Trinity River and Tributaries, Texas, Fort Worth Area, Part II

TRINITY RIVER AND TRIBUTARIES, TEXAS, FORT WORTH AREA, PART II

LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY, DATED MAY 18, 1962, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A REVIEW OF THE REPORTS ON THE TRINITY RIVER AND TRIBUTARIES, TEXAS, FORT WORTH AREA, PART II, REQUESTED BY A RESOLUTION OF THE COMMITTEE ON PUBLIC WORKS, HOUSE OF REPRESENTATIVES, ADOPTED JUNE 27, 1957

JUNE 25, 1962.—Referred to the Committee on Public Works and ordered to be printed with six illustrations

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U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1962

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APPENDIXES ACCOMPANYING THE REPORT OF THE DISTRICT ENGINEER

ILLUSTRATIONS ACCOMPANYING THE REPORT OF THE DISTRICT ENGINEER
(Only Plates 1, 2, 3, 9, 10, and 11 printed)

LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY
WASHINGTON 25, D.C.

IN REPLY REFER TO:

June 19, 1962

Honorable John W. McCormack

Speaker of the House of Representatives

Dear Mr. Speaker:

I am transmitting herewith a favorable report dated 18 May 1962, from the Chief of Engineers, Department of the Army, together with accompanying papers and illustrations, on a review of the reports on the Trinity River and Tributaries, Texas, Fort Worth Area, Part II, requested by a resolution of the Committee on Public Works, House of Representatives, adopted 27 June 1957.

In accordance with Section 1 of Public Law 534, 78th Congress, and Public Law 85-624, the views of Governor of Texas and the Department of the Interior are set forth in the inclosed communications. The views of the Public Health Service are inclosed also.

The Bureau of the Budget advises that there is no objection to the submission of the proposed report to the Congress; however, it states that no commitment can be made at this time as to when any estimate of appropriation would be submitted for construction of the project, if authorized by the Congress, since this would be governed by the President's budgetary objectives as determined by the then prevailing fiscal situation. A copy of the letter from the Bureau of the Budget is inclosed.

Sincerely yours,

Elvis J. Stahr, jr.

Elvis J. Stahr, Jr.
Secretary of the Army

1 Incl (dup)
Rept w/accompg
papers & illus

COMMENTS OF THE BUREAU OF THE BUDGET

EXECUTIVE OFFICE OF THE PRESIDENT
BUREAU OF THE BUDGET
WASHINGTON 25, D. C.

11 June 1962

Honorable Elvis J. Stahr, Jr.
Secretary of the Army
Washington 25, D. C.

Dear Mr. Secretary:

Assistant Secretary Schaub's letter of May 23, 1962, submits the proposed review report of the Chief of Engineers on the Trinity River and Tributaries, Texas, Fort Worth Area, Part II, requested by resolution of the Committee on Public Works, House of Representatives, adopted June 27, 1957.

The Chief of Engineers recommends, subject to certain conditions of local cooperation, channel rectification on the Clear Fork of Trinity River, between the head of the existing Fort Worth Floodway and the Southwest Loop 217, together with two leveed areas and four fill areas. The estimated cost of construction is $5,148,000 to the Federal Government and $2,878,000 to local interests. The benefit-cost ratio is stated to be 2.2.

I am authorized by the Director of the Bureau of the Budget to advise you that there would be no objection to the submission of the proposed report to the Congress. No commitment, however, can be made at this time as to when any estimate of appropriation would be submitted for construction of the project, if authorized by the Congress, since this would be governed by the President's budgetary's objectives as determined by the then prevailing fiscal situation.

Sincerely yours,

Carl H. Schwartz, Jr., Chief
Resources and Civil Works
Division

COMMENTS OF THE GOVERNOR OF TEXAS

EXECUTIVE DEPARTMENT
AUSTIN 11, TEXAS

PRICE DANIEL
GOVERNOR

March 30, 1962

Maj. Gen. Keith R. Barney
Acting Chief of Engineers
United States Army Corps of Engineers
Washington 25, D. C.

Dear General Barney:

This will supplement my letter of January 23, 1962, concerning your proposed report on the Trinity River and Tributaries, Texas, Fort Worth Area, Part II.

I am pleased to transmit herewith copy of an Order adopted by the Texas Water Commission relating to this project. I concur in the Commission findings and recommendations.

Sincerely yours,

Price Daniel

PD:gs

Enclosure

cc: Hon. Joe D. Carter, Chairman
Texas Water Commission
Capitol Station, P. O. Box 2311
Austin 11, Texas

TEXAS WATER COMMISSION

AN ORDER approving the feasibility of the United States Army Corps of Engineers Fort Worth Floodway, Texas, Project, Part II

BE IT ORDERED BY THE TEXAS WATER COMMISSION:

Section 1: Statement of Authority. Article 7472e Vernon's Annotated Civil Statutes, provides that upon receipt of any engineering report submitted by a Federal Agency seeking the Governor's approval of a Federal Project, the Texas Water Commission shall study and make recommendations to the Governor as to the feasibility of the Federal Project. The Commission shall cause a public hearing to be held to receive the views of persons or groups who might be affected should the Federal Project be initiated and completed.

Section 2: Statement of Jurisdiction. (a) By letter dated January 24, 1962, the Honorable Price Daniel, Governor of Texas, requested the Texas Water Commission to review the report of the Chief of Engineers, United States, Army, covering the Fort Worth Floodway Texas Project, entitled Review of Reports on Trinity River and Tributaries, Texas, covering West Fork Watershed Flood Protection-Fort Worth Area, Part II, and to enter its order finding said project to be feasible or not feasible, (b) In accordance with Article 7472e, the Commission caused a public hearing, after due notice by publication, to be held on March 23, 1962, at 10:30 o'clock a.m., in the auditorium of the Water Treatment Plant of North Texas Municipal Water District near Wylie, Texas, on the Fort Worth Floodway, Texas Project, Part II, and at which time all those interested or who may be affected should the project be initiated and completed were requested to come forward and give testimony.

Section 3: After fully considering all the evidence and exhibits presented by persons and groups who may be affected should the Federal Project be initiated and completed, including the matters set forth in Section 4 of Article 7472e, the Commission finds that the project is feasible and that the public interest will be served thereby.

Section 4: It is further ordered that a certified copy of this Order be transmitted to the Governor.

Section 5: This Order shall take effect on the 23rd day of March, 1962, the date of its passage, and it is so ordered.

SIGNED IN THE PRESENCE OF THE
TEXAS WATER COMMISSION

Joe D. Carter, Chairman

ATTEST:

Ben F. Looney, Jr., Secretary

I certify that the foregoing order was adopted by the Texas Water Commission at a meeting held on the 23rd day of March, 1962, upon motion of Commissioner Beckwith, seconded by Chairman Carter, Commissioner Beckwith voting "aye", Chairman Carter voting "aye", and Commissioner Dent being absent and excused.

Ben F. Looney, Jr., Secretary

STATE OF TEXAS §

COUNTY OF TRAVIS §

I, Ben F. Looney, Jr., Secretary of the Texas Water Commission do hereby certify that the foregoing is a true and correct copy of an order of said Commission, the original of which is filed in the permanent records of said Commission.

Given under my hand and the seal of the Texas Water Commission, this the 28th day of March, A.D., 1962.

Ben F. Looney, Jr., Secretary

COMMENTS OF THE DEPARTMENT OF THE INTERIOR

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON 25, D. C.

April 18, 1962

Lt. General Walter K. Wilson, Jr.
Chief of Engineers
Department of the Army
Washington 25, D. C.

Dear General Wilson:

This is in reply to your letter of January 19 requesting our comments on reports on the Trinity River and Tributaries, Texas, West Fork Watershed. The recommended improvements would provide flood protection for residential and commercial sections in the Fort Worth area.

