Reports: No 23

REPORT OF THE COST OF CONSTRUCTION OF WARNER=CARROLL= UNIVERSITY SUPPLY TO THE CITY OF SAN DIEGO AS OUTLINED IN OFFER OF THE VOLCAN LAND AND WATER COMPANY TO THE CITY OF SAN DIEGO

Dated May 22, 1914

BY WILLIAM S. POST AND C. E. HICKOK

October 10, 1914

2nd reprint 6 copies
6/18/15
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WILLIAM S. POST
ASSOC. MEM. A. S. C. E.
FLETCHER BLDG., 924 8TH ST.
SAN DIEGO, CALIFORNIA

REPORT OF THE COST OF CONSTRUCTION OF WARNER-CARROLL-UNIVERSITY SUPPLY TO THE CITY OF SAN DIEGO AS OUTLINED IN OFFER OF THE VOLCAN LAND AND WATER COMPANY TO THE CITY OF SAN DIEGO

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AUTHORITY

This report is made by instruction of William G. Henshaw, President of the Volcan Land & Water Company, in order to ascertain the total amount of money which would be required under the terms of the offer to the City of San Diego, under date of May 22nd, 1914, and letter dated May 15th.

OUTLINE

This proposal includes the building of Warner Dam to a height of 85 feet, with a water level at 80 feet and with a maximum capacity of 27 billion gallons; the building of a conduit from Warners Dam through the divide between the San Luis Rey River and the Santa Ysabel River with a maximum capacity of 35 million gallons daily; the construction of the Carroll Dam on the Lower Santa Ysabel River, 90 feet high with a water level of 90 feet and a maximum capacity of 7½

billion gallons; the erection of a pumping plant to lift the water from the CArroll Reservoir to an elevation of 515 feet above sea level; the construction of a conduit and pipe line from the Carroll Reservoir to University Heights Reservoir with a capacity of 10 million gallons daily.

ENGINEERING INFORMATION

All the elements of this projected system have been completely surveyed. Warner Dam has been completely cross-sectioned and its bed rock determined during the installation of a cut-off wall and further by extensive core drilling. The Warner Conduit has been completely surveyed and cross-sectioned. The Carroll Dam has been cross-sectioned and a core drill has completely determined the bed rock on this site. The pumping plant site, pipe line and conduit to University Heights Reservoir has been located. The maps accompanying this report give the results of these locations.

The prices used in this estimate have been drawn as far as possible from the unit cost of the work actually executed in the same region, by the Volcan Land & Water Company, or from contract prices in 1914 on similar work of the City of San Diego on the Cottonwood System. The prices of steel have been taken from the bids presented to the City of San Diego for the Bonita Pipe Line in September-1914, which is a similar construction to the Carroll-University pipe line. The price of cement has been taken at $2.00 per barrel F.O.B. San Diego. In the appendix, there are shown recent bids on pipe and concrete which confirm the prices used in this report. Engineering and administration

is taken to cost 10% and contingencies are taken at 15% of the cost of the work. Interest on cost of construction is taken at 8%. The question of haul has been thoroughly gone into and the mean haul of pipe, cement, etc., has been calculated.

Type of structures chosen for this system have been that of permanent construction throughout. The dams are of earth and masonry and may be considered to have a life of 200 years. The cement portion of the conduit may be considered to have a life of 100 years. The steel flume a life of 40 years and the lock bar pipe line from Carroll to University, a life of 25 years.

DETAILS OF STRUCTURE INCLUDED IN THIS ESTIMATE

WARNER RESERVOIR The type of dam chosen for this site is an earth dam. The top width will be 20 feet and the slope to be 2½ ft. horizontal to 1 ft. vertical on the down-stream face, and 3 ft. horizontal to 1 ft. vertical on the up-stream face. It is proposed to make the up-stream two-thirds of the crossection of the dam of specially selected clays and gravels lying immediately above the damsite. These clays were laid down under water in terraces in the old geological lake of the Warner Valley and are ideal material for the water proof section of the dam. These clays will however be mixed with sand and gravel from the stream bed because as they now exist, they are deficient in gravel. The plan of operation would include the use of one or two steam shovels in the clay beds and their delivery by dump cars upon the sides of the dam. Here the usual sluices of an hydraulic fill would be used into which elevators would add the required proportion of gravel from

the stream bed. Or the clay and gravel would be alternately dumped on the edge of the dam and the settlement and segregation of material accomplished by means of a centrifugal pump mounted on a barge midway between the two dykes. The latter method of segregation was originated and used by Mr. Mulholland on a Los Angeles Aqueduct reservoir and is a very successful and economic method of securing all the advantages of the hydraulic fill dam without extensive sluicing. The down-stream third of the dam is proposed to be of pervious material which will drain thoroughly and will be filled by steam shovel or from quarries on either side of the dam and by drag buckets on the river bed itself. The average excavation required to clear the bed rock would be about 20 feet depth. For that portion below the existing cut-off wall, no pump will be required and is comparatively a simple matter. Some excavation will have to be done above the cut-off wall to secure a perfect seal of the selected material, but since the outlet tunnel has been completed, it presents no difficulties, although some seepage water will have to be pumped. The outlet tower will be a circular concrete tower immediately in front of the outlet tunnel which has been constructed. It will be arranged with five inlet valves and screens to draw water from different levels of the reservoir.

WARNER CONDUIT. The Warner Conduit will be constructed along the south bank of the San Luis Rey River and is proposed to be constructed partly as an open cement lined canal and partly of semi-circular steel flume, especially on trestles and where special conditions require it. The conduit then pierces the

divide to the Santa Ysabel River by means of the Lusardi Tunnel. This will be 6,250 feet long and is to be 5 ft. x 7 ft. in size.

