

At a meeting of the TARRANT COUNTY WATER CONTROL & IMPROVEMENT DISTRICT NUMBER ONE, held in the City of Fort Worth, on the 30th day of July, A.D. 1927, at which were present the following Directors, to-wit: A. L. Baker, President, W. E. Bideker, Secretary, H. M. Hightower, L. C. Abbott and W. H. Slay, composing the entire membership of the Board, the following proceedings were had and done:

A. L. Baker presided over the meeting and W. E. Bideker was present in his aforesaid capacity as Secretary of the Board.

THEREUPON, came on to be heard the report of John B. Hawley and S. W. Freese, the engineers of the District, covering the plans and improvements contemplated by the Directors for the District and the plans covering the construction thereof, together with maps, plats, profiles and data, and containing a detailed estimate of the cost of the improvements in the District contemplated by the Board, showing, illustrating and explaining the same for the benefit of the Board.

And the Board having examined, considered and approved the report of said Engineers, and having as well considered the costs of the improvements by the Engineers report proposed and recommended to be constructed, together with the detailed estimates of the costs of the proposed works, including the cost of purchase of all property necessary to be purchased, do conclude and determine that the construction of such works is feasible and practicable, that the construction would be a benefit to the land and other property included in the district, would be a public benefit and utility, and that said works are urgently needed for the control of floods and the supply of water within the district. They further determine that said works should be constructed with all possible dispatch in order to carry out the purposes for which this district was created.

The Directors therefore do determine that said report, plans, maps, plats, profiles, data, and detailed estimates of costs of the improvements and property should be approved and adopted without change therein and without addition thereto.

THEN AND THEREUPON, Director Slay, seconded by Director Bideker, moved the adoption of the following resolution:

"BE IT RESOLVED BY THE BOARD OF DIRECTORS OF TARRANT COUNTY WATER CONTROL & IMPROVEMENT DISTRICT NUMBER ONE THAT THE REPORT OF MESSRS. JOHN B. HAWLEY AND S. W. FREESE, THE ENGINEERS OF THE DISTRICT, COVERING THE PLAN AND IMPROVEMENTS NOW AND HEREBY PROPOSED TO BE CONSTRUCTED BY THE DISTRICT, TOGETHER WITH MAPS, PLATS, PROFILES AND DATA FULLY SHOWING AND EXPLAINING SAME, AND ALSO A DETAILED ESTIMATE OF THE COST OF SUCH IMPROVEMENTS, INCLUDING THE COST OF ANY AND ALL PROPERTY NECESSARY TO BE PURCHASED, BE AND THE SAME IS HEREBY IN ALL THINGS APPROVED AND ADOPTED BY THE BOARD WITHOUT CHANGE THEREIN OR ADDITIONS THERETO, AND SAID REPORT IS ORDERED TO BE FILED WITH THE ARCHIVES, RECORDS AND PAPERS OF THE DISTRICT, AND SAME SHALL BE OPEN AT ALL TIMES TO THE INSPECTION OF THE PUBLIC, IN CONFORMITY TO SECTION 78 OF CHAPTER 25 OF THE ACTS OF THE 39TH LEGISLATURE OF TEXAS."

President Baker thereupon opened the motion for discussion and vote. After a full discussion Directors Slay, Abbott, Baker, Hightower and Bideker voted for the resolution and no Director voted against the same: It is so ordered.

There being no further business, the meeting was adjourned subject to call.

Wesley H. Baker  
Secretary.

Approved:

A. R. Baker  
President.



REPORT OF INVESTIGATIONS

for

A WATER SUPPLY AND FLOOD CONTROL

for

TARRANT COUNTY WATER CONTROL AND IMPROVEMENT DISTRICT NO. I

by

HAWLEY and FREESE  
District Engineers

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June 30, 1927  
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The report is divided into two major parts: - flood control and water supply. Under the heading of flood control, the intensity and volume of past floods and floods to be expected are compared with the capacities of the present levee system and the Lake Worth Spillway. The amount of retarding basin capacity necessary to prevent the disastrous floods which are sure to occur in the future, as in the past, is shown.

Under the heading of water supply, the present and predicted water consumption of the City of Fort Worth is compared with the present supply which is diminishing due to the silting of Lake Worth at such a rate that it will be inadequate in six or seven years; this statement is based on normal runoffs from the water shed of the West Fork of the Trinity during the predicted six or seven years. It does not take into account the drouth factor, which will be set out in a later paragraph of this report.

It is proposed to coordinate the two projects into a project of the whole by the construction of two storage-retarding basins on the West Fork with a total capacity of 1,500,000 acre feet, which is approximately forty-three times the original capacity of Lake Worth. One of the two sites, the Eagle Mountain site, is immediately above Lake Worth, and the other



near Bridgeport. The use of any of the sites on the Clear Fork is precluded by their small drainage area, even smaller relative storage-retarding capacities, and cost, the latter being ten times the Bridgeport unit cost and five times the Eagle Mountain unit cost.

In addition to the above two dams, it will be necessary to revise the Clear Fork levees within the City of Fort Worth, as part of the flood protection program.

