The METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

SECOND ANNUAL REPORT

THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

REPORT FOR THE PERIOD

July 1, 1938 to June 30, 1940

F. E. WEYMOUTH
GENERAL MANAGER AND CHIEF ENGINEER

LOS ANGELES, CALIFORNIA
1940

LETTER OF TRANSMITTAL

Los Angeles, California
September 30, 1940

BOARD OF DIRECTORS,
THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

Gentlemen:

There is transmitted herewith a copy of the report of The Metropolitan Water District of Southern California for the two fiscal years from July 1, 1938 to June 30, 1940. This report of construction and other activities during this period is a continuation of the record of District operations given in the history and first annual report for the period ending June 30, 1938.

Very truly yours,

F. E. WEYMOUTH,
General Manager and Chief Engineer

CONTENTS

TABLES

FIGURES

ILLUSTRATIONS

CONSTITUENT AREAS OF THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

	Date of membership
Anaheim	December 29, 1928
Beverly Hills	December 29, 1928
Burbank	December 29, 1928
Compton	July 10, 1931
Fullerton	March 13, 1931
Glendale	December 29, 1928
Long Beach	March 13, 1931
Los Angeles	December 29, 1928
Pasadena	December 29, 1928
San Marino	December 29, 1928
Santa Ana	December 29, 1928
Santa Monica	December 29, 1928
Torrance	March 13, 1931

DIRECTORS

Anaheim.....E. P. Hapgood
Beverly Hills.....Arthur Taylor
Burbank.....J. L. Norwood
Compton.....Warren W. Butler
Fullerton.....Walter Humphreys
Glendale.....Herman Nelson
Long Beach.....W. M. Cook
Los Angeles.....Otto J. Emme
Los Angeles.....Perry H. Greer
Los Angeles.....Louis S. Nordlinger (to June 8, 1940)
Los Angeles.....D. W. Pontius
Los Angeles.....John R. Richards
Los Angeles.....V. H. Rossetti
Los Angeles.....W. P. Whitsett
Pasadena.....Franklin Thomas
San Marino.....John H. Ramboz
Santa Ana.....S. H. Finley
Santa Monica.....Arthur P. Creel
Torrance.....Charles T. Rippy

OFFICERS OF BOARD

W. P. Whitsett.....*Chairman*
Franklin Thomas.....*Vice-Chairman*
S. H. Finley.....*Secretary*

EXECUTIVE OFFICERS

F. E. Weymouth.....*General Manager and Chief Engineer*

Controller

D. W. Pontius (to Oct. 7, 1938)
J. M. Luney

Treasurer

Charles H. Toll (to Oct. 7, 1938)
Ira R. Pontius

Assistant Controller

J. M. Luney (to Oct. 7, 1938)
G. D. Smith

Assistant Treasurer

J. C. Hilty (to Oct. 14, 1938)
C. G. Olson

EXECUTIVE STAFF

J. L. Burkholder (to Nov. 11, 1938) ..... *Assistant General Manager*
Julian Hinds ..... *Assistant Chief Engineer*
J. M. Gaylord ..... *Chief Electrical Engineer*
R. B. Diemer ..... *Distribution Engineer*
L. V. Branch ..... *Senior Engineer*
Chas. A. Bissell (to Nov. 7, 1939) ..... *Office Engineer*
James H. Howard ..... *General Counsel*
Arthur A. Weber ..... *Assistant General Counsel*
Don J. Kinsey ..... *Assistant to the General Manager*
C. C. Elder ..... *Hydrographic Engineer*
R. M. Peabody ..... *Mechanical Engineer*
E. W. Rockwell ..... *Electrical Engineer*
Geo. R. LeBaron ..... *Right of Way Agent*
H. A. Beall (to Nov. 8, 1938) ..... *Personnel Officer*
T. Sheridan Carey (to April 11, 1939) ..... *Chief Surgeon-Medical Officer*
Hugh M. Mason ..... *Medical Officer*
S. A. Joseph ..... *Purchasing Agent*
A. W. McKinlay ..... *Chief Accountant*
N. F. Jamieson (to Dec. 31, 1939) ..... *Employment Officer*

CONSTRUCTION STAFF

B. C. Leadbetter, *General Superintendent* ..... San Jacinto tunnel
T. T. Walsh, *Superintendent* (to Feb. 1, 1939) ..... Intake and Gene pumping plants
Field Superintendent ..... Pumping system
B. H. Martin, *Superintendent* (to Nov. 6, 1939) ..... Iron Mountain pumping plant
Superintendent ..... Water softening and filtration plant
R. C. Booth, *Superintendent* (to Feb. 1, 1939) } Eagle Mountain and
G. E. Archibald, *Superintendent* (Feb. 1, 1939 to Mar. 1, 1940) } Hayfield pumping plants
Robert N. Allen, *Engineer* ..... Transmission lines
Walter J. Neale, *Engineer* ..... Main aqueduct
C. P. Weaver, *Superintendent of Operations* (to Mar. 20, 1940) ..... Construction utilities

DIVISION ENGINEERS

W. E. Whittier (to Sept. 2, 1938) ..... Division 1
O. J. Schieber (to July 29, 1938) ..... Division 4
J. B. Bond (to July 13, 1938) ..... Division 5

ROLL OF DIRECTORS

Anaheim

A. W. Franzen	December	29,	1928	to	April	11, 1930
O. E. Steward*	April	18,	1930	to	April	7, 1935
E. P. Hapgood	May	3,	1935	to		*Present*

Beverly Hills

Paul E. Schwab	December	29,	1928	to	June	19, 1931
George R. Barker*	June	19,	1931	to	August	2, 1935
Arthur Taylor	August	2,	1935	to		*Present*

Burbank

Harvey E. Bruce*	December	29,	1928	to	February	11, 1933
J. L. Norwood	March	10,	1933	to		*Present*

Compton

C. A. Dickison	July	17,	1931	to	January	20, 1933
William H. Foster	January	20,	1933	to	June	28, 1935
Warren W. Butler	June	28,	1935	to		*Present*

Fullerton

Walter Humphreys	April	10,	1931	to		*Present*

Glendale

W. Turney Fox	December	29,	1928	to	November	27, 1931
Samuel G. McClure	November	27,	1931	to	January	13, 1933
Frank P. Taggart	January	13,	1933	to	August	31, 1934
Bernard C. Brennan	August	31,	1934	to	June	4, 1937
Herman Nelson	June	4,	1937	to		*Present*

Long Beach

Nowland M. Reid	April	10,	1931	to	January	27, 1933
W. M. Cook	January	27,	1933	to		*Present*

*Deceased.

ROLL OF DIRECTORS *(Continued)*

Los Angeles

John R. Haynes*	December	29, 1928	to	February	4, 1930
John R. Richards	December	29, 1928	to		*Present*
W. P. Whitsett	December	29, 1928	to		*Present*
John G. Bullock*	October	25, 1929	to	September	15, 1933
O. T. Johnson, Jr.	November	5, 1929	to	August	29, 1930
W. L. Honnold	February	28, 1930	to	July	21, 1933
I. Eisner	August	29, 1930	to	July	2, 1937
Walter A. Ham	January	20, 1933	to	January	4, 1935
D. W. Pontius	January	20, 1933	to		*Present*
Perry H. Greer	July	21, 1933	to		*Present*
V. H. Rossetti	October	13, 1933	to		*Present*
Otto J. Emme	January	11, 1935	to		*Present*
Louis S. Nordlinger*	August	13, 1937	to	June	8, 1940

Pasadena

Franklin Thomas	December	29, 1928	to		*Present*

San Marino

Harry L. Heffner	December	29, 1928	to	September	29, 1933
John H. Ramboz	September	29, 1933	to		*Present*

Santa Ana

S. H. Finley	December	29, 1928	to		*Present*

Santa Monica

George H. Hutton*	December	29, 1928	to	January	16, 1931
Arthur A. Weber	January	16, 1931	to	October	12, 1934
William H. Carter*	February	15, 1935	to	March	13, 1936
Edmond S. Gillette	June	12, 1936	to	January	8, 1937
Arthur P. Creel	January	8, 1937	to		*Present*

Torrance

John Dennis*	March	17, 1931	to	April	14, 1933
J. R. Jensen*	April	14, 1933	to	December	31, 1933
Charles T. Rippy	January	19, 1934	to		*Present*

*Deceased.

INTRODUCTION

THE Metropolitan Water District of Southern California, a public corporation, comprising the cities of Anaheim, Fullerton, and Santa Ana in Orange County, and Beverly Hills, Burbank, Compton, Glendale, Long Beach, Los Angeles, Pasadena, San Marino, Santa Monica, and Torrance in Los Angeles County, was incorporated December 6, 1928. The organization was effected under the state act, known as the Metropolitan Water District Act (California Statutes of 1927, chapter 429, page 694), permitting the joining together of cities and certain other governmental subdivisions, such as water districts, not necessarily contiguous, for cooperative effort in the development of a water supply. This public corporation was organized for the purpose of developing, storing, and distributing to its constituent areas water for domestic, industrial, and other beneficial uses. Incidentally it was intended also to provide a supply for such other coastal basin areas as later might join the enterprise.

On June 30, 1940 the first objective of the District, the construction of the initial development of the Colorado River aqueduct project, was approximately 96 per cent complete on the basis of ability to deliver water to all member cities.

Percentages of completion of the principal construction features on June 30, 1940 are as follows:

Main aqueduct:	
Tunnels	100.0
Canals, conduits, and siphons	100.0
Pumping plants	100.0
Dams and appurtenant works	100.0
Power transmission line and telephone line from Boulder dam	100.0
Canal and reservoir fencing	100.0
Distribution system:	
Lake Mathews (Cajalco reservoir)	100.0
Upper feeder pipe lines	100.0
Upper feeder tunnels	100.0
Water softening and filtration plant	55.0
Eagle Rock to Palos Verdes feeder	100.0
Palos Verdes reservoir	100.0
Glendale to Santa Monica feeder	1.0
Orange County feeder	0
Orange County reservoir	0
Morris reservoir connection	0

As described in the history and first annual report, this initial development of the project provides for construction of certain features to ultimate size or capacity, and other readily divisible features to half capacity, or less, with later expansion as the need for water develops. The pumping plants, for example, have a substructure of full size for nine pumps, superstructure for five pumps, and three pumps are now installed with a capacity of 200 cubic feet per second each.

During the period covered by this report the main aqueduct portion of the project, from the Intake pumping plant to Lake Mathews in the Cajalco basin was virtually completed and 51,000 acre feet of water delivered to Lake Mathews storage in connection with testing the five pumping plants. There remain only some minor additions to housing facilities at the camps, completion of the installation, now in progress, of lightning arresters on the 230,000-volt transmission lines, and provision at each pumping plant of a standby gas engine-driven generator to supply power in emergency for lighting and camp uses. On the distribution system the entire upper feeder is completed, extending through Pasadena to its terminus in Glendale. The feeder from Eagle Rock Canyon to Palos Verdes reservoir is finished, as well as laterals to the city limits of Compton, Torrance, and Long Beach. This feeder on its southerly course passes through the Eagle Rock and Highland Park sections of Los Angeles, through the west side of South Pasadena, through the east side of Los Angeles, with a lateral to the Ascot reservoir, through Vernon, and continues southwesterly in county territory to the Palos Verdes Hills.

On the Glendale-to-Santa Monica feeder construction of a short tunnel through the Hollywood hills under Mulholland Highway is in progress; contracts have been awarded and pipe is being fabricated for the portion from the west portal of San Rafael No. 2 tunnel in Glendale to Burbank; and contracts were awarded June 28, 1940 on the remaining portions between Burbank and Santa Monica. Specifications were issued June 21, 1940 for the Orange County feeder with bid opening set for July 10, 1940. At the water softening and filtration plant on the upper feeder, work is ahead of schedule, and construction will soon be under way on the waste water disposal line from the plant to Whittier, where connection can be made to the existing Los Angeles County sewer system.

On January 7, 1939 the official starting of the Intake pumps was celebrated, the event being broadcast nationally by the Columbia

Broadcasting System. The Gene reservoir was filled and Gene pumps were started on January 26, 1939. Copper Basin reservoir was filled, and on March 13th Colorado River water was released into Whipple Mountain tunnel. The Iron Mountain pumps began operating on April 5th, those at Eagle Mountain on April 10th, and Hayfield, the fifth and last lift, on July 25, 1939. First Colorado River water flowed from Valverde tunnel into the Cajalco basin on November 2, 1939.

The project is now approaching the position of ability to deliver water to cities within the District. It is possible to forecast quite closely the cost of the initial development contemplated when bonds were voted September 29, 1931. The following tabulation compares the present estimate of cost with that published in July 1931, prior to the bond election. It also gives the present estimate of cost of the deferred items to complete the project to its full ultimate capacity of 1,500 cubic feet per second.

COLORADO RIVER AQUEDUCT COST ESTIMATES

	Bond issue estimate July 1931	Present estimate June 30, 1940
Initial construction (to deliver 750 c.f.s.)		
Diversion dam	$ 13,058,000	$ 8,000,000
Main aqueduct	143,470,000	134,000,000
Terminal storage	17,352,000	15,000,000
Delivery lines	44,964,000	42,000,000
Total initial cost	$218,844,000	$199,000,000
Deferred items (to complete to 1,500 c.f.s.)		
Main aqueduct	$ 12,888,000	$ 19,500,000
Terminal storage	13,320,000	5,400,000
Delivery lines	38,484,000	34,600,000
Total deferred cost	$ 64,692,000	$ 59,500,000
Total ultimate construction cost, exclusive of water softening	$283,536,000	$258,500,000
Estimated cost of water softening not included in bond issue estimate		
Initial plant		$ (3,770,000)
Half-capacity plants		(9,000,000)
Full-capacity plants		16,500,000
Total ultimate construction cost, inclusive of water softening		$275,000,000

The present estimate of initial cost, including provision for two more pump units in each pumping plant, and additional distribution system lines, shows a saving of approximately $20,000,000 in the construction of this first development. What at this time are considered conservative estimates of the cost of the deferred items,

indicate a cost of $258,500,000, for what was contemplated in 1931 as the ultimate construction, a saving of about $25,000,000.

The desirability of softening Colorado River water for domestic use in the coastal basin has been under discussion for several years and methods of softening and filtering the water have been investigated. On December 9, 1938 the board of directors announced its policy to deliver softened and filtered water for domestic use in the member cities, and on March 10, 1939 approved construction of the necessary plant on the upper feeder near La Verne.

The Colorado

The softening method to be used is that known as the lime-zeolite in which carbonate hardness is removed by addition of lime, and noncarbonate, or sulphate, hardness by base exchange in the zeolite softener. Construction of the plant is proceeding rapidly and it is anticipated that operation will begin early in 1941.

The population and assessed valuation of the District cities are shown in table 1. The assessed valuation includes the operative property of public utilities, but not the property of municipal and other corporations aggregating more than $500,000,000, nor the property of veterans, aggregating more than $50,000,000, exempt from taxation. Assessed values theoretically represent about 50 per cent of the real values.

TABLE 1

Population and Assessed Valuation of District

	AREA, ACRES	POPULATION JUNE 1940 U. S. CENSUS (PRELIMINARY)	ASSESSED VALUATION 1940-1941
Anaheim	2,473	11,020	$ 8,936,570
Beverly Hills	3,219	26,453	62,441,560
Burbank	10,370	34,090	32,984,720
Compton	2,860	16,300	8,485,250
Fullerton	10,650	11,404	14,749,750
Glendale	12,783	82,426	61,181,620
Long Beach	19,822	163,441	175,419,850
Los Angeles	288,499	1,496,792	1,281,632,625
Pasadena	12,595	82,227	83,798,970
San Marino	2,384	8,143	16,238,525
Santa Ana	6,730	33,111	24,651,975
Santa Monica	5,120	53,314	49,133,145
Torrance	12,083	9,976	21,593,890
Total	389,588	2,028,697	$1,841,248,450

Population totals for each census year since 1890, for the District and for the entire south coastal basin which can be supplied with Colorado River water, are as follows:

YEAR	DISTRICT	GROWTH, PER CENT	SOUTH COASTAL BASIN	GROWTH, PER CENT
1890	62,322	-------	140,540	-------
1900	123,294	97.8	235,820	67.8
1910	391,595	217.6	668,038	183.3
1920	737,483	88.3	1,085,000	62.6
1930	1,665,833	125.9	2,491,000	129.3
1940	2,028,697	21.8	3,000,000	20.4

CHAPTER 1

FINANCING

THE financing of the District's construction operations was explained in the history and first annual report for the period ending June 30, 1938. Since that time construction costs have been financed from the final issue of $60,000,000 of bonds sold to the Reconstruction Finance Corporation on March 4, 1938.

As related in the report, in order to obviate the necessity of the District's carrying large sums of idle money and to materially minimize interest costs, the Reconstruction Finance Corporation permitted the District to deliver bonds (interim certificates) in installments as funds were required for the construction of the project. This practice has continued, and during the period from June 9, 1938 to June 30, 1940 interim certificates evidencing payment for $20,088,000 of said $60,000,000 of bonds were delivered to the Corporation. While this final issue of bonds bears interest at the rate of 5% per annum, on December 14, 1939 the Reconstruction Finance Corporation advised the District that it would adjust the interest rate to 4% per annum until March 31, 1942, so long as it held such bonds or interim certificates. Interest refunds have been made to the District accordingly.

Refinancing Operations

As stated in the previous report, $147,000,000 of refunding bonds, in temporary form and exchangeable for definitive bonds, were delivered to the Reconstruction Finance Corporation in exchange for interim certificates evidencing payment of $147,000,000 of original bonds bearing interest at the rate of 5% per annum; $73,556,000 of the refunding bonds bore an interest rate of 4% per annum, and $73,444,000 a rate of 4¼% per annum. In April, 1939 the Reconstruction Finance Corporation offered to exchange $16,992,000 of the 4¼% temporary refunding bonds for a like aggregate amount of 3½% temporary refunding bonds. The issuance and exchange of the refunding bonds were authorized by the board of directors and on April 19, 1939 $16,992,000 of 4¼% temporary refunding

bonds were surrendered to the District in exchange for a like aggregate amount of 3½% temporary refunding bonds. The average interest rate on the $147,000,000 issue is approximately 4%.

The $147,000,000 of temporary refunding bonds were subsequently sold by the Reconstruction Finance Corporation. Definitive refunding bonds were prepared, and up to June 30, 1940 temporary refunding bonds aggregating in amount $146,856,000 have been surrendered to the District in exchange for a like aggregate amount of definitive refunding bonds.

On June 10, 1940 an agreement was entered into between the Reconstruction Finance Corporation and the Bank of America National Trust and Saving Association, whereby the bank purchased from the Corporation the aforementioned interim certificates evidencing payment of $20,088,000 of bonds, being part of the $60,000,000 sale of March 4, 1938, bearing interest at the rate of 5% per annum, and agreed to deliver said interim certificates to the District in exchange for $20,088,000 of refunding bonds bearing interest at the rate of 4% per annum. On June 21, 1940 the board of directors of the District authorized the issuance of $20,088,000 of 4% refunding bonds and the delivery thereof in exchange for said interim certificates. The definitive refunding bonds are being prepared and the transaction will be completed in the very near future.

The total amount of bonds outstanding on June 30, 1940 is $168,588,000 and the average interest rate thereon is approximately 4% per annum. The bonds consist of:

Type	Interest rate	Amount
Refunding	3½	$ 16,992,000
Refunding	4	93,644,000
Refunding	4¼	56,452,000
Original	4	1,500,000[1]
		$168,588,000

An analysis of District costs to June 30, 1940 for preliminary engineering and organization, U. S. Government charges, and aqueduct construction is given in table 2; a condensed balance sheet as of the same date in table 3; and a statement of tax assessments and collections in table 4.

[1] These bonds were sold to the Public Works Administration in 1934 (see previous report). In November 1938 the interim certificate evidencing payment for said bonds was purchased by the Bank of America National Trust and Savings Association, and on November 15, 1938 definitive bonds in the aggregate amount of $1,500,000 bearing interest at the rate of 4% per annum were delivered to the bank and the interim certificate surrendered to the District.

TABLE 2

ANALYSIS OF COSTS
As of June 30, 1940

Preliminary engineering and organization:		
Prior to May 1, 1930:		
Surveys, legal, administration, etc.	$ 2,046,825.92	$
Interest on bonds and money advanced for above costs	1,194,674.17	3,241,500.09
After May 1, 1930:		
Field investigation expense	1,002,210.11	
General District expense	313,698.23	
General office expense	1,200,839.54	
Subtotal expense after May 1, 1930	2,516,747.88	
Less cash discounts	2,303.72	2,514,444.16
Net preliminary expense		5,755,944.25
U. S. Government charges:		
Water storage and unused power		2,432,680.75
Construction cost:		
Right of way and land	2,792,240.41	
Construction utilities:		
Roads	1,057,001.45	
Water	727,395.07	
Power	860,028.39	
Telephone	288,840.41	
Permanent buildings	48,073.83	
Transmission lines	2,433,116.37	
Pumping plants	15,235,283.44	
Parker dam and reservoir	6,798,026.83	
Main aqueduct	104,600,174.81	
Water distribution system	35,117,849.07	
Undistributed administration and engineering	*589,409.12*	
Undistributed costs	37.25	
Total construction costs	$169,368,658.21	
Less cash discounts, etc.	263,909.60	
Net construction costs		169,104,748.61
Total costs		$177,293,373.61

Credit balances are printed in italics.

TABLE 3

CONDENSED BALANCE SHEET
As of June 30, 1940

Assets

Preliminary surveys, engineering, etc.			
By City of Los Angeles prior to May 1, 1930	$ 2,096,221.54	$	$
Interest on City of Los Angeles cash expenditures	254,991.00		
By District after May 1, 1930	2,465,048.54	4,816,261.08	
Permanent			
Construction costs to date	169,104,748.61		
Contracts in progress not completed	3,463,342.22		
Avances for condemnation suits	673,002.45		
Morris dam	6,590,000.00	179,831,093.28	
Total construction cost			184,647,354.36
Interest, etc.			
Interest on 1925 bonds		939,683.17	
Interest on 1931 bonds (net)		28,041,363.66	
Government power not used and water storage in Lake Mead		2,432,680.75	31,413,727.58
Cash			
On hand and on deposit		5,858,320.04	
Advance to employees		2,000.00	5,860,320.04
Receivables			
Unpaid tax assessments		826,594.16	
Miscellaneous accounts		11,176.13	837,770.29
Total assets			$222,759,172.27

Liabilities

Bonded indebtedness			
Bonds sold to R.F.C.	$207,000,000.00	$	$
Less amounts not delivered	39,912,000.00	167,088,000.00	
Bonds sold to P.W.A.		1,500,000.00	
Total 1931 bonds outstanding		168,588,000.00[1]	
Accounts payable			
Sundry current accounts	285,645.92		
Contractors' holdback	372,063.05		
Accrued interest on 1931 bonds	2,723,084.16	3,380,793.13	
Contingent liabilities			
Uncompleted contracts	3,463,342.22		
Morris dam	6,590,000.00		
Special deposits, sales, etc.	15,922.85	10,069,265.07	
Reserves			
Compensation and other insurance	870,196.44		
Faithful performance contracts	160,300.00	1,030,496.44	
Undistributed revenue			
Interest on bank balances	166,836.71		
Interest refunded by R.F.C.	1,039,658.19	1,206,494.90	
Capital investment			
Tax assessments, interest credits, etc.	38,470,042.97		
Investment, withdrawn cities	14,079.76	38,484,122.73	
Total liabilities			$222,759,172.27

[1] As of June 30, 1940 all bonds, totaling $168,588,000, had been purchased by private capital from the Reconstruction Finance Corporation and Public Works Administration.

Horticulture in south coastal basin

TABLE 4

STATEMENT OF TAX ASSESSMENTS AND COLLECTIONS

As of June 30, 1940

CITIES	ASSESSMENTS 11 YEARS 1929 - 1940	ADJUSTMENTS	INTEREST AND PENALTIES	TAX REFUNDS	TOTAL COLLECTIBLE	TOTAL COLLECTIONS	UNCOLLECTED		PERCENTAGE OF ASSESSMENTS DUE AND UNCOLLECTED	
							PRIOR YEARS	THIS FISCAL YEAR	PRIOR YEARS	THIS FISCAL YEAR
Anaheim	$ 177,988.72	$ 85.28	$ 276.00	*$ 17.64*	$ 178,332.36	$ 174,022.30	$ 2,565.09	$ 1,744.97	1.83	4.58
Beverly Hills	1,176,882.18	2,575.12	4,294.89	*294.90*	1,183,457.29	1,165,960.32	6,346.75	11,150.22	.69	4.20
Burbank	480,759.57	*36.46*	4,007.01	*1,234.10*	483,496.02	463,647.81	12,655.59	7,192.62	3.51	6.01
Compton	156,135.62	636.27	879.42	*238.29*	157,413.02	152,989.94	3,089.92	1,333.26	2.55	3.86
Fullerton	283,657.05	92.05	813.84	*12.73*	284,550.21	278,917.22	3,164.28	2,468.71	1.43	3.94
Glendale	1,199,926.25	22,295.36	270.11	*6,768.28*	1,215,723.44	1,214,784.24	939.20	.....	.10	.....
Long Beach	3,230,768.02	4,341.78	19,746.08	*2,672.25*	3,252,183.63	3,194,401.15	32,268.92	25,513.56	1.30	3.40
Los Angeles	27,593,325.38	21,528.72	112,884.30	*11,278.19*	27,716,460.21	27,096,615.58	341,530.84	278,313.79	1.55	4.93
Pasadena	1,784,592.25	8,614.71	6,078.28	*1,142.98*	1,798,142.26	1,771,783.26	18,510.38	7,848.62	1.29	2.16
San Marino	292,864.71	*180.29*	978.34	*8.82*	293,653.94	290,294.83	1,086.52	2,272.59	.48	3.37
Santa Ana	481,744.93	298.44	891.54	*21.80*	482,913.11	470,657.58	8,181.98	4,073.55	2.15	4.02
Santa Monica	949,709.34	1,001.36	4,349.68	*193.64*	954,866.74	916,887.70	12,172.77	25,806.27	1.62	12.87
Torrance	417,227.92	933.40	1,506.78	*15.37*	419,652.73	403,364.64	11,613.10	4,674.99	3.61	4.85
Subtotal	$38,225,581.94	$62,185.74	$156,976.27	*$23,898.99*	$38,420,844.96	$37,594,326.57	$454,125.24	$372,393.15	1.50	4.66
Withdrawn cities	13,971.94				13,971.94	13,896.17	75.77		.54	
Grand total	$38,239,553.88	$62,185.74	$156,976.27	*$23,898.99*	$38,434,816.90	$37,608,222.74	$454,201.01	$372,393.15	1.50	4.66

Credit balances are printed in italics.

