

reservoirs will reduce the required peak capacity in the delivery lines, aid in the manipulation of water for power generation and increase the safety by division of storage.

Present plans contemplate an ultimate terminal storage capacity of 250,000 to 300,000 acre-ft. This will regulate the flow and provide a 60-day emergency supply. Of this amount 100,000 acre-ft. will be built now, leaving the remainder to be added as required. Unlimited seasonal storage is available in the Hoover Dam reservoir, local emergency storage being required only as a protection against an interruption of aqueduct flow.

### Wholesale delivery lines

The general location of the feeder lines is shown in Fig. 3. The northern line will have an initial capacity of 510 sec.-ft., which will be sufficient to meet

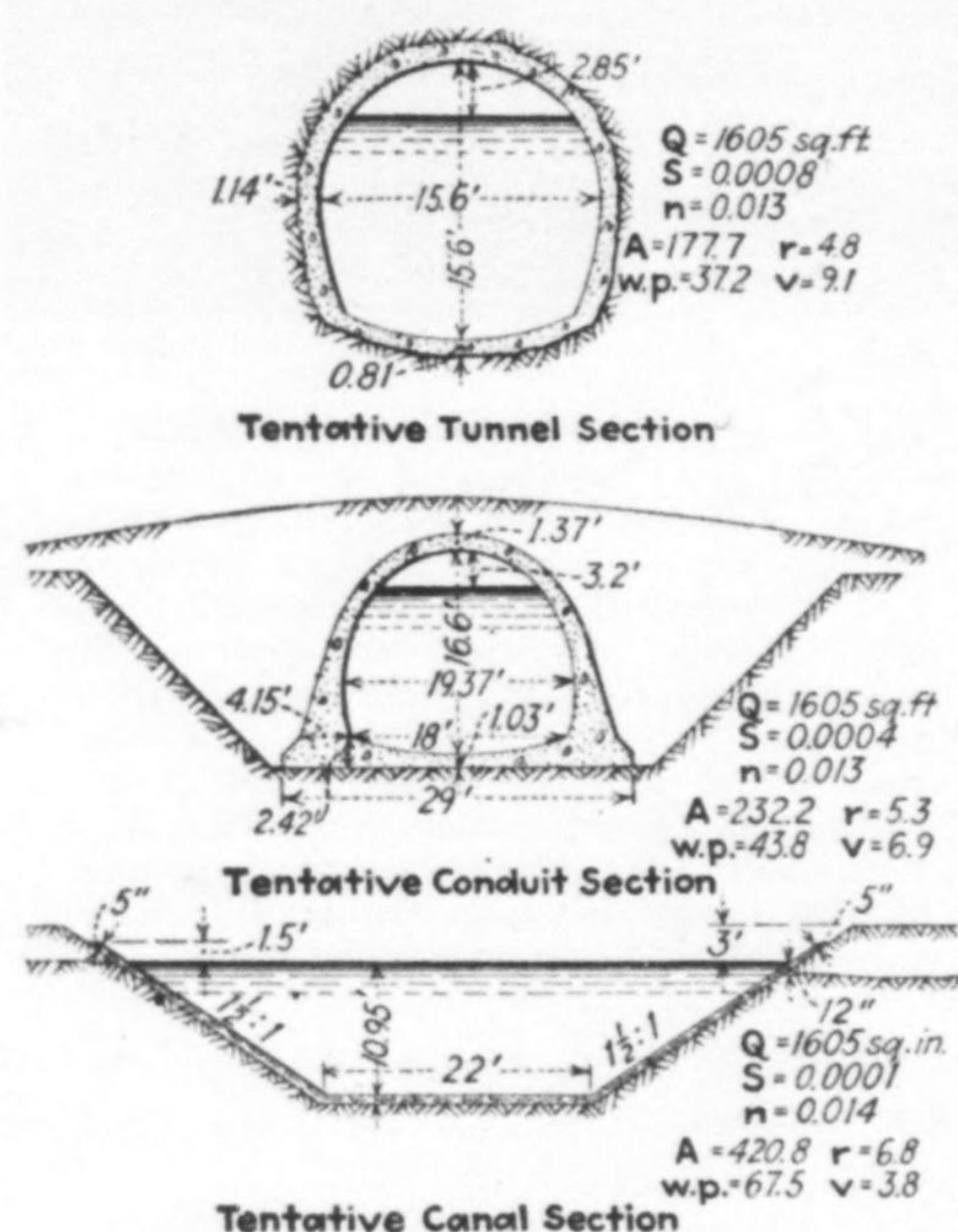


Fig. 6—The aqueduct will be made up chiefly of open canal, closed conduit or tunnel of sections shown here.

the ultimate needs of the higher areas to be served with Colorado River water. It will therefore have excess capacity at first. This excess capacity will be utilized temporarily to supply certain areas at intermediate levels, thus avoiding a separate line for these areas for the present. This line may utilize the Pine Canyon Reservoir in San Gabriel Canyon, contract for which has been let.

The initial construction will also include a low line of some 320 sec.-ft. capacity direct to Long Beach and the harbor district, supplying also the Orange County area. This line is to be controlled by a reservoir in San Juan Canyon. The area served by this line is at a relatively low elevation, and a power drop of 330 ft. is possible near the head of the line. For ultimate development, an intermediate line will be required, to relieve the draft on the high line and to supplement to some degree the low line deliveries. The prospective locations of these future lines are shown on Fig. 3.

Although plans for the distribution



Fig. 7—Thaddeus Merriman, consultant, and J. B. Bond, construction engineer of the district, getting first-hand information as to rock formations along the line of the aqueduct.

system have been worked out with great care, they are nevertheless to a certain extent tentative, as the ultimate composition of the district is not yet known. Also, before the plans become final they will be discussed in further detail with the waterworks officials of the various cities and adjusted, as far as possible, to meet all local needs.

### Present status of work

Active prosecution of construction work has not been possible pending

validation by the state supreme court of the district bond issue. This has now been accomplished by a unanimous decision of the court announced June 2, 1932, which decision, however, does not become final until 30 days after that date. As soon thereafter as funds are assured, calls will be issued for bids on several of the longer tunnels and other construction features. Until money thus becomes available no enlargement of the existing engineering organization or construction forces is planned.

