DEPARTMENT OF THE INTERIOR

UNITED STATES RECLAMATION SERVICE

R E P O R T

O N

S A N C A R L O S P R O J E C T

A R I Z O N A

VOLUN 2 APPENDIXIS

By

C. C. Fisher, Engineer

1920

PHOENIX, ARIZONA

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APPENDIX "A"

PRELIMINARY DESIGNS AND ESTIMATES

on

SAN CARLOS RESERVOIR

and

POWER and PUMPING PLANTS

by

Designing & Electrical Departments

Denver Office, U. S. Rec. Service.

1 9 2 0.

SAN CARLOS PROJECT - ARIZONA

SAN CARLOS RESERVOIR

Preliminary Design and Estimate.

Drawings Nos. 44-C-3 & 44-E-2.

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DESCRIPTIVE.

Data.

Report to the Secretary of War of a Board of Engineer Officers, United States Army, under Indian Appropriation Act of August 24, 1912, on the San Carlos Irrigation Project, Arizona, dated February 14, 1914.

"Hearings before the Committee on Indian Affairs", House of Representatives, Sixty-sixth Congress, first session, on "The Conditions of Various Tribes of Indians", dated November 11, 1915.

Report on Water Supply, San Carlos Project, by Engineer E. B. Debler, dated July, 1920.

Report on San Carlos Project, Arizona, by Engineer C. C. Fisher, dated 1920.

Report on Surveys and Estimates, San Carlos Project, by Engineer S. S. Carroll, dated December 6, 1920. This report covers relocation of Arizona Eastern Railroad around San Carlos Reservoir, the construction of a railroad from San Carlos to San Carlos Dam Site, wagon road from point near Rice to San Carlos Dam Site, and sand and gravel deposits in the vicinity of San Carlos Dam Site.

Letter - Project Manager to Chief of Construction, dated Yuma, Arizona, April 6, 1920.

Letter - Project Manager to Chief Engineer, dated Yuma, Arizona, July 6, 1920.

Letter - Engineer S. S. Carroll to Project Manager, Yuma, Arizona, dated July 13, 1920, report on sand and gravel.

Letter - Designing Engineer to Chief Engineer, dated August 19, 1920.

Maps Nos. 1, 2, 3 and 4 of Army Board Report.

Blue Print Indian Service drawing No. 38-B-19, "San Carlos Dam, Elevation of Dam and Spillway Looking Upstream. Also Center line Section of Spillway."

Blue Print Indian Service Drawing No. 38-B-18, "Section of San Carlos Dam".

Blue Print Indian Service Drawing (unnumbered) "Cross-Section of San Carlos Dam."

U. S. R.S. Drawing (unnumbered) "San Carlos Reservoir Site, Gila River, Arizona". made on the Yuma Project and dated March, 1920.

Reservoir.

The proposed site San Carlos Reservoir is on the Gila River at its junction with the San Carlos River in the San Carlos Indian Reservations, Gila County, Arizona. The dam is located in a box canyon about 8 miles down the river from the town of San Carlos on the Arizona and Eastern Railroad.

Preliminary estimates have been prepared for five reservoir capacities, all of which include 150,000 a.f. of silt, as follows:

389,000 a.f.	1,300,000 a.f.
710,000 a.f.	1,600,000 a.f.
	2,710,000 a.f.

The reservoir will be operated as hold over.

Dam Site.

Two sites called the "upper" and "lower" have been investigated by geological examination and by diamond drill holes. The upper site is generally accepted as being the better.

Faults occur in the immediate vicinity of both sites. At the upper site the dam is more favorably located with respect to faults, and rests upon what appears to be a solid mass of rock between two lines of fault. At the lower site a line of fault crossing the axis of the dam at the west abutment intersects a line of fault which crosses the river.

The rock at the upper site is quartzite or quartzite sandstone. The abutments are wholly in sight and appear to be sound. Bedrock is reached at depths of 15 to 28 feet.

At the lower site the rock is limestone, containing warm springs, which indicates the possibility of cavities. The west abutment is somewhat shattered, and indications are that it may possibly be detached from the mass of the hillside. (Army Report page 26). Bedrock is about 74 feet deep.

The upper site is more accessible for construction.

Dam.

On account of the apparent superiority of the upper site, the accompanying preliminary designs and estimates are based upon a dam at that location.

A masonry dam of gravity type and straight alignment is assumed for all capacities.

The dam has been designed to withstand an uplift equal to one-half the full head at the upstream face and diminishing uniformly to zero at the downstream face, acting over the entire area of the base.

A concrete cut-off is assumed to extend the entire length of the dam. The depth is assumed at 25% of the dam height at corresponding point. Extensive grouting of the foundation will also probably be necessary. Foundation drainage is provided by two rows of holes drilled downstream from the cut-off wall and leading to the inspection gallery.

When foundation is opened up it may be found that conditions warrant the omission of the concrete cut-off wall.

The base of the dam is assumed, for estimating, to be carried to an average depth of 3 feet into rock over the entire base.

The maximum inclined pressure for the highest dam is computed to be 18.7 tons per square foot at the downstream face with water at top of dam. The maximum vertical pressure at the upstream face with reservoir empty is computed to be 18.8 tons per square foot. The

pressures for the next highest dam (shown on drawing 44-C-3) are 18.1 and 19.0 tons per square foot respectively.

The maximum required sliding coefficient for the highest dam which occurs with a back pressure and uplift on the downstream face due to 74 foot head, is less than 0.657, the weight of a cubic foot of concrete being assumed at 145 pounds.

The required sliding coefficient with no back water on the downstream side of the dam is 0.583.

Five heights of dam have been estimated as follows:

Elev. Normal Army Board Datum	R.W. S. Sea Level Datum	Corresponding Maximum Heights including 10' Freeboard.
150'	2458'	186'
180'	2488'	216'
218'	2526'	254'
233'	2541'	269'
267'	2573'	803'

The fourth dam is shown upon the accompanying drawing. The quantities estimated are based upon a topographic map of the dam site, scale 1" = 30'. This map was enlarged from Map No. 4 of the Army Board report (scale 3/4" = 100'), which is the only topography of the dam site available at this time. The estimated quantities are therefore subject to considerable error.

The dam is assumed to be built of concrete of the following proportions: 1 Part cement, $2\frac{1}{2}$ parts sand, 6 parts gravel, 5 parts cobbles.

Spillway.

A flood discharge of about 150,000 second feet passed San Carlos in 1905.

The Debler report referred to gives an estimated probable maximum flood of 200,000 second feet. This report estimates that this peak will be reduced to about 130,000 second feet by the moderating effect of the freeboard storage for a 7-day flood.

The effect of freeboard storage upon the spillway discharge is not usually considered by this office in the preparation of preliminary estimates. However, the floods on the Gila are known to be of short duration and for the particular structure 130,000 second feet is believed to be conservative.

The same spillway capacity and design is proposed for all heights of dam.

Studies were made of open channel spillway of the type used at the Arrowrock Dam and of siphon units mounted on the dam itself.

The great length required for the spillway crest, the extremely unfavorable topography and comparatively soft rock makes the open spillway design very much more expensive than the siphon type.

Reinforced Concrete.

The spillway adopted consists of thirteen 16.3 x 16.5 siphon units mounted upon top of the dam and discharging into a cushion at the toe formed by secondary dam across the river channel. The computed depth of water cushion under full discharge is about 63 feet.

The efficiency of the siphons is computed to be about 77%.

Outlet Works and Penstocks.

Three 6 ft. diameter penstocks are provided to supply water to the power house which will be located below the secondary dam. Thru the dam these conduits are reinforced for water pressure. Below the dam they are located in concrete lined tunnels also reinforced.

Each penstock is controlled near the inlet by a 5' x 5' hydraulically operated slide gate, and is protected by a trash rack.

At a point between the main and auxiliary dams a 36" outlet tunnel takes off each penstock. These outlets are controlled by 36" balanced needle valves, and serve to release irrigation water when the power house is not operating. The needle valves discharge into the pool below the dam and are submerged to eliminate spray at the power house.

The penstock tunnels are contracted to 4' 6" diameter at the power house and an additional control is provided in the form of a 4' 6" motor operated gear valve for each tunnel. These valves are located in the power house and are for closing the penstock to divert flow thru the needle valves described above.

The intakes to the penstocks are located about 80 feet above the river bed, which is about three-quarters of the depth of 150,000 a.f. of silt storage.

Four 5-ft. sluice outlets, controlled by 5' x 5' hydraulically operated slide gates, are located at elevation 2318 and are protected by trash racks. The sluices discharge into the pool below the dam.

Railroads.

The cost of relocating and reconstructing the Arizona Eastern Railroad around San Carlos Reservoir and building a temporary construction railroad from San Carlos to the dam site are taken from a report by Engineer S. S. Carroll, dated December 6, 1920.

Wagon Road.

The cost of constructing a wagon road from San Carlos to the dam site is taken from a report by Engineer S. S. Carroll, dated December 6, 1920.

Power and Pumping System.

The preliminary design of the power plant at the San Carlos dam is shown on drawing 44-E-2. The head on the plant varies from 9o to 228 feet. At 90 foot head the capacity of the plant is 3240 kw. At heads from 133 to 228 ft. the capacity is 4800 kw. At the minimum head the turbines utilize the entire flow released for irrigation purposes.

The power plant will contain three 2300 HP vertical, variable head turbines direct connected to 2000 kv-a, 2300 volt, 3 phase, 25 cycle generators with direct connected exciters. The turbines have cast iron scroll cases and 54 inch motor operated gate valves, each turbine receiving its water thru a 6-ft. conduit from the reservoir. The building is a reinforced concrete structure the walls of which are designed to withstand external water pressure up to the main generator room floor. The elevation of this floor is above maximum tail water assuming a variation in tail water surface of 40 feet.

Two banks of transformers, each consisting of three 1000 kv.-a single phase water cooled outdoor type transformers, step the voltage up from 2300 to 44,000 volts. The transformers, lightning arresters, and 44,000 volt oil circuit breakers are to be located near the power plant on some suitable bench. Provision is made in the 44,000 volt switching arrangement for two outgoing lines although only one line is included in this estimate.

The transmission line connecting the power plant with the Florence-Casa Grande Unit is a single circuit, 44,000 volt, steel pole line approximately 80 miles in length. The conductors are No. 00 copper suspension type insulators, ground wire and a phone line are included. The operation of similar lines on the Salt River power system has demonstrated that this type of construction will be satisfactory.

On the Florence-Casa Grande Unit four outdoor type substations reduced the voltage from 44,000 to 4,000 for distribution to the pumping plants. Each of these substations consists of three single phase, self-cooled, 500 kv-a outdoor transformers, lightning arrester equipment on both the high and low voltage side, 44,000 volt oil circuit breaker and four 4,000 volt feeders with the necessary meters.

A single circuit 44,000 volt wood pole line approximately 28 miles in length connects the Florence-Casa Grande Unit with the present Sacaton substation of the Salt River power system. This line has No. 1 copper conductors and a telephone line. The substation on the Reservation Unit above Gila Crossing will receive power from this line. A similar line using No. 6 copper conductors will extend from the Sacaton substation to the substation on the Reservation Unit below Gila Crossing.

On each of the Reservation units there will be an outdoor substation which will step the voltage down from 44,000 to 11,000 volts for use at the pumping plants. Each of these substations will consist of a bank of three single phase, self-cooled, 400 kv-a transformers, 44,000 volt oil circuit breaker, 44,000 volt lightning arrester, 11,000 volt lightning arrester and two 11,000 volt feeders with meter equipment.

Switching equipment and meters are provided for interconnection at the Sacaton substation with the Salt River power system.

The pumping plants on the Florence-Casa Grande Unit are of the vertical turbine pump type. The pumps are installed in 16 inch wells, and are direct connected to vertical motors. At each pumping plant there is a three phase, outdoor transformer for reducing the voltage from 4,000 to 220, an oil circuit breaker, and lightning arrester. A suitable building houses the motor and switching equipment.

The pumping plants on the Reservation Units are of greater capacity than those on Florence-Casa Grande Unit and are of the same type as those now in operation near the Sacaton substation. Each plant consists of a vertical centrifugal pump installed in a concrete caisson and direct connected to a vertical motor. The caisson is directly over a 16" well.

An outdoor, three phase, transformer reduces the voltage from 11,000 to 220 volts. Lightning arresters, oil circuit breakers, starting equipment and buildings to house the motor and switching equipment are included.

Substations for supplying commercial load such as the towns of Florence and Casa Grande have not been included in this estimate.

Twenty-five cycle frequency and 44,000 volts for transmission has been chosen for the San Carlos power system so that connection can be made with the Salt River power system without the necessity of installing frequency changers and transformers at each point of connection.

It may be desirable to connect the San Carlos power plant with the Salt River power system by building a line to Miami but this line has not been included in this estimate.

Right of Way.

The estimate for right of way and property damage is taken from a letter from the Project Manager, Yuma, Arizona, to the Chief Engineer, dated December 1, 1920.

UNIT COSTS.

Cement

Cement is assumed to cost $4.70 per barrel at the mixers. This cost is based upon the following data which was in part supplied by the Purchasing Department July 2, 1920.

Cost per bbl. El Paso		$3.50
Freight to Rice		1.10
Assumed freight over Constn. R.R.		.10
Handling charge assumed		0.50
Gross		$5.00
Less 75% of sacks returned at 25¢ -	.75	
	.05	.80
		$4.20

Sand.

Sand is assumed to be excavated from nearby bars in the river channel, screened and washed.

The unit cost at the mixers is assumed as follows:

Excavating and transporting	$1.00
Screening and washing	.60
	$ 1.60

Gravel

Gravel is assumed to be taken from a bar 3/4 mile above dam. The unit cost is assumed as $1.60 per cubic yard at the mixers, as follows:

Excavating, screening and loading	$ 0.65
Washing	0.35
Transportation 3/4 mile at $0.55 per ton mile	0.62
	$ 1.62 say $1.62

Cobbles.

Cobbles are assumed in place at same price of sand and gravel.

GRAVITY DAM WITH SIPHON SPILLWAY

El.	Top of Dam	2585	El. Top of Parapets = 2589
El.	Normal W.S.	2575	Storage Capacity = 2,710,000 a.f.
31.	Spillway Crest		(includes 150,000 a.f. silt)
			Spillway capacity W.S. El. 2585 = 130,000 s.f.

Drawing 44-C-3

PRELIMINARY ESTIMATE

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
COFFER DAMS				$100,000
DEEP CUTOFF				
Excavation				
Class III	5400 c.y.	$ 7.50		40,500
Concrete 1:3:6				
Cement	5670 bbl.	4.20	$23,815	
Sand	2380 c.y.	1.60	3,808	
Gravel	4800 c.y.	1.60	7,680	
Mixing & Placing	5400 c.y.	1.50	8,100	
Plant Depreciation	5400 c.y.	1.00	5,400	
			$48,802	
Concrete in Place	5400 c.y.	9.00		48,600
TOTAL DEEP CUTOFF				89,100
FOUNDATION GROUTING				
Drilling	22000 l.ft.	1.50	33,000	
Grouting	22000 l.ft.	1.50	33,000	
TOTAL FOUNDATION GROUTING				66,000
FOUNDATION DRAINAGE				
Drilling	14700 l ft.	1.50	22,050	
TOTAL FOUNDATION DRAINAGE				22,050

	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
SECONDARY DAM				
Excavation				
Class II	57,600 c.y.	$2.00	$ 115,200	
Class III	26,000 c.y.	2.50	65,000	
Total Excavation				$ 180,200
Concrete, in Main Dam				
1:2½:6:3 Mix				
Cement	484,000 bbl.	$4.20	2,032,800	
Sand	171,000 c.y.	1.60	273,600	
Gravel	413,000 c.y.	1.60	660,800	
Cobbles	204,000 c.y.	1.60	326,400	
Forms	550,000 c.y.	1.50	825,000	
Mixing and Placing	550,000 c.y.	1.50	825,000	
Plant Depreciation	550,000 c.y.	1.00	550,000	
			5,493,600	
Concrete in Place, Main Dam	550,000 c.y.	10.00		$5,500,000
Concrete in Siphon.				
(Piers & Hood)				
1:2½:5 Mix Reinforced				
Cement	10,600 bbl.	4.20	$ 44,520	
Sand	3,770 c.y.	1.60	6,032	
Gravel	7,460 c.y.	1.60	11,936	
Rein.Steel 135 lbs. c.y.	1,160,000 lbs.	0.08	92,800	
Forms	8,580 c.y.	7.50	64,350	
Mixing and Placing	8,580 c.y.	3.00	25,740	
Plant Depreciation	8,580 c.y.	1.00	8,580	
			$ 253,958	
Concrete in Place in Siphon	8,580 c.y.	30.00		$ 257,400
Concrete in Secondary Dam				
1:2½:6:3 Mix				
Cement	12,100 bbl.	4.20	$ 50,820	
Sand	4,250 c.y.	1.60	6,800	
Gravel	10,300 c.y.	1.60	16,480	
Cobbles	5,070 c.y.	1.60	8,112	
Forms	13,700 c.y.	1.50	20,550	
Mixing and Placing	13,700 c.y.	1.50	20,550	
Plant Depreciation	13,700 c.y.	1.00	13,700	
			$ 137,012	
Concrete in Place in Secondary Dam	13,700 c.y.	$10.00		$ 137,000
TOTAL MAIN DAM - SIPHON SPILLWAY - SECONDARY DAM				$6,074,600

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
POWER HOUSE PENSTOCKS (3-6' Diam. partly conduits thru dam, partly tunnels and equipped with 3-5'x5' Hydraulic Operated Emergency Gates)				
Excavation Class III Tunnel	1100 c.y.	$8.00		$ 8,800
Concrete, Tunnel Lining 1:2½:5 Mix				
Cement	682 bbl.	4.20	$2,865	
Sand	242 c.y.	1.60	387	
Gravel	478 c.y.	1.60	765	
Rein. Steel (for full hydrostatic head)	106,000 lbs	0.08	8,480	
Forms	550 c.y.	3.50	1,925	
Mixing and Placing	550 c.y.	3.75	2,063	
Plant Depreciation	550 c.y.	1.00	550	
			17,035	
Concrete Tunnel Lining in Place	550 c.y.	31.50		17,325
Reinforcing Steel (Around conduits thru Dam	60,100 lbs	0.08		4,808
Emergency Gates (3-5' x 5' Hydraulic Operated Sliding)				
Gates, Frames, Bonnets & Cylinders.	189,000 lbs.	0.20	37,800	
Conduit Lining 36' of 60" C.I. Pipe	30,000 lbs	$0.075	2,250	
Oil Pump, Tank, Gages			1,000	
Piping and Gages			500	
Freight	240,000 lbs	0.01	2,400	
Haul	1200 T. Mi.	0.40	480	
Installation & Painting	240,000 lbs	0.03	7,200	
			51,630	
Emergency Gates in Place	3	17,210		51,630
Trash Rack	1	8,000		8,000
TOTAL POWER HOUSE PENSTOCKS				90,563

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
REGULATING OUTLETS (3- Branch Tunnels from Power House Penstocks, 3-36" Balanced Needle Valves equipped with 3-3' x 3' Hydraulic Operated Emergency Gates)				
Excavation				
Class III Open Cut	1770 c.y.	$ 2.50	$ 4,425	
Class III Tunnel	300 c.y.	8.00	2,400	
Total Excavation				$ 6,825
Valves & Gates				
3-36" Needle Valves	190800 lbs.	0.25	$ 47,700	
Pump & Strainer			300	
Control Pipe & Fittings	4000 lbs.	0.15	600	
3 - 3' x 3' Emergency Gates (complete)	180000 lbs.	0.20	36,000	
Oil Pump, Tank, Gages & Oil			1,000	
Piping & Gages	6600 lbs.	0.15	990	
Miscel. Metal Work	10000 lbs.	0.10	1,000	
Freight	391400 lbs.	0.01	3,914	
Hauling	1960 T.Miles	0.40	784	
Installation & Painting	391400 lbs.	0.03	11,742	
Gate House	1		6,000	
Total Valves and Gates				$110,030
Concrete, Tunnel Lining 1:2½:5 Mix				
Cement	248 bbls.	4.20	1,042	
Sand	88 c.y.	1.60	141	
Gravel	174 c.y.	1.60	279	
Rein. Steel (for full hydrostatic head)	27000 lbs.	0.08	2,160	
Forms	200 c.y.	7.50	1,500	
Mixing and Placing	200 c.y.	7.50	1,500	
Plant Depreciation	200 c.y.	1.00	200	
			6,822	
Concrete Tunnel Lining in Place	200 c.y.	34.00		6,800

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
REGULATING OUTLETS (cont'd.)				
Finishing 3' Tunnel Lining	240' Linft.	$10.00		$ 2,400
Concrete about Valves				
1:2½:5 Mix				
Cement	210 bbls.	4.20	$ 882	
Sand	75 c.y.	1.60	120	
Gravel	148 c.y.	1.60	237	
Rein. Steel 60 lbs. c.y.	10200 lbs.	0.08	816	
Forms	170 c.y.	3.00	510	
Mixing & Placing	170 c.y.	2.00	340	
Plant Depreciation	170 c.y.	1.00	170	
			$ 3,075	
Concrete about valves in place	170 c.y.	18.00		$ 3,060
TOTAL REGULATING OUTLETS				
SLUICE OUTLETS				
4 - 5' x 5' Hydraulic Operated Sliding Gates, same as Penstock Emergency Gates.	4	17,210	$68,840	
Finishing 5' Conduit Lining	600 l.ft.	15.00	9,000	
Trashrack Structure	1		11,000	
TOTAL SLUICE OUTLETS				$ 88,840
PARAPETS	1634 l.ft.	10.00		16,340
LAMP POSTS	20	50.00		1,000
CONSTRUCTION CAMP				134,000
FINISHING & CLEANING UP				$ 33,000
Total Estimated Field Cost				684,408
Contingencies 10%				684,451
Administrative & Engineering 15%				1,026,692

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
RELOCATION & CONSTN. ARIZONA EASTERN R.R.				
Estimate Engr. S.S. Carroll, Dec. 6, 1920				$3,000,720
CONSTRUCTION R.R. SAN CARLOS TO DAM SITE				
Estimate Engr. S. S. Carroll Dec. 6, 1920				$ 296,780
ROAD SAN CARLOS TO DAM SITE				
Estimate Engr. S.S. Carroll Dec. 6, 1920				$ 15,690
RIGHT OF WAY (per P.M. Letter Dec. 1, 1920)				
Irrigated Land	568 A.	$150.	$85,200	
Land Susceptible of Irrigation	3022 A.	$22.50	68,000	
Grazing Land	21950 A.	2.00	43,900	
				$ 197,100
Moving San Carlos River Bridge				20,000
Indian Agency Property				150,000
Indian Buildings				3,500
TOTAL RIGHT OF WAY				$ 370,000
GROSS TOTAL COST				$12,230,551
Less Salvage of Arizona Eastern R.R. per Est. Engr. S. S. Carroll, Dec. 6, 1920				140,000
NET GRAND TOTAL COST				$12,099,551

Cost per a.f. gross 2,710,000 at $4.45

" " " Net 2,560,000 at $4.72

GRAVITY DAM WITH SIPHON SPILLWAY.

El. Top of Dam - 2551
El. Normal W.S.- 2541
El. Spillway Crest 2541.

El. Top of Parapets - 2555
Storage Capacity of 1,600,000 a.f.
(includes 150,000 a.f. silt)
Spillway Capacity w.s. El. 2551 - 310,000 s.f.
Drawing 44-C-3

PRELIMINARY ESTIMATE

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
COFFER DAMS				$ 100,000
DEEP CUTOFF				
Excavation - Class III	4,440 c.y.	$7.50	$ 33,300	
Concrete -1:3:6 Mix	4,440 "	9.00	39,960	
TOTAL DEEP CUTOFF				$ 73,260
FOUNDATION GROUTING				
Drilling	18,000 l.ft	$1.50	$ 27,000	
Grouting	18,000 l.ft	1.50	27,000	
TOTAL FOUNDATION GROUTING				$ 54,000
FOUNDATION DRAINAGE				
Drilling	12,000 l.ft.	$1.50	$ 18,000	
TOTAL FOUNDATION DRAINAGE				$ 18,000
MAIN DAM - SIPHON SPILLWAY - SECONDARY DAM				
Excavation				
Class II	53,500 c.y.	$2.00	$107,000	
Class III	25,000 c.y.	2.50	62,500	
Total Excavation			$169,500	
Concrete in Main Dam. 1:2½:6:3 Mix	374,000 c.y.	$10.00	$374,000	
Concrete in Siphon (Piers & Hood) L:2½:6:3: Mix Reinforced	8,500 "	$30.00	257,400	
Concrete in Secondary Dam 1:2½:6:3: Mix	13,700 "	$10.00	137,000	
TOTAL MAIN DAM - SIPHON SPILLWAY - SECONDARY DAM				$4,303,900

ITEM	QUANTITY	UNIT	TOTAL	SUMMARY
POWER HOUSE PENSTOCK - 3-6' DIAM.				
Same as for Dam Top El. 2585				$ 90,563
REGULATING OUTLETS				
Same as for Dam Top El. 2585				$ 129,115
SLUICE OUTLETS				
Same as for Dam Top El. 2585				$ 88,840
PARAPETS	1550 l.ft.	10.00		$ 15,500
LAMP POSTS	20	50.00		$ 1,000
CONSTRUCTION ON CAMP				$ 100,000
FINISHING & CLEANING UP				$ 25,000
ESTIMATED FIELD COST				$ 4,999,178
Contingencies, 10%				499,918
Administration & Engineering				$ 749,877
RELOCATION & CONSTRUCTION ARIZONA EASTERN R.R.				
Same as for Dam Top El. 2585				$ 3,000,720
CONSTRUCTION R.R. SAN CARLOS TO DAM SITE				
Same as for Dam Top El. 2585				$ 296,780
ROAD SAN CARLOS TO DAM SITE				
Same as for Dam Top El. 2585				$ 15,690
RIGHT OF WAY				$ 370,600
GROSS TOTAL COST				$9,932,763
Less Salvage Arizona Eastern R.R.				140,000
NET GRAND TOTAL COST				$ 9,792,763

Cost per a.f. Gross 1,600,000 a.f. at $6.12
" " " Net 1,450,000 a.f. " $6.75

GRAVITY DAM WITH SIPHON SPILLWAY.

El. Top of Dam - 2536
El. Normal W.S. - 2526
El. Spillway Crest 2526

El. Top of Parapets - 2540
Storage Capacity 1,300,000 a.f.
(includes 150,000 a.f. silt.)
Spillway Capacity W.S. El. 2536 -
130,000 s.f.

Drawing 44-C-3

Preliminary Estimate

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
COFFER DAMS				$100,000
DEEP CUTOFF				
Excavation Class III	4,050 c.y.	$7.50	$30,375	
Concrete 1:3:6: Mix	4,050 c.y.	9.00	36,450	
TOTAL DEEP CUTOFF				66,825
FOUNDATION GROUTING				
Drilling	16,300 lft	$1.50	$ 24,450	
Grouting	16,300 l."	$1.50	24,450	
TOTAL FOUNDATION GROUTING				$48,900
FOUNDATION DRAINAGE				
Drilling	10,900 l.ft	$1.50	$ 16,350	
TOTAL FOUNDATION DRAINAGE				$ 16,350
MAIN DAM - SIPHON SPILLWAY - SECONDARY DAM				
Excavation - Class II	52,200 l.ft	$2.50	$104,400	
" - Class III	23,800 "	2.50	59,500	
Total Excavation			$ 163,900	$163,900
Concrete in Main Dam 1:2½:6:3 Mix	325,000 "	$10.00	3,250,000	
Concrete in Siphon Head (Piers & Hood) 1:2½:5 Mix, Reinforced 135-3/4 per c.y.	8,580 "	30.00	257,400	

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
Concrete in Secondary Dam 1:2½:6:3 Mix	13,700 c.y.	$10.00	$137,000	
Total Concrete			3,644,400	$3,644,400
TOTAL MAIN DAM - SIPHON SPILLWAY SECONDARY DAM				3,808,300
POWER HOUSE, PENSTOCKS Same as for Dam Top El. 2585				$ 90,563
REGULATING OUTLETS Same as for Dam Top El. 2585				$ 129,115
SLUICE OUTLETS Same as for Dam Top El. 2585				$ 88,840
PARAPETS	1400 l.ft.	$10.00		$ 14,000
LAMP POSTS	20	$50.00		$ 1,000
CONSTRUCTION CAMP				$ 90,000
FINISHING & CLEANING UP				$ 22,000
ESTIMATED FIELD COST				$4,475,893
Contingencies, 10%				$ 447,589
Administrative & Engineering				$ 671,384
RELOCATION & CONSTRUCTION ARIZONA EASTERN R.R. Same as for Dam top El. 2585				$3,000,720
CONSTRUCTION R.R. SAN CARLOS TO DAM SITE Same as for Dam Top El. 2585				$ 296,780
ROAD, SAN CARLOS TO DAM SITE Same as for Dam Top El. 2585				$ 18,690
RIGHT OF WAY Same as for Dam Top El. 2585				$ 370,600
GROSS TOTAL COST				$9,278,655

I T E M	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
Gross Total Cost, (Brought forward)				$9,278,656
Less Salvage, Arizona Eastern per Engineer S.S. Carroll				140,000
NET TOTAL COST				$9,138,656

Cost per A.F. Gross 1,300,000 A.F. at $7.03
Net 1,150,000 A.F. at $7.95

GRAVITY DAM WITH SIPHON SPILLWAY

El. Top of Dam - 2498
El. Normal W.S. - 2488
El. Spillway Crest 2488

El. Top of Parapets - 2502
Storage Capacity - 710,000 a.f.
(includes 150,000 a.f. silt)
Spillway Capacity W.S. El.
2498 - 130,000 s.f.

Drawing 44 - C - 3.

PRELIMINARY ESTIMATE.