CHAPTER 2

MAIN AQUEDUCT

CONSTRUCTION UTILITIES

The construction utilities required during the building of the aqueduct, including the water and power systems, the telephone system, and the District built roads, were described in the history and first annual report. Portions of the water system serving District camps were operated until the end of 1939, but dismantling for sale or removal to salvage of the unused lines, tanks, and equipment was begun in June of that year. The construction power system was first energized in March 1933 and continued to deliver power until January 15, 1940 when the last section in use, serving San Jacinto tunnel, was deenergized. The telephone system main lines have been retained for the permanent communication system to provide necessary service for aqueduct operation and maintenance. The Banning exchange has been closed, a switchboard opened at Hayfield, and all unnecessary tap lines dismantled. District roads have been transferred to Riverside and San Bernardino counties, excepting patrol roads, branch roads to Hayfield, Eagle Mountain, and Iron Mountain camps and the main and branch roads in the Colorado River area north of Earp, California.

Construction Water System

With the exception of a small amount of water used by one contractor in completing Hayfield pumping plant construction, all water produced and delivered since June 30, 1938 was for use of District forces installing pumping plant equipment, testing and conditioning aqueduct features, and maintaining moisture in covered conduits and tunnels. Service was necessarily maintained in those portions of the system which supplied Gene, Iron Mountain, Eagle Mountain, and Hayfield camps until Colorado River water was flowing through the aqueduct and each plant was equipped to make use thereof. Delivery of water through the construction system ended in December 1939, after nearly seven years of service during which 198,166,742 cubic feet of water, equivalent to 4,549 acre feet, were delivered for construction purposes and domestic use, between Morongo Canyon camp in the Coachella Valley and

the Colorado River. That quantity of water under continuous flow conditions would supply a city of about 5,000 people.

In June 1939 is was possible to dismantle the booster stations at the Buried Mountain wells, at Grommet, Vidal wells, Whipple Mountain, and Earp. Salvaging of pipe, tanks, and remaining equipment not sold in place was completed in February 1940.

The costs of the construction water system are given in table 5.

TABLE 5

CONSTRUCTION WATER SYSTEM
Costs to June 30, 1940

CALENDAR YEAR	CONSTRUCTION COST	OPERATION AND MAINTENANCE COST	CREDITS	ACCUMULATED NET COST	WATER SALES, CUBIC FEET
1933	$728,451.80	$ 27,008.25	*$ 8,766.86*	$746,693.19	5,845,933
1934	77,099.43	48,087.26	*34,034.44*		22,566,708
		1,417.67[1]		839,263.11	
1935	44,460.01	63,416.77	*74,859.02*		39,415,784
		229.93[1]		872,050.94	
1936	13,597.83	84,695.05	*118,477.50*		59,797,801
	1,170.32[2]	964.54[1]		851,660.54	
1937	----------	68,242.04	*99,205.95*		49,733,073
	260.00[2]	*906.50*[1]		819,530.13	
1938	*7,750.00*	36,251.12	*32,056.45*		16,338,747
	1,189.62[2]	*1,245.78*[1]		813,539.41	
1939	----------	13,124.35	*6,248.25*		4,468,696
	17,016.57[2]			803,398.94	
1940	----------	----------	----------	----------	----------
	76,003.87[2]			727,395.07	
Totals	$855,859.07	$340,824.84	*$373,648.47*	$727,395.07	198,166,742
	95,640.37[2]				

[1] Cost of operation and maintenance equipment less depreciation applied during the year.
[2] Net salvage of pipe lines and equipment.
Credit balances are printed in italics.

Construction Power System

In August 1938 the Fan Hill substation was removed from service, following completion of all construction requiring 33-kv power in the Coachella area. During this month and in September severe electrical storms starting at the Colorado River and working westward caused disturbances in the system, but the only prolonged outage was one of 25 minutes.

In September, six 2,000-kva transformers were removed from substations and transferred to the Intake pumping plant. In November, upon completion of San Jacinto excavation, six more similar transformers became available completing the required number at Intake, to which point also two 69-kv oil circuit breakers were transferred from the Fan Hill substation for permanent use.

On October 5, 1938 contract No. 2 for the supply of construction power was terminated after being in effect 66 months and 12 days. This contract originally made with the Southern California Edison Company, Los Angeles Gas and Electric Corporation, and Southern Sierras Power Company had become, through changes in ownership and corporate name, a contract with the Edison Company, City of Los Angeles, and California-Nevada Electric Corporation. During its life the District received 354,380,192 kilowatt-hours of electric energy for which it paid $2,214,205.14, an average cost of 6¼ mills per kilowatt-hour.

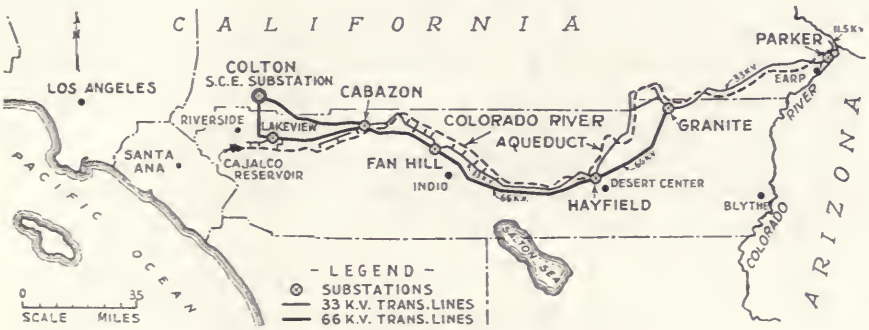


Fig. 1. Construction power system

The power necessary for the remainder of the main aqueduct construction was purchased under a new contract with the Southern California Edison Company and at a lower rate. This company also entered into a contract for the purchase of a portion of the District's unused firm energy from Boulder dam, the effect of the two contracts being to permit the District to use some of its Boulder power for aqueduct construction, by paying the Edison Company a charge for generation and transmission. Power was taken under this contract until January 15, 1940, when the construction power system was deenergized and a final meter reading made, the delivery being 18,170,280 kw-hr, and the cost $75,891.65, or 4.18 mills per kw-hr.

Dismantling of unused substations and 33-kv tap lines continued into 1939, the salvaged materials being sold or moved into the Banning salvage yard. In October 1939 the board of directors approved the sale of the 34.8-mile 66-kv transmission line from Colton to Cabazon via San Timoteo Canyon, including the District's

interest in the right of way, to the California-Nevada Electric Corporation, of Riverside, California, for $48,000. In December 380 miles of 66- and 33-kv lines were sold standing, for $273,508.85. The 66-kv line from Cabazon to Indio and some of the 33-kv lines in the Lakeview and San Jacinto areas were acquired by the California-Nevada Electric Corporation for use; the remainder were removed by the buyers.

In September 1939 two 5,000-kva synchronous condensers were leased to the Salt River Valley Water Users' Association, for use in delivery to Phoenix, Arizona, of surplus District power from Boulder dam, and a similar condenser at Parker substation was sold to the U. S. Bureau of Reclamation.

The costs of the construction power system are given in table 6. Giving effect to the credits for power sold and delivered at a charge of slightly more than one cent per kw-hr and including all system costs, the net cost to the District was 2.31 mills per kw-hr purchased at Colton. The average line loss in the entire construction power system during its almost seven years of operation was approximately 8.7 per cent.

TABLE 6

CONSTRUCTION POWER SYSTEM
Costs to June 30, 1940

CALENDAR YEAR	CONSTRUCTION COST	OPERATION AND MAINTENANCE COST[1]	CREDIT POWER SALES	ACCUMULATED NET COST	POWER PURCHASED, KW-HR
1933	$1,734,014.10	$121,200.35	*$ 90,206.00*	$1,765,008.45	10,209,780
1934	85,330.17	394,063.98	*512,152.74*		50,162,630
		17,610.72[2]		1,749,860.58	
1935	121,070.32	571,438.19	*771,259.10*		81,010,560
		227.76[3]		1,670,882.23	
1936	50,980.22	592,517.84	*772,142.26*		82,521,752
	19,609.37[2]	*2,129.69*[3]		1,520,498.97	
1937	23,794.67	583,974.16	*709,381.41*		77,730,065
	574.71[2]	*3,510.75*[3]		1,414,800.93	
1938	7,604.69	436,137.70	*533,918.11*		58,190,491
	60,475.89[2]	*7,869.00*[3]		1,256,280.32	
1939	.....	99,132.23	*101,155.82*		12,725,194
	55,902.38[2]	*3,873.52*[3]		1,198,354.35	
1940 to June 30	.....				
	334,452.44[2]			860,028.39	
Totals	$2,022,794.17	$2,798,464.45	*$3,490,215.44*	$ 860,028.39	372,550,472
	471,014.79[2]				

[1] Includes cost of purchased power.
[2] Net salvage of lines and equipment.
[3] Cost of operation and maintenance equipment less depreciation applied during the year.
Credit balances are printed in italics.

Telephone System

In August 1938, with decrease in traffic, one leased wire between Los Angeles and Banning was discontinued. In September circuits to serve the permanent camps at Gene and Iron Mountain were installed and a clear circuit to Boulder dam was provided. Because of construction of the Headgate Rock dam on the Colorado River just above Parker, Arizona, by the U. S. Indian Service, it was necessary to remove from the reservoir area a short section of line north of Earp. This relocation was completed in February 1939 at the expense of the Indian Service. Completed in the same month was the relocation near Searchlight, Nevada, at the request and expense of the Nevada Highway Division of a short section which interfered with realignment of the Boulder City-Needles highway.

In April 1939 a main trunk lead was built into the Hayfield pumping plant and a switchboard was installed. With the closing of the Banning exchange in January 1940 all traffic was transferred to this Hayfield switchboard. Dismantling of all unnecessary tap lines and removal of poles and material to salvage stocks were

TABLE 7

CONSTRUCTION TELEPHONE SYSTEM
Costs to June 30, 1940

CALENDAR YEAR	CONSTRUCTION COST	OPERATION AND MAINTENANCE COST	CREDITS	ACCUMULATED NET COST
1933	$259,691.65	$ 14,411.97	*$ 13,731.95*	$260,371.67
1934	30,608.81	43,230.67	*66,634.10*	
		1,084.35[1]		268,661.40
1935	7,105.85	51,492.35	*88,890.62*	
		478.51[1]		238,847.49
1936	2,462.36	65,571.28	*101,184.28*	
	42.06[2]	511.80[1]		206,166.59
1937	461.61	66,440.84	*88,670.20*	
	873.88[2]	*809.59*[1]		184,463.13
1938	*178.18*	54,465.71	*57,508.30*	
	331.22[2]	*1,265.07*[1]		179,646.07
1939	.....	35,168.11	*36,517.17*	
	297.78[2]			177,999.23
1940 to June 30	.....	.....	.....	
	4,831.27[2]			173,167.96
Totals	$300,152.10	$330,780.93	*$453,136.62*	$173,167.96
	4,628.45[2]			

[1] Cost of operation and maintenance equipment less depreciation applied during the year.
[2] Net salvage of lines and equipment removed.
Credit balances are printed in italics.

completed prior to disbanding the construction utilities operation and maintenance forces in February 1940.

The net cost of the construction telephone system to June 30, 1940 is shown in table 7. The main lines and equipment of this system have now become a part of the permanent communications system of the project, which includes also the telephone line from Iron Mountain to Camino switching station and Boulder dam. In addition to the net cost of $173,167.96 shown for the construction system, there has been expended, as of June 30, 1940, on the Boulder line a total of $115,672.45, making a grand total cost to date for the entire telephone system of $288,840.41.

Construction Road System

In February 1938 the principal District roads along the north side of the Coachella Valley, between Garnet and Indio, were transferred to Riverside County.

The transfer of the trunk road from Desert Center in Riverside County to Earp in San Bernardino County was authorized by two resolutions of the District board of directors and the portion in each county was accepted by the respective boards of supervisors on the same date, December 12, 1938.

Hauling heavy equipment

The District still retains and maintains the river road from Earp to Parker dam, and the branch roads to the Intake and other pumping plants. Construction during the period consisted of enlargement of the Gene Wash culvert on the road to the Intake pumping plant, similar work at the Copper Basin culvert on the river road below Parker dam, and relocation of a portion of the river road near Earp. The culvert work was done by District forces. The relocation below Parker dam was done by the U. S. Indian Service to remove the road from the reservoir to be formed by building of its Headgate Rock dam.

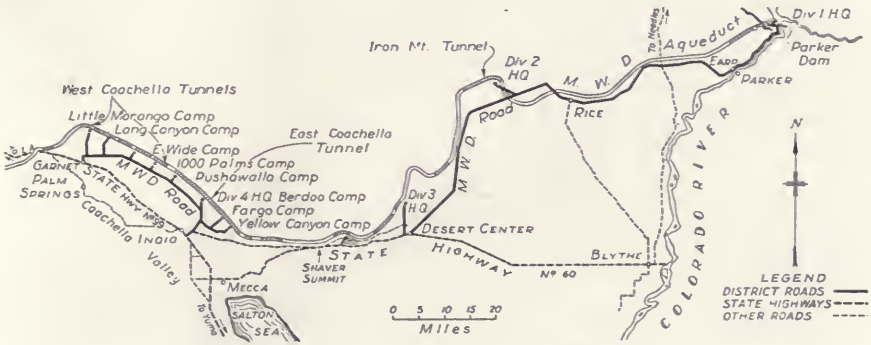


Fig. 2. Construction road system

The severe desert storms of September 1939 caused only moderate damage to District roads. Shoulders were eroded in spots and some surfacing destroyed, dips were filled with sand, and in the river area slides occurred from banks. All debris was quickly removed and surfacing restored.

The cost of construction and of operation and maintenance of the road system to December 31, 1939 is shown in table 8.

Since January 1, 1940 the District paved roads and the unpaved patrol roads have been maintained by the regular main aqueduct, pumping plant, and transmission line forces.

TUNNELS

Tunnel construction operations on the main aqueduct were confined to San Jacinto tunnel, all others having been completed prior to the period covered by this report. On June 30, 1938 there remained to be excavated 1,049 feet between the Cabazon West and

TABLE 8

CONSTRUCTION ROAD SYSTEM
Costs to December 31, 1939

WORK	MILES	WORK COMPLETED	COST
Surveys			$ 9,232.90
Construction			
Garnet to Indio	35.88	July 26, 1933	185,851.80
Desert Center to Earp	83.96	Aug. 15, 1933	389,555.87
Branch to Division 3 headquarters	7.71	Nov. 17, 1933	47,781.28
Earp to Parker dam [1]	15.32	Jan. 22, 1934	65,837.43
Branch to Division 1 headquarters [2]	2.39	Jan. 22, 1934	38,968.72
Branch to Intake pumping plant [2]	1.99	May 23, 1934	146,392.38
Branch to Division 2 headquarters	2.43	Nov. 10, 1934	8,969.83
Training ditches			1,374.51
State Highway Division (Shaver's Summit road)			20,000.00
Hayfield pumping plant road	3.50	Nov. 29, 1937	9,962.51
Subtotal—construction	153.18		$ 923,927.23
Maintenance 1933	$19,268.22		
1934	15,896.92		
1935	19,740.36		
1936	38,469.46		
1937	22,589.39		
1938	9,938.08		
1939	7,171.79		133,074.22
Total			$1,057,001.45

[1] Grading of road from Earp to Parker dam was done by City of Los Angeles; paved and completed by District.
[2] Roads to Division 1 and Intake had heavy rock cuts and fills.

River road to Parker dam

Lawrence East headings and 5,692 feet between Lawrence and Potrero. Of concrete lining 20,232 feet of arch and 20,233 feet of invert remained to be placed from the east portal and 12,840 feet of arch together with 11,560 feet of invert to be placed from the west portal.

Excavation

In Cabazon West and Lawrence East headings, bad rock conditions had been encountered in June 1938 necessitating frequent use of crown bars and breastboards in the face. Soft and fractured rock continued into the first week of July, when both headings entered a zone of good rock, making excellent progress until holing through on the 28th of that month. In this period progress in Cabazon West was 529 feet and in Lawrence East 520 feet.

In the latter part of May the Lawrence West heading advanced out of badly fractured and into firm, hard granodiorite, better rock conditions continuing until the connection was made with Potrero East on November 19, 1938. Up to the first week in August water flows, occasionally under pressure, were encountered in test holes drilled ahead of the face. During this period some time was lost in making grout connections to the test holes and injecting cement grout under pressures up to 1,400 pounds per square inch, accomplishing virtually complete stoppage of the flows. The best month's progress in this heading was 847 feet made in October, with a total advance between July 1st and November 19th of 2,950 feet, at the excellent average rate of 21 feet per working day of three 8-hour shifts.

In the Potrero East heading, where from its beginning in 1934, so much difficulty was experienced due to bad ground and water, better rock had been entered at the end of March 1938, and this continued through the remaining distance. Occasional zones of badly fractured and soft decomposed granite, necessitating the use of both crown bars and breastboards, were passed through, but only moderate quantities of water were encountered and rapid progress was maintained in excavation. The best monthly progress ever made in this heading was the 775 feet advanced in October 1938, the last full month of operation. The total progress from July 1st to November 19th was 2,742 feet, at a rate of 19.6 feet per working day.

The two headings met exactly on line and only 0.11 of a foot off in grade, the final shot occurring at 10:04 a.m. November 19, 1938,

to complete all tunnel driving at San Jacinto and on the main aqueduct. A large gathering of District directors and officials with their guests saw the closing of the blasting switch to detonate the explosive in the last barrier, and then visited the point of holing through. The event was broadcast nationwide by the Columbia Broadcasting System.

Concrete Lining — East Portal Plant

Following the completion of excavation between Cabazon and Lawrence adit, crews operating from the east portal immediately began tunnel clean-up in the unfinished sections easterly from Lawrence, preparatory to lining. Ventilation pipes were removed, and water lines were rearranged to permit pumping Lawrence and Cabazon inflow to the east portal pending the connection with Potrero. Concrete lining was resumed August 30, 1939, when the placing of curbs was started at a point 502 feet east of Lawrence

Last barrier at San Jacinto holed through

adit, working toward the east. Placing of invert concrete was begun near the same station on November 1st and finished to the previously lined section at the west end of the Cabazon pioneer on December 3rd, a total of 10,369 feet being completed in this time. The 9,341 feet of invert between the east end of the Cabazon pioneer and Cabazon adit was placed in the four weeks from January 8 to February 4, 1939.

In the meantime arch forms had been moved in and set against the arch concrete previously placed by the west portal crews, 582 feet east of Lawrence adit, in preparation for the final run in this eastern portion of the tunnel. Arch concreting was started February 8th and the remaining 20,232 feet was completed May 22, 1939, involving the hauling, mixing, and placing of 64,163 cubic yards of concrete. The best week's progress was 2,063 linear feet. The best month was March, when in 93 shifts 19,783 cubic yards of concrete were placed in 6,437 feet of arch, an average of 8.65 feet and 26.6 cubic yards per hour.

West Portal Plant

The concrete lining crews in the western portion of the tunnel continued placing operations concurrently with excavation until the connection was made, in November 1938, between the Potrero and Lawrence headings. In order more readily to handle the large volume of inflowing water, standard procedure was to prepare a section for lining, place concrete curbs along both sides with drain tile as needed, and follow at a short distance with the invert. Inflowing water was either diverted into the pioneer or piped over the area of operations to be dumped on the completed invert west of Potrero shaft or pumped to the west portal. Temporary bridging for track was moved along on the curbs, being progressively replaced by a bridge supported on posts resting on the newly finished invert. Then arch forms were set on the curbs and the arch concrete placed to complete the section.

Prior to June 30, 1938, in Potrero East, concrete curbs and invert had been completed to a point 6,112 feet east of Potrero shaft, and arch concrete was being placed from that point toward the shaft. During July and August this arch work was finished to a connection with the existing lining just west of Potrero shaft, except for three short sections temporarily left unlined. The concrete placing crews then advanced curbs and invert as rapidly as possible behind the excavation forces. When the headings met, November 19, 1938,

the concrete crews were within a few hundred feet of the point of connection. The last concrete curb was placed by the west portal crews just east of Lawrence adit December 31, 1938 and the last invert three days later. On January 10, 1939 concreting of the arch was started by them 582 feet east of Lawrence adit and completed at Potrero on May 29th. This work was done with a fixed length of 121 feet of forms, which limited the speed of placing to that distance as a daily maximum. The best monthly progress was made in March with 3,423 feet of arch completed.

Grouting Behind Concrete Lining

Grouting to fill voids back of the lining and to seal off infiltering water was performed generally soon after the concrete had set. The operation was carried on in stages. Test holes were drilled through the lining systematically around the entire section, arch, side walls, and invert. Where voids were found or seepage was evident, grout was injected through the test holes under pressures up to 100 pounds per square inch and allowed to set. Later, further test drilling was done, particularly where rising water levels caused percolation through joints in the lining, and high-pressure grouting was resorted to. In this second operation, using mainly neat cement, pressures up to 400 pounds per square inch were used. With the lining and grouting completed the water inflow in the thirteen miles of tunnel was reduced from an average of 31,200 gallons per minute in June 1938, at which time 53 per cent of the lining had been placed, to 710 g.p.m. in October 1939.

Clean-up

Following completion of the grouting operations, the tunnel track and utilities were removed and the concrete lining was scraped and scrubbed clean. The tunnel was ready to carry water before the end of October and the first Colorado River water actually entered the east portal about 11:30 a.m. of November 1, 1939, when 10 cubic feet per second of the aqueduct flow of 200 c.f.s. was admitted into the tunnel, the remainder being spilled into San Gorgonio Wash. This small flow reached the west portal at 7:08 p.m., compared with the time of passage at theoretical velocity for full flow of about 2¼ hours.

In the camps removal of plant and buildings was begun as soon as possible after their use was discontinued. Heavy equipment, hoists, and compressors, have been left on their foundations, with necessary protective housing, pending sale. For the most part build-

ings have been sold and removed, and equipment has been sold or moved into the Banning salvage yard and prepared for sale. At the east portal a heavy steel door has been placed at the adit entrance. At Cabazon, track was taken up in the adit access to the main tunnel; pumps, motors and accessories were removed from the underground stations; the headframe was dismantled and the shaft covered with heavy steel plate. Utilities and track were taken out of Lawrence adit and the portal was sealed with steel plate. At Potrero, the shaft was stripped of utilities and cable, the headframe was dismantled, and the shaft covered with steel plate. The west portal area has been cleaned up, all equipment moved to the Banning yard, and the remaining buildings boarded up.

The main aqueduct field headquarters and San Jacinto office building at Banning were closed on January 20, 1940. The general superintendent's office was moved into the warehouse; the hydrographic division into the testing laboratory; and the telephone ex-

Official inspection party at San Jacinto tunnel

change was moved to Hayfield. The garage at headquarters was closed at the end of February 1940.

Costs

Revised costs of the completed tunnels are given in table 9. Due to sundry credits and adjustments in charges for District items on the contract tunnels and credits for sale of salvaged equipment on the Coachella tunnels there is a slight reduction in the costs as given in the first annual report.

CANAL, CONDUIT AND SIPHONS

All construction of canal, cut-and-cover conduit, and inverted siphons, with the exception of a short section of siphon at the west portal of San Jacinto tunnel, was finished before June 30, 1938. During the summer of 1939 preparation of these structures for operation was completed from the Colorado River to San Jacinto tunnel. This work consisted of removing invert dams which had been installed to hold water for curing purposes, from the cut-and-cover conduit, bulkheads from siphon entrances, and cleaning up canal sections where blow sand had accumulated.

With the completion of San Jacinto tunnel approaching, preparatory work was started in April 1939 on siphon schedules 20A and 20B, comprising the 752-foot portion of Casa Loma siphon at the west portal. Partial excavation for this section had been made at the time of opening the west portal early in 1935, when pipes were laid in the cut to carry tunnel water into San Jacinto River. To permit excavating the remainder of the trench the pipe lines were relaid around the unfinished siphon schedules and excavation was begun May 11th, followed by start of concreting June 19, 1939. Owing to the existing high groundwater level it was necessary to excavate below grade and lay and roll in the trench a gravel blanket, upon which a 6-inch concrete slab was placed. The reinforcement steel cage was assembled on the slab, inside and outside forms were set, and the barrel concrete was placed in short sections.

The last concrete was shovelled into the transition structure of this siphon by District directors, on October 14, 1939 during a ceremony to celebrate the completion of main aqueduct construction, by placing this remaining concrete and by unveiling a commemorative plaque set in the west portal headwall of San Jacinto tunnel. The backfilling and levelling of the area were finished in

TABLE 9

MAIN AQUEDUCT TUNNELS
Cost to June 30, 1940

TUNNEL	CONTRACTOR	CONTRACT AWARDED	WORK COMPLETED	LENGTH IN FEET	TOTAL COST	COST PER FOOT
Colorado River	Walsh Construction Company	June 16, 1933	Jan. 29, 1936	5,482	$ 629,152.68	$114.77
Copper Basin Nos. 1 and 2	Walsh Construction Company	June 16, 1933	Feb. 23, 1936	12,273	1,339,258.50	109.12
Whipple Mt.	Walsh Construction Company	June 16, 1933	Feb. 24, 1937	32,238	3,092,405.21	95.92
Iron Mt. (east portion)	Winston Bros. Company	Apr. 21, 1933	Oct. 30, 1936	23,645	3,086,527.78	130.54
Iron Mt. (west portion)	Utah Construction Company	Apr. 21, 1933	Feb. 26, 1937	16,208	2,279,037.09	140.61
Coxcomb	Winston Bros. Company	Apr. 21, 1933	Apr. 22, 1937	17,795	2,206,033.54	123.97
East Eagle Mt.	Broderick & Gordon	Feb. 2, 1934	July 23, 1937	9,440	1,046,655.24	110.87
West Eagle Mt. (east portion)	Broderick & Gordon	June 2, 1933	May 6, 1937	15,845	1,947,990.90	122.94
West Eagle Mt. (west portion)	L. E. Dixon and Bent Bros.	June 2, 1933	Mar. 12, 1936	10,649	1,343,082.82	126.12
Hayfield No. 1	Hunkin-Conkey Const. Co.	June 2, 1933	Jan. 9, 1936	9,734	1,172,385.34	120.44
Hayfield No. 2	Floyd Shofner and J. N. Gordon	June 2, 1933	July 27, 1935	5,435	652,069.78	119.98
Cottonwood	J. F. Shea Co., Inc.	Apr. 21, 1933	Dec. 27, 1935	20,105	2,728,643.44	135.72
Mecca Pass Nos. 1, 2 and 3	Morrison-Knudsen Company	June 2, 1933	Mar. 1, 1935	5,940	795,604.26	133.94
Whitewater Nos. 1 and 2	West Construction Company	June 16, 1933	Apr. 15, 1935	10,232	1,279,308.69	125.03
Subtotal				195,021	23,598,155.27	121.00
Bernasconi	Hamilton & Gleason Company	Apr. 7, 1933	Nov. 18, 1935	6,220	491,233.57	78.98
Valverde	Dravo Contracting Company	Apr. 7, 1933	Oct. 18, 1936	38,015	4,620,500.13	121.54
Subtotal				44,235	5,111,733.70	115.56
Subtotal contract work				239,256	28,709,888.97	120.00
Coachellas	District force account	Dec. 21, 1932	May 8, 1937	178,142	17,543,568.72	98.48
Subtotal				417,398	46,253,457.69	110.81
San Jacinto	Contract and District forces	Feb. 10, 1933[1]	Oct. 31, 1939	68,843		
Total tunnels (92.09 miles)				486,241		

NOTE—All tunnels are 16 feet in diameter except Bernasconi and Valverde which are 15 feet 3 inches.