In addition to the two major headings are minor considerations, such as the possible creation of two parks with a total acreage of 10,000 acres, and the improvement of the raw water furnished the City of Fort Worth by the greatly increased storage periods.

#### FEASIBILITY

The total cost of the project, exclusive of organization expense, will be within \$6,425,000.00. This includes all costs up to the time the works may be completed and service therefrom commenced. This cost will be for each 327,000 gallons (1 acre foot) stored for beneficial use, \$12.85. The costs to regulate an additional abnormal flood flow of 1,000,000 acre feet and to increase levee capacity to care for the Clear Fork flood are included as part of the cost to store water for beneficial use. In other words, this charges the flood control to the stored water. The cost per acre foot for water stored and flood flow control will be \$4.28 per acre foot. Compare this with the cost of Lake Worth, which exceeded \$29.00 per acre foot of original capacity. Also compare with cost of the Garza Reservoir to supply the City of Dallas. This cost was \$25.00 per acre foot.

#### FLOOD CONTROL

Past Floods: The maximum flood of record which has occurred



at Fort Worth was that of April 25th, 1922, with a flow of 85,000 second feet. Of this 85,000 second feet from both forks of the Trinity, 74,000 were from the Clear Fork with its 530 square miles of drainage area, and 11,000 second feet were from the 2,000 square miles of West Fork drainage area. The above discharges were computed by the slope method; using Kutter's formula (average hydraulic factors from six cross sections between Mary's Creek and Frisco Railway bridge in Clear Fork --  $A = 17,700$  sq.ft.;  $P = 2,449$  ft.;  $R = 7.2$  ft.;  $N = 0.055$ ;  $S = 0.0015$ ;  $V = 4.2$  ft. per sec.;  $Q = 74,000$  second ft.) Discharge for West Fork of Trinity River at Lake Worth as determined by formula  $Q = 3.33 LH^{\frac{3}{2}}$ ;  $H = 26$  inches;  $Q = 8,100$  second feet; inflow between Dam and Fort Worth estimated at 2,500 second feet; total for West Fork, 10,600 second feet.

The amount of water flowing past Fort Worth during the entire storm is given in the following table:

	CLEAR FORK	WEST FORK	BOTH FORKS
	99,900 Acre Ft.	16,100 Acre Ft.	116,000 Acre Ft.
April 25th, 1922			
April 26th, 1922	71,100 " "	23,600 " "	94,700 " "
April 27th, 1922	22,700 " "	12,900 " "	35,600 " "
Total.....,.....	193,700 " "	52,600 " "	246,300 " "

The flow for the maximum day amounted to a runoff of 3.53 inches from the Clear Fork water shed, for the maximum two days, 6.05 inches, and for the three days, 6.85 inches. The total rainfall on the Clear Fork during this storm was 10.17 inches, of which 67 per cent, i.e. 6.85 inches, ran off as storm flow.

Maximum Floods: A study of the various storms which have occurred in this section of the United States indicates that the 74,000 second foot flow of the April 1922 storm was a maximum for the Clear Fork



and that a 200,000 second foot flow should be taken as a maximum for the West Fork. The maximum intensity of run-off for the entire watershed above Fort Worth is placed at 220,000 second feet. These maximum flows give the following intensities per square mile of drainage area.

Clear Fork	531 sq.mi.	@ 139 Sec. Ft. per Sq.Mi.	= 74,000 sec. ft.
West Fork	2,011 sq.mi.	@ 99 Sec. Ft. per Sq.Mi.	=200,000 sec. ft.
Both Forks	2,542 sq.mi.	@ 87 Sec. Ft. per Sq.Mi.	=220,000 sec. ft.

However important the above maximum run-off intensity figures may be in the design of a levee system or of spillways, they do not control the design of flood retarding basins such as are proposed for this District. Their design is ~~in~~ dependent on the total amount of run-off during a storm rather than the intensity. A three day storm has been selected as the one placing the maximum load on such a basin; hydrographs for storms for more than three days duration show the present levee system to be sufficient to care for the run-off for the time in excess of the maximum three days. A possible run-off of ten inches in three days has been assumed as a maximum for the drainage areas under consideration.

Rainfall records for this section show ten inches to be the maximum three day rainfall to be expected for a given spot once each hundred years. The ten inch maximum run-off assumed for design would necessitate both a one hundred per cent run-off and that the rainfall should average ten inches over the entire drainage area; the former, i.e. the one hundred per cent run-off, is impossible, the latter, highly improbable, and it is certain that a combination of the two will not occur at one time.



Flood flow capacities: The Clear Fork of the Trinity has a capacity between levees of 30,000 second feet. The West Fork has a corresponding capacity above the forks of 70,000 second feet. Below the junction of the two forks, the stretch of river between the Fort Worth Power & Light Company's plant and the Samuels Avenue Bridge has a capacity of 65,000 second feet only. The safe capacity of the Lake Worth Spillway is 80,000 second feet.