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
COFFER DAMS				$ 100,000
DEEP CUTOFF				
Excavation				
Class III	3200 c.y.	$7.50	$ 24,000	
Concrete				
1:3:6 Mix	3200 c.y.	9.00	28,800	
TOTAL DEEP CUTOFF				$ 52,800
FOUNDATION GROUTING				
Drilling	13,800 l.ft	$1.50	$ 20,700	
Grouting	13,800 "	$1.50	$ 20,700	
TOTAL FOUNDATION GROUTING				$ 41,400
FOUNDATION DRAINAGE				
Drilling	9,200 l.ft	$1.50	$ 13,800	
TOTAL FOUNDATION DRAINAGE				$ 13,800
MAIN DAM- SIPHON SPILLWAY				
SECONDARY DAM				
Excavation				
Class II	52,200 c.y.	$2.00	$104,400	
Class III	26,000 c.y.	2.50	65,000	
Total Excavation			$169,400	$ 169,400

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
MAIN DAM etc., (Cont'd)				
Concrete in Main Dam 1:2½:6:3 Mix	221,000c.y.	$10.00	$2,210,000	
Concrete in Siphon Head (Biers & Head) 1:2½:5 Mix, Reinforced 135-3/4 per c.y.	8580 c.y.	$30.00	$ 257,400	
Concrete in Secondary Dam L:2½:6:3 Mix	15700 c.y.	$10.00	$ 137,000	
Total Concrete				$2,604,400
TOTAL MAIN DAM - SIPHON SPILLWAY - SECONDARY DAM				$2,773,800
POWER HOUSE PENSTOCKS - 6' Diam. Same as for Dam Top El. 2585				$ 90,563
REGULATING OUTLETS Same as for Dam Top El. 2585				$ 129,115
SLUICE OUTLETS Same as for Dam Top El. 2585				$ 88,840
PARAPETS	1100 l.f.	$10.00		$ 11,000
LAMP POSTS	20	$50.00		$ 1,000
CONSTRUCTION CAMP				$ 70,000
FINISHING & CLEANING UP				$ 17,000
Estimated Cost				$3,389,318
Contingencies, 10%				338,932
Administrative & Engineering, 15%				508,398

ITEM		UNIT COST	TOTAL COST	SUMMARY
RELOCATION AND CONSTRUCTION ARIZONA EASTERN R.R. Same as for Dam Top El. 2585				$3,000,720
CONSTRUCTION R. R. SAN CARLOS TO DAM SITE Same as for Dam Top El. 2585				$ 296,780
ROAD SAN CARLOS TO DAM SITE Same as for Dam Top El. 2585				$ 15,690
RIGHT OF WAY Same as for Dam Top El. 2585				$ 370,600
GROSS TOTAL COST				$7,920,438
Less Salvage Arizona Eastern per Engr. S. S. Carroll				$ 140,000
NET TOTAL COST				$7,780,438

Cost per a.f. Gross 710,000 a.f. $10.96
Net 560,000 a.f. $13.89

GRAVITY DAM WITH SIPHON SPILLWAY

El. Top of Dam = 2468
El. Normal W.S. = 2458
El. Spillway crest = 2458

El. Top of Parapet = 2572
Storage Capacity = 389,000 a.f.
(includes 150,000 a.f. silt)
Spillway Capacity W.S. El. 2468 = 130,000 s.f

Drawing 44- C - 3

PRELIMINARY ESTIMATE

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
COFFER DAMS				$ 100,000
DEEP CUTOFF				
Excavation				
Class III	2,530 c.y.	$7.50	$18,975	
Concrete				
1:3:6 Mix	2,530 c.y.	9.00	22,770	
TOTAL DEEP CUTOFF				$ 41,745
FOUNDATION GROUTING				
Drilling	10,300 l.ft	$ 1.50	$15,450	
Grouting	10,300 "	1.50	$15,450	
TOTAL FOUNDATION GROUTING				$ 30,900
FOUNDATION DRAINAGE				
Drilling	6,900 l.ft	$1.50	$10,350	
TOTAL FOUNDATION DRAINAGE				$ 10,350
MAIN DAM - SIPHON SPILLWAY- SECONDARY DAM				
Excavation				
Class II	52,200 c.y.	$2.00	$104,400	
Class III	28,400 "	$2.50	71,000	
Total Excavation				$ 175,400
Concrete in Main Dam L:2½:6:3 Mix	153,600 c.y.	$10.00	1,536,000	
Concrete in Siphon Head(Piers & Hood) 1:2½:5½ Mix - Reinforced 135-3/4 per c.y.	8580 c.y.	$30.00	257,400	
Concrete in Secondary Dam 1:2½:6:3 Mix	13,700 "	$10.00	137,000	
Total Concrete			1,930,400	$1,930,400
TOTAL MAIN DAM - SIPHON SPILLWAY SECONDARY DAM				2,105,800

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
POWER HOUSE PENSTOCKS (3 - 6' Diam.) Same as for Dam Top El. 2585				$ 90,563
Regulating Outlets. Same as for Dam Top El. 2585				$ 129,115
SLUICE OUTLETS Same as for Dam Top El. 2585				$ 88,840
PARAPETS	1050 l.ft.	$10.00		$ 10,500
LAMP POSTS	20	$50.00		$ 1,000
CONSTRUCTION CAMP				$ 52,000
FINISHING & CLEANING UP				$ 13,000
Estimated Field Cost				$2,673,813
Contingencies - 10%				267,381
Engineering & Administration 15%				401,072
RELOCATION AND CONSTRUCTION ARIZONA EASTERN R.R. Same as for Dam Top El. 2585				3,000,720
CONSTRUCTION R.R. SAN CARLOS TO DAM SITE Same as for Dam Top El. 2585				296,780
ROAD SAN CARLOS TO DAM SITE				15,690
RIGHT OF WAY Same as for Dam Top El. 2585				$ 370,600
GROSS TOTAL COST				$7,026,056
Less Salvage -Arizona Eastern R.R.				140,000
NET TOTAL COST				$6,896,056

Cost per a.f. - Gross 389,000 a.f. at $17.70
Cost per a.f. - Net 239,000 a.f. at $28.80

POWER PLANT

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
PRELIMINARY WORK				$ 4,000
COFFERDAM AND PUMPING.				
SUBSTRUCTURE (Below El. 2355)				
Excavation Class III	400 c.y.	$10.00	$ 4,400	
" " III	2360 "	2.50	$ 6,400	
Backfill	1000 "	0.50	$ 500	
Concrete Draft Tubes	200 "	$45.00	$ 9,000	
Walls & Floors	826 "	$38.00	$31,400	
Conduit and Buried Pipe			1,000	
TOTAL SUBSTRUCTURE				$ 52,700
SUPERSTRUCTURE				
Concrete	251 c.y.	$45.00	$11,300	
Structural Steel	10 Tons	$200.00	2,000	
Lumber	2 M	$ 75.00	150	
Windows & Doors			3,200	
Plumbing and Hardware			600	
Conduit & Fixtures			700	
Telephone Booth			150	
Painting & Cleaning			800	
Miscell. Labor & Material			6,100	
TOTAL SUPERSTRUCTURES				$ 25,000
SWITCHYARD				
Excavation Class III	200 c.y.	$ 2.50	500	
Backfill	200 c.y.	0.50	100	
Concrete	34 c.y.	$30.00	1,000	
Structural Steel	6 Tons	200.00	1,200	
Conduit & Piping			800	
Cable & Fittings			1,200	
TOTAL SWITCHYARD				$ 4,800

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
MACHINERY				
Hydraulic			$133,500	
Electrical			142,900	
Auxiliary			7,200	
Switchboard & Fittings			6,200	
Miscellaneous Piping *			5,000	
Freight & Handling			18,000	
Labor Installing			32,900	
TOTAL MACHINERY				$345,700
PENSTOCKS				
Steel Penstocks in Place	50,000 lbs.	$ 0.12	$ 6,000	
Concrete Grouting	167 c.y.	45.00	7,500	
TOTAL PENSTOCKS				$ 13,500
OPERATOR'S QUARTERS				8,000
IMPROVEMENT TO GROUNDS				2,000
TOTAL ESTIMATED FIELD COST				$457,700
Contingencies 10%				45,700
Administration & Engineering 15%				68,600
GRAND TOTAL ESTIMATED COST POWER PLANT				$572,000

TRANSMISSION LINES.

44,000 Volt - SAN CARLOS TO FLORENCE-CASA GRANDE				
Unit, 80 miles single circuit,				
STEEL POLES-suspension insulators				
No. 00 Copper				
COST PER MILE				
Preparatory Work		$ 110		
Poles - 1500 lbs. each	16¢ per mi	$ 2,160		
Wire, cabled insulators		1,800		
Hauling		120		
Miscellaneous Material		110		
Erection		600		
TOTAL FIELD COST PER MILE			$4,900	
TOTAL COST - 80 MILES OF LINE		$ 4,900		$392,000

ITEM	UNIT COST	TOTAL COST	SUMMARY
44,000 Volt - FLORENCE TO SACATON SUB.			
28 miles - single circuit, wood pole, pin type insulators, #1 copper			
COST PER MILE	$ 40		
Preparatory Work			
Poles, Crossarms, etc.,	300		
Wire, Cables, & Insulaters	1,075		
Hauling	75		
Miscellaneous Material	100		
Erection	260		
TOTAL FIELD COST PER MILE		$1,850	
TOTAL COST - 28 Miles of Line	$1,850		$51,800
44,000 Volt - Sacaton Sub. to LOWER RESERVATION SUB.			
15 Miles - single circuit, wood pole, pin type insulators - No. 6 Copper.			
COST PER MILE: Preparatory Work.	$ 35		
Poles, Crossarms, etc.,	300		
Wire, Cables & Insulators	570		
Hauling	75		
Miscellaneous Material	100		
Erection	250		
TOTAL FIELD COST PER MILE		$ 1,330	
TOTAL COST - 15 MILES OF LINE			$19,950
TOTAL ESTIMATED FIELD COST			$463,750
Contingencies 10%			46,375
Administration & Engineering 15%			69,575
GRAND TOTAL - ESTIMATED COST - TRANSMISSION LINES:			$579,700

SUBSTATIONS

ITEM	UNIT COST	TOTAL COST	SUMMARY
FLORENCE- CASA GRANDE UNIT.			
4 Substations - 1500 kv-a each, each 44,000 to 4,000 volts			
COST PER SUBSTATION			
3 - 500 kv-a Transformers -sing.ph-O.I.S.C.	20,000		
1 - 44,000 Volt Oil Circuit Breaker	2,050		
3 - " " Disconnecting Switches	230		
1 - " Lightning Arrester	2,500		
3 - " Volt Choke Coils	250		
4 - 4,000 " Oil Circuit Breakers	1,000		
12 - " " Choke Coils	420		
24 - " " Disconnecting Switches	900		
4 - " " Lightning Arresters	2,000		
4 - " " Meter Equipments	400		
1 - Meter House	150		
Steel Towers	1,000		
Miscellaneous Material	1,500		
Freight and Hauling	1,000		
Labor Installing	1,000		
TOTAL FIELD COST - ONE SUBSTATION		$33,800	
TOTAL COST - FOUR SUBSTATIONS	33,800		$135,200
RESERVATION UNIT			
2 Substations - 1200 kv-a, 44,000 to 11,000 volts.			
COST PER SUBSTATION.			
3 - 400 kv-a Transformers-sing.ph-O.I.S.C.	18,000		
1 - 44,000 Volt Oil Circuit Breaker	2,050		
3 - 44,000 Volt Disconnecting Switches	225		
1 - " " Lightning Arrester	2,500		
3 - " " Choke Coils	250		
2 - 11,000 " Oil Circuit Breakers	3,200		
6 - " " Choke Coils	225		
12 - " " Disconnecting Switches	500		
2 - " " Lightning Arresters	1,700		
2 - " " Meter Equipments	1,400		
1 - Meter House	150		
1 - Steel Tower	400		
Miscellaneous Material	1,500		
Freight & Hauling	1,000		
Labor Installing	1,000		
TOTAL FIELD COST - ONE SUBSTATION		$34,100	
TOTAL COST - TWO SUBSTATIONS			$ 68,200
TOTAL ESTIMATED FIELD COST			$203,400
Contingencies, 10%			20,300
Administration & Engineering, 15%			30,100
GRAND TOTAL - ESTIMATED COST OF SUBSTATIONS			$253,800

DISTRIBUTION LINES

ITEM	UNIT COST	TOTAL COST	SUMMARY
4,000 Volt - FLORENCE - CASA GRANDE UNIT			
60 miles - single cisuit, wood pole - No. 4 copper.			
COST PER MILE			
Preparatory Work	$ 35		
Poles, Crossarms, etc.,	200		
Wire, Cable, Insulators	500		
Hauling	70		
Miscellaneous Material	100		
Erection	250	$ 1,155	
TOTAL FIELD COST PER MILE	$1,155		
TOTAL COST - 60 MILES OF LINE			$ 69,300
11,000 Volt - RESERVATION UNIT			
40 Miles - single circuit, wood pole,- No. 6 copper			
COST PER MILE			
Preparatory	$ 35		
Poles, Crossarms, etc.,	200		
Wire, Cable, Insulators	475		
Hauling	70		
Miscellaneous Material	100		
Erection	250		
TOTAL FIELD COST PER MILE		$1,130	
TOTAL COST - 40 MILES OF LINE	$1,130		$ 45,200
TOTAL ESTIMATED FIELD COST			$114,500
Contingencies, 10%			11,400
Administration & Engineering 15%			17,100
GRAND TOTAL - ESTIMATED COST OF DISTRIBUTION LINES			$143,000

PUMPING PLANTS.

ITEM	UNIT COST	TOTAL COST	SUMMARY
FLORENCE - CASA GRANDE UNIT			
225 Plants, capacity 2-3 sec. ft. each, lift	40 ft.		
COST OF ONE PLANT			
Drilling 1 - 16" Well - 100 ft. deep	$ 350		
100 ft. of 16" Well Casing	$ 450		
1 - 25 hp. Vertical Motor, 220 v.	$ 500		
1 - 2-3 sec. ft. Deep Well Turbine Pump	$2,000		
1 - 30 kv-a Transformer, 3 ph., 2200 to 220 Volts	$ 450		
3 - 2200 volt Lightning Arresters	$ 50		
1 - " " Oil Circuit breaker	$ 75		
3 - " " Choke Coils	$ 50		
1 - Watthour Meter	$ 85		
Discharge Pipe	$ 50		
Building	$ 700		
Miscellaneous Material	$ 250		
Freight & Hauling	$ 300		
Labor Installing	$ 250		
TOTAL FIELD COST - ONE PUMPING PLANT		$ 5,560	
TOTAL COST - 225 PUMPING PLANTS	$5,560		$1,251,000
RESERVATION UNIT			
72 Plants, capacity 3-5 sec.ft., lift 20-30 ft.			
COST PER PLANT			
Drilling 1 - 16" Well, 100 feet deep	$ 350		
100 ft. of 16" Well Casing	$ 450		
1 - 40 hp. Vertical Motor, 220 v.	$ 700		
1 - 10" Vert. Centrifugal Pump	$1,500		
1 - 50 kv-a Transformer, 3 ph. 11000 to 220 volt	$ 840		
Lightning Arrester	150		
1 - 11000 volt Oil Circuit Breaker	150		
3 - " " Choke Coils	$ 100		
1 - Watthour Meter	$ 85		
Discharge Pipe	$ 75		
Building	$ 700		
Caisson - Labor	$2,650		
Materials	$1,350		
Miscellaneous Material	$ 300		
Freight and Hauling	350		
Labor Installing	250		
TOTAL FIELD COST - ONE PUMPING PLANT		$ 10,000	
TOTAL COST - 72 PUMPING PLANTS	$10,000		$ 720,000

ITEM	UNIT COST	TOTAL COST	SUMMARY
TOTAL ESTIMATED FIELD COST			$1,971,000
Contingencies, 10%			197,000
Administration & Engineering 15%			295,700
GRAND TOTAL - ESTIMATED COST OF PUMPING PLANTS			$2,463,800

SUMMARY OF ESTIMATED COST - POWER AND PUMPING SYSTEM

POWER PLANT	$ 572,000
TRANSMISSION LINES	579,700
SUBSTATIONS	253,800
DISTRIBUTING LINES	143,000
PUMPING PLANTS	$2,463,800
GRAND TOTAL - ESTIMATED COST - POWER & PUMPING SYSTEM	$ 4,012,300

POWER & PUMPING SYSTEM

(Memorandum by C. C. Fisher, Engr.)

The foregoing report on "Power and Pumping System" does not bring out the point as to whether or not excess power may be developed at the San Carlos dam over and above that required for pumping on project lands. The following figures are therefore presented upon this point, which result in a showing that there is an excess gross horse power at the reservoir of about 3,000 H.P. during the period of maximum irrigation requirement. This computation is based on the assumption of a minimum head in the reservoir at the time of maximum use, which is a condition that could exist only in the occasional short years. This excess horse power will reduce during the months of lesser irrigation demand in proportion to such reduction in irrigation to a minimum of about 1,000 h.p., gross.

The computations as above outlined are as follows:

POWER REQUIRED FOR PUMPING &
POWER AVAILABLE AT SAN CARLOS RESERVOIR.

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FLORENCE - CASA GRANDE UNIT

Pumping area	36,000 acres
Mean lift	40 ft.
Max. delivery, 12% of 3 a.f. per acre in 30 days	216 s.f.
Max. power required at pumps	980 h.p.
*Overall efficiency	40%
*Max. power required at reservoir	2,450 H.P.

RESERVATION UNIT

Above Gila Crossing.

Pumping area (new lands)	11,000 acres
Mean Lift	30 ft.
Max. delivery	56 s.f.
Max. power required at Pumps	225 H.P.

Below Gila Crossing.

Pumping area (new lands)	12,000 acres
Mean lift	20 ft.
Max. delivery	72 s.f.
Max. power required at pumps	165 H.P.
Total Reservation unit at pumps	390 H.P.
Max. power required at reservoir	980 H.P.
Grand total required at reservoir	3,430 H.P.

POWER AVAILABLE AT RESERVOIR.

Max. required outflow for irrigation	540 s.f.
Minimum head	90 ft.
Gross H.P. available	6,500 H.P.
Excess gross H.P. available	3,070 H.P.

*Detail of Power Efficiency:

Turbines	75%
Generators	92%
Transmission	95%
Transformers	97%
Motors	90%
Pumps and discharge Pipe	70%
Net efficiency	40%

APPENDIX "B"

R E P O R T A N D E S T I M A T E

ON

RAILROAD AROUND SAN CARLOS RESERVOIR

also

Railroad and Wagon Road to San Carlos Damsite

and

Gravel Pits for Concrete

by

S. S. Carroll, Engineer, U. S. R. S.

1 9 2 0.

****

Denver, Colorado, Dec. 6, 1920.

From Engineer S. S. Carroll

To Project Manager, Yuma, Arizona.

Subject: Report upon Surveys and Estimates, Railroads, Roads and Gravel Pits - San Carlos Reservoir - San Carlos Project.

Ground Covered by Report

Following is a report on surveys and estimates on the San Carlos Project, begun May 20 last. The report includes a relocation of the Arizona Eastern Railroad around San Carlos Reservoir between Mile Posts 73/4557 feet and 102/4372 feet, the location of a highway to the San Carlos Dam Site from a point on the State Road about three miles east of Rice Station, an approximate estimate for a temporary construction railroad from the Arizona Eastern at San Carlos to the San Carlos Dam Site, and an examination of the sand and gravel supply for the San Carlos Dam.

Conclusions

The results of the studies show that the construction railroad and the highway can be built at moderate cost; that there is a sufficient supply of sand and gravel of fair quality near the dam site, and that the construction of the Arizona Eastern Railroad on the new location is practicable, though it will enter as a considerable item in the total cost of the project.

RELOCATION OF ARIZONA EASTERN RAILROAD

Degree of Accuracy

It is understood that the railroad company will demand a considerable sum above the cost of the new line as capitalization, the proceeds to be used to pay the increaseln cost of operation. For this reason it was assumed at the start that the survey should be made with somewhat greater accuracy and detail than the ordinary preliminary survey requires, so that the results could be compared with confidence with figures based on an independent survey which the railroad company will doubtless make. The various items of cost included in the estimate have been analyzed with equal detail. The slight additional cost of this extra

work seems to be justified by the fact that the amount of money involved, including the proposed capitalization, is more than three million dollars.

Location

The new location starts with station 3900+57 of the Arizona Eastern Railroad, about three-quarters of a mile west of Bylas Station, and ends at Station 5458+64, at Rice (Station 1534+90, new line). The conditions to be satisfied restrict the location to an unusual degree for railroad work. The choice of routes lies between the possible reservoir high water contour of 2575 on one side and the foothills of the Gila Mountains on the other. Two feasible river crossings are to be found, and the line must be kept as short and the grades as low as possible. The general route is at right angles with all drainage lines.

River Crossings.

There is no natural bridge site on the Gila within several miles of the point where the high water contour crosses and the departure from the old line was taken as near this point as would permit a suitable grade and alignment across the river. The bridge site is feasible, though some protective work will be required at each end of the bridge.

The San Carlos can be crossed at any point between the high water contour and Rice Station, but the best site is at Rice and the topography here allows a better alignment for the approaches than would be possible at any point below. A crossing near Rice is also determined by the limiting grade of one percent and certain controlling points several miles back on the line.

Grade and Alignment.

The new line has a grade approximating one percent for about half the distance and at its farthest point is about 5 miles back from the high water contour of the reservoir. The choice of this location as against one more nearly following the edge of the reservoir should be explained. It is the most direct line between the terminal points, and the topography on this location is more favorable than in the region bordering the reservoir, or on any possible line between.

Starting with the Gila River, there is a narrow strip of bottom land ranging in elevation from five to ten feet above the river. From this bench the ground rises with a slope of twenty or thirty percent to a general elevation 80 to 150 feet higher. The line of this second bench is very crooked and is broken at frequent intervals by the mouths of canyons and steep coulees. A location climbing this bench is obviously impracticable. It is, therefore, necessary to get on top of the bench at some favorable point as soon as possible after leaving the river.

The area between the top of the bench and the foothills, a strip 8 or 10 miles wide, is one side of an old lake bed in which the prevailing material is caliche, with caprock of lava on the higher points. This entire area, which has a slope of about three percent toward the river, is badly eroded and is crossed by a large number of deep canyons. The divides between canyons are characterized by steep buttes and hog-backs of caliche or other hard material.

The canyons aregenerally too narrow and crooked to permit running up-stream for a low crossing, while the slope of the intervening ridges is two or three times the one percent taken as maximum grade. In nearly all cases the canyon walls are nearly perpendicular for twenty to fifty feet from the bottom, but above this the slope gradually flattens out, so that the usual method of approaching a crossing with a cut, or cut and tunnel, can not be employed. The larger canyons are generally parallelled at a short distance by high hogbacks which extend to within a mile or two from the river. As would be expected this topography furnishes a series of controlling points which determine the location within narrow limits.

Methods Used in Survey.

The location was made according to the usual methods for rough country. A reconnaissance was made between the Gila and San Carlos bridge sites and this was followed by a stadia trial line on which the preliminary was based. The preliminary was run with transit and chain and staked out in 100-foot stations. The survey was made from the east end to Sta. 703+50 and from the west end to Sta. 829+55.5 (= 703+50). Levels were run from U. S. G. S. bench marks at Bylas and Rice, with an error at the above point of 0.50 feet. Topography was taken with a hand level

and chain to a distance of 100 feet on each side of the line and sketched for about a hundred feet farther. For distances greater than 200 feet from the line, at tunnel and bridge sites and at controlling points, topography was taken with transit and stadia. Hubs were set at all transit points. Elevations for all stakes and hubs were recorded in the field books. The topography was plotted on sheets to a scale of 200 feet to the inch and a paper location showing the proposed final location, with curve elements, is shown in pencil on blue print s of these sheets, which are on file in the Denver Office. It will be possible to find the stakes and hubs for several years and a final location in the field, when required, can be made in a short time. The party consisted of four men and a pack outfit.

Records of Survey.

Records of the Survey consist of the following:

5 Field Note Books
1 Profile of preliminary location
1 Profile of paper location
25 Sheets showing topography and paper location on preliminary line.
1 General Map
1 Small scale profile of paper location
1 Report and Estimate.

Comparison of Lines.

Figures for the Arizona Eastern in the following table are taken from the profile and right-of-way maps furnished by the Company, which are dated 1915.

I T E M	Present Line	New Location.
Length	28.98 miles	29.07 miles
Maximum Grade	0.864%	1.00%
Total up-grade toward Rice	238.5 ft.	556 feet
Total down-grade toward Rice	219.5 feet	537 feet
Maximum curvature	7 degrees	8 degrees
Total curvature, degrees	1035 "	2809 "
Average degree of curve	2° 58'	4° 07'
Number of culverts	64	73
Number of bridges and trestles	52	45
Total length of " " "	4805 feet	9494 feet

The following unit cost of material f.o.b. shipping point and freight rates to San Carlos and Florence, Arizona, were furnished by the Denver Office. The unit costs used in the estimate were obtained by adding to the unit cost of material at shipping point the freight to San Carlos and the estimated cost of handling and hauling from San Carlos to the point of use at forty cents per ton mile. It is assumed that the operation of a construction train would result in a hauling cost approximately equal to that for motor trucks.

MATERIAL	Shipping Point	Unit Cost	Shipping Rate per Cwt. To San Carlos C. L.	To San Carlos L.C.L.	To Florence C.L.	To Florence L.C.L.
RAILROAD						
75# Rails	Colo.Com. Pts.	$65.00 Ton	$1.095	$1.25	$0.875	$1.0375
Ties, Green Sawed	Portland, Ore.	$25.00 M.B.M.	0.559		0.466	
Ties, Creosoted	" "	$65.00 M.B.M.	0.559		0.466	
Switch Ties	" "	$27.00 "	0.559		0.466	
Track Spikes	Colo. Com. Pts.	$ 4.55 cwt.		$1.25		$1.0375
Track Bolts	" " "	$ 5.80 "		1.25		1.0375
Angle Bars	" " "	3.50 "		1.25		1.0375
Frogs, Rigid	" " "	65.00 ea.		1.25		1.0375
Frogs, Spring Rail	" " "	125.00 ea.		1.25		1.0375
Switches with stands	" " "	130.00 "		1.25		1.0375
Fence Posts, Split	Northwest	0.145 "	0.559		0.466	
Barbed Wire (Gal)	Colo. Com. Pts.	4.285 Reel		1.25		1.0375
Telegraph Poles	Northwest "	0.30 ft.(Av.)	0.559		0.466	
Telegraph Wire (Gal)	Colo. Com. Pts.	6.905 cwt.		1.25		1.0375
Four Wire Cross Arms	" " "	0.51 each		1.25		1.0375
Pony Insulators #9	" " "	5.00 per Hun.		1.25		1.0375
Insulator Pegs #9	" " "	2.50 " "		1.25		1.0375
Lumber						
1" x 12" x 16'						
2" x 12" x 24' & under	Portland, Ore.	33.00 M.B.M.	0.559		0.466	
3" x 12" x 24'	" "	26.00 "	0.559		0.466	
4" x 14" x 32'	" "	26.00 "	0.599		0.466	

MATERIAL	Shipping Point	Unit Cost	Shipping Rate per Cwt. To San Carlos C.L.	To San Carlos L.C.L.	To Florence C.L.	To Florence L.C.L.
6" x 14" x 32'	Portland, Ore.	$30.00 M.B.M.	$ 0.599		$ 0.466	
8" x 16" x 32'	" "	30.00 "	0.599		0.466	
12" x 16" x 32'	" "	30.00 "	0.599		0.466	
BOLTS, ETC.						
Drift Bolts, 3/4" x 26" and under	Colo. Com. Pts.	$ 9.50 cwt.		$ 1.25		$ 1.0375
Machine Bolts *	" " "	20% off list		1.25		1.0375
Carriage Bolts *	" " "	20% off list		1.25		1.0375
"D" Bolts *	" " "	20% off list		1.25		1.0375
Bridge Spikes	" " "	6.50 cwt.		1.25		1.0375
Wire Nails **	" " "	4.25 base cwt		1.25		1.0375
CONCRETE						
Cement in Sacks	El Paso, Tex.	$ 3.60 bbl.	$ 0.3375		$ 0.495	
Credit - Sacks Returned		0.25 each				
Reinforcing Steel						
3/4" to 1-1/2"	Colo. Com. Pts.	4.15 base cwt.	1.095		0.875	
PILING						
Round Stick 20'	Northwest	$ 5.60 each	0.559		0.466	
" " 40'	"	11.60 "	0.559		0.466	
" " 60'	"	24.00 "	0.559		0.466	
Creosoting only		40.00 MBM				
Steel Sheet	Chicago, Ill.	3.58 cwt.	1.46		1.2275	
GATES, ETC.						
C. I. Sliding Gates	Denver, Colo.	0.15 lb.		1.7600		1.4225
Gate Hoists	" "	0.33 lb.		1.7600		1.4225

* See Baker, Hamilton & Pacific Co. Catalog. Pages 606-7-8.
3/4" x 19" machine belts $21.56 per 100 bolts at shipping point.
3/4" x 17" " " $19.80 " " " " " "

** See Baker, Hamilton & Pacific Co. Catalog. Page 578.

The cost of grading per cubic yard is estimated at 40 cents for earth, 75 cents for loose rock, 75 cents and $1.00 for caliche, and $1.50 for solid rock. The estimated cost for overhaul is 2 cents per cubic yard per station for distances over 500 feet. The profile shows that there are several rather deep cuts which would probably be made with steam shovel equipment for which overhaul costs are lower than for lighter equipment.

The cost of finished concrete lined tunnel is estimated at $98.00 per linear foot. This cost is based on excavation at $6.45 per cubic yard including some timbering and reinforced concrete at $23.85 per cubic yard. A uniform amount ($1700.00) each has been added in cases for earth tunnel portals. The economic point of change from open cut to tunnel with the assumed unit costs is at depth of cut of 45 feet.

The cost of reinforced concrete pipe for culverts is estimated at $2.50 per linear foot for 36" diameter pipe and $4.00 per linear foot for 48" diameter pipe. The cost of work at the ends of the culverts is estimated at $180.00 and $200.00, respectively.

Plain concrete arch culverts Of 6 foot span are estimated at $33.00 per linear foot with $566.00 added to each culvert to cover work required at the ends of the barrel.

In all cases an item, depending upon the height of trestle, has been added to the cost of trestles to cover the cost of abutments.

Fencing is estimated at $640 per mile while cattle guards and crossings are estimated at $110 each.

Telegraph line is estimated at $520 per mile.

Basis of Preliminary Estimate.

The estimate is given by miles to facilitate studies for the final location and in order that proper deductions may be made, if it is decided to shorten the line by decreasing the reservoir capacity. A method for doing this is suggested on Page 48.

The estimate is made from an analysis of the following items:

Grading
Track materials and track laying.
Structures
Fencing
Telegraph Line
Station equipment
Clearing right-of-way
Purchase of right-of-way
Salvage.

Grading.

According to the standards in common use, which are based on traffic requirements and speed of trains, the Arizona Eastern is a Class "C" road, for which the subgrade width of road-bed is 14 feet. The sections used in computing earthwork are for fill - top width 14 feet, side slope $1\frac{1}{2}$:1: for cut - base width 20 feet, side slopes 1:1.

The classification of material was made entirely from surface indications and from observation of ledges exposedoon the sides and bottoms of water courses. The principal materials to be excavated are caliche and earth. There is very little loose or solid rock. The caliche varies considerably in hardness. In this locality, the caliche is a very fine sedimentary deposit cemented with lime, which appears in many places over the upper part of the lake basin. It is not believed that all of it could be handled by teams after blasting, although a large part of it doubtless could be thus removed. On the other hand it is probable that some of this material can be excavated by steam shovels without blasting. A large part of the work consists of caliche covered by a thin layer of earth. In some cases the grade line is kept somewhat above the position that would balance cut and fill yardage for the reason that it will probably be cheaper to borrow surface materials of earth than to excavate and haul the harder material. An approximate estimate of overhaul has been included in the grading costs.

Track.

The estimate for track materials is based upon the use of the following, which are standard, on the portion of the line to be abandoned:

75 lb. rail
6" x 8" x 8' -0" ties
23" angle plates
3/4" x $4\frac{1}{2}$" track bolts

9/16" x 5½" track spikes
Spring-rail frogs and standard switches.