[1] District took over the work February 12, 1935 and completed construction. Litigation is pending, in consequence of which total cost is indeterminate.

TABLE 10

MAIN AQUEDUCT CANALS
Cost to June 30, 1940

SCHEDULE	CONTRACTOR	CONTRACT AWARDED	WORK COMPLETED	LENGTH IN FEET	TOTAL COST	COST PER FOOT
3	Barrett & Hilp and Macco Corporation	Oct. 19, 1934	May 25, 1937	28,154	$ 827,743.13	$29.40
4	Jahn & Bressi Construction Company	Oct. 19, 1934	Mar. 18, 1937	50,143	1,093,760.22	21.81
5	Jahn & Bressi Construction Company	Oct. 19, 1934	Nov. 17, 1936	49,568	1,070,128.21	21.59
7A	Barrett & Hilp and Macco Corporation	Oct. 19, 1934	Jan. 25, 1936	15,357	425,511.85	27.71
8	C. W. Wood and M. J. Bevanda	Oct. 19, 1934	July 28, 1937	41,449	956,473.17	23.08
9	Utah Construction Company	Oct. 19, 1934	May 15, 1937	41,164	1,038,108.59	25.22
10	Aqueduct Construction Company	Oct. 19, 1934	Apr. 6, 1936	39,655	928,818.58	23.42
11	Aqueduct Construction Company	Oct. 19, 1934	June 24, 1937	33,682	786,859.12	23.36
13	Aqueduct Construction Company	Oct. 19, 1934	Jan. 30, 1937	28,300	626,409.90	22.13
	Subtotal			327,472	$7,753,812.77	$23.68
	Various canal sections, part of pumping plant contracts			4,164		
	Total lined canal (62.81 miles)			331,636		
23A	Griffith Company	Dec. 7, 1934	Oct. 24, 1936	5,568	$ 143,324.37	$25.74
	Total unlined canal (1.05 miles)					

NOTE—Schedule 23A consists of an unlined channel from the west portal of Valverde tunnel to Lake Mathews.

TABLE 11

MAIN AQUEDUCT CUT-AND-COVER CONDUITS
Cost to June 30, 1940

SCHEDULE	CONTRACTOR	CONTRACT AWARDED	WORK COMPLETED	LENGTH IN FEET	TOTAL COST	COST PER FOOT
1	Aqueduct Construction Company	Oct. 19, 1934	July 14, 1936	20,325	$1,381,086.95	$67.95
2	Barrett & Hilp and Macco Corporation	Oct. 19, 1934	May 25, 1937	24,584	1,357,054.62	55.20
7	Barrett & Hilp and Macco Corporation	Oct. 19, 1934	Jan. 25, 1936	12,350	780,406.21	63.19
9A	Utah Construction Company	Oct. 19, 1934	May 15, 1937	3,289	231,219.44	70.30
11A	Aqueduct Construction Company	Oct. 19, 1934	June 24, 1937	3,188	185,538.88	58.20
12	Three Companics, Inc.	Oct. 19, 1934	Nov. 6, 1937	31,233	1,727,660.42	55.32
13A	Aqueduct Construction Company	Oct. 19, 1934	Jan. 30, 1937	1,005	64,886.41	64.56
14	Thompson-Starrett Company, Inc.	Oct. 19, 1934	June 3, 1936	30,222	1,284,743.26	42.51
15	Thompson-Starrett Company, Inc.	Oct. 19, 1934	July 31, 1937	33,953	1,390,373.19	40.95
16	Thompson-Starrett Company, Inc.	Oct. 19, 1934	May 20, 1938	17,139	814,857.15	47.54
18	J. F. Shea Co., Inc.	Nov. 9, 1934	Aug. 14, 1937	26,887	1,197,787.97	44.55
19	J. F. Shea Co., Inc	Nov. 9, 1934	May 30, 1938	34,870	1,616,313.65	46.35
23	Griffith Company	Dec. 7, 1934	Oct. 13, 1936	33,145	1,381,568.61	41.68
Fan Hill	Experimental section, by District forces	Oct. 13, 1933	Nov. 19, 1934	890	106,558.16	119.73
17 & 17A	District forces	Nov. 2, 1934	June 15, 1937	12,331	604,900.75	49.06
	Subtotal			285,411	$14,124,955.67	$49.49
	Modified conduit in portal cuts, part of tunnel contracts			2,111		
	Total cut-and-cover conduit (54.45 miles)			287,522		

CHAIRMAN WHITSETT DIRECTOR ROSSETTI

Placing last concrete on main aqueduct

SECRETARY FINLEY VICE-CHAIRMAN THOMAS

Placing District records in vault at San Jacinto tunnel

TABLE 12

MAIN AQUEDUCT FULL-CAPACITY SIPHONS
Cost to June 30, 1940

SCHEDULE	CONTRACTOR	CONTRACT AWARDED	WORK COMPLETED	NUMBER OF SIPHONS	LENGTH IN FEET	TOTAL COST	COST PER FOOT
	Siphons with single 16′-0″ diameter barrel						
1A	Aqueduct Construction Company	Oct. 19, 1934	July 14, 1936	3	810	$ 92,223.99	$113.86
15B	Thompson-Starrett Company, Inc.	Oct. 19, 1934	July 31, 1937	2	495	62,440.38	126.14
16B	Thompson-Starrett Company, Inc.	Oct. 19, 1934	May 20, 1938	4	1,080	124,654.21	115.42
Gene Inlet	Winston Bros. Company and Wm. C. Crowell	Nov. 22, 1935	Apr. 29, 1938	1	1,831	257,427.92	140.59
Copper Basin	Winston Bros. Company and Wm. C. Crowell	Nov. 22, 1935	Apr. 29, 1938	1	415	52,672.95	126.92
	Total (0.88 mile)			11	4,631	$ 589,419.45	$127.28
	Inlet siphons, part of pumping plant contracts				890		
	Siphons with three 9′-9″ square barrels						
3A	Barrett & Hilp and Macco Corporation	Oct. 19, 1934	May 25, 1937	12	4,070	$ 379,970.08	$ 93.36
4A	Jahn & Bressi Construction Company	Oct. 19, 1934	Mar. 18, 1937	10	3,075	242,488.33	78.86
5A	Jahn & Bressi Construction Company	Oct. 19, 1934	Nov. 17, 1936	12	4,020	340,934.81	84.81
8A	C. W. Wood and M. J. Bevanda	Oct. 19, 1934	July 28, 1937	13	4,930	421,067.44	85.41
9B	Utah Construction Company	Oct. 19, 1934	May 15, 1937	8	2,910	283,766.27	97.51
10A	Aqueduct Construction Company	Oct. 19, 1934	Apr. 6, 1936	10	3,750	330,779.54	88.21
11B	Aqueduct Construction Company	Oct. 19, 1934	June 24, 1937	9	3,735	352,615.17	94.41
13B	Aqueduct Construction Company	Oct. 19, 1934	Jan. 30, 1937	6	2,660	245,520.61	92.30
Hayfield	L. E. Dixon Company and Case Construction Company	Sept. 4, 1936	July 27, 1937	1	300	34,247.47	114.16
	Total (5.58 miles)			81	29,450	$2,631,389.72	$ 89.35

TABLE 13

MAIN AQUEDUCT HALF-CAPACITY SIPHONS
(One of two barrels constructed for initial development)
Cost to June 30, 1940

SCHEDULE	CONTRACTOR	CONTRACT AWARDED	WORK COMPLETED	NUMBER OF SIPHONS	LENGTH IN FEET	TOTAL COST	COST PER FOOT
1B	Aqueduct Construction Company	Oct. 19, 1934	July 14, 1936	2	890	$ 74.273.64	$ 83.45
2B	Barrett & Hilp and Macco Corporation	Oct. 19, 1934	May 25, 1937	7	5,985	352,639.20	58.92
3B[1]	Barrett & Hilp and Macco Corporation	Oct. 19, 1934	May 25, 1937	8	8,275	448,607.29	54.21
6	C. W. Wood and M. J. Bevanda	Oct. 19, 1934	July 28, 1937	1	15,520	761,320.10	49.05
8B[1]	C. W. Wood and M. J. Bevanda	Oct. 19, 1934	July 28, 1937	3	2,960	146,948.44	49.64
10B[1]	Aqueduct Construction Company	Oct. 19, 1934	Apr. 6, 1936	1	1,100	70,147.93	63.77
11C[1]	Aqueduct Construction Company	Oct. 19, 1934	June 24, 1937	1	3,400	176,287.05	51.85
12A	Three Companies, Inc.	Oct. 19, 1934	Nov. 6, 1937	2	1,738	230,379.08	132.55
14A	Thompson-Starrett Company, Inc.	Oct. 19, 1934	June 3, 1936	1	2,150	127,085.65	59.11
15A	Thompson-Starrett Company, Inc.	Oct. 19, 1934	July 31, 1937	2	1,400	99,483.17	71.06
16A	Thompson-Starrett Company, Inc.	Oct. 19, 1934	May 20, 1938	2	1,127	91,883.02	81.53
17B	M. W. D. forces	Nov. 2, 1934	June 15, 1937	10	9,621	878,202.21	91.28
Fan Hill	Experimental section, by District forces	Oct. 13, 1933	Nov. 19, 1934	1	790	82,894.51	104.93
Little Morongo	Experimental section built by United Concrete Pipe Corporation	Nov. 17, 1933	Aug. 20, 1934	1	660	82,620.88	125.18
18A	J. F. Shea Co., Inc.	Nov. 9, 1934	Aug. 14, 1937	2	650	61,433.55	94.51
18J	Morrison-Knudsen Company	Jan. 11, 1935	Sept. 16, 1936	2	9,811	559,148.50	56.99
19A	J. F. Shea Co., Inc.	Nov. 9, 1934	May 30, 1938	1	2,235	130,895.14	58.57
20	J. F. Shea Co., Inc.	Nov. 9, 1934	Dec. 24, 1935	1	18,618	934,147.92	50.17
20A & 20B	Griffith Company and District forces	Dec. 7, 1934	Feb. 15, 1940	1	752	113,992.07	151.59
20C	Griffith Company	Dec. 7, 1934	Sept. 14, 1935	1	7,000	374,243.23	53.46
21	Griffith Company	Dec. 7, 1934	Oct. 13, 1936	3	14,608	546,674.20	37.42
22	Griffith Company	Dec. 7, 1934	Oct. 13, 1936	1	7,229	265,113.49	36.67
	Total (22.07 miles)			52	116,519	$6,608,420.27	$ 56.72

[1] 12′-9″ circular barrel; the remainder are all 12′-4″ circular barrel, except Little Morongo siphon, which is 12′-0″ diameter, and Schedule 19A, which is 11′-5″ diameter.

Completed canal near Pinto Wash

November, after which Riverside County restored the Soboba road where it crosses over the siphon. Final clean-up of the siphon area was delayed until aggregate bins, batching, and other tunnel plant and equipment could be sold and removed, but was accomplished February 15, 1940.

Revised costs of completed canal, cut-and-cover conduit, and siphons are given in tables 10, 11, 12, and 13. In practically all cases the costs are reduced slightly from those given in the first annual report due to credits on District items.

MAINTENANCE

During the construction period, protection and maintenance of completed features were supervised by the several division engineers along the line. Following completion of the main aqueduct features and discontinuance of the division engineers' organizations, an aqueduct maintenance force was formed to take over and continue such work. The headquarters of this force is at Iron Mountain pumping plant, formerly Division 2 camp, with patrolmen located also at Vidal Wash, Eagle Mountain and Banning to cover the entire 242 miles of main aqueduct between the Intake and Lake Mathews (Cajalco), together with branch roads to camps and other roads not transferred to the counties of Riverside and San Bernardino.

During the period under review the maintenance forces have cleared the Hayfield reservoir site, repaired storm damage to diagonal drains, patrol roads, and highways, established the permanent service yard at Iron Mountain, erected experimental sand fences along certain portions of the canal, made such repairs as necessary to prepare the aqueduct sections for operation, removed sand from sand traps, built stilling basins for wasteway discharge outlets, moved cottages from discontinued substations and set them up for use at the Iron Mountain camp and at Vidal Wash patrol station.

Between September 3 and 7, 1939 a widespread area along the aqueduct was subjected to rainstorms of great intensity. Lake beds like Danby, Cadiz, and Bristol, which had been dry for years, were transformed into bodies of water. The intensity and general distribution of rainfall for the storm duration are shown by the following tabulation of official records:

Station	Inches of rain
Gene pumping plant	4.74
Iron Mountain	5.59
Hayfield	5.95
Indio	2.03
Banning	0.59

Following the storm a detailed inspection was made of the aqueduct between the west portal of the Whipple Mountain tunnel and Whitewater siphon. No damage to the aqueduct proper was found. Diagonal drains, parallel drains, backfill over siphons and conduit, and patrol roads were damaged in varying degree at different locations, particularly in Vidal Wash, at Sand Draw, along schedule 8 approaching Iron Mountain, and along schedule 10 east of the Coxcombs. At Vidal Wash part of the upper canal embankment was eroded for a distance of about 650 feet, following failure and destruction of diagonal drains at two locations for a total length of 1,100 feet, allowing flood water to wash against the embankment. It is estimated that during the peak of the storm Vidal Wash carried across the aqueduct line 6,800 cubic feet of water per second from the drainage area above. At other locations breaks in the

Copper Basin reservoir

drains occurred, but being subsequent to the flood peaks little erosion of embankments took place. Restoration of drains and reconstruction of embankment were accomplished by regular maintenance crews and equipment. Patrol road repairs have been made with bulldozer-equipped tractors and with graders.

Immediately following the Imperial Valley earthquake, which occurred on May 18, 1940, an inspection was made of all aqueduct structures. No evidence of any damage could be detected.

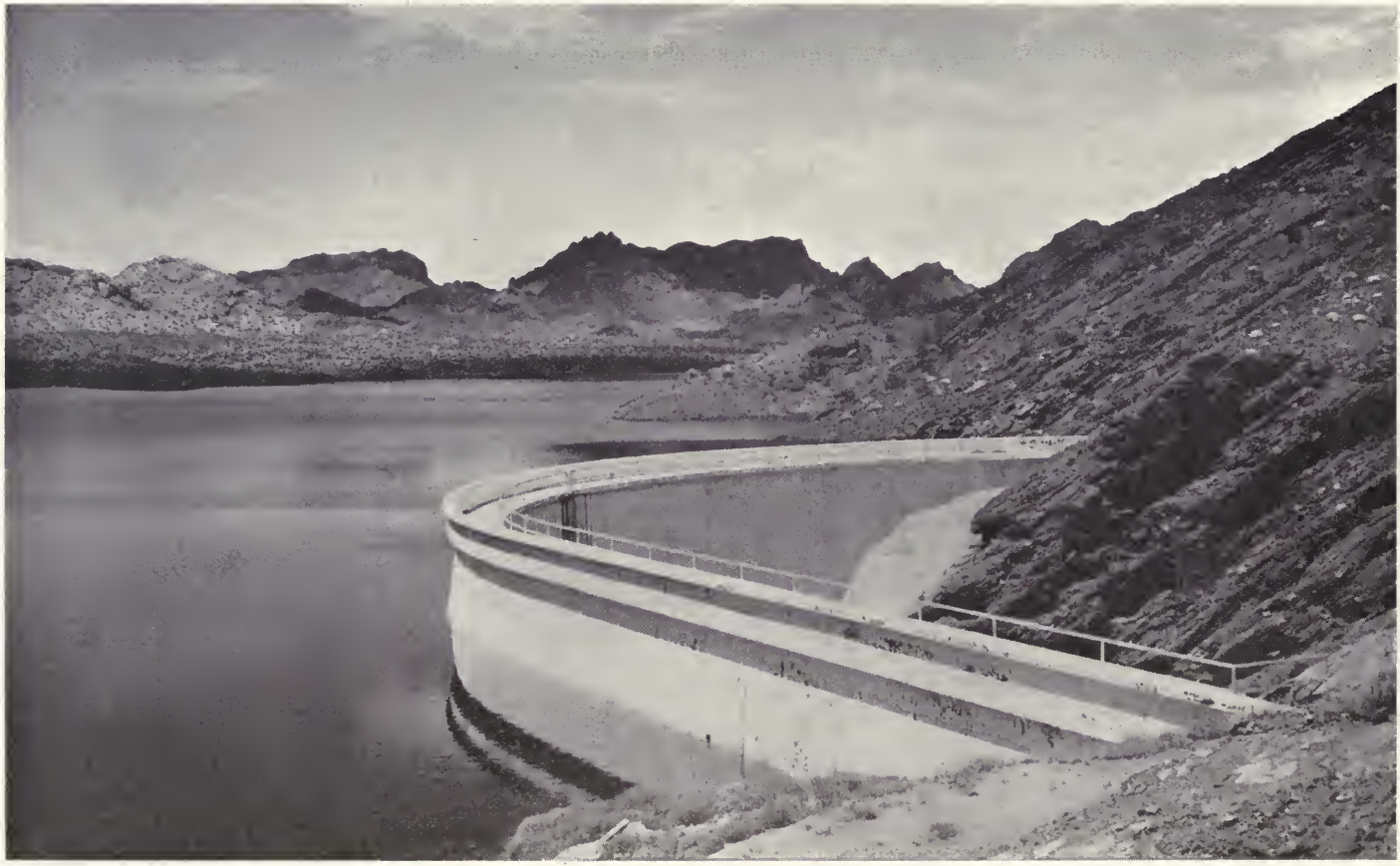
DAMS AND RESERVOIRS

Parker Dam and Lake Havasu

On June 30, 1938 construction of Parker dam was approaching completion. The concrete plug had been placed in the inner diversion tunnel and the bulkhead had just been seated at the upstream end of the outer tunnel, diverting the river flow back into its old channel. First water flowed through the spillway gates on July 1, 1938.

During July all concrete work was completed, including the outer tunnel plug, and all remaining metal was installed. In August, work under the contract was finished and the contract was terminated on the last day of the month. Some miscellaneous jobs were done by forces of the Bureau of Reclamation, all work being completed in November. Stop logs were constructed and placed in position on the trashrack structure, to permit unwatering the forebay while work is under way on the penstock tunnels for the power development. Composition roofing was placed on the gate house and the ornamental lighting units were installed along the roadway on the dam. Filling of the reservoir began October 16, 1938, and release of water at Boulder dam for this purpose ended at noon, November 15th. On November 17th the water surface had reached elevation 440.5. Through the cooperation of the operator of the U. S. Geological Survey gaging station below the dam, tests were run over a considerable time interval to determine the rate of discharge under the various conditions of gate openings and with changing head in the reservoir.

In October the District awarded a contract for drilling grout holes in the California abutment, through which to form a grout curtain below the top of the dam, by sealing any fissures which might exist. Twenty-two holes were drilled and grouted under high pressures. Nine refused grout altogether; one took 30 sacks of cement; one took 29; one took 12; and the remainder from 1 to



Gene Wash dam

6 sacks, indicating a tight formation in the diorite rock, free from open joints and fissures.

To provide protection under normal full reservoir conditions, the installation was started in December 1938 of asphalt-filled plate steel incasements for the lower portions of the structural steel of the highway bridge crossing the Colorado River at Topock. This protective work was completed in February 1939 and inspected and approved by engineers of the Arizona Highway Department and the Division of Highways, California Department of Public Works. Arrangements were made with the A. T. & S. F. Railway whereby it would provide protection for its bridge at Topock as and when it becomes necessary.

The lake formed by Parker dam was officially named Lake Havasu on June 1, 1939. Large numbers of tourists were attracted to the area following the filling of the lake, upwards of 1,000 per week visiting the site during the cool winter and spring months.

In September 1939 a general desert storm swept over the area, beginning the evening of the 3rd and lasting through the 7th, followed by other storms and resulting in a total rainfall of 7.85 inches during the month. In the first storm a total of 4.74 inches of rain was registered at Gene headquarters gage. This heavy precipitation, 1.99 inches on September 4th, 1.61 inches on the 5th, and 0.94 of an inch on the 6th, caused flood flows into Lake Havasu which raised the water level to a maximum elevation of 447.4. The estimated maximum inflow of 146,000 c.f.s. occurred between 11:30 p.m., September 6th, and 2:00 a.m., September 7th, made up of 9,000 released at Boulder, 43,000 entering the reservoir above the Bill Williams River, and 94,000 from the Bill Williams alone. These floods were leveled off in Lake Havasu storage to a maximum discharge through the five gates at Parker dam of 50,000 c.f.s., doubtless preventing serious damage in the lower valleys.

The flooding of the reservoir area brought large quantities of driftwood from the banks of the Colorado and Bill Williams rivers into the basin above the dam. It has been necessary for District forces to remove large quantities of this floating debris and haul it away for burning.

During the remainder of the period a small Bureau of Reclamation force has operated and maintained the dam and reservoir, holding the water surface approximately at elevation 440, except during periods of storm run-off.

Table 14 gives the principal data concerning the construction

TABLE 14

PARKER DAM

The U. S. Bureau of Reclamation issued specifications 574 covering this work and bids were received by the Bureau at Los Angeles, July 26, 1934. Construction was officially completed August 31, 1938 by the J. F. Shea Co., Inc., subcontractor for Six Companies, Inc. Storage of water began October 16, 1938.

RESERVOIR	
Area of water surface	25,000 acres
Capacity	717,000 acre feet
Maximum elevation water surface	450 feet
EXCAVATION QUANTITIES	
Dam and cofferdams	1,757,724 cy
Diversion works—approach cuts	107,779 cy
—tunnels	118,918 cy
Forebay and sluice tunnel	207,787 cy
Power plant	67,894 cy
Roads	68,050 cy
Removal of cofferdams	203,514 cy
CONCRETE QUANTITIES	
Dam	290,751 cy
Forebay structures	5,600 cy
Diversion works—tunnel lining	19,505 cy
—tunnel plugs	4,984 cy
Power house substructure	15,713 cy
DAM	
Length, at roadway level	800 feet
Height, lowest foundation to roadway level	320 feet
Elevation, spillway crest	400 feet
Elevation, top of stoney gates	450 feet
Thickness, at spillway lip	50½ feet
Thickness, maximum base	100 feet
Radius, upstream face	315 feet
Radius, downstream face	variable
DIVERSION TUNNELS	
Length, west, No. 1	1,759 feet
Length, east, No. 2	1,704 feet
Section, horseshoe, 29 feet inside of lining	
COFFERDAMS	
Elevation, top of upper	437 feet
Elevation, top of lower	400 feet
Earthfill and riprap	468,054 cy

of the dam and appurtenant works. The construction cost to the District on June 30, 1940 was $7,298,026.83. The actual cost is reduced by a P.W.A. grant of $500,000.00, to a net cost of $6,798,026.83.

Parker Power Plant

The construction of Parker dam not only provided a clear reservoir from which to divert water into the aqueduct and reduced the pump lift by 72 feet, it also created a head of the same amount and made possible the development of 100,000 kilowatts of hydro-

Parker dam

electric power. The contract of February 10, 1933, between the United States and the District for the cooperative construction of Parker dam gave the United States one-half of the power privilege at this site, the other half being retained by the District. The development of the site earlier than originally planned was undertaken by the U. S. Bureau of Reclamation under a supplemental contract dated April 7, 1939, in order to relieve a severe shortage of power in Phoenix, Arizona, and to furnish power for pumping on the Gila irrigation project in southwestern Arizona. The first installation is to consist of three 25,000-kw generating units, one to supply the Gila load, and two for the Phoenix power customers—the Salt River Valley Water Users' Association and the Central Arizona Light and Power Company. Funds for the construction of the plant are being advanced by the United States. One of the three units is to be installed in the District's half of the power plant, but for at least ten years after being placed in operation this unit is to be used on the Phoenix load. During this period one-half the

revenue from the sale of energy, exclusive of that used by the Gila project, less one-third of the operating cost of the power plant, will be credited to the District and applied to the amortization of that portion of the cost of the plant chargeable to the District.

Should the demand for power exceed 75,000 kilowatts, the capacity of the three units, the fourth unit may be installed by the United States, and in that event the District would be charged with one-half of the operating expense and credited with two-thirds of the revenue from the sale of all power, except that taken by the Gila project.

It is anticipated that the net income from the sale of power will amortize the District's portion of the cost within 12 to 15 years. After amortization is completed, the District's share of the net revenues is to be applied to any charges owing to the United States from the District.

Surface excavation and the construction of the penstock tunnels were started by the Bureau of Reclamation in November 1939, under a contract with Clyde W. Wood, of Los Angeles, and this work was nearing completion on June 30, 1940. Contracts have also been let to Chicago Bridge and Iron Company for steel penstocks in the tunnels, to the S. Morgan Smith Company for three turbines, and to the Westinghouse Electric & Manufacturing Company for three generators.

The construction of the power house is being carried on by Government forces. The foundations have been unwatered within the power house substructure, which was built while the dam was under construction. The concreting plant has been erected and forms partially constructed. Some delay was occasioned by a fire on June 28, 1940, which destroyed the warehouse where forms were being fabricated.

The estimated cost of the plant, with three units installed, is $8,758,000, of which approximately $4,000,000 is chargeable to the District. It is expected that the plant will be placed in operation in the summer of 1941.

