Preliminary Report of the

Survey of the Proposed Boulder Canyon Reservoir & Dam Site on the Colorado River in Nevada and Arizona

Department of the Interior, U.S. Reclamation Service
By: H.L. Baldwin

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UNITED STATES RECLAMATION SERVICE

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OF THE SURVEY OF THE PROPOSED
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ON THE
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IN
NEVADA AND ARIZONA

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I N D E X

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STORAGE AREA

The storage area of the proposed Boulder Canyon Reservoir, as enclosed by the 1250 foot contour, will be in the neighborhood of two hundred square miles, with a maximum depth of about 540 feet. The area covered lies chiefly in the Virgin ~~Creek~~ River Valley, extending northward from its junction with the Colorado River for about thirty-two miles, and with an average width of nearly four miles.

Ten miles south from its extreme north end, Muddy Creek joins the Virgin and this branch extends about nine miles up that valley to near the lower limits of Overton, and thus submerges the villages of Kaolin and St. Thomas.

This branch will average two miles in width and has a maximum depth of 150 feet. The greatest width of the reservoir is in the region of Stone Ferry on the Colorado River at the junction with Sacramento Wash, where it has a shape approximately that of an equilateral triangle with sides twelve miles in length, one apex of which will be close to the proposed dam site.

The storage area along the Colorado River above the junction with the Virgin Valley has not yet been determined fully but will have an average width of nearly three miles for the first thirteen miles of linear distance. At this point, which is at the junction with Salt Spring Wash, is

an abandoned stamp mill known as "Senator Mill", situated at the lower end of Virgin Canyon ten miles in length, the upper end of which is at Scanlon Ferry, now known as Gregg Ferry.

This ten miles of canyon will have a relatively small storage as the maximum depth will be less than 430 feet and the average width less than 3/4 of a mile as judged from Senator Mill. This is the uppermost point which has been reached in the survey.

It is stated by persons fairly familiar with the region that at Gregg Ferry the canyon will open out considerably, but that the storage at and above this point will be comparatively small. Also at the Grand Wash, although the canyon becomes wider, storage will not be greatly increased. These suppositions will likely be mainly correct as the various washes entering the canyon almost invariably prove shorter than indicated on the Geological Survey Quadrangles.

COLORADO RIVER

The Colorado River has an average width at high water of about seven hundred feet but varies widely therefrom, and the average fall of three and one-half feet per mile at this stage gives a current with velocity of ten or more miles per hour, and against which any progress by rowing is impossible, and only by taking advantage of the slower and shallower

currents away from the main channel, is any progress at all possible.

At no point between the head of Boulder Canyon and Senator Mill was there noted any sign of bedrock, the numerous rapids which occur in this twenty-five miles of river surveyed being produced solely by the gravel and boulder deposits brought into the river at the mouth of the larger washes, which deposits are periodically renewed by the cloudbursts or torrential rains which occasionally occur. Such points can only be passed by towing of boats and where this is impracticable from willows which overhang the bank, all progress upstream is at an end.

VIRGIN RIVER

The Virgin River carries a small amount of water in the late winter and early spring months but is dry the greater portion of the year. It has everywhere a sandy bed with a width varying from about two hundred feet at each of two narrows, to considerably over a quarter of a mile, and along which the usually small stream of water meanders from side to side. The average fall of the river per mile in the limits of the reservoir is about sixteen feet, a value not greatly departed from at any point. Fording with a loaded wagon is practicable almost anywhere and at almost any time. The little quicksand which occurs seldom if ever exceeds one foot in depth and a wagon can be readily extricated therefrom in case of any trouble of this kind.

The sand and silt of the Colorado River is different in nature from that of the Virgin River, and fording at any place or time is not attempted.

SOIL AND ROCK.

The character of soil and rock in the limits of the reservoir varies from a silt or very fine grained sand which would be very fertile if cultivated, to granite and malpais. There is a little sandstone in the vicinity of the upper narrows east of St. Thomas, but with this exception, and considerable malpais rock at and in the vicinity of the lower narrows some fourteen miles south of St. Thomas, rock does not occur sufficient even to form a setting for the bench mark tablets used in the level line, and where it does occur, is very soft and friable. This sand, everywhere so abundant is subject to constant movement by the wind, and dunes form and shift with every movement thereof.

The Muddy Mountain range lying west of the Virgin River is of volcanic formation and the foothills approach close to and even cross this river at the lower narrows. This formation is eruptive, with very little lava flow, and where such is found, it is on a very decided dip and not always with the same strike.

GYPSUM DEPOSITS.

Large, but discontinuous, areas of gypsum several

hundred feet in thickness occur. When north of the Colorado River, these are always west of the Virgin River. If any deposits of such were formed on the east side of the river, as is probable, they are now covered with the drift from the south extension of the Virgin Mountains. All these deposits were formed at the time, and as a result of, the eruption and are not greatly disturbed in horizon except at the head of Boulder Canyon.

Total area of this formation is about thirty-five square miles. It is very soft and fissured and impassable canyons fifty to one hundred feet deep are found cutting thru. In addition to the calcium sulphate, magnesium sulphate also abounds. The formation occurs in a large blanket deposit along the east flank of the mountains, and as seen from the vicinity of the mouth of the Virgin River appears to occupy a synclinal trough with the Colorado River in the syncline, and gives the impression that this formed the weak point of entrance which enabled the river to brust thru the barrier made by the granitic mountains further west.

Such, however, was not the case, but the extruding lavas had their greatest action at points north and south of the river, the upthrust causing a dip to the eastward such that the gypsum deposits are apparently conformable therewith, and therefore dip away from, rather than toward, the eruptive center.

North of the lower narrows this deposit of gypsum covers an area of perhaps eight square miles in the reservoir limits, but in the area lying south of the Colorado River it has its greatest extent. Here the porosity and fissured nature of the deposit is such that it will add a not inconsiderable amount to the storage capacity of the reservoir, and it covers an area of over twenty square miles. The eastern edge of this deposit shows an incomplete transition from the original limestone, due to the fact of its distance from the more intense volcanic activity ten or more miles to the westward, so that unchanged limestone and completely formed gypsum are found in adjacent localities.

Beginning some three miles above the mouth of the Virgin River and evidenced chiefly on the south side of the Colorado River, is the lower extension of the disturbance which formed the Virgin Mountain Range, and malpais ledges extend for several miles up the river but chiefly on the south side. On the north side of the river, this has been covered to a considerable depth with drift from the Virgin Mountains in the form of a coarse grained firmly cemented conglomerate, which erodes in the form of gulches ten to fifty feet perpendicular and from five to twenty feet wide, which are impassable for long distances, and thus forms a great obstacle to any travel other than along the ridges.

Overlying the conglomerate on the north and mal-

pais on the south, is a deposit of fine grained sandstone consisting of numerous strata with a total thickness of several hundred feet and which erodes in angular but very regular shapes and has formed objects quite appropriately named "The Campanile", "Napoleon's Tomb", "The Temple", etc.

A few miles above Temple Bar this formation disappears and vulcanism alone holds sway to at least the upper limit of the canyon at Gregg Ferry. From Temple Bar, which is five miles below Senator Mill, several gravel terraces formed by the river at elevation of from 850 to 1050 feet occur, while at greater heights the gravel gives evidence of marine or lacustrine origin.

FAULTING

Faulting is noticed in various areas in the reservoir, the most marked of which is along the line of Boulder Wash whish extends northwest from the head of the canyon, but this will in no wise endanger the stability of a dam built below.

It is the opinion of local prospectors that the canyon is on a fault line, but I could not learn of any fact which would support the theory. I was also told that seams and veins in the canyon walls were the same on either side, seeming to indicate no displacement either longitudinally or vertically. The event of a displacement merely lateral would seem to be quite remote.

A careful reconnaissance thru the canyon might serve

to settle this point.

MATERIALS FOR CEMENT

The hill on the north side of the head of Boulder Canyon and nearly 1,000 feet above river bed, is unaltered limestone with brown stain, and occurs in sufficient quantity for cement purposes. Considerable red oxide of iron is found in the low hills east of Boulder Wash, and there is some blue shale in the drift which evidently came from visible deposits a couple of miles northward and at 2,000 feet or more elevation above sea. This was the only argillaceous material noted in the region of the reservoir, except that the banks of the river show some red clay, apparently a river deposit, and therefore in limited amounts. Clay is said to occur in Muddy Creek Valley a few miles below Moapa.

VEGETATION

The annual rainfall being very small, only the most hardy forms of vegetable life are found. Even cactus in its various forms is quite scarce. No trees of any kind occur naturally except a little mesquite along or close to the river and considerable of a variety of greasewood locally known as "evergreen". Sagebrush, that almost universal habitant of the desert scarcely occurs at all. A very few cattle range hereabouts, and from their appearance obtain an unsatisfactory subsistence, which in summer must be precarious indeed

when the Virgin River, almost the sole source of water, goes dry. All feed must therefore be hauled in traveling thru the country, and as very little is raised at St. Thomas or the neighboring settlement of Overton and Bunkerville, such may even have to be shipped in by rail, grain especially.