NATURAL WATER WAY. From the mouth of this tunnel the water flows down the natural stream bed of Temescal Creek or Pamo Creek to a junction with the main Santa Ysabel River; thence it will flow through the San Pasqual Valley, combined with the waters of the Santa Ysabel River to the Carroll Reservoir.

CARROLL RESERVOIR. The Carroll Damsite is located on a volcanic dyke, a rock of exceptional hardness and lasting qualities. The average depth of the over-burden is about 10 feet. The excellent quality of the foundation indicates the use of the multiple arch type of concrete dam which has been successfully designed by Mr. J. C. Eastwood of San Francisco, for a number of dams in California. The advantage of the multiple type is a saving of about one-third in the amount of concrete required over a straight masonry dam of the so-called gravity type. It also shows a saving over the single arched type with a long radius such as used at the Sweetwater Dam.

PUMPING PLANT. The pumping station will be located some 600 feet below the dam and the suction pipe will be directly connected to the dam gates so that it will gain the back pressure of whatever stage the water may be in the reservoir. The station is planned to be a steam turbine plant with centrifugal pumps operated with fuel oil. This type of installation will furnish a low cost of pumping and while it might be modified into an electrically operated or even a gas engine station, it is considered to be typical for purposes of an estimate of const.

The discharge line will force the water to an elevation of 515 feet, the avefage pumping lift being 250 feet.

CARROLL-UNIVERSITY CONDUIT AND PIPE LINE. The first 8,000 feet of this line will be cement lined conduit on the hydraulic grade. The remainder to the University Heights Reservoir will be pipe line. The first few miles traverse a number of canyons at right angles to the line until the Los Penasquitos Canyon is crossed, when the pipe line for 7 or 8 miles is very near the hydraulic grade in its course across the Linda Vista Mesa. The two miles crossing the San Diego River require the heaviest pressure, a maximum of 480 feet. Lock bar pipe has been selected for this estimate as being approved by good practice.

ESTIMATED COST OF WARNER DAM

Height 85 feet; Top Elevation 2705 feet; Depth of water 80 feet.

October 8, 1914.

Excavation:		
10350 cu yd at .70	$ 7,245.00	
45500 cu yd at .25	11,375.00	$ 18,620.00
Pumping		5,000.00
Embankment 285,000 cu yd at .30		85,500.00
Facing of concrete slabs 4" thick 16,900 sq yds at $1.50		25,350.00
Cut off wall		30,000.00
Concrete gutter 600 lin ft at $1.00		600.00
6" Drain tile 2500 lin ft at .15		375.00
Outlet tunnel 1020 lin ft at $18.00		18,360.00
Outlet basin, weir, etc.		3,000.00
Outlet tower		15,000.00
Foot bridge to tower		1,000.00
Spillway on south side 200 ft. wide:		
482 cu yd concrete at $8.00	$ 3,856.00	
225 cu yd excavation at .50	112.00	
Flashboard arrangement	500.00	4,468.00
Spillway on north side 100 ft. wide:		
65000 cu yd excavation at .30	$ 19,500.00	
3" concrete lining 5900 sq yds at $1.	5,900.00	
Flashboards and foundations	1,000.00	26,400.00
Buildings and water supply to buildings		7,000.00
Equipment and tools		4,000.00
Improvement of grounds, fencing, etc.		2,000.00
Total cost without overhead		$ 246,673.00
Deduct expenditures to Sept. 1, 1914:		
Cut off wall	$ 30,000.00	
Outlet tunnel	9,050.00	
Buildings and water supply to buildings	7,000.00	
Equipment and tools	4,000.00	
Improvement of grounds	2,000.00	52,050.00
		$ 194,623.00
Add 25% for engineering and contingencies		48,656.00
		$ 243,279.00
Interest during construction:		
8% for 4 months (⅓ period)		6,487.00
ESTIMATED TOTAL COST TO COMPLETE		$ 249,766.00

ESTIMATED COST OF WARNER CONDUIT

To South end of Lusardi Tunnel - designed to carry 54.2 second ft.

October 8, 1914.

44 ft.	box flume	at $3.74	$	164.00
19245 ft.	of lined conduit	at 2.45		47,103.00
850 ft.	steel flume on trestles -	at 5.76		4,887.00
2961 ft.	steel flume on bench	at 3.86		11,427.00
6430 ft.	lined tunnel	at 20.00		128,600.00
3670 ft.	lined tunnel	at 16.50		60,555.00
33200 lin. ft.			$	252,736.00
892 ft.	culverts	at $ .16	$	142.00
24.26 acres	clearing and grubbing -	at $250.		6,060.00
Construction roads				4,000.00
County road changes				2,000.00
			$	264,938.00

Deduct Expenditures to September 1, 1914:

Conduit clearing and grubbing	$ 536.37	
Canal excavation	2,601.88	
Culverts	20.60	
Construction roads	2,263.08	
County road changes	308.58	5,731.00
		$ 259,207.00
Add 25% for engineering and contangencies		64,802.00
		$ 324,009.00
Interest during construction:		
8% for 6 months (½ period)		12,960.00
TOTAL COST TO COMPLETE		$ 336,969.00

ESTIMATED COST OF CARROLL DAM

Height 90 feet; Depth of water 90 feet; Type Multiple Arch Concrete.

October 8, 1914.