Track laying cost is estimated for dirt ballast, only.

Structures.

The most important structures are the Gila and San Carlos bridges, which are to be moved from San Carlos Station to the new locations. These are deck plate-girder bridges with concrete abutments. The Gila bridge has concrete piers and the piers of the San Carlos bridge are concrete filled steel tubes. Both bridges appear to be of first class construction.

The dimensions of the San Carlos bridge are as follows: Number of spans - 6, length of spans 60 feet; depth of girders 6' 6", thickness of webb plate 3/8"; diameter of piers 5' 8", thickness of plate 1/4"; abutments 16' 0" x 23' 0" on top, batter 1:12.

Following are the dimensions of the Gila Bridge: Number of spans 10, length of spans 70 feet; depth of girders 8' 4", thickness of webb plate 7/16"; east abutment 16' 0" x 63' 3" on top, west abutment 16' 0" x 33' 6", batter 1:12; concrete piers, area top section 72.5 sq. ft., batter 1:12. Profiles of both crossings are given on the 1915 revised profile of the Arizona Eastern, on file in the Denver Office.

The estimate for moving the above bridges includes the cost of temporary trestles at the present location and protective work for fills at both ends at the new locations. It is assumed that bed-rock will not be found and that abutments and piers will be on creosoted pile foundations.

The estimate for the three tunnels, totaling 1240 feet, shown on the profile, is for a section 16 by 20 feet, concrete lined. The material to be excavated is believed to be caliche and some timbering will probably be necessary.

Thirty-six inch and forty-eight inch reinforced concrete pipe and plain concrete arches of 6 ft. span are used for small drainage openings, the quantities being taken from standard plans for railroad construction.

Framed wooden trestles are used for larger openings. Bottoms of canyons and arroyos are Caliche or other hard material which would prevent the driving of

piles. There are several unusually high trestles, but no practicable location can be found, that would avoid these. The limit of height for the economic construction of wooden trestles is given by some authorities as about 100 feet. All trestles are considerably under this height except that at Salt Creek, which has a maximum height of 116 feet.

The estimate for trestles with framed bents is based on timbers of the following dimensions: Three lines of 8" x 16" stringers under each rail, 12" x 14" caps, five 12" x 12" posts for each bent, 12" x 14" sills on concrete piers, 4" x 10" and 8" x 12" longitudinal and transverse struts, 4" x 10" diagonal bracing, 6" x 8" guard rails, 6" x 8" ties 12" c-c.

Fencing.

Fencing, with cattle guards and crossings every mile, will be required. This item includes two lines of barbed wire fence with four wires each and posts spaced one rod apart, pit cattle guards and plank crossings.

Telegraph Line

A four-wire telegraph line will be required to replace the present line. This item includes thirty 25-foot poles to the mile, four lines of No. 9 wire, guy wires and anchors, standard cross-arms and insulators.

Station Equipment.

Stations will be submerged at San Carlos and Calva and side tracks at Naches and Peridot. The station at Calva consists of a 23' x 29' section house, 26' x 57' bunk house, 12' x 14' tool house, stock pens, one spur and one siding, totaling 4080 feet of track.

The equipment at San Carlos consists of a depot about 35' x 70', a 24' x 56' bunk house, a 24' x 29' section house, pumping plant and water tank, coal bin, ore bin, oil house and tool house, two spurs and two sidings, totaling 4160 feet of track. The passing track at Naches is 3146 feet long and the spur at Peridot about 500 feet long.

Under the item of station equipment are included the costs of replacing San Carlos Station at Rice, and Calva somewhere near the Chiriquahua Ranch Road, in Mile 6, as this is the location most convenient to the large cow outfits north of the river which now use Calva as a loading point. Another station will be required about half way between Calva and Rice, with section house equipment and passing tracks of capacity equal to those now at San Carlos. The estimate assumes that buildings at Calva and San Carlos would be wrecked and replacements would be built of new material. The pumping plant and water tank would be used at Rice.

In making the estimate it is assumed that in the weight, dimensions, and quality of track and other construction materials, as well as in workmanship on construction, the new track will be equal to the old.

Summary of Preliminary Estimated Cost per Mile.

The total for the following four items, which are the same per mile for the entire line, is included in the total by miles shown in the fourth column of the following table. The length of the line is 29.07 miles.

(a)	Track Materials, in place, per mile	$16,600
(b)	Right-of-way, fencing, cattle guards, and crossings	750
(c)	Telegraph Line	520
(d)	Clearing right-of-way	250
	Total per mile	$18,120

Three sums for station equipment, $22,200 in Mile 6, $16,400 in Mile 18, and $12,800 in Mile 30, are also included in the totals.

ESTIMATED COST PER MILE.

Mile	Grading	Structures	Total estimated cost, per mile.
1	$ 45,400	$127,100	$190,620
2	5,870	530	24,520
3	30,900	10,000	59,020
4	22,600	3,880	44,600
5	80,400	79,100	177,620

Estimated Cost Per Mile (Continued)

Mile	Grading	Structures	Total estimated cost, per mile.
6	$ 81,800	$ 71,600	$ 193,720
7	51,600	2,590	72,310
8	61,300	53,300	132,720
9	66,800	104,500	189,420
10	46,800	10,600	75,520
11	22,900	2,600	43,620
12	41,300	5,940	65,360
13	33,900	85,200	137,220
14	28,900	69,100	116,120
15	49,500	2,770	70,390
16	55,100	10,500	83,720
17	34,400	180,700	233,220
18	36,600	4,760	75,880
19	80,900	12,300	111,320
20	51,600	5,190	74,910
21	24,900	21,900	64,920
22	69,600	2,210	89,930
23	49,600	14,500	82,220
24	8,490	1,900	28,510
25	4,750	2,340	25,210
26	11,100	1,140	30,360
27	24,600	38,900	81,620
28	24,200	8,200	50,520
29	21,000	47,400	86,520
30*	500		14,570
Totals	$1,167,310	$980,750	$2,726,210

* 370 feet of new track.

Note: - Cost of tunnels in miles 5,8, and 13 is included under structures.

Estimated cost	$2,726,210
Engineering and contingencies, 10%	272,620
Right-of-Way	1,890
Total estimated cost	$3,000,720.

Salvage.

Any value borne by materials salvaged from the track of the Arizona Eastern should be deducted from the estimated cost. As all the rail, probably 50% of the ties, and a considerable portion of other materials could be used in temporary construction track at the San Carlos Dam and other points, the government could afford a somewhat higher estimate on salvage than their market value as junk. It is believed that the following credits for this second hand material would be fairly conservative.

Rail and angle plates, frogs & Switches	$95,000
Ties	$25,000
Bridge Timbers	$15,000
Telegraph line and fencing	5,000
Total estimated salvage	$140,000

Correction for other Heights of San Carlos Dam

If it is decided to decrease the height of the dam and shorten the railroad by a corresponding amount, an approximate estimate could be reached by comparison with the estimate for the line as located. Although no survey was made for such a line a thorough examination of the area between the survey and the river leads to the conclusion that any other line would cost more, except for about two miles from the river at each end. It is suggested that an estimate which would be sufficient for the purpose of studying comparative costs for various high water elevations could be arrived at by applying the per mile cost found in the above estimate for a distance of about two miles from each end, and an increase of, say, 10% for any other parts of the line that are changed.

Other bridge sites can be found farther down on the Gila that would be as good as the one used. The location as made uses the best bridge site on the San Carlos but it is probable other locations could be found that would be safe enough with some protective work.

RAILROAD FROM S AN CARLOS TO SAN CARLOS DAM SITE

Approximate length 8.5 miles.

Basis of Estimate.

No survey w as made for this estimate but the ground was gone over several times during the progress of other work and the following figures are probably close enough for an approximate estimate. Costs are based on new 60 lb. rail and other new track materials. An average fill of four feet is assumed for the first six miles where the railroad follows the river bottom and the cost of grading the other 2½ miles is estimated by comparison with similar country where surveys have been made. Cost of structures is estimated in the same way.

Summary of Preliminary Estimate

Track Materials and track laying	$117,300
Grading	90,000
Structures	45,000
Yards and Switches	15,000
Fencing	2,500
Estimated Cost -	$269,800
Engineering & contingencies, 10%	26,980
TOTAL ESTIMATED COST	$296,780

WAGON ROAD TO SAN CARLOS DAM SITE.

Approximate Length 14 Miles.

Location

The following estimate is for a road to the dam site, leaving the State Road between Globe and Safford at a point about 3 miles south of Rice, and running along the West side of the proposed reservoir. There would be no very difficult work, most of the material to be moved being Class 1 and a large part of the work could be done with road graders.

Basis of Estimate

The estimate is made from a reconnaissance survey and is for a 16 ft. unsurfaced roadway, with metal pipe culverts for openings up to 36 inches and wooden culverts for larger openings. Grade crossings are used for arroyos having rock or hard gravel bottoms.

Summary of Preliminary Estimate

Gradings	$8,800
Culverts, bridges and grade crossings	5,300
Clearing	680
Contingencies, 5%	740
Right-of-Way	170
Total Estimated Cost	$15,690

SAND & GRAVEL SUPPLY AT SAN CARLOS DAM SITE

There is apparently no gravel at the location of the dam but there are bars of considerable extent both above and below.

The gravel is generally of good quality, the pebbles are of hard material and well graded in size. The sand is of good quality, and sharp, but varies considerably in fineness. There appears to be an excess of sand in the gravel and there are large deposits of sand that do not contain gravel.

In some cases there are layers of silt and drift sand in the gravel that are unfit for use.

There are two large areas within a quarter of a mile of the dam site that are covered with hard cobbles and boulders of suitable size for crushing and there is a large quantity of loose granite that could be crushed into aggregate.

All the material described above is below high water except the granite, but the larger part of it is probably above water at normal stage.

My conclusions are that enough sand and gravel are available within an average distance from the dam site of 2,000 feet, that both are of fair quality and that all gravel will have to be screened. In case the amount of gravel should prove insufficient, good aggregate could be made from loose stone to be found within a quarter of a mile of the dam site at moderate cost. For the lower part of the dam, sand and gravel can be hauled to the dam site on the canyon bottom, except during high water. The cost of a road built along either side of the canyon to the top of the dam would be high.

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APPENDIX "C"

PRELIMINARY DESIGN AND ESTIMATE

ON

ALMA RESERVOIR

by

Designing Department

DENVER OFFICE, U.S. RECLAMATION SERVICE.

1 9 2 0 .

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SAN CARLOS PROJECT - ARIZONA

ALMA RESERVOIR

Drawing No. 44 - C - 4

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Descriptive Notes.

Design Data

Letter of June 1, 1920 from Project Manager to Chief Engineer.

Report for Month of April, 1920 from Project Manager to Chief Engineer.

Report of April 27, 1920 from Geo. A. Hammond, Diamond Drill Foreman to Project Manager.

Letter of August 10, 1920 from Engineer C. C. Fisher to Chief Engineer, inclosing capacity table for Alma Reservoir.

Letter of September 3, 1920 from Engineer C. C. Fisher to Chief Engineer.

Letter of September 7, 1920 from Engineer C. C. Fisher to Chief Engineer.

Drawing 99 - C - 126

Preliminary Estimate Alma Dam dated August 20, 1920.

Reservoir.

Located on the San Francisco River in the southwestern part of New Mexico with dam about 1-1/2 miles below the town of Alma. Drainage area above the dam site is about 1700 square miles. The gross capacity with water surface at elevation 4992 is 182,000 acre feet, of which 168,000 acre feet is assumed as irrigation storage and 14,000 acre feet as silt storage.

The stored water is to be used on the San Carlos Project in Arizona, the reservoir being supplementary to the San Carlos Reservoir.

Dam

Located near the section corner common to Sections 4,5,8 and 9, T. 11, S. , R. 20 W., N. M. P. M., about 56 miles northwest of Silver City, N. Mexico, the nearest railroad point.

Silver City is the end of the Silver City, Deming and Pacific R. R., which connects with the Santa Fe and Southern Pacific at Deming, New Mexico.

An arch dam has been selected as being the type most suitable for the site. It is designed as a constant radius dam with an upstream radius of 160 feet. The maximum height is 222 feet above bedrock. Provision has been made for a wagon road across the top of the dam. The design limits the arch thrust to 300 pounds per square inch based upon a formula which corrects for thickness of the arch ring.

The dam site has been explored by diamond drilling. Seven holes were put down which indicate about 40 feet of sand, gravel and cobbles overlapping lava. The side walls are lava very much broken up with pockets of soft ash and conglomerate.

Spillway.

An overflow spillway without gates, paralleling the river, is provided at the north abutment of the dam. It is designed to discharge 50,000 second feet in accordance with the Williams runoff formula, using "C" = 1.5. This discharge also agrees with calculations made by Engineer Debler. The weir is 450 feet long and is designed to pass the flood with a 10 foot depth on the crest.

The wagon road is carried across the spillway channel by a concrete bridge designed to carry the arch thrust due to the water load on the upper portion of the dam.

Outlet Works.

Consist of two 5' - 0" diameter regulating outlets controlled by 58" Balanced Needle Valves with 5' x 5' hydraulic operated emergency slide gates, and two 5' - 0" diameter sluicing outlets controlled by 5' x 5' hydraulic operated slide gates. Trash racks are provided for all outlets.

The required capacity of the regulating outlets is 700 second feet. It is estimated that one outlet will pass

the required discharge under a head of 46.2 feet and two under a head of 11.6 feet.

All outlets are lined with semi-steel to carry the arch thrust in the dam.

Wagon Roads.

The distance from Silver City to the dam site by road is about 75 miles. At present the road is in poor condition. The first 30 miles is to be put in good condition in the near future and it is estimated that the last 45 miles can be made serviceable for about $1,000 per mile. It is doubtful if heavy hauling can be done during wet weather.

Rights of Way.

The estimate for right of way is that furnished by Engineer C. C. Fisher for right of way for a dam impounding water at elevation 5030. The same amount is assumed for this lower dam for lack of other definite data.

Materials.

Cement is assumed to cost $9.00 per barrel at the dam site, based upon the following:

Cost, f.o.b. El Paso	$3.25	
Freight to Silver City	0.65	
Truck Haul to dam site, 75 mi.	5.70	
Handling	0.25	
Gross Cost	$9.85	
Less 3 Sax returned	.75	
Less $0.05 discount	.05	
Net Cost	$9.05	(say $9.00)

Sand and gravel may be obtained at the dam site at an assumed cost of $1.50 per cubic yard.

Plum rock is assumed in place at $4.00 per cubic yard based upon the following:

Cableway Charge	$0.75
Derrick	2.00
Sorting & Washing plum rock.	1.25
	$4.00

PRELIMINARY ESTIMATE

Top of parapets	El. 5006	Gross Storage	182,000 A.F.
Top of Dam	El. 5002	Irrigation Storage	168,000 A.F.
Normal W. S.	El. 4992	Spillway capacity	50,000 S.F.

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
COFFER DAM & PUMPING				$ 50,000
DAM				
Excavation				
Class II	17,800 c.y.	$2.00	$ 35,600	
Class III	8,600 c.y.	2.50	21,500	
Total Excavation				57,100
Concrete 1-2½-5 Mix				
Cement	54,700 bbl.	$9.00	$492,300	
Sand	19,400 c.y.	1.50	29,100	
Gravel	38,400 c.y.	1.50	57,600	
Forms	44,100 c.y.	1.50	66,150	
Mixing & Placing	44,100 c.y.	1.50	66,150	
Plant Depreciation	44,100 c.y.	1.00	44,100	
			$755,400	
Concrete in Place	44,100 c.y.	17.25		760,725
Reinforced Concrete 1:2½:5 Mix				
Cement	620 bbl.	9.00	5,580	
Sand	220 c.y.	1.50	330	
Gravel	435 c.y.	1.50	653	
Rein. Steel	30,00 lbs.	0.08	2,400	
Forms	500 c.y.	5.00	2,500	
Mixing and Placing	500 cy.	2.00	1,000	
Plant Depreciation	500 c.y.	1.00	500	
			$ 12,963	
Reinforced Concrete in place	500 c.y.	26.00		13,000
Parapets	1,120 lin.ft	10.00		11,200
TOTAL DAM				$ 842,025

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
OUTLET WORKS Q = 700 s.f.				
Regulating Outlets				
2 58" Bal. Needle Valves	190,800 lbs.	$ 0.25	$ 47,700	
Pump & Strainer			300	
Control Piping & Fittings	4,000 lbs.	0.15	600	
2 5 x 5' Hydraulic Operated Emerg. Gates	180,000 lbs.	0.20	36,000	
Oil Pump Tank, Gates, etc.			1,000	
Control Piping	6,600 lbs.	0.15	990	
Miscl. Metal Work	10,000 lbs.	0.10	1,000	
2 60" C.I. Conduit Linings	105,000 lbs.	0.10	10,500	
Freight	497,000 lbs.	0.01	4,970	
Hauling 75 Miles	18,600 T.M.	0.40	7,440	
Installation & Painting	497,000 lbs.	0.03	14,910	
Gate House			4,000	
Trash Rack Structure			11,000	
			140,410	
Regulating Outlets	2	70,200		$140,400
Sluice Outlets				
2 5 x 5' Hydraulic Operated Gates	126,000 lbs.	0.20	$ 25,200	
Oil Pump, Tank, Gates, etc.,			1,000	
Control Piping	6,600 lbs.	0.15	990	
2 60" C.I. Conduit Linings	15,000 lbs.	0.10	11,500	
Freight	248,000 lbs.	0.01	2,480	
Hauling 75 Miles	9,300 T.M.	0.40	3,720	
Installation & Painting	248,000 lbs.	0.03	7,440	
Trash Rack Structure			5,500	
			$ 57,830	
Sluice Outlets	2	29,000		$ 58,000
TOTAL OUTLET WORKS				$198,400
SPILLWAY Q = 50,000 s.f.				
Excavation				
Class III	135,000 c.y.	$ 1.75	$ 236,250	$236,250
Concrete Crest 1-3-6 Mix				
Cement	1,670 bbl.	9.00	15,030	
Sand	700 c.y.	1.50	1,050	
Gravel	1,420 c.y.	1.50	2,130	
Forms	1,590 c.y.	1.00	1,590	
Mixing & Placing	1,590 c.y.	1.50	2,385	
Plant Depreciation	1.590 c.y.	1.00	1,590	
			23,775	
Concrete in Place	1,590 c.y.	15.00		$ 23,850

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
Concrete Lining 1-2½-5 Mix				
Cement	8,330 bbl	$ 9.00	$ 74,970	
Sand	2,960 c.y.	1.50	4,440	
Gravel	5,850 c.y.	1.50	8,775	
Forms	6,720 c.y.	2.25	15,120	
Mixing & Placing	6,720 c.y.	1.75	11,760	
Plant Depreciation	6,720 c.y.	1.00	6,720	
			$121,785	
Concrete in Place	6,720 c.y.	18.00		$ 120,960
TOTAL SPILLWAY				$ 381,060
ROADS. Repairs & Betterments.				
Road Silver City to Dam Site				$ 50,000
CONSTRUCTION CAMP				$ 30,000
FINISHING AND CLEANING UP				$ 7,500
Total Estimated Cost				$1,558,985
Contingencies - 13%				202,668
Engineering & Administrative 17%				265,027
RIGHT OF WAY per Engineer C.C. Fisher letter Sept.3, 1920 to Chief Engineer.				132,620
GRAND TOTAL COST				$2,159,300

Cost per Ac. F. Gross 182,000 a.f. at $11.86

Net 168,000 a.f. at $12.85

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
Note: If character of rock is such that it is suitable for plums and if 20% plum rock can be placed, the cost is estimated as follows:				
COFFER DAM & PUMPING				$ 50,000
DAM				
Excavation				57,100
Concrete 1-2½-5 with 20% plum rock				
Cement	43,700 bbl.	$9.00	$ 393,300	
Sand	15,500 c.y.	1.50	23,250	
Gravel	30,870 c.y.	1.50	46,305	
Plum Rock	8,820 c.y.	4.00	35,280	
Forms	44,100 c.y.	1.50	66,150	
Mixing & Placing	44,100 c.y.	1.50	66,150	
Plant Depreciati on	44,100 c.y.	1.00	44,100	
			$674,535	
Concrete in Place	44,100 c.y.	15.25		$ 672,525
Reinforced Concrete				13,000
Parapets				11,200
TOTAL DAM				$ 753,825
OUTLET WORKS				$ 198,400
SPILLWAY				$ 381,060
ROADS				$ 50,000
CONSTRUCTION CAMP				$ 28,000
FINISHING & CLEANING UP				$ 7,000
Total Estimated Cost				$1,468,285
Contingencies, 13%				190,877
Engineering & Administration, 17%				249,608
RIGHT OF WAY				132,620
GRAND TOTAL COST				$2,041,390

ITEM	QUANTITY	UNIT COST	TOTAL COST	SUMMARY
NOTE: If the mixture for the dam be assumed as one part cement, two and one half of sand, five of gravel and three of cobbles, the cost is estimated as follows:				
COFFER DAM AND PUMPING				$ 50,000
DAM				
Excavation				$ 57,100
Concrete 1-2½-5-3 Mix				
Cement	42,300 bbl	$9.00	380,700	
Sand	15,000 c.y.	1.50	22,500	
Gravel	29,500 c.y.	1.50	44,250	
5" Cobbles	17,600 c.y.	1.50	26,400	
Forms	44,100 c.y.	1.50	66,150	
Mixing & Placing	44,100 c.y.	1.50	66,150	
Plant Depreciation	44,100 c.y.	1.00	44,100	
			650,250	
Concrete in Place	44,100 c.y.	$14.75		$ 650,475
Reinforced Concrete				13,000
Parapets				11,200
TOTAL DAM				$ 731,775
OUTLET WORKS				$ 198,400
SPILLWAY				$ 381,060
ROADS				$ 50,000
CONSTRUCTION CAMP				$ 28,000
FINISHING & CLEANING UP				$ 7,000
Total Estimated Cost				$ 1,446,235
Contingencies, 13%				188,011
Engineering & Admintrative 17%				245,860
RIGHT OF WAY				132,620
GRAND TOTAL ESTIMATED COST				$ 2,012,726

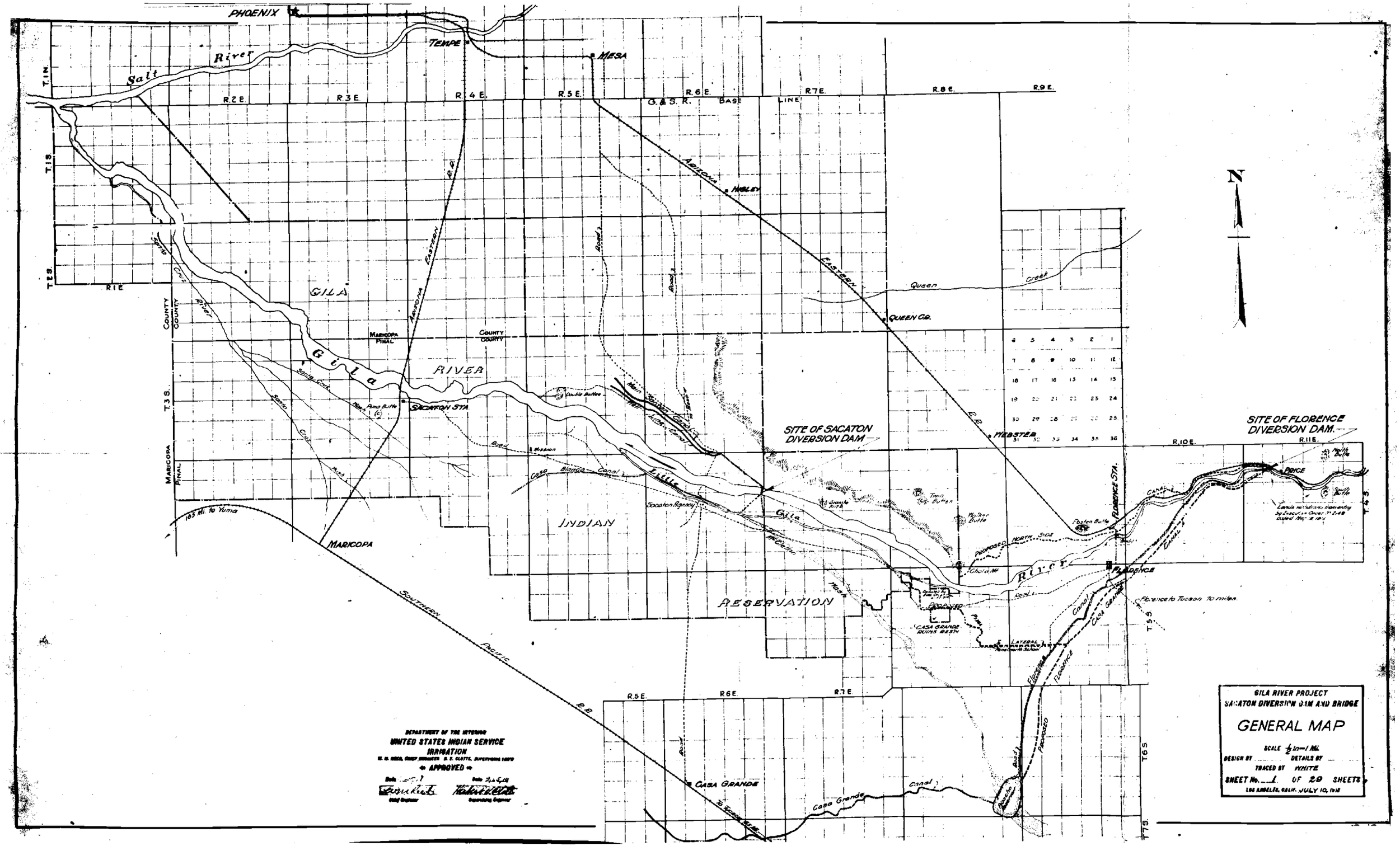
APPENDIX "D"

P H O T O G R A P H S

AND

D R A W I N G S.

-oooo0oooo-

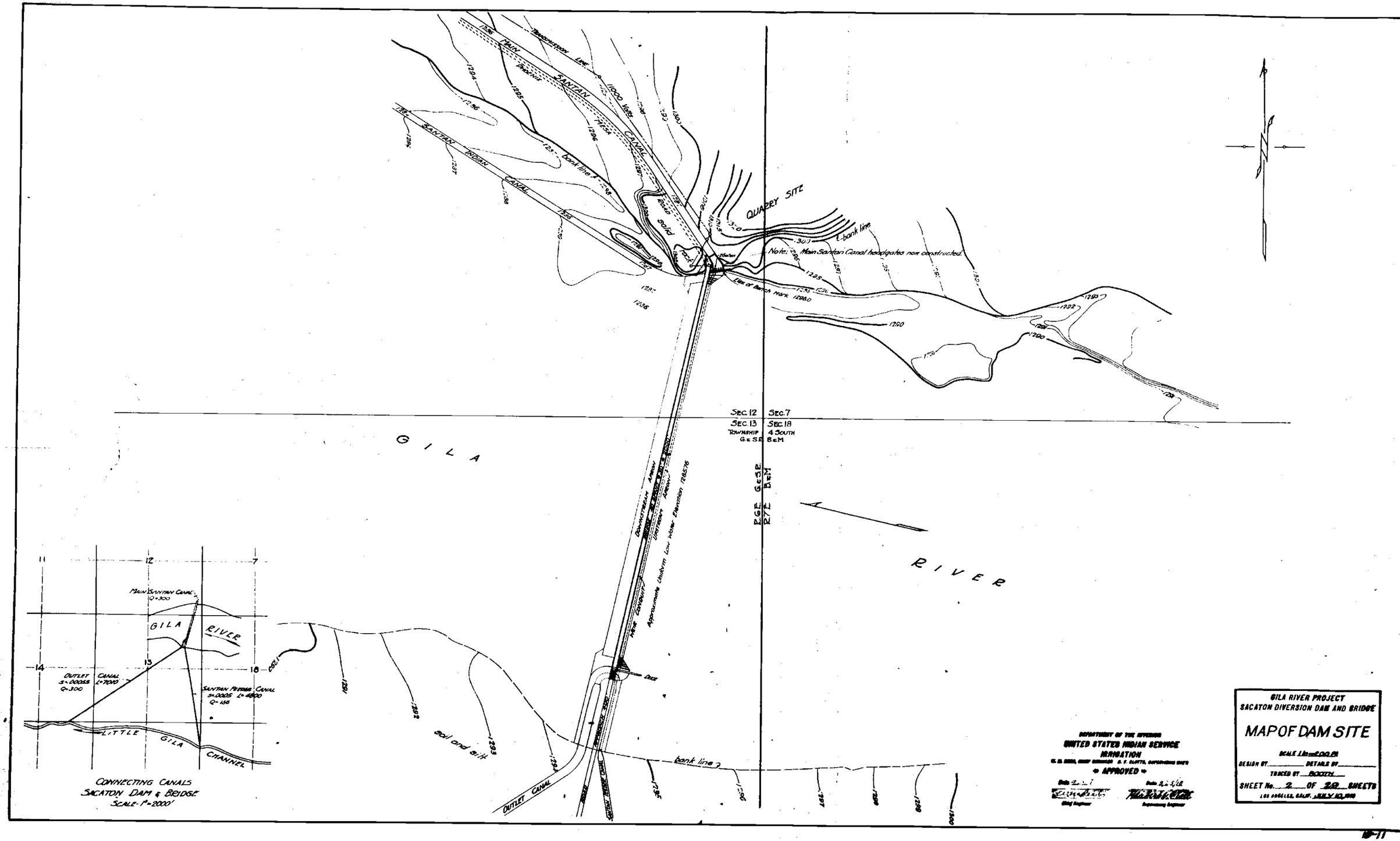


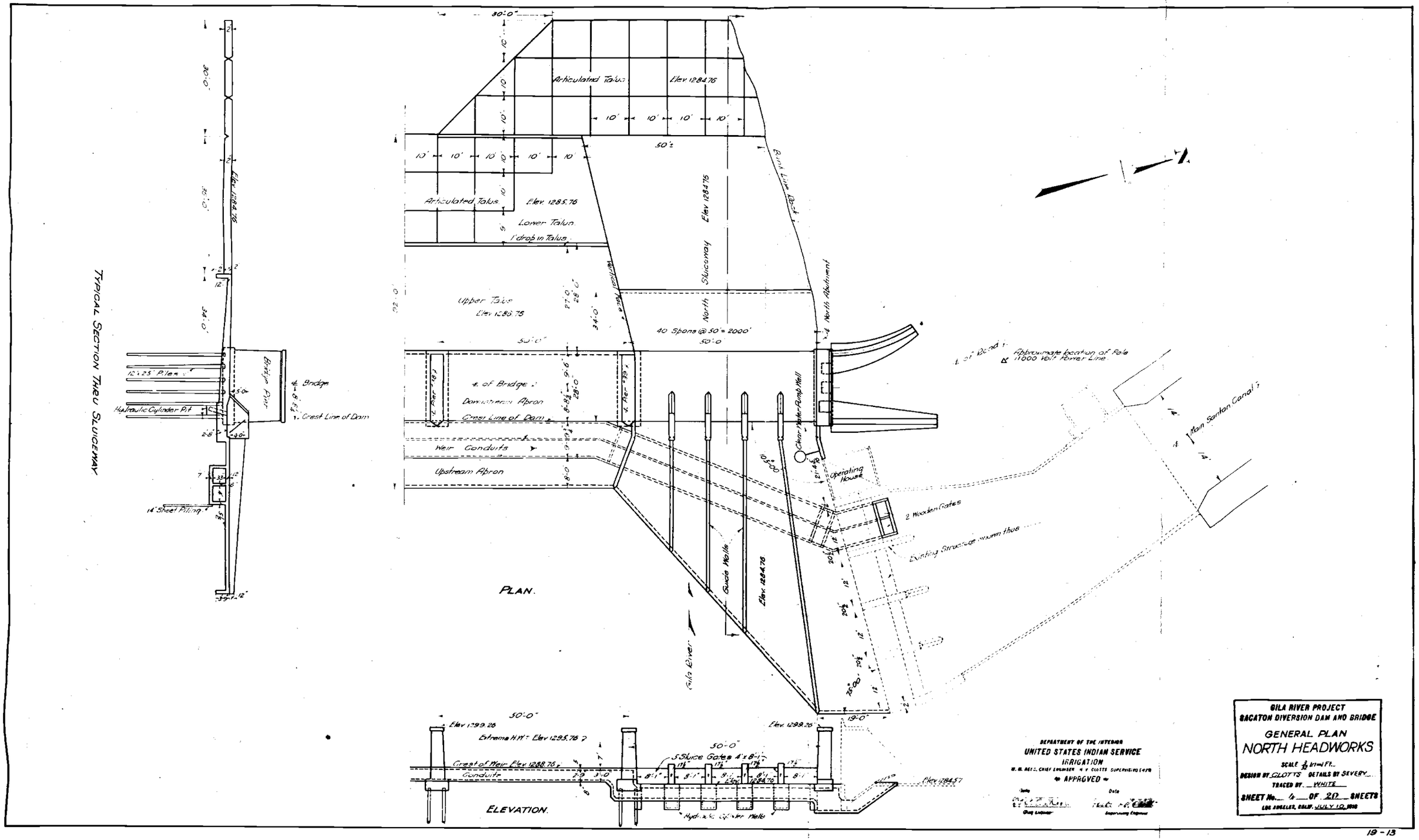
DEPARTMENT OF THE INTERIOR
UNITED STATES INDIAN SERVICE
IRRIGATION
W. H. HICS, CHIEF ENGINEER R. F. CLOTTS, SUPERVISING ENGR.
APPROVED
Date 2-1-1917 Date 2-1-1917
Chief Engineer Supervising Engineer