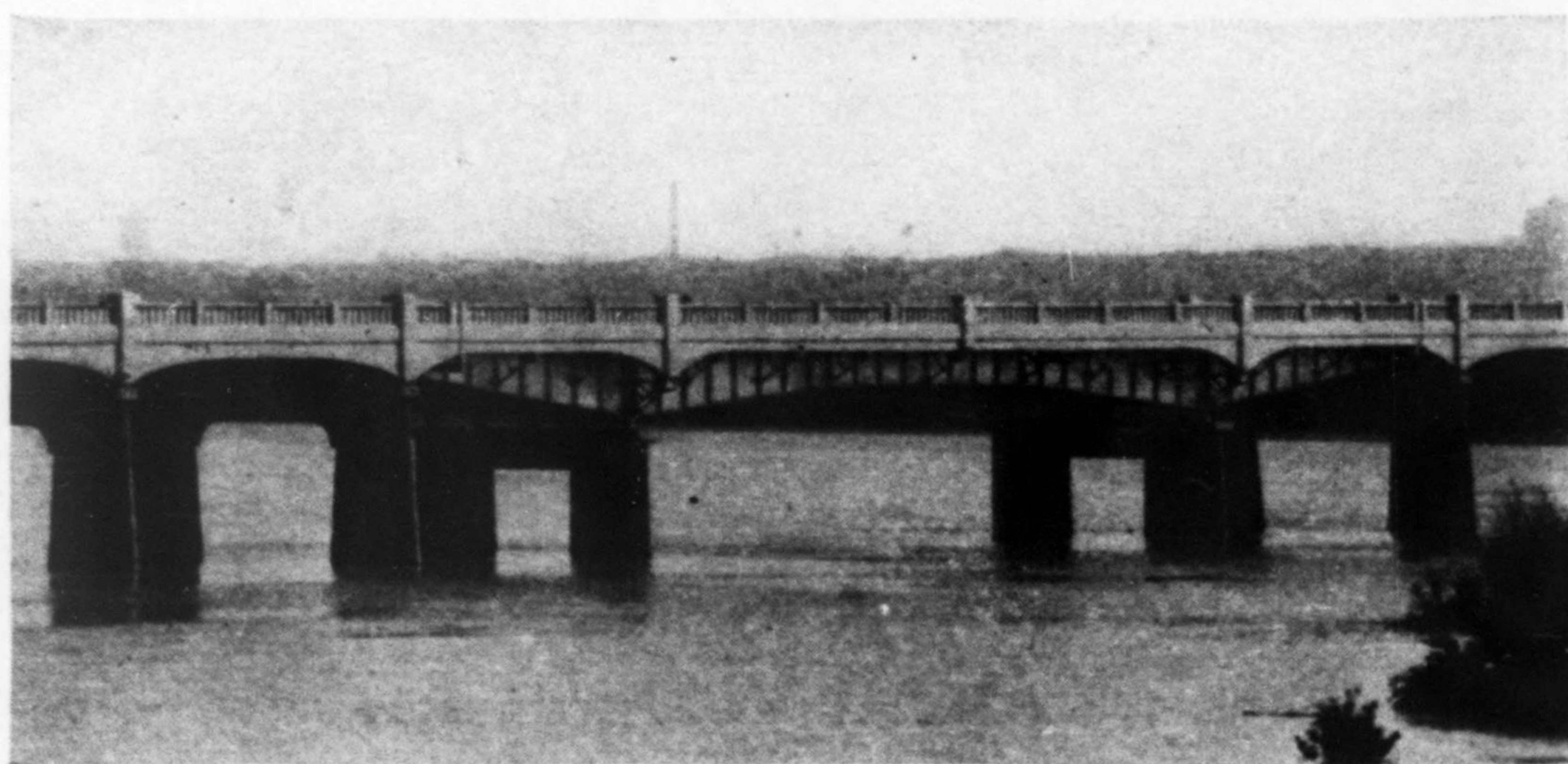
On account of the present unemployment situation, men are now available in southern California in excess of all requirements for every opening that the aqueduct work can possibly afford for months to come, and in the hope of avoiding the otherwise inevitable disappointment and possible suffering awaiting newcomers and their families the board of directors last fall announced the policy, effective until conditions have materially improved, of permitting the employment in the district work of none but those who have resided within the district for at least one year. W. P. Whitsett is chairman of the board of directors of the district, and the author is general manager and chief engineer. Julian Hinds is chief designing engineer.

## Long Cantilevers in Trinity River Crossings at Dallas

CONSTRUCTION of the Trinity River levees at Dallas, Tex., required four major bridge structures over the floodway at Lamar, Commerce, Cadiz and Clarence Sts. The view shows a portion of the Lamar St. viaduct, which is about 2,000 ft. long and typical of the other structures. The particular element of interest in the bridges centers on the steel channel spans, which are haunched-cantilever girders 200 ft. long over all, made up of two 40-ft. anchor arms and a 120-ft. main span. In addition to their unusual length, these channel spans are given

the same concrete fascia finish as the flanking concrete spans, thus providing an appearance of continuity for the bridge as a whole. F. D. Hughes, consulting engineer, Dallas, Tex., designed the viaducts, the total cost of which was about \$1,865,000. Because of many duplications of spans and piers the cost per square foot of all the structures was very low, about \$3.60 per square foot, including lighting and paving. The total bids were about 27 per cent under the estimated cost.

Typical new viaduct in Dallas, Tex., which crosses newly created floodway for Trinity River.





# Dallas Reclaims 10,000 Acres in the Heart of the City

**Leveed Channel Will Confine Trinity River and Provide Large Areas for Industrial and Commercial Expansion—Project Involves Moving About 17,000,000 Cu.Yd. of Earth and Construction of Pumping Plants and Sluiceways**