The Fish and Wildlife Service advises that project effects upon fish and wildlife resources of the area would be insignificant and has no suggestions for protection of these resources or for their enhancement.

The interests of this Department would not be adversely affected by the proposed construction.

Sincerely yours,

Assistant Secretary of the Interior

COMMENTS OF THE PUBLIC HEALTH SERVICE

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

PUBLIC HEALTH SERVICE — WASHINGTON 25, D. C.

BUREAU OF STATE SERVICES — Refer to:

April 25, 1962

Major General Walter K. Wilson, Jr.
Chief of Engineers
Department of the Army
Washington 25, D. C.

Dear General Wilson:

This is in reply to General Barney's letter of January 19, 1962, requesting comments on the U. S. Army Engineers' Report on the Trinity River and Tributaries, Texas, covering West Fork Watershed.

We have no comments in addition to those included in Appendix IV of the Report which were submitted to the District Engineer by our Dallas Regional Office in May 1960.

The opportunity to review the report is appreciated. We stand ready to provide further consultation concerning vector control, water supply and pollution control aspects of the project on your request.

Sincerely yours,

Keith S. Krause

Keith S. Krause
Chief, Technical Services Branch
Division of Water Supply and
Pollution Control

TRINITY RIVER AND TRIBUTARIES, TEXAS, FORT WORTH AREA, PART II

REPORT OF THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY

HEADQUARTERS
DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON 25, D.C.

IN REPLY REFER TO

18 May 1962

ENGCW-PD

SUBJECT: Fort Worth Floodway, Texas

TO: THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress the report of the Board of Engineers for Rivers and Harbors on Fort Worth Floodway, Texas, in final response to the resolution of the Committee on Public Works of the House of Representatives, adopted 27 June 1957, requesting the Board to review the reports on the Trinity River Basin contained in House Document Number 403, Seventy-seventh Congress, and other pertinent reports to determine whether it would be advisable at this time to modify the existing projects for flood control and other purposes along the Trinity River, including the West Fork and Clear Fork in the Fort Worth area, particularly with the view of determining the advisability of extending the Fort Worth Floodway upstream to Lake Worth, or extending downstream as warranted by present and potential development or any other modifications required in the interest of flood control. The report considers the advisability of extending the Fort Worth Floodway upstream to Benbrook Dam on the Clear Fork of Trinity River and downstream to Big Fossil Creek on the West Fork of Trinity River. An interim report on upstream extension of the floodway on the West Fork of Trinity River has been submitted previously under this authority.

2. The District and Division Engineers find that the only economically justified improvements in the area would consist of channel rectification on the Clear Fork between the head of the existing floodway and the Southwest Loop 217, together with two leveed areas and four fill areas. They recommend the improvements at an estimated cost of $8,026,000, of which $5,148,000 would be

the Federal cost for construction, and $2,878,000 would be the non-Federal cost for lands, easements, rights-of-way, sumps, spoil disposal areas, and alterations to highways, utilites except railroads, and other facilities; provided local interests agree to maintain and operate the improvements and meet other indicated conditions of cooperation. The benefit-cost ratio is 2.2.

3. The Board concurs generally in the findings of the reporting officers and recommends modification of the existing project for Trinity River and tributaries, Texas, substantially in accordance with the plan of the District Engineer, subject to local cooperation.

4. I concur in the views and recommendations of the Board.

W. K. WILSON, JR.
Lieutenant General, USA
Chief of Engineers

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

CORPS OF ENGINEERS, U. S. ARMY
BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON 25, D. C.

ENGBR 14 November 1961

SUBJECT: Fort Worth Floodway, Texas

TO: Chief of Engineers
Department of the Army

1. Authority and scope.--This report is in final response to the following resolution adopted 27 June 1957:

> Resolved by the Committee on Public Works of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the reports on the Trinity River Basin contained in House Document No. 403, 77th Congress and other pertinent reports to determine whether it would be advisable at this time to modify the existing projects for flood control and other purposes along the Trinity River including the West Fork and Clear Fork in the Fort Worth area, particularly with the view of determining the advisability of extending the Fort Worth Floodway upstream to Lake Worth or extending downstream as warranted by present and potential development or any other modifications required in the interest of flood control.

The report considers the advisability of extending the Fort Worth Floodway upstream to Benbrook Dam on the Clear Fork of Trinity River and downstream to Big Fossil Creek on the West Fork of Trinity River. An interim report on upstream extension of the floodway on the West Fork of Trinity River has been submitted previously under this authority.

2. Basin description.--The West Fork of Trinity River rises in north-central Texas. It flows about 211 miles southeastward, through Fort Worth, to join Elm Fork immediately upstream from Dallas and form Trinity River. Its watershed contains 3,502 square miles, of which 2,088 are upstream from the existing Fort Worth Floodway. Its main tributary, Clear Fork, rises in Parker County and flows about 65 miles in an arc southeastward to the

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head of Benbrook Reservoir and thence northeastward to join the West Fork in Fort Worth, about 6 miles downstream from the head of the existing floodway. Clear Fork drains 531 square miles. Marys Creek, having a drainage area of 57 square miles, enters Clear Fork from the left bank at river mile 10.7, about 4.3 miles downstream from Benbrook Dam. Stream characteristics in the problem areas are tabulated below.

Item	West Fork (a)	Clear Fork (b)	Marys Creek (c)
Length of reach, miles	9.6	13.4	7.7
Streambed slope, feet per mile	2.4	7.3	18.9
Average channel depth, feet	33.6	23.0	18.4
Minimum channel capacity, cubic feet per second	10,000	8,000	12,000

(a) From downstream end of existing floodway to Big Fossil Creek.
(b) From Benbrook Dam to head of existing floodway.
(c) From considered dam site to mouth of creek.

The watershed upstream from Fort Worth is devoted predominantly to farming and ranching, while diversified industrial development exists in the Fort Worth area.

3. Federal projects for flood control, affecting the problem area, consist of the existing Fort Worth Floodway, extending along a 13-mile reach on the West Fork and 1.6 miles on the Clear Fork in the city of Fort Worth; and the Benbrook Reservoir at mile 15 on Clear Fork. Upstream extension of the floodway, 5.9 miles on the West Fork and 0.6 mile on Farmers Branch, is authorized but not started. The Soil Conservation Service, Department of Agriculture, has constructed 1.63 miles of floodway and 15 flood-detention reservoirs in the headwaters of the West Fork, and 33 flood-detention reservoirs in the headwaters of Clear Fork. It is planning 33 additional flood-detention reservoirs in the two watersheds. The principal existing improvements by local interests which affect the problem area on the West Fork are Lake Bridgeport, Eagle

Mountain Lake, and Lake Worth, on the main stem of the West Fork, about 63, 19, and 7 miles, respectively, upstream from the existing Fort Worth Floodway. These reservoirs are used for water conservation but provide some flood protection to downstream areas. Other improvements by local interests, affecting the problem area on the West Fork to a lesser extent, consist of the Marine Creek and Cement Creek Reservoirs for flood control and recreation in the Marine Creek watershed, a tributary to the West Fork immediately downstream from the mouth of Clear Fork; and two levees on the right bank of Clear Fork at the head of the Fort Worth Floodway.

4. Flood damages.--Developments in the West Fork flood plain include limited commercial and residential sections, a sewage-disposal plant, a drive-in theater, a small private hospital, and some agricultural land. The Clear Fork flood plain has several extensive residential and commercial sections, a large municipal recreation park, a private recreation park, a private golf course, a municipal water pumping plant, a large public school, and an area for which residential and commercial development plans are complete. The Marys Creek flood plain contains a few business and inexpensive residential properties; however, additional residential developments are planned. Pertinent data relative to values and flood damages, based on January 1960 prices and conditions, in the two main areas are:

Item	West Fork	Clear Fork
Value	$12,087,000	$32,487,000
Percent residential	2	45
Estimated damages, maximum flood of record (May 1949)	$ 560,000	$ 4,286,000
Estimated average annual damages	$ 41,000	$ 374,900

5. Improvements desired.--Local interests desire extension of the Fort Worth Floodway upstream on the Clear Fork to Marys Creek and downstream on the West Fork to some point below East First Street, with provision for pumping interior runoff from behind the levees; and investigation for a multiple-purpose

reservoir on Marys Creek. They are willing to cooperate in the desired improvements.