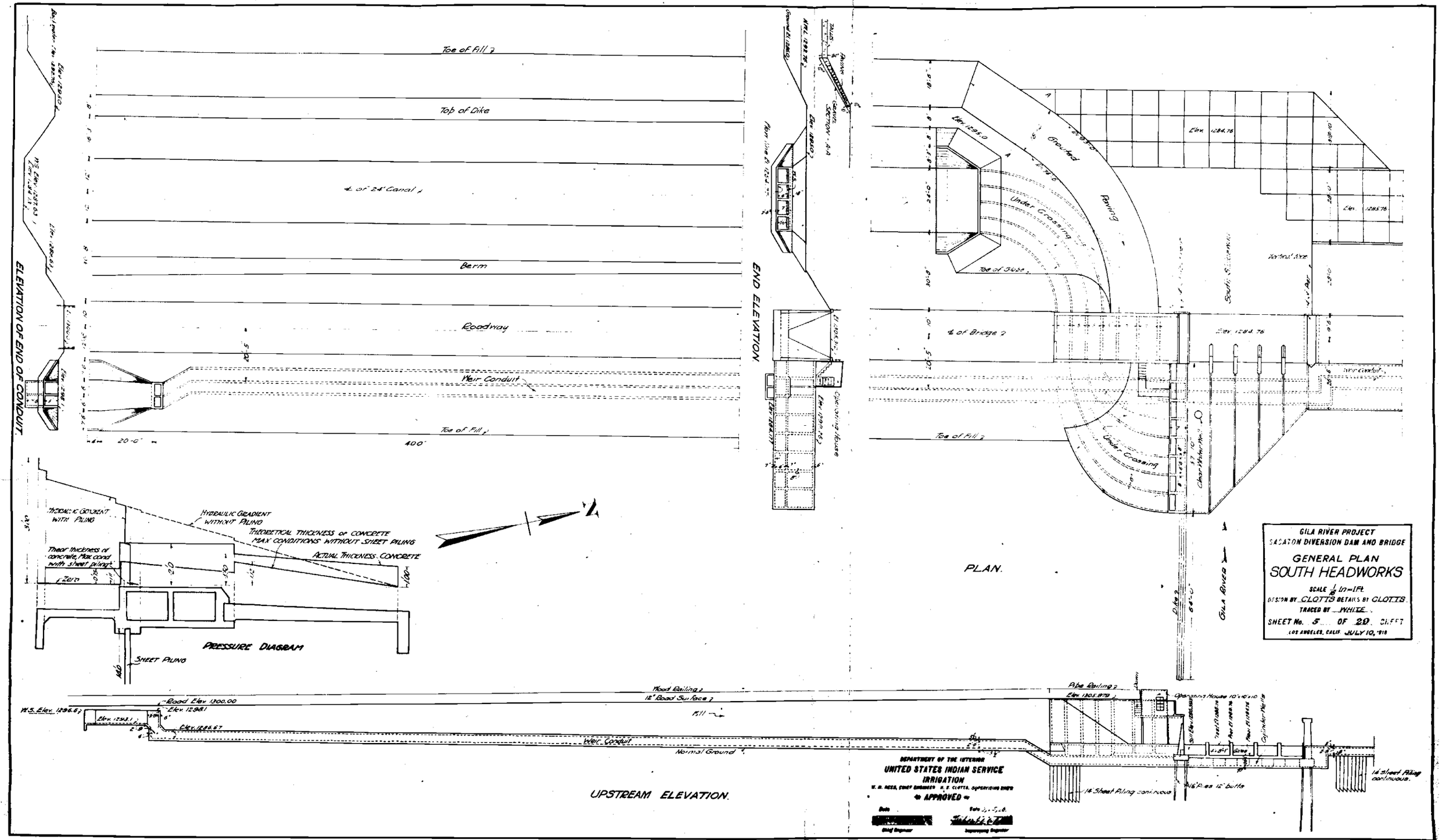
GILA RIVER PROJECT
SACATON DIVERSION DAM AND BRIDGE

GENERAL MAP

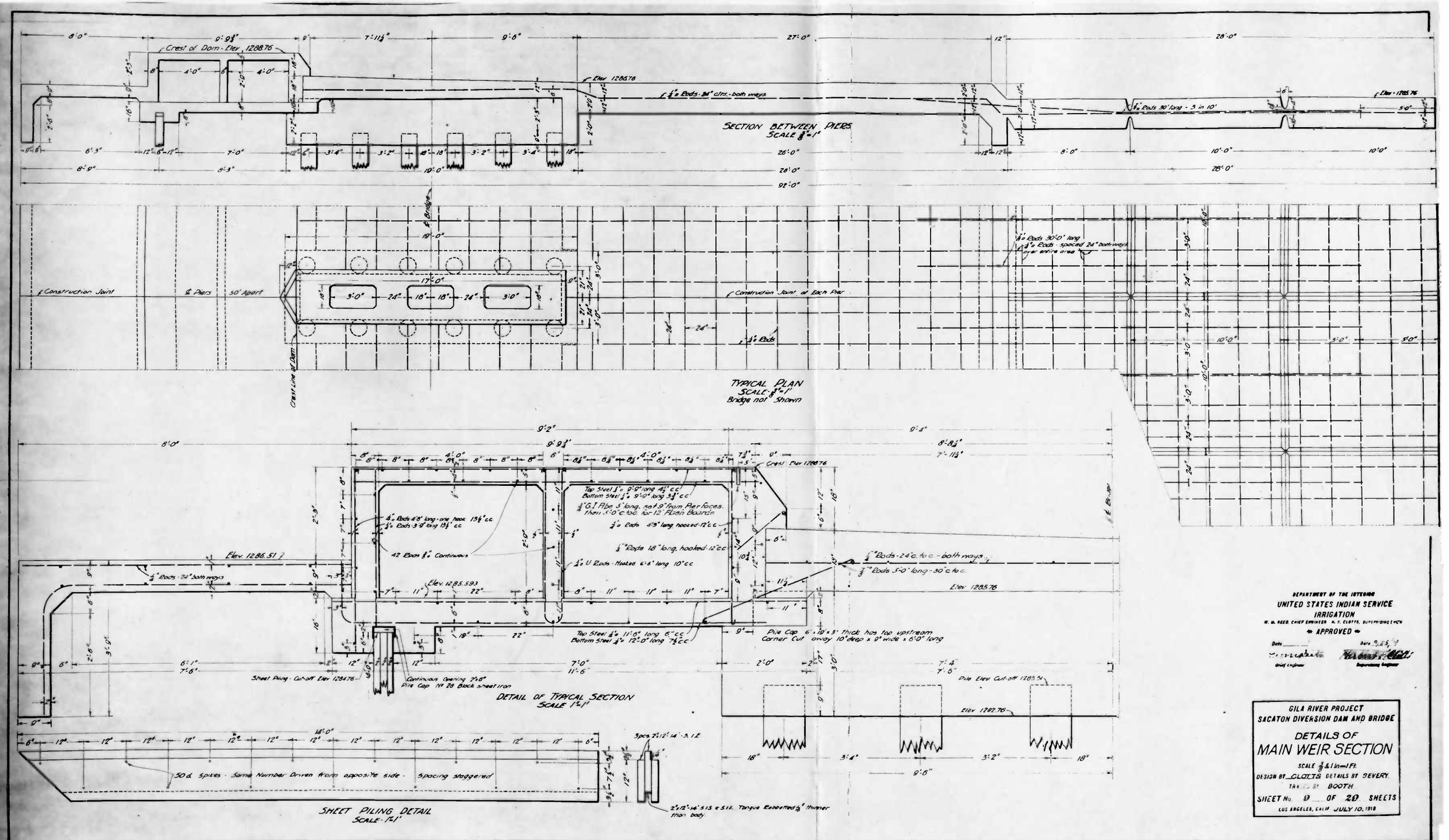
SCALE ½ in = 1 Mi.
DESIGN BY ____ DETAILS BY ____
TRACED BY WHITE
SHEET No. 1 OF 29 SHEETS
LOS ANGELES, CALIF. JULY 10, 1918


SANTAN CANAL
1000 Yds
SANTAN INDIAN CANAL
bank line
solid rock
QUARRY SITE
Note: Main Santan Canal headgates now constructed.
Elev. of Bench Mark 1290.0
SEC. 12
SEC. 7
SEC. 13
SEC. 18
TOWNSHIP 4 SOUTH
G & S.R. B.&M.
R.6E. G.&S.R.
R.7E. B.&M.
GILA
RIVER
Downstream Apron
Approximate Uniform Low Water Elevation 1285.76
New Concrete Dam
Dam
soil and silt
OUTLET CANAL
bank line
MAIN SANTAN CANAL Q=300
GILA RIVER
OUTLET CANAL S=.00055 L=7000 Q=300
SANTAN PUMPING CANAL S=.0005 L=4800 Q=156
LITTLE GILA CHANNEL
CONNECTING CANALS
SACATON DAM & BRIDGE
SCALE-1"=2000'
DEPARTMENT OF THE INTERIOR
UNITED STATES INDIAN SERVICE
IRRIGATION
APPROVED
GILA RIVER PROJECT
SACATON DIVERSION DAM AND BRIDGE
MAP OF DAM SITE
SCALE 1 in = 200 ft
DESIGN BY
DETAILS BY
TRACED BY BOOTH
SHEET No. 2 OF 20 SHEETS
LOS ANGELES, CALIF. JULY 10, 1930

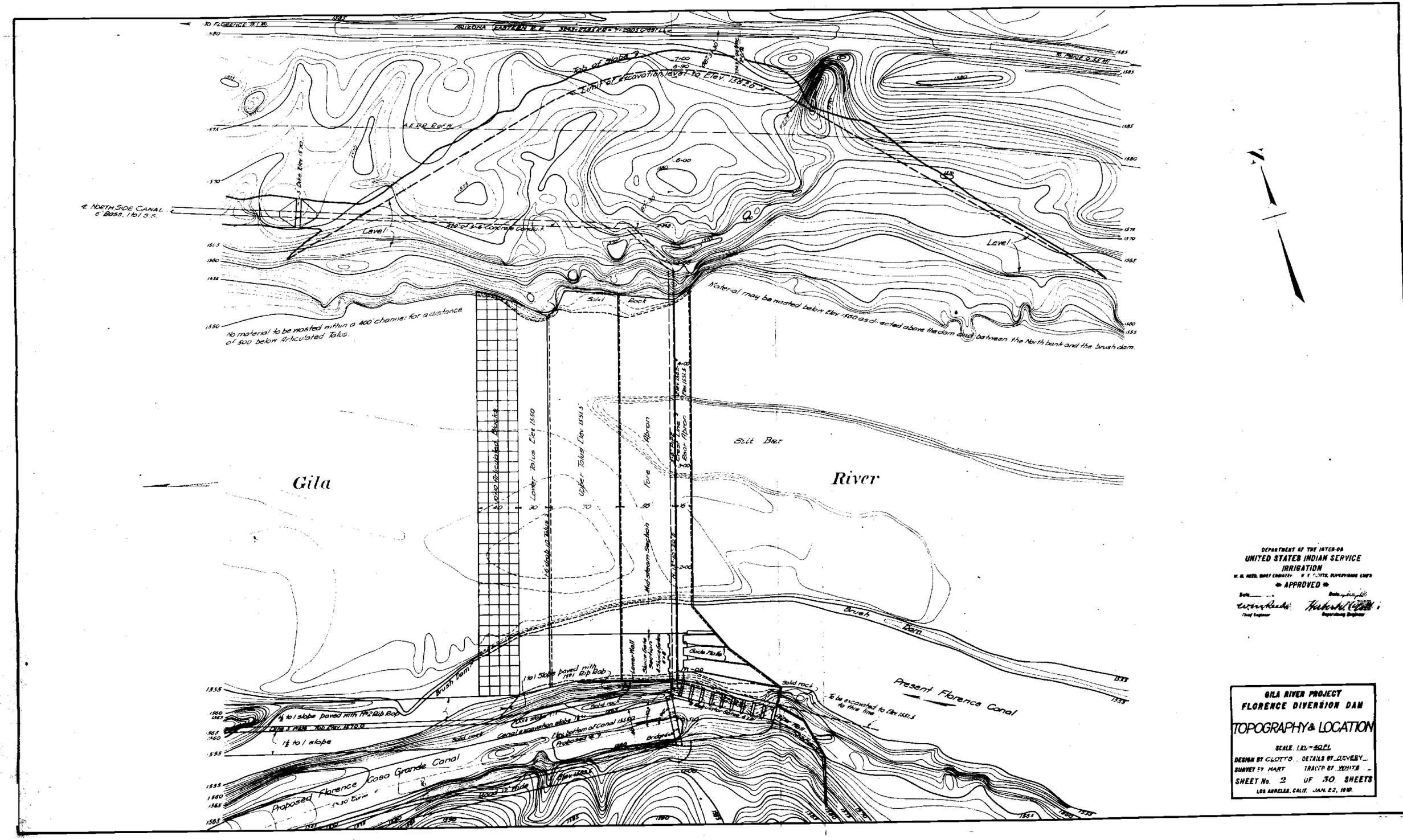

TYPICAL SECTION THRU SLUICEWAY
Bridge Pier
℄ Bridge
Crest Line of Dam
12"x25' Piles
Hydraulic Cylinder Pit
14" Sheet Piling
Elev. 1284.76
PLAN.
Articulated Talus
Elev. 1284.76
Elev. 1285.76
Lower Talus
1' drop in Talus
Upper Talus
Elev. 1285.76
Elev. 1284.76
North Sluiceway
40 Spans @ 50' = 2000'
Point Line Back
℄ North Abutment
℄ of Bridge
Downstream Apron
Crest Line of Dam
Weir Conduits
Upstream Apron
Sluice Walls
Elev. 1284.76
Gila River
Clear Water Pump Well
Operating House
2 Wooden Gates
Existing Structure shown thus
Approximate location of Pole ⊥ 11000 Volt Power Line
Main Santan Canal
ELEVATION.
Elev. 1299.26
Extreme H.W. = Elev. 1295.76
Crest of Weir Elev. 1288.76
Conduits
5 Sluice Gates 4'x8'-1"
Elev. 1284.57
Hydraulic Cylinder Wells
DEPARTMENT OF THE INTERIOR
UNITED STATES INDIAN SERVICE
IRRIGATION
APPROVED
GILA RIVER PROJECT
SACATON DIVERSION DAM AND BRIDGE
GENERAL PLAN
NORTH HEADWORKS
SCALE 1/32 IN=1 FT.
DESIGN BY CLOTTS DETAILS BY SEVERY
TRACED BY WHITE
SHEET No. 4 OF 20 SHEETS
LOS ANGELES, CALIF. JULY 10, 1940


ELEVATION OF END OF CONDUIT.
Toe of Fill
Top of Dike
℄ of 24' Canal
Berm
Roadway
Weir Conduit
Toe of Fill
20'-0"
400'
END ELEVATION
Grouted Paving
Under Crossing
Elev. 1285.0
Elev. 1284.76
Elev. 1285.76
Toe of Slope
℄ of Bridge
Toe of Fill
Weir Conduit
Clear Water Flow
South Canal
Centrol Axis
Pipe
GILA RIVER
PLAN.
HYDRAULIC GRADIENT WITH PILING
HYDRAULIC GRADIENT WITHOUT PILING
THEORETICAL THICKNESS OF CONCRETE MAX CONDITIONS WITHOUT SHEET PILING
ACTUAL THICKNESS CONCRETE
Theor. thickness of concrete, Max. cond. with sheet piling
Zero
PRESSURE DIAGRAM
SHEET PILING
Road Railing
12' Road Surface
Road Elev. 1300.00
Elev. 1298.1
Elev. 1296.67
W.S. Elev. 1296.6
Fill
Weir Conduit
Normal Ground
Pipe Railing
Elev. 1303.875
Operating House 10'x10'x10'
14 Sheet Piling continuous
16 Piles 12" butts
14 Sheet Piling continuous.
UPSTREAM ELEVATION.
DEPARTMENT OF THE INTERIOR
UNITED STATES INDIAN SERVICE
IRRIGATION
W. H. REED, CHIEF ENGINEER H. E. CLOTTS, SUPERVISING ENGR.
APPROVED
Chief Engineer
Supervising Engineer
GILA RIVER PROJECT
SACATON DIVERSION DAM AND BRIDGE
GENERAL PLAN
SOUTH HEADWORKS
SCALE 1/20 In=1Ft.
DESIGN BY CLOTTS DETAILS BY CLOTTS
TRACED BY WHITE
SHEET No. 5 OF 29 SHEET
LOS ANGELES, CALIF. JULY 10, 1918

19-14

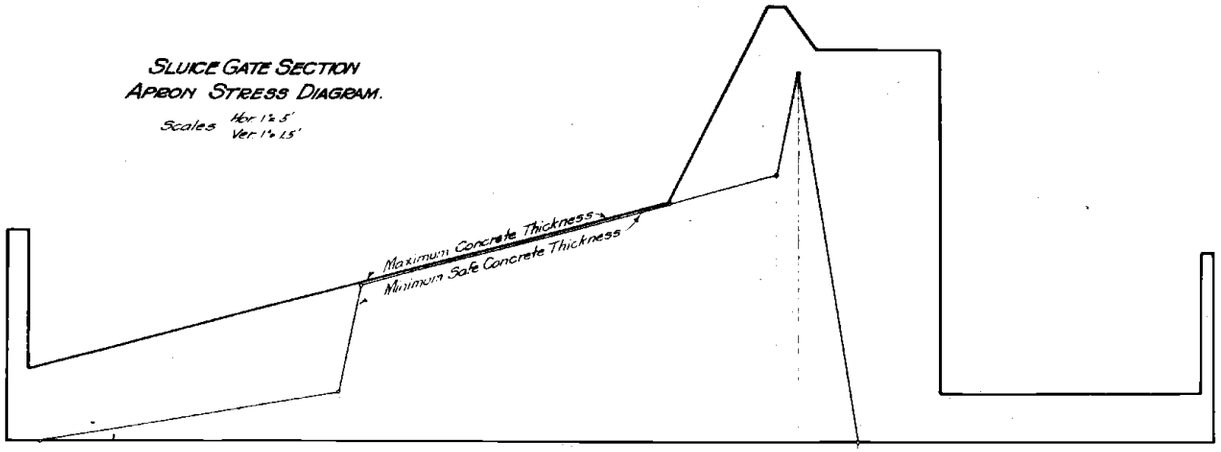

Crest of Dam - Elev. 1288.76
Elev. 1288.76
SECTION BETWEEN PIERS
SCALE 3/8" = 1'
Construction Joint
℄ Piers
50' Apart
Construction Joint at Each Pier
Crest Line of Dam
TYPICAL PLAN
SCALE: 3/8" = 1'
Bridge not Shown
Elev. 1286.51
Elev. 1285.593
Elev. 1288.76
Crest Pier 1288.76
Sheet Piling - Cut-off Elev. 1284.76
Continuous Opening 7'x6"
Pile Cap 1x 28 Black sheet iron
Pile Cap 6' x 10' x 3' thick has top upstream Corner Cut away 10' deep x 9' wide x 6'-0" long
Pile Elev. Cut-off 1283.51
Elev. 1282.76
DETAIL OF TYPICAL SECTION
SCALE 1/2"
50 d. Spikes - Same Number Driven from opposite side - Spacing staggered
SHEET PILING DETAIL
SCALE - 1/2"
DEPARTMENT OF THE INTERIOR
UNITED STATES INDIAN SERVICE
IRRIGATION
W. H. REED, CHIEF ENGINEER A. T. CLOTTS, SUPERVISING ENG'R
APPROVED
Chief Engineer
Engineering Engineer
GILA RIVER PROJECT
SACATON DIVERSION DAM AND BRIDGE
DETAILS OF
MAIN WEIR SECTION
SCALE 3/8 & 1 In = 1 Ft.
DESIGN BY CLOTTS DETAILS BY SEVERY
TRACED BY BOOTH
SHEET No. 9 OF 20 SHEETS
LOS ANGELES, CALIF. JULY 10, 1918

19-18

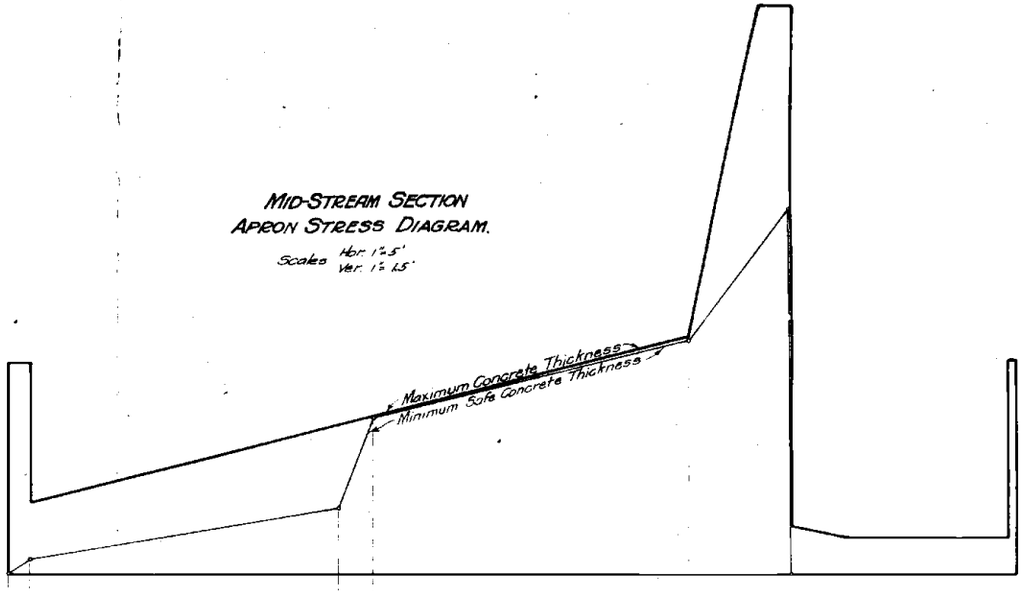


DEPARTMENT OF THE INTERIOR
UNITED STATES INDIAN SERVICE
IRRIGATION
W. H. REED, CHIEF ENGINEER H. T. CUTTS, SUPERVISING ENG'R
APPROVED
Date _____ Date _____
Chief Engineer Supervising Engineer

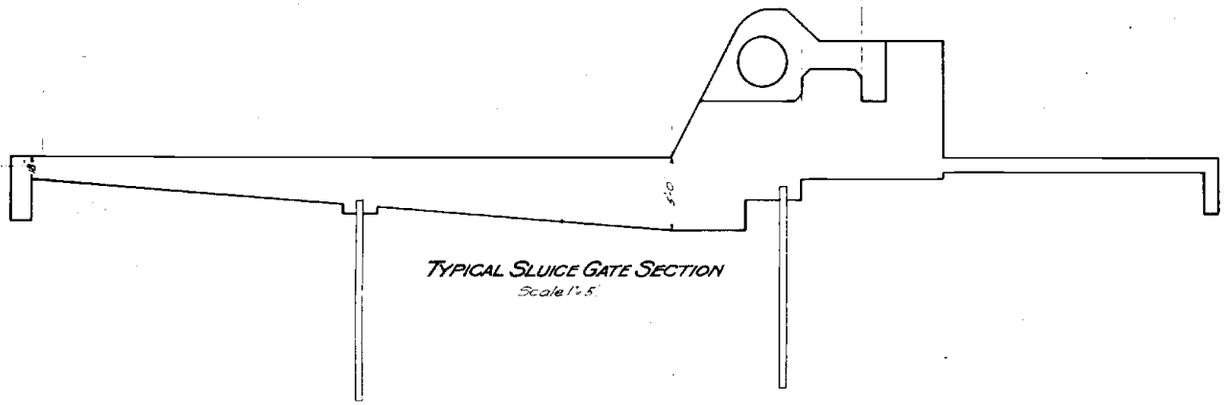
GILA RIVER PROJECT
FLORENCE DIVERSION DAM
TOPOGRAPHY & LOCATION
SCALE 1 in. = 50 ft.
DESIGN BY CLOTTS DETAILS BY SEVERY
SURVEY BY HART TRACED BY WHITE
SHEET No. 2 OF 30 SHEETS
LOS ANGELES, CALIF. JAN. 22, 1919.



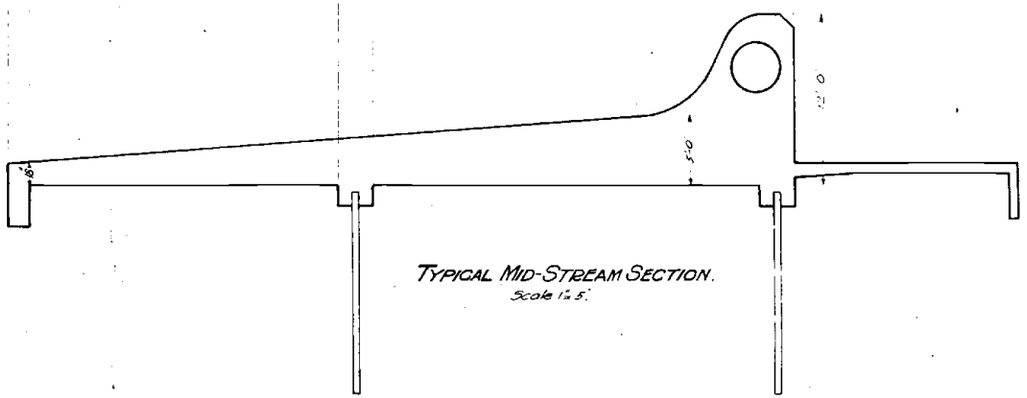
SLUICE GATE SECTION
APRON STRESS DIAGRAM.
Scales Hor. 1"=5'
Ver. 1"=15'



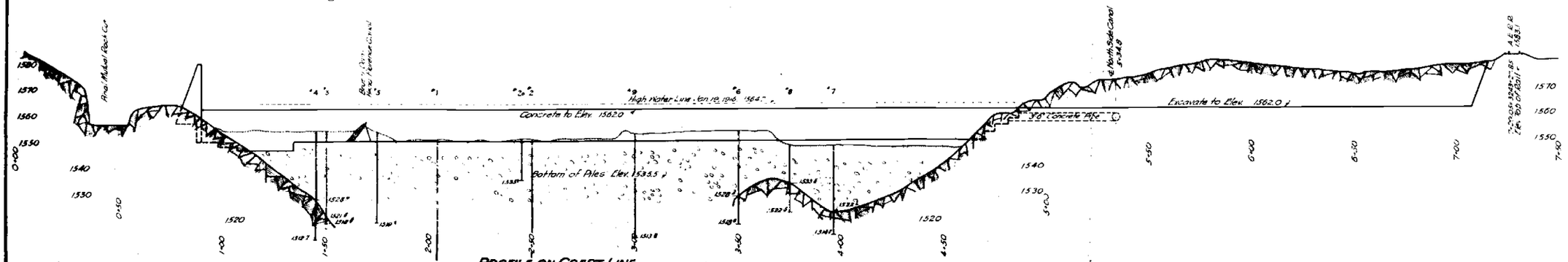
MID-STREAM SECTION
APRON STRESS DIAGRAM.
Scales Hor. 1"=5'
Ver. 1"=15'



TYPICAL SLUICE GATE SECTION
Scale 1"=5'



TYPICAL MID-STREAM SECTION.
Scale 1"=5'



PROFILE ON CREST LINE
Scales Hor. 1"=25'
Ver. 1"=20'

DEPARTMENT OF THE INTERIOR
UNITED STATES INDIAN SERVICE
IRRIGATION
W. H. REED, CHIEF ENGINEER A. V. CHITTS, SUPERVISING ENGR.