By ALBERT S. FRY

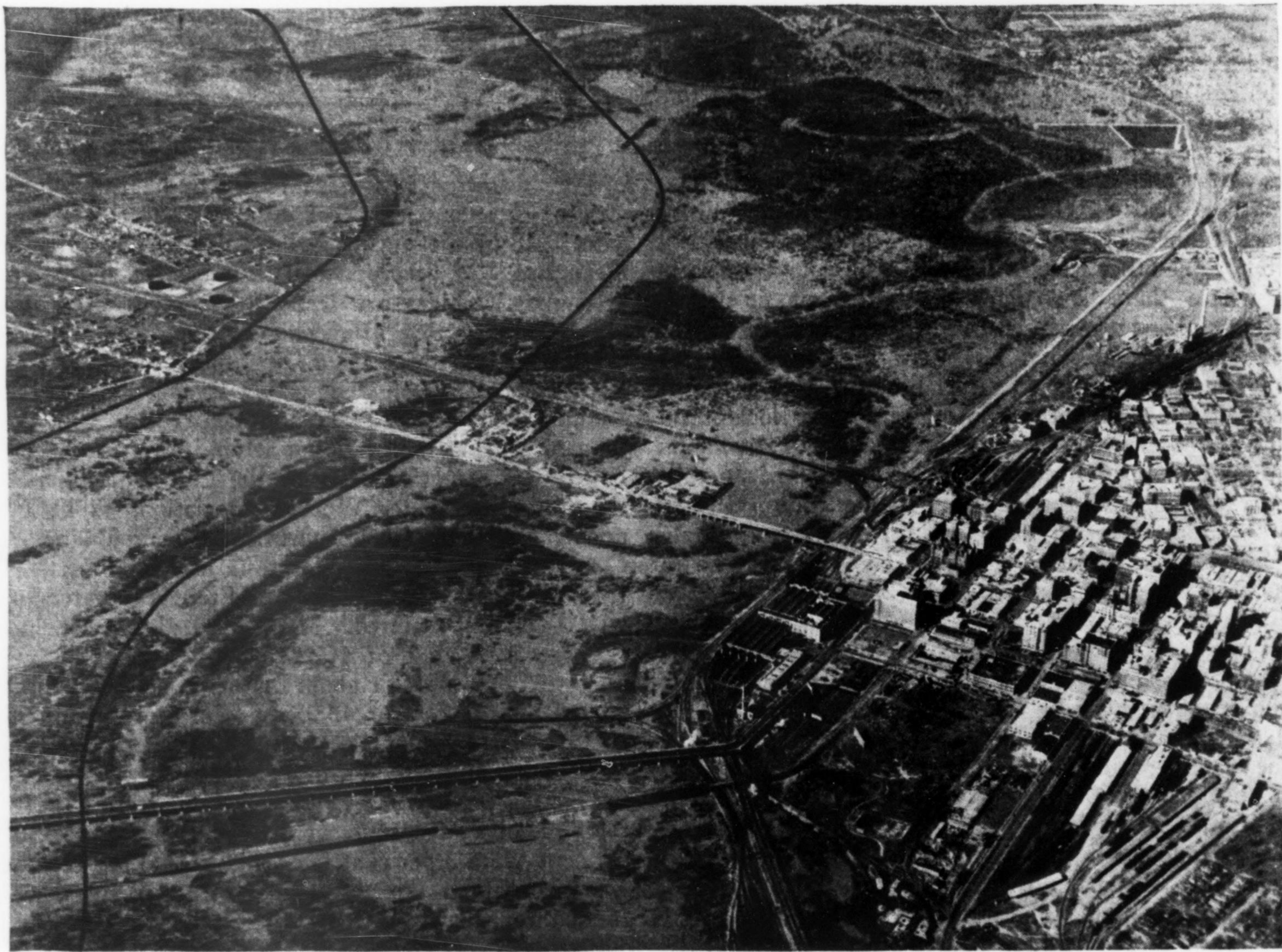
*Assistant Engineer, Morgan Engineering Company,  
Memphis, Tenn.*

**A** FLOOD-PROTECTION project now under construction at Dallas, Tex., will reclaim 9,940 acres of land in the valley of the Trinity River. As this land is subject to overflow, it has constituted a barrier separating the main part of the city on the east side from Oak Cliff and West Dallas on the west side, where about one-third of the city's population lives. The condition with the river in moderate flood and at an elevation of 37.6 on the gage in December, 1928, is shown in Fig. 1, but the record flood (1908) was 15 ft. higher. A general plan of the project is given in Fig. 2.

Flooding has occurred too frequently to permit profitable development of any except the higher lands around the rim of the area, where overflows occur least often. This reclamation is being undertaken primarily for industrial and commercial purposes, with incidental residence development in parts of the area. On both sides of the

valley the present business and industrial districts may readily be extended down into the reclaimed area.

*Topography and Drainage Area*—Within the limits of this project the valley is about 7 miles long and 1 to 4 miles wide. Its lands are generally flat, with slopes increasing around the borders of the project to meet the steeper surrounding hillsides. Surface slopes lengthwise of the valley vary from 2 to 3 ft. per mile to practically level. Near the middle of the area the Elm Fork and West Fork of the river unite to form the main Trinity River. These streams wind in tortuous channels through the flood plain and carry the ordinary flow, but are insufficient to carry any appreciable flood discharge. Above Dallas the drainage area is 6,050 square miles, of which 2,684 are on Elm Fork and 3,366 on West Fork. Excepting the valleys of the two forks, the drainage area is generally rolling.



**FIG. 1—TRINITY RIVER IN MODERATE FLOOD, DECEMBER, 1928**

New levees shown by black lines planned to eliminate such overflow and reclaim bottom lands for industrial development. Crossing in foreground is electric railway bridge. Next is the Oak Cliff viaduct, the only high-water crossing. Above this is the union station, then the Commerce St. bridge and the Texas & Pacific Railroad crossing. At the upper right, outside the curve in the Rock Island Railroad, is the Turtle Creek pumping station of the city water-works.



**Floods**—Daily stages in Trinity River at Dallas have been kept by the U. S. Weather Bureau since 1903. Earlier records of the highest floods have been preserved back to 1844. Flood stage is 25 ft. on the gage. The four largest floods on record had 50.7 ft. gage height in 1844, 49.2 ft. in 1866, 47.4 ft. in 1871 and 52.6 ft. in May, 1908. It is estimated that the peak discharge during this latest and largest flood was in excess of 200,000 sec.-ft. but did not exceed 250,000 sec.-ft. Its water line is indicated in Fig. 2. West Dallas was over-

by the levees, while diversion channels will deliver the ordinary flow of the two forks to the floodway extending through the city and discharging into the present river channel. Pumping plants and sluiceways, together with storage in the old channels and borrowpits, will care for runoff from and through the reclaimed area.

This plan will require 26 miles of floodway levees, 15 miles of diversion channels and 2 miles of auxiliary channels. Levee embankment will amount to 10,400,000 cu.yd. and new channel excavation to 2,320,000 cu.yd. On account of necessary double handling of material, the equivalent of 16,880,000 cu.yd. of earth will be moved in constructing the levees and channels. Hydraulic-fill work amounts to 2,750,000 cu.yd.