Excavation 17,000 cu yd at $1.00		$ 17,000.00
Concrete 9846 cu yd at $10.00	$ 98,460.00	
6770 cu yd at $ 7.00	47,390.00	
300 cu yd at $15.00	4,500.00	150,350.00
Outlet pipes, gates, screens, etc.,		5,500.00
Outlet basin, weir, etc.,		2,500.00
Clearing and grubbing flowage area 400 acres at $25-		10,000.00
Buildings, water supply, etc.,		6,000.00
Improving grounds, fencing, etc.,		1,000.00
Equipment, tools, etc.,		1,500.00
Changing county road		10,000.00
		$ 203,850.00
Add 25% for engineering and contingencies		50,963.00
		$ 254,813.00
Interest during construction: 8% for 6 months (½ period)		10,193.00
ESTIMATED TOTAL COST		$ 265,006.00

ESTIMATED COST OF CARROLL PUMPING PLANT

October 8, 1914

Pumping Plant - 310 ft. net head.

Discharge = 10 million gallons per day = 15.5 second feet.

850 H.P.Steam Turbine with direct connected 3 stage Centrifugal pump at $14.50 H.P.		$ 12,325.00
Condensing apparatus		5,600.00
1200 H.p, Steam boilers at $12.00		14,400.00
Erection		4,000.00
Hauling Machinery		250.00
Excavation for pump house		1,600.00
Buildings for pump house		2,300.00
Pipe from Reservoir to pump: 600 ft. 30" - 5/16" thick at $5.17 laid		3,102.00
Pipe from Pump to Canal: 350 lin.ft.30" Lock bar pipe 3/16" at $3.55 laid	$ 1,242.00	
150 lin.ft. 30" Lock Bar pipe 1/4" at $4.38 laid	657.00	1,899.00
500 lin.ft.		
Extra cost of trench and refill - due to difficult side hill		400.00
Anchors for pipe		275.00
Receiving basin into canal		500.00
Total		$ 46,851.00
Add 25% for engineering and contingencies		11,713.00
		$ 58,564.00
Interest during construction: 8% for 3 months (¼ period)		1,171.00
TOTAL COST		$ 59,735.00

ESTIMATED COST OF CARROLL-UNIVERSITY HEIGHTS PIPE LINE

October 8, 1914.

Clearing right of way - 32 acres - at $50.00 -------		$ 1,600.00
Canal - 8000 ft. at $2.01 ----------		16,080.00
Basin at end of canal ----------		3,000.00
Lock Bar Pipe:		
57,000 Lin.ft. 34" diam. 3/16" thick at 90#	5,130,000#	
4,033 lin.ft. 34" diam. 1/4" thick at 116# ----------	467,830#	
38,454 lin.ft. 30" diam. 3/16" thick at 80# ----------	3,076,320#	
1,316 lin.ft. 30" diam. 1/4" thick at 104# ----------	136,860#	
565 lin.ft. 30" diam. 5/16" thick at 127# ----------	71,760#	
4,100 lin.ft. 30" diam. 3/8" thick at 151# ----------	619,100#	
105,468 lin. ft. ----------	9,501,870#	
at .03 per lb. ----------		$ 285,056.00
(318 ft. extra, due to slope distance is included in above)		
40 - 4" air valves at $60.00 ----------		$ 2,400.00
20 - 12" blow offs " 37.50 ----------		750.00
10 - 8" blow offs " 20.50 ----------		205.00
Specials, bends, etc. ----------	5,000.00	8,355.00
Trench excavation and refill, 44,000 cu. yds at $1.85 ----------		81,400.00
Pipe laying - 15% of pipe cost ----------		42,750.00
Pipe leading - 4736 tons at $1.00 ----------		4,736.00
Pipe hauling - 23,800 ton miles at 20¢ ----------		4,760.00
San Diego River crossing ----------		3,000.00
Right of way - 70 acres at $50. -------	$ 3,500.00	
Costs of acquiring permits along county roads - 10 miles at $100. ----	1,000.00	4,500.00
Total ----------		$ 455,237.00
Add 25% for engineering and contingencies ----------		113,809.00
		$ 569,046.00
Interest during construction: 8% for 9 months (¾ period) ----------		34,142.00
TOTAL COST ----------		$ 603,188.00

SUMMARY OF COST

Warner Dam ----------	$ 249,766.00
Warner Conduit ----------	336,969.00
Carroll Dam ----------	265,006.00
Pumping Plant ----------	59,735.00
Carroll-University Pipe Line ----------	603,188.00
GRAND TOTAL ----------	$1,514,664.00

OPERATING COSTS

Pumping Plant to deliver 10 million gallons daily.

Cost per day:

Fuel at 1 lb oil per H.P. per hour and oil at .90 per bbl delivered	$ 62.50
Labor - 6 men at $3.00	18.00
Waste and packing, supplies, incidentals	10.00
Depreciation and repairs 5% on $59,735	8.20
Interest 8%	13.10
Taxes at $2.50 per $100 (½ value)	2.04
PER DAY	$ 113.84
PER YEAR	$41,551.00

Cost per year:

Warner Dam and Carroll Dam:

Interest on $514,772.00 at 8%	$ 41,182.00	
Depreciation ½ of 1%	2,574.00	
Taxes $2.50 per $100 at ½ value	6,432.00	
Maintenance	4,000.00	54,188.00

Warner Conduit:

Interest on $336,969 at 8%	$ 26,957.00	
Depreciation 2½% on $21,000	525.00	
1% on $315,969	3,160.00	
Taxes $2.50 per $100 (½ value)	4,212.00	
Maintenance	10,000.00	44,854.00

Carroll-University Heights Pipe Line:

Interest on $603,188 at 8%	$ 48,255.00	
Depreciation 4%	24,127.00	
Taxes $2.50 per $100 (½ value)	7,540.00	
Maintenance	20,000.00	99,922.00
TOTAL COST PER YEAR		$240,515.00

This will deliver 10 million gallons per day at 6.6¢ per 1,000 gallons.

