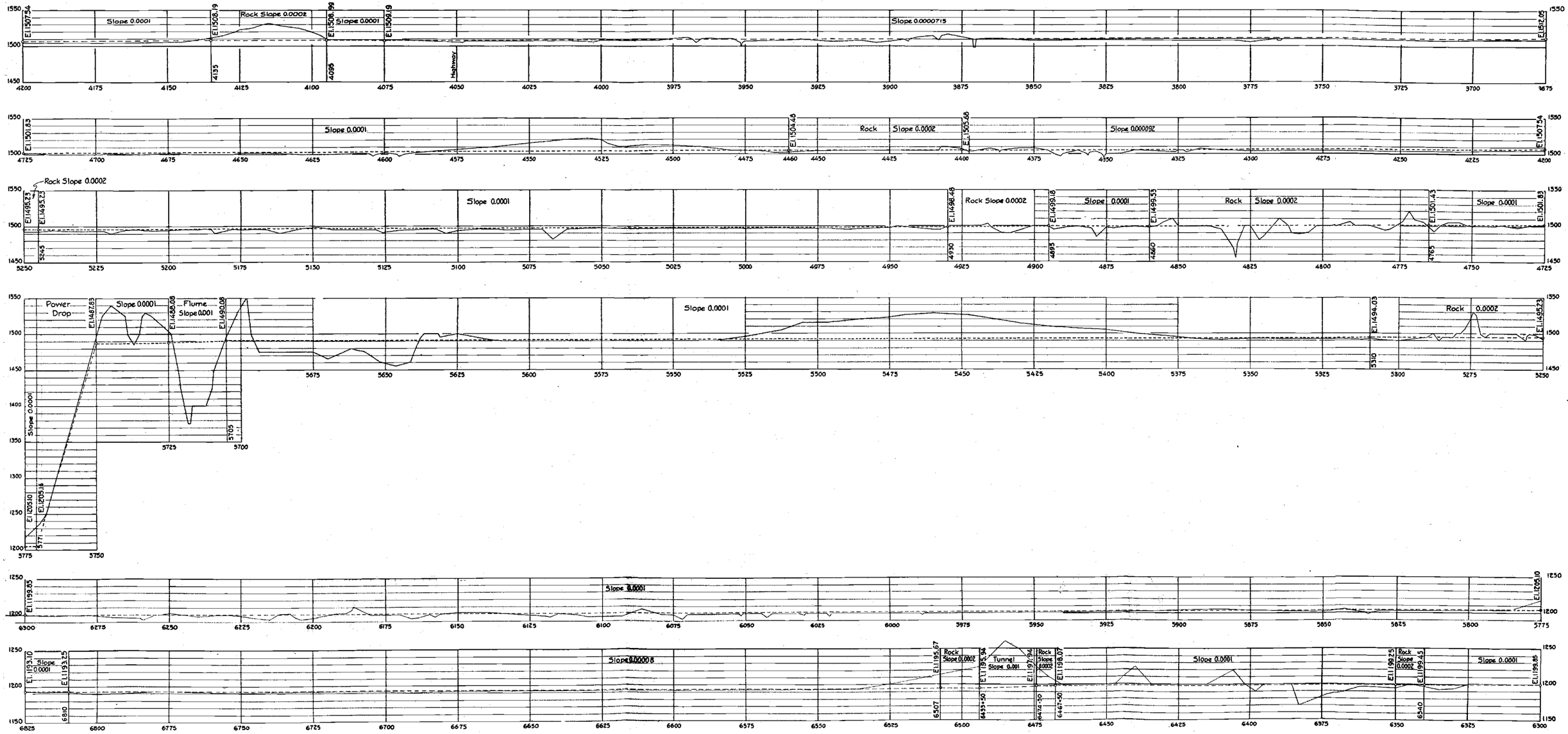
ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