The following is a tabulation of these figures and the previously given maximum flow figures in terms of second feet and in terms of inches run-off per day from the drainage area:

PRESENT CAPACITY

	<u>Second Feet</u>	<u>Ins. per day</u>	<u>Sec.Ft.</u>	<u>Ins. per day</u>
Lake Worth Spillway	80,000	1.50	200,000	3.70
West Fork in Fort Worth	70,000	1.30	200,000	3.70
Clear Fork in Fort Worth	30,000	2.10	74,000	5.20
Trinity River in Ft.Worth	65,000	.95	220,000	3.20

Rainfall statistics for this section of the United States record a six inch rainfall per day each fifteen years, a six and one-half inch rainfall per day each twenty-five years, and a seven inch rainfall each fifty years. It is not only evident that the present levee system will be overtaxed by recurring floods, as has been the case in the past, but also that it is only a matter of time until the capacity of the Lake Worth Spillway will be exceeded and the earthen part of the dam washed out.

Retarding basins: In order to prevent the overflowing of the existing levee system and the Lake Worth Spillway, it is proposed to



construct a retarding basin or basins of sufficient capacity to store the excess flood waters, releasing same from the basins by suitable regulatory works as rapidly as the river channel will permit. Due to the excessive cost of a retarding basin on the Clear Fork (See Page 13) with its comparatively small drainage area (See Map No. 1), it will be found much more economical to enlarge the present levee system (within the City limits) so as to care for a maximum storm from the Clear Fork while shutting off entirely, by means of the retarding basins, the flow from the West Fork, with its comparatively large drainage area (See Map No. 1), until such time as the storm flow from the Clear Fork shall have subsided.

In order to care for the assumed ten inch maximum three days run-off from the 1890 square miles of drainage area above the retarding basin site of the West Fork (Eagle Mountain -- See Map No. 1), a basin capacity of an even 1,000,000 acre feet will be required. Of this 1,000,000 acre feet, 580,000 acre feet can be most economically cared for at the Bridgeport site (See Map No. 1,) which commands a drainage area of 1,100 square miles, leaving 420,000 acre feet from the most easterly tributaries of the West Fork, and draining the intervening 790 square miles will be cared for at the Eagle Mountain Site.

#### WATER SUPPLY

A projected population curve for the City of Fort Worth, comparing its predicted growth with the past growth of other cities is shown in Figure 1. At present the City of Fort Worth is using an average of approximately 4,000,000,000 gallons of water per annum. It is



estimated that there is an industrial use of more than 2,000,000,000 gallons per annum not supplied by the City. Assuming that cheaper water rates will give the City an increasing proportion of the industrial demand to supply, the following table with a graduated use per capita has been predicted, indicating a water requirement (from the City Water Works) of forty-five million gallons per day in 1950.

<u>YEAR</u>	<u>POPULATION</u>	<u>PER CAPITA USE</u> Gal. per day	<u>TOTAL USE</u> Gal. per day	<u>LAKE WORTH SUPPLY</u> <u>DURING DROUTH</u> Gal. per day
1925	165,000	55	9,000,000	25,000,000
1930	195,000	70	14,000,000	20,000,000
1935	235,000	85	20,000,000	15,000,000
1940	275,000	100	27,500,000	-----
1945	315,000	115	36,000,000	-----
1950	350,000	130	45,000,000	-----

While this estimate is based on the factors in common use by Engineers, it should be borne in mind that the growth of an industrial or commercial city depends almost entirely on the progress of the entire area which it serves and upon the initiative and energy of the people of the City in stimulating the development of the City and the area which it serves. Considering the potential growth of the territory most conveniently served by Fort Worth, and considering the present growth of the City itself, it is no doubt true that the estimate stated for a given year may be reached much in advance of that time. The tabulated estimates are highly conservative.

LAKE WORTH AS AN AVAILABLE WATER SUPPLY

The majority report of the Engineers who designed Lake Worth stated that the capacity was 10,000,000,000 gallons. For this purpose we assume that the capacity may have been 11,000,000,000 gallons. Of that quantity approximately 2,300,000,000 gallons were below the conduit.



The original capacity available for use was 8,700,000,000 gallons. A very conservative estimate of evaporation of Lake Worth per annum is 4,500,000,000 gallons. This in a year of little or no flow would leave available for use by gravity 4,200,000,000 gallons.

In 1925 the State Board of Water Engineers, co-operating with the District, actually measured the siltation which had taken place in Lake Worth from 1914 to 1925. This was shown to be at a rate exceeding 900 acre feet per year, which is equal to loss of storage space for 294,000,000 gallons of water each year. Siltation for the entire period has now been in excess of 4,000,000,000 gallons storage loss. From an analysis of location of the deposit of silt it would appear that probably one half of the siltation has been in the area of present useable capacity. Much of the remaining siltation has occurred during abnormal flood flow and has been deposited above the normal water line in such manner that it would serve to lessen storage space, which might otherwise be available if the height of the Lake Worth Dam were to be raised. The proportion of total siltation chargeable to present capacity of Lake Worth is approximately 900,000,000 gallons, leaving - after deduction for evaporation - 3,300,000,000 gallons available storage for use from Lake Worth in a year of little or no flow.