ROUTE TO THE RESERVOIR.

The reservoir is reached by the Los Angeles and Salt Lake railway to Overton and St. Thomas, via a spur from Moapa twenty miles in length all the way down the Muddy Creek Valley, and over which a motor car makes six trips per week. The railway can readily be extended to the dam site with very little heavy work, this extra distance being about thirty-five miles, and now reached by a very sandy wagon road. It is probable that a shorter route can be had by leaving the Virgin Valley ten miles below St. Thomas, then via Bitter Spring and Boulder Wash. This route, while shorter and nearly free from sand, will not be so good a grade as the former. It is said that a road can be constructed from Los Vegas to the dam site without difficulty, but this would require more miles and without having been over the route, is not thought to be as feasible, although for truck hauling the character of the road bed would be superior to the sandy stretches of the Virgin. A ferry formerly existed at Stone Ferry, later at Bonelli's two and a half miles above, but this was discon-

tinued about a year ago. The road from here goes up the Sacramento Wash to Chloride, a station on a branch of the Atchison, Topeka and Santa Fe railway fifty miles distant.

The Colorado River Valley has been traversed by more or less passable wagon roads continuously from a point six miles below the mouth of the Virgin to Pierces Ferry, this road, however, leaving the river two miles below Temple Bar, coming in again about a mile above Temple Bar, then leaving river to reach it again at Scanlon (now Gregg) Ferry. Most of this road is now impassable, but the expenditure of a few hundred dollars would make it again usable. An interstate bridge is proposed at Hobo Point and also at Gregg Ferry.

Road from St. Thomas to Bonelli's Ferry, twenty-five miles distant, is good but sandy. Road from St. Thomas to Gregg, sixty miles distant, is impassable at a point some ten miles or less from Gregg's, but can be readily fixed at an expense of a few hundred dollars. The road from St. Thomas to Pierces Ferry, sixty miles, is passable at present.

Water occurs at satisfactory intervals along these roads.

SUBSISTENCE AND FORAGE

Feed for stock must be hauled, as animals cannot subsist anywhere in the region without hauling all feed consumed, and none can be had nearer than St. Thomas or Overton,

and only in limited quantity at these places. At the latter place is the nearest dependable store, Harry Gentry's at St. Thomas, who is alsc postmaster, carries a very small stock due to his limited credit, but he is an unusually obliging person and well informed as to the country. Subsistence supplies should be mostly obtained at Salt Lake City.

After St. Thomas is left, there are no habitations or improvements whatever until the "Placer Claim" of Harry Armitage,a trapper, living two miles above Bonelli's Ferry is reached.

Gregg Ferry, twenty-three miles above Armitages, or twenty-five miles above Bonelli's Ferry can be crossed except at high water when ferry will not risk the crossing of river. Twenty miles above this is Pierce's Ferry, which is also in operation at all times. There is also a settler living at Grand Wash a few miles below, but nothing except emergency supplies can be obtained at any of these places.

MINES

There are some gold placer claims on the Colorado River, but none that are or ever have been extensively worked. Senator Mill is a stamp mill on the Arizona side and has not operated for many years, and everything hereabouts is in a very dilapidated condition.

Temple Bar is said to have been a stock selling

organization originated chiefly as a scheme of revenge by clericals expelled from France, and most of the stock sold in that country. Many millions of stock was sold and an expensive pumping plant was installed. Much of the machinery still remains although the plant was abandoned many years ago after working for only a short time.

Quartz ledges are found in vicinity of Hobo Point, but not worked, due to it being unlawful to use the cyanide process and discharge the tailings into the river.

Some magganese claims are held by Perkins of St. Thomas in Boulder Wash, and upon which not even the assessment work would appear to have been done.

Rock salt occurs at several places in the Virgin Valley notably at:-

(1) The Bonelli mine in Section 4, Township 20 South, Range 68 East, which has apparently not been much worked;

(2) Black Salt Mines in Section 16, Township 19 South, Range 68 East, the extent of the working being several drifts, none of which exceed twenty feet in length, run into the deposit;

(3) Calico Salt Mines in Sections 31 and 32, Township 18 South, Range 68 East, show evidence of considerable prospecting but very little salt has apparently been mined, although the size of the deposit is large;

(4) The "Salt Mine" in Section 34, Township 17 South,

Range 68 East. This mine is worked considerably and the rock salt hauled by wagon to the railroad at St. Thomas five and a half miles distant where it is worth $7 per ton. This mine was recently sold for a price supposed to be about $50,000. Some salt has also been removed from Section 27 in this Township. No other mines or prospects of any kind are known which could be affected by the construction of the reservoir.

VALUE OF IMPROVEMENTS.

If the reservoir is constructed to a height of 1250 feet, the town of Overton would be at the upper end thereof and not injuriously affected thereby.

About six and a half miles of the Los Angeles & Salt Lake railroad below Overton would be submerged, as would also the villages of Kaolin and St. Thomas situated thereon.

Assisted by a resident whose interests are not particularly involved, I made an estimate of the total value of all improvements, houses, fences, ditches, irrigable lands, etc.; in the valleys above junction of Muddy Creek and Virgin River, itemizing each article, and I place the total value thereof at a little less than $450,000. This covers the villages of Kaolin and St. Thomas above mentioned, but does not cover the value of railway property, which consists of

roadbed alone and no buildings. The irrigated land can not be valued at much, if any, exceeding $125 per acre.

The crops raised are wheat, alfalfa, a few grapes for raisins, cantaloupe, and some garden produce.

None of these seem profitable and the community, Mormon with three exceptions, is far from being a thrifty, enterprising or successful one. In the Virgin Valley are two ranches with very little in the way of improvements, and both located near St. Thomas. There is considerable land below St. Thomas that would likely sub-irrigate from the underground flow of the Virgin, but nothing has been done to attempt to use it.

A canal, heading near the crossing of the Virgin River east of St. Thomas, and some ten miles in length, was constructed four or five years ago to irrigate the irrigable areas of Sections 10, 15, 16, 21 and 22 of Township 18 South, Range 68 East, less than 1,000 acres in extent, but thru bad management was never completed and the present value of the improvements is practically nil.

The only remaining improvement is the house on the placer claim of Harry Armitage, not over a couple hundred dollars value, and Bonelli's well-built stone house at the mouth of the Virgin River, probable value not to exceed $2,000.

DAM SITES

There are a number of good dam sites on the Muddy

Creek a few miles below Moapa and above the limits of the reservoir. A fair location for a dam occurs on the Virgin River at the lower narrows and at an elevation of about 895 feet above sea level.

A 200-foot dam could readily be constructed at this point to control the flow of the Virgin River and about four hours were taken to make an approximate survey thereof, the plat being filed with Mr. Homer Hamlin, consulting engineer, Los Angeles, California.

Below the head of Boulder Canyon are numerous sites where the walls, nearly vertical for several hundred feet, are separated by not over 200 feet at the base, therefore, the only problem in this locality will be to select the best.

The slopes to the final mountain tops are quite steep, such that gravity alone would likely suffice to bring blasted material all the way to the surface of the river.

These heights vary from about 2300 feet above sea at head of canyon, to 3300 feet at points less than a mile further down, and which is about the maximum height reached in proximity to the canyon. (See 1st annual report, U.S.R.S. Page 109).

CONSTRUCTION HEADQUARTERS

Such would be located at the junction with Boulder Wash on the north side of the river, and while rather crowded for space, expansion could be had further up the river. From

Boulder Wash to the dam will be about one and a half miles, to be reached by trail or boat. A wagon road would be very expensive due to the vertical cliffs although at low water such could be made and used along the talus at foot of bluffs.

Materials for a barge for the drilling crew and the necessary machinery should be freighted to Bonnelli's Ferry and all floated to the mouth of Boulder Wash, or material could be freighted to construction headquarters direct, and I incline to the latter method if the character of road, grades, etc., via Bitter Wash and Boulder Wash will admit.

The dam could also be reached from Chloride on the Santa Fe railroad some fifty miles distant, and by an excellent grade, although likely to be quite sandy. It is possible this branch could be built more cheaply than the extension of the St. Thomas branch.

ASSISTANTS

I was quite ably assisted in this work by Mr. Stanford W. Oberg who ran practically all the levels between Moapa and the dam site, such being based upon sea level elevation, as well as a branch thereof up the Virgin River to near the head of the proposed reservoir. He also did all the field work of triangulation and most of the computation incident thereto as well as a few days spent on topography.

Mr. Hugh L. Lord who served in the capacity of cook and Mr. Sam B. Gentry who furnished teams and acted as stadia

rodman, both of whom live at St. Thomas, were efficient in their respective positions.