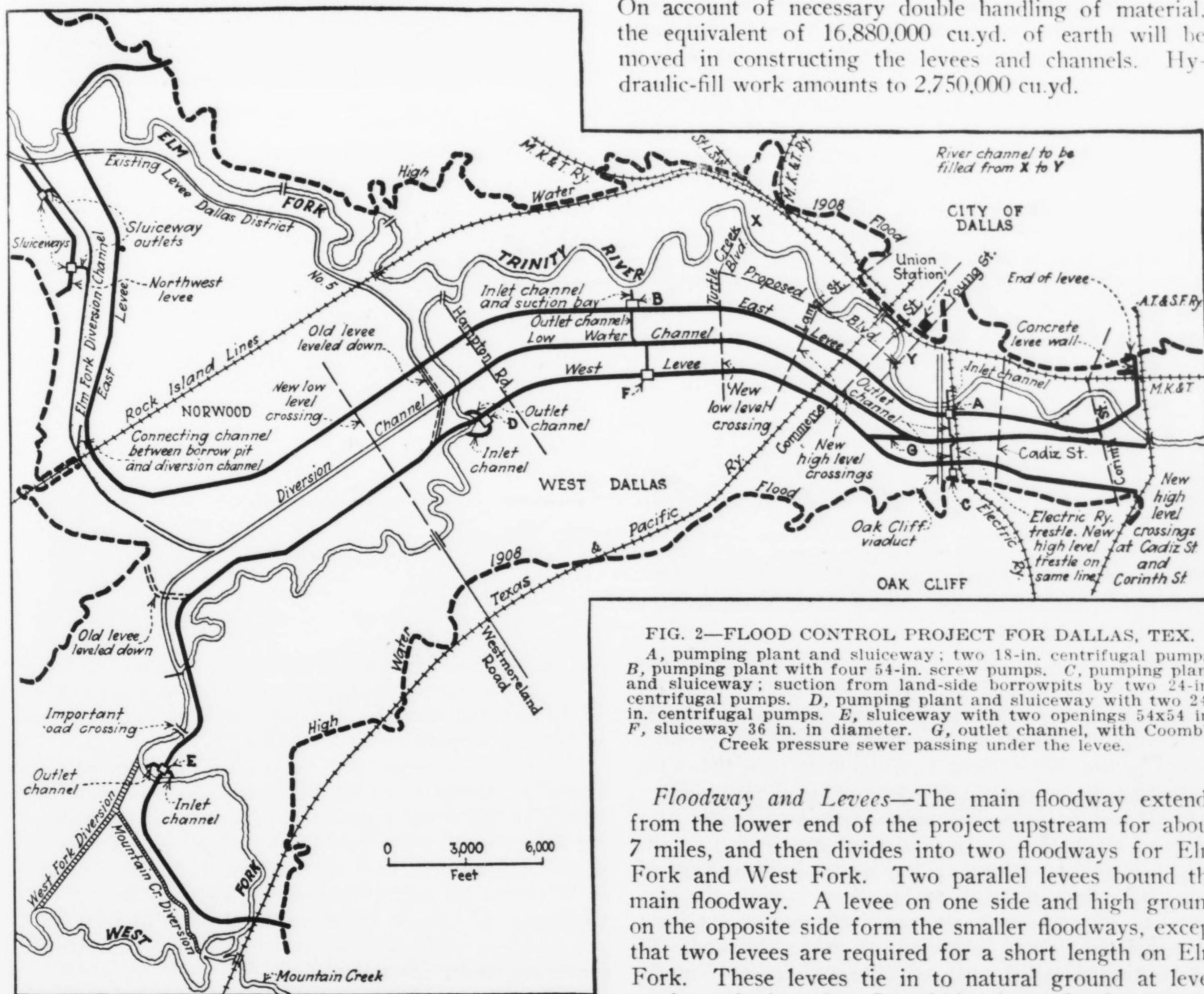


FIG. 2—FLOOD CONTROL PROJECT FOR DALLAS, TEX.

A, pumping plant and sluiceway; two 18-in. centrifugal pumps. B, pumping plant with four 54-in. screw pumps. C, pumping plant and sluiceway; suction from land-side borrowpits by two 24-in. centrifugal pumps. D, pumping plant and sluiceway with two 24-in. centrifugal pumps. E, sluiceway with two openings 54x54 in. F, sluiceway 36 in. in diameter. G, outlet channel, with Coomb's Creek pressure sewer passing under the levee.

**Floodway and Levees**—The main floodway extends from the lower end of the project upstream for about 7 miles, and then divides into two floodways for Elm Fork and West Fork. Two parallel levees bound the main floodway. A levee on one side and high ground on the opposite side form the smaller floodways, except that two levees are required for a short length on Elm Fork. These levees tie in to natural ground at levee grade at both ends. In width, the main floodway is 2,000 ft. c. to c. of levees for its lower 3 miles and then widens in 1.7 miles to 3,000 ft., which is maintained up to the junction of the two fork floodways, which have minimum widths of 1,500 ft.

This floodway is designed to have a capacity approximately double the discharge of the 1908 record flood. Its entire area is to be cleared and maintained clear. For 2.7 miles beyond the lower end of the district the valley is to be kept clear for a width of 3,000 ft. in order to lower the water level at the outlet of the floodway. In the northwest corner of the district a small agricultural area is protected by a separate levee which will be 11 ft. lower than the east levee on the opposite side of the floodway but will protect the land against ordinary floods, so that farming operations can be carried on. Rare and extreme floods will overtop this levee and afford a wider floodway at this location.

A typical cross-section of the main levee is shown in Fig. 3. It was adopted after consideration of the short

flowed and all railroad service cut off, while basements in the business section were flooded by backwater. Damage was estimated at \$2,500,000. Recurrence of such a flood at the present time would cause much greater damage, because of changes and improvements within the flooded area.

**Organization of Project**—Above the confluence of Elm Fork and West Fork the area between the two streams was organized in 1918 as Dallas County Levee Improvement District No. 5. This district constructed a levee high enough to protect against ordinary floods and to reclaim the land for agricultural purposes. In April, 1926, the City and County of Dallas Levee Improvement District was organized and the two districts co-operated on a joint plan to give complete flood protection in both districts.

**Flood-Protection Works**—Under the flood-protection plan, floodwaters will be confined within a leveed floodway. The old channels of the three streams are cut off



duration of floods in the Trinity River and of the available materials for construction. Floods are at crest only a few hours and recede entirely within a comparatively few days, not lasting long enough to saturate the levees and cause seepage. Most of the material available is impervious in either the levee or its foundation for any period of time during which a flood stands against it. An addition of 20 per cent is made to the net volume of fill to allow for shrinkage. In height, the levees vary from 18 to 33 ft., with an average of 28 ft.

Soil borings were made under the levees and in special cases over the borrowpit areas to determine the character of the subsoils. Sand and gravel found under parts of the levee were usually underlain by exceptionally hard, impervious clay locally known as shale. In such cases a core trench is excavated down to the shale and back-filled with impervious material in order to form a cutoff to prevent seepage under the fill. In general, two-thirds of the material for the levee is taken from the reclaimed side borrowpit, the rest being taken from the floodway pit and shallow berm stripping. The limiting depth is 15 ft. for floodway borrowpit and 18 ft. for reclaimed side pit.