If the Lake Worth Dam is to be raised 5 feet, it would add approximately 7,100,000,000 gallons. This added to the original useable capacity would give 15,800,000,000 gallons. The deduction for evaporation from the larger surface would be 5,700,000,000 gallons, leaving a net of 10,100,000,000 gallons. From this must be deducted loss of storage space through silt already deposited above the normal water line, which would



make the net useable in a year of little or no flow of approximately 8,000,000,000 gallons. It is to be observed that this is just about the original useable capacity of the Lake. The stated rate of siltation may be expected to continue.

A YEAR OF LITTLE OR NO FLOW

The record of the flow of the Trinity River is more adequate than that for any other stream in Texas, due to the project for navigation upon that stream from Dallas to the Gulf. The United States Government, in January, 1906, began measurement of the flow of this stream at Dallas and four other stations below. This has been maintained. Unfortunately, there was no similar measurement of the individual flow of the West Fork, Clear Fork, Elm Fork and Denton Fork. The measurement at Dallas station reflected the flow of all tributaries above that point. From these records it appears that from January, 1909 to October, 1913. A period of approximately  $4\frac{3}{4}$  years, the runoff at Dallas station was approximately  $1/17$ th of normal. That for part of 1910, all of 1911 and part of 1912 the runoff was approximately  $1/29$ th of normal. The expectancy of runoff from the four contributing streams is greater than for one of the contributing streams.

Based upon this known record, the Engineers who designed the Garza Dam as a water supply for the City of Dallas, advised that during times of normal flow they should if possible store a sufficient quantity of water to tide the City over a period of similar or worse drouth. Their judgment in this we now confirm. While using the expression, "during a year of little or no flow", it is to be observed that the known period of little flow was in duration approximately five years. Adequate



protection in the case of Dallas was deemed to be a capacity of 63,000,000,000 gallons. This quantity Garza Dam will store, with provision to add 7,000,000,000 gallons. Lake Worth, with 5' added, would have useable capacity of approximately 8,300,000,000 gallons. The Dallas factor of safety would be approximately eight times greater.

Their plans did not contemplate use of water for irrigation. Under the plans proposed by us the District may have a storage for more than 80,000,000,000 gallons at about the same cost as would be required for one half the amount. This is due to combining storage with control of floods.

#### EFFECT OF WEST FORK RESERVOIRS ON LAKE WORTH

Should these reservoirs be built it will not be necessary to increase the height of Lake Worth dam. The siltation would be almost entirely eliminated in the present Lake. The regulated release of water would keep Lake Worth at approximate spillway level, would keep covered the unsightly mud banks which mar the Lake at times of low water. Regulation of the flood flow would prevent abnormally high water lines and the deposit of silt above normal water lines.

The quality of the water in Lake Worth will be much improved by the long storage period in the reservoirs higher up the stream and the flow of the water in reaching Lake Worth.

It is proposed to store water in the two dams, for the industrial and domestic water supply of the cities of Fort Worth and Bridgeport and the possible future irrigation development, to the amount of 500,000 acre feet, as this amount of storage will fully develop the water rights of the Tarrant County Water Control and Improvement District. This 500,000



acre feet will be in addition to the 1,000,000 acre feet of flood retarding basin capacity.

The drainage areas, total water requirements, and flood control requirements are such that 210,000 acre feet of storage and 420,000 acre feet of additional retarding basin capacity, a total of 630,000 acre feet, are needed at the Eagle Mountain Site, whereas 290,000 acre feet of storage and 530,000 acre feet of retarding basin capacity, a total of 870,000 acre feet, are needed at the Bridgeport site. The water stored for beneficial use may be from seven to fourteen times the original capacity of Lake Worth, the greater quantity stored not to materially affect the cost. This gross total of 1,500,000 acre feet capacity is approximately forty-three times the original capacity of Lake Worth. At the top level of water supply storage, which will be the bottom of the retarding basin, a flood flow outlet of 50,000 second feet capacity should be constructed in the hill at the side of the Eagle Mountain Dam and a similar outlet of 30,000 second feet capacity at the Bridgeport Dam. It is contemplated that these outlets shall be so built as to insure that the retarding basins above the storage basins shall be empty except in time of flood flows. The following table gives data relative to the two dams:

	Ht. Ft.	Earthwork Cu.Yds.	Storage Reservoir Area-Acres	Retarding Basin Area-Acres
Eagle Mountain	80	2,000,000	8,600	20,000 (gross)
Bridgeport	110	1,500,000	10,000	19,000 (gross)

It is to be noted that the storage reservoirs, containing some 19,000 acres of land are surrounded by twenty thousand acres of land to be used as retarding basins. Of this twenty thousand acres, ten



thousand can be used advantageously as parks while the upper ten thousand acres, which will be rarely, if ever, flooded, should be resold or leased as farming or grazing lands.