Gene and Copper Basin Dams

The construction of the major items of these dams was completed on June 30, 1938, and described in the history and first annual report, but the contractor had not then finished the clearing and clean-up of the reservoir areas, the placing of backfill, and the installation of metalwork. During July these remaining items were completed and construction equipment was removed. Testing of

the high-pressure gate valves and sluiceway discharge valves was done early in August and the contract was completed on the 15th of that month. The contractor was released from the requirement to finish cooling of the concrete in Copper Basin dam during the summer heat, the District preferring to perform this operation when the outside temperature more nearly conformed with the desired internal temperatures. His refrigerating plant, however, was retained by agreement, and after completion of the cooling by District forces, during October and November, was returned to his Parker dam storage camp. Grouting of cooling pipes embedded in the dam and removal of all surface piping were accomplished in December. The following month the electrical equipment installation to operate the Copper Basin outlet gates was made, completing all construction on these two dams.

Following the official starting of the Intake pumps, celebrated at Gene camp and west portal of Colorado River tunnel January 7, 1939, simultaneous operation of three pumps for 283 pump-hours delivered 5,450 acre feet into Gene reservoir storage bringing the water level to 3.9 feet below the spillway lip elevation of 736 feet. There was no measurable deflection of the arch dam during the filling of the reservoir. On January 29th pump No. 3 at Gene

First water flowing into Copper Basin

TABLE 15

GENE WASH AND COPPER BASIN DAMS

	Gene Wash	Copper Basin
Contractor	J. F. Shea Co., Inc.	
Contract awarded	March 26, 1937	
Contract completed	August 15, 1938	
First water in reservoir	January 7, 1939	January 31, 1939
Height of dam (maximum), feet	138	210
Length (crest), feet	430	254
Crest thickness, feet	5	5
Base thickness, feet	26.5	35
Area of reservoir, acres	224	425
Capacity of reservoir, acre feet	6,300	24,200
Dam		
Excavation, cubic yards	9,061	11,685
Concrete, cubic yards	14,417	17,338
Metalwork and reinforcement steel, lbs.	380,800	478,302
Spillway		
Excavation, cubic yards	4,763	8,137
Concrete, cubic yards	4,725	2,050
Backfill, cubic yards	503	171
Metalwork and reinforcement steel, lbs.	59,603	.....
Dike		
Excavation	2,361	.....
Earthfill, cubic yards	8,710	.....
Concrete, cubic yards	926	.....
Reinforcement steel, lbs.	72,430	.....

plant was placed on line and started pumping into the Copper Basin No. 1 tunnel. At 11:00 a.m. on the 31st Colorado River water began filling Copper Basin. As the water level rose readings were taken of the deflection in the Copper Basin arch dam. With water level up to elevation 1025.85 or 2.15 feet below the spillway lip the maximum deflection was $\frac{7}{16}$ of an inch. On the morning of March 13th one of the three outlet gates was opened sufficiently to release into the Whipple Mountain tunnel 10 c.f.s. of Colorado River water on its way to the third pump lift at Iron Mountain.

Final quantities and other data concerning the dams are given in table 15. The total costs of dams and appurtenant works as of June 30, 1940 are $19,791.59 for exploratory work, $392,210.02 at Gene Wash, and $644,546.62 at Copper Basin.

PUMPING PLANTS

Construction

The location and a general description of the pumping plants and major equipment were given in the history and first annual report.

On June 30, 1938 the general construction contracts for the pumping plant buildings and appurtenant structures, including the delivery pipe lines, sand traps, and forebays, had been completed except at Hayfield. All major pumping equipment purchased by the District had been delivered and the installation of the equipment by District forces was in progress at all plants.

Intake and Gene

Erection of the main pumps and motors at these plants was completed by July 15, 1938, and work was in progress on the installation of auxiliary apparatus, power cables, wiring, switchboards, main transformers, and circuit breakers. In September this work was sufficiently far advanced so that testing and preliminary operation of all control circuits were commenced. On November 1, 1938 the 230-kv transmission line was energized from Boulder power plant and the pumps at Intake plant were operated for short periods on November 17th. During the remainder of 1939 circuit testing was completed at Intake and the test crew transferred to Gene. Gene plant was ready for operation January 25, 1939.

Iron Mountain

The general contract on this plant had been completed in the summer of 1937 and equipment installation started immediately thereafter. By June 30, 1938 the main pumps and motors were completely erected, and after that date a small crew continued with the power and control wiring and the installation of the auxiliary equipment. This work was completed in December 1938.

Eagle Mountain

On June 30, 1938 the pump casings had been placed, the pumps assembled, and work was in progress on the concrete supports for the main motors. Erection of the motors was completed in September 1938. Installation of auxiliary equipment, switchboards, control and power cables, transformers, and circuit breakers was completed in February 1939.

Hayfield

L. E. Dixon Company and Case Construction Company, the general contractors for the Hayfield plant, completed their work on July 21, 1938. Several months prior to that date the switch

Intake pumping plant on Lake Havasu

house, transformer rack, and switch rack had been completed by the contractor to an extent sufficient to permit District forces to proceed with the installation of equipment in these structures. Erection of the pumps and motors was commenced immediately following completion of the general contract and continued throughout the winter of 1938-39. The last concrete work, that for the motor foundation, was placed November 22, 1938. Erection of the motors was completed in March 1939, and in July 1939 equipment installation was completed and the pumps were ready for operation.

Camps and Housing

Concurrently with the installation of equipment, District forces were engaged in improvement of the grounds around the pumping plants and the rearrangement of the construction camps to provide living quarters for the permanent operating personnel. Yards and roads immediately adjacent to the plants and roads in the camp areas were graded and surfaced with an oil mix paving. Five additional four-room dwellings of a permanent nature, stucco with tile roof, were constructed under contract at Iron Mountain, one at Eagle Mountain, and two at Hayfield. One new residence was built by District forces at Gene camp. Frame dwellings used at the various substations on the construction power system were moved to the Gene, Iron Mountain, and Hayfield camps and remodeled. Air conditioning equipment was added, and they are now used as operators' cottages. The guest house and the office of Division 3 camp at Eagle Mountain were remodeled into two family dwellings.

Preliminary Operation

On October 16, 1938 the spillway gates at Parker dam were lowered and excess water was released from storage at Boulder to begin filling Lake Havasu, the reservoir created by Parker dam. By January 1, 1939 the reservoir had filled to a depth sufficient to permit pumping at the Intake plant. On January 7th, in the presence of the board of directors, members of the District staff, and invited guests, including representatives of the cities in the District, the Intake plant was formally placed in operation. The ceremonies were held at the west portal of the Colorado River tunnel. After addresses by Chairman Whitsett, Director Emme, and General Manager Weymouth, the general manager directed Chief Electrical Engineer J. M. Gaylord to start the pumps. The entire ceremony, including an address by Senator Hiram Johnson from Washington, D. C., the starting of the pumps and the arrival of the first water

at the west portal of the Colorado River tunnel, was broadcast over the Columbia Broadcasting System.

Pumping at Intake continued until the filling of Gene reservoir on January 14, 1939. Testing of pumps at Gene plant was started and the first water delivered to the Copper Basin reservoir on January 31st. This reservoir was filled on February 27th, and water was first released through the outlet gates on March 13th, in small volume, for the purpose of filling the siphons and testing the canal between Copper Basin and Iron Mountain. On March 30th, larger flows were released from Copper Basin, the forebay at Iron Mountain plant was filled, and pumping started at that plant on April 5th, sufficient water being pumped to fill the Eagle Mountain forebay. The first pump operation at Eagle was on April 10th. Pumping at all plants except Hayfield continued intermittently to test out equipment and fill reservoirs, with occasional shutdowns to adjust equipment and inspect structures. On July 25th the pumps at Hayfield were started and operated sufficiently to test and adjust the main pumping and control equipment, the water pumped being turned out of the aqueduct at the San Gorgonio wasteway just east of the San Jacinto tunnel.

The San Jacinto tunnel was completed, cleaned up, and ready for water in October 1939. On October 31st pumping was resumed at Hayfield and the first water reached Lake Mathews on November 2nd. All plants have been operated since that date to supply water for testing and conditioning aqueduct structures, filling the terminal reservoir, and adjusting equipment in preparation for regular operation.

No difficulties of a serious nature were encountered in starting up the pumping system. During the past year of intermittent operation there have been some severe storms with heavy lightning, in the main aqueduct area. The protective system has functioned properly under all conditions and there was practically no damage to any of the equipment during this period.

The successful operation of this pumping system, which is the largest ever installed and involves pumping equipment of unprecedented size, reflects the careful thought and planning given to every phase of the design, manufacture, and construction of the entire installation.

Tests of Aqueduct Pumps

During the year 1939 field tests of unusual thoroughness and precision were carried out on the pumps in the five pumping plants.

Rotor for 9000-horsepower motor at Gene

The purpose of the tests was to determine whether the pumps comply with all of the requirements of the specifications.

The most important characteristics are capacity and efficiency; that is, the ability of the pumps to deliver the required amount of water and their economy in the use of electric power. The pump manufacturers were required by the District to guarantee that each pump would deliver not less than 200 cubic feet per second of water with an efficiency of 88 per cent, and were offered a bonus if the pump efficiency exceeded that percentage. The efficiency is the ratio between the useful work performed by the pump in lifting the water the required height and the actual amount of energy delivered to the pump by the driving motor.

In making the pump tests it was necessary to make accurate measurements of capacity, head, power, and the speed of rotation of the pump.

Capacity is the quantity of water delivered by the pump expressed in cubic feet per second. Head is the net pressure developed by the pump, including the lift through which the water is raised, and the pressure necessary to overcome the friction of the water in the pipe lines. From the measured head and capacity, the useful work done by the pump is calculated.

The power is measured in kilowatts of electrical energy put into the driving motor. Each of the motors was completely tested at the factory and the motor losses determined. When the power input to the motor was measured in the field the known motor losses were deducted to give the net power delivered to the pump shaft. The motor losses are less than 3 per cent, which means that more than 97 per cent of the power delivered to the motors by the transmission line from the Boulder power plant is used in driving the pumps.

For measuring the power input, a special set of test meters was used. These meters were carefully matched against standard instruments of known accuracy both before and after the tests at each plant in order that any variation which might have taken place during the tests could be detected. The precise measurement of electric power requires that the meters be kept at a constant temperature during calibration and while in use in the field tests. This was accomplished by placing the meters in an insulated box in which constant temperature was maintained by electric heating elements.

Measurements of speed were made with a cathode ray oscilloscope. This instrument compares visually the electrical speed of

Iron Mountain pumping plant

Eagle Mountain pumping plant

the motor and pump in cycles per second with a known constant speed source controlled by a carefully standardized tuning fork. The difference between the speed of the pump and the standard constant speed is shown on the illuminated face of the instrument by a series of waves traveling across it. If the wave stands still it indicates that the frequency or speed of the motor is exactly the same as the frequency of the constant speed source. Waves progressing in one direction show that the motor is running at a higher speed, and progress in the opposite direction indicates a lower speed. A mechanical counter registers the number of waves that pass in a given time and with this information the speed of the motor and pump in revolutions per minute can be accurately calculated. Measurement of speed is important because the guarantees of pump capacity and power are made for a certain definite speed and if the speed during a test is even slightly more or less, appropriate correction must be made.

The head, or pressure against which the pump lifted the water, was measured by mercury columns and by pressure gages which were carefully calibrated against known weights. The pumps all being submerged below the inlet water level, there is always a positive pressure on the pump inlet and the difference between the inlet pressure and the discharge pressure is the net pressure or head. It is somewhat greater than the actual height that the water is lifted on account of the friction losses in the inlet and delivery pipes.

The quantity of water discharged by each pump was measured by the salt velocity method. This method was devised and developed by Professor C. M. Allen, head of the department of mechanical engineering at Worcester Polytechnic Institute, in Massachusetts, and is generally considered by hydraulic engineers to be one of the most accurate methods that can be used in measuring large volumes of water flowing in pipes. It is based on the principle that if a concentrated solution of common salt is injected into water, the electrical conductivity of the water is thereby increased. Two electrodes are placed in the pump discharge pipe a known distance apart, and connected to an ammeter which records on a rapidly moving chart the conductivity of the water as it passes the electrodes. Concentrated brine is injected into the pipe a short distance ahead of the electrodes, and as this quick "shot" of brine passes each electrode, its increased conductivity makes a "hump" in the otherwise straight line on the chart. Time, in seconds, is also marked on the chart by an accurate clock, so that the distance between the

humps on the chart is a measure of the time taken for the water to travel a known distance. While the principle of the method is direct and simple, there is a great amount of work involved in its accurate application.

The results of the tests were gratifying in that all of the pumps exceeded the guarantees by a considerable margin. The highest capacity was shown by the pumps at Gene plant, with an average per pump of 216 cubic feet per second, or more than 93,000 gallons per minute. The pumps at Iron Mountain plant showed the highest efficiency, averaging 91.3 per cent. The average efficiency of all pumps in the five plants is nearly 90.5 per cent, which is an outstanding record in pump performance.

The bonus rate for each per cent above the stipulated 88 was $10,000 at Intake and Gene, $5,000 at Iron Mountain, and $15,000 at Eagle Mountain and Hayfield, resulting in payments of $29,000, $29,000, $16,500, $24,000, and $28,500, respectively, a total of $127,000.

Table 16 contains engineering and cost data pertaining to each plant. The cost is shown as of June 30, 1940, with all work of construction and installation of equipment virtually completed. It does not include cost of housing, which is shown separately for each of the four camps, one camp at Gene serving two plants.

POWER SUPPLY

The principal power supply for the Colorado River aqueduct is obtained from Boulder dam under a contract with the United States dated April 26, 1930, and amendments thereto, by which 36 per cent of the firm energy and all of the secondary energy at Boulder dam is allotted to the District. This contract assures a supply of firm power sufficient to pump about 1,000 cubic feet per second, but when the water demand exceeds that amount Boulder power must be supplemented from other sources during periods when sufficient secondary energy is not available. In this connection power from the Parker power plant among others will be utilized.

The District's obligation to pay for its allotment of firm energy started at 55 per cent in July 1938, and will increase to 100 per cent of the allotment after July 1941. It is estimated that the demand for water will not reach 1,000 cubic feet per second until 1960, or later, and therefore during the next 15 or 20 years a con-

TABLE 16

PUMPING PLANTS

	INTAKE	GENE	IRON MOUNTAIN	EAGLE MOUNTAIN	HAYFIELD
Miles from Lake Havasu	0	2	69	110	126
Normal static lift, feet	291	303	144	438	441
Average pumping head, feet	294	310	146	440	444
Elevation of hydraulic grade at top of lift, feet	740	1,037	1,047	1,404	1,807
Delivery lines, slope length, feet	946	2,202	689	947	1,284
Diameter main lines, feet	10	10	10	10	10
Diameter branch lines, feet	6	6	6	6	6
Number of units installed	3	3	3	3	3
Pump manufacturer	Byron Jackson Co. and Pelton Water Wheel Co.		Allis-Chalmers Manufacturing Co.	Worthington Pump and Machinery Corporation	
Motor manufacturer	General Electric Company		Allis-Chalmers Manufacturing Co.	Westinghouse Electric and Manufacturing Co.	
Horsepower, each motor	9,000	9,000	4,300	12,500	12,500
Kilowatts to operate each motor at average head	6,100	6,450	2,850	8,800	8,800
Speed, r.p.m.	400	400	300	450	450
Capacity each pump at average head, c.f.s.	216	217	204	204	204
Average pump efficiency, per cent	90.9	90.9	91.3	89.6	89.9
Cost to June 30, 1940	$2,605,717.34	$2,927,523.04	$2,182,796.82	$2,896,873.89	$3,544,845.76
Cost of permanent quarters		$162,653.42	$ 65,802.39	$ 64,786.47	$ 83,218.95

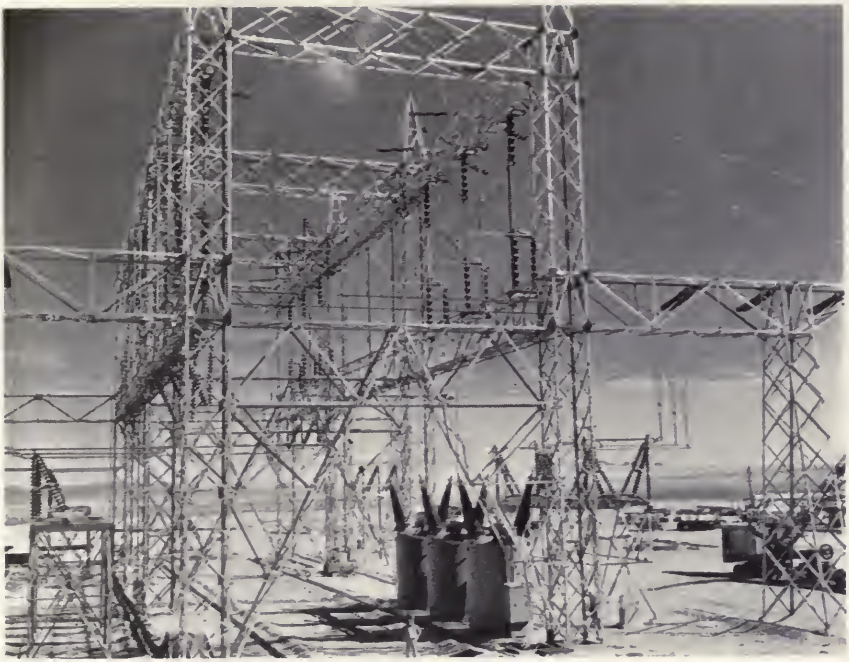
siderable portion of the District's allotment will not be required for pumping. The energy remaining unused by the District is available for disposition by the Secretary of the Interior, the proceeds being credited to the District.

The following contracts have been made by the Secretary for disposition of the District's unused firm energy:

Contractor	Date of contract	Date of expiration	Amount of energy
California-Pacific Utilities Co., Needles, California..	Dec. 28, 1937	Dec. 31, 1954	20,000,000 kw-hr per year
Citizens Utilities Co., Kingman, Arizona	Jan. 7, 1938	Dec. 31, 1954	50,000,000 kw-hr per year
Southern California Edison Co., Ltd., Los Angeles, California..	Oct. 14, 1938	June 1, 1940	50,000,000 kw-hr (minimum)
Salt River Valley Water Users' Association, Phoenix, Arizona	Dec. 23, 1939	May 31, 1945	Available transformer capacity (about 30,000 kw)

Unused firm energy within the District's allotment to the extent of over one billion kw-hr will be available for sale during 1941, and a diminishing amount thereafter as the pumping load grows. A contract for the delivery of 500 kw of such power to the U. S. Indian Service for use on the Colorado River Indian Reservation and vicinity has been negotiated and is pending before the Department of the Interior. Several additional applications aggregating 75,000 kw are under consideration. The basis of negotiations in all such cases is the cost of the energy to the District plus generation and transmission charges. If not disposed of to other customers, a large portion of the District's unused energy undoubtedly will be taken by the City of Los Angeles and the Southern California Edison Company, which have the right, under their Boulder lease contract, to take at secondary rates, certain energy in excess of their firm allotments.

The Bureau of Power and Light of the City of Los Angeles is the generating agency for the District's energy at Boulder dam. The District does not maintain an organization at that plant, but has the privilege of specifying the capacity and type of generating units for its service. Two generators have been installed at the District's request, but since the present demand does not exceed the capacity of one such unit (82,500 kw) one of the generators was released December 1, 1939 for a period of 33 months for the



230-kv switch racks at pumping plant

principal use of the City of Los Angeles in consideration of the assumption by the city of the fixed and operating charges upon this unit.

A supplemental contract with the United States dated July 13, 1938 gives the District the right to defer until 1955, the payment for part of its unused energy. Deferred payments, however, are to bear interest until paid and the accumulated deficit must be repaid between 1955 and 1987. The District has not as yet exercised the right of deferment of payments conferred by this contract.

Beginning in 1937, the District has actively sought a revision of the basis of charges for electric energy generated at Boulder dam. The seven states of the Colorado River basin, as well as nine power allottees, participated in the negotiations with the Secretary of the Interior, and the resulting Boulder Canyon Project Adjustment Act, H. R. 9877, (passed by the Congress on July 11th and signed by the President July 19, 1940), effects a solution of many difficult and controversial problems. This act will become effective if, before June 1, 1941, contractors holding 90 per cent of the allot-

ments of firm energy have executed new contracts accepting the revised basis of charges. The act provides that the rates to be paid shall be determined on the basis of the cost of energy, including amortization within 50 years with 3 per cent interest on the cost of the works, less $25,000,000 allocated to flood control. Included in the costs are annual payments to Arizona and Nevada of $300,000 each, and $500,000 to a Colorado River development fund, in addition to operation, maintenance, and replacement expenses. The resulting rate will represent a considerable reduction below the present falling water rates of 1.63 mills per kilowatt-hour for firm energy and one-half mill per kw-hr for secondary energy. Generating charges, which must be paid in addition to the falling water rates, will continue to be paid on the basis of actual cost. The cost of energy over the 50-year period of the contract, on the present basis of competitive cost, is uncertain since the periodic adjustments of rates would be highly controversial. The rates under the new law should be substantially uniform and the periodic adjustments relatively simple. Under the new law the power users will receive the benefit of the economical production of power possible at the remarkably fine Boulder power plant.

230-KV TRANSMISSION LINE

The construction of the 230-kv transmission line from Boulder dam to Camino switching station with one branch from that point to Gene and another to Iron Mountain, Eagle Mountain and Hayfield, was completed in May 1938, except the terminal span at Boulder, which awaited building of the switch rack by the U. S. Bureau of Reclamation. On November 1, 1938 the entire 230-kv line was energized without incident and transmission of Boulder power to the pumping plants was begun.

Since the transmission line has been in operation severe electrical storms have caused a number of short service interruptions. Notable among these were the storms of July 27 and 28, 1939 when ten outages occurred, with a total outage time of 50 minutes, and the period of August 22-29 when fifteen outages occurred aggregating 92 minutes.

Early in September 1939 a general rainstorm of very severe intensity passed over the area between Vidal and Needles causing the Chemehuevi Wash which crosses the 230-kv line right of way 39 miles south of Camino to run 11 feet deep at the point of cross-

Tower on 230-kilovolt transmission line

ing. This storm caused considerable damage to the patrol roads but did no damage to the transmission line.

A week later a smaller but more violent rainstorm struck the Pinto Springs area north of Camino switching station, washing out some two miles of the Santa Fe railroad and damaging the patrol road in a number of places. Damage to the transmission line consisted only of washing out some 3 to 4 feet of soil around two footings of one tower where Pinto Wash overflowed its banks and cut a new channel.

In December 1939 control panels and metering equipment were installed at Gene for the Phoenix transmission line and construction of the wood pole tie line was started to connect the Gene-Intake 69-kv line to the Phoenix line at Parker dam. On February 1, 1940 delivery of energy over this tie line to the Salt River Valley Water Users' Association was begun. This is a part of the District's unused energy generated at Boulder dam, transmitted over the District's 230-kv and 69-kv lines, and delivered to the Phoenix line at Parker dam. The kilowatt hours of energy delivered to this line from commencement until June 30, 1940 are as follows:

February	11,136,000
March	13,716,000
April	13,524,000
May	13,862,400
June	15,472,800

The maximum load was approximately 22,000 kilowatts.

CHAPTER 3

DISTRIBUTION SYSTEM

Lake Mathews, formerly known as Cajalco reservoir, is the terminus of the main aqueduct and the beginning of the distribution system to convey Colorado River water to the constituent areas of the District in the coastal basin of Southern California.

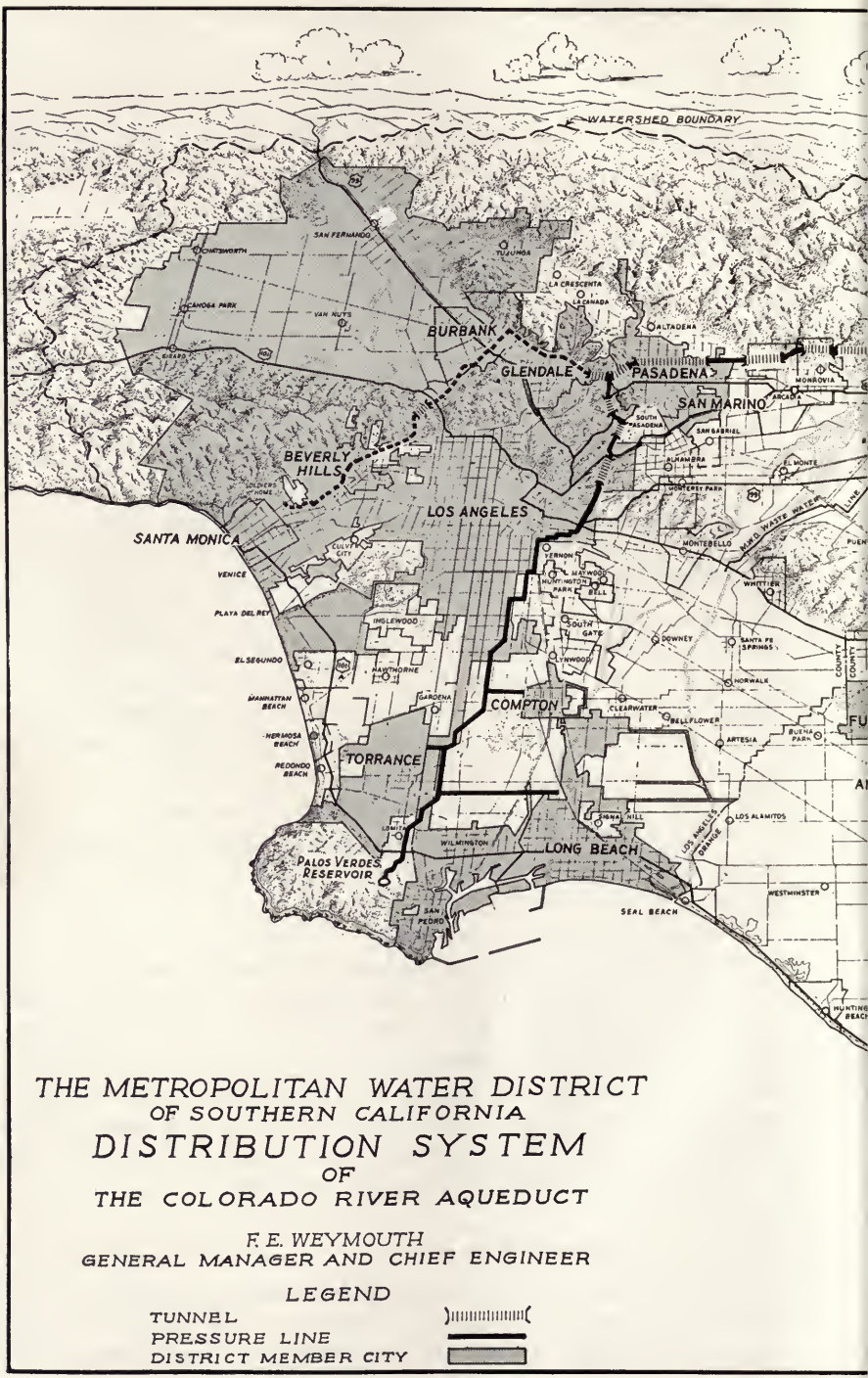
This reservoir, located about 10 miles south of the City of Riverside, is at an elevation such that gravity delivery of water can be made under pressure to the coastal plain, through feeder pipe lines and laterals. The system, discussed more fully in the history and first annual report, will consist initially of Lake Mathews, the headworks, 60 miles of upper feeder pipe lines and tunnels and approximately 90 miles of branch feeders and laterals with necessary spillways and various auxiliary and control structures, a water softening and filtration plant, and storage regulating reservoirs within the metropolitan area. This initial development is shown on the map, figure 3.