Mr. Ernest Ward, whose post office address is St. Thomas, but who at present lives with Harry Armitage on the Colorado River near Bonelli's Ferry is an excellent boatman, and while his experience on the river does not extend above Senator Mill, his extensive knowledge of the river in other places is such that his superior in this respect would not likely be found. He is also willing, obliging and will turn his hand to anything necessary, a qualification not always to be met with.

A small row boat, one of the two purchased for my use, and the boat ordered by Mr. Homer Hamlin, are left in charge of Mr. Harry Armitage at his place on the Colorado River, but I found the latter boat not nearly so convenient for my work as one furnished me by Mr. Armitage, who, with Ward, will likely be willing to take up and help complete the work when resumed this fall.

Another row boat, the mess outfit and tents, and two Evinrude motors are stored with Harry Gentry at St. Thomas.

Should Ward or Armitage not be available, help of this kind may possibly be secured at Gregg Ferry by applying in advance. People around St. Thomas and nearby settlements are afraid of and will not work on the river, so such

help can not be obtained at that point.

CONCLUSION

In concluding this preliminary report, it may be well to reiterate that:-

(1) The storage capacity of the reservoir will be large.

(2) The amount of improved property to condemn will be small.

(3) Transportation will not be difficult owing to the proximity of two railroads.

(4) A rockfill dam would be relatively inexpensive owing to the towering cliffs on either side.

(5) A masonry dam will likely not prove relatively expensive owing to the prevalence of proper stone and cement forming materials at or near the dam site, fuel alone having to be hauled a considerable distance.

(6) The only uncertain feature apparent to the writer is whether the canyon is or is not on a fault line, and therefore the stability of a dam is problematical.

H L Bacchus
Engineer

TOPO RAPHY OF BOULDER CANYON RESERVOIR - IN TEN SHEETS
Scale 1/63360 Contour Interval 50'

BY H. L. BALDWIN - ENGINEER July 1919.

ELEVATION

Based on "Y" levels from U. S. Coast and Geodetic Survey bench marks at Mospe, via Los Angeles and Salt Lake Railroad to St. Thomas; thence via the wagon road to Bonelli's Ferry; thence along level plateau westward to terminus of line one-quarter mile below rapids at head of Boulder Canyon.

Also from St. Thomas northward across divide to Virgin Valley; thence along Virgin River to terminus of line at B.M. stamped 1235 on east side of Virgin River.

HORIZONTAL CONTROL

Deflection line run by transit from a point (unmarked) in Virgin River bed, 3/4 miles south of the B.M. on west side of Virgin River, stamped 1235; thence to station North Base, not permanently marked and about 500 feet south of the "Dugway" road crossing; thence by a triangulation from double measured base line through a series of triangles and quadrilaterals, angles measured by transit, closures usually less than 1'; sides about 2 or 3 miles in length, to Colorado River; thence down same to near dam site, also up same to upper end of survey.

A check base was measured between two stations of the triangulation about 8 miles south of first base and 2 miles apart, the agreement being within 4 feet. Computation was by coordinates, expressed in chains, and frequent Polaris observations taken for Meridian. The supposed best triangles of the quadrilaterals were used and discrepancies arbitrarily adjusted.

COORDINATES

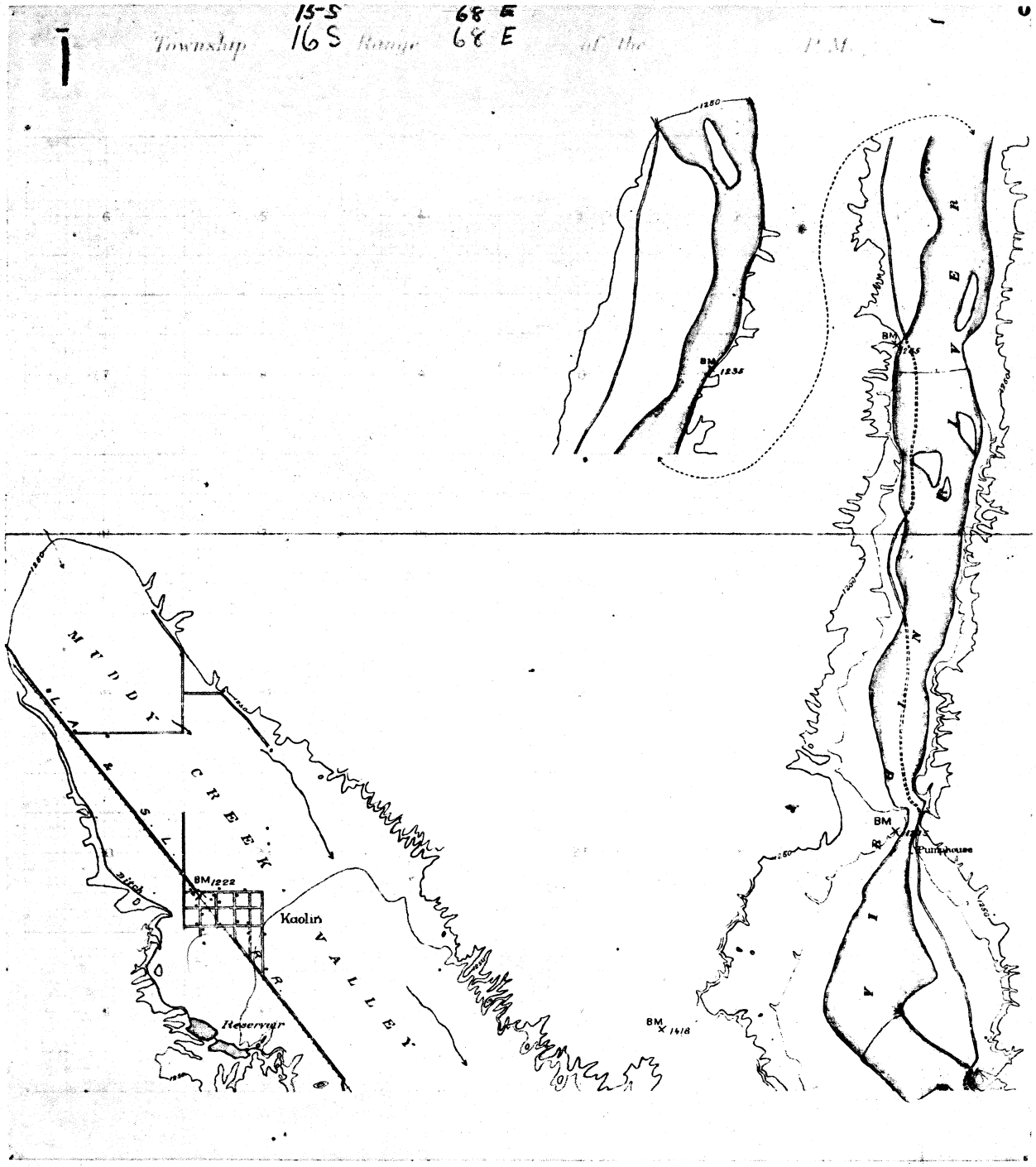
All positions are referred to the supposed section corner, 10, 11, 14 and 15 at St. Thomas and plotted by rectangular coordinates. Other section corners were searched for but none found until the 5th standard parallel was reached on the Colorado River, and these are marked upon the plats.

Topography of the General Land Office Plats in no wise agrees with mine except along Township and Range lines, and it is certain the interior corners were not originally established as purported.