6. Improvements considered.--The District Engineer considered several plans for downstream extension of the floodway on the West Fork and finds that the costs greatly exceed the prospective benefits. For the problem area on Clear Fork, he considered a reservoir on Marys Creek for flood control alone, and with other purposes added, as well as in combination with downstream channel and levee improvements. His studies disclose that a reservoir in the upstream part of the watershed would not appreciably reduce the cost of levee and channel work required on Clear Fork, and that the cost of a reservoir near the mouth of Marys Creek would be prohibitive. He finds that the most suitable plan would consist of channel rectification between the existing floodway on Clear Fork and the Southwest Loop 217, near the mouth of Marys Creek, together with two leveed areas and four fill areas. The channel would be enlarged and straightened to convey the maximum flood of record as modified by the Benbrook project, 26,000 cubic feet per second. The levees and fill areas would have freeboards of 4 and 2 feet, respectively, above a standard project flood of 75,000 cubic feet per second, confined throughout by the proposed levees, fill areas, and other works not presently justified. The two leveed areas would have gated culverts for interior drainage, together with sufficient sump capacity to control interior runoff from a 24-hour, 50-year rainfall. The work would require modification of seven existing bridges, removal and reconstruction of three channel dams, and relocation of various utilities. The District Engineer estimates the construction cost of the work, based on January 1960 prices, at $8,025,500, exclusive of $12,500 for preauthorization study costs, of which $5,148,000 would be Federal and $2,877,500, non-Federal. The annual charges are estimated at $402,700, including $59,900 for operation and maintenance. He estimates the average annual benefits at $886,000, consisting of damages prevented to existing and future developments in the flood plain. The benefit-cost ratio is 2.2. The District Engineer recommends modification of the existing project for Trinity River and tributaries, Texas, to provide for upstream extension of the Fort Worth Floodway on the Clear Fork, in accordance with his plan, subject to certain conditions of local cooperation. The Division Engineer concurs.

7. Public notice.--The Division Engineer issued a public notice stating the recommendations of the reporting officers and affording interested parties an opportunity to present additional information to the Board. Careful consideration has been given to the communications received.

Views and Recommendations of the Board of Engineers for Rivers and Harbors.

8. Views.--The Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the reporting officers. It notes that effects of a reservoir in the upstream reaches of Marys Creek would not materially reduce the cost of the floodway extension. It agrees that local interests should exercise, to the full extent of their legal capability, the establishment of flood-plain zoning and building restrictions to prevent development in the unprotected areas; and that if these areas are to be developed, responsibility for their protection should rest with the developers or other local interests. The Board concludes that the plan recommended by the District Engineer is the most suitable for flood protection in the problem area. It further finds that the plan is economically justified and that the proposed requirements of local cooperation are proper.

9. Recommendations.--Accordingly, the Board recommends modification of the existing project for Trinity River and tributaries, Texas, to provide for the upstream extension of the Fort Worth Floodway on the Clear Fork to the vininity of the Southwest Loop 217, to include:

Enlarging and realigning about 6.5 miles of the channel;

Constructing about 3.0 miles of levee and 900 feet of floodwall along the right bank at the Convair and Tanglewood areas;

Constructing necessary interior drainage facilities, including sump-storage areas, gated culverts through the levees, and diversion channels with related works in lieu of additional sump-storage areas; and

Filling of four unprotected areas adjacent to the improved channel to elevations about 2 feet above design water surface by utilizing waste material from channel excavation;

all generally in accordance with the plan of the District Engineer, and with such modifications thereof as in the discretion of the Chief of Engineers may be advisable; at an estimated cost to the United States of $5,148,000 for construction; provided that, prior to construction, local interests give assurances satisfactory to the Secretary of the Army that they will:

a. Furnish without cost to the United States all lands, easements, and rights-of-way necessary for construction of the project, including those required for sump areas and those designated for disposal of excavation waste;

b. Make any alterations to existing improvements which may be required for construction of the project, including modification of the narrow-gage railroad bridge and highway bridges, and removal and reconstruction of three channel dams, but excluding modification of the standard-gage railroad bridges;

c. Hold and save the United States free from damages due to the construction works;

d. Prohibit encroachment in the sump areas and on the flood-carrying capacity of the floodway extension; and

e. Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army.

FOR THE BOARD:

KEITH R. BARNEY
Major General, USA
Chairman

REVIEW OF REPORTS
ON
TRINITY RIVER AND TRIBUTARIES, TEXAS
COVERING
WEST FORK WATERSHED
FLOOD PROTECTION - FORT WORTH AREA
PART II

SYLLABUS

The District Engineer finds from his investigations that a potentially serious flood problem exists on the Clear Fork of the Trinity River in the unprotected area between the existing Fort Worth Floodway and Benbrook Dam. He concludes that the flood problem can be partially solved at this time by the construction of certain floodway and channel improvement works on the Clear Fork between the existing Fort Worth Floodway project and the Southwest Loop 217. He concludes further that there is an immediate need for the channel improvement and floodway extension works and that they are fully justified.

Accordingly, the District Engineer recommends that the existing project for Trinity River, Texas, be modified to provide for the construction of the economically justified channel improvement and floodway extension works on the Clear Fork between the existing Fort Worth Floodway project and the Southwest Loop 217 generally as outlined in this report at an estimated construction cost to the United States of $5,148,000, subject to certain conditions of local cooperation.

U. S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS
May 27, 1960

SUBJECT: Review of Reports on Trinity River and Tributaries, Texas, Covering the West Fork Watershed, Flood Protection, Fort Worth Area, Part II

THROUGH: Division Engineer
U. S. Army Engineer Division, Southwestern
Dallas, Texas

TO: Chief of Engineers
Department of the Army
Washington, D. C.

INTRODUCTION

1. AUTHORITY.- This report is submitted in partial response to the following congressional resolution adopted June 27, 1957:

"Resolved by the Committee on Public Works of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the reports on the Trinity River Basin contained in House Document No. 403, 77th Congress, and other pertinent reports to determine whether it would be advisable at this time to modify the existing projects for flood control and other purposes along the Trinity River including the West Fork and Clear Fork in the Fort Worth area, particularly with the view of determining the advisability of extending the Fort Worth Floodway upstream to Lake Worth or extending downstream as warranted by present and potential development or any other modifications required in the interest of flood control."

2. The report requested in the above-cited congressional authorization is being prepared in two parts to expedite solutions to the flood problems in the area most seriously affected during the floods of April-June 1957. The Chief of Engineers approved this report procedure on April 2, 1958. Part I of this report was submitted to the Office, Chief of Engineers on August 21, 1959. The improvements recommended in the Part I report were authorized for construction by the Flood Control Act approved July 14, 1960.

3. SCOPE.- The review report authorized by the above-cited resolution will consider the desirability of modifying the existing projects along the Trinity River, for flood control and other purposes,

with particular reference to the Fort Worth area where considerable urban development has occurred in recent years. This report, Part II, discusses improvements for the protection of the flood-problem areas located on the West Fork downstream from the existing Fort Worth floodway project and on the Clear Fork and Marys Creek upstream from the Clear Fork portion of the existing floodway project. A watershed map, the existing improvements, and the plans of improvement considered for the West Fork, Clear Fork, and Marys Creek flood-plain areas are shown on plates 1, 2, and 3.