Geology: The geological examinations indicate no serious defects in the two proposed sites nor in any of the other sites which were investigated. The full geological report follows as Appendix I. The West Fork sites are underlain with a compacted sandy clay of thirty to fifty feet in thickness; this sandy clay is excellent embankment material. Underneath this material at the Eagle Mountain site is a layer of water bearing sand which it will be necessary to intercept with a steel sheet-piling cut-off wall; little seepage, however, would be anticipated, even though the cut-off wall were not to be constructed, as the base width of the dam in proportion to the normal head of water is high, due to the fact that the superimposed retarding basin, requiring a much higher dam, will be rarely filled with water.

Earthwork and Land required: The amount of earthwork and land required to construct reservoirs of any given capacity at the different sites is shown graphically on Figures 3 and 4.

Arlington Site: The Arlington site should not be developed by this District for the following reasons:

1. It offers no flood protection for District lands.
2. Its elevation being lower than the City of Fort Worth and drainage from the City of Fort Worth make it undesirable as a source of water supply.
3. Its elevation precludes the possibility of irrigation



of any appreciable acreage of District lands by gravity.

Benbrook and Plover Sites: The physical and economic defects of the Benbrook and Plover sites are likewise well nigh insuperable and are as follows:

1. The drainage areas (Benbrook: 517 square miles; Plover; 338 square miles) are too small to be of great advantage to the District from the standpoint of either flood control or irrigation.

2. The cost of building dams at Benbrook and Plover is five times the cost per acre foot of water stored at the Eagle Mountain site and ten times the cost of water stored at the Bridgeport site.

Eagle Mountain Dido Sites: Eagle Mountain-Dido Site No. 3, referred to herein as the Eagle Mountain Site, is the most economical of the various Eagle Mountain Dido Sites and has the following advantages:

SUMMARY OF ADVANTAGES

1. It commands a drainage area such that a reservoir there can completely control floods when the Clear Fork levees are enlarged to care for the maximum Clear Fork storms.

2. Its drainage area is sufficient to supply the necessary water for irrigation and for the City of Fort Worth.

3. It affords flood protection for the Lake Worth dam.

4. The cost of developing this site is reasonable and within the bounds of economic development.

5. Its position and elevation are such that water will flow by gravity into Lake Worth, thence into the City water supply conduit.



6. A reservoir at this site would have sufficient capacity to develop fully the drainage area for water supply and irrigation, and would furnish complete flood control.

7. While possible to store the full quantity at Eagle Mountain it is not advisable to do so for the reason that the water line would submerge several miles of the Rock Island Railroad and the town of Newark, as well as much valuable farming land. This would greatly increase the cost to store the full quantity at Eagle Mountain.

The potential demand for water to irrigate approximately 36,000 acres of land included within the boundaries of Wise County Water Control and Improvement District No. I should produce for this District a substantial income that is a further material factor in determining the feasibility of the Bridgeport Reservoir.

Bridgeport Site: It is proposed to develop the upper 1100 square miles of the Eagle Mountain drainage area (1891 square miles) by building a dam at the Bridgeport site for the reason that water can be stored there for less than one-half the cost per acre foot at the Eagle Mountain site. In other words, in spite of the comparative low cost per acre foot of capacity at Eagle Mountain, the even lower cost (less than 50 per cent) at Bridgeport makes the construction of two dams cheaper than the cost of one large dam at the lower site.

There are incidental advantages of the dam at Bridgeport such as the irrigation and flood protection of the valley land between the Bridgeport Dam and the Eagle Mountain Reservoir.



ESTIMATE OF COSTS

Bridgeport Dam (including lands and property).....	\$ 2,520,000.00
Eagle Mountain Dam " " " " .....	3,655,000.00
Clear Fork Levee Improvements " " .....	250,000.00
	<u>\$ 6,425,000.00</u>