PROFILE

GILA RIVER TO WEST

STATION 0+00 STATION 367.5



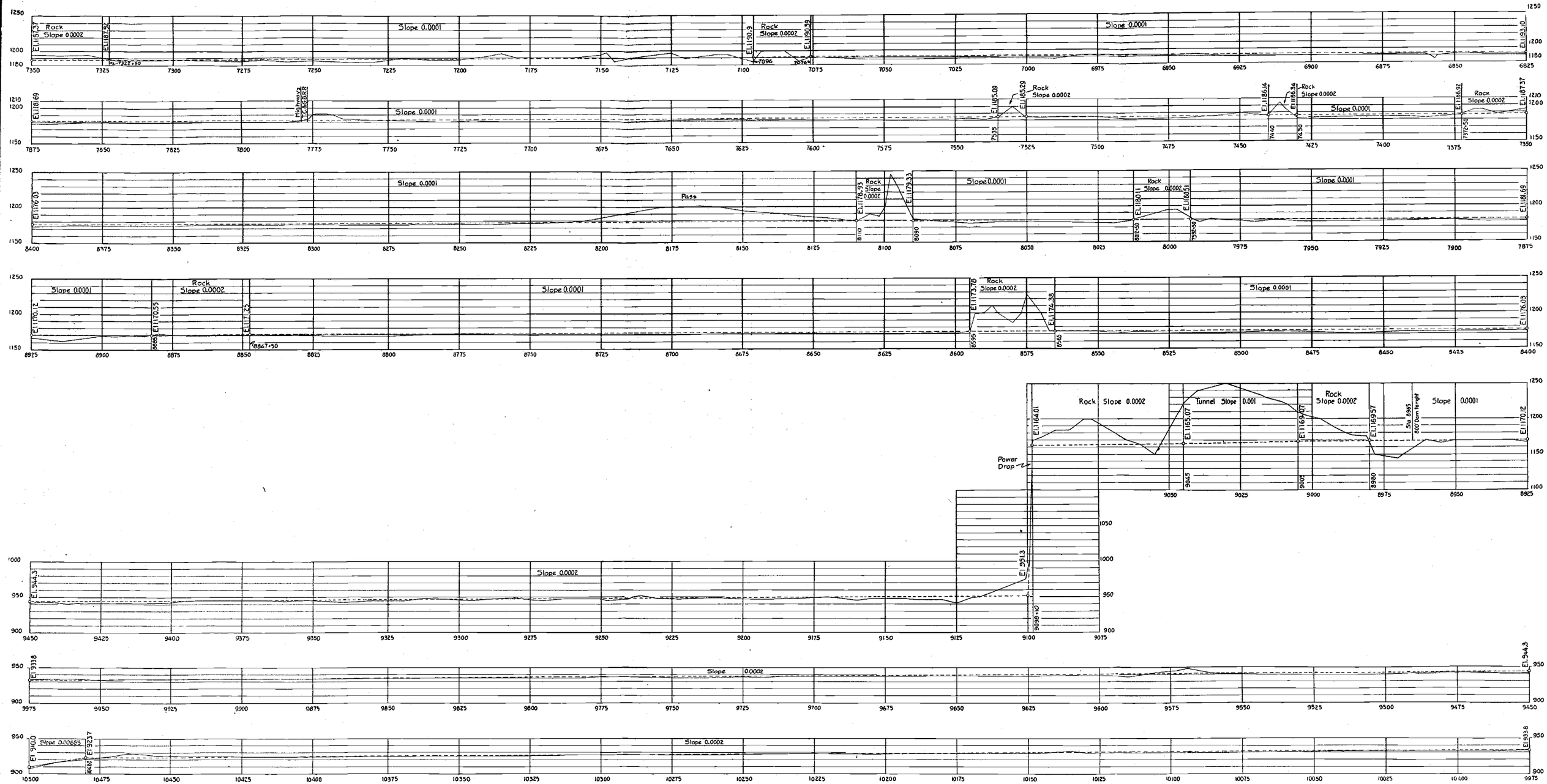
ARIZONA COLORADO RIVER COMMISSION

COLORADO - VERDE · PROJECT

PROFILE

GILA RIVER TO WEST

STATION 3675 — STATION 6825



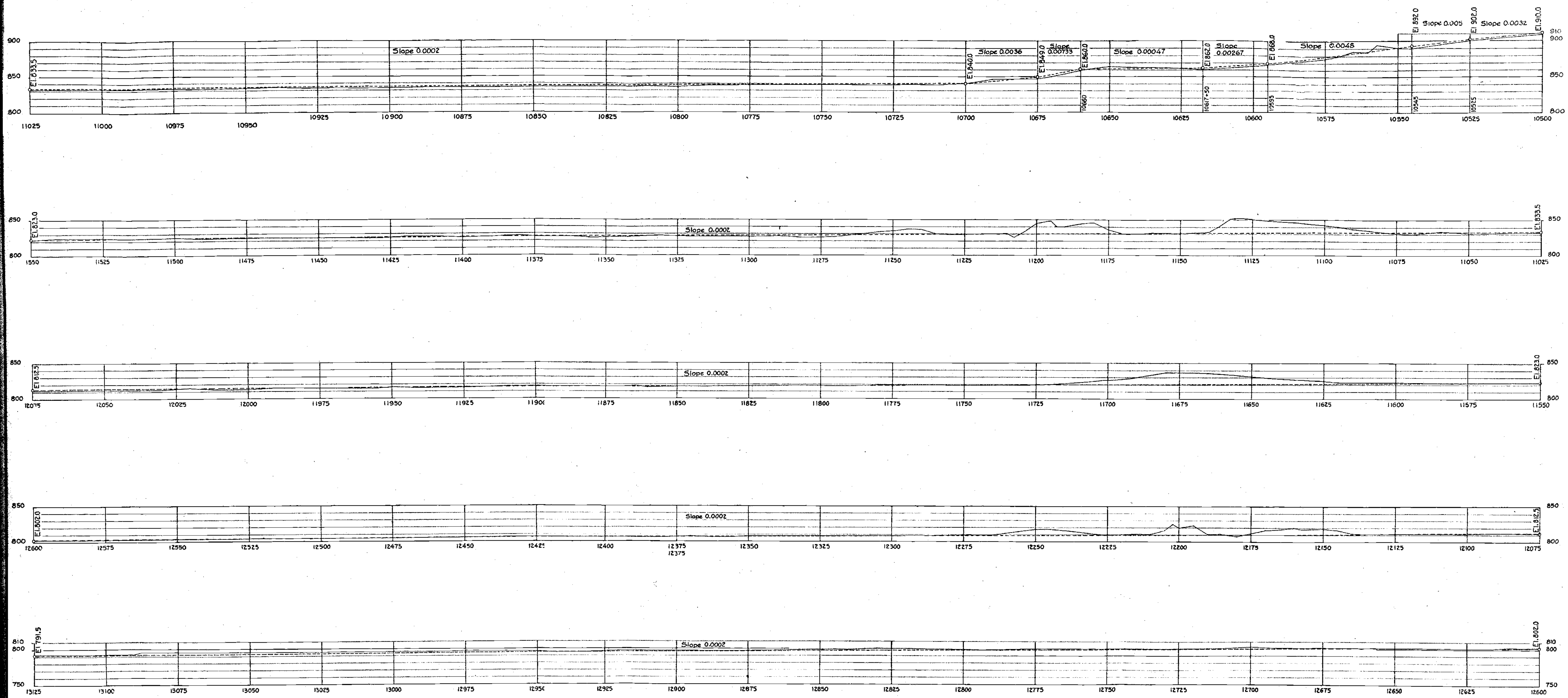
ARIZONA COLORADO RIVER COMMISSION