The District will deliver Colorado River water in wholesale quantities to its constituent areas. All retail deliveries will be made to the individual users by the existing water bureaus or departments, or other operating agencies.

Although the 1940 population of the member cities is above 2,000,000, the potential service area comprises all of the coastal plain with a constantly growing population which now numbers more than 3,000,000. Estimated future demands for water and rates of increase of demand require a degree of flexibility in the present distribution system, therefore the plan for development of the distribution system contemplates building in progressive stages with essential portions, adequate for several years, built at first, and additional units constructed as required.

Operation Characteristics

In the preliminary studies of the location and design of the initial distribution system, the water systems of the member cities were examined and data collected concerning points of delivery, desired



THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

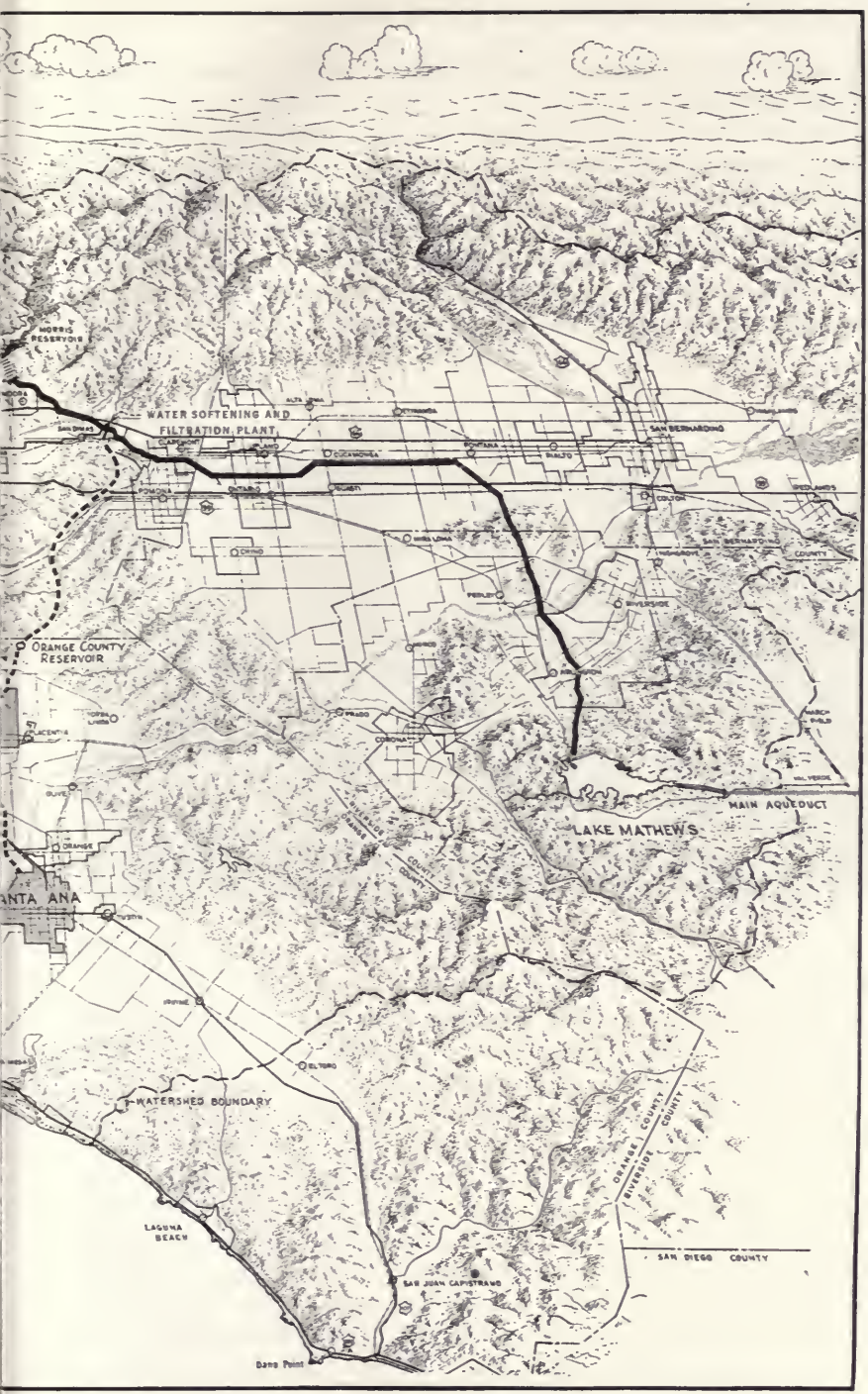
DISTRIBUTION SYSTEM
OF
THE COLORADO RIVER AQUEDUCT

F. E. WEYMOUTH
GENERAL MANAGER AND CHIEF ENGINEER

LEGEND

TUNNEL
PRESSURE LINE
DISTRICT MEMBER CITY

Fig. 3. Di


MORRIS RESERVOIR
WATER SOFTENING AND FILTRATION PLANT
SAN BERNARDINO
ORANGE COUNTY RESERVOIR
MAIN AQUEDUCT
LAKE MATHEWS
WATERSHED BOUNDARY
ORANGE COUNTY
RIVERSIDE COUNTY
SAN DIEGO COUNTY
LAGUNA BEACH
SAN JUAN CAPISTRANO
Dana Point

ion system

pressures, elevations of service at different locations, present needs, and future demands.

Because of the character of the service required and the great quantities of water to be conveyed over long distances the distribution system of the District does not correspond to a conventional municipal pattern. The long distances from the main storage at Lake Mathews to the points of delivery require considerable drop in the elevations of hydraulic gradient to maintain the necessary flow. If these large pipe lines were designed in a manner similar to conventional distribution systems with shutoff valves at the

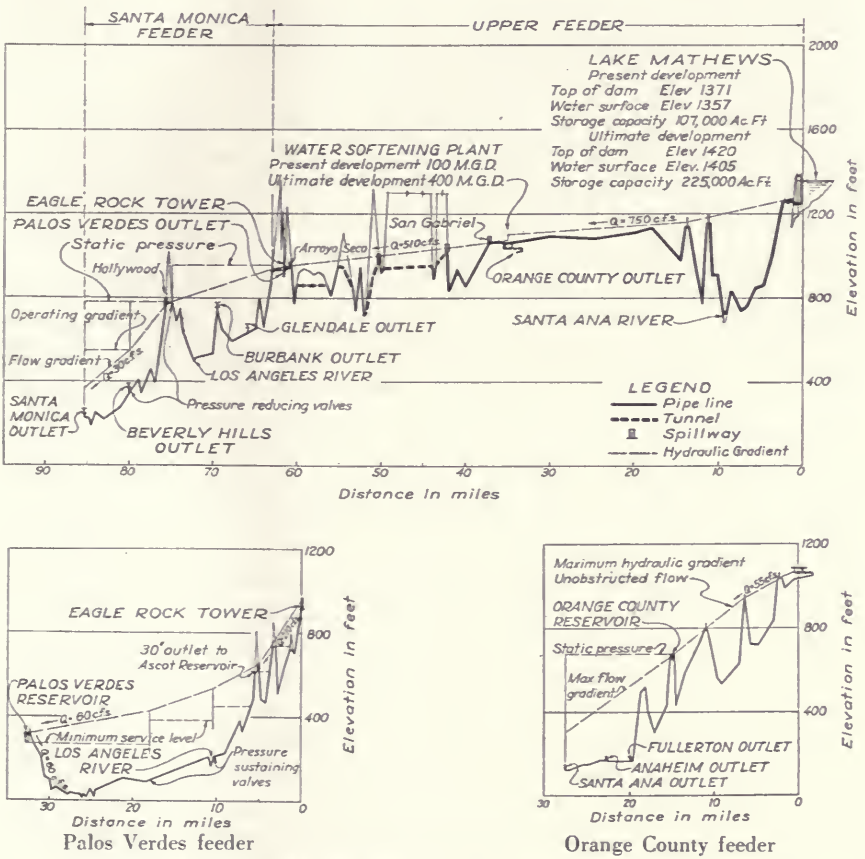
Outlet tower at Lake Mathews

end of the pipe, when the demand diminished or was shut off altogether at the lower end of the line the pressure in the pipe would build up to the level of the water at the upstream source of supply. To provide for this greatly increased pressure the strength of the pipe would have to be increased and the cost of the pipe would be correspondingly increased. In the case of the upper feeder the increase in cost to provide for such a design would amount to several millions of dollars. Economy therefore dictated that the upper feeder be designed for a hydraulic gradient with an unobstructed flow of maximum required capacity. The demand for water at the points of delivery will be satisfied by the careful dispatching of water from Lake Mathews and the excess or deficiency in the release of water therefrom will be absorbed or supplied by equaliz-

ing reservoirs operating in conjunction with automatic regulating and relief valves, and spillways at the lower ends of the pipe lines. To guard against an excessive rise of pressure in the feeders from sudden plugging up of tunnels and pipes due to seismic disturbances or other causes there are provided a number of overflow spillways and wasteways at strategic points.

Diagrammatic profiles of the initial development of the distribution system in figure 4 show the operating characteristics of flows and pressures in the system and also illustrate the requirements met in designing the pipe lines and the controls.

The upper feeder, constituting the main trunk of the system, extends from Lake Mathews to the west portal of San Rafael No. 2 tunnel and branches out into the Orange County feeder, the Palos.



Palos Verdes feeder

Orange County feeder

Fig. 4. Diagrammatic profiles of feeders

Verdes feeder, and the Santa Monica feeder. It traverses the City of Pasadena under Mountain Street and can deliver water through a short connection directly into Pasadena's Sunset reservoir.

The Orange County feeder will deliver water to the cities of Fullerton, Anaheim, and Santa Ana. The point of diversion is at the water softening and filtration plant turnout so that water can be taken from the upper feeder either on the upstream or the downstream side of the plant. In this way raw water can be supplied for irrigation needs or softened and filtered water for domestic and industrial use as required. The amount of water released into this feeder will be controlled by manually operated throttling valves, the operator being guided by a flow indicator on the venturi meter at the beginning of the feeder. This feeder was designed for an unobstructed flow of 55 c.f.s. for a length of about 15 miles. At the end of this section the water will be discharged into, or can be by-passed around, an equalizing reservoir at hydraulic grade. The remainder of the feeder below the reservoir was designed as a conventional delivery line and will be subjected to a full reservoir pressure at the time of no demand, with correspondingly lower pressures at the time of withdrawals. Provision was made in designing this feeder for extending the delivery of Colorado River water to the south coastal cities of Orange County.

The Palos Verdes feeder will deliver water to the cities of Los Angeles, Compton, Torrance, and Long Beach. It will also receive the excess water dispatched from Lake Mathews and not taken by the cities supplied from the Santa Monica feeder. This excess water will flow to the Palos Verdes reservoir at the end of the line to be stored there until delivered by backflow to the member cities named above. This feeder was designed for a maximum graded flow, starting with 210 c.f.s. at the Eagle Rock Canyon turnout structure and discharging 60 c.f.s. into the Palos Verdes reservoir. Proper allowance was made for the rise of static pressure and for water hammer which may be caused by the closing of sectionalizing valves located about every five miles along the thirty-one miles of this feeder. The automatic pressure control valves operating this system were designed to pass all the water unless there was some deficiency in the supply coming from Lake Mathews. In the latter case these valves would automatically throttle or close and the supply for the lower areas of Los Angeles, Compton, Torrance, and Long Beach would come by backflow from the Palos Verdes reservoir.

The Santa Monica feeder will supply the cities of Glendale, Burbank, Los Angeles, Beverly Hills, and Santa Monica. Since this feeder has no equalizing reservoir it was designed in a series of level pressure belts which would be a limiting condition for no demand. For maximum demand the sizes were selected for graded flow starting with 79 c.f.s. at the west portal of San Rafael No. 2 tunnel and delivering 30 c.f.s. to the City of Santa Monica. The portion of this feeder between the San Rafael and Hollywood tunnels is protected by the Arroyo Seco spillway; the Hollywood tunnel spillway protects the next section down to the Beverly Hills delivery; and the remainder of the line is guarded by pressure-reducing valves backed up by pressure relief valves. The pressure-reducing and the relief valves will insure against an undesirable rise of pressure in the pipe line through the valuable and highly developed residential areas of Beverly Hills, Hollywood, and Santa Monica. However, a failure of mechanical equipment is always a possibility, and therefore the pipe line has been provided with an ample factor of safety to meet such a contingency.

As stated in the history and first annual report for the period ending June 30, 1938, the Lake Mathews dam and dike were then completed, the upper feeder pipe line and tunnels were nearing completion, and work was in progress on the headworks and on the Palos Verdes feeder from Eagle Rock Canyon, the first of the supply lines to member cities to be built. The work accomplished during the two years ending June 30, 1940 is briefly described in the following pages.

Lake Mathews

Construction of the dam and appurtenant works was finished on February 11, 1938. Approval of the construction by the state engineer's office, as required by California law, was granted on November 25, 1938 and a certificate issued accordingly.

A small District force has been engaged since June 30, 1938 on miscellaneous work in the reservoir area. Trees, brush, and weeds have been cleaned up, windrowed, and burned. A cottage for the operator was moved from the Lakeview substation on the construction power system, reconditioned, and set up above the west end of the dike and a house was reconditioned for a patrolman. A garage and a boathouse were built and a motor boat purchased for use on the lake. A water system, for domestic use and sprinkling of plants and ornamental trees, and power and telephone facilities were installed. Protective growth was planted on the north slope

Distribution system headwork at Lake Mathews

of the dike and around the headworks, and trees supplied by the U. S. and state forest services were set out. Drain manholes and berm ditches on the dike were cleared of debris washed in by winter rains. Additional roads were graded, Hazel road surfacing was remixed, relaid, sealcoated and brushed, and guard posts were put in around curves.

The first Colorado River water flowed from Valverde tunnel into the reservoir on November 2, 1939. The first water discharge into the upper feeder occurred in February 1940 when 104 acre feet were released, part of which flowed through the pipe lines to the Palos Verdes reservoir.

On May 17, 1940 the public relations committee of the board of directors recommended that Cajalco reservoir and dam be designated Lake Mathews and Mathews dam in honor of the late W. B. Mathews, first general counsel of the District. This recommendation was unanimously approved.

Headworks

The headworks structure between the Cajalco outlet tunnel and the upper feeder is required to control the flow and pressure of water released from Lake Mathews. A contract for its construction was awarded to The Contracting Engineers Co., of Los Angeles, on March 25, 1938. The principal features were a concrete structure containing a welded steel manifold connected to the steel lining of the outlet tunnel, with regulating valves; a concrete-lined forebay

having a capacity of 46 acre feet; a forebay outlet structure, with provision for slide gates; a 338-foot cast-in-place concrete pipe connection to the existing precast pipe of the upper feeder, including a venturi meter section; and a short section of pipe leading from the forebay outlet structure to provide ready connection to a future lower feeder to Orange County.

Excavation was nearly finished at the end of June 1938 and placing of concrete was started on the following July 23rd. The installation of valves and equipment was begun on December 5th, fencing on December 12th, and the entire contract was completed on February 7, 1939. District forces made necessary electrical connections to supply power for operating, adjusted and lubricated valves, removed the bulkhead from the outlet tunnel, drained and cleaned the forebay prior to the first release of Colorado River water from Lake Mathews in February 1940. The cost of the headworks structure, including valves and all District items, is $274,168.16.

Upper Feeder Tunnels

Two tunnels only of the upper feeder had not been completed on June 30, 1938, namely, Monrovia No. 3 and Monrovia No. 4. Of these the latter was finished on July 12, 1938 but the No. 3 tunnel work did not reach completion until October 10, 1938, because of delay occasioned by the storm of March 1938, when the contractor's batching plant at the Fish Canyon adit was destroyed, with only 2,969 feet of lining remaining. A portable batching plant was brought in to the west portal and the lining finished from that point. The tunnel was grouted behind the lining under pressures up to 60 pounds per square inch. Following this the portion west of Fish Canyon adit was regrouted using pressures from 100 to 450 pounds per square inch to seal off water encountered in this area. All clean-up was completed on the date noted above. Tunnel data are given in table 17.

Precast Concrete Pipe

The construction of all of the precast concrete pipe schedules on the upper feeder has been completed. The last of these to be built, schedule 9P, between Monrovia No. 4 and Sierra Madre tunnels, crossing Big and Little Santa Anita washes, was constructed easterly from the completed Sierra Madre tunnel to within 280 feet of Monrovia No. 4 and there stopped October 9, 1937 until the tunnel contractor completed his work at the west portal on

Table 17

DISTRIBUTION SYSTEM TUNNELS
Costs to June 30, 1940

Tunnel	Contractor	Contract awarded	Work completed	Length in feet	Total cost	Cost per foot
Monrovia No. 1 Monrovia No. 2	West Construction Company	Dec. 21, 1934	May 17, 1937	7,868 940	$ 670,783.59	$76.16
Monrovia No. 3	West Construction Company	Dec. 21, 1934	Oct. 10, 1938	32,105	2,507,368.13	78.10
Monrovia No. 4	L. E. Dixon Company, Bent Brothers, Inc. Johnson, Inc.	July 26, 1935[1]	July 12, 1938	8,133	848,523.87	104.33
Sierra Madre	J. F. Shea Co., Inc.	Aug. 9, 1935	Oct. 31, 1936	6,700	465,732.22	69.51
Pasadena extension	L. E. Dixon Company, Bent Brothers, Inc. Johnson, Inc.	Aug. 9, 1935	Nov. 24, 1936	5,604	416,819.98	74.38
Pasadena	L. E. Dixon Company, Bent Brothers, Inc. Johnson, Inc.	Dec. 21, 1934	Apr. 23, 1937	12,140	1,058,048.25	87.15
San Rafael No. 1 San Rafael No. 2	L. E. Dixon Company, Bent Brothers, Inc. Johnson, Inc.	July 26, 1935[1]	Oct. 15, 1937	4,047 5,669	629,251.46	64.76
Total (15.76 miles)				83,206	$6,596,527.50	$79.28

[1]One contract.

July 12, 1938 and released the area to the pipe line contractor. The last section of pipe was laid August 6th; the line was cleaned up, pipe tested for leakage, and the schedule accepted as completed October 31, 1938.

Cast-in-Place Concrete Pipe

Three short schedules of this type of construction occur on the upper feeder at the crossings of San Gabriel, Monrovia, and Eagle Rock canyons. The first two, 520 and 600 feet long, respectively, were built with an inside diameter of 10 feet, shell thickness varying from 12 to 18 inches, and heavily reinforced with elliptical and circular hoops and longitudinal bars. The Eagle Rock Canyon crossing, 533 feet long, has an inside diameter of 7 feet and shell thickness of 9 inches, with similar reinforcement. Contract for the three schedules was awarded to Basich Brothers, of Torrance, February 19, 1937. Work was started on the Monrovia Canyon crossing in April and continued until October, when suspension became necessary until the contractor on Monrovia No. 3 tunnel could release the necessary area at the west portal. This did not occur until July 1938, at which time work was resumed and the remaining pipe and structures were completed in January 1939.

Santa Ana River crossing

Construction of the San Gabriel Canyon crossing was begun in May 1937. At the time of the February-March 1938 storm, when a peak of 67,000 cubic feet per second of flood run-off passed Morris dam, the pipe line across the bottom of the canyon and the access structure had been completed and the valve structure started. Little damage was done to the works in the schedule, but the contractor's plant and equipment and some District furnished material were washed away or buried in the debris, and the road to the work destroyed. A new road was built, some equipment and materials were recovered, and work was resumed in August. The schedule was completed in November 1938.

The construction of the Eagle Rock Canyon crossing was not started until April 1938, but then it progressed uniformly to completion in December. All clean-up and testing of the three crossings was finished and the work accepted on February 8, 1939.

Cost and other data on both precast concrete pipe lines and cast-in-place concrete pipe lines are given in table 18.

San Gabriel Spillway

A spillway, located about 600 feet below Morris dam, provides an emergency discharge outlet, or pressure relief, in case of sudden stoppage of flow in the upper feeder west of San Gabriel Canyon. It consists of a 10-foot diameter circular tunnel, 112 feet long, extending up at an angle of 20 degrees from Monrovia No. 2 tunnel to the spillway chamber built into the side of the canyon. The upper feeder, for which Monrovia No. 2 tunnel makes a connection to Morris reservoir, is a pressure conduit. The invert elevation at the junction of Monrovia No. 2 and the spillway tunnel is 971.94, whereas, hydraulic grade at this point, under normal full flow conditions, is elevation 1,036.1. The spillway lip is at elevation 1,037.5.

A contract for construction of the spillway was awarded to the J. F. Shea Co., Inc., of Los Angeles, November 4, 1938 and work was started at the site on February 7, 1939. Excavation was finished early in April, followed by concrete work and grouting, the entire spillway being completed on June 30, 1939. The total cost on June 30, 1940, including District items, was $31,618.14.

Steel Pipe Lines

The steel pipe lines built for the distribution system, during the period under review, consisted of the Eagle Rock to Palos Verdes feeder, with a short connection to the Ascot reservoir of the Los

TABLE 18

DISTRIBUTION SYSTEM PRECAST CONCRETE PIPE LINES
Costs to June 30, 1940

SCHEDULE	CONTRACTOR	CONTRACT AWARDED	WORK COMPLETED	INSIDE DIAMETER	LENGTH IN FEET	TOTAL COST	COST PER FOOT
1P	American Concrete & Steel Pipe Company	Jan. 10, 1936	Dec. 23, 1937	11′-8″	12,277	$ 662,114.62	$53.93
3P	American Concrete & Steel Pipe Company	Jan. 10, 1936	Dec. 23, 1937	11′-8″	20,124	1,236,240.37	61.43
4P	American Concrete & Steel Pipe Company	Nov. 1, 1935	June 18, 1937	12′-8″	25,867	1,312,350.00	50.73
5P	American Concrete & Steel Pipe Company	Nov. 1, 1935	June 18, 1937	12′-8″	24,892	1,163,327.78	46.74
6P	J. F. Shea Co., Inc.	Dec. 20, 1935	May 24, 1938	11′-8″	27,294	1,529,519.59	56.04
7P	J. F. Shea Co., Inc.	Dec. 20, 1935	May 24, 1938	11′-8″	29,950	1,735,488.30	57.95
8P	United Concrete Pipe Corporation	Nov. 1, 1935	Mar. 17 1937	10′-3″	24,529	1,508,193.29	61.49
9P	United Concrete Pipe Corporation	Aug. 7, 1936	Oct. 31, 1938	9′-8″	8,691	464,968.37	53.50
10P	United Concrete Pipe Corporation	Aug. 7, 1936	Aug. 13, 1937	9′-8″	10,517	538,978.41	51.25
11P	United Concrete Pipe Corporation	Aug. 7, 1936	Nov. 27, 1937	9′-8″	4,127	305,106.59	73.93
	Total (35.66 miles)				188,268	$10,456,287.32	$55.54
	CAST-IN-PLACE CONCRETE PIPE LINES						
8C	Basich Brothers	Feb. 19, 1937	Feb. 8, 1939	10′-0″	520	$ 184,182.22	$354.20
9C	Basich Brothers	Feb. 19, 1937	Feb. 8, 1939	10′-0″	600	112,683.57	187.81
12C	Basich Brothers	Feb. 19, 1937	Dec. 11, 1938	7′-0″	533	85,356.71	160.14
	Total (0.31 mile)				1,653	$ 382,222.50	$231.23

Angeles water system, and three laterals to provide delivery to the boundaries of Compton, Torrance, and Long Beach. This feeder, extending from the upper feeder at Eagle Rock Canyon in a southerly and westerly direction to the Palos Verdes reservoir, has a total length of 163,072 feet, or 30.88 miles. The three laterals have a total length of 38,377 feet, or 7.27 miles.

These pipe lines were built under three contracts. The first contract, covering 17.38 miles of feeder from Eagle Rock Canyon in the City of Pasadena to 98th Street and Wadsworth Avenue in the City of Los Angeles, was awarded to the J. F. Shea Co., Inc., September 10, 1937 and was approximately 45 per cent complete at the beginning of the period under review, July 1, 1938. All work under the contract was completed on March 26, 1939. Aside from numerous railroad and street crossings, three short tunnels and the Ascot adit to eliminate long pipe lines around the hills, all pipe was laid in open trench.

Fine grading for pipe line

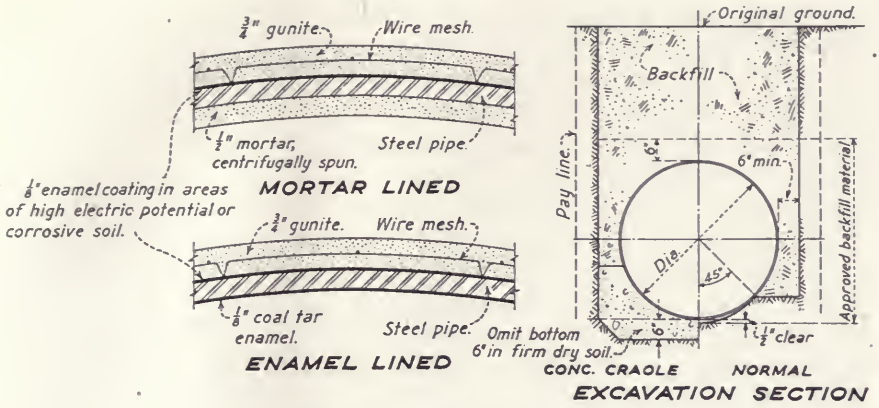


Fig. 5. Welded steel pipe

Construction was performed by two separate crews. One crew started at the southern end of the contract and worked north on schedules 23SC and 22SC to Valley Boulevard. The other progressed from the northern end through schedule 21SC into schedule 22SC to connection at Valley Boulevard. Three types of equipment were used for excavation, the trenching machine, dragline, and crane with clamshell bucket. Most of the trench in the northern portion, because of hard ground and many large boulders, was excavated by dragline, while in the southern portion the trenching machine was operated advantageously. The clamshell crane excavated bell holes necessary for welding and guniting the pipe joints and did the miscellaneous work. In general a vertical trench section was used, 78 inches wide for the 55-inch pipe and 72 inches for the 51-inch pipe. The depth varied from 7 to 30 feet. Side lagging required was dependent upon the character of the ground. In some portions lagging was driven skin-tight as excavation proceeded; in others excavation was completed and 2" x 12" lagging was then placed on 2- to 10-foot centers, using trench jacks in all cases to hold lagging in position. Crossing of existing underground utilities required special treatment in order not to disturb service while the construction was being carried on. Railroad crossings were accomplished mainly by tunneling, or by jacking steel culvert pipe, across the line deep under the tracks. Then the steel pipe sections were welded together and pulled through the tunnel or culvert, after which the space around the pipe was filled with concrete.