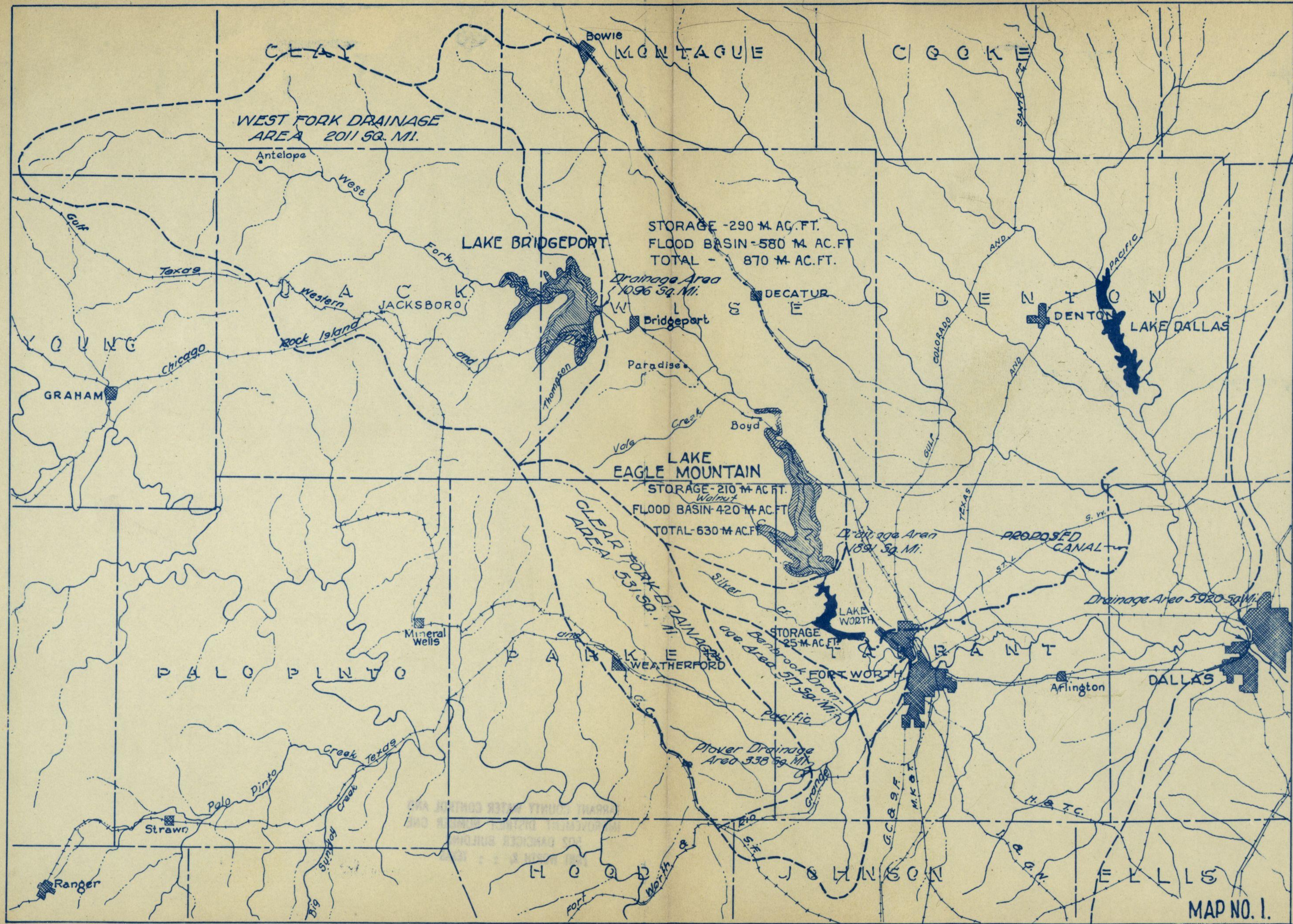
The time to be required for the completion of said works so that service therefrom can be commenced, is thirty (30) months from and after the beginning of the construction of such works.

The costs estimated above cover all expenditures necessary for completion within the time stated.