4. This report includes a general description of the West Fork watershed and the Clear Fork watershed, information on existing Federal and non-Federal improvements that have a bearing on flood control and water conservation problems in the Fort Worth area, and a brief summary of the views and desires of local interests as expressed at the public hearing concerning flood problems in the Fort Worth area. Detailed field investigations for this report consisted of establishing the high water marks for the floods of record, delineating the flood plains, conducting topographic surveys to obtain necessary cross sections of the West Fork, Clear Fork, and Marys Creek channels, making explorations consisting of 12 borings to determine subsurface conditions for channel and levee improvements, and conducting an economic survey to determine the character and value of the physical property in the flood plains and the damages resulting from floods. Office studies consisted of analyses of hydrologic, hydraulic, and economic data, engineering studies to develop alternate feasible plans of improvement, and determinations of costs and benefits for various plans of improvement investigated.

5. A public hearing was held in Fort Worth as discussed in paragraph 42. Also, during the investigation, the District Engineer made a reconnaissance of the area under consideration and held conferences with local interests to discuss the possible plans of improvement and the probable requirements of local cooperation.

6. The Soil Conservation Service, Department of Agriculture, was authorized by the Flood Control Act, approved December 22, 1944, to undertake a program of runoff and waterflow retardation and soil-erosion prevention on the Upper Trinity Basin, including the area under consideration herein. During the report investigations, planning of the Corps of Engineers and Soil Conservation Service was coordinated at field level.

7. REPORTS REVIEWED.- Reports concerned with flood control on the West Fork and Clear Fork watersheds and reviewed prior to preparation of this report are those contained in House Document No. 403, 77th Congress, 1st Session, and those contained in House Document No. 242, 81st Congress, 1st Session. These reports are discussed below and are the only prior reports concerned with flood control on the West Fork watershed in the Fort Worth area.

a. House Document No. 403.- The reports contained in House Document No. 403 recommended improvements for flood control and other purposes in the upper Trinity River Basin. These improvements, which have been constructed and are in operation, are as follow:

Project	Location
Benbrook Reservoir	Clear Fork
Grapevine Reservoir	Denton Creek
Lewisville Reservoir	Elm Fork
Lavon Reservoir	East Fork
Floodway improvements	Fort Worth, Texas
Floodway improvements	Dallas, Texas

Only the Benbrook Reservoir and the Fort Worth Floodway projects are pertinent to the Fort Worth area. Locations of these improvements are shown on plates 1, 2, and 3.

b. House Document No. 242.- The reports contained in House Document No. 242 consist of a review of the reports in House Document No. 403 to determine if the authorized floodways through Fort Worth and Dallas should be supplemented by adding interior drainage facilities. It was concluded that the authorized Fort Worth Floodway and Benbrook Reservoir would so improve the efficiency of the existing facilities for disposal of interior runoff in the Fort Worth leveed areas that no further improvements were justified.

8. WEST FORK WATERSHED, FLOOD PROTECTION - FORT WORTH AREA, PART I.- Part I of this report, which was submitted to the Office, Chief of Engineers on August 21, 1959, was in partial response to the congressional resolution quoted in paragraph 1. The flood problem area between the existing Fort Worth Floodway and Lake Worth Dam was investigated. These investigations showed that a potentially serious flood problem exists in the unprotected area of this reach, that there is an immediate need for floodway-extension works, and that such protection is economically justified. It was recommended that the existing project for Trinity River, Texas, be modified to provide for the upstream extension of the Fort Worth Floodway on the West Fork to the vicinity of Lake Worth Dam. The improvements recommended in the Part I report were authorized for construction by the Flood Control Act approved July 14, 1960.

DESCRIPTION

9. GEOGRAPHY.- The city of Fort Worth is located in Tarrant County in the upper Trinity River Basin. The West Fork of the Trinity River and the Clear Fork, a tributary of the West Fork, enter the city of Fort Worth and have their confluence near the center of the city at Trinity River mile 558.7. From this point the West Fork flows in an

easterly direction for a distance of about 53 miles to its junction with the Elm Fork at Dallas to form the main stem of the Trinity River. The Clear Fork of the Trinity River has its headwaters in the upper portion of Parker County and flows in a southeasterly direction to Benbrook Reservoir, thence northeasterly to its confluence with the West Fork of the Trinity River near the center of the city of Fort Worth. Marys Creek, which is one of the principal tributaries of the Clear Fork, has its headwaters in the southeastern portion of Parker County and flows in a southeasterly direction to its confluence with the Clear Fork, about 4.3 miles downstream from Benbrook Dam or just upstream of the Southwest Loop 217 crossing.

10. The West Fork watershed has an over-all length of about 115 miles and a maximum width of about 37 miles. The watershed lies within 11 Texas counties and covers an area of 3,502 square miles. The West Fork watershed drains generally southeastwardly from Archer and Young Counties to the city of Fort Worth, thence eastwardly through Fort Worth to the city of Dallas in Dallas County. The watershed is bounded generally on the north, northeast, and southwest by the drainage areas of the Red River, Elm Fork of the Trinity River, and the Brazos River, respectively. The Clear Fork drainage area has an over-all length of about 50 miles and a maximum width of about 20 miles. It lies principally within Parker and Tarrant Counties and covers an area of 531 square miles. The Clear Fork watershed drains generally southeastwardly from the upper portion of Parker County to Benbrook Reservoir, just southwest of Fort Worth, thence northeastwardly to the center of Fort Worth. Marys Creek has a drainage area of about 57 square miles. The location and extent of the West Fork watershed are shown on plate 1. The component drainage areas of the West Fork watershed, particularly those of the Clear Fork and Marys Creek, are shown on plate 4.

11. PHYSIOGRAPHY.- The upstream portion of the West Fork watershed lies within the Osage Plains section of the Central Lowland physiographic province whereas the downstream portion of the West Fork watershed and all of the Clear Fork subwatershed lie within the West Gulf Coastal Plains province. The sections contain the following belts: Western Cross Timbers, Grand Prairie, Eastern Cross Timbers, and Black Prairies, which possess distinctive features of relief, soils, and native vegetation. Topography varies from relatively rugged and hilly terrain in the area upstream from Fort Worth to generally rolling to flat terrain in the downstream portion between Fort Worth and Dallas. Land elevations of the West Fork watershed vary from about 1,250 feet at the headwaters to about 550 feet at the mouth of the Clear Fork at Fort Worth, thence to about 390 feet near the mouth of the West Fork at Dallas. The alluvial soils within the belts subject to overflow are predominantly dark, varying in texture from waxy clay to sandy loam. These soils are fertile and generally deep. Under natural conditions these soils support growth of grasses

and hardwood tress, and are developed extensively as farm and crop lands.

12. GEOLOGY.- The watershed has surface outcrops of primary strata of the Pennsylvanian, Lower Cretaceous, and Upper Cretaceous geologic periods which consist of shales, sandstones, limestone, conglomerates, sands, clays, and marls. A total of 12 borings were made in the flood problem area being studies for this report; six were made along the West Fork, four along the Clear Fork, and two along the proposed diversion channel of the Clear Fork. Locations of these borings are shown on plates 2 and 3 and logs of borings near the proposed channel are shown on plates 13 through 16. The boring logs show that the subsurface materials along the West Fork consist of sandy clays and silty sands varying in thickness from 16 to 53 feet, and are underlain by limestone and shale. Along the Clear Fork the sandy clays and silty sands range from 18 to 30 feet in thickness. These strata are also underlain by limestone and shale.