Varying subsoil conditions necessitate some departure from the typical cross-section, so far as borrowpits are

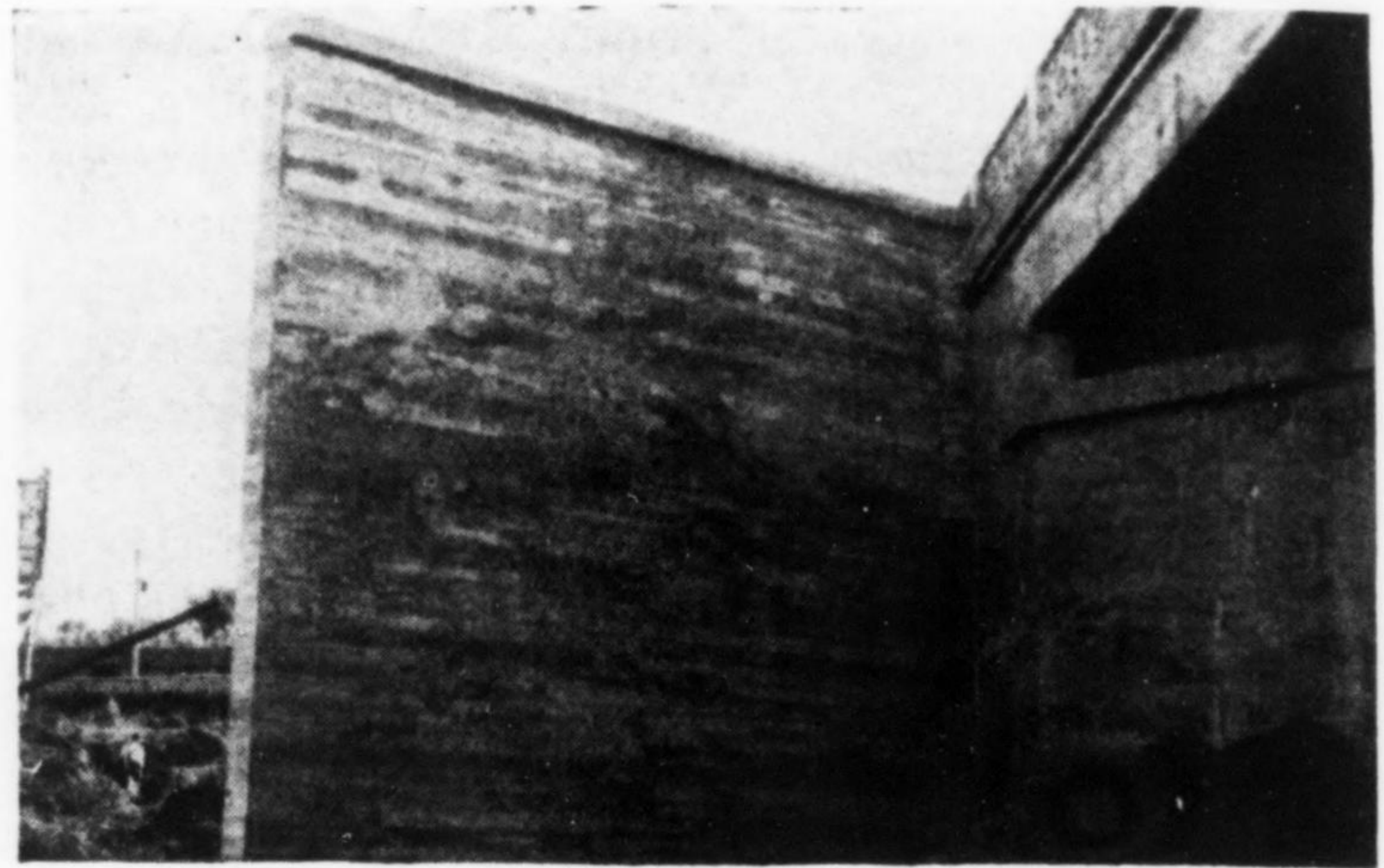


FIG. 5—CUTOFF WALL IN LEVEE AT BRIDGE

ported in wagons hauled by crawler tractors from the floodway, a banquette being built on the reclaimed side wide enough to produce a ratio of water travel to water depth of 20 to 1. The floodway side of this levee is shown in Fig. 4.

Where the new levee crosses the old river channels a banquette is built on both sides of the levee, the width being 75 ft. on the floodway side and 50 ft. on the reclaimed side. As the west levee intersects the concrete

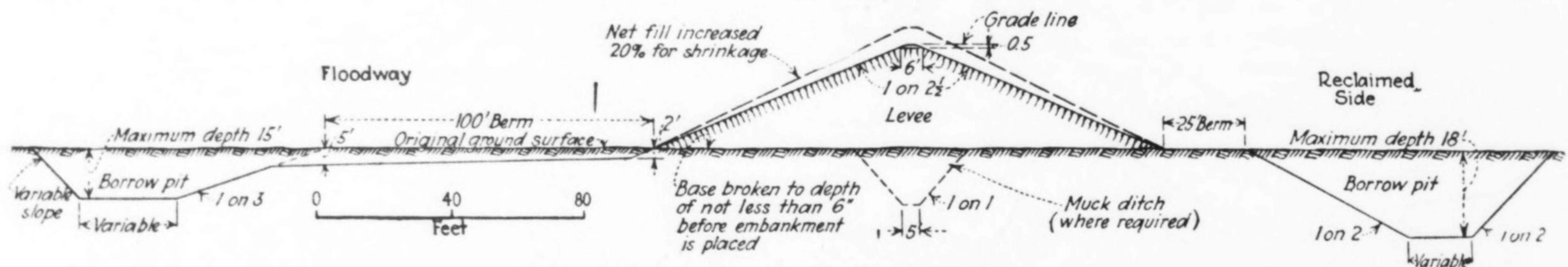


FIG. 3—TYPICAL SECTION OF LEVEES

concerned. For  $1\frac{1}{4}$  miles upstream from the lower end of the east levee all material is to be obtained from the reclaimed pit, in order to prevent erosion that might occur in a borrowpit at this location due to velocities caused by the drop-off curve of the water surface at the floodway outlet.

In its lower section the west levee is underlain at a depth of about 8 ft. by a 6-ft. stratum of sand on the rock. As this levee extends through a built-up part of Oak Cliff, where right-of-way costs were high, the borrowpit on the reclaimed side was eliminated except for a short distance, where a shallow pit was excavated. In co-operation with the city of Dallas and Dallas County, a concrete storm sewer is being constructed along this section to furnish drainage. The levee material was obtained from a borrowpit on the floodway side, leaving a 300-ft. berm beyond the toe of the levee and borrowing only 3 ft. deep for the next 100 ft.