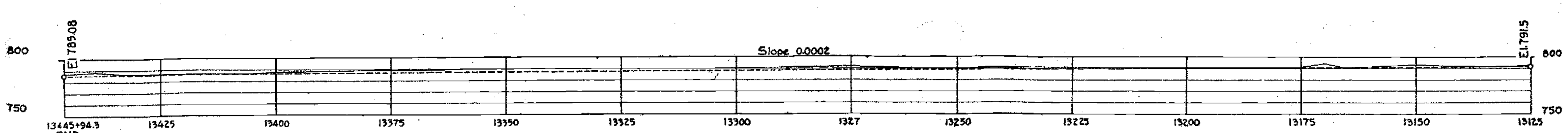
COLORADO-VERDE PROJECT

PROFILE

GILA RIVER TO WEST

STATION 6825 — STATION 10500





ARIZONA COLORADO RIVER COMMISSION

COLORADO - VERDE PROJECT

PROFILE

GILA RIVER TO WEST

STATION 10500 —— STATION 13445 + 94.3 END

ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

EAST WATERMAN VALLEY LINE

STATION 0+00 — STATION 450+00

BRANCH TO EAST SIDE ESTRELLA MTS

STATION 0+00 — STATION 356+757 END

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 25 FEET

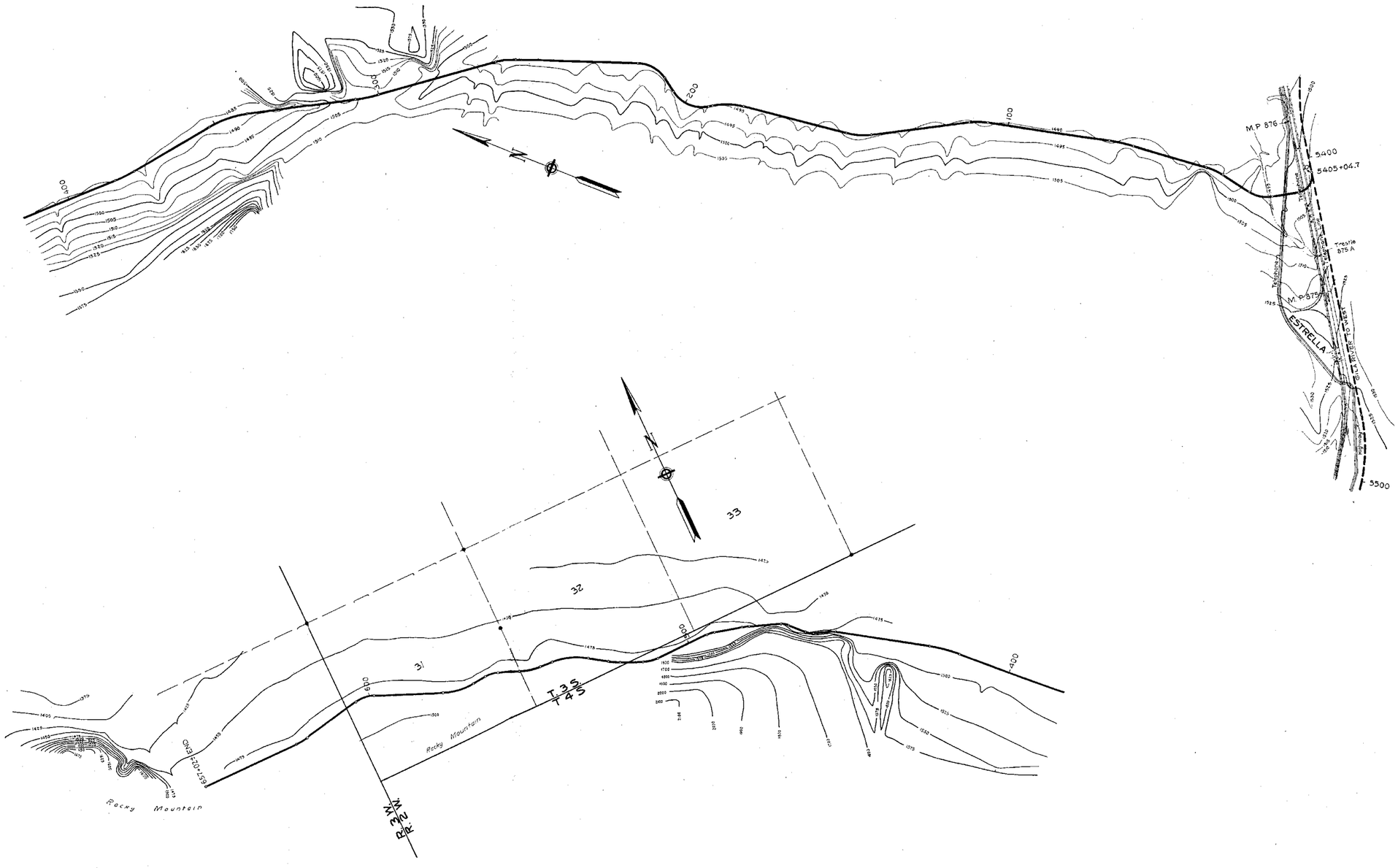
ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