13. STREAM CHARACTERISTICS.- The West Fork of the Trinity River has a total length of about 211 miles and an average streambed slope of approximately 4 feet per mile. The Clear Fork of the Trinity River has a total length of about 65 miles and an average streambed slope of approximately 11 feet per mile. Marys Creek has a total length of about 17 miles and an average streambed slope of about 27.7 feet per mile. The following tabulation shows the average streambed slope, average channel depth, and the nondamaging channel capacity of the flood problem reaches as follow: (a) the West Fork between the downstream end of the existing Fort Worth Floodway and the vicinity of the Handley-Ederville Road bridge, (b) the Clear Fork between Benbrook Dam and the upstream end of the Floodway project, and (c) Marys Creek downstream from the damsite investigated in the vicinity of creek mile 7.7.

Item	West Fork (a)	Clear Fork (b)	Marys Creek (c)
Length of reach, miles	9.6	13.4	7.7
Average streambed slope, feet/mile	2.4	7.3	18.9
Average channel depth, feet	33.6	23.0	18.4
Minimum channel capacity, second-feet	10,000	8,000	12,000

14. ECONOMIC DEVELOPMENT.- The economy of the West Fork and Clear Fork watersheds is well balanced with farming and ranching in the upstream portions of the watershed and highly diversified industrial development in the downstream portions, particularly in the Dallas-Fort Worth area. Beef cattle, poultry, goats, sheep, swine, and dairy products are produced extensively. Cotton, wheat, oats,

sorghums, corn, peanuts, watermelons, alfalfa, clover, fruits, and vegetables are principal farm crops. Oil, natural gas, brick-and-tile clay, sand, gravel, building stone, and limestone are produced in considerable quantity. Several small deposits of coal are found in the area. Industries in the watershed include automobile assembly, oil refining, flour milling, meat packing, cottonseed oil processing, poultry processing, production of stone products and portland cement, manufacturing of oil field equipment, leather goods, garments, and some of the nation's largest aircraft manufacturing.

15. Fort Worth, the largest city lying wholly within the West Fork and Clear Fork watersheds, is located in Tarrant County, which has an area of 877 square miles and is one of the four great metropolitan counties of Texas. The Fort Worth area is outstanding as a national livestock and grain market and is a jobbing and wholesale center for a large area. The area is the hub of rail, highway, and air transportation systems with extensive railroad construction and repair shops. Pertinent information regarding business in Tarrant County as estimated for the year 1960 is given below:

Income	$1,050,000,000
Manufacturing value	460,000,000
Wholesale sales	730,000,000
Retail sales	630,000,000

Tarrant County is served by transportation facilities consisting of numerous airports, nine railroads, and a network of Federal, State, and County highways.

16. The preliminary estimate of population of the West Fork watershed in 1960 was about 620,000, of which about 88 percent was urban. Population data for the city of Fort Worth and for Tarrant County, based on the preliminary 1960 census estimate, are as follow:

	Preliminary 1960 Census
Tarrant County	523,452
City of Fort Worth	347,368

CLIMATOLOGICAL, RUNOFF, AND FLOOD DATA

17. CLIMATOLOGICAL DATA.- The climate of the West Fork watershed is generally mild and is not affected by any important topographic features. The growing season normally extends from the middle of March to the middle of November. The mean annual temperature at Fort Worth is about 66 degrees Fahrenheit. Freezing temperatures and snowfalls are occasionally experienced during the movement of cold, high-pressure air masses from the northwest. The days are hot during the summer and the nights are moderately warm. Extremes in temperature have ranged from a maximum of 112 degrees in August 1936 to a minimum of minus 8 degrees in February 1899. The average relative humidities at 12:30 a.m., 6:30 a.m., 12:30 p.m., and 6:30 p.m. are 70, 80, 53, and 53 percent, respectively. The maximum recorded wind velocity (fastest mile) at Fort Worth was 68 miles per hour from the west in May 1935.

18. PRECIPITATION.- The mean annual precipitation at Fort Worth, based on the combined records for the city and airport stations, is 31.53 inches. Annual precipitation has ranged from a maximum of 51.03 inches in 1932 to a minimum of 17.91 inches in 1921. The maximum annual precipitation reported on the West Fork watershed upstream from Fort Worth was 55.88 inches in 1957 at Weatherford and the minimum was 14.09 inches in 1924 at Jacksboro. Monthly precipitation at Fort Worth has ranged from a maximum of 17.64 inches in April 1922 to a minimum of none during several months. The maximum monthly precipitation on the West Fork watershed upstream from Fort Worth was 27.94 inches recorded in May 1884 at Weatherford. Hourly precipitation records at Fort Worth date back to 1899. The official U. S. Weather Bureau gage record has been obtained at three general locations: downtown Fort Worth (at the old Federal Building and at the U. S. Courthouse), Meacham Field, and Amon Carter Field. Meacham Field and Amon Carter Field are located about 5.5 miles north-northwest and 17 miles east-northeast of the post office, respectively. Maximum precipitation recorded at the official Fort Worth gage for selected durations is shown in the following tabulation:

Duration (hours)	Precipitation (inches)
1	3.35
2	5.59
3	5.99
6	6.93
12	9.04
24	9.57

Although the official U. S. Weather Bureau rain gage is located now at Amon Carter Field, the recording gage at Meacham Field is still being

maintained. Recording rainfall records are also available from a gage maintained since 1955 by the Corps of Engineers in downtown Fort Worth, Leonard Building. The following rainfall amounts measured at the Corps' gage during the storm of October 8, 1958, are representative of maximums that can be expected in this general area: 15-minute duration, 1.45 inches; 30-minute duration, 2.38 inches; 1-hour duration, 3.96 inches; 1-1/2 hour duration, 4.71 inches; and total storm duration of 1 hour and 50 minutes, 4.86 inches. The maximum 24-hour precipitation reported on the West Fork watershed upstream from Fort Worth was 11.0 inches on a ranch 5 miles northeast of Cresson on May 16-17, 1949.

19. RUNOFF DATA.- Streamflow records are available from seven active and three discontinued gaging stations on the West Fork watershed upstream from the problem areas. Lake levels also are available for the three existing reservoirs on the West Fork and Benbrook Reservoir on the Clear Fork. The following tabulation summarizes the annual runoff at selected stream-gaging stations on the West Fork and the Clear Fork at and in the vicinity of Fort Worth. The runoffs shown are the observed runoffs and have not been corrected for reservoir storage or evaporation. The locations of the stream-gaging stations are shown on plate 4.

Station	Drainage area (sq.mi.)	Period of record	Annual runoff (inches)*		
			Maximum	Minimum	Average
West Fork at Bridgeport	1,147	1908-1930	6.39	0.58	2.44
Big Sandy Creek nr Bridgeport	332	1936-1958	13.74	0.09	3.60
West Fork nr Boyd	1,729	1947-1958	6.03	0.45	1.94
West Fork at Lake Worth Dam above Fort Worth	2,069	1923-1934	4.53	0.26	2.06
Clear Fork at Fort Worth	526	1924-1958	8.28	0.12	2.75
West Fork at Fort Worth	2,627	1920-1958	8.44	0.08	2.23

*Water year, October through September

20. FLOODS.- The maximum floods recorded at the gage on the Clear Fork in Fort Worth were in 1922 with a peak of 74,300 second-feet and in 1949 with a peak of 107,000 second-feet. Operation of Benbrook Reservoir would reduce the peak flow at the Fort Worth gage on the Clear Fork to an estimated 26,000 second-feet. Historical information indicates that a major flood occurred in May 1908. Only limited data are available for this flood; however, studies based upon these data indicate that, with the present reservoirs in operation, the flood of May 1908 would have been about the same magnitude as the flood of May 1957, which produced a peak flow of 14,200 second-feet at the Fort Worth gage on the Clear Fork. The reconstructed flood series indicates that 13 damaging floods (more than 8,000 second-feet) were experienced in the problem area on the Clear Fork from 1900 through 1957 and that six of these floods exceeded the May 1957 flood.