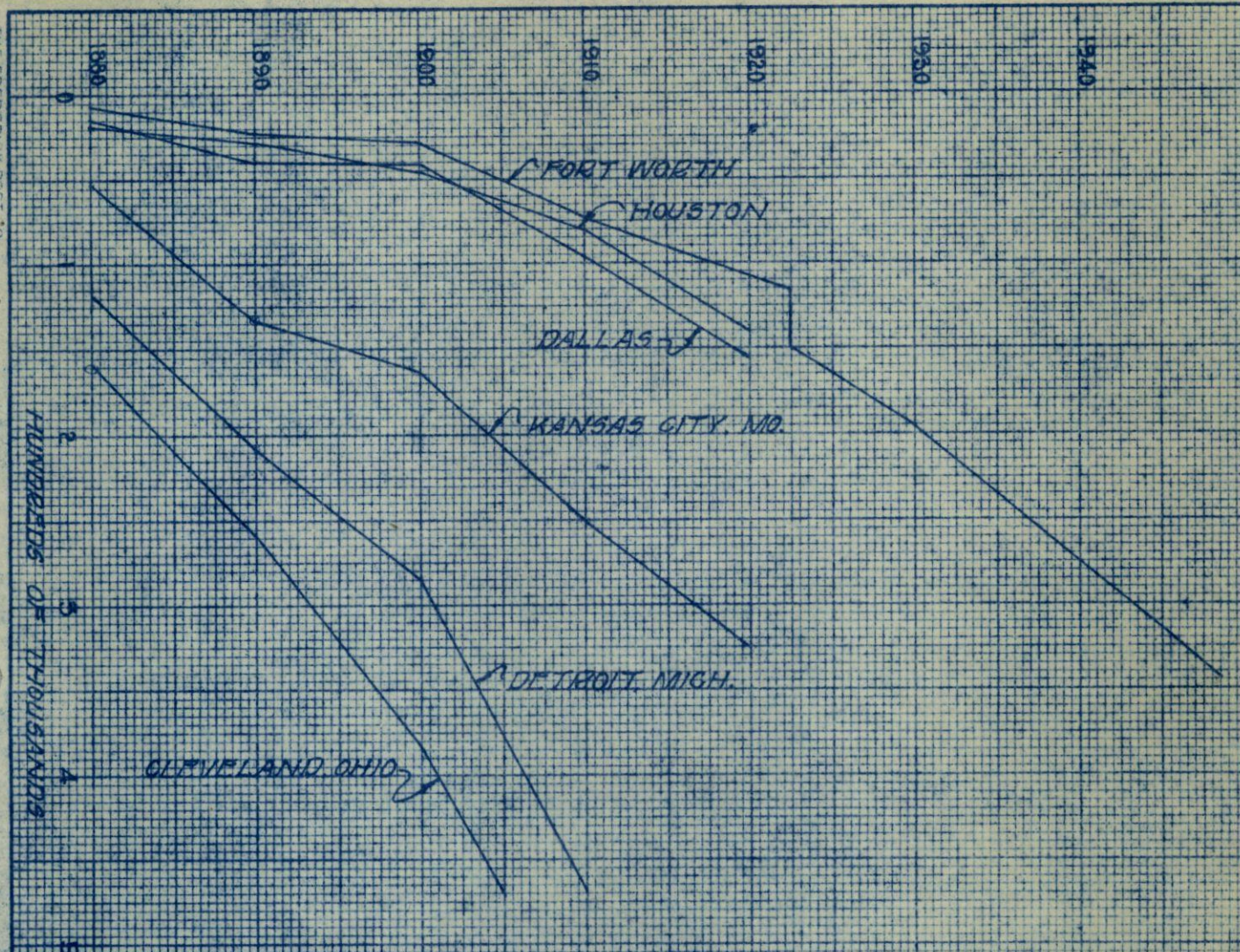
HAWLEY and FREESE, District Engineers,

By John B. Hawley  
John B. Hawley.