APPROVED

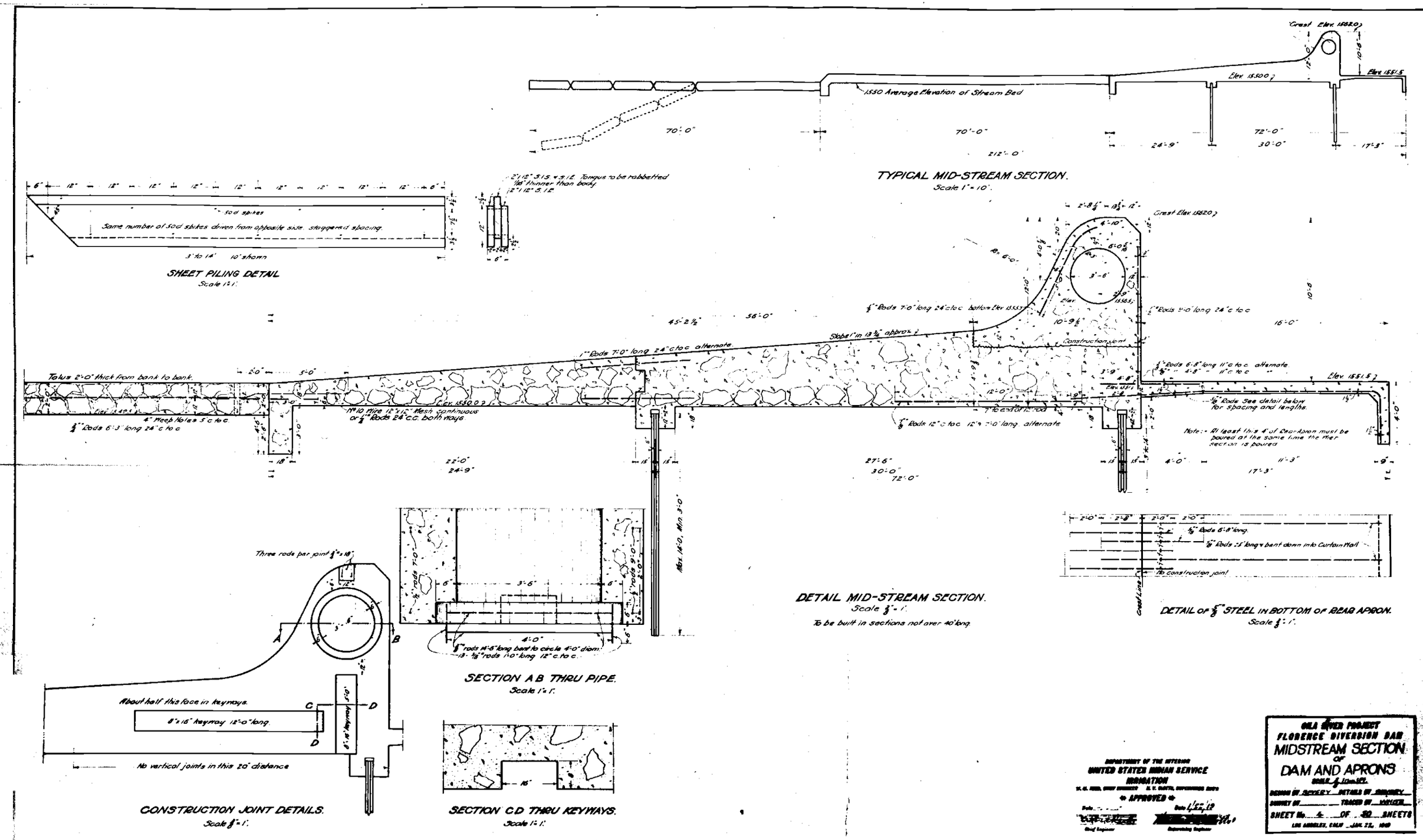
Date _____ Date 4/22/19

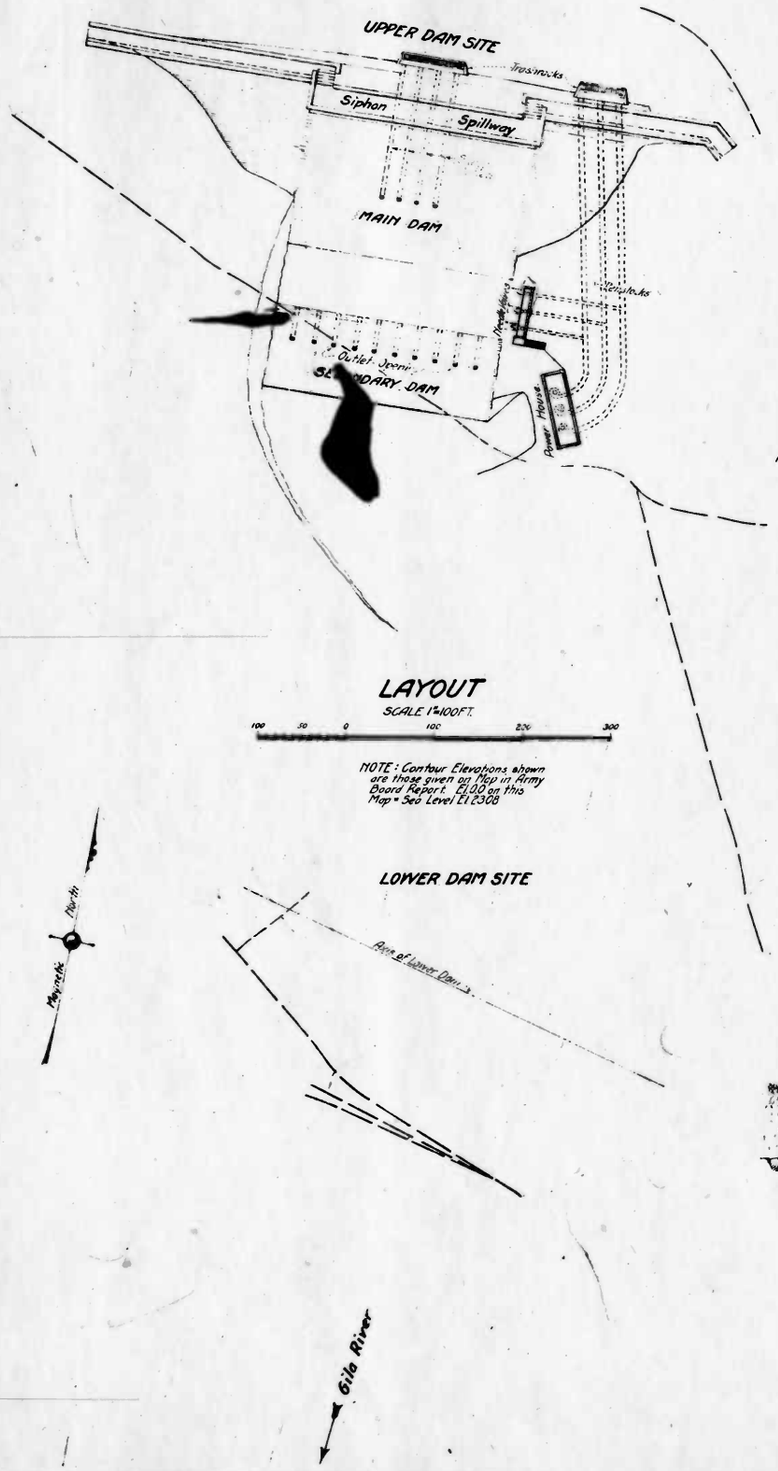
Chief Engineer — Supervising Engineer

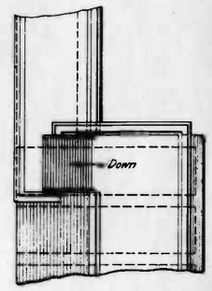
GILA RIVER PROJECT
FLORENCE DIVERSION DAM
STRESS DIAGRAMS
AND
PROFILE ON CREST LINE
SCALE AS SHOWN

DESIGNED BY SEVERY DETAILS BY SEVERY
SURVEY BY HART TRACED BY WHITE
SHEET No. 3 OF 30 SHEETS
LOS ANGELES, CALIF. JAN. 22, 1919

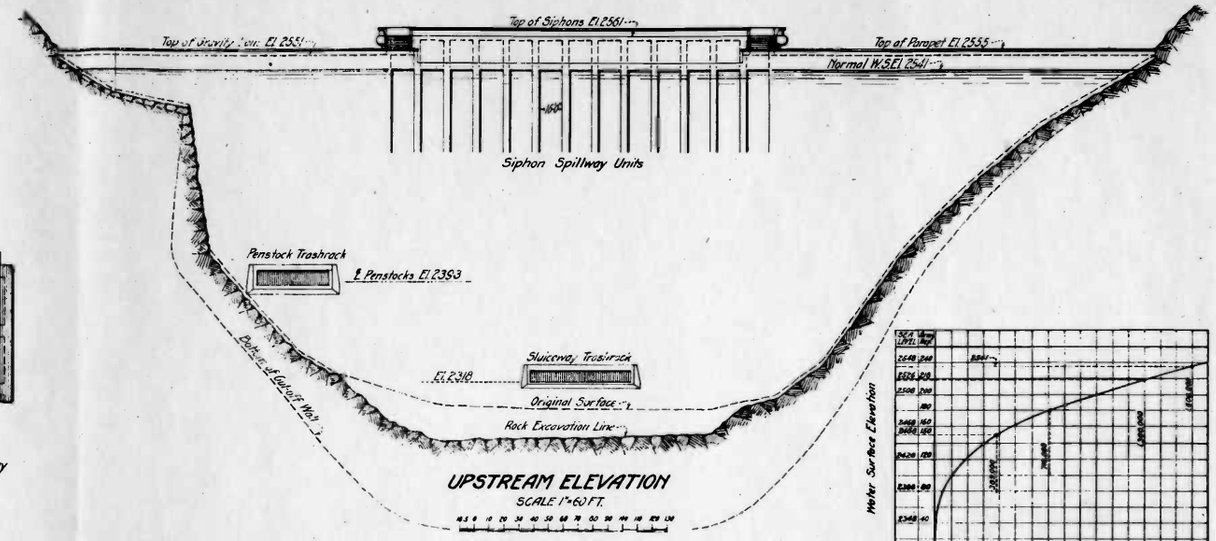
22-15

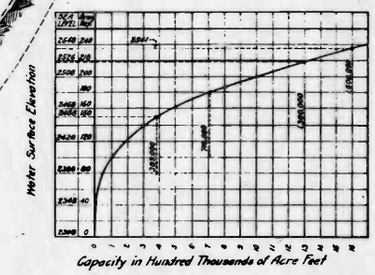

TYPICAL MID-STREAM SECTION.
Scale 1" = 10'.
1550 Average Elevation of Stream Bed
Crest Elev. 1562.0
Elev. 1551.5
Elev. 1550.0
70'-0"
70'-0"
212'-0"
24'-9"
72'-0"
30'-0"
17'-3"
SHEET PILING DETAIL
Scale 1" = 1'.
Same number of sod spikes driven from opposite side, staggered spacing.
3' to 14'
10' shown
2"x12" S.I.S. x 5'-12' Tongue to be rabbetted 1/8" thinner than body
DETAIL MID-STREAM SECTION.
Scale 3/8" = 1'.
To be built in sections not over 40' long.
Talus 2'-0" thick from bank to bank.
4" Weep Holes 5' c to c.
3/4" Rods 6'-3" long 24" c to c
No. 10 Wire 12"x12" Mesh continuous or 1/2" Rods 24" c.c. both ways.
1" Rods 7'-0" long 24" c to c alternate
Slope 1" in 13 3/4" approx.
3/4" Rods 7'-0" long 24" c to c bottom Elev. 1555.7
1/2" Rods 5'-0" long 24" c to c
Construction joint
3/4" Rods 6'-8" long 11" c to c alternate
1/2" Rods See detail below for spacing and lengths.
Note:- At least this 4' of Rear-Apron must be poured at the same time the Weir section is poured
3/4" Rods 12" c to c 12'-0" long alternate
Min. 14'-0, Min 3'-0"
Three rods per joint 3/4"x18'
About half this face in keyways.
8"x16" keyway 12'-0" long.
No vertical joints in this 20' distance
CONSTRUCTION JOINT DETAILS.
Scale 3/8" = 1'.
SECTION A B THRU PIPE.
Scale 1" = 1'.
3/4" rods 14'-5" long bent to circle 4'-0" diam.
13-5/8" rods 1'-0" long 12" c to c.
SECTION C D THRU KEYWAYS.
Scale 1" = 1'.
DETAIL OF 5/8" STEEL IN BOTTOM OF REAR APRON.
Scale 3/8" = 1'.
5/8" Rods 6'-8" long.
5/8" Rods 2'-5" long, bent down into Curtain Wall
To Construction joint
Center Line
DEPARTMENT OF THE INTERIOR
UNITED STATES INDIAN SERVICE
IRRIGATION
APPROVED
Chief Engineer
Engineering Engineer
OKLA RIVER PROJECT
FLORENCE DIVERSION DAM
MIDSTREAM SECTION
OF
DAM AND APRONS
SCALE 3/8" = 1 FT.
DESIGN BY SEVERY DETAILS BY
SURVEY OF TRACED BY
SHEET No. 4 OF 20 SHEETS
LOS ANGELES, CALIF. JAN. 22, 1919



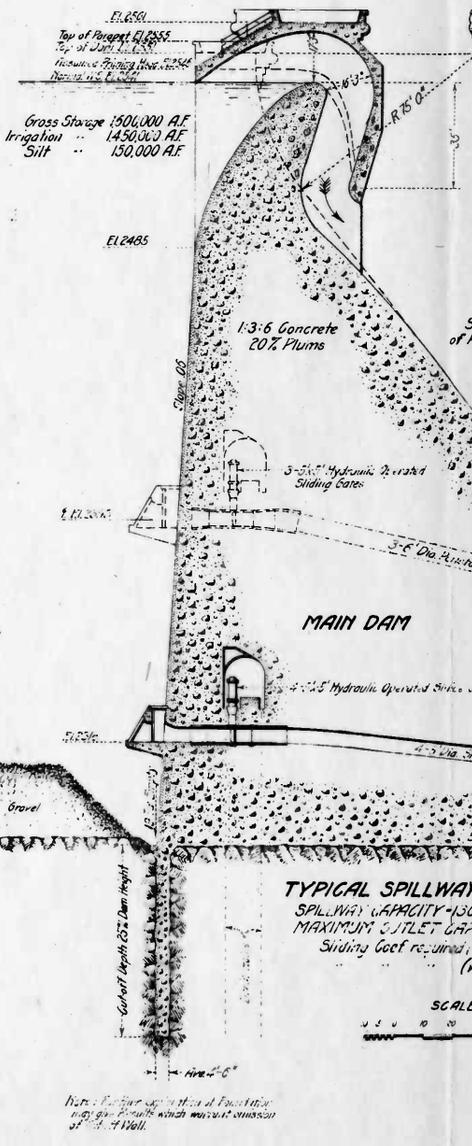


PLAN
Showing Parapet at End of Spillway

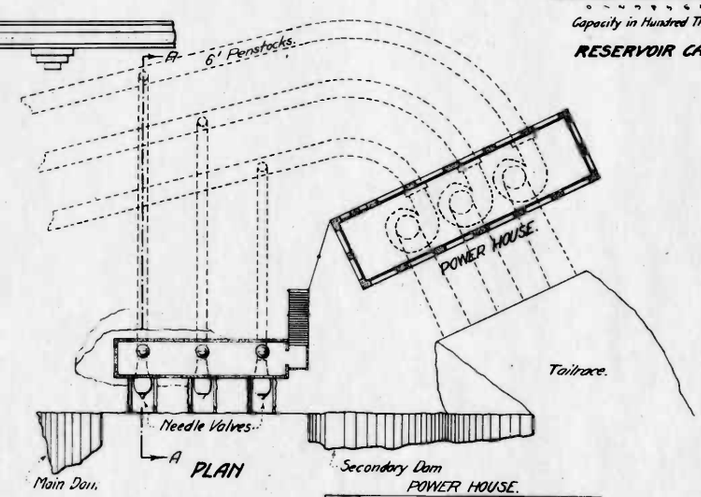




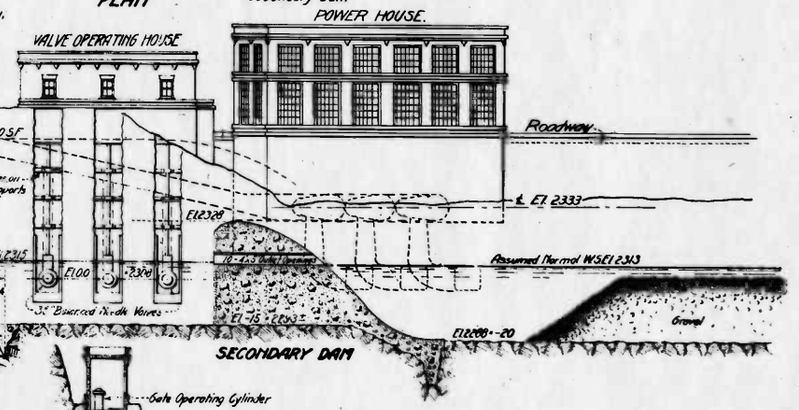
RESERVOIR CAPACITY CURVE

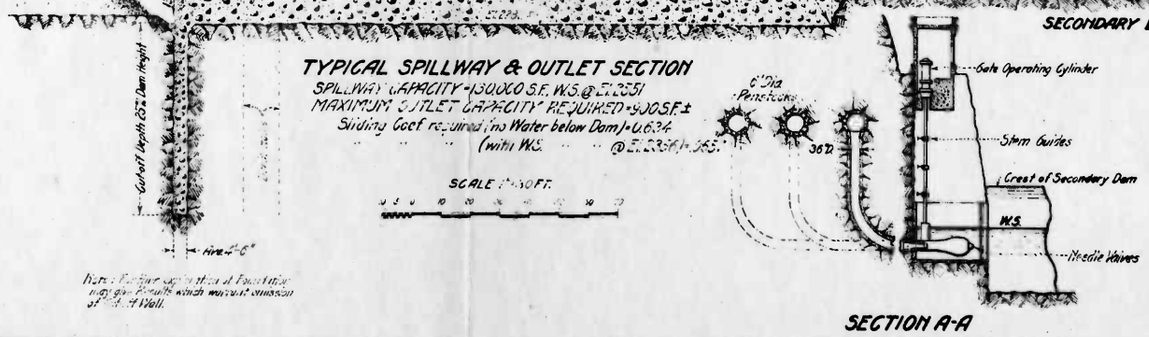


ELEVATION
Showing Downstream View of Parapet at End of Spillway



PLAN



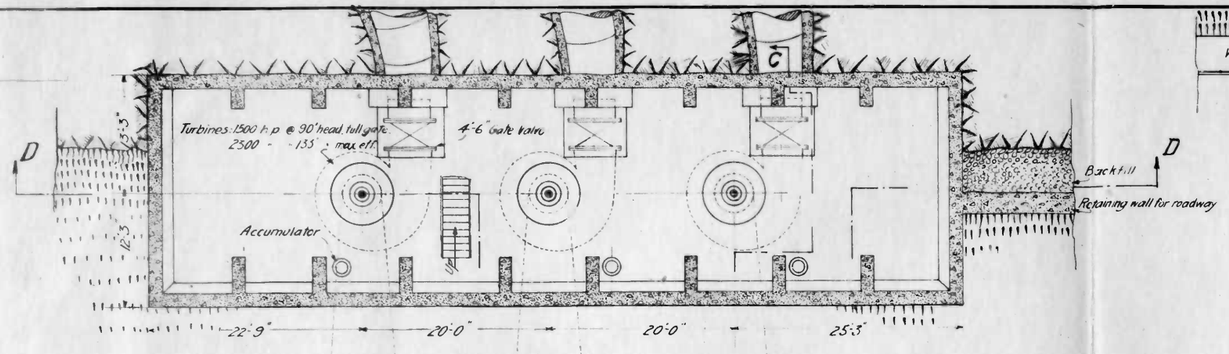


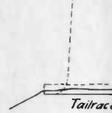
DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.
SAN CARLOS PROJECT-ARIZONA

SAN CARLOS DAM

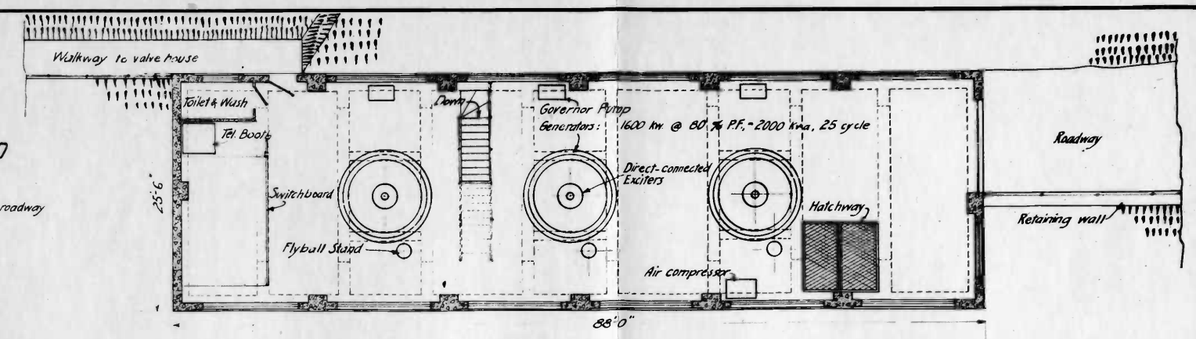
PRELIMINARY ESTIMATE DRAWING

DRAWN: C.H.H.-E.B.H. RECOMMENDED:
CHECKED: R.L. APPROVED:
Denver, Colo. Sept. 7, 1920 44-C-3

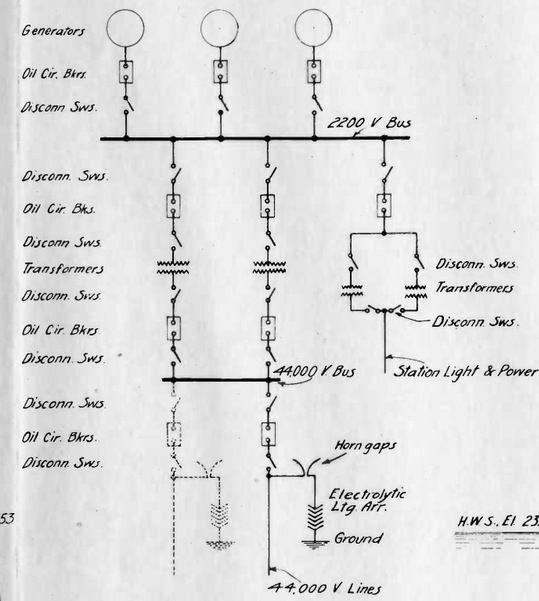




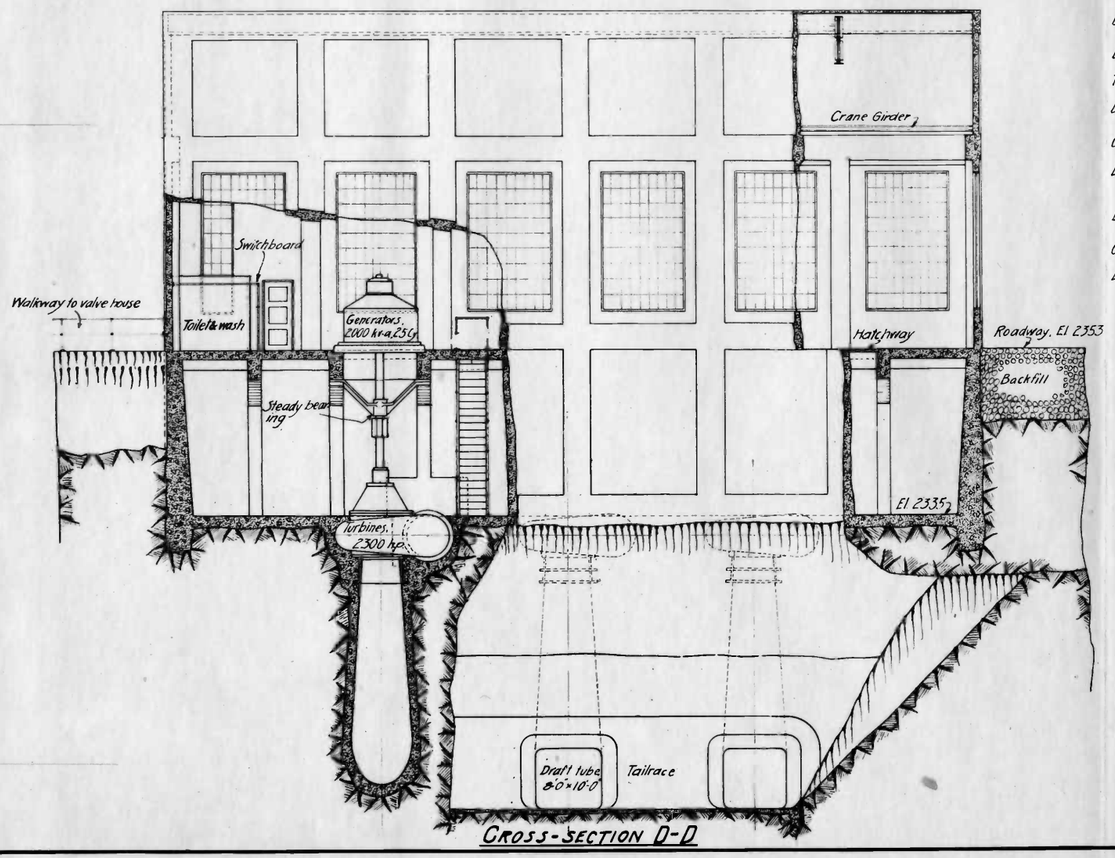
PLAN SECTION A-A



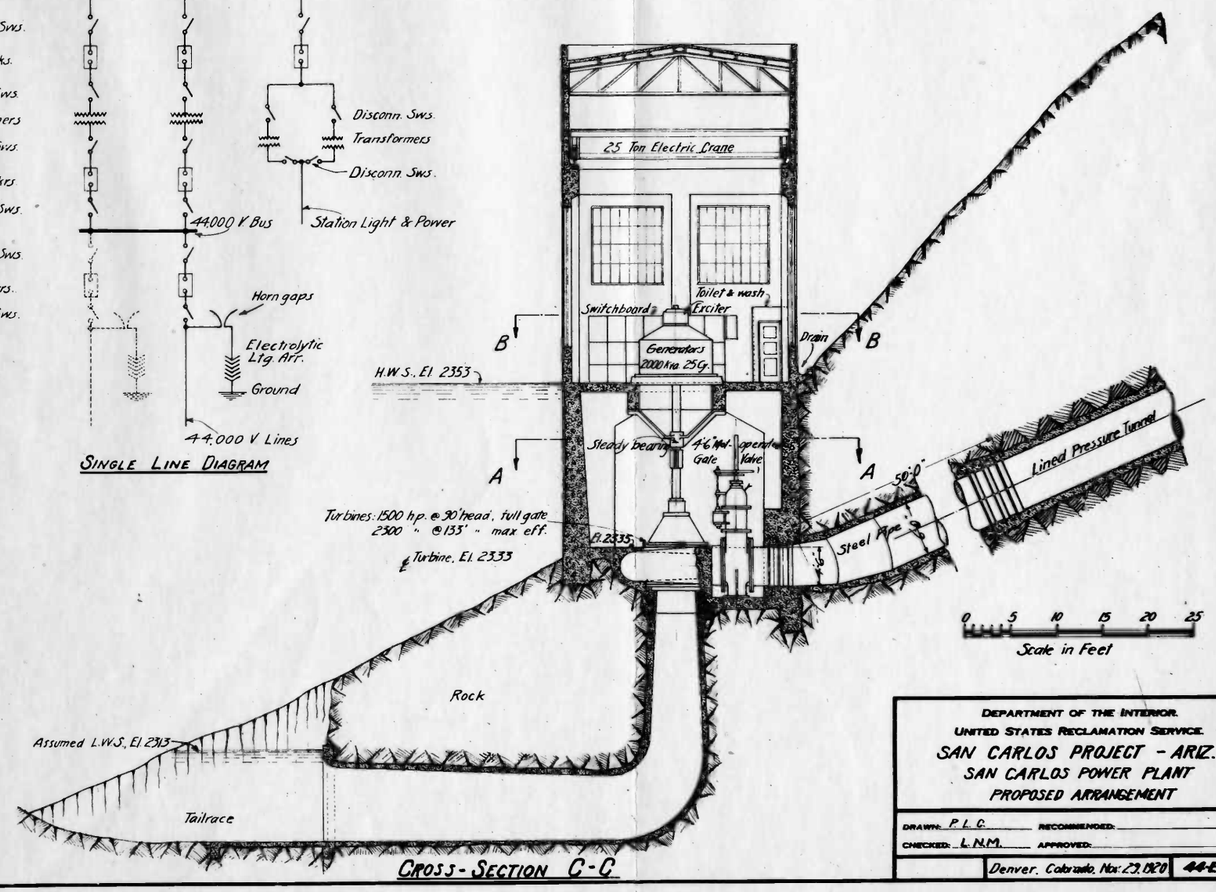
PLAN SECTION B-B



SINGLE LINE DIAGRAM



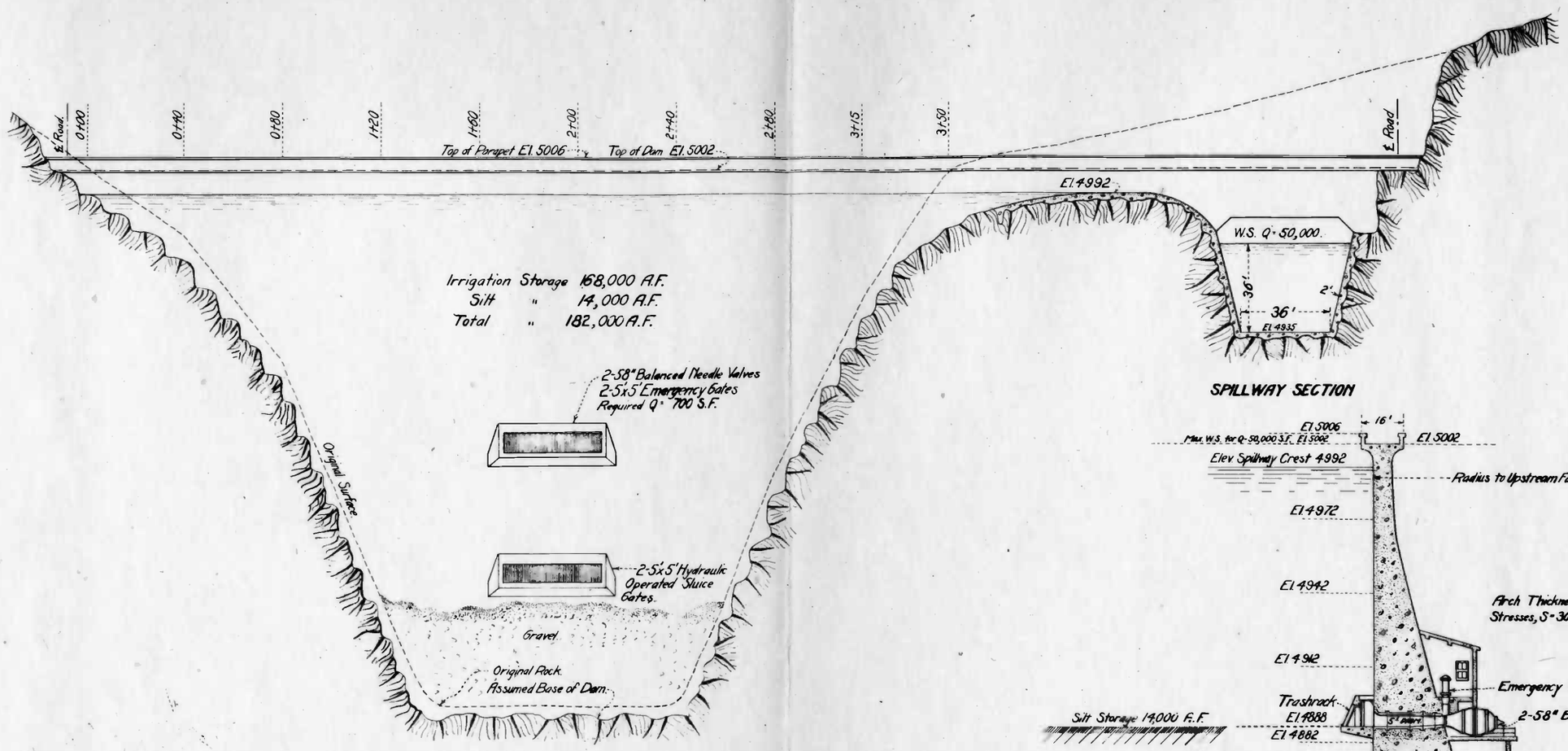
CROSS-SECTION D-D



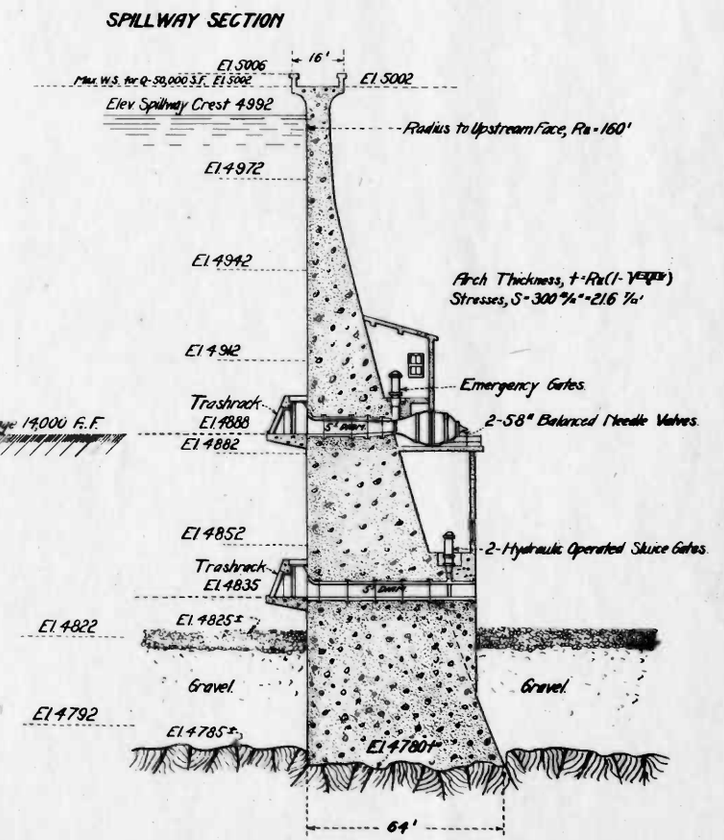
CROSS-SECTION C-C

DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.
SAN CARLOS PROJECT - ARIZ.
SAN CARLOS POWER PLANT
PROPOSED ARRANGEMENT