The three tunnels and adit, totaling 2,701 feet, were excavated to a diameter of approximately 6 feet using steel rib support in all

but the 262-foot Rockdale tunnel on North Figueroa Street in Los Angeles where the only support necessary was one timber set. No swelling nor heavy ground was encountered. Each pipe section was moved into the tunnels on special railroad dollies, jacked up to permit removal of dollies and track, then set on line and grade and welded to the previously placed section. The final operation was the complete filling of the tunnel outside of the pipe with concrete.

The welded steel pipe was fabricated by Consolidated Steel Corporation, Ltd., at its east Los Angeles plant from mild steel plate ranging in thickness from ¼ to ½ of an inch, generally in 30-foot lengths having a 2-inch belled end. The inside of this pipe was protected by a ½-inch coating of cement mortar applied cen-

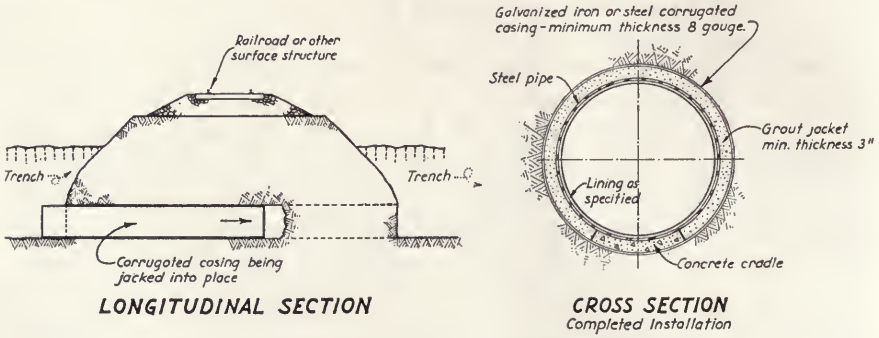
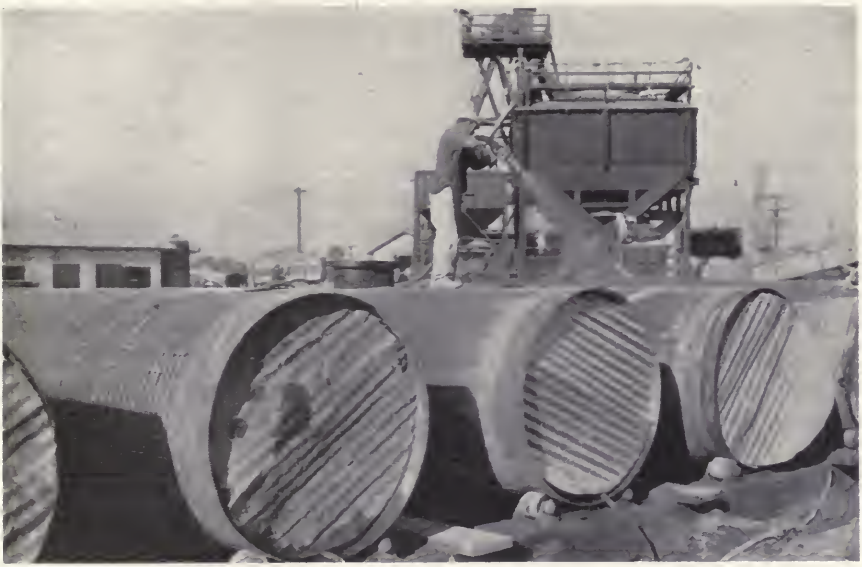


Fig. 6. Jacked incasement under structures

trifugally to a shotblasted surface. The exterior was given a ¾-inch gunite coating reinforced with wire mesh and having an ⅛-inch coat of coal-tar enamel under the gunite if it was to be laid where corrosive soils or electrolytic conditions existed. The coating was applied at the fabrication plant.

Pipe laying followed closely the machine excavation and hand grading of the trench, the sections being delivered to the line by semitrailer trucks and lowered into place by crane. All field joints were welded, tested, and coated. To prevent deflection of the pipe in backfilling, steel plate bulkheads were installed about 1,000 feet apart, each section between bulkheads being filled with water and maintained under a pressure of not less than 20 pounds per square inch. Backfill was then placed and thoroughly sluiced. The street resurfacing was completed as soon as possible thereafter.

Special structures were numerous, consisting of blowoff valves at low points, shutoff valves at strategic locations, pressure-regu-



Applying gunite coating to steel pipe

lating and relief valves at the Los Angeles River crossing, venturi meters, and manholes at intervals of about 1,000 feet.

The second contract, covering the remainder of the Eagle Rock-Palos Verdes feeder, was awarded to the Emsco Derrick and Equipment Company, of Los Angeles, on October 14, 1938. It comprised two schedules, 24SC and 25SC, consisting of 13.5 miles of pipe extending from 98th Street and Wadsworth Avenue to a connection with the supply line into Palos Verdes reservoir. The low bid was for welded steel pipe, 51 inches in diameter, and identical with the pipe line in the northerly portion of this feeder.

On November 18, 1938 the general contractor subcontracted all work, except the furnishing of steel pipe, steel plate specials and fittings, to Macco Construction Company of Clearwater. The latter in turn resublet all excavation, all pipe laying but not field welding and testing, all backfill, concrete and metalwork in structures, replacing utilities, and clean-up to Artukovich Brothers of Hynes; and hauling of pipe from the Emsco plant to the Macco plant for coating and thence to the trench to the Belyea Truck Company. Fabrication of pipe specials was started by the general contractor on December 8, 1938, coating of pipe by the subcontractor on January 25, 1939, and laying of pipe on February 27, 1939.

Trench excavation and pipe laying were started in schedule 24SC at Nigger Slough near 189th Street and were continued northerly to a connection with the completed schedule 23SC at 98th Street and Wadsworth Avenue. The equipment was then moved to 223rd Street, in schedule 25SC, working north to 189th Street, and finally to the tunnel portal of Palos Verdes reservoir working northerly to complete the line at 223rd Street. All trench, except for a few short sections, was excavated with a trenching machine through silty clay which required only skeleton lagging on 8- to 30-foot centers. With the exception of 600 feet at the south crossing of Nigger Slough and 400 feet on the north slope of the Palos Verdes Hills, where small quantities of water were encountered, the trench was dry. The depth of trench varied from 8 feet to 12 feet and the average net rate of excavation approximated 100 feet per hour. A dragline and a truck crane equipped with a clamshell bucket performed the remaining excavation, the latter being used for bell holes and miscellaneous jobs. Following rough excavation the bottom of the trench was finished by hand, a screed being used to complete a cradle for the pipe.

All pipe was fabricated in 30-foot lengths at the plant of the general contractor, using mild steel plate from ⅜ to ½ of an inch in thickness. The ends were trimmed and belled as required, each

Laying steel pipe

section was submitted to rigid hydrostatic test, checked for roundness, fitted with inside braces to maintain its shape and then trucked to the Macco yard in Clearwater. Here the specified coating was applied, inside and outside, and cured. These operations covered a minimum period of about 15 days, after which the pipe was trucked directly to the line, and using a crawler-type crane with 50-foot boom, was laid in the trench, ready for welding. Laying was done on the day shift only. From 18 to 24 sections were laid daily throughout most of this job, with a maximum on one day of 33. Arc welding of joints, by certified welders working in pairs, one inside and one outside, followed as closely behind the laying operations as possible. At no time was welding done simultaneously on the inside and outside of the same joint. After welding, every joint was tested with a liquid soap solution pumped into the lapped space between the inside and outside welds under a pressure of about 80 pounds per square inch. When all welding and testing had been completed the joints were cleaned, enameled, if required, and gunited to make all coating continuous on both inside and outside surfaces.

During the backfilling of the trench the pipe was filled with water between temporary steel bulkheads welded in place at about 1,000-foot intervals and a pressure of 50 pounds per square inch applied. The backfill was placed carefully without injury to the pipe and jetted for thorough compaction. In private right of way the original ground surface was restored, and in public streets the paving was replaced in accord with city or county requirements. The final tests prior to acceptance of the work showed a leakage well within the specified limits. All construction of pipe lines, including necessary lateral turnout, relief valve, pressure-regulating valve, blowoff valve, manhole, and other structures was completed on October 31, 1939.

The third contract for the laterals to Long Beach, Torrance, and Compton, schedules 26SC, 27SC, and 28SC, respectively, was awarded December 30, 1938 to Western Pipe and Steel Company, of Los Angeles, on its low bid for welded steel pipe with spun-mortar lining and gunite exterior coating. Except for the diameters these pipe lines are identical with the Palos Verdes feeder, of which they are branches.

The general contractor fabricated all steel pipe and specials and did the field welding of all joints. The hauling and coating of the pipe were subcontracted to Macco Construction Company, which

in turn resublet the hauling to Belyea Truck Company. All coating except joint sections was applied in the Macco yard at Clearwater. The joint coating was finished in the field, following the welding. Excavation, backfill, concrete work, placing of reinforcement and installation of miscellaneous metal were sublet to R. A. Wattson Company, Inc.

The trench was excavated with a trenching machine, which made most of the bell hole cuts in passing, and which left the rough grade in such condition that a minimum of hand work was required to complete the cradlelike bottom section. The bell holes were finished with a clamshell bucket and by hand. No free water was encountered in the alluvial deposits, which consisted of well compacted silt, except on the Long Beach lateral near the Los Angeles River where river sand occurs. Skeleton lagging only was required, the sides of the trench being sloped in the river sand area. Trench excavation was started April 27, 1939 on the Long Beach line working from the valve structure on the cross feeder at 223rd Street easterly in that street to the west bank of the Los Angeles River. Pipe laying was completed on July 7th, and all backfilling on September 2, 1939. This line has a capacity of 30 cubic feet per second under a head which varies from 240 to 420 feet. Excavation

Welding steel pipe

for the Torrance line was started July 10th and finished July 25, 1939, the entire line being completed on September 1st. The capacity of this lateral is 20 c.f.s. and the head varies from 255 to 400 feet. The pipe was laid in 190th Street from the valve structure east of Vermont Avenue to the city limits at Western Avenue. Trench excavation on the Compton line was accomplished between July 31st and August 10th, and all construction was completed September 8, 1939. This line, extending along Rosecrans Avenue from the valve turnout at Avalon Boulevard to the west boundary of the city, has a capacity of 10 c.f.s. under a head which varies from 210 to 440 feet. Following the customary specified hydrostatic tests of these lines for leakage, all clean-up was finished and the work was accepted by the District on September 30, 1939. Data concerning welded steel pipe lines will be found in table 19.

Glendale to Santa Monica Feeder

This feeder extends from the west portal of San Rafael No. 2 tunnel in the City of Glendale, through Glendale, Burbank, North Hollywood, Hollywood, Beverly Hills, and West Los Angeles to a reservoir of the City of Santa Monica on Bundy Drive near Wilshire Boulevard. It consists of five pipe schedules, in addition to the Hollywood tunnel through the ridge between Cahuenga Boulevard freeway and Nichols Canyon. The total length is about 23.4 miles. A contract for constructing the first section, designated schedule 29P, consisting of precast concrete pipe with lock joints extending from San Rafael tunnel to Glendale Avenue at Glenoaks Boulevard in Glendale, was awarded May 17, 1940 to American Concrete and Steel Pipe Company. On the same day a contract was awarded to the J. F. Shea Co., Inc. for schedule 30SC, a welded steel pipe with spun-mortar lining and gunite exterior coating, extending from schedule 29P to the intersection of Kenneth Road and Verdugo Avenue in Burbank. Field construction on these two schedules had not been started on June 30, 1940.

A contract for the 3,739-foot Hollywood tunnel also was awarded May 17, 1940 to J. F. Shea Co., Inc., which moved equipment to the north portal and began approach cut excavation June 6, 1940. One week later the south portal cut was started and by the end of the month 304 feet had been excavated in the two headings.

On June 28, 1940 contracts were awarded to United Concrete Pipe Corporation for schedule 31P, consisting of precast concrete pipe with lock joints, between schedule 30SC and the north portal of Hollywood tunnel, and to Artukovich Brothers for schedules

TABLE 19

DISTRIBUTION SYSTEM WELDED STEEL PIPE LINES
Costs to June 30, 1940

SCHEDULE	CONTRACTOR	CONTRACT AWARDED	WORK COMPLETED	INSIDE DIAMETER, INCHES	LENGTH IN FEET	TOTAL COST	COST PER FOOT
	UPPER FEEDER						
2S & 2B	Western Pipe & Steel Company	Jan. 10, 1936	Nov. 24, 1937	116-138	54,530 (10.33 miles)	$4,792,318.36	$87.88
	PALOS VERDES FEEDER						
21SC	J. F. Shea Co., Inc.	Sept. 10, 1937	Mar. 26, 1939	55	28,927	930,054.77	32.15
22SC	J. F. Shea Co., Inc.	Sept. 10, 1937	Mar. 26, 1939	51	28,384	876,443.23	30.88
23SC	J. F. Shea Co., Inc.	Sept. 10, 1937	Mar. 26, 1939	51	34,465	967,210.77	28.06
24SC	Emsco Derrick & Equipment Company	Oct. 14, 1938	Oct. 31, 1939	51	35,937	681,494.56	18.96
25SC	Emsco Derrick & Equipment Company	Oct. 14, 1938	Oct. 31, 1939	51	35,359	669,218.26	18.93
	Total (30.88 miles)				163,072	$4,124,421.59	$25.29
	LATERALS						
26SC	Western Pipe & Steel Company	Dec. 30, 1938	Sept. 30, 1939	37	24,863	321,037.92	12.91
27SC	Western Pipe & Steel Company	Dec. 30, 1938	Sept. 30, 1939	31	6,502	73,260.45	11.27
28SC	Western Pipe & Steel Company	Dec. 30, 1938	Sept. 30, 1939	22	7,012	59,440.26	8.48
	Total (7.27 miles)				38,377	$453,738.63	$11.82
	Total all welded steel pipe lines (48.48 miles)				255,979	$9,370,478.58	$36.61

Note: All SC schedules, with spun-mortar lining, have effective diameter one inch less than shown.

32CI and 33CI, consisting of spun-mortar lined cast-iron pipe extending from the tunnel south portal to the feeder terminus at the Santa Monica reservoir.

In order to complete the crossing of the Cahuenga Boulevard freeway while the construction of that project was in progress and

Hollywood tunnel

thus avoid cutting across the new highway after its completion, a section of pipe line approximately 790 feet in length was withdrawn from schedule 31P and awarded, June 28, 1940, to Radich & Brown, contractors on the freeway work, for installation by them as their construction proceeds.

Orange County Feeder

Specifications were issued June 21, 1940, with bids to be opened July 10, 1940, for this feeder in four schedules, extending approximately 27.7 miles from the water softening and filtration plant through Brea Canyon to serve the cities of Fullerton, Anaheim, and Santa Ana.

Palos Verdes Reservoir

Palos Verdes reservoir, lying at the southern end of the Eagle Rock to Palos Verdes feeder, is designed to act as a flow-regulating and supply reservoir for the lower end of the distribution line which supplies water to Compton, Torrance, Long Beach, and the harbor district. The reservoir lies in a small drainage basin on the

northeast side of the Palos Verdes Hills, south of the town of Lomita.

This reservoir will serve as an important unit in connection with satisfactory operation of the distribution system. It has a capacity of 1,000 acre feet, or 325,850,000 gallons, a water surface of 28 acres, and a maximum depth of 50 feet. High water surface will be at elevation 320.

Water will enter and leave the reservoir through the same pipe line, the direction of flow depending upon whether the demand for water by the cities is less or greater than the supply furnished by the feeder.

Palos Verdes reservoir

Bids were opened on December 23, 1938 for the construction of this reservoir and appurtenant works. The Daley Corporation, of San Diego, low bidder, subsequently submitted satisfactory proof that important items had been omitted in computing its bid. At the meeting on December 30, 1938 the board of directors permitted the low bidder to withdraw his bid without penalty, and awarded a contract to the next low bidder, W. E. Hall Company, of Alhambra, on its bid of $588,960.00. The contract covered all excavation to form the reservoir and for the control tower, rolling of an earthfill embankment, gunite lining of the reservoir, and construction of a supply tunnel, a concrete control tower, and a concrete channel to carry storm run-off around the area.

The earthfill embankment closing the east side of the reservoir was made of materials excavated from the reservoir area, hauled in

Lining reservoir with gunite

carryalls and dumptors, and compacted with sheepsfoot rollers. This work required the moving of some 1,528,000 cubic yards of materials. An earth blanket, varying in thickness from 3 to 10 feet, was placed and compacted on the sides and bottom of the basin, except on the embankment section. The entire 1,294,802 square feet of interior surface of the reservoir was lined, in order to maintain the quality of the water and to prevent erosion. The lining consists of a two-inch thickness of gunite, reinforced with wire mesh.

A 51-inch mortar-lined steel pipe extends from the south end of schedule 25SC to the outlet tower. This line is 780 feet long and 684 feet of it runs through a tunnel on the north side of the reservoir. The pipe inside the tunnel is backed with concrete.

Water will be admitted to and released from the reservoir through the outlet tower, a circular concrete structure 16 feet in diameter and 87 feet high. A 50-inch motor-operated cylinder valve and four 30-inch manually operated gate valves installed at ports on four different levels will control the inflow and outflow. The inflow will enter at the lowest level and be diffused at the far sides of the reservoir by means of two 24-inch pipes lying on the bottom of the reservoir. Flap gates prevent the outflow water from entering the inflow pipes.

A 12-foot by 12-foot covered reinforced concrete storm drain, 2,884 feet long, will carry any run-off from the slopes above,

around the northern side of the reservoir into a stilling basin below the embankment. Excavation for the drain was made with carryalls and tractors, very little hand trimming of the cut being required. The entire reservoir is enclosed by a chain link fabric fence 7 feet high and 6,779 feet long. The contract date for completion of all construction was December 31, 1939 and on that date the District accepted the work as finished.

District forces have installed a water tank, pump, and piping for a service water system in the reservoir area; have landscaped the grounds, setting out pines, incense cedars, and ice plants; and have completed installation of electrical equipment and valves in the outlet tower. Total cost of Palos Verdes reservoir, exclusive of right of way, to June 30, 1940 is $847,197.26.

Orange County Reservoir

To improve the operation characteristics of the Orange County feeder, studies have been made and designs started for a small equalizing reservoir located a short distance north of the City of Brea and about 15 miles from the point of diversion on the upper feeder. This work was in progress at the close of the period.

Softening and Filtration Plant

The question of softening and filtering Colorado River water before it is delivered to domestic and industrial consumers has been under consideration since the start of the aqueduct project. The engineering board of review, in its report on an aqueduct from the Colorado River to the Metropolitan Water District of Southern California, made in 1930, stated that softening would be desirable, particularly of water to be used for industrial purposes. During 1933-34 special investigations on the subject were made by the District under the direction of Arthur Taylor, consulting engineer, now District director representing Beverly Hills. In 1935-36 an independent report on water softening was made for the District by Metcalf and Eddy, consulting engineers. Thereafter investigations and special research were continued by the District staff.

As a result of these investigations the board of directors on October 21, 1938 authorized the general manager and chief engineer to proceed with the preparation of plans and specifications for a water softening and filtration plant having an initial capacity of 100 million gallons daily, equivalent to 155 cubic feet per second, and to engage the services of experts for assistance in this work. Following this action, the firm of Hoover and Montgomery, of

Columbus, Ohio, was retained to advise on the design, construction, and preliminary operation of the plant. The site chosen was the point of take-out for the Orange County feeder, which is near the City of La Verne, about 30 miles east of Los Angeles.

The method of softening to be used is known as the lime-zeolite process. Following extensive experiments made at the water softening plant in Boulder City, Nevada, which uses Colorado River water, and thorough investigation of all modern water treatment methods, it was adopted as the best and most economical process applicable to the softening of Colorado River water. The hardness of natural Colorado River water is due primarily to three compounds which are held in solution. These are calcium bicarbonate causing carbonate hardness and calcium and magnesium sulfates causing noncarbonate hardness. The carbonate hardness, in the softening method adopted, is reduced by the addition of lime, the cheapest softening agent available. All of the water is put through the plant and lime softened. The noncarbonate hardness which cannot be removed with lime is reduced by passing the water through beds of zeolite, a sandlike base exchange mineral, which has the property of taking out of water passing through it the hardness-forming calcium and magnesium, replacing them with nonhardness-forming sodium. As the zeolite becomes saturated with the calcium and magnesium it loses its softening capacity. When thus exhausted it is not replaced but is regenerated by passing through it a strong solution of sodium chloride—common salt. The zeolite-softened water is reduced to zero hardness, an extent not economically warranted for most domestic uses. Therefore only a portion of the lime-softened water is passed through the zeolite, the zero water being recombined with the by-passed water in the proper proportions to produce the desired degree of hardness. All of the softened

Architect's sketch of softening and filtration plant

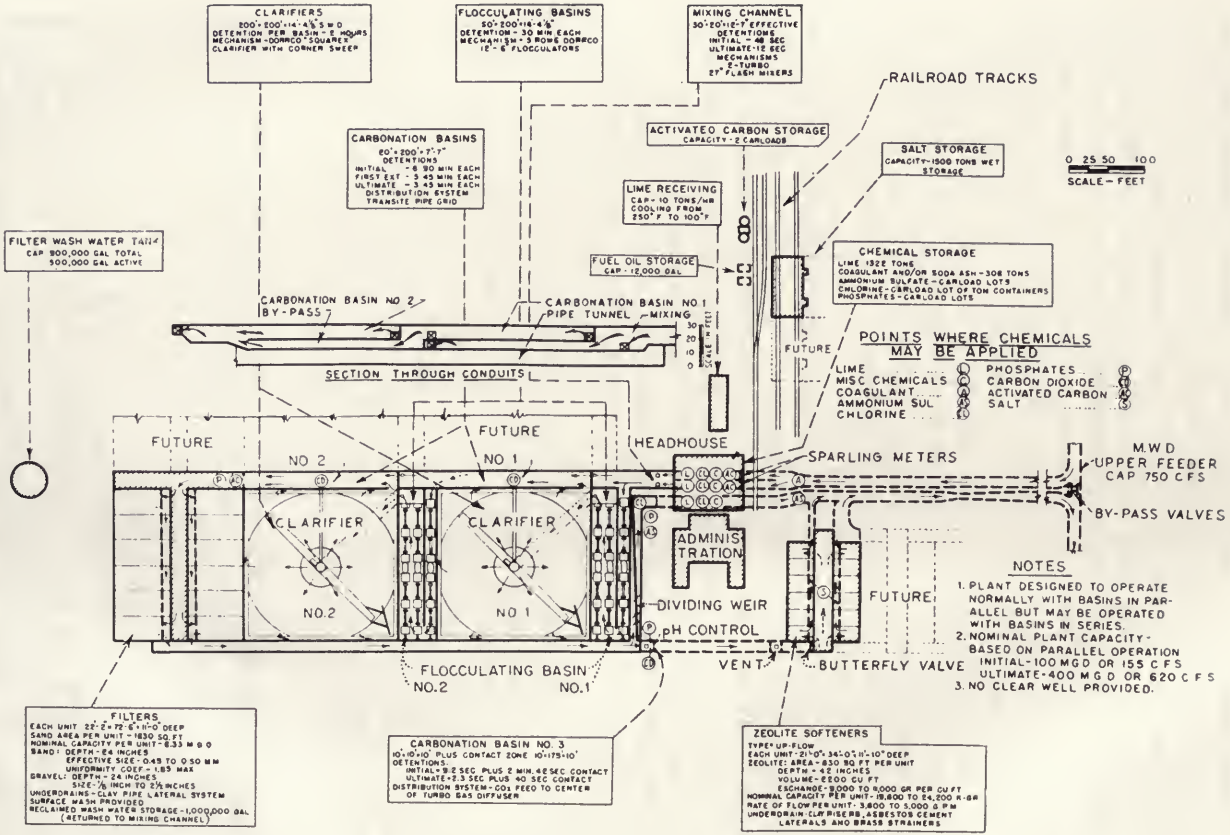


Fig. 7. General plan of water softening and filtration plant

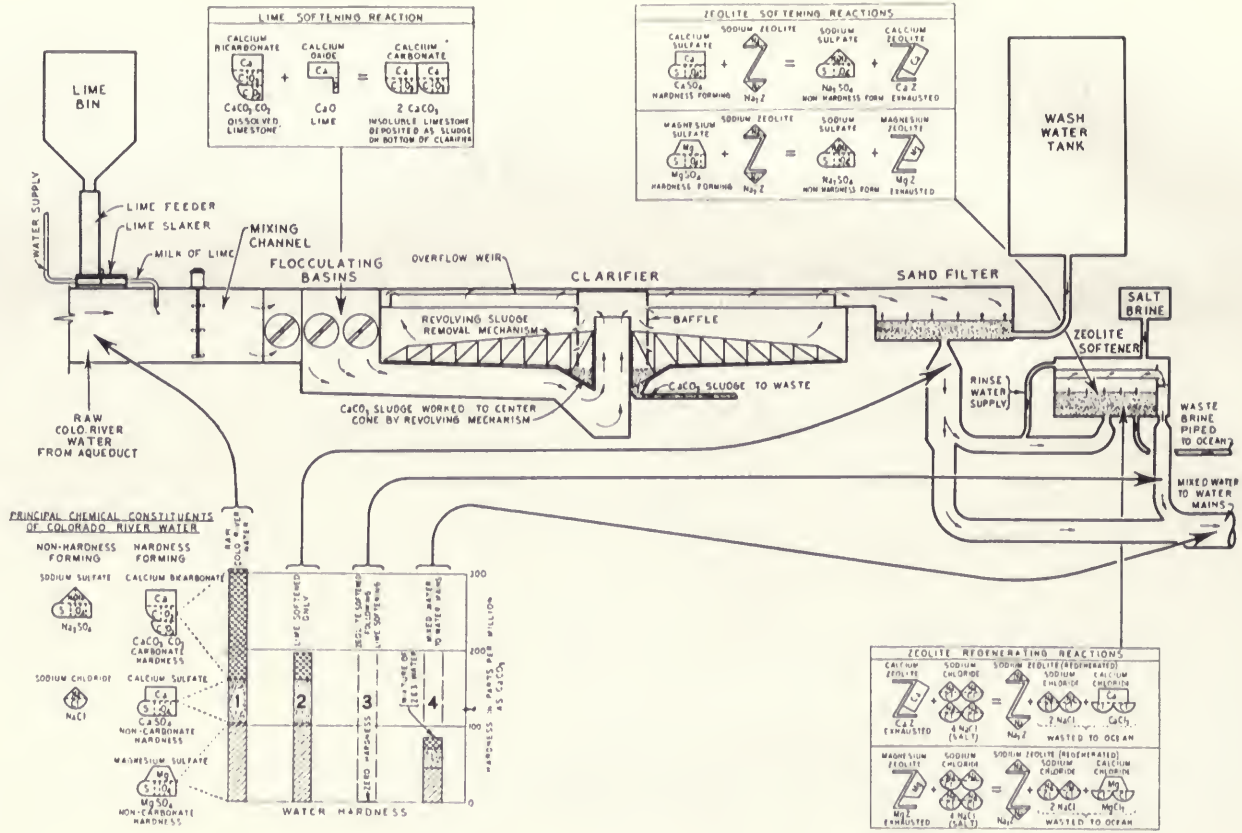


Fig. 8. Flow diagram and softening reactions

water will be filtered and chlorinated as a precautionary measure, and will be clear and of excellent quality as it leaves the plant.