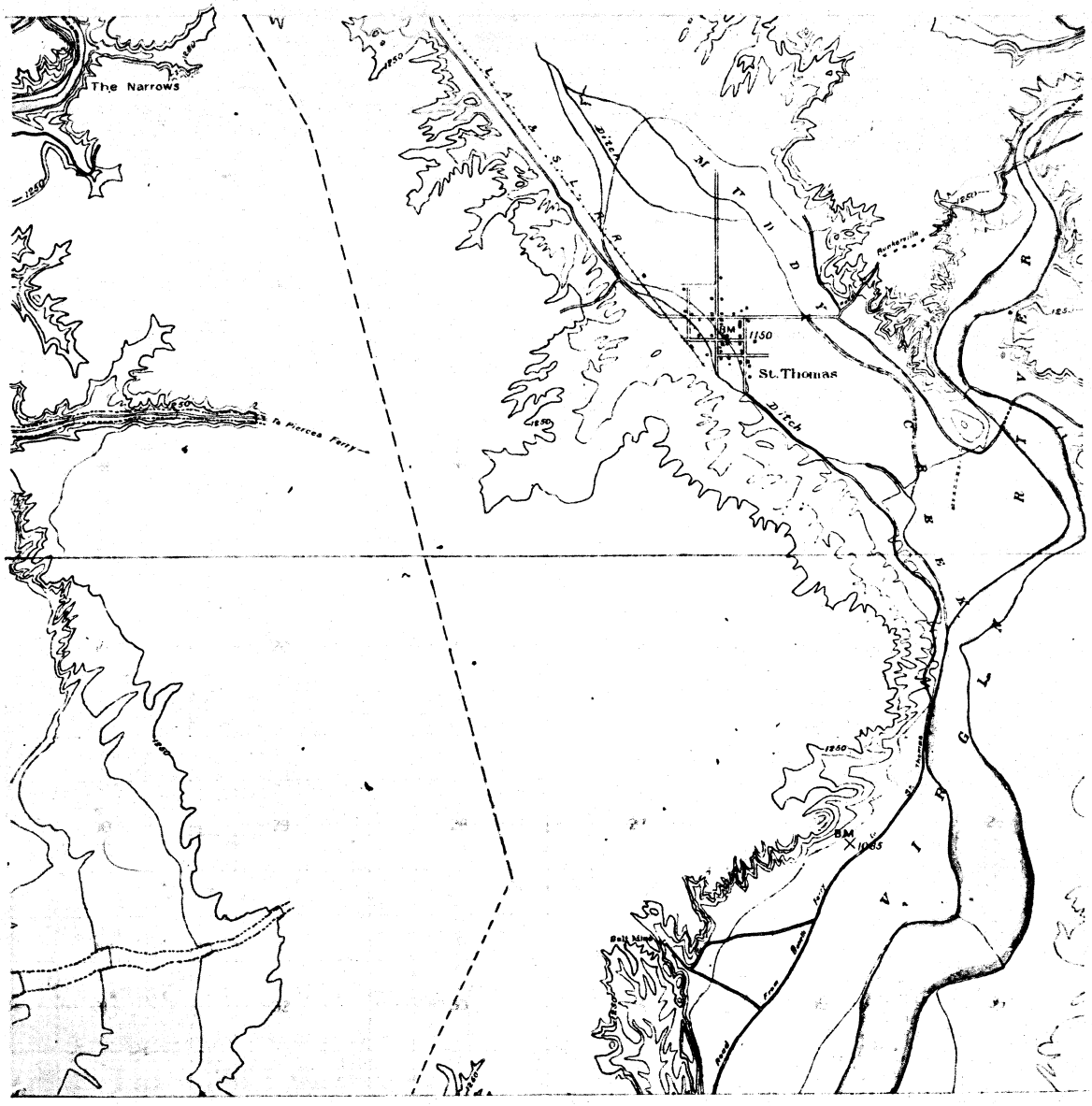
The 5th Standard Parallel was found about 1600 feet north of the theorectic position, which error is accounted for by the rough nature of country covered by original surveys and the general character of work known to have been done nearly fifty years ago when these surveys were made.

Therefore the general position of topographic forms is in the theorectic position, and not the actual position that a retracement survey would place them.

15-S 68 E
Township 16S Range 68E of the 6th P.M.

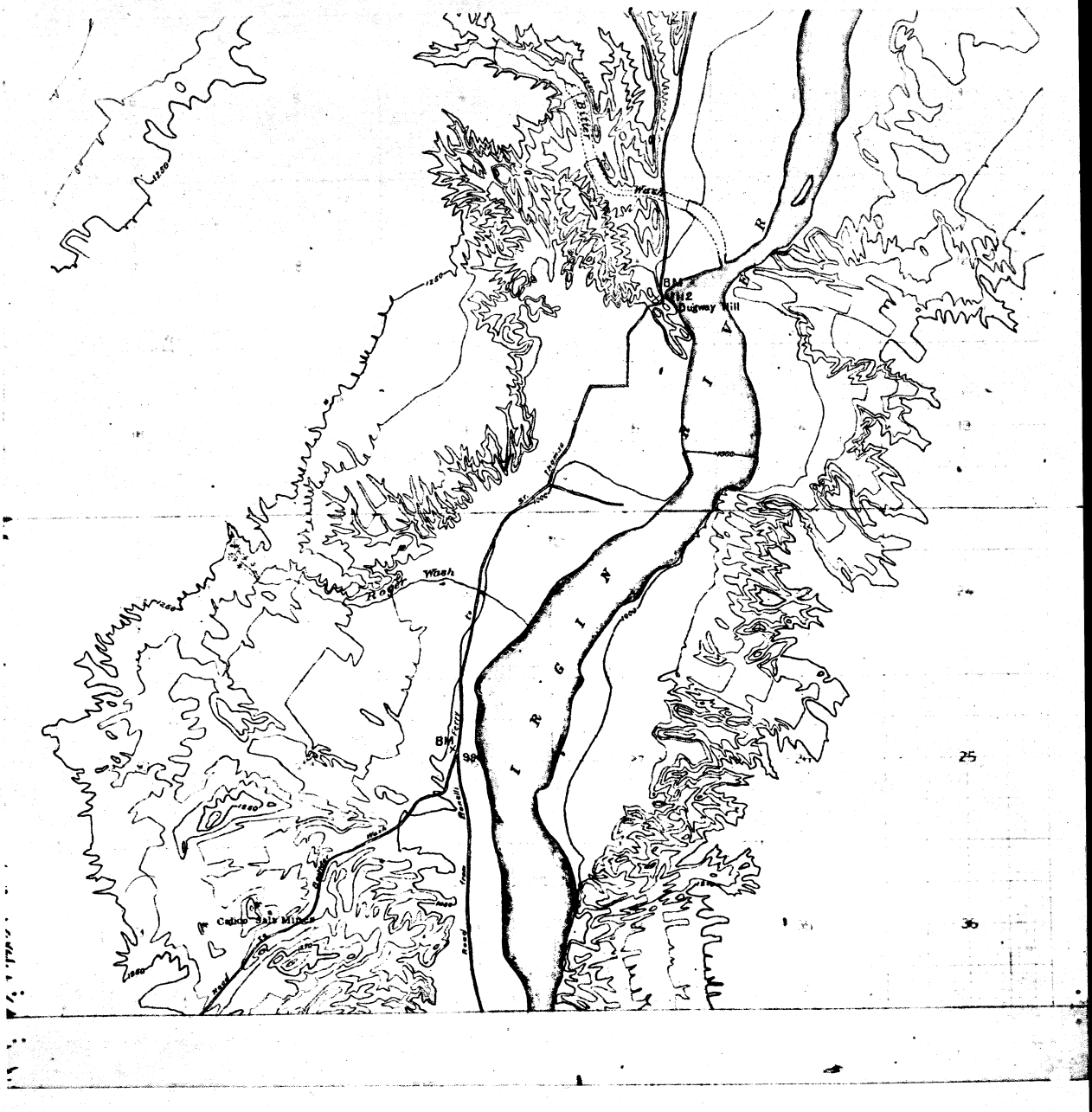


2 Township 17 S Range 68 68 E



3

Township 18 S Range 68 & 69 E of the [illegible] P.M.



Township 19 S Range 68 E of the P.M.