21. The maximum floods recorded at the gage on the West Fork in Fort Worth occurred in 1922 with a peak flow of 85,000 second-feet and in 1949 with a peak flow of 64,300 second-feet. Operation of the existing reservoirs on the West Fork and Benbrook Reservoir on the Clear Fork would reduce the peak flow of 85,000 second-feet to an estimated 36,000 second-feet on the West Fork at the Fort Worth gage and 45,000 second-feet on the West Fork downstream from Sycamore Creek. The flood of May 1908, which was discussed in paragraph 20, would have had a peak flow of 26,800 second-feet at the Fort Worth gage on the West Fork with the present upstream reservoirs in operation. The channel capacity on the West Fork downstream from the problem area is 7,000 second-feet. In the problem area the bankfull capacity at the smallest section is 10,000 second-feet; however, appreciable damage does not occur until a discharge of 20,000 second-feet is attained. The reconstructed flood series (1900 - 1957) in the problem area indicates that six of the floods would have exceeded damaging stage and three of the floods would have exceeded the May 1957 floods.

FLOODED AREAS AND FLOOD DAMAGES

22. GENERAL- The flood plains under study consist of two separate problem areas, one on the West Fork of the Trinity River immediately downstream from the existing Fort Worth Floodway, and the other on the Clear Fork of the Trinity River immediately upstream of the existing Fort Worth Floodway.

23. Information for analyzing economic aspects of the flood problems was obtained through a survey involving personal interviews and correspondence with property owners, municipal officials, engineers, and residents of the areas subject to flooding. Inspections were made of all property subject to flood damage. The flood plains investigated in detail are those for the flood of May 1949 (as modified by Benbrook Reservoir), the maximum flood of record in the areas being studied in this report. The flood plains resulting from this flood are shown on plates 2 and 3.

24. DEVELOPMENT IN THE WEST FORK FLOOD PLAIN.- The flood plain of the West Fork problem area contains limited commercial and residential sections with streets and utilities, a sewage disposal plant, a commercial egg-processing facility, a drive-in theater, a small private hospital, producing gravel pits, and some agricultural land, a portion of which is used for grazing.

25. The flood plain under study on the West Fork has a total area of about 2,975 acres, exclusive of 115 acres of channel area. The total value of physical property within this area is estimated at $12,087,000 based on January 1960 prices and values. A breakdown of this property value by principal classes is given in table 1.

TABLE 1

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
WEST FORK OF THE TRINITY RIVER
(January 1960 Price Level)

Item	Amount
Urban property - Fort Worth	
Residential property	$ 240,000
Business and industrial property	2,570,000
Recreational facilities (private)	15,000
Churches	9,000
City property	
Streets and bridges	88,000
Sewage system	6,800,000
Water supply system	100,000
Local utilities	102,000
County roads and bridges	248,000
Railroads and bridges	81,000
Highways	180,000
Undeveloped land	1,654,000
Total	$12,087,000

26. FLOOD DAMAGES ON THE WEST FORK.- The flood damage data obtained through an economic survey in the field formed the basis for estimating the average annual damages. These data included the flood of May 1949 (as modified by Benbrook Reservoir). Based on backwater computations for selected rates of discharge and estimates of damages at various elevations of flooding, stage-damage relationships were developed. By use of rainfall records, gage records on the West Fork of the Trinity River, synthetic unit hydrographs, and historical flood information furnished by local interests and observed by personnel of the Fort Worth District, relationships between peak stage and frequency were developed.

27. It is estimated that a recurrence of the May 1949 flood (as modified by Benbrook Reservoir) under the present conditions of flood plain development would result in estimated damages to the West Fork problem area of $560,000 as shown on table 2. From the stage-damage and stage-frequency relationships described in paragraph 26, a damage-frequency curve was constructed and used to compute the average annual damages. The average annual damages to the West Fork problem area under existing conditions are estimated to be $41,000.

TABLE 2

ESTIMATED DAMAGES UNDER PRESENT STATE OF
DEVELOPMENT FROM A FLOOD EQUAL TO THAT OF MAY 1949
(Modified by Benbrook Reservoir)
WEST FORK OF THE TRINITY RIVER
(January 1960 Price Level)

Item	Damages
1. Urban property - Fort Worth area	
Residential property	$ 70,500
Business and industrial property	221,000
Recreational facilities (private)	1,000
Churches	1,000
City property	
Streets and bridges	4,300
Sewage system	68,000
Water supply system	5,000
Local utilities	3,800
Railroads	8,000
County roads and bridges	23,200
Highways	900
Crops and livestock	47,000
2. Loss of wages	30,000
3. Interruption to traffic and communications	50,000
4. Cost of rescue work and policing	8,300
5. Cost of combating insects and disease	8,000
6. Cost of relief and care of flood victims	10,000
Total damages	$560,000

28. DEVELOPMENT IN THE CLEAR FORK FLOOD PLAIN.- The flood plain of the Clear Fork problem area contains several extensive residential and commercial sections, including attendant urban development, such as streets and utilities; a public recreation park with picnicking facilities, rides and other concessions, and an aquarium, all municipally operated; a portion of a large privately-owned golf course; a private recreational park with picnicking facilities and riding stables; a municipal water pumping plant; a large public school building; and an area of residential and commercial development now under construction or on which final planning has been completed.

29. The flood plain under study on the Clear Fork has a total area of about 1,447 acres, exclusive of 96 acres of channel area. The total value of physical property within this area is estimated at $32,487,000 based on January 1960 prices and values. A breakdown of this property value by principal classes is given in table 3.

TABLE 3

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
CLEAR FORK OF THE TRINITY RIVER
(January 1960 Price Level)

Item	: Amount
Urban property - Fort Worth area	
Residential property	$14,573,000
Business and industrial property	8,883,000
Recreational facilities (private)	1,058,000
Schools	505,000
City property	
Parks	2,392,000
Streets and bridges	1,531,000
Sewage system	813,000
Water supply system	842,000
Local utilities	416,000
State highways	847,000
Railroads	113,000
Undeveloped land	514,000
Total	$32,487,000

30. FLOOD DAMAGES ON THE CLEAR FORK.- The basis for estimating the average annual damages was the same as that used for the West Fork as discussed in paragraph 26. A recurrence of the May 1949 flood (as modified by Benbrook Reservoir) under the present conditions of flood plain development would result in estimated damages to the Clear Fork problem area of $4,286,000 as shown in table 4. From the stage-damage and stage-frequency relationships described in paragraph 26 above, a damage-frequency curve, shown as curve A on plate 25, was constructed and used to compute the average annual damages. The average annual damages to the Clear Fork problem area under existing conditions are estimated to be $374,900.

TABLE 4

ESTIMATED DAMAGES UNDER PRESENT STATE OF DEVELOPMENT
FROM A FLOOD EQUAL TO THAT OF MAY 1949
(Modified by Benbrook Reservoir)
CLEAR FORK OF THE TRINITY RIVER
(January 1960 Price Level)

Item	Damages
1. Urban property - Fort Worth area	
Residential property	$2,237,000
Business and industrial property	1,279,000
Recreational facilities (private)	70,000
School	54,000
City property	
Park	97,000
Streets and bridges	21,000
Sewage system	29,000
Water supply system	29,000
Local utilities	43,000
State highways	16,000
Railroads	10,000
Undeveloped land	29,000
2. Loss of wages	116,000
3. Interruption to traffic and communications	125,000
4. Cost of rescue work and policing	68,000
5. Cost of combating insects and disease	32,000
6. Cost of relief and care of flood victims	31,000
Total damages	$4,286,000

EXISTING CORPS OF ENGINEERS FLOOD CONTROL PROJECTS

31. GENERAL.- The existing flood control projects constructed by the Corps of Engineers on the West Fork and Clear Fork watersheds are the Benbrook Reservoir and the Fort Worth Floodway. Locations of the projects are shown on plate 1. These projects were authorized by the River and Harbor Act of March 2, 1945 (Public Law No. 14, 79th Congress, 1st Session), as a part of a comprehensive plan of improvement for the Trinity River Basin.