DRAWN: P.L.C. RECOMMENDED:
CHECKED: L.N.M. APPROVED:
Denver, Colorado, Nov. 29, 1920 44-E-2

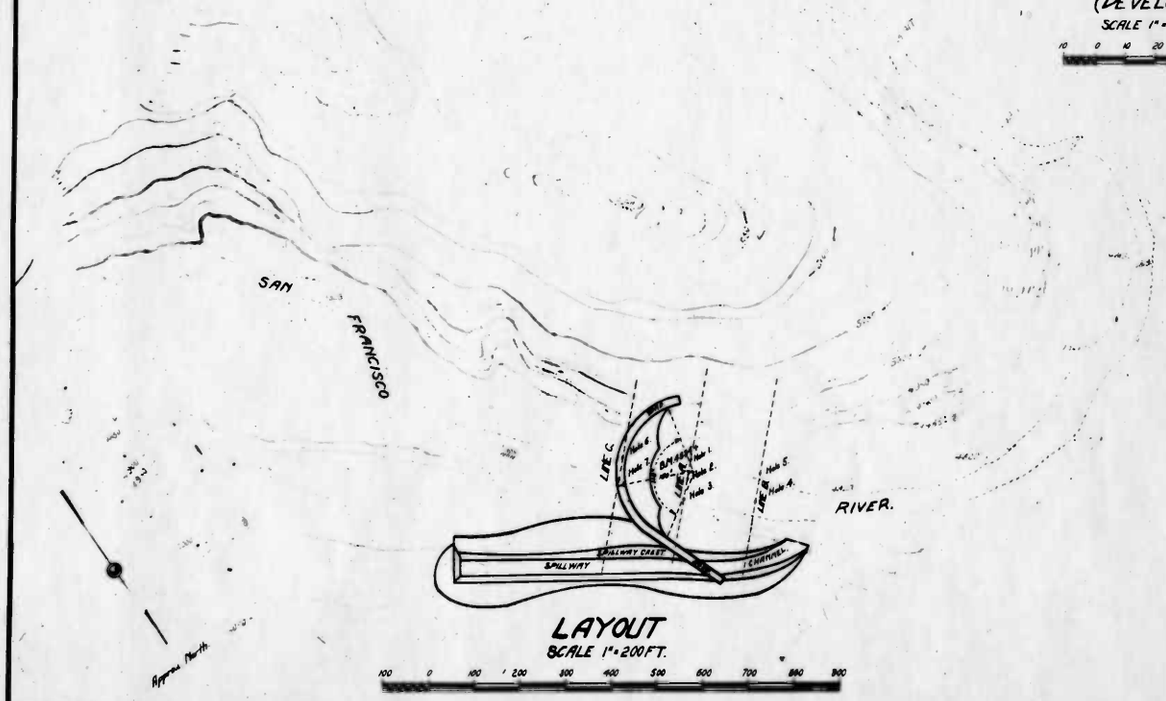


UPSTREAM ELEVATION
(DEVELOPED)
SCALE 1" = 30 FT.

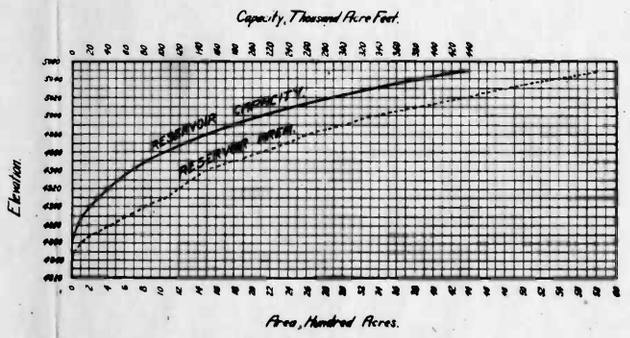


SPILLWAY SECTION

SECTION THRU BALANCED NEEDLE VALVE



LAYOUT
SCALE 1" = 200 FT.



CAPACITY & AREA CURVE
(Letter Aug 10 1920 Eng. C.C. Fisher)

NOTE:

Total Reservoir Capacity 182,000 A.F.
Alma Dam To Store 330,000 A.F.
Shown On Drawing 44-C-2.

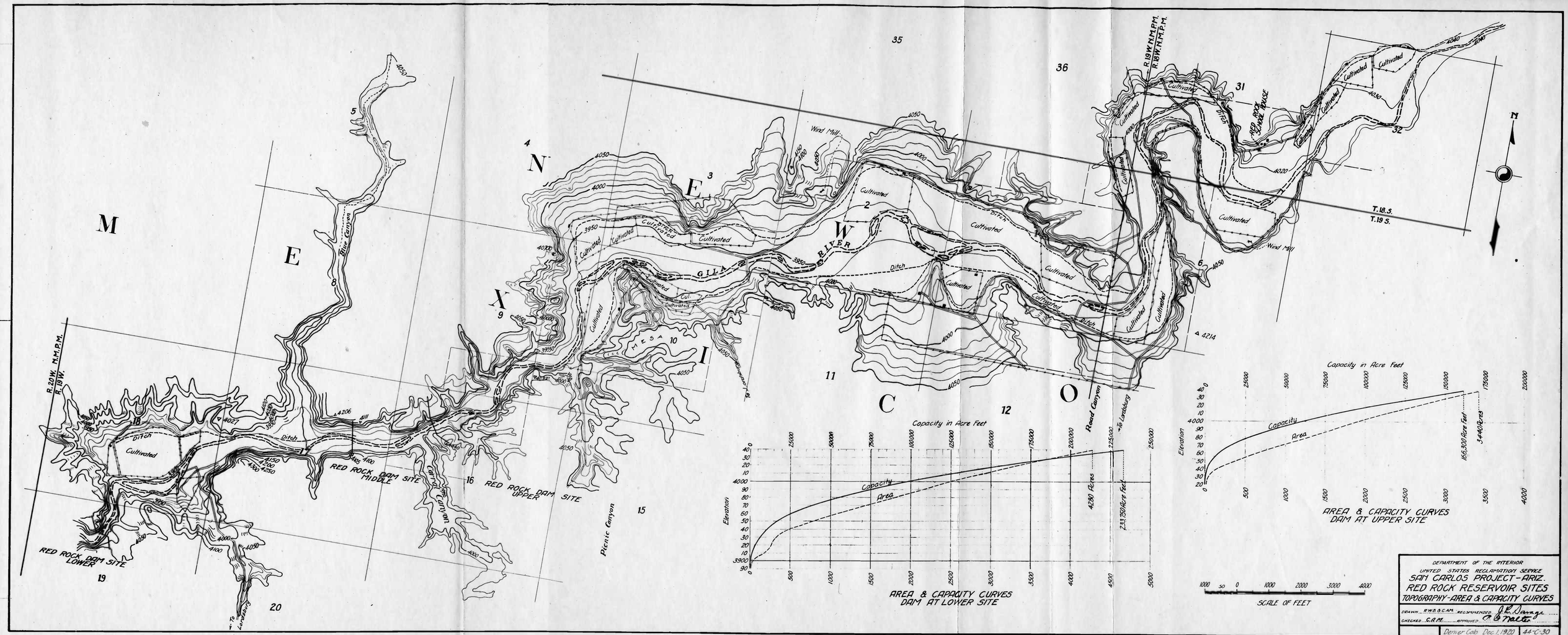
DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.
SAN CARLOS PROJECT - ARIZONA.

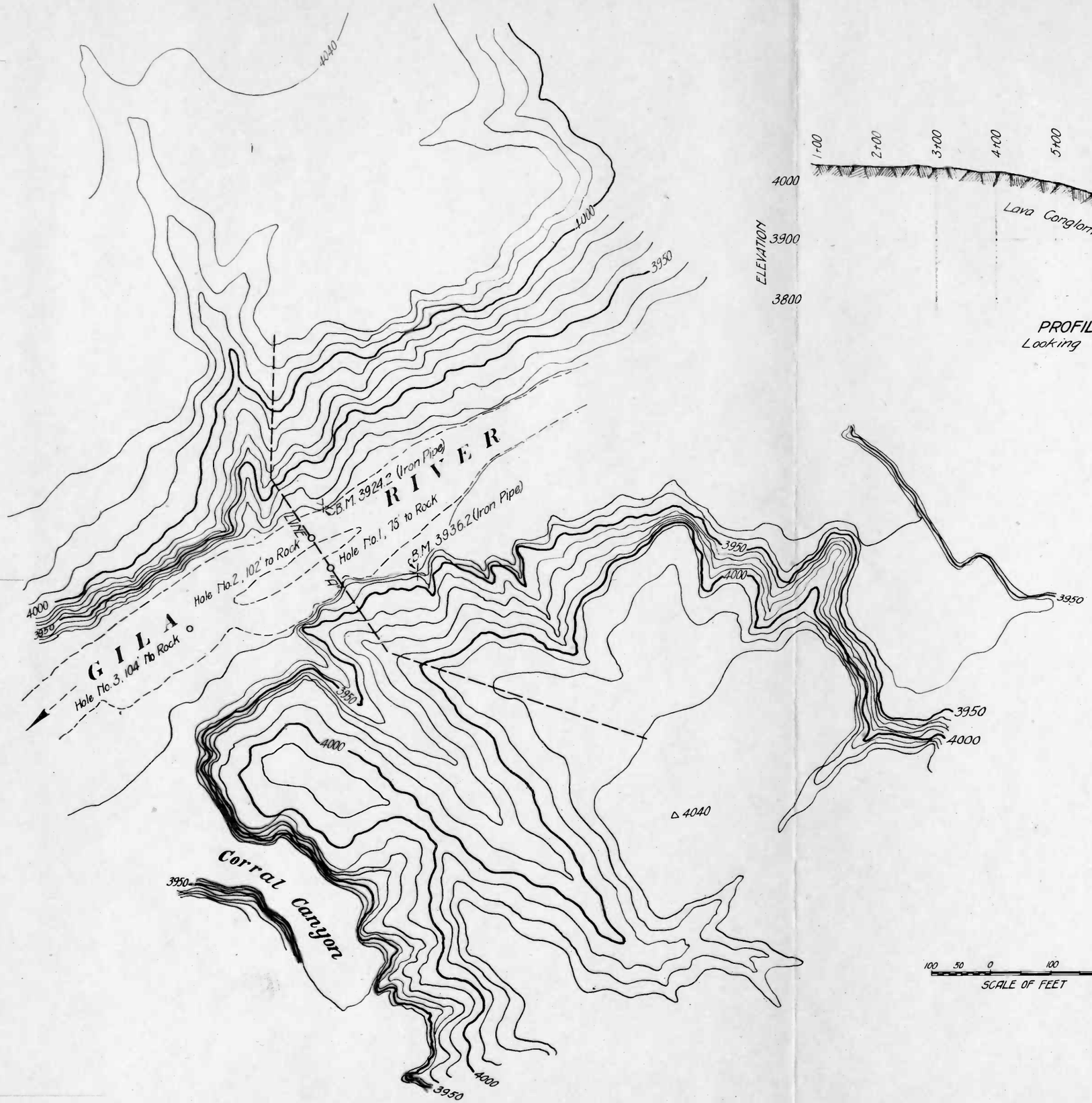
ALMA DAM

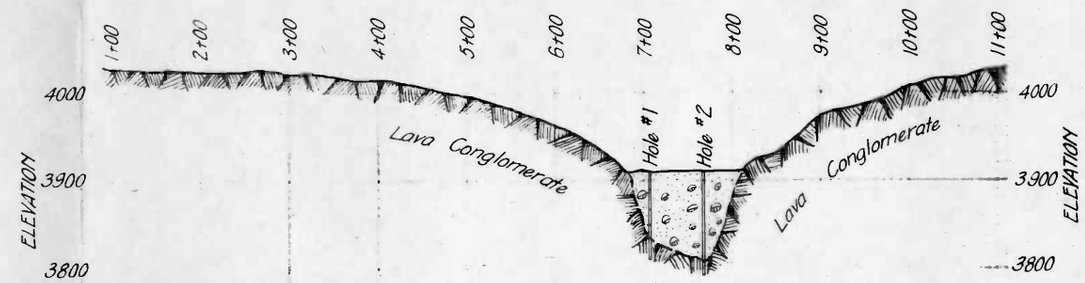
PRELIMINARY ESTIMATE DRAWING

DRAWN: C.H.M. R.H.E. RECOMMENDED:
CHECKED: C.K.H. APPROVED:

Denver Colo. Oct. 2, 1920. 44-C-4
Old Drawing No. 39-C-132


M E X I C O
N E W
GILA RIVER
MESA
Blue Canyon
Picnic Canyon
Road Canyon
Wind Mill
Ditch
Cultivated
RED ROCK DAM SITE LOWER
RED ROCK DAM SITE MIDDLE
RED ROCK DAM SITE UPPER
RED ROCK SCHOOL HOUSE
R.20W. N.M.P.M.
R.19W.
R.19W. N.M.P.M.
R.18W. N.M.P.M.
T.18.S.
T.19.S.
To Lordsburg
N
Capacity in Acre Feet
Elevation
Capacity
Area
4280 Acres
233,750 Acre Feet
AREA & CAPACITY CURVES
DAM AT LOWER SITE
166,300 Acre Feet
3440 Acres
AREA & CAPACITY CURVES
DAM AT UPPER SITE
SCALE OF FEET
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
SAN CARLOS PROJECT - ARIZ.
RED ROCK RESERVOIR SITES
TOPOGRAPHY - AREA & CAPACITY CURVES
DRAWN R.W.B. & C.A.M. RECOMMENDED
CHECKED C.A.M. APPROVED
Denver Colo. Dec. 1, 1920
44-C-30





PROFILE LINE "A"
Looking Downstream.

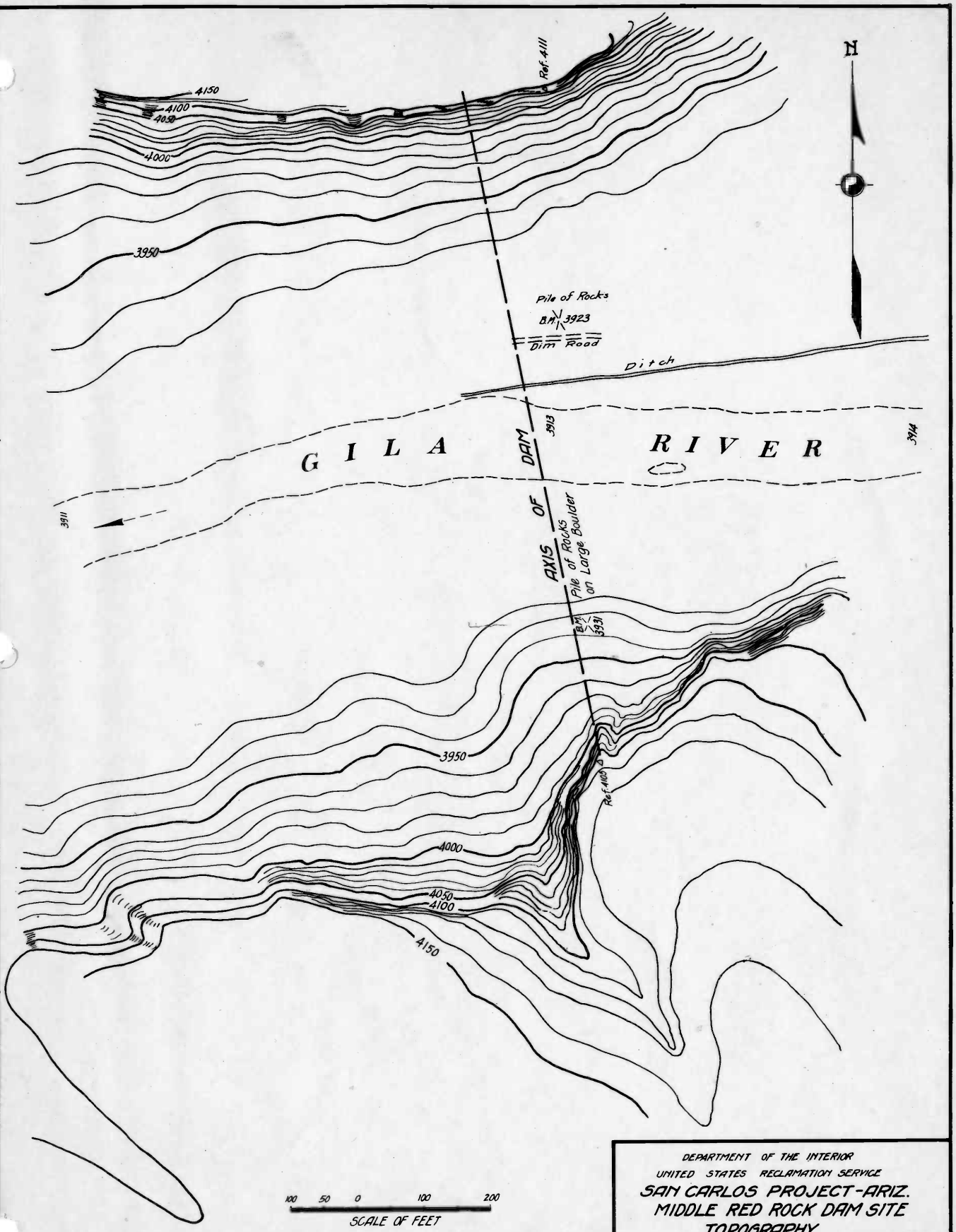
N

100 50 0 100 200
SCALE OF FEET

DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.
SAN CARLOS PROJECT - ARIZ
UPPER RED ROCK DAM SITE
TOPOGRAPHY & PROFILE

DRAWN: R.W.B.-S.J. RECOMMENDED: J.L. Savage
CHECKED: C.A.M. APPROVED: G.E. Nash

Denver Colo Dec. 1, 1920 44-C-31.

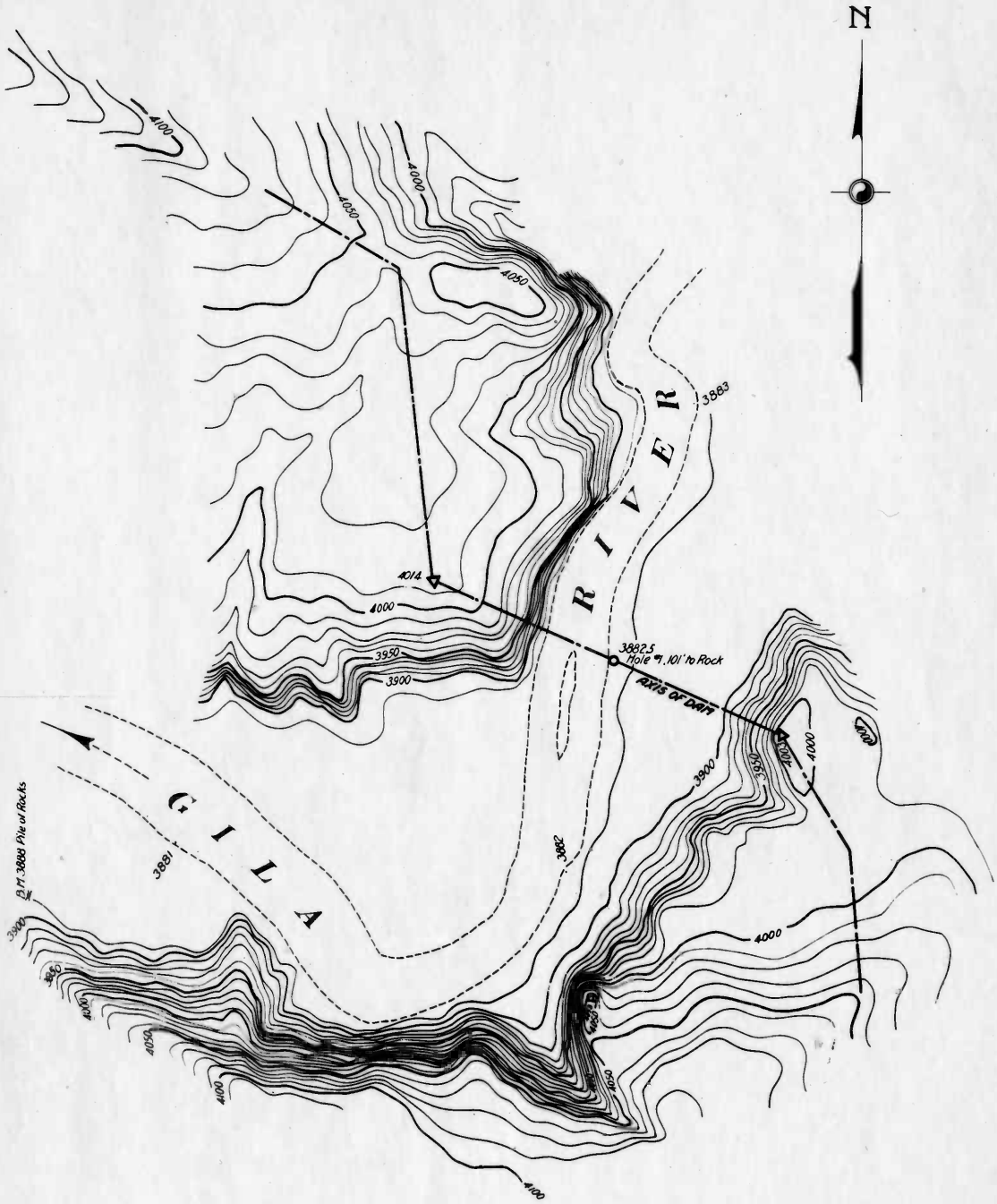


DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE

SAN CARLOS PROJECT-ARIZ.
MIDDLE RED ROCK DAM SITE
TOPOGRAPHY

DRAWN: R.W.B. - S.I. RECOMMENDED: J. L. Savage
CHECKED: G.A.M. APPROVED: A. J. Walter

Denver Colo. Dec. 1, 1920 | 44-C-32



100 50 0 100 200

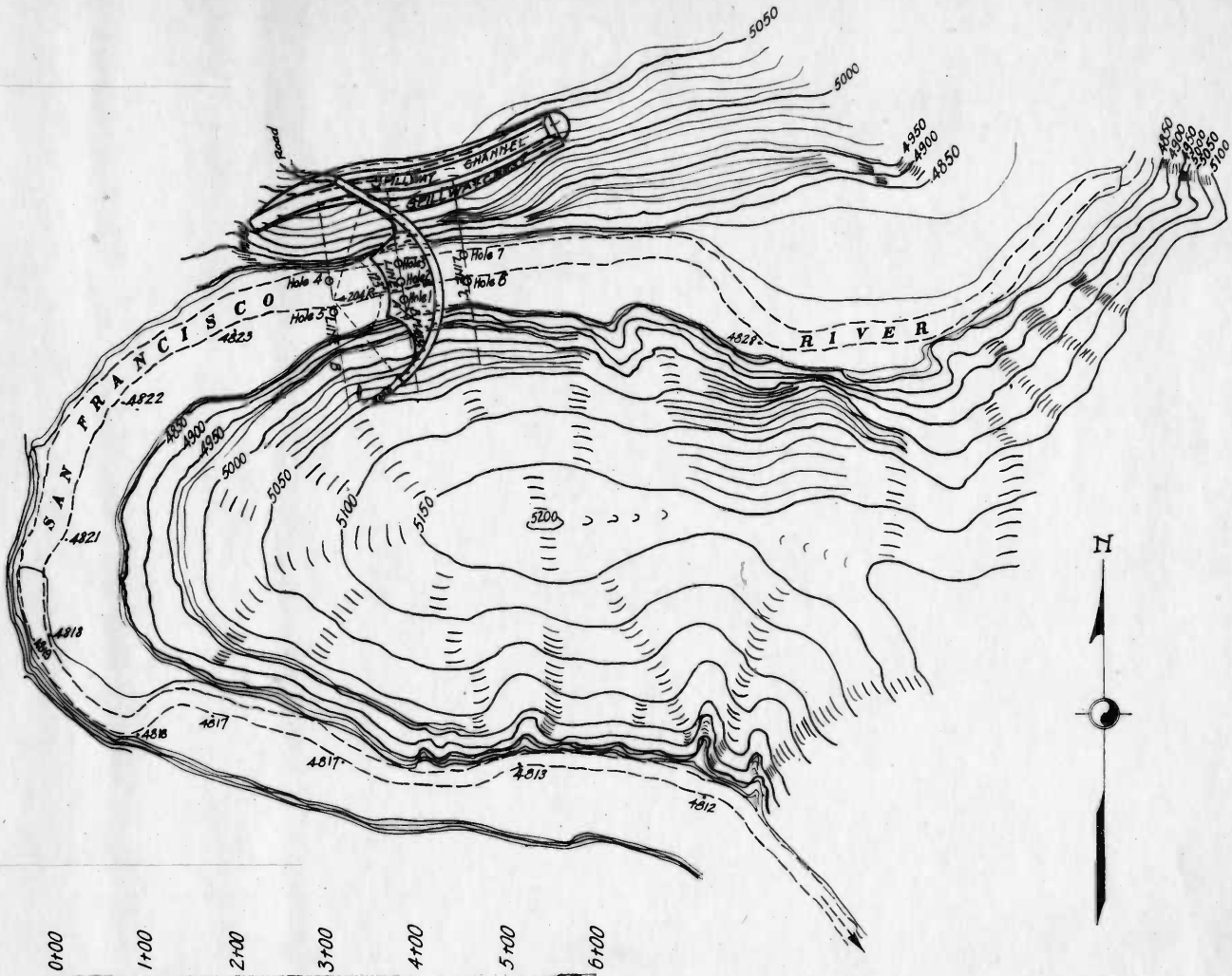
SCALE OF FEET

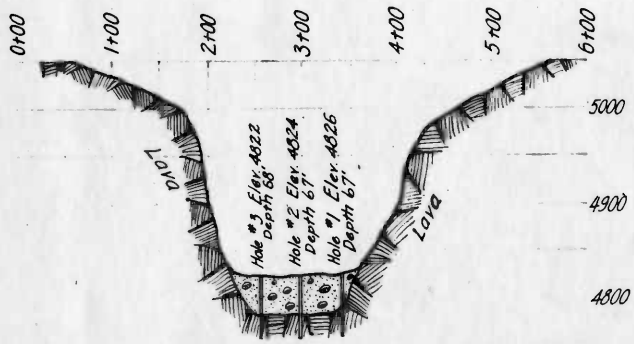
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
SAN CARLOS PROJECT ARIZ.
LOWER RED ROCK DAM SITE
TOPOGRAPHY

DRAWN B.H.S. RECOMMENDED J. L. Savage
CHECKED C.A.M. APPROVED A. P. Martin

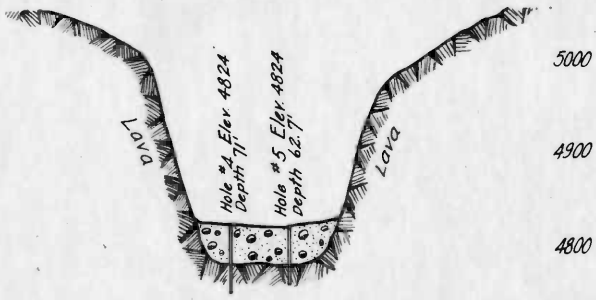
Denver, Colo, Dec. 1, 1920. 44-G-33

NEW MEXICO
N
R.21W.N.M.P.M.
R.20W.N.M.P.M.
T.10S.
T.11S.
Pueblo Canyon
Long Canyon
Deep Creek
Same Line
Thomas Flat Draw
Ranger Canyon
Thomas Flats
Keller Canyon
San Francisco River
Race Track Mesa
W.S. Ranch
Gravel Wash
Sheridan Lane Draw
McKeens Ranch Hdq.
Tank
Vigil Canyon
ALMA
H.U. Ranch
Slaughter Pen Canyon
Telephone Line
ALMA DAM
B.M. 4834
Cultivated
Pub.
NOTES
Elevations refer to Sea Level Datum.
Low Water Level of Dam Site = El. 4824.
Capacity required to utilize Mean Annual Flow = 306,000 A.F. with W.S. El. 5025.
Saddle leading out of Reservoir at El. 5037.
Area in Hundred Acres
Elevations
Area Curve
Capacity Curve
306,000 Capacity required to utilize Mean Flow
Capacity in Thousand Acre Feet
AREA & CAPACITY CURVES
DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.
SAN CARLOS PROJECT - ARIZ.
ALMA RESERVOIR SITE
TOPOGRAPHY-AREA & CAPACITY CURVES
DRAWN: R.W.B.-E.B.H.
RECOMMENDED: J.L. Savage
CHECKED: C.A.M.
APPROVED: A.J. Mahr
Denver, Colo. Dec. 1, 1920.
44-C-34

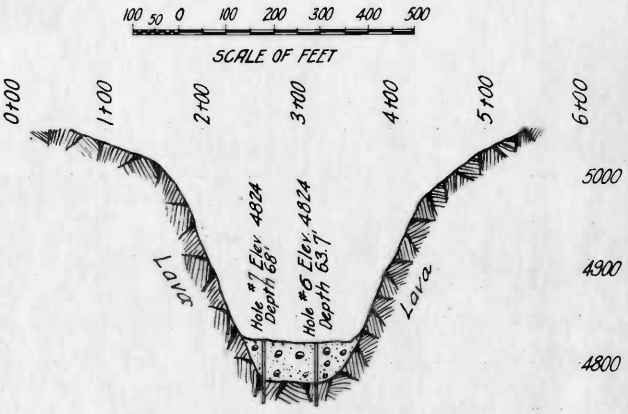




LINE 'A'



LINE 'B'



LINE 'C'

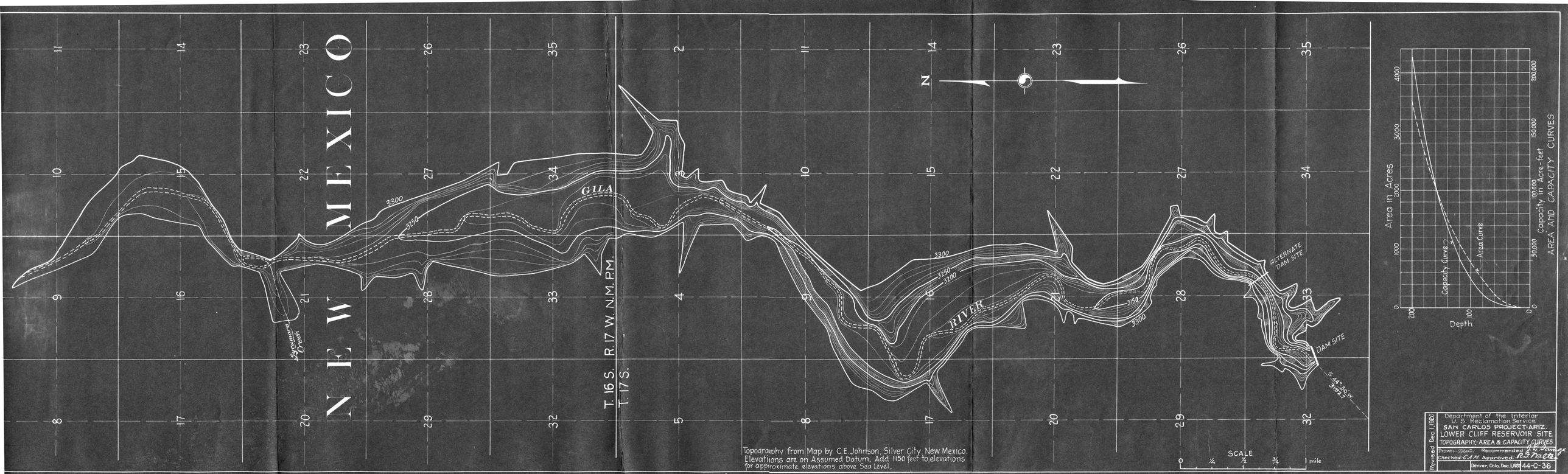
All sections looking upstream.