Part of the west levee is on a sand ridge which could not be cut off by a core trench, and here no borrowpits were permitted. Material for the levee is being trans-



FIG. 4—FLOODWAY SIDE OF LEVEE

abutment of the Oak Cliff viaduct, a concrete key wall (Fig. 5) is recessed into the abutment face and extended 25 ft. into the levee for the full depth of the abutment, to prevent seepage along the masonry.

At its downstream end the east levee intersects the Santa Fe Railway and the Missouri-Kansas-Texas Railroad 7 ft. below levee grade. On account of the railroad tracks, an earth levee could not be built and a concrete wall is substituted, with openings at the track crossings to be closed by stop planks during extreme floods. To support these planks, structural steel posts in each track and between tracks will be set in wells in a concrete sill extending under the railroad.

Embankments, floodway side berms and the floodway borrowpit slope nearest the levee are to be sodded with Bermuda grass, which discourages weeds and resists erosion. Living sprigs of Bermuda grass are placed 2 ft. c. to c. in rows also spaced 2 ft. c. to c., the sods being then covered with 1 in. of earth.

**Diversion Channels**—As built, the diversion channels are smaller and of less depth than the old river channels, but it is expected that these new channels will be enlarged and deepened by erosion. Observation of small excavated pilot channels in other parts of the Trinity River valley, in soils like those at Dallas and under similar conditions of flow, has demonstrated their enlargement to much greater sections of capacity in excess of the old river channel.

The new main diversion channel is being excavated with a bottom width of 15 ft., side slopes of  $\frac{3}{4}$  on 1, average depth, 20 ft. The West Fork channel has 5 ft. base width, 1 on 1 side slopes and 22 ft. average depth. The Elm Fork diversion channel will have a base of



35 ft., side slopes 1 on 1 and an average depth of 20 ft., the wider base being used on account of the very flat character of the land, and the possibility of erosion being less rapid than on the other channels. All berms are 20 ft. wide between the margin of excavation and toe of spoil bank. This width permits the banks to cave and the material to wash down stream, enlarging the channel so that when the spoil banks begin to cave no detrimental obstruction of the channel is likely to occur.

Water was diverted into the West Fork diversion channel about Nov. 15, 1928, the flow being returned to a part of the old channel which will be in the new floodway. This new channel is 1.4 miles long, whereas the old channel is approximately 4.5 miles from the head to the outlet of the diversion. Enlargement has taken place rapidly in this channel since its excavation, as shown by Fig. 6. The sequence of channel construction is worked

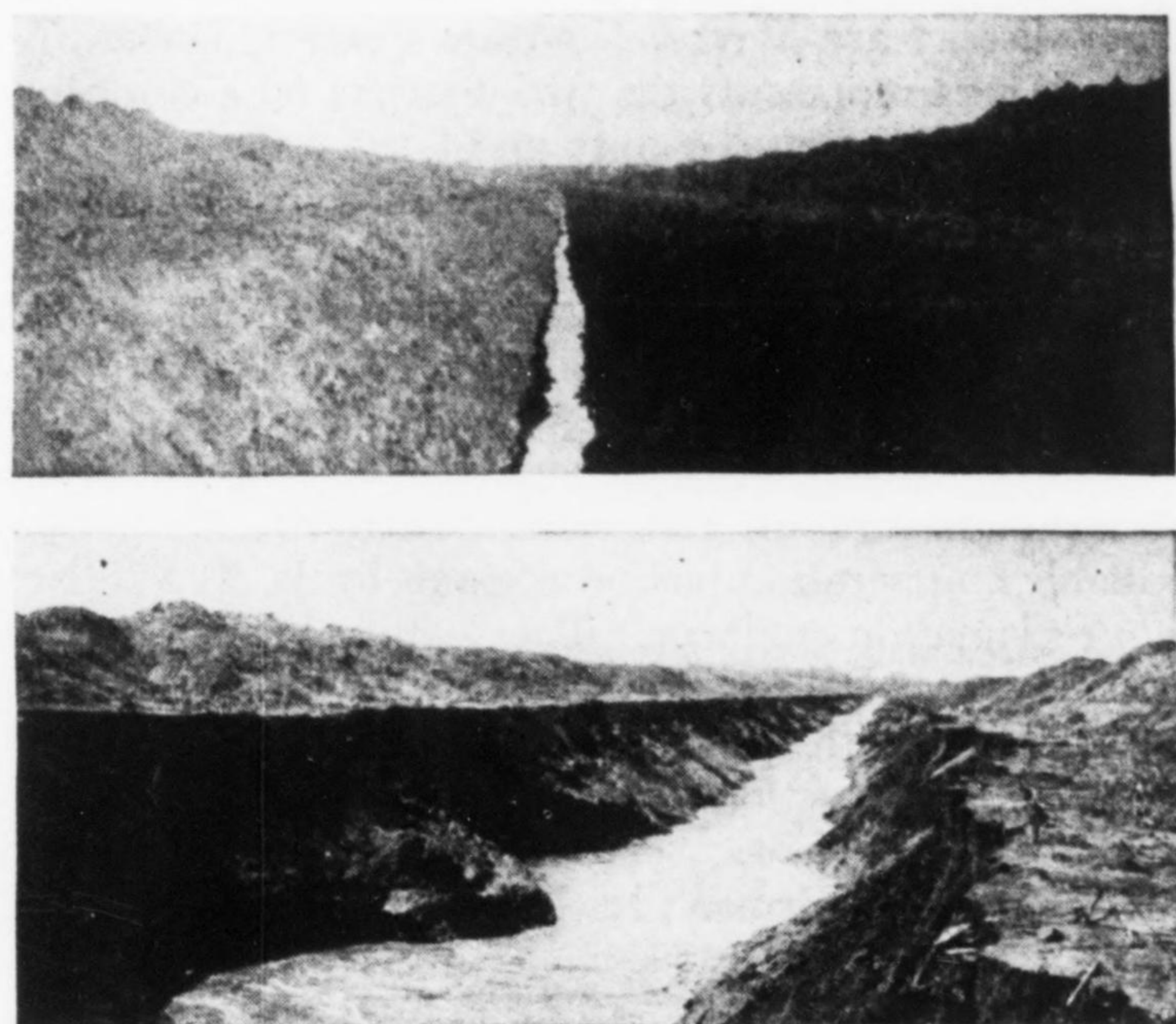


FIG. 6—WEST FORK DIVERSION CHANNEL  
Above—Channel as excavated. Below—Channel as enlarged by erosion in four months.

out so that the upper portions, where erosion would ordinarily take place last, are being constructed first, wherever temporary deep outlets can be secured in the old river channels. These upper sections will thus have a chance to erode and enlarge to the grade of the old channel temporary outlets before the latter are finally cut off by the new floodway levees.