32. BENBROOK RESERVOIR.- The Benbrook Reservoir project was constructed for flood control and water conservation (navigation) purposes on the Clear Fork at about river mile 15.0, just southwest of the city of Fort Worth. The project was in operation on September 29, 1952. The flood control portion of the project, which provides for the control of major flood flows originating on 433 square miles of drainage area upstream from Benbrook Dam, affords a measure of protection to the flood plains downstream from the dam. In conjunction with the Fort Worth Floodway, the Benbrook Reservoir affords a high degree of protection to the leveed areas within the city of Fort Worth. The water conservation portion of the Benbrook Reservoir project is designated as navigation storage and will provide part of the water required for any future canalization of the Trinity River. Studies and investigations for possible canalization of the Trinity River are currently in progress as part of the comprehensive survey of the Trinity River and tributaries. Congress authorized the Secretary of the Army in Public Law 782, 84th Congress, 2nd Session, to contract with the city of Fort Worth for the use of the water conservation storage in Benbrook Reservoir for municipal water supply until the water conservation storage is needed for navigation purposes.

33. The uncontrolled spillway at Benbrook Dam has a total length of 500 feet, consisting of an ogee section 400 feet long with crest at elevation 724.0, and a notch section 100 feet long in the center of the spillway with crest at elevation 710.0. Below spillway crest elevation 724.0, Benbrook Reservoir has a total storage capacity of 258,600 acre-feet including 170,350 acre-feet for flood control, 72,500 acre-feet for water conservation (navigation), and 15,750 acre-feet for sedimentation. Generally, the plan for regulation of Benbrook Reservoir for flood control provides that regulated releases from the flood control storage be limited to such rates that the total stream flow on the Clear Fork downstream from the reservoir and on the West Fork to Dallas will not exceed 6,000 second-feet. At normal pool elevation 694.0, the reservoir surface extends approximately 10.6 miles upstream from Benbrook Dam. The Benbrook Reservoir project has a current estimated project first cost of $11,088,000 based on July 1958 prices. The average annual cost of maintenance and operation during the 5-year period ending June 30, 1958, was $50,269. The total project costs to June 30, 1958, were $10,834,444 for new work and $289,705 for maintenance.

34. FORT WORTH FLOODWAY.- The improved channel of the Fort Worth Floodway project extends on the West Fork from about river mile 551.5, just upstream of the Riverside Drive bridge, to about river mile 564.7, just downstream of the lower White Settlement Road bridge, and extends on the Clear Fork from the confluence of the West and Clear Forks upstream to about river mile 1.6, just downstream of the West Lancaster Street bridge. The construction of the existing Fort Worth Floodway project involved about 58,200 feet of channel improvements by enlargement, straightening, and clearing; the construction of about 15,800 feet of new levee; the strengthening of about 57,300 feet of existing levee previously constructed by local interests; the stabilization of embankment and channel slopes; and miscellaneous installation, alteration, and relocation works pertaining to highways, roads, railroads, and drainage structures. The floodway design capacities of the Fort Worth Floodway are 95,000 second-feet on the West Fork downstream from the mouth of the Clear Fork, 75,000 second-feet on the Clear Fork, and 50,000 second-feet on the West Fork upstream from the mouth of the Clear Fork. The floodway design capacities are approximately the same as the peak discharges of the standard project flood. The establishment of the above design capacities included consideration of the flow and discharge conditions through the Fort Worth Floodway as affected by the Benbrook Reservoir on the Clear Fork, as well as by the existing Lake Bridgeport, Eagle Mountain Lake, and Lake Worth reservoirs on the West Fork. Based on the July 1958 price level, the Fort Worth Floodway project has a current total estimated first cost of $9,547,000, of which $3,904,100 is estimated Federal cost and $5,642,900 is the estimated cost of non-Federal participation. Of the total project estimated first cost, $4,278,494 was for new work, of which $3,882,566 was from regular Federal funds and $395,928 was from contributed funds.

35. ADEQUACY OF EXISTING PROJECTS.- The only severe storm experienced on the West Fork watershed since the construction of the Benbrook Reservoir and Fort Worth Floodway projects was during the period of April-June 1957, when intense rainfall occurred over the upper Trinity Basin. The Fort Worth Floodway operated as designed and safely passed the resultant peak discharges occurring on the West and Clear Forks. Benbrook Reservoir adequately controlled several peak inflows which varied from 18,000 second-feet to 32,600 second-feet during the storm period and afforded a considerable measure of flood control and protection during the occurrence and passage of the maximum peak discharges on the West and Clear Forks through the Fort Worth Floodway. The maximum peak discharges experienced at Fort Worth during the storm period occurred on May 25, 1957, and were 14,200 second-feet on the Clear Fork and 26,800 second-feet on the West Fork just downstream from the mouth of the Clear Fork. At the time of these peak discharges, there were no releases from Benbrook Reservoir; however, there was a maximum discharge of 19,200 second-feet recorded at Lake Worth Dam on the West Fork. Subsequent to the construction

of the Benbrook Reservoir and Fort Worth Floodway projects, there have been extensive urban developments on the Clear Fork between the head of the floodway project and Benbrook Dam and on the West Fork between the head of the floodway project and Lake Worth Dam, where the minimum channel capacities are about 8,000 and 5,000 second-feet respectively. The West Fork reach upstream from the existing floodway project experienced extensive flood damages while only moderate flood damages were experienced in the West Fork reach just downstream from the floodway project and in the Clear Fork reach just upstream from the floodway project.

IMPROVEMENTS BY OTHER FEDERAL AGENCIES

36. SOIL CONSERVATION SERVICE.- The Soil Conservation Service, U. S. Department of Agriculture, has been authorized by the Flood Control Act, approved December 22, 1944, to undertake a program of runoff and waterflow retardation and soil-erosion prevention in the upper Trinity River Basin, including the West Fork watershed. The above authorization was based on the recommendations contained in House Document No. 708, 77th Congress, 1st Session. Based upon information presented at the hearings before the subcommittee of the Committee on Appropriations, House of Representatives, 85th Congress, 2nd Session, for fiscal year 1959, the authorized program on the upper Trinity River Basin has a total estimated Federal cost of $80,274,576 and the total Federal obligations through June 30, 1957, amounted to $14,518,668.

37. Under the authorized program, the Soil Conservation Service has constructed on the West Fork watershed 48 flood-water-retarding reservoirs and 1.63 miles of channel improvement at a total Federal construction cost of about $1,991,520, and has participated in land treatment measures over a period of 12-1/2 years at a total Federal cost of about $1,025,300. The 1.63 miles of floodway and 15 of the flood-detention reservoirs are located in the West Fork area upstream from Eagle Mountain Lake and the remaining 33 flood-detention reservoirs are located in the Clear Fork area upstream from Benbrook Reservoir. The reservoirs provide a total storage of 40,076 acre-feet, of which 33,088 is for flood detention and 6,988 is for sedimentation. Local interests participated in the cost of the reservoirs to the extent of furnishing the required lands. The locations of the constructed reservoirs and the floodway are shown on plate 1.

38. The Soil Conservation Service has planned 33 additional flood-detention reservoirs under the authorized program on the planned subwatersheds upstream from Eagle Mountain Lake and Benbrook Reservoir at an estimated Federal construction cost of approximately $1,436,760. The planned structures would provide a total storage of 40,273 acre-feet, including 34,134 acre-feet for flood-detention and 6,139 acre-feet for sediment.