ALTERNATIVE CONSIDERATIONS

The preceding estimates have followed exactly the lines of the proposal of the Volcan Company to the City of San Diego of May 22, 1914, but it should be clearly understood that this construction brings more than 10 million gallons daily as far as the Carroll Dam. If on further consideration it were found that only 5 millions or 6½ millions daily was the total amount required for the next few years, the above estimate should be materially reduced. In order to make this clear, the safe yield of the Santa Ysabel River as regulated by the dam 90 feet high at Carroll, has been computed, and is found to be 6.8 million gallons daily. In order to secure this amount it will not be necessary to build the Warner Dam and Warner Conduit and the following is the corresponding estimate of cost for this requirement, which will be called "Alternative Proposition No. 2."

ESTIMATE OF ALTERNATIVE PROPOSITION NO. 2.

Carroll Dam	$ 265,006.00
Carroll Pumping Plant	59,735.00
Carroll-University Heights Pipe Line	603,188.00
	$ 927,929.00

This report has the personal basis of familiarity with the particular region of one of the writers dating from 1906, and observation and experience of transportation costs, the use of Mexican labor in an hydraulic work in San Diego County in exact duplication of the one here projected. Observation has been made since 1912 by both of the writers of the uncertain elements of construction, such as weather, flood periods and their intensity and effect on future construction. There is therefore incorporated in these estimates the net results of a local experience with the conditions of some years, including the consideration and frequently the rejection of various types of construction. It may be observed there is no "hard frost" or "ice" action in this region, and certain features of conduit construction for instance on this project are much simplified in consequence.

No attempt has been made to expand the detail basis of the following conslusions, but attention should be drawn that the constant policy of the Company has been to thoroughly investigate and eliminate all uncertainties both in water supply and proposed constructions and the writers have been supported heartily in their inquiry by Mr. Henshaw.

CONCLUSIONS

1. The offer to the City, of May 22, 1914 virtually provides for 13.5 million gallons delivered from Warners to the Carroll Dam, while the Santa Ysabel River itself will furnish 6.8 millions. The proposal is virtually then one for 20.3 million gallons delivered to Carroll and 10 millions delivered to University Heights Reservoir.

This would cost $1,514,664.00.

2. By duplicating the pipe line and pumping plant, the amount which could be delivered, would become 16 to 20 million gallons, depending somewhat on the rate of use by the City, at a total cost of $2,169,505.00.

3. A modified proposition is strongly recommended, guaranteeing only 6½ million gallons daily, at a cost of $927,929.00 as shown in Proposition No. 2.

4. The cost per 1,000 gallons would be as follows:

	Cost per 1,000 gals.
On the basis of offer ----------	6.6¢
On basis of 16 millions daily to City ----------	6.1¢
On basis of 6½ millions daily ---	6.75¢

APPENDIX - MISCELLANEOUS NOTES

Bids submitted to City of San Diego in September-1914 for 28" Pipe

Thickness	Head Ft.	Quantity	Western Pipe & Steel Co. Steel pipe riveted	East Jersey Pipe Co. "Lock Bar"	Llewellyn Iron Works Riveted Steel
1/4"	300 to 440	30500 lin.ft.	$2.37½	$2.70	$2.27-7/8
3/16"	100 to 300	10000 "	$1.89	$2.30	$1.75½

Safe Heads of Pipe Lines Used in These Estimates.

Thickness	34" Pipe	30" Pipe
3/16"	180	230
1/4"	280	323
5/16"	365	416
3/8"	445	508

Based on factor of safety of 5.

PRICES

Excavation:

The prices for conduit excavation ware an average of the contract prices on the conduit work of the City of San Diego, on the upper Cottonwood Creek, as follows:

Earth	$ .40 per cu yd
Solid Rock	1.24 " " "
Used	$ .89 per cu yd

Our assumption is made that a unit price of .89 can be bid without classification, or if classified the material will be 50% earth and 50% solid rock, which is a very liberal assumption.

Excavation:

Prices for excavation at dam were determined after consultation with superintendents and contractors, considering the use of large drag buckets.-1-

Embankment:

Prices for Warner Dam resulted from a study by a construction superintendent and steam shovel expert.

Pipe:

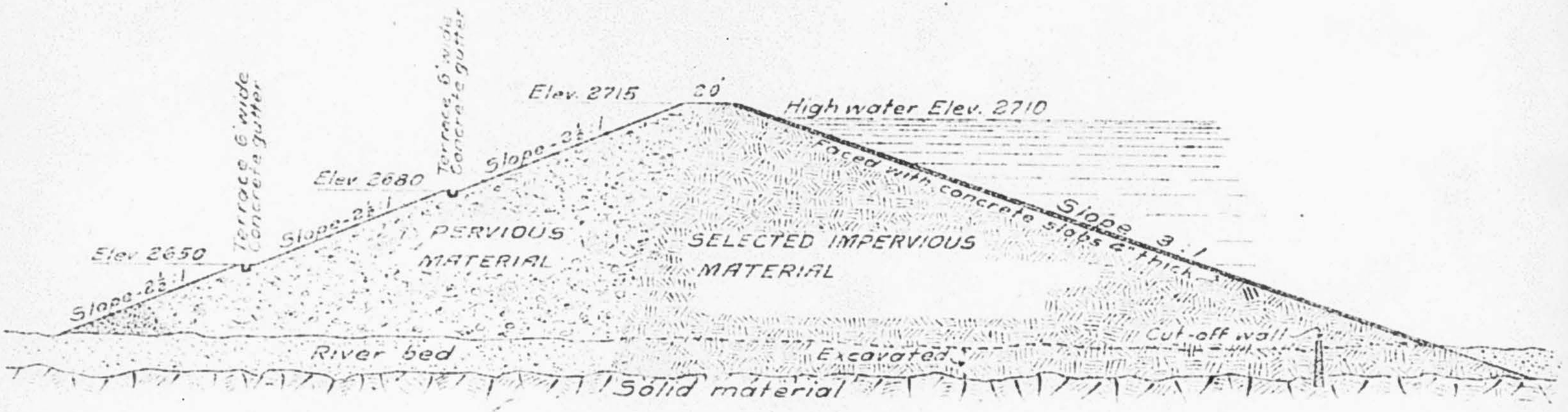
Prices taken from recent bids shown above.

Steel Flume:

Prices from 1913 construction of Cuyamaca Flume under direction of W. S. Post.

Trench Excavation:

Prices from 8 mile pipe line of Cuyamaca Water Co. in 1914, under direction of W. S. Post.



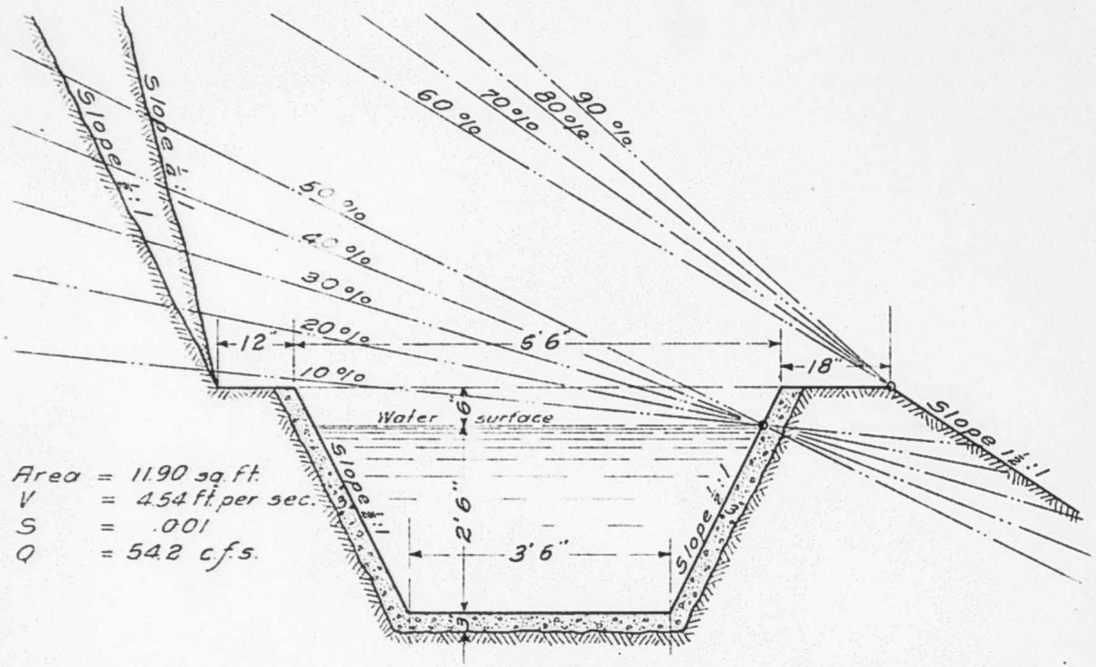
CROSS SECTION
AT GREATEST DEPTH

VOLCAN LAND & WATER CO
WARNER DAM

SCALE: 1" = 60'

W. S. POST, Eng'r OCT. 7, 1914

Drawing No 467
File No T-1



CROSS SECTION

TABLE OF EXCAVATION & CONCRETE
FOR 1 LINEAR FT.

Slope	Up to 10%	20%	30%	40%	50%	60%	70%	80%
Excavation Cu. yds.	0.6	0.7	0.8	1.0	1.2	1.7	2.0	2.2
Concrete Cu yds	.097	.097	.097	.097	.097	.097	.097	.097

VOLCAN LAND & WATER CO.