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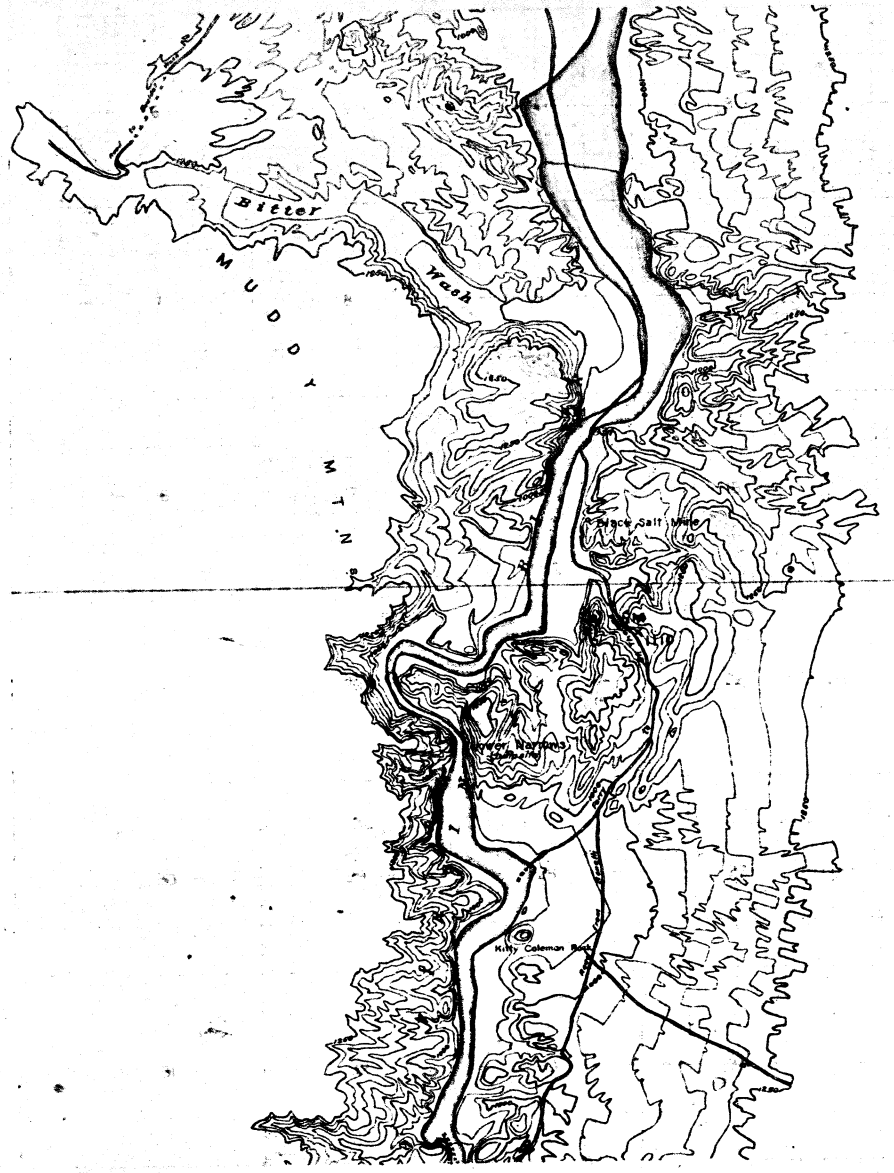
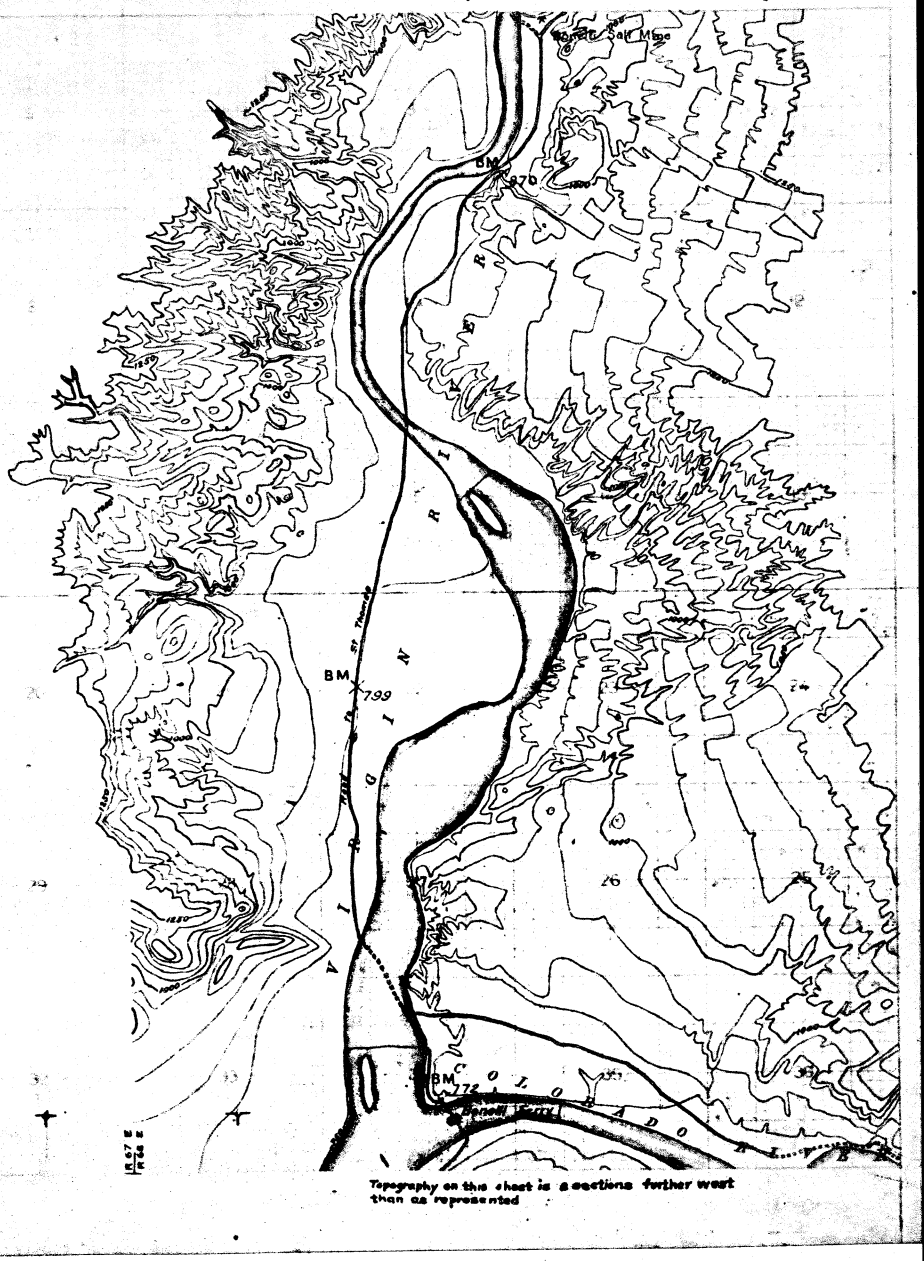
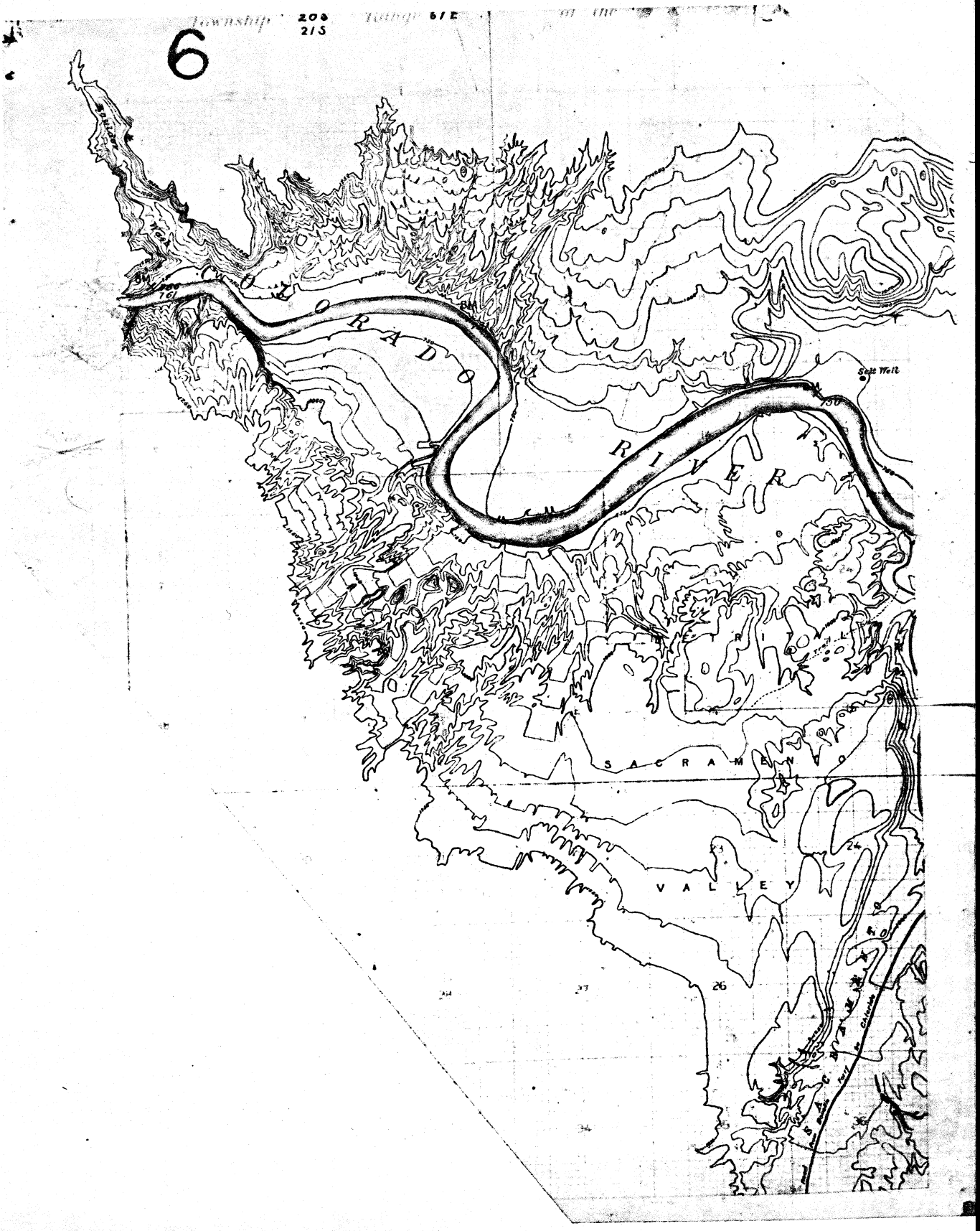
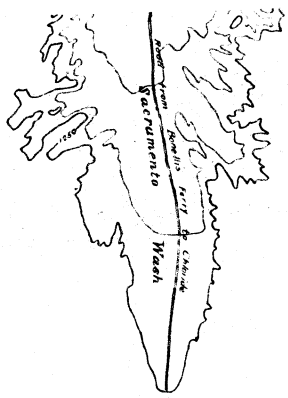