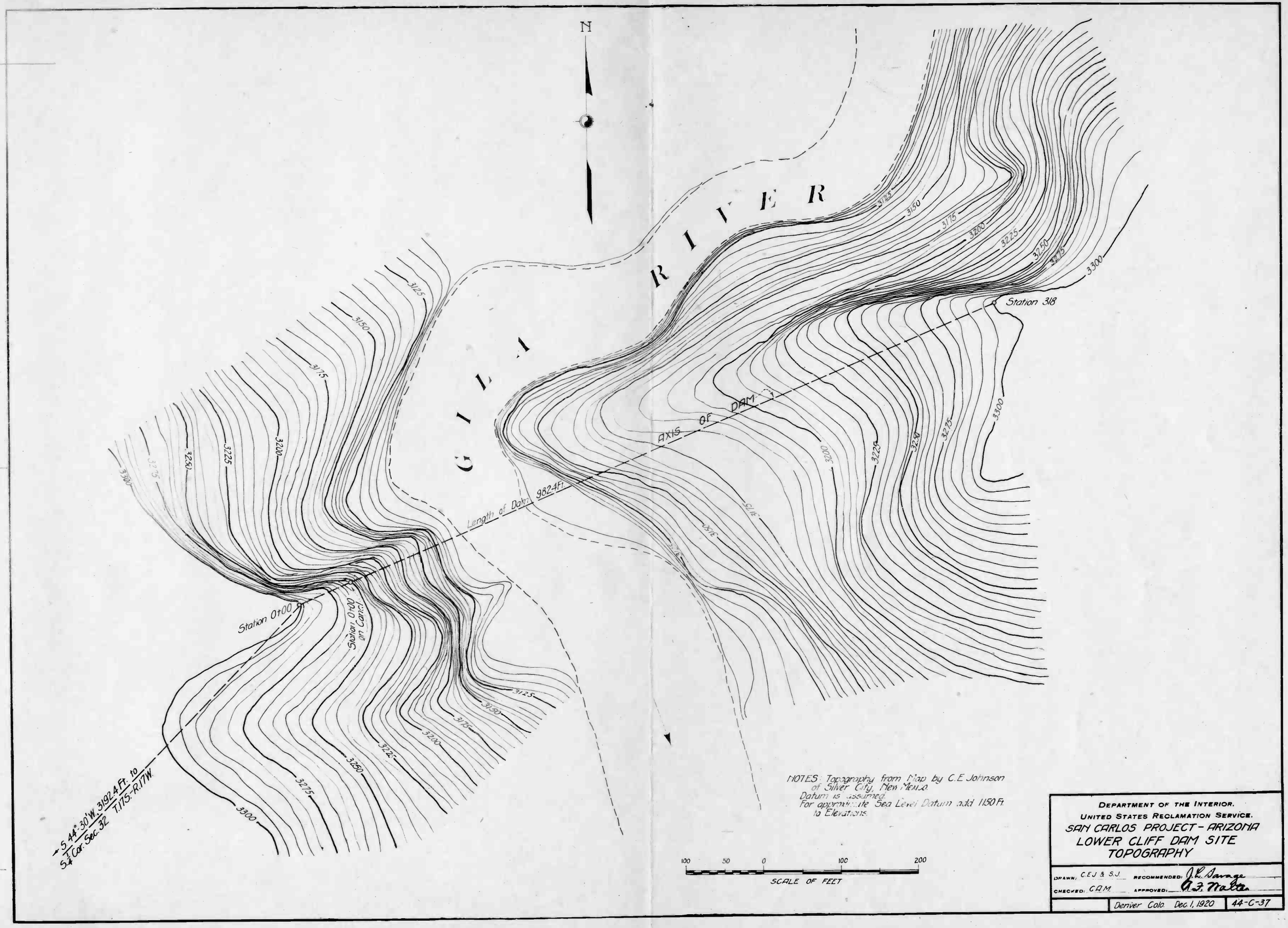
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE

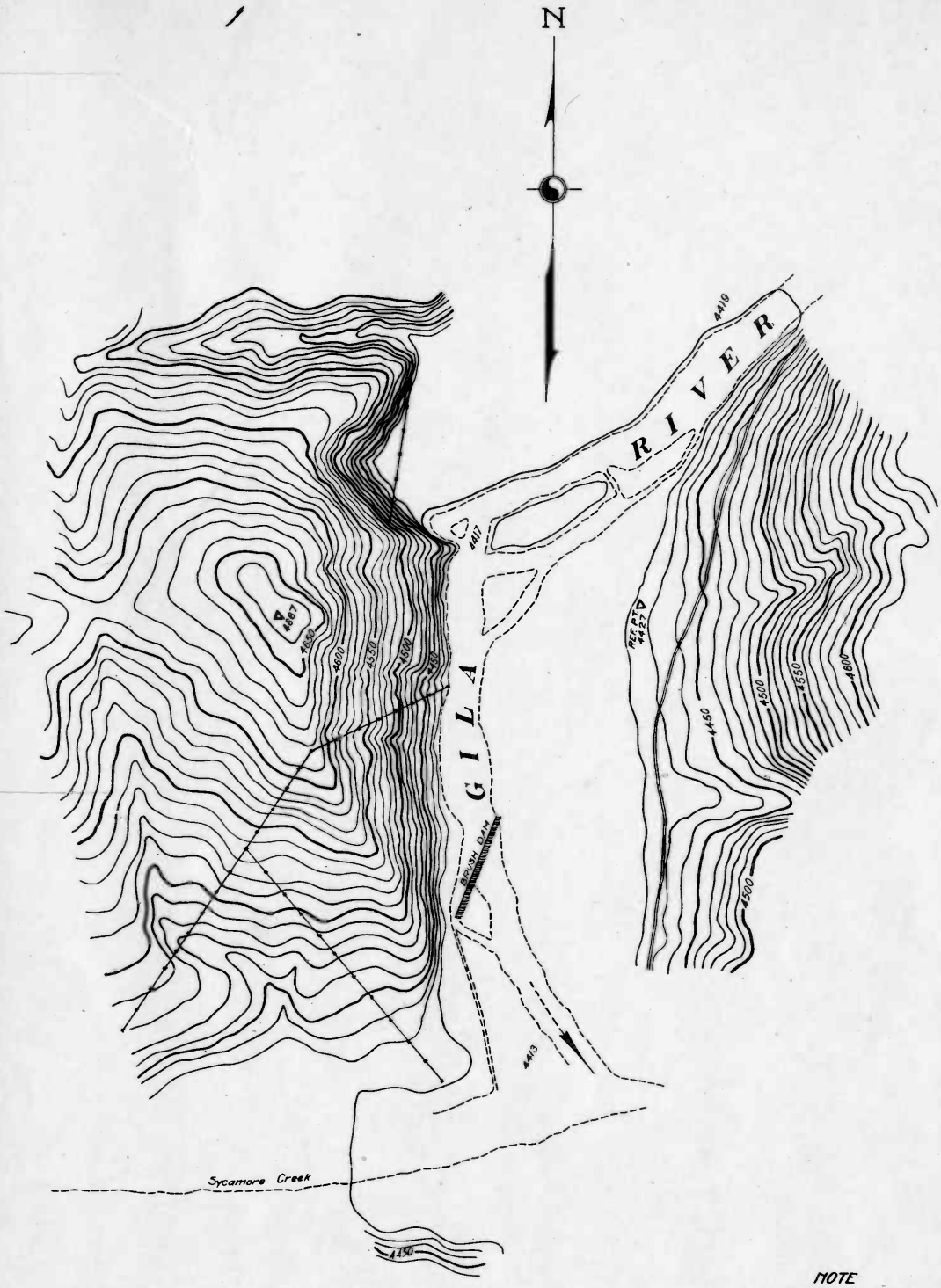
SAN CARLOS PROJECT-ARIZ.
ALMA DAM SITE
TOPOGRAPHY & PROFILES

DRAWN R.W.B. S.J. RECOMMENDED J.L. Savage
CHECKED C.A.M. APPROVED A.J. Malte

Denver Colo. Dec. 1, 1920. 44-C-35


NEW MEXICO
T. 16 S.
T. 17 S.
R. 17 W. N.M.P.M.
GILA
RIVER
Sycamore Creek
3300
3250
3200
3150
ALTERNATE DAM SITE
DAM SITE
S. 45° 26' W.
3967.7
N
SCALE
0
1/4
1/2
3/4
1 mile
Area in Acres
Capacity Curve
Area Curve
Capacity in Acre-feet
Depth
AREA AND CAPACITY CURVES
Topography from Map by C.E. Johnson, Silver City, New Mexico.
Elevations are on Assumed Datum. Add 1150 feet to elevations for approximate elevations above Sea Level.
Department of the Interior
U. S. Reclamation Service
SAN CARLOS PROJECT-ARIZ.
LOWER CLIFF RESERVOIR SITE
TOPOGRAPHY, AREA & CAPACITY CURVES
Drawn: J.G.C. Recommended: H. Dougherty
Checked: C.A.M. Approved: R. J. Tracy
Denver, Colo. Dec. 1, 1926
44-C-36
Revised Dec. 1, 1926


N
GILA RIVER
Station 3+18
AXIS OF DAM
Length of Dam 982.4 Ft.
Station 0+00
Station 0+00 on Canal
S 44° 30' W. 3192.4 Ft. to S.¼ Cor. Sec. 32 T.17S.-R.17W.
3125
3150
3175
3200
3225
3250
3275
3300
NOTES: Topography from Map by C.E. Johnson of Silver City, New Mexico.
Datum is assumed.
For approximate Sea Level Datum add 1150 Ft. to Elevations.
100 50 0 100 200
SCALE OF FEET
DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.
SAN CARLOS PROJECT - ARIZONA
LOWER CLIFF DAM SITE
TOPOGRAPHY
DRAWN: C.E.J. & S.J.
RECOMMENDED: J.L. Savage
CHECKED: C.A.M.
APPROVED: A.P. Martin
Denver Colo. Dec. 1, 1920
44-C-37



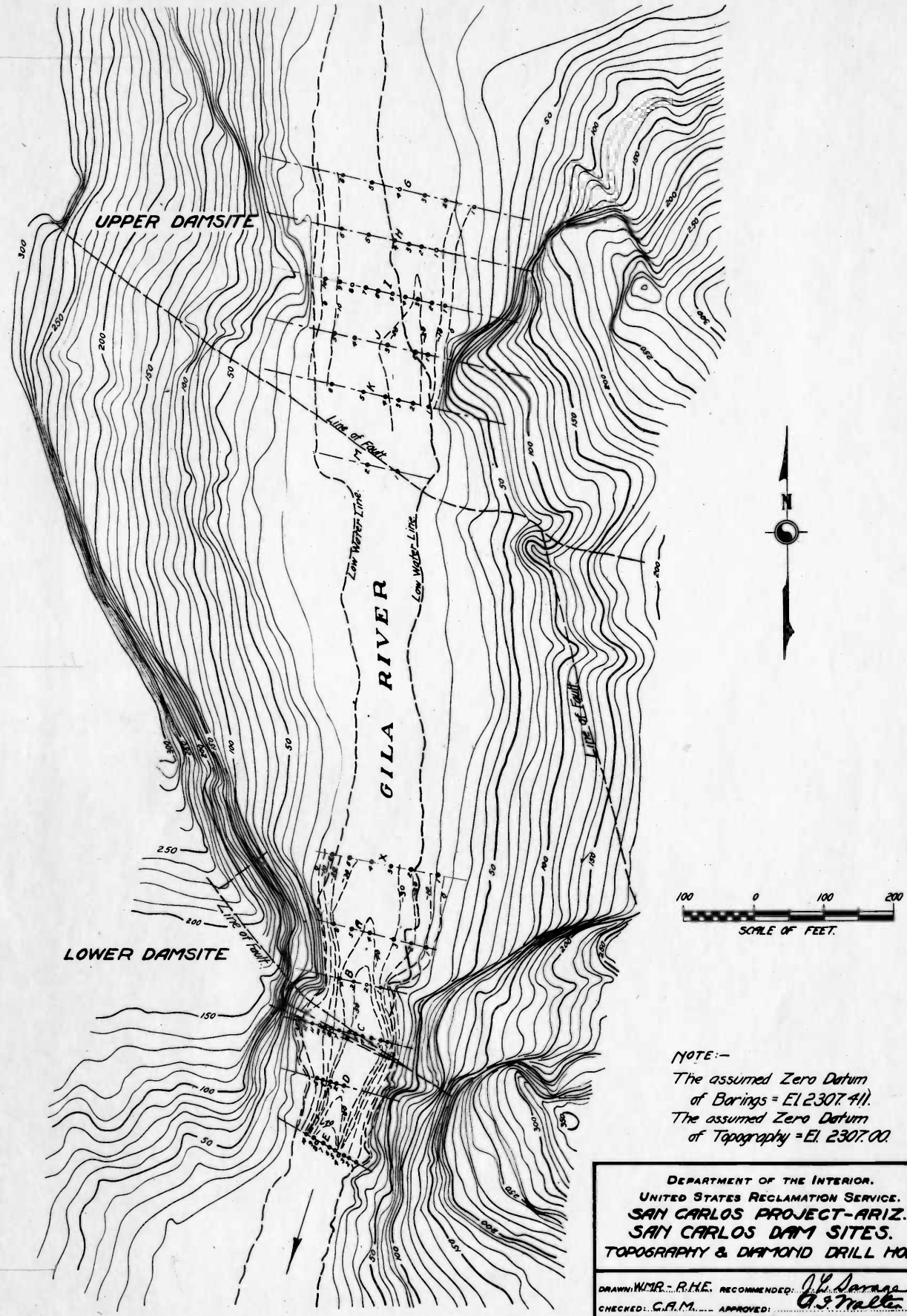
NOTE
Location N.E. ¼ Sec. 21, T.16 S., R.17 W., N.M.P.M.
Sea Level Datum.

100 50 0 100 200 300 400 500
SCALE OF FEET

DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
SAN CARLOS PROJECT ARIZ.
CLIFF DAM SITE
TOPOGRAPHY

DRAWN R.N.B. G.C.W. E.B.H. RECOMMENDED J. L. Savage
CHECKED G.A.M. APPROVED G. F. Walter

Denver, Colo., Dec. 1, 1920. 44-C-38



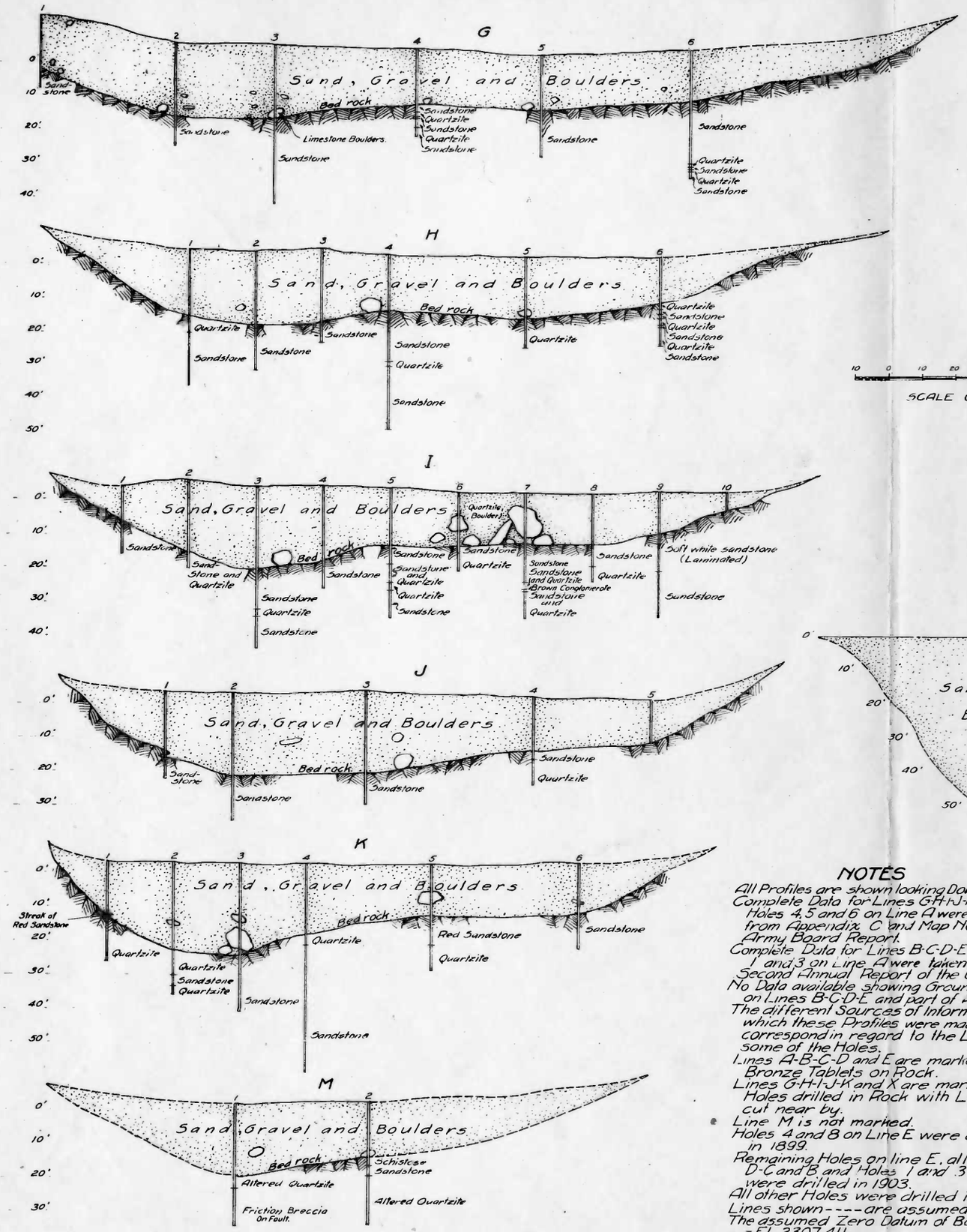
NOTE:-
The assumed Zero Datum of Borings = El. 2307.411.
The assumed Zero Datum of Topography = El. 2307.00.

DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.
SAN CARLOS PROJECT-ARIZ.
SAN CARLOS DAM SITES.
TOPOGRAPHY & DIAMOND DRILL HOLES

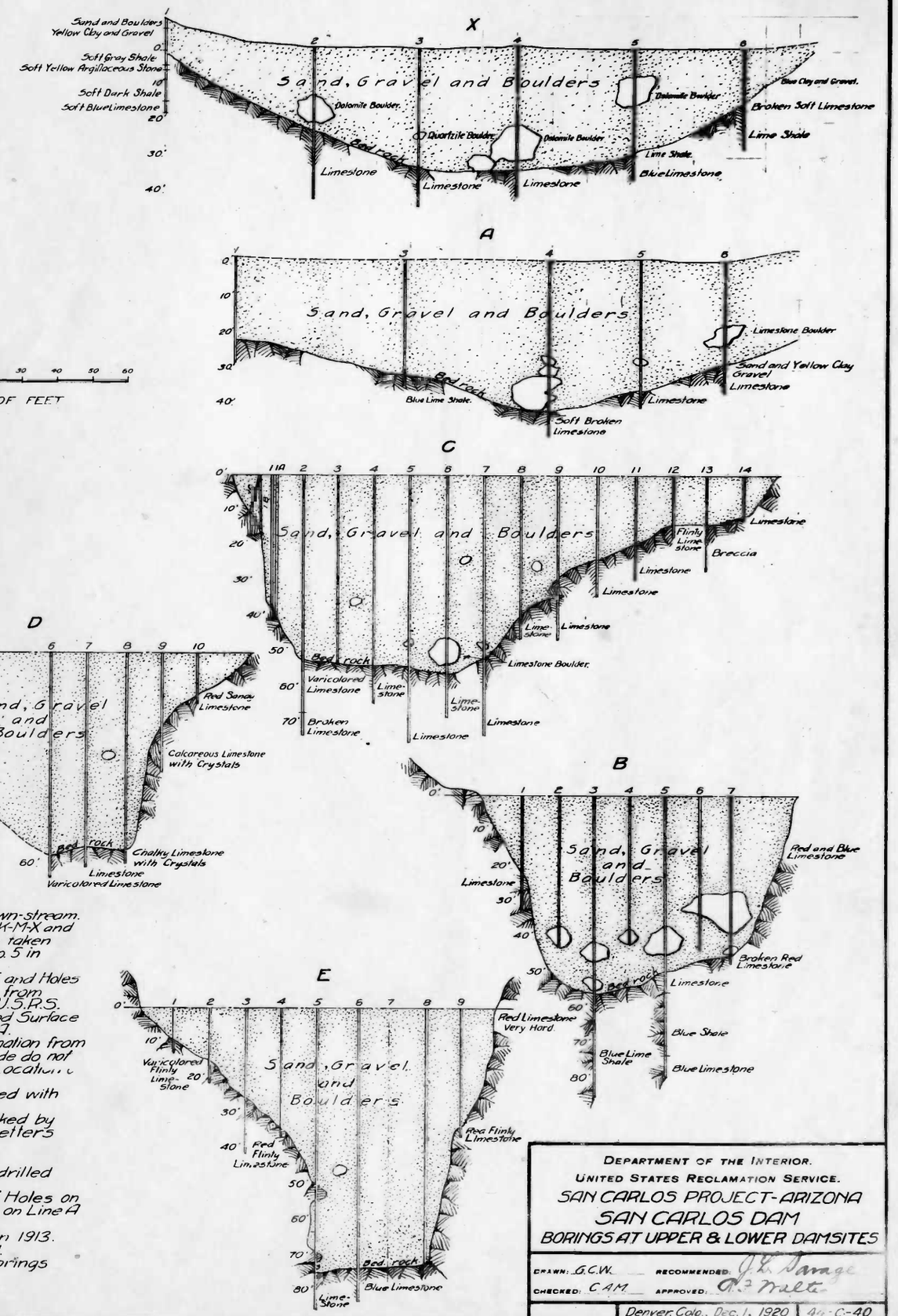
DRAWN: W.M.R. - R.H.E. RECOMMENDED: J. L. Savage
CHECKED: C.A.M. APPROVED: A. J. Walter

Denver, Colo. Dec. 1, 1920. 44-C-39

UPPER SITE



LOWER SITE



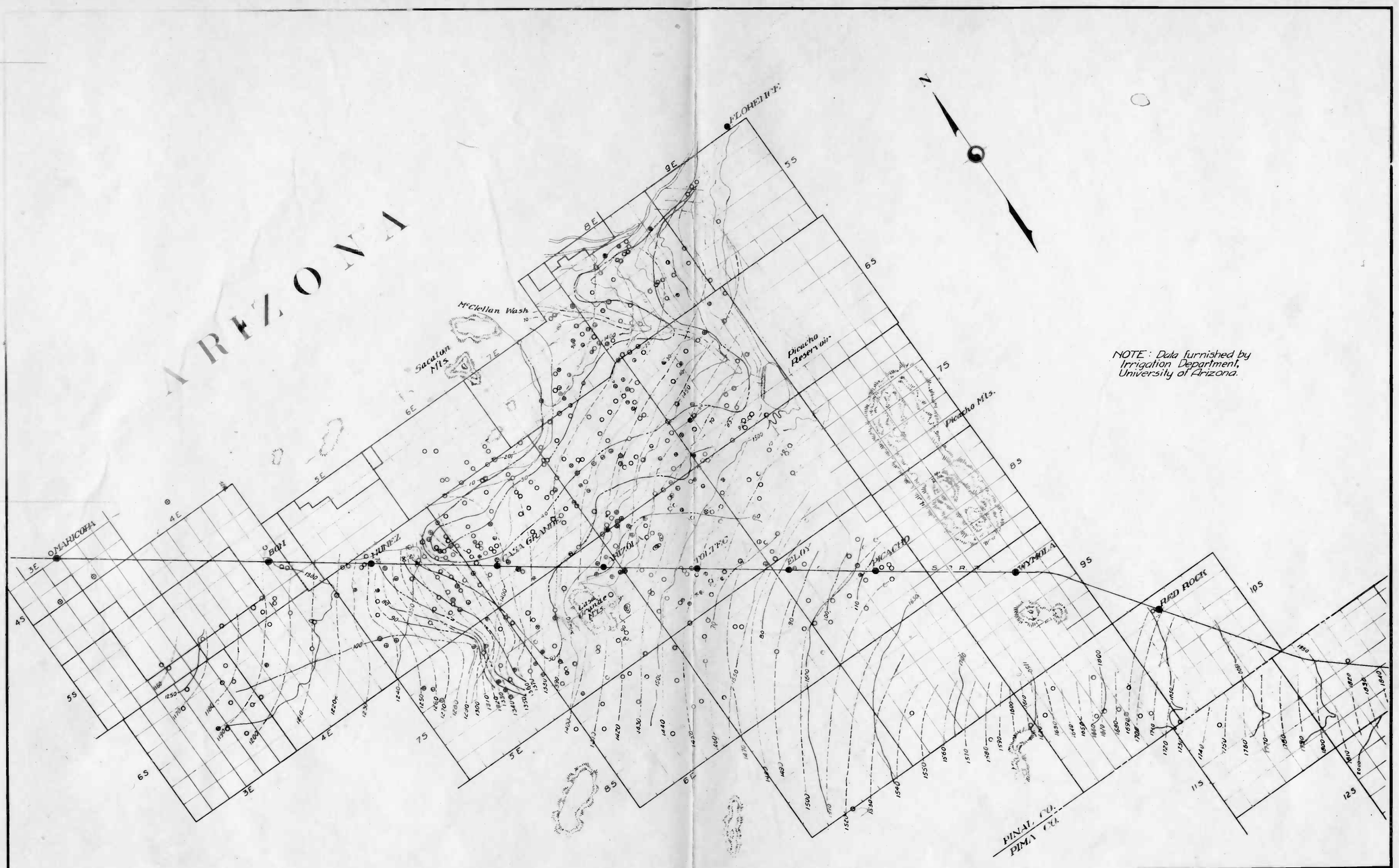
NOTES

All Profiles are shown looking Down-stream.
Complete Data for Lines G-H-I-J-K-M-X and Holes 4, 5 and 6 on Line A were taken from Appendix C and Map No. 5 in Army Board Report.
Complete Data for Lines B-C-D-E and Holes 1 and 3 on Line A were taken from Second Annual Report of the U.S.R.S.
No Data available showing Ground Surface on Lines B-C-D-E and part of A.
The different Sources of Information from which these Profiles were made do not correspond in regard to the Location of some of the Holes.
Lines A-B-C-D and E are marked with Bronze Tablets on Rock.
Lines G-H-I-J-K and X are marked by Holes drilled in Rock with Letters cut near by.
Line M is not marked.
Holes 4 and 8 on Line E were drilled in 1899.
Remaining Holes on line E, all Holes on D-C and B, and Holes 1 and 3 on Line A were drilled in 1903.
All other Holes were drilled in 1913.
Lines shown - - - - are assumed.
The assumed Zero Datum of Borings = El. 2307.411.

DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.
SAN CARLOS PROJECT-ARIZONA
SAN CARLOS DAM
BORINGS AT UPPER & LOWER DAMSITES

DRAWN: G.C.W. RECOMMENDED: J. L. Savage
CHECKED: C.A.M. APPROVED: A. P. Melton

Denver, Colo., Dec. 1, 1920 | 44-C-40



LEGEND

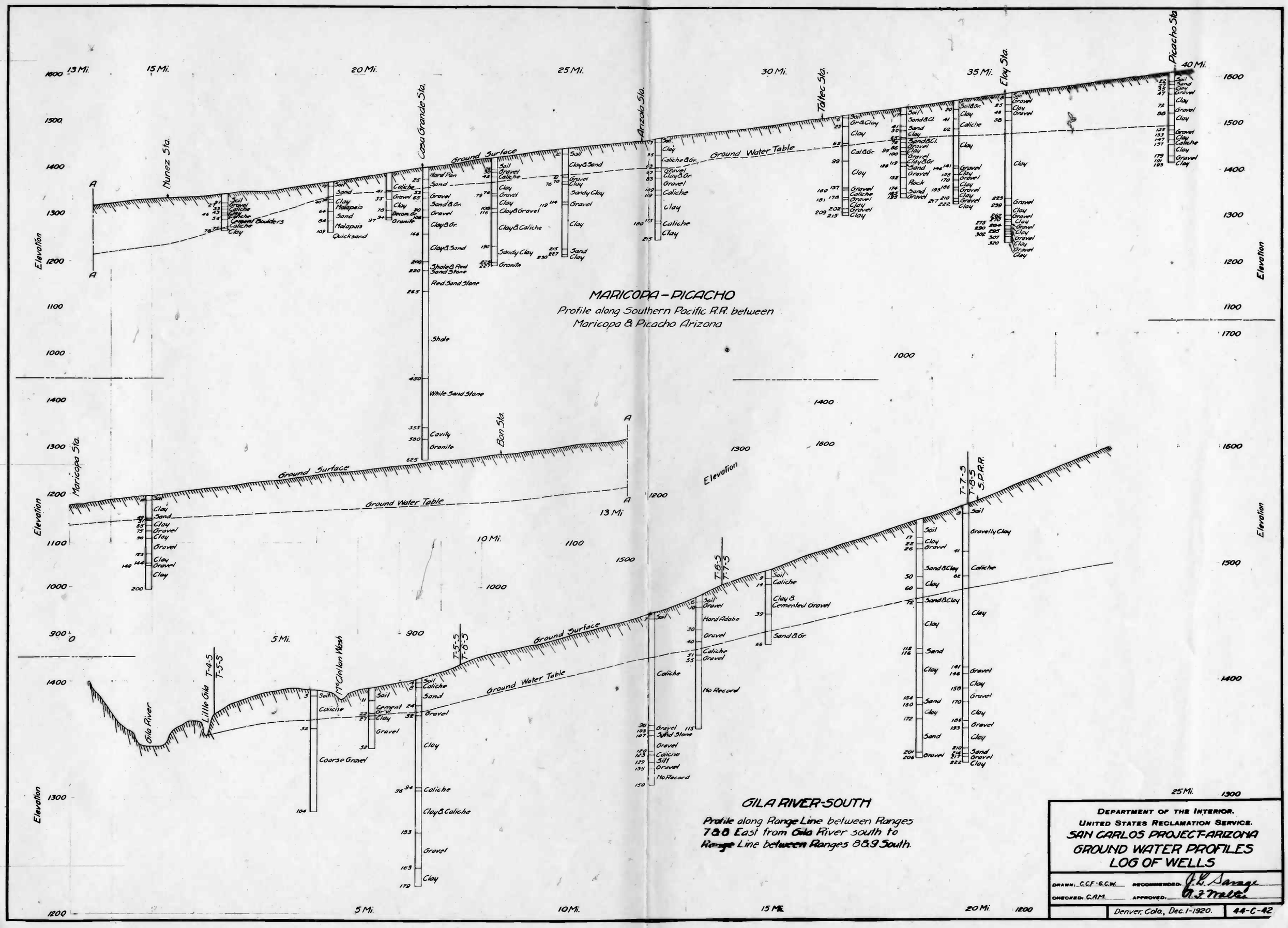
- ○ Domestic Wells
- ⊕ Irrigation Wells
- 10' Contours
- 50' Contours
- Depth Contours
- Under Ground Contours

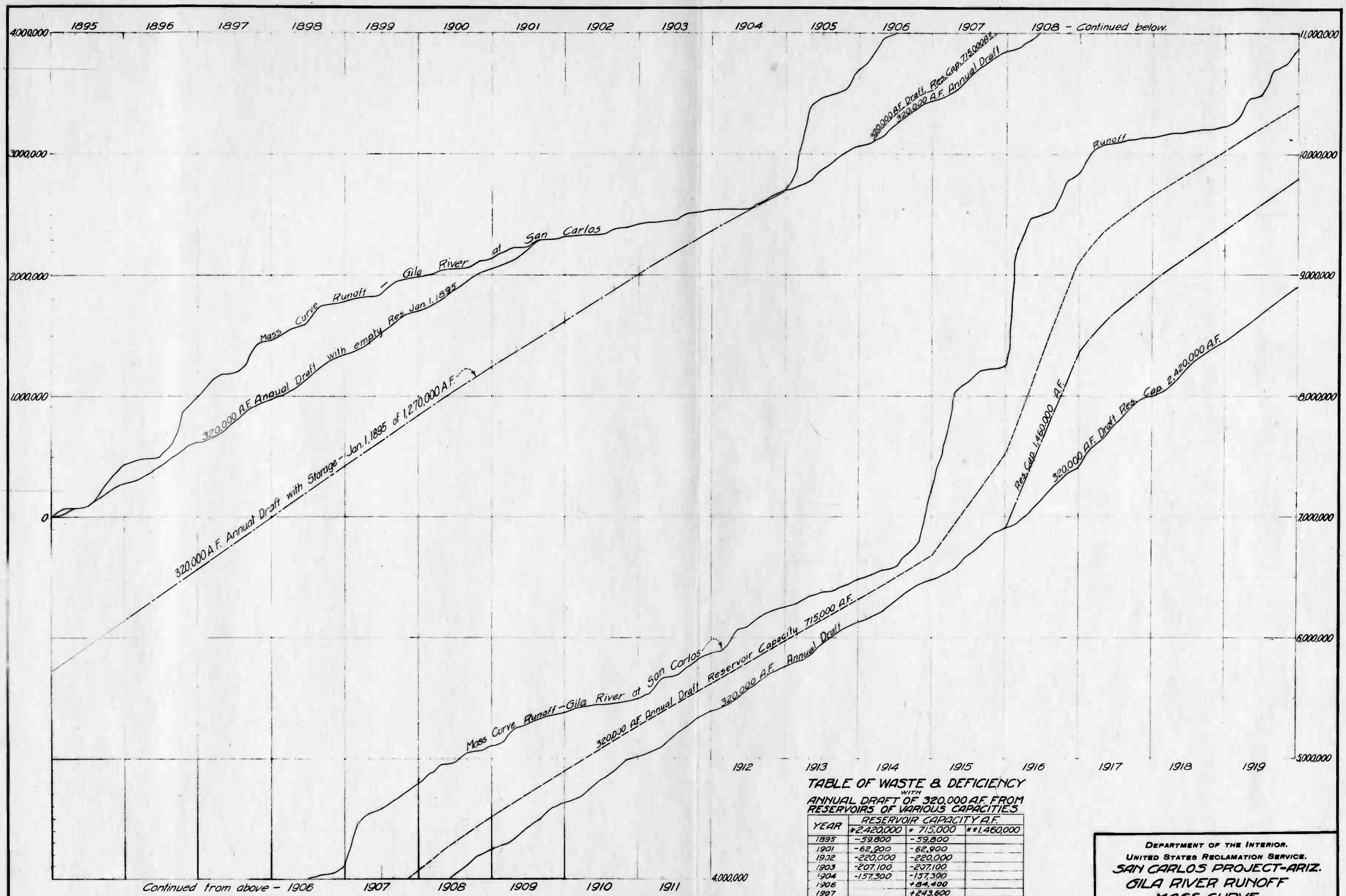
DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.

SAN CARLOS PROJECT-ARIZ.
CASA GRANDE VALLEY
GROUND WATER MAP

DRAWN: S.C.W. RECOMMENDED: J. L. Savage
CHECKED: C.A.M. APPROVED: A. J. Malta

Denver, Colo., Dec. 1 - 1920 | 44-C-41


MARICOPA-PICACHO
Profile along Southern Pacific R.R. between
Maricopa & Picacho Arizona
Ground Surface
Ground Water Table
Elevation
Munez Sta.
Casa Grande Sta.
Arizola Sta.
Toltec Sta.
Eloy Sta.
Picacho Sta.
Maricopa Sta.
Bon Sta.
13 Mi.
15 Mi.
20 Mi.
25 Mi.
30 Mi.
35 Mi.
40 Mi.
10 Mi.
5 Mi.
GILA RIVER-SOUTH
Profile along Range Line between Ranges
7 & 8 East from Gila River south to
Range Line between Ranges 8 & 9 South.
Gila River
Little Gila
McClellan Wash
T-4-5
T-5-5
T-6-5
T-7-5
T-8-5
S.P.R.R.
DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.
SAN CARLOS PROJECT ARIZONA
GROUND WATER PROFILES
LOG OF WELLS
DRAWN: C.C.F.-G.C.W.
RECOMMENDED: J.L. Savage
CHECKED: C.A.M.
APPROVED: A.J. Mels
Denver, Colo., Dec. 1-1920.
44-C-42



NOTE: Vertical Distance between Runoff Curve and Draft Curve equals Storage

TABLE OF WASTE & DEFICIENCY WITH ANNUAL DRAFT OF 320,000 A.F. FROM RESERVOIRS OF VARIOUS CAPACITIES

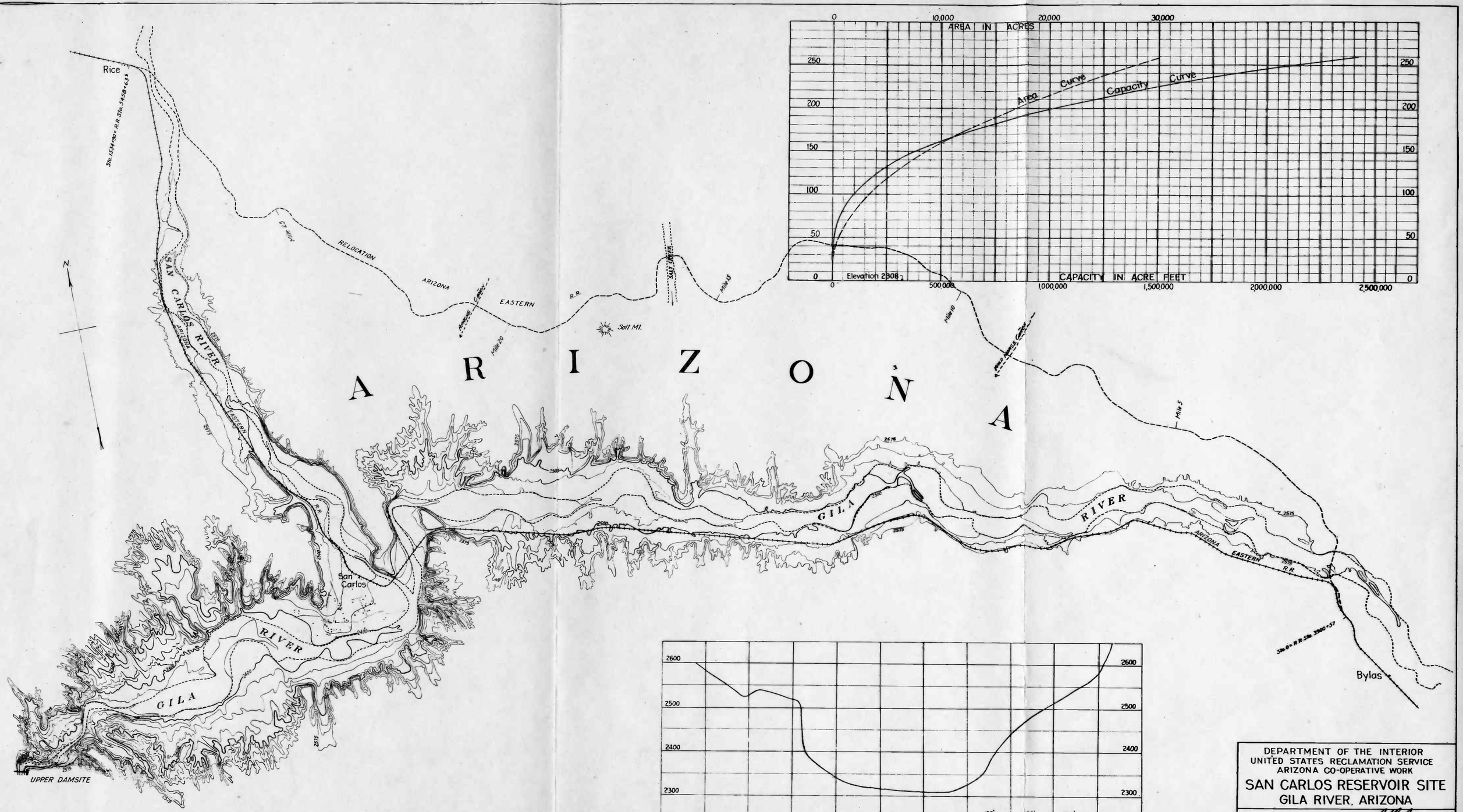
YEAR	RESERVOIR CAPACITY A.F.		
	*2,420,000	* 715,000	**1,460,000
1895	-59,800	-59,800	
1901	-62,900	-62,900	
1902	-220,000	-220,000	
1903	-207,100	-207,100	
1904	-157,300	-157,300	
1906		+84,400	
1907		+243,600	
1908		+88,000	
1915		+481,500	
1916	+36,600	+1,203,800	+1,037,300
1917	+130,800	+149,400	+139,800

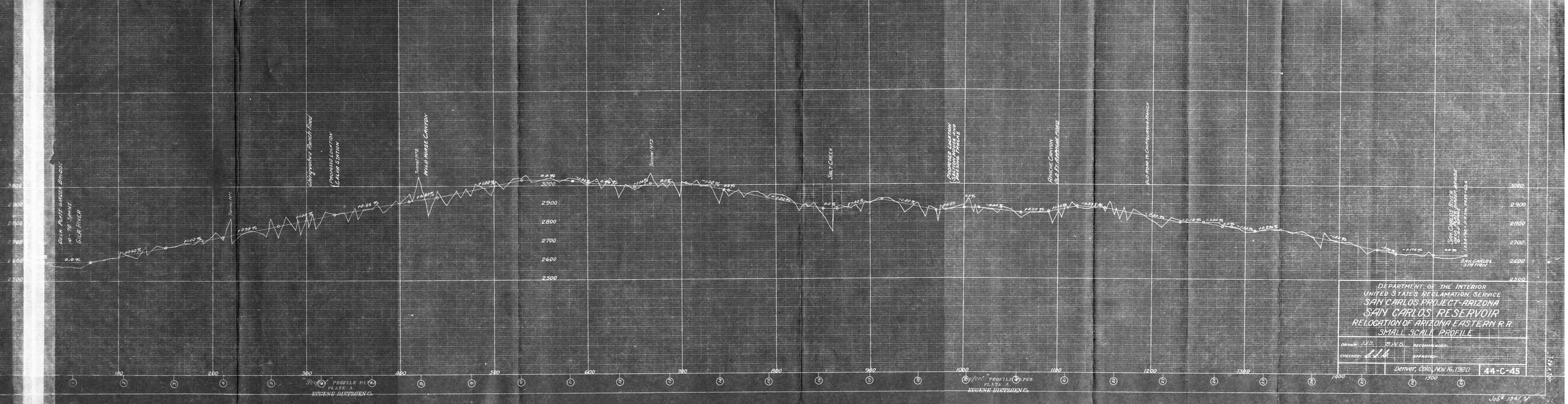
* Res. assumed empty on Jan. 1, 1895
** Res. assumed to contain 1,270,000 A.F. on Jan. 1, 1895
\+ Indicates a Waste. — Indicates a Deficiency

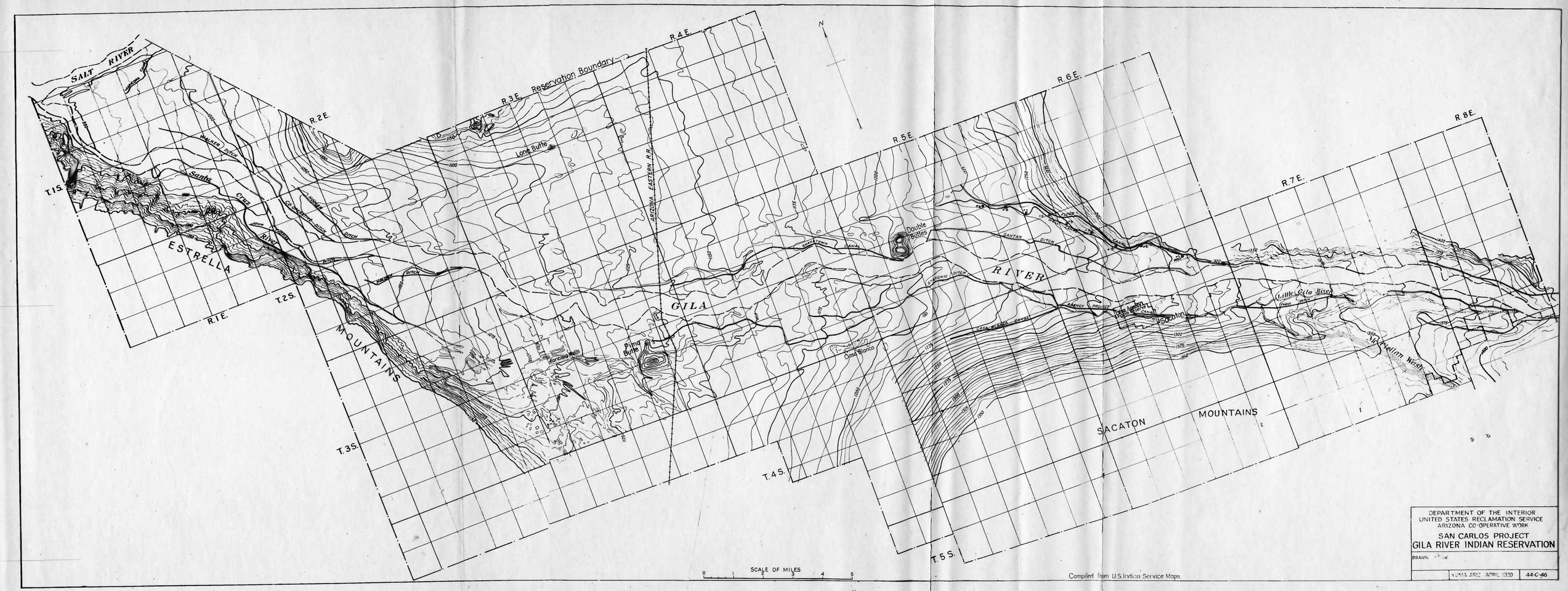
DEPARTMENT OF THE INTERIOR.
UNITED STATES RECLAMATION SERVICE.
SAN CARLOS PROJECT-ARIZ.
GILA RIVER RUNOFF
MASS CURVE

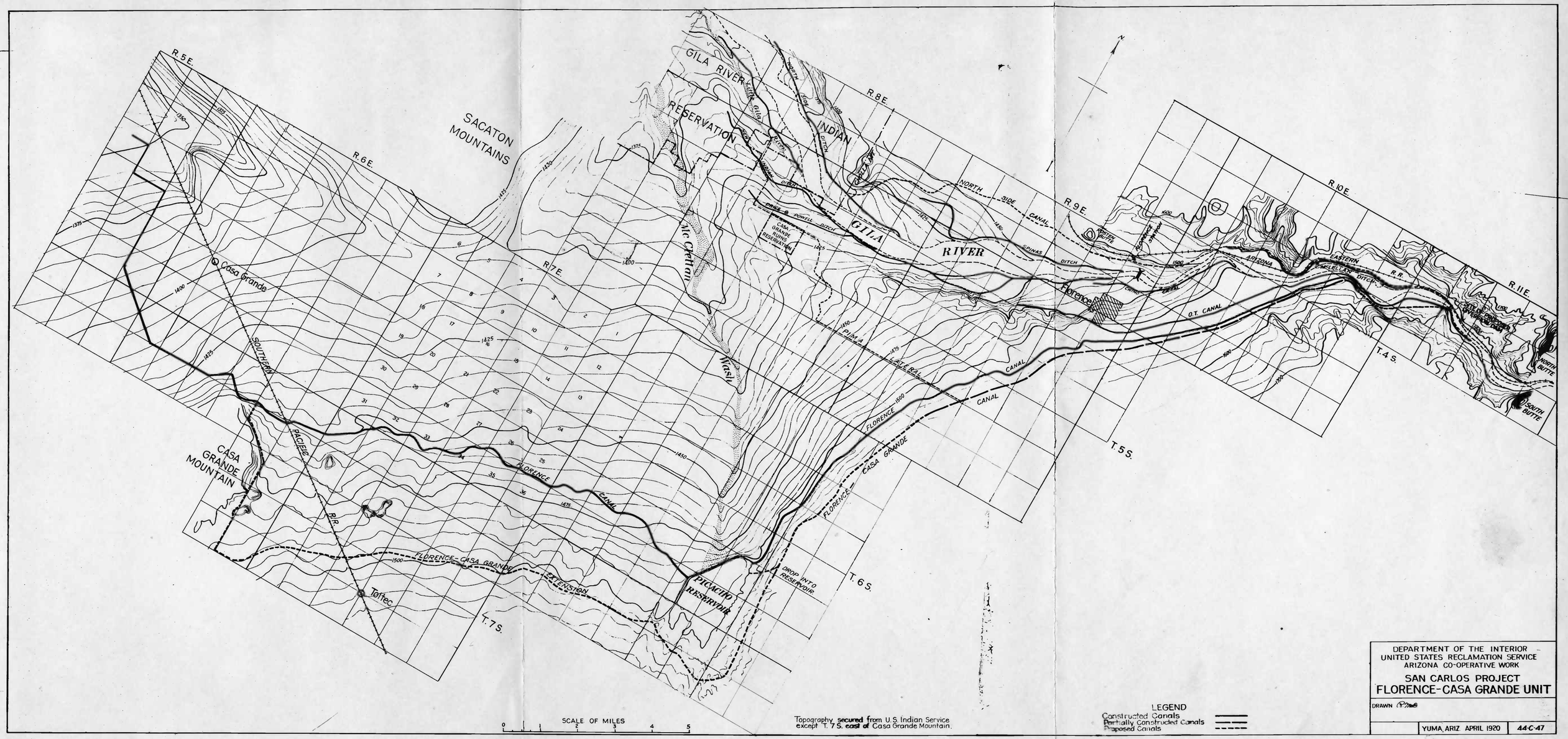
DRAWN: G.C.W. RECOMMENDED: J. L. Savage
CHECKED: C.A.M. APPROVED: G. F. Nelle

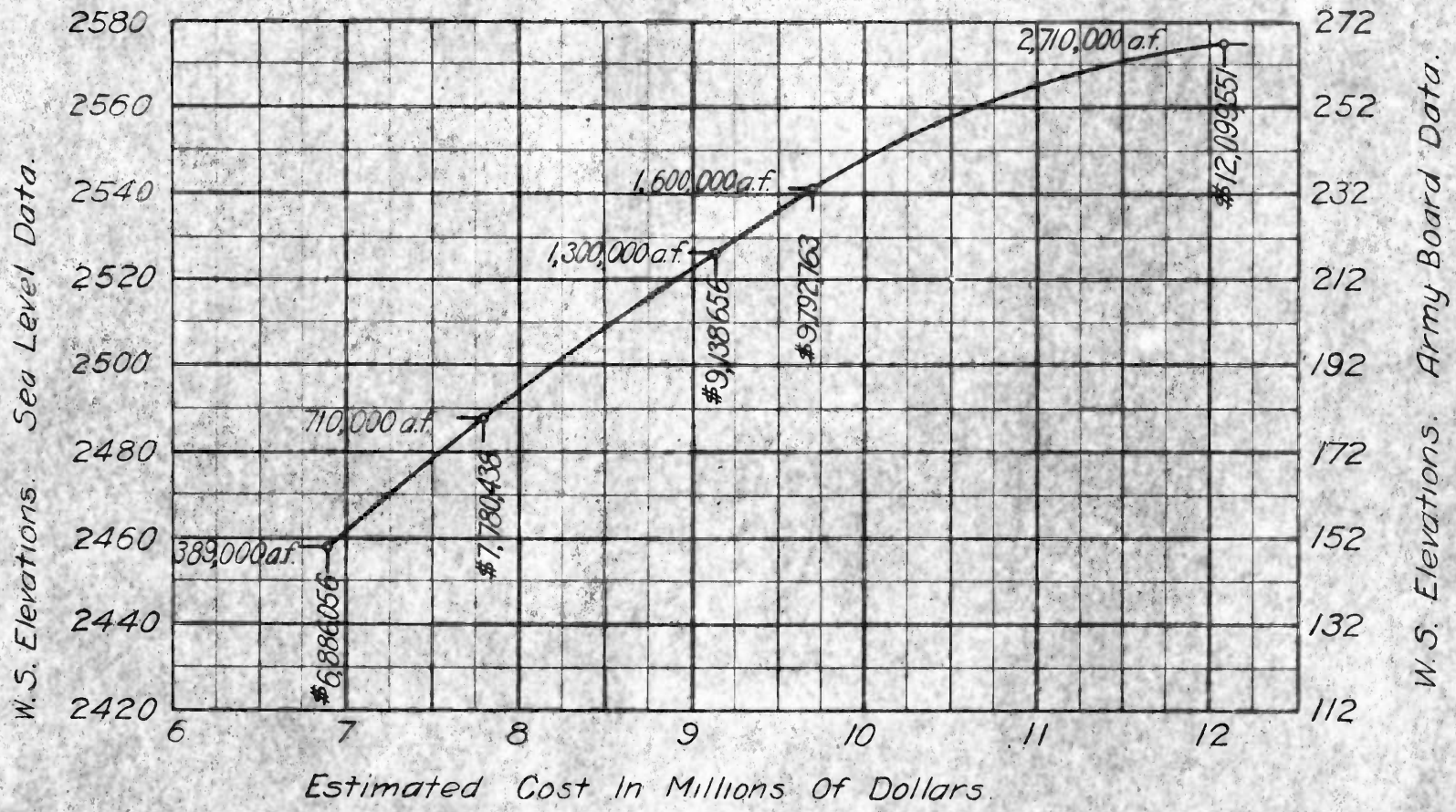
Denver Colo. Dec 1, 1920 | 44-C-43


AREA IN ACRES
0
10,000
20,000
30,000
250
200
150
100
50
0
Area Curve
Capacity Curve
Elevation 2308
CAPACITY IN ACRE FEET
500,000
1,000,000
1,500,000
2,000,000
2,500,000
Rice
Sta. 1534+90 = R.R. Sta. 5458+63
N.
SAN CARLOS RIVER
ARIZONA
EASTERN
R.R.
RELOCATION
Mile 25
Mile 20
Mile 15
Mile 10
Mile 5
Salt Mt.
A R I Z O N A
GILA
RIVER
San Carlos
UPPER DAMSITE
Bylas
Sta. 0 = R.R. Sta. 3500+37
2600
2500
2400
2300
100'
CROSS SECTION OF DAM SITE
LOOKING DOWN STREAM
SCALE OF FEET
0
5000
10,000
15,000
20,000
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
ARIZONA CO-OPERATIVE WORK
SAN CARLOS RESERVOIR SITE
GILA RIVER, ARIZONA
DRAWN
RECOMMENDED
CHECKED
APPROVED
YUMA, ARIZ. MAR. 1920
44-644


DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
SAN CARLOS PROJECT-ARIZONA
SAN CARLOS RESERVOIR
RELOCATION OF ARIZONA EASTERN R.R.
SMALL SCALE PROFILE
DRAWN: J.A.S. 17.IX.31. RECOMMENDED:
CHECKED: APPROVED:
Denver, Colo. Nov. 16, 1920
44-C-45
Job# 134/N
Scale "A" PROFILE PAPER PLATE A EUGENE DIVISION Co.
Scale "A" PROFILE PAPER PLATE A EUGENE DIVISION Co.
Cottonwood Transit Road
PROPOSED LOCATION CALVIN STATION
WILD HORSE CANYON
Tunnel #1
Tunnel #2
Tunnel #3
SALT CREEK
PROPOSED LOCATION CALVIN STATION TO PIONEER
APACHE CANYON
OLD TO PIONEER ROAD
OLD ROAD TO CAMPGROUND RANCH
SAN CARLOS RIVER
SAN CARLOS STATION
3000
2900
2800
2700
2600
2500
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500


SALT RIVER
Reservation Boundary
R.2E.
R.3E.
R.4E.
R.5E.
R.6E.
R.7E.
R.8E.
T.1S.
T.2S.
T.3S.
T.4S.
T.5S.
R.1E.
WALKER DITCH
Santa
CRUZ
RIVER
CENTRAL ARIZONA DITCH
ESTRELLA
MOUNTAINS
Long Butte
ARIZONA EASTERN R.R.
GILA
Pima Butte
Arizona Wells
Casa Blanca
Double Buttes
SANTAN DITCH
SANTAN CANAL
SYPHON DITCH
RIVER
ARIZONA DIVIDE
Pima Wells
Sacaton
Little Gila River
Pleasant Valley
Pleasant Wash
SACATON
MOUNTAINS
SCALE OF MILES
0 1 2 3 4 5
Compiled from U.S. Indian Service Maps.
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
ARIZONA CO-OPERATIVE WORK
SAN CARLOS PROJECT
GILA RIVER INDIAN RESERVATION
DRAWN
YUMA ARIZ. APRIL 1930
44-C-46


R.5E.
R.6E.
R.7E.
R.8E.
R.9E.
R.10E.
R.11E.
T.4S.
T.5S.
T.6S.
T.7S.
SACATON MOUNTAINS
GILA RIVER INDIAN RESERVATION
GILA RIVER
Casa Grande
CASA GRANDE MOUNTAIN
SOUTHERN PACIFIC R.R.
Toftec
FLORENCE-CASA GRANDE EXTENSION
FLORENCE CANAL
PICACHO RESERVOIR
DROP INTO RESERVOIR
FLORENCE-CASA GRANDE CANAL
FLORENCE CANAL
PIMA LATERAL
CASA GRANDE RUINS RESERVATION
PONTIL DITCH
NORTH SIDE CANAL
SPINAS DITCH
Florence
O.T. CANAL
ARIZONA EASTERN R.R.
McCLELLAND DITCH
NORTH BUTTE
SOUTH BUTTE
SCALE OF MILES
0 1 2 3 4 5
Topography secured from U.S. Indian Service except T. 7 S. east of Casa Grande Mountain.
LEGEND
Constructed Canals
Partially Constructed Canals
Proposed Canals
DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
ARIZONA CO-OPERATIVE WORK
SAN CARLOS PROJECT
FLORENCE-CASA GRANDE UNIT
DRAWN
YUMA, ARIZ. APRIL 1920
44-C-47



DEPARTMENT OF THE INTERIOR,
UNITED STATES RECLAMATION SERVICE.
SAN CARLOS PROJECT
SAN CARLOS RESERVOIR
CURVE OF ESTIMATED COSTS

DRAWN: C.H.-BHS RECOMMENDED:
CHECKED: APPROVED:

Denver, Colo. Jan. 4, '21 | 44-C-48