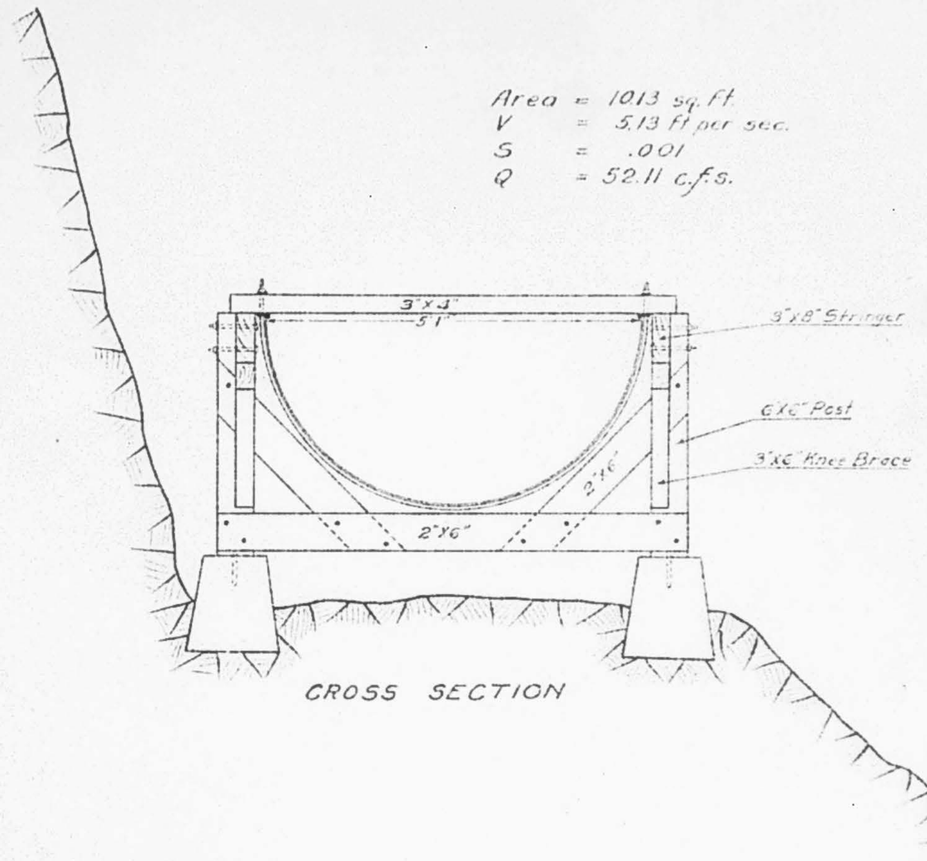
WARNER CONDUIT

CANAL

SCALE : ½" = 1'

W.S. POST, Eng'r OCT. 9, 1914

Drawing No 469
File No T-1



CROSS SECTION

VOLCAN LAND & WATER CO.

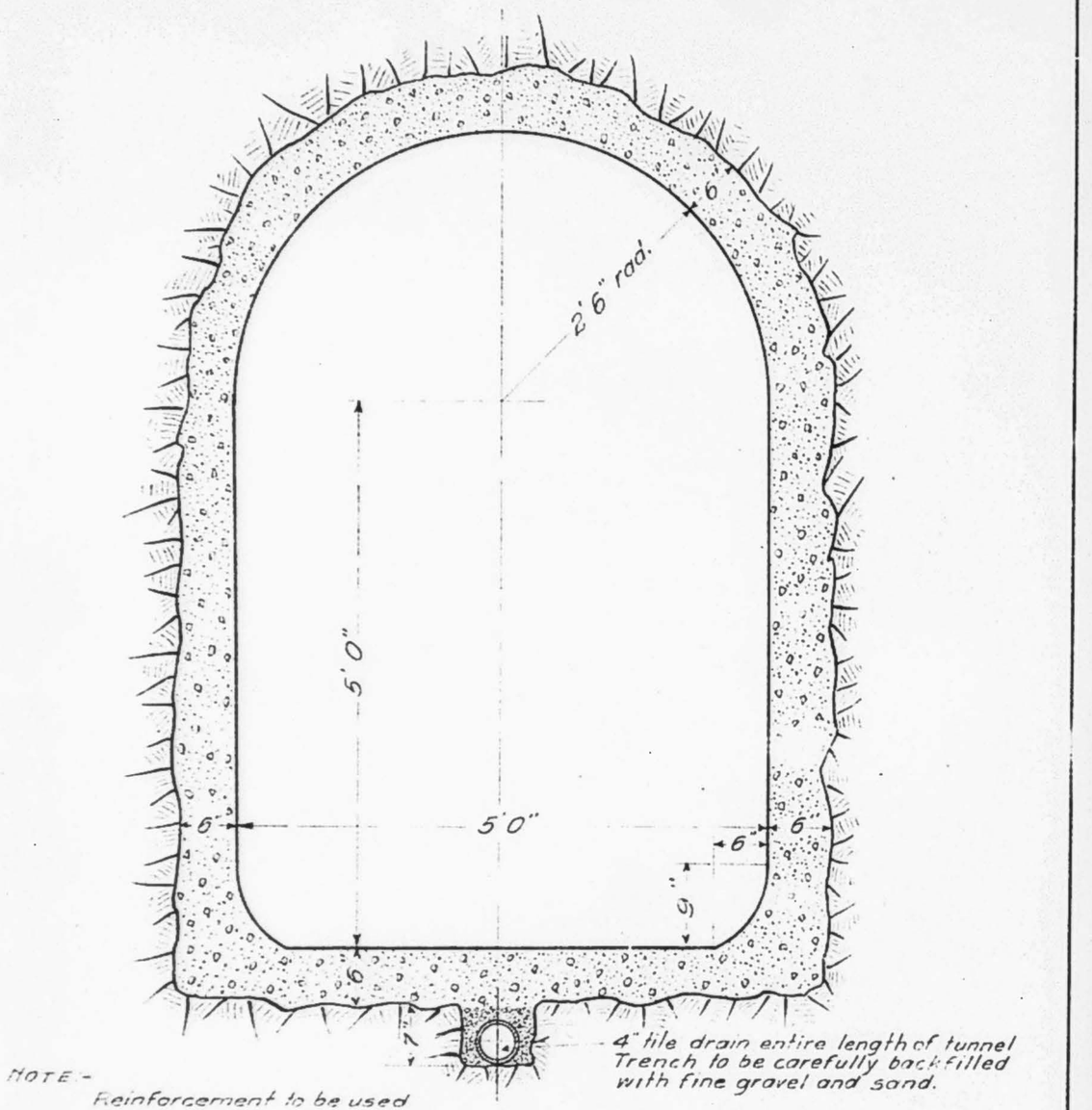
WARNER CONDUIT

METAL FLUME

SCALE : ½" = 1'

W.S. POST, Eng'r. OCT. 9, 1914.