5 Township 20 S Range 67 & 68 E of the 6th P.M




6
Township 20S 21S
Range 6 E
COLORADO RIVER
Salt Well
SACRAMENTO
VALLEY
23
24
25
26
27
35
36

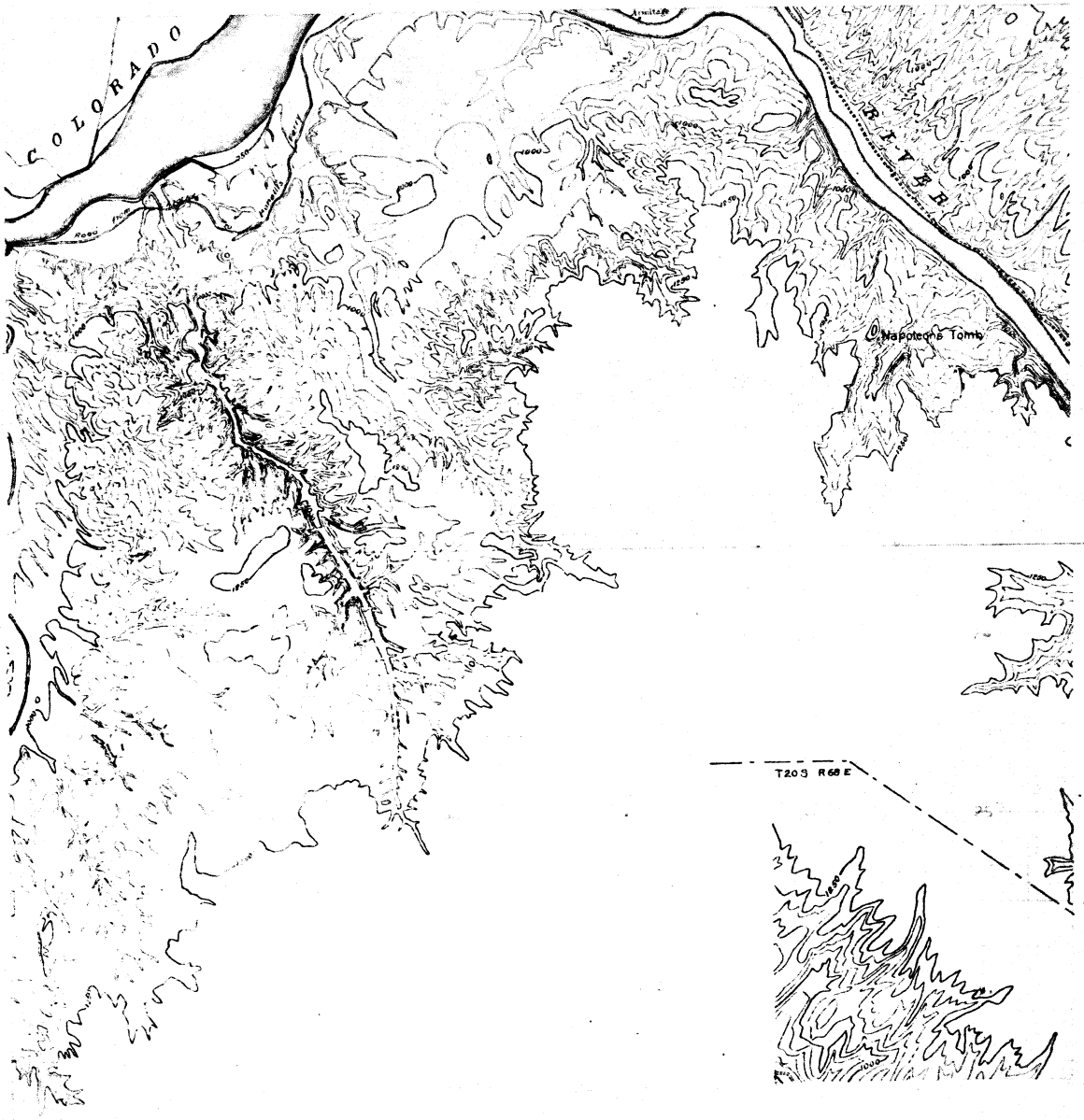
7 Township 22 S Range 67 E of the



8

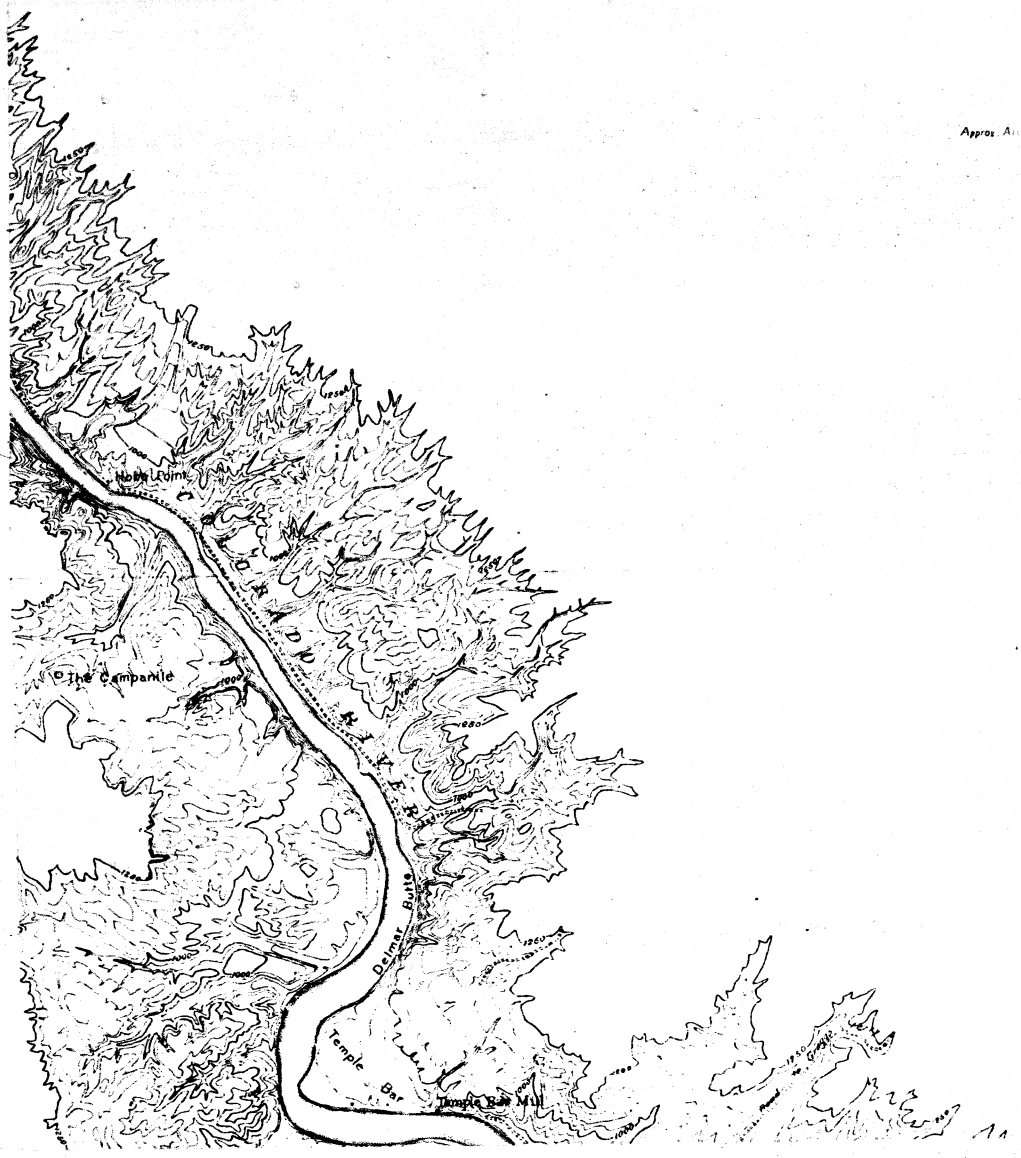
20 S
21 S

68 E



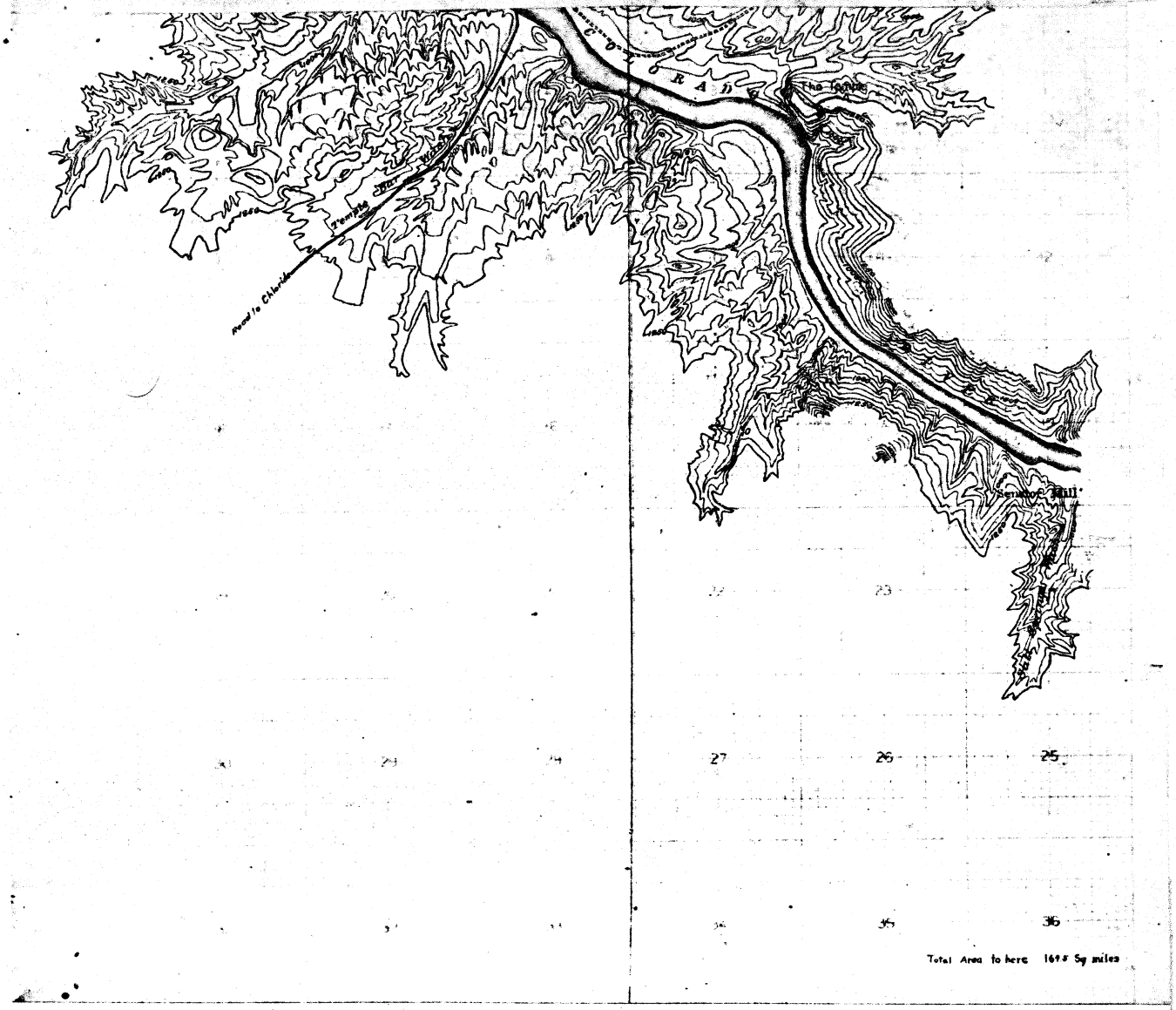
9 Township 21S Range 69 E

Approx. Area 12 Sq miles



10

T22S R69E



Total Area to here 1695 Sq miles

MAN'S QUEST FOR WATER

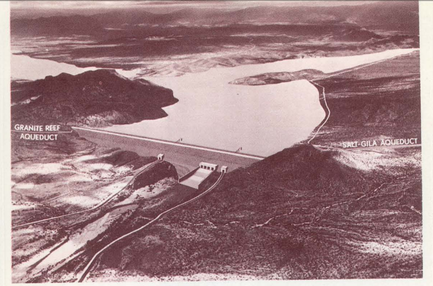
Colorado River water will someday flow to the fertile valleys of central Arizona where, before the time of Christ, the Hohokam Indians established an extensive irrigation civilization. Had these primitive people known how to build storage dams and drainage systems as does man today, they might not be called Hohokam—"the people who are gone." Although Central Arizona Project water will lessen the impact of continued ground water overdraft to maintain the existing economy, by the end of this century, or before, additional water must be imported from other sources to stave off water bankruptcy.

WHAT CAP WILL DO

The Central Arizona Project was authorized by the Colorado River Basin Project Act (Public Law 90–537) of September 30, 1968.

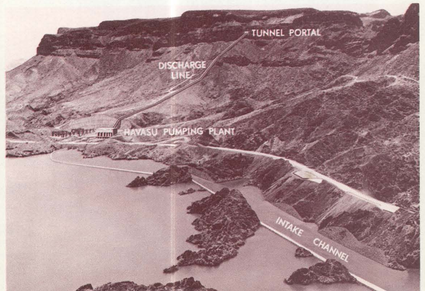
Constant vigilance in the development and management of water resources has been essential in sustaining a strong economy in central and southern Arizona. For over three decades, central Arizona's natural water supply has been out of balance with total water demands, and the agricultural economy in particular has flourished and declined in direct relationship to the adequacy of water resources. Massive overpumping of ground water reserves has been necessary to balance the yearly supply-demand relationship. The current annual overdraft of the underground basins is over two million acre-feet. The importation of Colorado River water through construction of the Central Arizona Project will be a giant step toward reducing this annual overdraft, which is causing ground water levels to decline at an average rate of 8 to 10 feet per year with serious land subsidence occurring in many areas.

The Central Arizona Project will provide supplemental water for established agricultural areas in Maricopa, Pinal and Pima Counties, as well as municipal and industrial water for the rapidly expanding Phoenix and Tucson metropolitan areas. Other water-deficient areas of Arizona and western New Mexico will also benefit from the Project under the water exchange principle. In addition, the Project will provide substantial benefits from flood control, outdoor recreation, fish and wildlife conservation, and sediment retention.



THE CAP PLAN