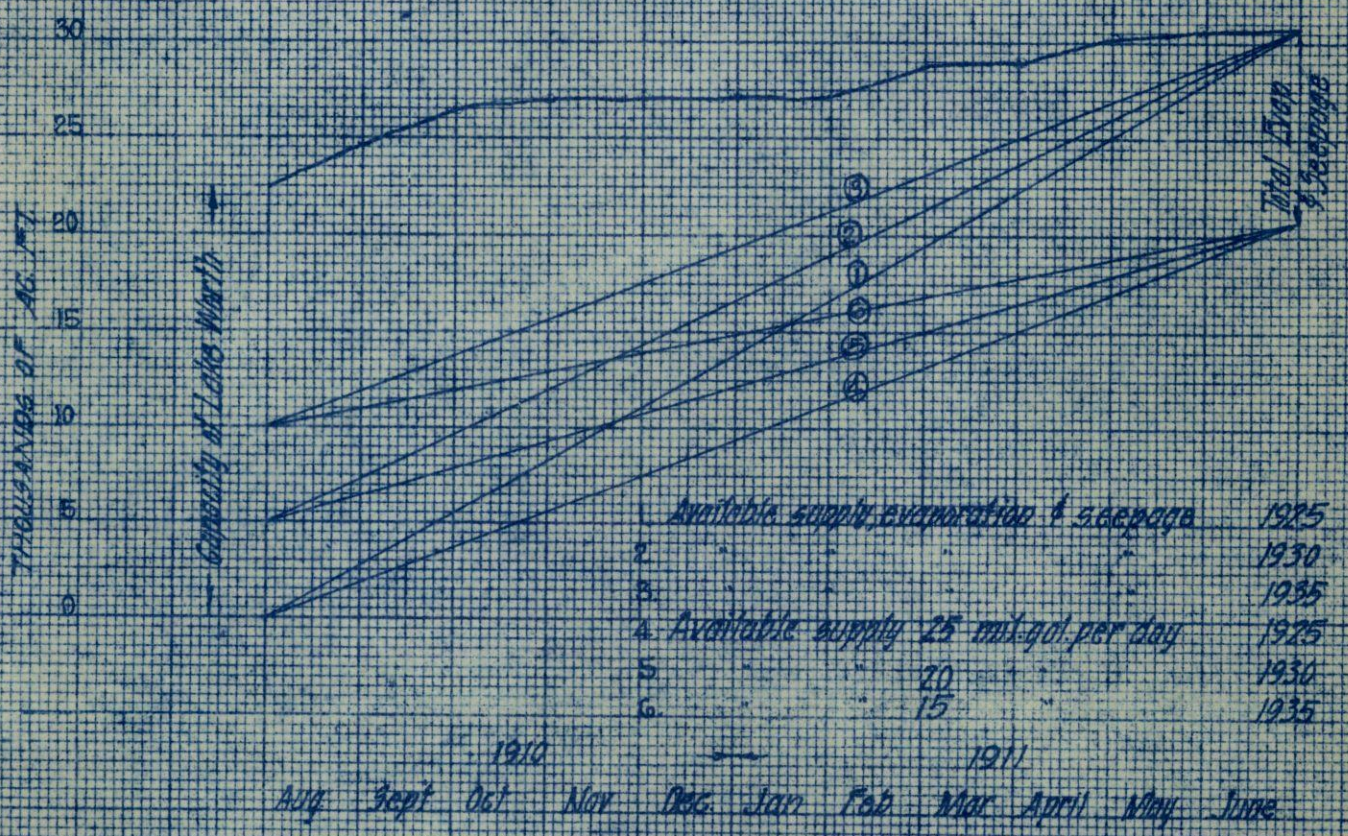


**PREDICTED POPULATION  
CURVE  
• FORT WORTH •**

Fig. No. 1



INFLOW IN ACRES FEET											
2280	1850	380	100	50	60	1230	130	1100	660	0	
RAINFALL IN INCHES											
0.26	2.21	0.68	0.14	1.23	0.21	3.84	1.81	3.33	0.22	0.23	
EVAPORATION IN INCHES											
6.18	5.66	5.41	2.68	2.80	1.90	1.28	4.22	4.71	6.03	8.25	
NET EVAPORATION IN FEET											
10.66	10.29	10.39	+0.21	+0.13	+0.14	-0.20	10.20	10.12	10.49	10.65	



• MASS CURVE •  
for  
• LAKE WORTH •

Fig. No. 2



# EARTHWORK

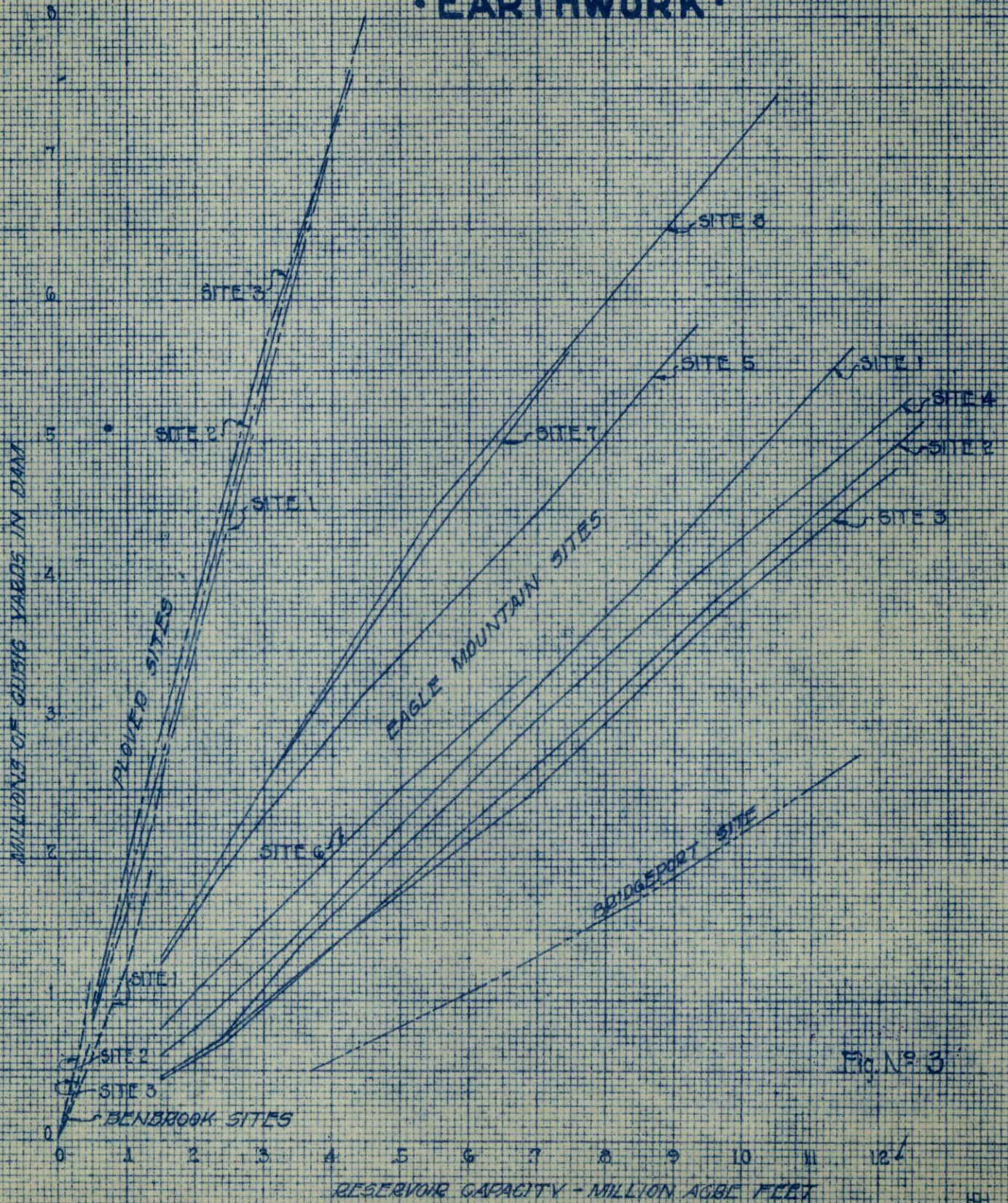


Fig. No 3



# • RESERVOIR ACREAGE •

THOUSANDS OF ACRES IN RESERVOIR

RESERVOIR CAPACITY - MILLION ACRE FEET

No 285 TX

No N° 4