This water, with a hardness of about 85 parts per million, is compared with the present water of the District cities in the following tabulation. With the exception of Beverly Hills no member city filters or softens its present water supply. While the quality of the water in any one city is never absolutely uniform, the data given are believed representative of average city-wide conditions.

City	Average total hardness, parts per million
Anaheim	273
Beverly Hills (softened and filtered)	132
Burbank	191
Compton	232
Fullerton	304
Glendale	197
Long Beach	40
Los Angeles (aqueduct supply)	112
Los Angeles (Los Angeles River galleries)	279
Pasadena	186
San Marino	96
Santa Ana	217
Santa Monica	428
Torrance	149
Approximate weighted average	150
Colorado River (softened and filtered)	85

The design of the softening and filtration plant conforms to well-established practice except that the units, in some respects, establish new precedents for size. The most modern improvements have been incorporated and the plant is designed for flexibility so that future developments may be utilized if desirable. The plant will have an initial capacity of 100 million gallons per day with provision for enlargement to 400 million gallons per day when required. The features which cannot be readily duplicated or enlarged, such as the influent and effluent conduits, head house, administration building, and main channels, are built on a 400-m.g.d. capacity basis in the initial development. The remainder of the plant, consisting of the mixing and settling basins, filters, and zeolite softeners, is being built to the 100-m.g.d. capacity only.

The preparation of plans and specifications for the softening plant was begun in November 1938. The first equipment contract was awarded March 10, 1939 and bids were received on the general contract for construction of the plant on October 27, 1939. The general contract was awarded to the Griffith Company, of Los

Water softening and filtration plant under construction

Angeles, November 3rd, and the first equipment arrived on the job on November 13, 1939. The plant is scheduled to be completed about the middle of January 1941. As of June 30, 1940 the construction was about 55 per cent completed.

To dispose of the spent brine used for regeneration of the zeolite in the softeners, a precast concrete waste water line is to be constructed from the softening plant to a point near Whittier, where it will connect to the outfall sewer, which serves several Los Angeles County sanitation districts, for discharge into the ocean. As the softening plant is enlarged and the amount of spent brine increases this waste water line may be extended to tidewater. The contract for the initial waste water disposal line was awarded April 12, 1940 to the United Concrete Pipe Corporation of Los Angeles. The manufacture of the pipe was started on June 20, 1940 at the contractor's Baldwin Park yard.

CHAPTER 4

SPECIFICATIONS AND CONTRACTS

The preparation of specifications for construction, and for construction equipment and materials, was fully covered in the history and first annual report, together with the related testing and inspection of work and material in process.

In the two-year period of this report the District has issued 54 major specifications for construction and for furnishing supplies, materials, and equipment, making a total of 335 issued up to June 30, 1940. A considerable number of minor specifications, covering miscellaneous work, materials, and equipment have also been issued. These resulted in 67 formal contracts for a total to date of 472, with aggregate earnings of $118,597,142.01, and estimated total contract value of $121,044,000.

Table 21 lists all the principal construction contracts on the main aqueduct and distribution system and gives data on contractors' personnel and dates of work. Relations between the contractors and the District organization have been excellent. Satisfactory settlements of all completed contracts were reached, except that litigation in connection with the Wenzel & Henoch Construction Company contract for San Jacinto tunnel is still pending, as noted elsewhere in this report.

Outlet gates at Copper Basin

TABLE 20

PRINCIPAL CONSTRUCTION CONTRACTS AND CONTRACTORS' PERSONNEL

CONSTRUCTION FEATURE	CONTRACT AWARDED	CONTRACTOR	HOME OFFICE	CONSTRUCTION SUPERINTENDENTS	WORK COMPLETED
Main aqueduct tunnels					
Colorado River, Copper Basin Nos. 1 and 2, and Whipple Mt.	June 16. 1933	Walsh Construction Co.	Davenport, Ia.	Floyd Huntington and J. H. Gill	Feb. 24, 1937
Iron Mountain; east portion	April 21, 1933	Winston Brothers Co.	Minneapolis, Minnesota	E. A. Bernard, excav; R. V. Johnson, conc.	Oct. 30, 1936
Iron Mountain; west portion	April 21, 1933	The Utah Constr. Co.	San Francisco and Ogden	Ben Arp	Feb. 26, 1937
Coxcomb	April 21, 1933	Winston Brothers Co.	Minneapolis, Minnesota	E. A. Bernard, excav; R. V. Johnson, conc.	April 22, 1937
East Eagle Mountain	Feb. 2, 1934	Broderick and Gordon	Denver, Colo.	F. E. Stokes, C. J. Kavanagh, excav,	July 23, 1937
West Eagle Mt.; east portion	June 2, 1933	Broderick and Gordon		John Will, conc.	May 6, 1937
West Eagle Mt.; west portion	June 2, 1933	L. E. Dixon Co. and Bent Bros., Inc.	Los Angeles	Paul C. Guinn	Mar. 12, 1936
Hayfield No. 1	June 2, 1933	The Hunkin-Conkey Constr. Co.	Cleveland, Ohio	Geo. B. Hoag	Jan. 9, 1936
Hayfield No. 2	June 2, 1933	Shofner and Gordon	Los Angeles	H. E. Warden	July 27, 1935
Cottonwood	Apr. 21, 1933	J. F. Shea Co., Inc.	Los Angeles	Gilbert J. Shea	Dec. 27, 1935
Mecca Pass Nos. 1, 2, & 3	June 2, 1933	Morrison-Knudsen Co.	Boise, Idaho	S. A. Dahlberg, excav; Geo. Fortier, conc.	Mar. 1, 1935
Whitewater Nos. 1 and 2	June 16, 1933	West Construction Co.	Boston, Mass.	H. E. Carleton	Apr. 15, 1935
San Jacinto	Feb. 10, 1933	Wenzel & Henoch Construction Co. (by M.W.D. on force account since Feb. 12, 1935)	Milwaukee, Wis.	Otto Seefeld	----------
Bernasconi	April 7, 1933	Hamilton & Gleason Co.	Denver, Colo.	H. J. King, excav; H. S. Stocker, conc.	Nov. 18, 1935
Valverde	April 7, 1933	The Dravo Contracting Co.	Pittsburgh, Pa.	R. W. Remp	Oct. 18, 1936

Main aqueduct surface work

Canal; conduit; siphon	Oct. 19, 1934	Aqueduct Construction Co.	San Francisco and Los Angeles	C. M. Elliott and S. T. Corfield	June 24, 1937
Canal; conduit; siphon	Oct. 19, 1934	Barrett & Hilp and Macco Corp.	San Francisco and Los Angeles	H. W. McKinley	May 25, 1937
Canal; siphon	Oct. 19, 1934	Jahn & Bressi Constr. Co.	Los Angeles	Joseph Muscolo	Mar. 18, 1937
Canal; siphon	Oct. 19, 1934	C. W. Wood and M. J. Bevanda	Stockton, Calif.	A. F. Weesner	July 28, 1937
Canal; conduit; siphon	Oct. 19, 1934	The Utah Constr. Co.	San Francisco and Ogden	Ben Arp	May 15, 1937
Conduit; siphon	Oct. 19, 1934	Three Companies, Inc.	Denver and Albuquerque	C. G. Clapp, C. J. Kavanagh, John Wills	Nov. 6, 1937
Conduit; siphon	Oct. 19, 1934	Thompson-Starrett Co., Inc.	New York, N. Y.	Rodney J. Smith	May 20, 1938
Little Morongo siphon	Nov. 17, 1933	United Concrete Pipe Corp.	Los Angeles	Fred Jenkins	Aug. 20, 1934
Conduit; siphon	Nov. 9, 1934	J. F. Shea Co., Inc.	Los Angeles	W. F. Rennebohm	May 30, 1938
Siphon	Jan. 11, 1935	Morrison-Knudsen Co.	Boise, Idaho	J. O. Young	Sept. 16, 1936
Conduit; siphon	Dec. 7, 1934	Griffith Company	Los Angeles	Harry Davis	Oct. 13, 1936

Main aqueduct dams, pumping plants, and appurtenant works

Parker dam [1]	Aug. 25, 1934	Six Companies, Inc.	San Francisco	F. T. Crowe	Aug. 31, 1938
Intake and Gene pumping plant buildings	Nov. 22, 1935	Winston Bros. Co. and William C. Crowell	Minneapolis and Pasadena	R. A. Crowell	April 29, 1938
Iron Mountain pumping plant buildings	Jan. 24, 1936	C. W. Wood and M. J. Bevanda	Stockton, Calif.	A. F. Weesner	Sept. 1, 1937
Eagle Mountain pumping plant buildings	Mar. 27, 1936	L. E. Dixon Co.	Los Angeles	F. H. Strohecker and J. H. Larkin	April 16, 1938
Hayfield pumping plant buildings	Sept. 4, 1936	L. E. Dixon Co. and Case Constr. Co., Inc.	Los Angeles and Alhambra	Crawford Strohecker and W. N. Evans	July 21, 1938

[1] Constructed under cooperative agreement with U. S. Bureau of Reclamation.

TABLE 20 *(continued)*

PRINCIPAL CONSTRUCTION CONTRACTS AND CONTRACTORS' PERSONNEL

CONSTRUCTION FEATURE	CONTRACT AWARDED	CONTRACTOR	HOME OFFICE	CONSTRUCTION SUPERINTENDENTS	WORK COMPLETED
Main aqueduct dams, pumping plants, and appurtenant works					
Gene Wash and Copper Basin dams	Mar. 26, 1937	J. F. Shea Co., Inc.	Los Angeles	F. T. Crowe	Aug. 15, 1938
230-kv Boulder transmission line	Sept. 27, 1935	Fritz Ziebarth	Long Beach	M. S. Elliott	Aug. 16, 1937
Whipple patrol road	Feb. 25, 1935	Bennett and Taylor	Los Angeles	Knight Bennett	Oct. 15, 1935
Boulder telephone line	Sept. 13, 1935	Newbery Electric Corp.	Los Angeles	Jack Sager	May 27, 1936
Fence schedule No. 1	Nov. 19, 1937	Anchor Post Fence Co.	Los Angeles	W. H. Mendell	June 14, 1938
Fence schedule No. 2	Nov. 19, 1937	Pittsburgh Steel Co.	Pittsburgh, Pa.	H. W. M. Coleman	June 5, 1938
Fence schedule Nos. 3, 4, and 5	Nov. 19, 1937	L. A. Fencing Co.	Los Angeles	H. Henderson	June 18, 1938
Distribution tunnels					
Monrovia Nos. 1, 2, and 3	Dec. 21, 1934	West Construction Co.	Boston, Mass.	H. E. Carleton	Oct. 10, 1938
Monrovia No. 4; San Rafael Nos. 1 and 2	July 26, 1935	L. E. Dixon Co., Bent Bros., Inc., and Johnson, Inc.	Los Angeles	Paul C. Guinn and W. N. Evans	July 12, 1938
Sierra Madre	Aug. 9, 1935	J. F. Shea Co., Inc.	Los Angeles	Ed. H. Shea	Oct. 31, 1936
Pasadena	Dec. 21, 1934	L. E. Dixon Co., Bent Bros., Inc., and Johnson, Inc.	Los Angeles	H. J. King, excav; S. D. Hackley, conc.	April 23, 1937
Pasadena extension	Aug. 9, 1935	L. E. Dixon Co., Bent Bros., Inc., and Johnson, Inc.	Los Angeles	H. J. King, excav; S. D. Hackley, conc.	Nov. 24, 1936
Cajalco reservoir, distribution pipe lines, and appurtenant works					
Cajalco dam, dike, and appurtenant works	Aug. 16, 1935	Griffith Company	Los Angeles	R. B. Sawyer, Harry Davis, and Franz Fohl	Feb. 9, 1938
Headworks structure	Mar. 25, 1938	The Contracting Engineers Co.	Los Angeles	Julian Huddelston	Feb. 7, 1939
Precast concrete pipe	Jan. 10, 1936	American Concrete and Steel Pipe Company	Los Angeles	D. H. Rankin	Dec. 23, 1937

Steel pipe and steel bridge	Jan. 10, 1936	Western Pipe & Steel Co.	Los Angeles	L. L. White	Nov. 24, 1937
Precast concrete pipe	Nov. 1, 1935	American Concrete and Steel Pipe Co.	Los Angeles	J. C. Connell	June 18, 1937
Precast concrete pipe	Dec. 20, 1935	J. F. Shea Co., Inc.	Los Angeles	Ed. H. Shea	May 24, 1938
Precast concrete pipe	Nov. 1, 1935	United Concrete Pipe Corp.	Los Angeles	Charles Johnston	Mar. 17, 1937
Canyon crossings	Feb. 19, 1937	Basich Bros.	Torrance	Dick Noble	Feb. 2, 1939
Precast concrete pipe	Aug. 7, 1936	United Concrete Pipe Corp.	Los Angeles	Roy Richards	Oct. 31, 1938
Mortar-lined steel pipe	Sept. 10, 1937	J. F. Shea Co., Inc.	Los Angeles	W. F. Rennebohm and Charles A. Shea, Jr.	Mar. 26, 1939
Mortar-lined steel pipe	Oct. 14, 1938	Emsco Derrick & Equip. Co.	Los Angeles	F. O. Mjellem, Hans Gude	Oct. 31, 1939
San Gabriel River spillway	Nov. 4, 1938	J. F. Shea Co., Inc.	Los Angeles	W. F. Rennebohm	June 30, 1939
Mortar-lined steel pipe	Dec. 30, 1938	Western Pipe & Steel Co.	Los Angeles	C. D. Sander, S. F. Walker, Hans Gude	Sept. 30, 1939
Palos Verdes reservoir	Dec. 30, 1938	W. E. Hall Co.	Alhambra	M. Hjalmarson, W. E. Hall	Dec. 31, 1939
Water softening and filtration plant	Nov. 3, 1939	Griffith Company	Los Angeles	Olen Evans	.....
Waste water disposal line	April 12, 1940	United Concrete Pipe Corp.	Los Angeles	.....	.....
Precast concrete pipe	May 17, 1940	American Concrete and Steel Pipe Co.	Los Angeles	.....	.....
Mortar-lined steel pipe	May 17, 1940	J. F. Shea Co., Inc.	Los Angeles	.....	.....
Hollywood tunnel	May 17, 1940	J. F. Shea Co., Inc.	Los Angeles	.....	.....
Precast concrete pipe	June 28, 1940	United Concrete Pipe Corp.	Los Angeles	.....	.....
Cast-iron pipe	June 28, 1940	Artukovich Bros.	Hynes	.....	.....

CHAPTER 5

LEGAL

The organic act, under which The Metropolitan Water District of Southern California was incorporated December 6, 1928, was amended during the period covered by this report, in two particulars (Stats. 1939, page 1778, chapter 445). The amendatory statute was approved by the Governor June 6, 1939, and became effective September 19, 1939. It added two new sections, numbered 8.1 and 14.1.

Section 8.1 was adopted to correct a technical difficulty in the levying and collecting of District taxes on unsecured personal property and to remedy a defect in the tax structure relative to refunds of taxes paid by unsecured personal property owners in a city, which subsequently elects to pay all or a portion of such taxes out of municipal funds.

Section 14.1 authorizes the board of directors of a metropolitan water district, by ordinance, to establish a retirement system for officers and employees of such district. This amendment was adopted to confer authority upon the board of directors to establish a retirement system. The amendment is merely permissive.

As outlined in the history and first annual report of the District, covering the period from its incorporation on December 6, 1928 to June 30, 1938, legal problems of major importance were presented to the courts, resulting in far-reaching decisions "establishing the status of the District as a municipal corporation, clarifying its powers, and defining the scope of the Boulder Canyon project undertaken by the United States, with which the District's project is interrelated." No comparable legal development occurred during the last two years but the District was confronted with many legal and legislative problems of importance and the activities in connection therewith are summarized briefly in the following pages.

Contractors' Suits

An action brought by Wenzel & Henoch Construction Company, contractor on the San Jacinto tunnel, based on alleged breach of

contract, was pending. The major case, which had been tried and decided in favor of the District in the spring of 1938, was appealed to the United States Circuit Court of Appeals for the Ninth Circuit. The record was prepared, briefs were filed, and the cause was argued and submitted, but no decision as yet has been rendered. The complaint for conversion of the machinery and equipment taken over and used by the District, which had been filed in February 1938, was continued under stipulation that the District need not appear nor plead to the complaint until thirty days after written notice from the company that judgment in the main case pending on appeal, as above noted, had become final.

Damages to Lands and Water Rights

Claims for damages in substantial amounts have been filed alleging interference with, or deprivation of, water rights. Some of these claims had merit and a continuous effort has been made to settle such cases in order to avoid litigation, wherever possible. A number of claims have been settled upon terms which resulted in substantial savings to the claimants and to the District. Other claims lack merit, or are too broad and may have to be litigated.

Taxes

Six suits by Southern California Telephone Company to recover taxes for the fiscal years 1937-38, 1938-39, and 1939-40, paid under protest, were pending, recovery being sought on ground of arbitrary and discriminatory valuations assessed by the state board of equalization. Under stipulation, the District need not plead thereto until after written notice. Three of these actions were filed in Los Angeles County and three in Orange County. Two suits were filed by the District against the County of Riverside, to recover taxes for the fiscal years 1936-37, 1937-38, 1938-39, and the first installment of taxes for the fiscal year 1939-40, on the ground that the District's lands outside its boundaries are not taxable under section 1 of article XIII of the state constitution. These actions are pending on demurrer.

Condemnation

The District's appeal from the judgments after trial of group 1 of the parcels involved in the Cajalco reservoir action in Riverside County resulted in reversals by the Fourth District Court of Appeal. Hearing was granted by the Supreme Court, and the appeal was further argued and briefed in that court, where it is awaiting

decision. Other condemnation cases were filed and prosecuted during the period covered by this report.

California Legislation

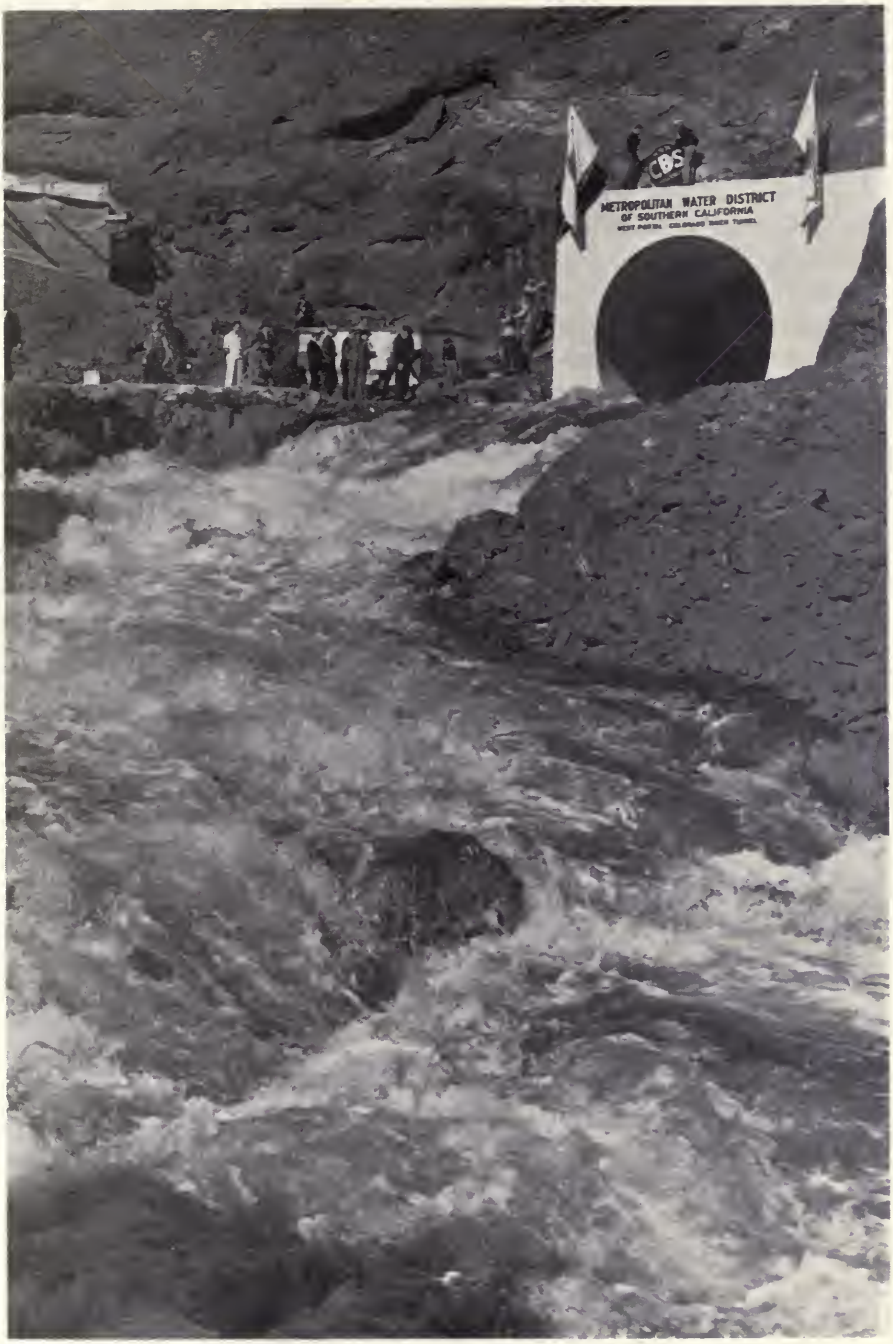
Amendments to the Metropolitan Water District Act previously have been noted. At the 1939 session, and the two 1940 special sessions, of the state legislature, other measures were introduced, which required examination and consideration as to their possible effect upon the District.

United States Legislation

The Boulder Canyon Project Act, adopted in 1928, provided for the lease of power privilege at Boulder dam as one of the possible methods of operation, and for the execution of contracts for electrical energy there produced. The contracts which were negotiated and executed during the years 1930 and 1931 by the lessees of the power privilege and other contractors for energy, including the District, prescribed rates computed to be sufficient to operate and maintain the project and repay advances therefor within fifty years. In 1945, and at ten-year intervals thereafter, rates were to be adjusted upon a competitive basis.

In 1930 and 1931 the District, although incorporated, had not been financed, and its contract to take and pay for 36 per cent of the firm energy was not considered in the computation of repayment requirements. For this, and other reasons, the rates established in 1930 were found to be unnecessarily high. The District joined with other lessees and contractors for energy, in an effort to procure a modification of the Boulder Canyon Project Act which would authorize the establishment of rates computed (taking into account the District's obligation) to amortize the advances for the project between 1937 and 1987.

After several years of negotiation between the lessees and contractors and the representatives of the seven Colorado River basin states, together with the Secretary of the Interior, the provisions of a bill were agreed upon, which was enacted by the Congress as the Boulder Canyon Project Adjustment Act (1940). The adjustment act authorizes the execution of new contracts under which rates may be established which will provide revenue sufficient, among other things, to operate and maintain the project and to amortize the investment of the Federal Government at Boulder dam within the prescribed fifty-year period, interest computations being on a 3 per cent basis instead of 4 per cent, the rate formerly



Jan. 7, 1939, when Intake pumps were officially started

prescribed. It also defers, without interest, until after the fifty-year repayment period, the repayment of advances for flood control, in the amount of $25,000,000. Negotiation of new contracts under the adjustment act is now under way.

When executed, such contracts will be retroactive and the rates therein prescribed will be operative from 1937, that being prior to the date when the District first became obligated to pay for electrical energy under its original contract. A reduction of energy rates under the adjustment act will result in a substantial reduction of operating expenses of the District.

Congressional legislation was obtained, by which the Metropolitan Water District of Southern California will be permitted to lease public sodium-producing lands in the same manner, and to the same extent, as other corporations. This was deemed advisable in order to place the District in a favorable position in meeting its sodium chloride requirements.

Much of the area inundated or affected by the creation of Lake Havasu, back of Parker dam, is held in trust for the Chemehuevi and Mojave tribes of Indians. To transfer these lands to the United States for reservoir use, congressional authority was required. An act was passed by Congress to accomplish that purpose.

CHAPTER 6

PURCHASING, RIGHT OF WAY, MEDICAL, SAFETY, PERSONNEL, MISCELLANEOUS ACTIVITIES

Purchasing

The purchase of supplies, materials, and equipment has been on a decreasing scale in step with the reduction in construction, particularly force account work on pumping plants and San Jacinto tunnel, as completion of the initial stage of the project approaches. The number of purchase orders issued in the two-year period was 16,570, totaling approximately $1,280,000. Transportation requirements were equivalent to 3,036 carloads at a cost of $270,000.