The basic plan calls for construction of a series of pumping plants and aqueducts, which will lift Colorado River water hundreds of feet from Lake Havasu and carry it to the Project service areas in Maricopa, Pinal and Pima Counties. Construction of dams and reservoirs on the Salt, Gila, and San Pedro Rivers will provide needed regulatory, conservation and flood control storage capacity, as well as additional recreational and water exchange opportunities. Federal participation in the Navajo thermal generation powerplant near Page, Ariz., will provide pumping power requirements for the Project. Water salvage measures along the main stem of the Colorado River, such as phreatophyte control and the utilization of Project return flows, will provide additional water necessary for the long-range success of the Project.



Orme Dam And Reservoir

Orme Dam, an earthfill structure, will be located about 25 miles northeast of Phoenix, near the confluence of the Salt and Verde Rivers. The multipurpose storage reservoir will be operated with the present Salt River Project storage system, as well as the Colorado River Aqueduct system, and will provide terminal regulatory capacity for the Granite Reef Aqueduct, flood control capacity to meet the requirements of the Phoenix metropolitan area, sediment control, and additional conservation capacity. Orme Reservoir will also provide an excellent outdoor recreational facility for Phoenix metropolitan area residents. Recreational development of the entire reservoir, including Indian lands and Federally-owned lands adjacent to the reservoir, will be in accordance with the coordinated master plan approved by the Secretary of the Interior.

Havasu Diversion–Granite Reef Aqueduct

An intake channel and high-lift pumping plant located on the south shoreline of the Bill Williams River arm of Lake Havasu, some 2½ miles upstream from Parker Dam, will divert Colorado River water for Project uses. The pumping plant will lift water over 800 feet from the lake to the inlet portal of the 6½-mile-long Buckskin Mountains Tunnel. The Granite Reef Aqueduct will carry water from the tunnel about 190 miles to Orme Dam. The concrete-lined aqueduct will have a maximum capacity of 3,000 cubic feet per second. In addition to the initial pumping plant at Lake Havasu, the Aqueduct will require four relift pumping stations located at the Bouse Hills, Little Harquahala Mountains, Belmont Mountains and near the Hassayampa River. To deliver water from the Colorado River to Orme Dam will require a total pump lift of about 1,200 feet.

Salt-Gila Aqueduct

When constructed, the Salt-Gila Aqueduct will be nearly 97 miles in length, with a capacity of 1,800 cubic feet per second over its first 63 miles and a capacity of 750 cubic feet per second over the last 34 miles. It will be fed either directly from the Granite Reef Aqueduct or by releases from Orme Reservoir. A pumping plant will be required to lift Project water into the Aqueduct from either source, and two additional pumping plants will lift the water about 460 feet for passage through the Picacho Mountains. Colorado River water will be carried by this Aqueduct into the agricultural areas of southeastern Maricopa County and the lower Gila and Santa Cruz agricultural areas of Pinal County. The system will also provide the means to convey municipal and industrial water to the rapidly growing metropolitan area of Tucson.