Drawing No 470.
File No T-



NOTE -
Reinforcement to be used
in weak places only.

VOLCAN LAND & WATER CO.

CROSS SECTION

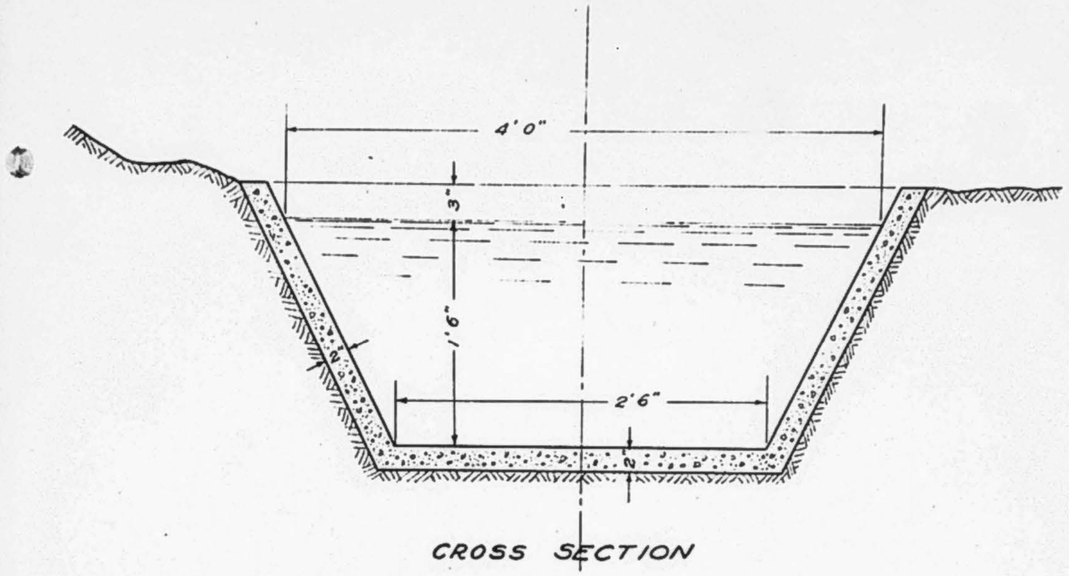
OF

CONDUIT TUNNEL

SCALE: $\frac{3}{4}$" = 1'

W.S POST, Eng'r OCT 8, 1914

Drawing No 468
File No T-1



CROSS SECTION

Area = 4.87 sq. ft.
p = 5.86
r = .832
S = .001
c = 120
v = 3.48
Q = 16.9 sec. Ft. = 10.9 mill. galls per day.

VOLCAN LAND & WATER CO.

CARROLL-UNIVERSITY HEIGHTS CONDUIT

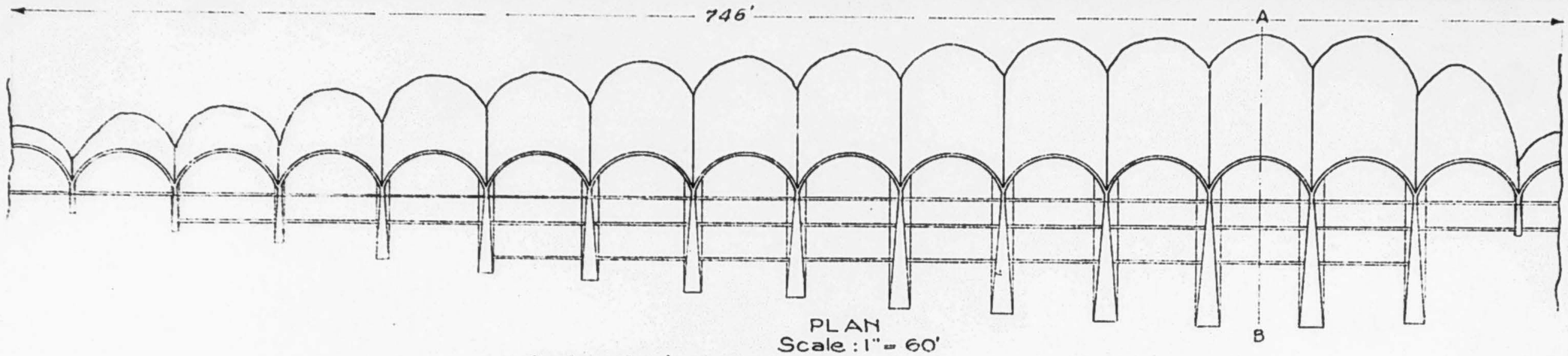
CANAL

SCALE: 1" = 1'