During this period the disposal of salvage stock from the storage yard at Banning and as released from service at San Jacinto camps or other points on the aqueduct has been satisfactorily active. Sales of the District's heavy equipment have been stimulated by beginning of construction on the Central Valley project in California, particularly railroad relocation in the vicinity of Shasta dam, and of the extension of the New York city aqueduct, with a large amount of tunnel work. Contractors on the Colorado River project have been heavy buyers of mucking machines, electric locomotives, cars, drill carriages, rock drills, and drill sharpeners for use on their contracts elsewhere. In addition, two large mine hoists have been sold to one California gold mining company, compressors have been disposed of to airplane manufacturers, several mucking machines were shipped to Cardiff, England, a drill carriage was sent to South America, and two motor-driven pumps were sold to the Mexican government for use in that country. The amount of $1,210,000 was received from salvage sales in the two-year period and materials and equipment to the value of $110,000, at appraised prices, were transferred to other project features. As described under construction utilities, use of the water and power systems was terminated at the end of 1939. Steel tanks and pipe lines of the water system have been sold in place and removed.

Substations, main lines, and tap lines of the construction power system have been sold standing, or have been dismantled for reuse by the District, or sale from salvage. Considerable quantities of electrical equipment have been sold to existing utility companies in this area. The transmission line itself from Colton to Cabazon through San Timoteo Canyon and from Cabazon to Indio, totaling 83 miles was sold, including right of way, to the California-Nevada Electric Corporation, of Riverside, California. This corporation also purchased two other short lines, aggregating 10 miles, to serve San Jacinto Valley.

Bowls for main pumps

Right of Way

The activities of the right of way division, during the two-year period, have been concerned mainly with operation and leasing of District property, and acquisition of rights of way consisting of lands within the Parker and Cajalco areas, acreage for the softening and filtration plant and for the Palos Verdes and Orange County reservoirs, and pipe line easements. Public streets and highways are used where available for the distribution lines, but when necessary or more economical to cross privately owned land, easements have been obtained. These easements are in the form of a narrow permanent easement, in which the pipe is placed generally along its center line and deep under the surface, and a temporary easement, having a definite termination date and varying width, for construction purposes only.

Including the waste water disposal pipe line from the water softening and filtration plant and connections to delivery systems of member cities, 115 miles of pipe, with inside diameters of 58 inches or less, make up the distributing lines thus far authorized,

and extending from the upper feeder. Of this length 82 miles are constructed in public streets and highways, the remaining 33 miles being in privately owned land. Easements have been purchased at reasonable prices, except in a small number of cases, in which condemnation proceedings have been necessary. Where claims arose for damages to crops and improvements due to pipe line construction operations, satisfactory settlements were made.

On the permanent telephone line, portions of the right of way formerly held under lease during the aqueduct construction period, were acquired. Extensive areas of public lands, together with some small private holdings, have been purchased below main aqueduct wasteways, where flooding might occur with discharge of considerable quantities of water from the aqueduct.

The District's nonoperative properties are in charge of the right of way division which has negotiated all sales and leases, collected all cash and crop rentals, and operated the citrus grove in which the softening and filtration plant is situated.

Medical, Surgical, and Hospital Services

The employees' medical fund continued to provide medical services to all employees who are contributing members. Membership is optional in Los Angeles and vicinity, but compulsory for field forces in remote areas.

While none of the contractors on District construction has found it necessary during this period to maintain camps for the workmen, the specifications have continued to require adequate medical, surgical, and hospital care for employees. This service has been provided by arrangement with licensed practitioners and established hospitals in communities near the work.

At San Jacinto tunnel the District medical unit, in charge of a doctor and male nurse, continued to function in the south wing of the Banning headquarters office until December 31, 1939, when the station was closed and its equipment appraised preparatory to sale. Since that date all medical cases in the Banning area have been attended by a local physician. A first-aid station was maintained at Gene camp until June 7, 1940, when it was moved to Iron Mountain camp to provide medical and surgical aid to employees at District camps and along the main aqueduct. Patients requiring hospitalization have been brought to Los Angeles since the closing of the District hospital at Berdoo in October 1936.

A medical office and clinic have been operated in the Los Angeles headquarters building, to examine applicants for employment and

to render medical aid under both the employees' medical fund and the compensation fund.

Safety

Outstanding features of the record of safety on the Colorado River aqueduct are the marked downward trend of accidents through the construction period and the low fatality rate. On the District's force account operations a very substantial saving was made in the cost of compensation insurance, at California manual rates, by virtue of the District's self-insurance and its comprehensive safety program, and a great reduction was effected in human suffering from accidents.

With the completion of construction of all main aqueduct works, except San Jacinto, virtually accomplished, the safety division as such was closed in July 1938. The remaining safety program for San Jacinto was handled by the District geologist at Banning until July 1939, and by the distribution division on its pipe line and other contracts up to date.

The lost-time accident frequency, that is, the number of accidents causing the loss of one day or more per million man-hours worked. for San Jacinto tunnel during the calendar year 1938 was 142 and for the eight months to August 31, 1939 was 82. The average for District force account work on San Jacinto from February 12 1935 to August 31, 1939 was 118. During this same period of more than four years, eight fatal accidents occurred, but no particular accident claimed the life of more than one individual.

On the distribution system more than 38 miles of pipe line were completed, including several tunnels, and many crossings under railroads and highways by means of short tunnels or jacked pipe incasement, with only seventeen lost-time accidents. On one schedule, however, a cave-in caused the death of two men. Distribution engineers and inspectors have been alert to point out danger spots and contractors have cooperated readily in every effort to prevent accidents.

Personnel

On October 31, 1938 the labor office at 770 South San Pedro Street, Los Angeles, was closed and all its activities transferred to the personnel division offices at 306 West Third Street, with a reduction in force.

From July 1, 1938 to June 30, 1940 applications received for classified positions numbered 387, of which 38 were graded and

approved. The number of classified positions filled was 252, of which 157 were supplied by transfer. In the unclassified service, 2,436 men registered for work, 387 men were sent out on force account work, and 2,363 men to contractors. Identification certificates were issued to 1,280 men, making a total of 27,157 such certificates given to qualified District citizens to date. Interviews with applicants during the two-year period totalled 18,582.

The personnel division has kept in touch with construction projects and employers elsewhere, and has been able to direct a considerable number of terminated employees to new positions. There is also a steady increase in inquiries from employers, civil service commissions, credit associations, state aid, and other organizations, for information about the District's former employees.

The established policy of the District to employ only qualified residents of the member cities was adhered to for both classified and unclassified positions. Moreover, from the beginning of construction operations employment has been spread among the member cities as nearly as possible in proportion to their interest in the project. The residential cities of Beverly Hills and San Marino have consistently fallen far below their entitled amount because of the limited number of their citizens seeking employment, while Burbank and Santa Monica have held relatively close to their proportion.

Table 21 shows the distribution of pay rolls from January 1, 1932, prior to actual beginning of construction, to June 30, 1940.

Observation point at Lake Mathews

The legal residence at the time of employment is used for the distribution.

TABLE 21

DISTRIBUTION OF PAY ROLLS
January 1, 1932 to June 30, 1940

MEMBER CITIES	ENTITLED	RECEIVED	DISTRICT	CONTRACT
Anaheim	$ 269,684.47	$ 294,381.66	$ 146,202.05	$ 148,179.61
Beverly Hills	1,767,293.91	393,884.70	290,112.16	103,772.54
Burbank	722,983.88	655,184.35	406,089.81	249,094.54
Compton	235,256.66	338,335.77	130,269.53	208,066.24
Fullerton	424,609.58	473,114.86	317,077.82	156,037.04
Glendale	1,801,721.71	1,888,782.07	1,134,960.72	753,821.35
Long Beach	4,848,582.30	4,717,428.12	2,666,462.36	2,050,965.76
Los Angeles	41,416,647.33	42,750,919.77	22,992,439.80	19,758,479.97
Pasadena	2,679,630.69	2,016,201.25		1,186,065.17
(Pine Canyon dam)		808,936.00	830,136.08	808,936.00
San Marino	441,823.48	260,774.79	229,088.26	31,686.53
Santa Ana	722,983.87	794,685.66	389,529.92	405,155.74
Santa Monica	1,423,015.87	1,358,377.27	1,023,774.38	334,602.89
Torrance	625,438.43	628,665.91	447,442.83	181,223.08
	57,379,672.18	57,379,672.18	31,003,585.72	26,376,086.46
Other California cities within metropolitan area		602,485.70	304,746.33	297,739.37
Other California cities outside the area		1,301,509.00	507,464.66	794,044.34
Outside California		1,009,597.13	701,789.24	307,807.89
Unknown address		166,905.48		166,905.48
Total payrolls		$60,460,169.49	$32,517,585.95	$27,942,583.54

The maximum monthly employment from start of construction to date is given in the following tabulation:

FISCAL YEAR ENDING JUNE 30	MAXIMUM MONTHLY EMPLOYMENT
1933	2,170
1934	5,490
1935	9,017
1936	10,781
1937	10,533
1938	5,481
1939	3,180
1940	1,472

The number of employees is the total reported on all contractors' and District's pay rolls.

Miscellaneous Activities Division

During the two years covered by this report the District continued its practice of making available through newspapers, period-

icals, and other channels authoritative information concerning the operations and policies of the District. In response to numerous requests, several District employees volunteered their services as speakers and appeared before meetings of civic, commercial, and technical groups to give information relating to the aqueduct and the operation of the District in general.

A photographic section with a staff photographer in charge was maintained to secure a photographic record of construction operations.

Motion Picture

On December 14, 1938 members of the board of directors, the staff, employees of the District and representatives of the District cities previewed a new aqueduct film entitled, *The Thirteen Golden Cities*. Since that night the picture has been exhibited to

	Aggregate attendance
425 schools, largely junior and senior high	172,800
605 civic groups	79,700
143 theaters within the District	410,400
125 theaters not in District	252,800
Total	915,700

In addition, prints of this picture have been furnished to the visual education departments of the Los Angeles, Long Beach, and Pasadena boards of education for classroom study.

Literature

The fourth edition of the *Colorado River Aqueduct,* a booklet descriptive of the project, was issued in March 1939 and widely distributed. There have been given away locally and sent to all parts of the United States and to several foreign countries more than 6,000 copies.

A four-color lithograph map folder was prepared in August 1939 for general public distribution. The original order was for 25,000, but public demand for the maps has required three reprints, making a total of 150,000.

By using engravings originally prepared for the *Aqueduct News,* the Los Angeles board of education has prepared for use in its visual education program 500 copies of a series of three illustrated booklets describing the need for the construction and use of the aqueduct.

Exhibits and Displays

To answer the many requests for model and pictorial representations of the aqueduct, twelve identical relief map models were cast in plaster and encased in folding carrying cases. The maps are approximately two feet by seven feet in size. The cover of the map when raised displays photographs and information regarding the project. Eleven of the maps have been circulated among the various District city public offices, schools, libraries, and civic organizations, while the twelfth has been on permanent display in the lobby of the capitol at Sacramento.

Another larger relief map model of the aqueduct, equipped with a display of colored photographs, has been exhibited at the Biltmore Hotel, the Pan Pacific Auditorium, and the Public Library in Los Angeles, at the Pasadena City Schools Museum, and the Long Beach Municipal Auditorium.

Requests for window display material were filled by the use of twelve folding display boards, each carrying representative colored photographs and a pictorial map. Many bank and similar windows throughout the District area have displayed these boards.

Larger displays and exhibits have also been provided upon request. Typical of the larger window displays are those at the Dis-

Near Year's Day, 1940, Pasadena Tournament of Roses

trict's headquarters and a recent display in Bullock's at Seventh and Hill Streets, Los Angeles. Exhibits of colored pictures are being shown at the Automobile Club of Southern California in Los Angeles and at various chambers of commerce. Exhibits have also been installed in schools for study use in connection with the District's films.

At Lake Mathews and Palos Verdes reservoirs, large permanent signs inform thousands of visitors of aqueduct facts. Arrangements have been made to distribute informative literature at convenient points at Lake Mathews.

Floral floats representative of the Colorado River aqueduct and the benefits to be derived therefrom were entered by the District in the 1939 and 1940 Pasadena Tournament of Roses.

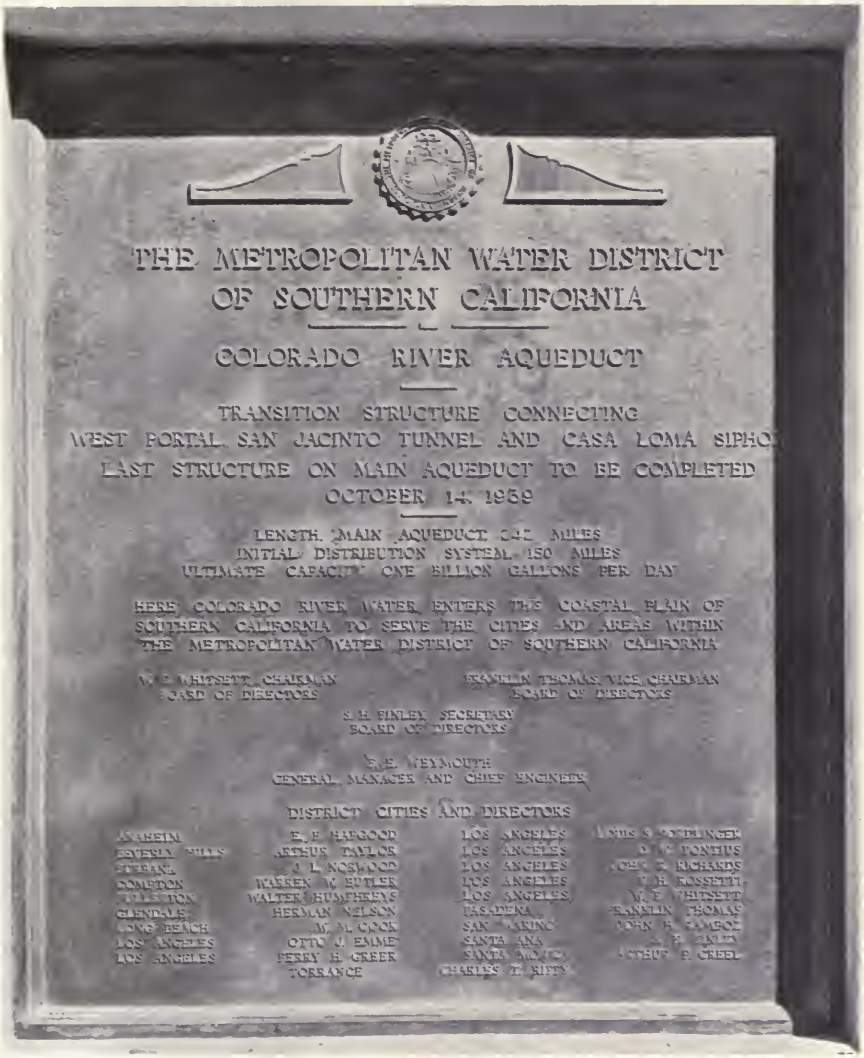
Aqueduct News

As one of the means of publicly and accurately reporting the progress of the construction of the aqueduct and of the policies of the District, publication of the *Colorado River Aqueduct News* has been continued. Started in 1934 as a semimonthly publication, the issue of the magazine was placed on a monthly basis in 1938. Since that time about 4,500 copies per month have been printed. In the distribution of these issues approximately 3,000 copies are mailed to interested citizens and organizations, both within and without the District, and the remainder are distributed to force account and contract employees working on the job.

Radio Programs

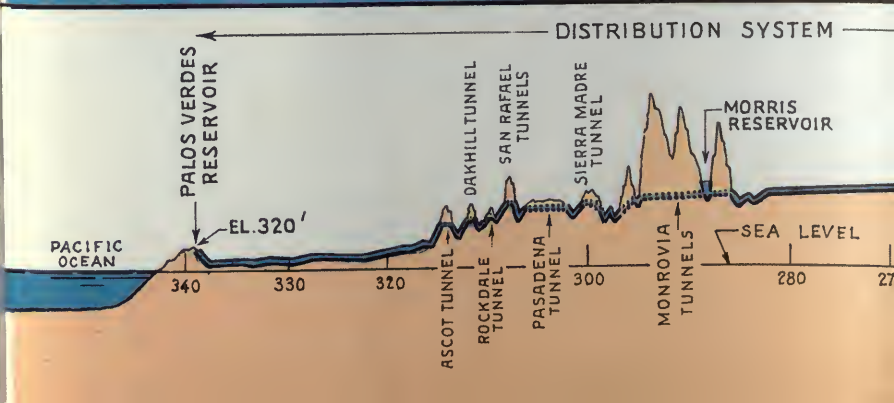
Because of the national interest attracted by the construction of the Colorado River aqueduct, and because the colorful activities of the construction work have proved to be adaptable for radio presentation, a large number of radio programs originating on the aqueduct were broadcast to local and nationwide listening audiences during the period covered by this report. All of these programs were sponsored by the Columbia Broadcasting System and were produced through the cooperation of Mr. Fox Case, director of public relations for the western division of the system. Each program was designed faithfully to present the construction scene at the various points of origin, and as a result of their high degree of educational and entertainment value, a number of the programs received national professional acclaim as being outstanding in the field of public event broadcasts. During the period 12 broadcasts were presented, of which two were released over the coast-to-coast

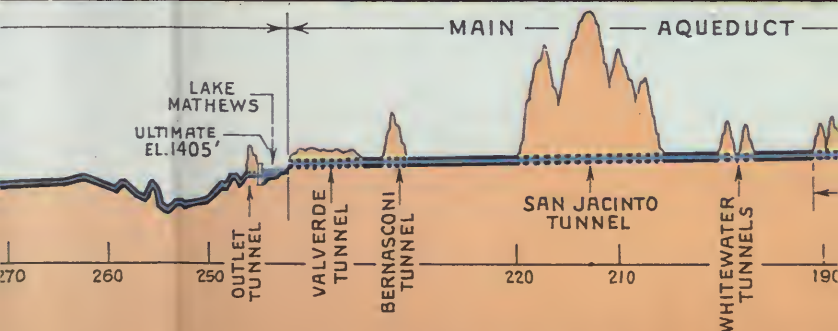
network of the Columbia Broadcasting System and 10 were released over the Pacific coast network of the system. Most of the programs were released in the evening at a time when they could be heard by a large number of listeners. In response to requests from such listeners, the District sent many hundreds of pamphlets describing the aqueduct to all parts of the nation. Having both educational and historical interest in this series of radio programs were those in connection with the holing through of the last two headings in San Jacinto tunnel, November 19, 1938, the beginning of operation of the Intake pumping plant on January 7, 1939, the completion of the heavy construction of the main aqueduct, October 14, 1939, and the regular delivery of Colorado River water and its storage in Lake Mathews on November 19, 1939.



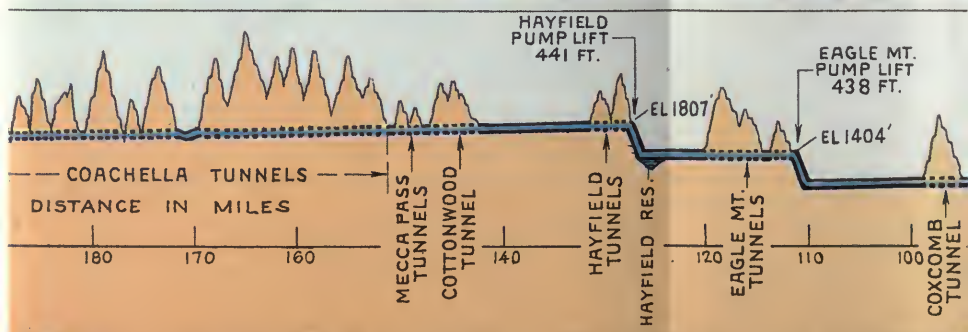
Bronze tablet at San Jacinto tunnel


UNITED STATES
AREA COVERED BY MAP
MORRIS RESERVOIR
BURBANK
PASADENA
SOFTEN
FILTRAT
BEVERLY HILLS
GLENDALE
SAN MARINO
SANTA MONICA
LOS ANGELES
FULLERTON
TORRANCE
COMPTON
ANAHEIM
LAKE MATHEW
LONG BEACH
SANTA ANA
PALOS VERDES RESERVOIR

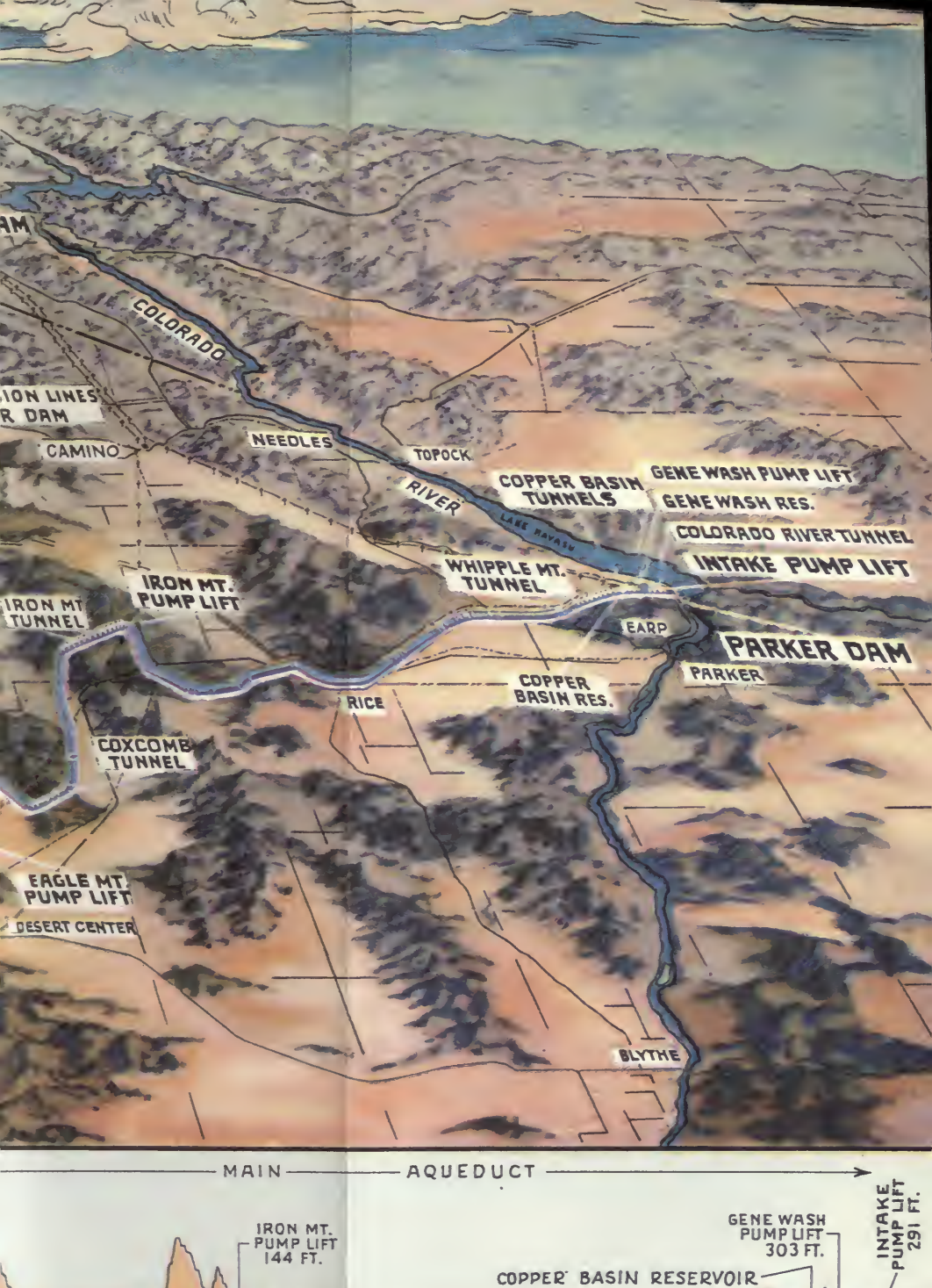

DISTRIBUTION SYSTEM
PALOS VERDES RESERVOIR
EL. 320'
OAKHILL TUNNEL
SAN RAFAEL TUNNELS
SIERRA MADRE TUNNEL
MORRIS RESERVOIR
PACIFIC OCEAN
SEA LEVEL
340
330
320
300
280
ASCOT TUNNEL
ROCKDALE TUNNEL
PASADENA TUNNEL
MONROVIA TUNNELS

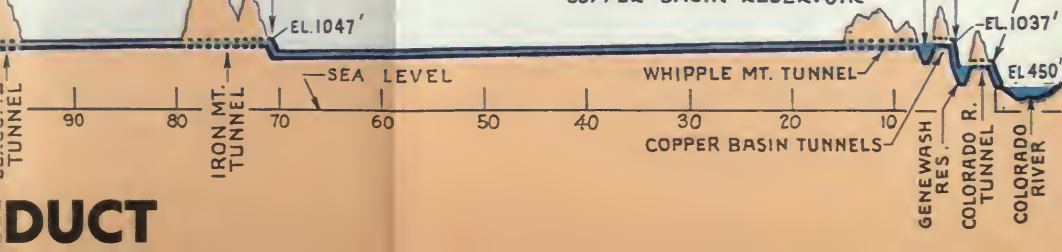


MAP AND PROFILE OF



THE COLORADO RIVER AQUED


COLORADO
CAMINO
NEEDLES
TOPOCK
RIVER
LAKE HAVASU
COPPER BASIN TUNNELS
GENE WASH PUMP LIFT
GENE WASH RES.
COLORADO RIVER TUNNEL
INTAKE PUMP LIFT
WHIPPLE MT. TUNNEL
IRON MT. PUMP LIFT
IRON MT TUNNEL
EARP
PARKER DAM
PARKER
COPPER BASIN RES.
RICE
COXCOMB TUNNEL
EAGLE MT. PUMP LIFT
DESERT CENTER
BLYTHE


MAIN AQUEDUCT
IRON MT. PUMP LIFT 144 FT.
EL. 1047'
GENE WASH PUMP LIFT 303 FT.
COPPER BASIN RESERVOIR
INTAKE PUMP LIFT 291 FT.
EL. 1037'
EL. 450'
SEA LEVEL
WHIPPLE MT. TUNNEL
90
80
70
60
50
40
30
20
10
IRON MT. TUNNEL
COPPER BASIN TUNNELS
GENE WASH RES.
COLORADO R. TUNNEL
COLORADO RIVER

DUCT