Buttes Dam And Reservoir

Buttes Dam will be constructed on the Gila River within Pinal County about 4 miles upstream from the existing Ashurst-Hayden Diversion Dam. This multipurpose storage facility will provide conservation and flood and sediment control capacity. The control and regulation of Gila River irrigation releases for the San Carlos Project will be greatly improved by Buttes Reservoir. Realization of important outdoor recreation and fish and wildlife benefits will also be afforded by creation of this multipurpose Project facility.

Tucson Aqueduct

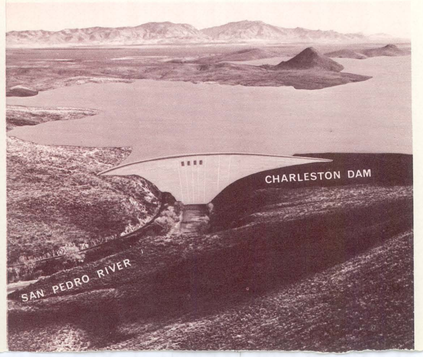
The Tucson Aqueduct, originating at the terminus of the Salt-Gila Aqueduct, near Marana, Ariz., will convey municipal and industrial water to the city of Tucson. The 20-mile-long concrete pipe aqueduct will have a capacity of 150 cubic feet per second. Two pumping plants located near Marana will be required to lift the water over 450 feet from the Salt-Gila Aqueduct to the city of Tucson.

Charleston Dam And Reservoir

Charleston Dam, a multipurpose storage facility to provide conservation and flood control capacity, will be constructed on the San Pedro River in Cochise County about 65 miles southeast of Tucson. The water supplied from the reservoir will be used primarily for municipal and industrial purposes in Tucson; however, improved regulation of San Pedro River flows will benefit downstream water users as well. Important water-oriented outdoor recreation, as well as sediment retention, will be realized by this segment of the Project.

San Pedro Aqueduct

This 70-mile concrete pipeline will carry about 12,000 acre-feet of water annually from the Charleston Reservoir to the Tucson area. The total pumplift for this Aqueduct will be nearly 330 feet.



Distribution System

Congress has authorized an additional $100 million to be appropriated for construction of distribution and drainage systems necessary to convey water to non-Indian lands. These funds could be made available in three ways. First, the distribution systems may be constructed under the provisions of the Distribution Systems Loan Act of 1955, Public Law 84–130. This allows an irrigation district or similar water user entity to hire a consulting engineer to plan, design, and supervise the construction of the district's distribution system under designs approved by the Bureau of Reclamation. Second, for smaller districts or those which can be broken into small integral units, Public Law 84–984, the Small Reclamation Projects Act, may be most appropriate. Again, the district obtains a loan and hires consultant services. Third, the district may prefer to have the Bureau of Reclamation plan, design, and supervise the construction of the system.

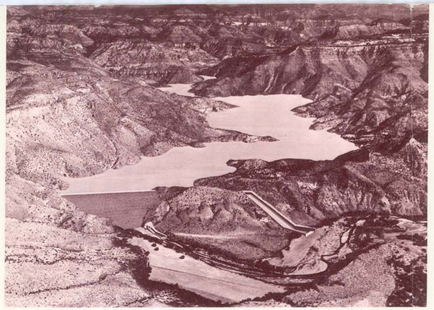
Cost of constructing distribution systems for Indian lands is included in the estimated cost for the Project.

CONSTRUCTION

About 10 years will be required to construct all Project facilities prior to water delivery. The Project should be completed by 1980 if funds are appropriated according to schedule. Construction of the entire Project will require about 3.5 million cubic yards of concrete, 5 million barrels of cement, and 240 million pounds of reinforcing and miscellaneous steels. Earth movement for dam and canal construction will be about 140 million cubic yards.

Water Salvage

Included in the Project are water salvage measures consisting of utilization of Yuma Project return flow and phreatophyte clearing along the lower Colorado River. It has been estimated that these undertakings may yield as much as 320,000 acre-feet of water annually for use in the Lower Colorado River Basin if current plans are fully implemented. This, together with water salvaged under other programs along the river, will be necessary to realize the projected diversion of water to the Central Arizona Project, particularly in years of low water supply. The phreatophyte eradication and management program will be coordinated with outdoor recreation and wildlife habitat and refuge programs on the lower Colorado River.



Hooker Dam And Reservoir

Hooker Dam or a suitable alternative will be located on the Gila River in Grant County, New Mexico. The structure, a multipurpose storage facility, will allow water users in New Mexico to increase their consumptive use from the Gila River and its tributaries. This increased water use in New Mexico will be implemented through Project water exchange agreements with downstream water users in Arizona. Primary uses of the water will be for domestic and mining-oriented industrial purposes. The storage facility will also optimize flood and sediment control, as well as regulate river flows, for the benefit of developed agricultural lands downstream from the dam. Extensive outdoor recreation and fish and wildlife benefits will also be provided by the reservoir.

Electrical Power Requirement

Approximately 560 megawatts of capacity will be required in the operation of the Central Arizona Project. To meet this requirement, arrangements have been made for the United States to acquire an entitlement to a portion of the capacity of the Navajo Thermal Generating Station and its associated transmission system. These facilities will be constructed by non-Federal interests. The Generating Station will be located near Page, Ariz., and will be fueled by coal from nearby Black Mesa and other deposits on the Hopi and Navajo Indian Reservations.

COST AND REPAYMENT

The estimated construction cost of the Central Arizona Project is $832,180,000. Construction costs are allocated to the purposes of municipal and industrial water, irrigation water, power, outdoor recreation, flood control, and fish and wildlife. Costs of the water salvage, Indian land distribution systems, and fish hatcheries and wildlife refuge programs are also included. No interest will be charged on costs allocated to irrigation; however, irrigation water charges will repay all operation and maintenance costs and a share of the construction costs. Financial assistance in excess of irrigators' ability to repay construction costs will be obtained from Arizona's portion of the Lower Colorado River Basin Development Fund. This fund is derived from Central Arizona Project revenues and surplus revenues acquired from the Boulder Canyon Project, Parker-Davis Project, and the Pacific Northwest-Pacific Southwest Intertie power operations, after completion of their respective repayment contracts.

About 87 percent of the construction costs will be returned to the Government by the people who benefit directly from the Project. Since the direct beneficiaries of flood protection and water salvage expenditures cannot be identified, these costs will be nonreimbursable. A portion of the recreation and fish and wildlife costs will be repaid in accordance with Public Law 89–72, where applicable. Costs for the Indian distribution systems, in excess of the repayment capability of Indian lands, will be nonreimbursable.

As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities for water, fish, wildlife, mineral, land, park, and recreational resources. Indian and Territorial affairs are other major concerns of America's "Department of Natural Resources."

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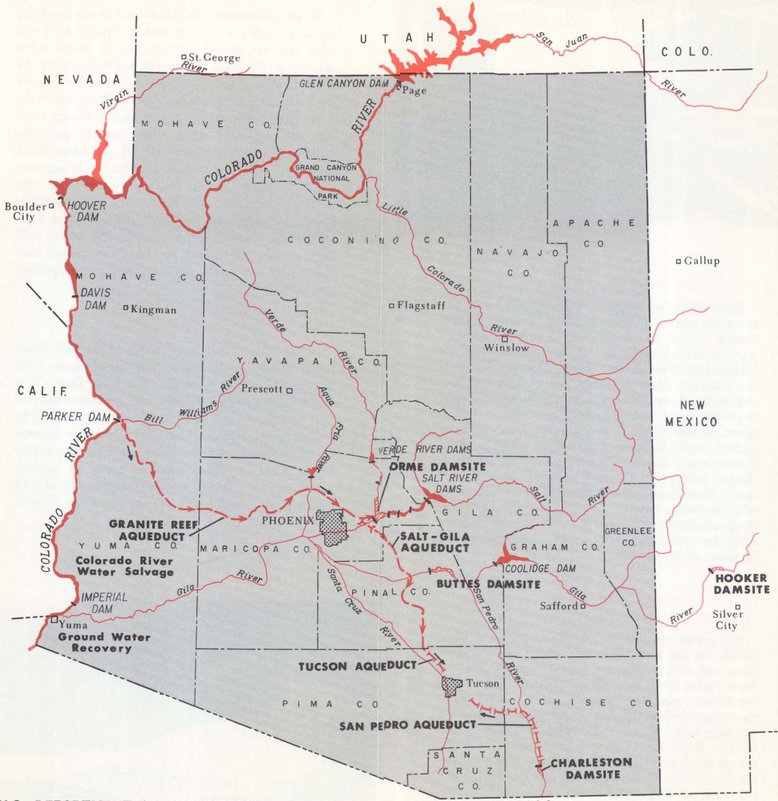

U.S. DEPARTMENT OF THE INTERIOR
Walter J. Hickel, Secretary

BUREAU OF RECLAMATION
Ellis L. Armstrong, Commissioner

WATER FOR CITIES, FARMS, AND FACTORIES

Central Arizona PROJECT