**Pumping Plants and Sluiceways**—Storm runoff from the reclaiming areas will drain normally under the levees by gravity into the new diversion channels through reinforced-concrete sluiceways and connecting channels. With the river in flood and gravity drainage thus cut off, runoff behind the levees will be collected and stored in the old river channels and the land side borrowpits, to be removed by pumping or stored for gravity flow after the flood has receded. Without this utilization of the old river channels and the borrowpits as storage basins for interior runoff, which is an essential part of the plan, the size and cost of pumping plants would have to be increased greatly. To take care of runoff from surrounding lands, the city has authorized the construction of four pressure storm sewers. These will begin at the flood level elevation and extend as closed pressure conduits across the district to outlets in the floodway.

There will be four pumping plants. The largest will be equipped with four 54-in. screw pumps, each operated by a 350-hp. motor. Two stations will each have two 24-in. vertical double open suction centrifugal pumps

driven by motors of 125 hp. and the smallest station will have two 18-in. centrifugal pumps operated by 80 hp. motors. Power will be purchased from the Dallas Power & Light Company. An area at the upper end of the west levee has no pumps, as there was sufficient capacity in the old river channel and borrowpits within this area to store the storm runoff during flood times. This water will be drained out through a sluiceway after the flood has passed. The area protected by the northwest levee will be drained in the same way through sluiceways by gravity. All sluiceways will be provided with mechanically controlled sluice gates and all except the largest station will be equipped with automatic gates as an additional precaution to prevent water backing into the storage basins in the event of a quick rise in the floodway before the main gates are closed. The mechanical gates at the pumping plants will be electrically controlled, and those at the sluiceways will be manually controlled. Concrete collars 3 ft. wide extend outside the sluiceways at 20-ft. intervals to intercept any seepage.

**Hydraulic Fill**—Material will be pumped from the floodway to fill the old Trinity River channel for  $2\frac{1}{4}$  miles immediately adjacent to the business district and to fill some depressions to the general level of adjacent land. In addition, hydraulic fills will be placed around the heads of the three new floodway crossings to bring

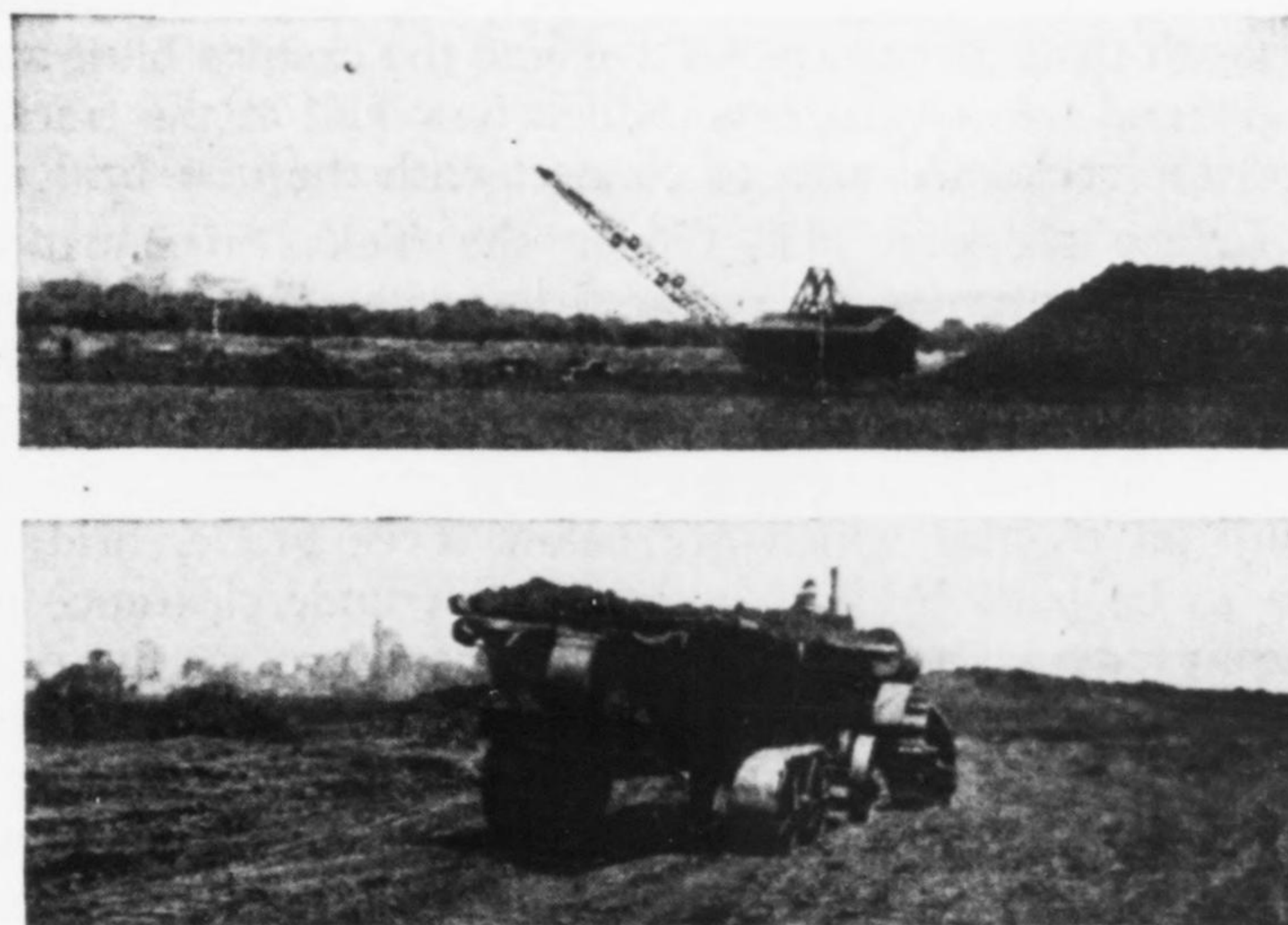


FIG. 7—LEVEE CONSTRUCTION WORK  
Above—Walking dragline building west levee. Below—7-yd. crawler wagon hauled by 10-ton tractor. Skyline of city at left

the adjoining lands to the elevation of the bridge approaches. These fills will slope back on easy grades from the approaches to meet the natural ground surface.