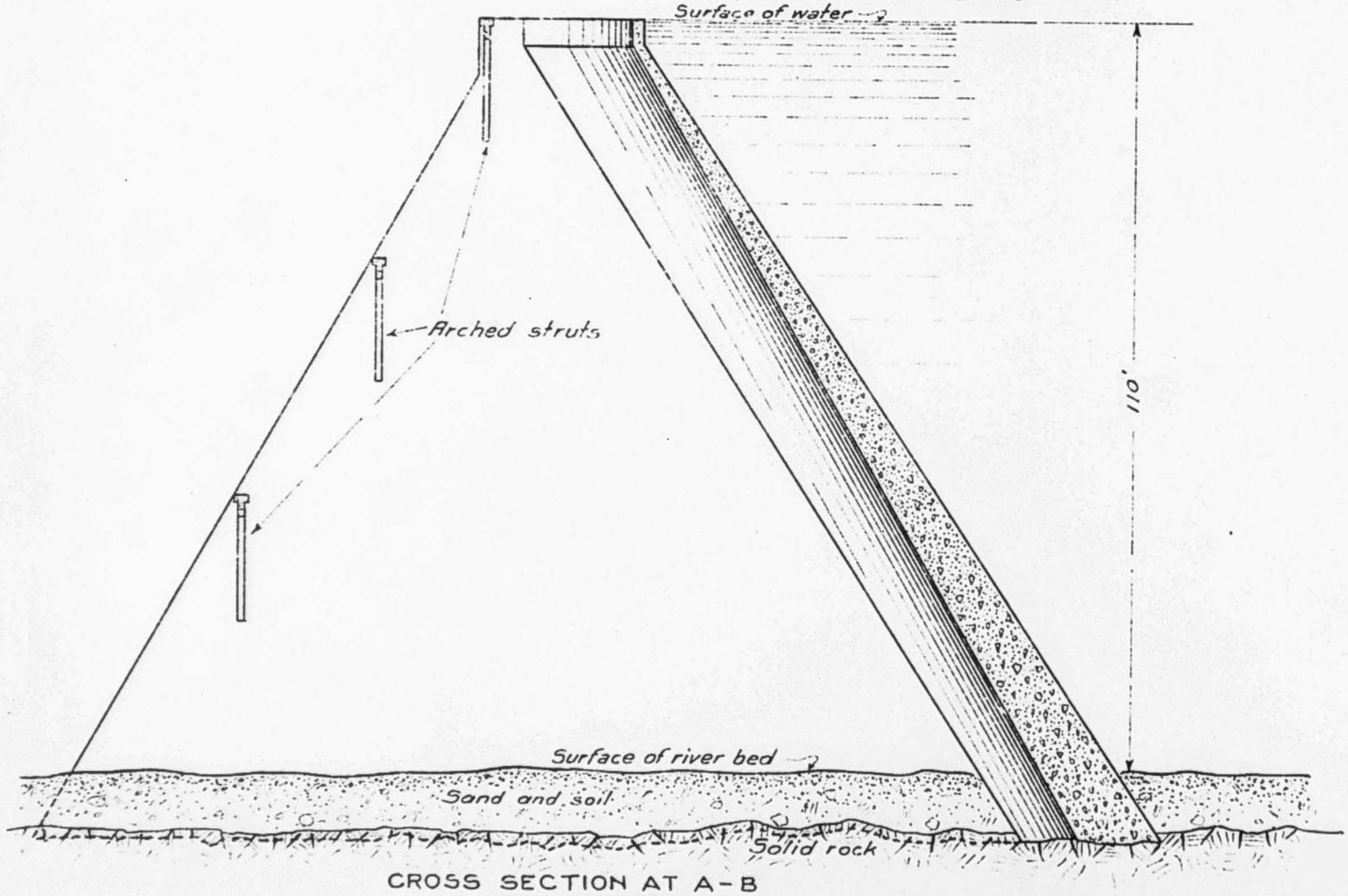
W.S. POST, Eng'r.

OCTOBER 12, 1914.

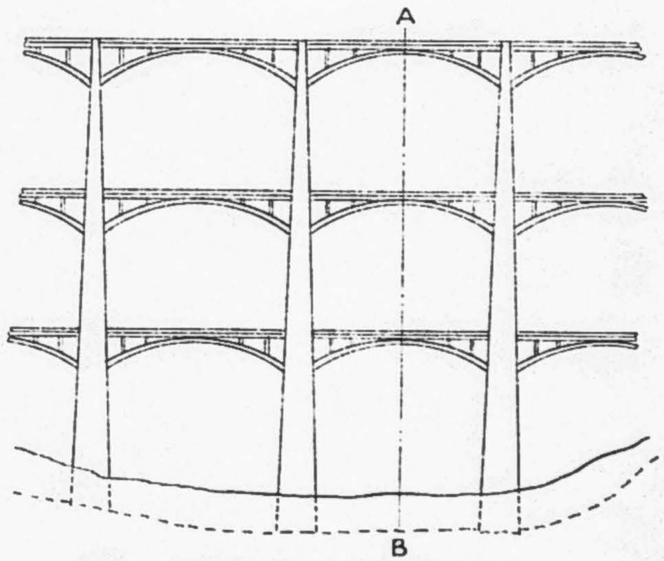
Drawing No. 471.
File No T-1.



PLAN
Scale: 1" = 60'



CROSS SECTION AT A-B
Scale: 1" = 20'



REAR ELEVATION
Scale: 1" = 40'

VOLCAN LAND & WATER CO.

CARROLL RESERVOIR

DESIGN OF

CONCRETE DAM

MULTIPLE ARCH TYPE

W.S. POST, Eng'r
Drawn by LAO
Traced by

OCT. 1, 1914

Drawing No 459
File No T-2

Ed Fletcher Papers

1870-1955

MSS.81

Box: 41 Folder: 6

Business Records - Reports - Post, W.S - "Report of the Cost of Construction of Warner-Carroll-University Supply to the City of San Diego as outlined in Offer of the Volcan Co. to San Diego"