EAST WATERMAN VALLEY LINE

STATION 450+00 — STATION 1388+24.8 END

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL 25 FEET



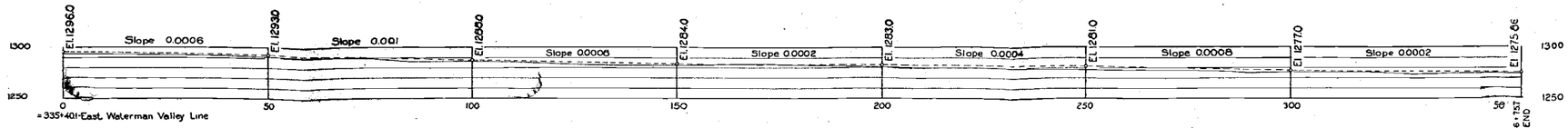
ARIZONA COLORADO RIVER COMMISSION

COLORADO–VERDE PROJECT

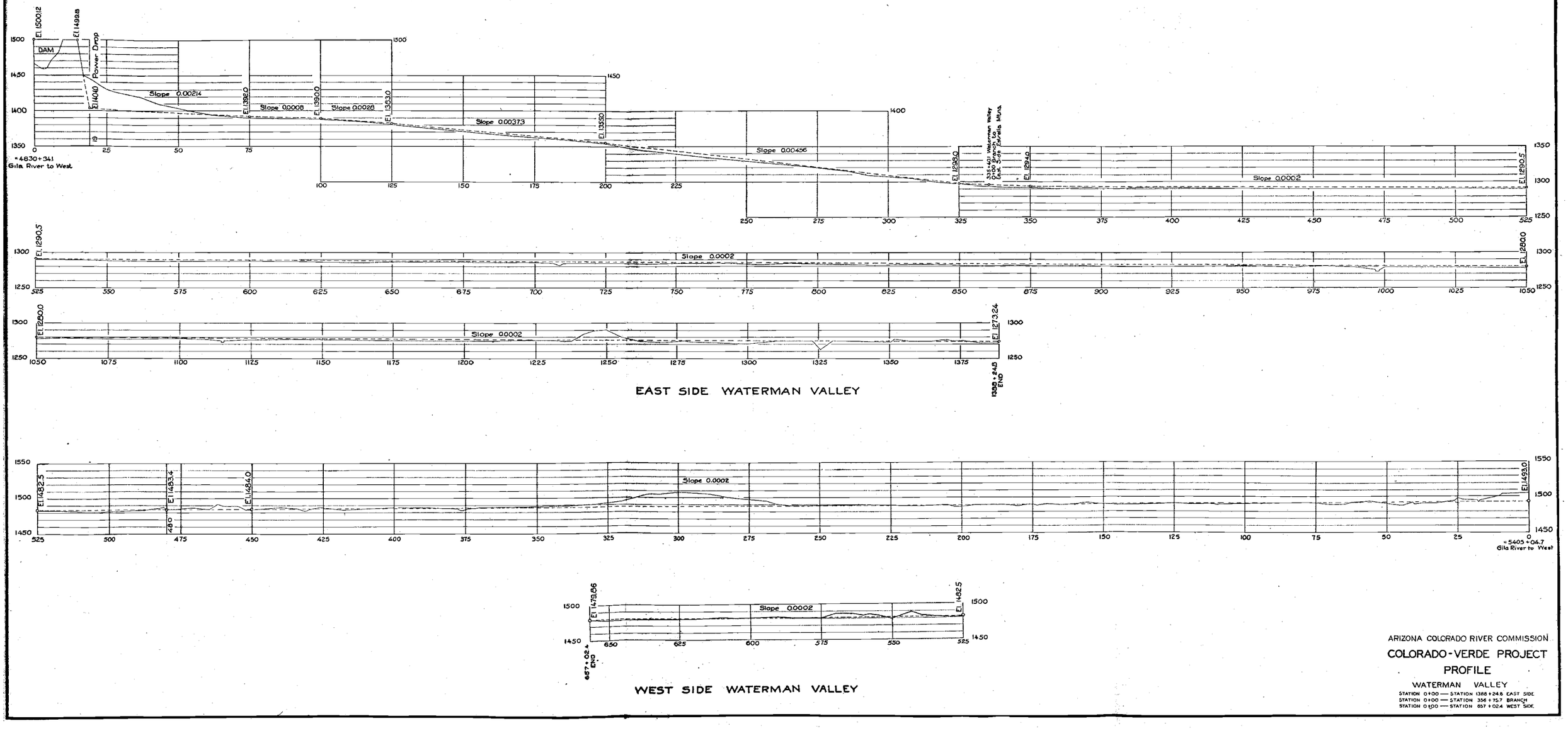
WEST WATERMAN VALLEY LINE

STATION 0+00 —— STATION 657+02.4 END

SCALE 1 INCH = 1000 FEET CONTOUR INTERVAL AS SHOWN



BRANCH TO EAST SIDE ESTRELLA MOUNTAINS



ARIZONA COLORADO RIVER COMMISSION

COLORADO-VERDE PROJECT

PROFILE

WATERMAN VALLEY

STATION 0+00 — STATION 1388+24.8 EAST SIDE
STATION 0+00 — STATION 356+75.7 BRANCH
STATION 0+00 — STATION 657+02.4 WEST SIDE