A complete street and storm sewer layout has been made for this area, to be constructed as development proceeds. The cost of the hydraulic fill has been assessed against the lands benefited, which are to be developed for high-class industrial and commercial uses.

**Construction Equipment**—The levees and channels are being constructed with nine dragline machines and four crawler tractor wagon outfits (see Fig. 7). Seven draglines are of the walking type and two of the crawler type. Two have 6-yd. buckets on 100- and 125-ft. booms, two have 4-yd. buckets on 100-ft. booms, and four have 3-yd. buckets on booms 65 to 80 ft. long. One small dragline carries a 1-yd. bucket on a 45-ft. boom. The tractor wagons are rated at 7-cu.yd. capacity and are drawn by 10-ton tractors. These wagons are loaded by the small dragline and are used on the section of west levee where levee material is hauled in from the floodway. Trucks were used on a part of this work. A suction dredge will be installed for the hydraulic filling.



*Progress*—Construction work was started in July, 1928. A time limit of 700 working days is specified for all work except the hydraulic fill, which has a limit of 900 working days. About 35 per cent of the work was completed by July 1, 1929. Work has progressed on the west levee so that the area reclaimed by it may be entirely protected by the end of the present season.

*Corollary Construction*—Adjacent to the main business section of Dallas and Oak Cliff, the Trinity River flood waters will be confined between levees to a width less than half that of the previous overflowed valley. This reduced width has made it economically possible for Dallas County to construct four new highway bridges. This has been impossible before because of the high cost of the long structures. These four bridges, now under construction at Corinth, Cadiz, Commerce and Lemar Sts., will relieve traffic congestion on the present high-level viaduct between Dallas and Oak Cliff.

In addition, roads are to be constructed by the county across the floodway and over the levees at Turtle Creek Boulevard, Westmoreland Road and Hampton Road, with a high-water trestle at Irving Road. Approaches to the viaducts will also be built. Hard-surfaced highways are to be extended through the reclaimed area to form connecting links in the county highway system, which were not feasible in the unprotected overflow valley. The city has voted bonds for constructing five underpasses beneath the railroad tracks that line the eastern bluff and to extend five city streets, which now end at the tracks, into the reclaimed area to connect with the new bridges.

*Utility Adjustments*—Under the Texas reclamation law, public utilities are required to make changes at their own expense to conform to the works of an improvement district. As the new floodway is crossed by the Texas & Pacific Railroad and the Northern Texas Traction Company on trestles which are below levee grade, bridges are to be built by both utilities with underclearance at levee grade. The Rock Island Railroad crosses the new Elm Fork floodway on a low embankment which is to be replaced with a bridge at levee grade.

Several oil and gas pipe lines are being reconstructed to pass over the levees and under the borrowpits and channels. Some small lines have been permitted to remain under the levees after concrete seepage collars were constructed around the pipes. City sewers are being reconstructed under the levees with collars to intercept seepage and with cutoff valves to prevent back flow in case of a break in the sewer in the floodway during high water. Adjustment in power lines, telephone and telegraph lines are being made by the owners as construction requires.

*Contracts and Costs*—The construction work was divided into fourteen contracts, all of which were let May 12, 1928. Under the Texas law, no contract for construction work in a levee improvement district is valid until contracts for all works required have been awarded. The principal unit prices are as follows: Embankment in levees, 20c. per cubic yard; embankment for river fills, 32c.; channel and core trench excavation, 12c.; hydraulic fill, 30c.; clearing, \$40 per acre; grubbing, \$100 per acre; concrete, \$21 per cubic yard; reinforcing steel, 5c. per pound; sodding, \$500 per mile.

Costs were assessed in each of the two co-operating levee improvement districts as follows: The City and County of Dallas Levee Improvement District reclaims and benefits 6,812 acres at a total cost of \$6,000,000, or an average of \$880 per acre of reclaimed land. Since the area is intended for commercial and industrial devel-

opment and other city uses, this cost is better expressed on a square foot basis. The cost per square foot of reclaimed land, without deduction for streets, alleys, railroad reservations, etc., varies from a maximum of about 19c. to a minimum of about  $\frac{1}{4}$ c., the former being for property nearest the Dallas business district and within the area to be especially improved and the latter for property most remote from the business centers. In the Dallas County Levee Improvement District No. 5 there are 3,128 acres protected at a cost of \$500,000, or \$160 per acre.

The cost of the works to be constructed by the city and county and which have been made possible by the levee project amount to about \$6,000,000. Including the costs to be borne by the utility and railroad companies in conforming their properties to the improvements, a total of about \$13,000,000 is to be expended.

*Engineers and Contractors*—The engineers for the larger district are Myers, Noyes & Forrest, Dallas, Tex. E. L. Myers represents the two districts on a co-ordinating committee of city, county and levee interests. E. N. Noyes and T. C. Forrest, Jr., are directly in charge of construction. The Morgan Engineering Company, Memphis, Tenn., is consulting engineer and also designed the improvements. Ned H. Sayford is in charge for this company and the writer is assistant engineer. H. W. English is resident engineer and also represents the consulting engineers on the construction of the project. Valuable co-operation has been given by B. F. Williams, state reclamation engineer. The Trinity Farm Construction Company, Dallas, Tex., is general contractor for the entire work, with J. D. Kirven, general manager, in charge of construction. The district is governed by a board of supervisors serving without compensation: J. J. Simmons, chairman; Leslie A. Stemmons and W. J. Wyatt.

### Strength of Brick Walls Determined by Bureau of Standards

The Bureau of Standards, in co-operation with the Common Brick Manufacturers' Association, has just completed a comprehensive series of strength tests of masonry. The results of these tests appeared in the October issue of the Bureau of Standards *Journal of Research* and answered many questions for which heretofore there has been no authoritative answer.

The tests showed that brick walls which had been kept damp for one week after they were built were no stronger at the age of 60 days than similar walls allowed to cure in the laboratory. They showed that higher strengths can be obtained by having the horizontal mortar beds smooth and level, eliminating all trowel marks and having all joints filled. When the strengths of several of the recently developed types of hollow walls were divided by the allowable working load permitted by building codes governing masonry construction, an ample factor of safety was obtained. The relation between brick strength and wall strength and between the strengths of walls of different size was investigated.

Careful records were kept of the material used in the walls and the time required to build them. These data, showing the saving in brick, mortar and time for all the types of hollow walls, as compared with solid walls of brick of the same thickness and coupled with the strength tests, give information which will be of assistance to prospective builders in selecting the type of wall for their homes.