IMPROVEMENTS BY NON-FEDERAL AGENCIES

39. GENERAL.- The existing improvements constructed by non-Federal interests on the West Fork watershed upstream from and in the vicinity of Fort Worth consist of seven reservoirs, one channel dam (Nutt Dam) on the West Fork at Fort Worth, and two small levee systems on the Clear Fork at Fort Worth. Pertinent data for these improvements are presented in table 5 and locations are shown on plates 1, 2, and 3. In addition, there are five small channel dams on the Clear Fork for water supply purposes. The records of the State Board of Water Engineers indicate that permits in regard to the appropriation of water were filed by E. G. Rall in 1914 for irrigation purposes, by the City of Fort Worth in 1914 for municipal purposes, and by the Texas and Pacific Railway Company in 1923 for industrial purposes. The locations of the Rall Dam, City Dams 2, 3, and 4, and the Texas and Pacific Railway Dam are shown on plate 3.

40. PRINCIPAL IMPROVEMENTS.- The principal improvements made by local interests, which are related to the subject problem area on the West Fork, are the Lake Bridgeport, Eagle Mountain Lake, and Lake Worth reservoirs. These reservoirs, in the order named above, are located on the West Fork about 69, 25, and 13 river miles upstream from the confluence of the West Fork with the Clear Fork within Fort Worth. The Lake Bridgeport and Eagle Mountain Lake reservoirs were constructed in 1932 and 1934, respectively, by the Tarrant County Water Control and Improvement District Number One, principally for water conservation purposes. Releases from Lake Bridgeport are controlled by three 48-inch and one 30-inch valves and a 60-foot ogee spillway consisting of two gated and one ungated 20-foot bays. Flows from Eagle Mountain Lake are controlled by four 48-inch valves and a 100-foot ogee spillway consisting of three gated and one ungated 25-foot bays. The Lake Worth reservoir was constructed in 1913 by the city of Fort Worth for industrial and municipal water supply purposes. Flows from Lake Worth are regulated by a 36-inch valve and an uncontrolled 700-foot ogee concrete spillway. These three reservoirs provide some degree of protection for the areas downstream from the reservoirs during floods that might occur when reservoir storages are below spillway crest. The surcharge storage between spillway crest and top of gates is 534,500 acre-feet at Lake Bridgeport and 458,000 acre-feet at Eagle Mountain Lake. Since the spillways are relatively narrow at these two reservoirs, the surcharge storage will reduce flood peaks even when the spillway crest elevation is exceeded. Lake Worth also has some effect in the reduction of flood peaks. Even though the three reservoirs are effective in reducing flood peaks originating on the drainage area upstream from the dams, hydrologic studies indicate that a discharge of about 50,000 second-feet is possible in the problem area on the basis of the standard project storm centered between Eagle Mountain Reservoir and the head of the existing Fort Worth Floodway.

TABLE 5

IMPROVEMENTS BY NON-FEDERAL AGENCIES

Name	Ownership	Purpose	Location		Drainage area above dam (sq.mi.)	Reservoir capacity (2) (ac. ft.)	Year constr.	Cost
			Stream	R.M.				
Lake Worth	City of Ft. Worth	Water conservation	West Fork	572.1	2,069	33,700	1913	$1,600,000
Eagle Mountain Lake	WCID (1)	Water conservation	West Fork	583.3	1,974	181,900	1934	3,637,000
Lake Bridgeport	WCID (1)	Water conservation	West Fork	626.2	1,114	269,300	1932	2,316,000
Amon Carter Reservoir	City of Bowie	Water conservation	Big Sandy	31.0	103	20,000	1956	281,608
Marine Creek Reservoir	WCID (1)	Flood control and recreation	Marine Creek	4.7	10	15,366	1957	800,000
Cement Creek Reservoir	WCID (1)	Flood control and recreation	Cement Creek	--	4	3,952	1957	
Nutt Dam	Texas Electric Service Co.	Cooling water for steam electric generating plant	West Fork	558.3	2,627	5	1957	321,400
Weatherford Reservoir	City of Weatherford	Water conservation	Clear Fork	39.8	105	19,470	1956	422,088
Crawford Levee (3,785')	City of Ft. Worth	Flood control	Clear Fork	1.9	NA	NA	1956	74,500
Ft. Worth Water Works Levee (1,515')	City of Ft. Worth	Flood control	Clear Fork	1.4	NA	NA	1910	Unknown

(1) Tarrant County Water Control and Improvement District Number One
(2) Capacities shown reflect the latest known sedimentation surveys
NA - Not Applicable

41. OTHER IMPROVEMENTS.- Other improvements which provide flood protection to the Fort Worth area are the Marine Creek and Cement Creek Reservoirs on the Marine Creek subwatershed, and two levees located on the right bank of the Clear Fork at the head of the existing Fort Worth Floodway project. The Marine Creek and Cement Creek Reservoirs were constructed in 1957 (on Marine Creek, a tributary to the West Fork at Fort Worth just downstream from the mouth of the Clear Fork) by the Tarrant County Water Control and Improvement District Number One for flood control and recreational purposes. The two reservoirs provide flood protection to the local area between the dams and the West Fork channel. The two levees are the Fort Worth City Water Works levee and the Crawford levee constructed by the city of Fort Worth in 1910 and 1956, respectively, for protection of the city's water plant and certain urban areas on the Clear Fork.

IMPROVEMENTS DESIRED

42. PUBLIC HEARING.- A public hearing was held in Fort Worth, Texas, on February 19, 1958, concerning possible improvements for flood control and allied purposes on the West Fork watershed in the Fort Worth area. The proceedings of the hearing are available for review in the Office, Chief of Engineers, Washington, D. C., and in the U. S. Army Engineer District Office, Fort Worth, Texas. Federal,State, and local agencies, business and industrial concerns, and other local interests were given an opportunity at the hearing to express their opinions concerning the aforementioned improvements. The following State and Federal governmental representatives and agencies submitted briefs or proposals for the record either before, during, or after the hearing: Honorable James C. Wright, United States House of Representatives, sponsor of the subject investigation; Honorable Ralph W. Yarborough, United States Senate; Southwestern Power Administration, Bureau of Indian Affairs, and the Trinity River Authority of Texas. The Federal and State governmental agencies represented at the hearing were the U. S. Soil Conservation Service, U. S. Weather Bureau, U. S. Bureau of Sport Fisheries and Wildlife, U. S. Department of Agriculture, and the Texas State Board of Water Engineers.

43. IMPROVEMENTS DESIRED BY LOCAL INTERESTS.- Most of the improvements suggested by local interests were presented by officials of the city of Fort Worth and were indorsed by various State and local agencies and organizations, including the Tarrant County Water Control and Improvement District Number One, the Trinity River Authority, the Trinity Improvement Association, and the Fort Worth Chamber of Commerce. The principal improvements and investigations requested by local interests are summarized briefly as follow:

a. Investigation of the floodway channel through Fort Worth for the purpose of considering the following:

(1) Extension of the existing project upstream on the West Fork to the vicinity of Lake Worth Dam, downstream on the West Fork to some point downstream from East First Street, and upstream on the Clear Fork to Marys Creek.

(2) Installation of pumps for the discharge of interior drainage runoff behind the levee systems of the existing floodway project and of any proposed floodway extension.

(3) Provision of additional channel-slope protection for the existing Fort Worth Floodway.

b. Investigation of new reservoirs for flood control, water conservation, and other purposes, particularly on the following streams:

(1) Marys Creek, one of the principal tributaries of the Clear Fork.

(2) Silver Creek, a tributary of the West Fork at Lake Worth.

(3) West Fork in the vicinity of Boyd, Texas, between Eagle Mountain Lake and Lake Bridgeport.

(4) Big Fossil Creek, a tributary of the West Fork just downstream from Fort Worth.

c. Investigation of existing reservoirs on the West Fork to determine their adequacy based on current engineering criteria and the additional runoff data now available.

d. Yield-determination studies of the West Fork area upstream from Lake Worth Dam and of the Clear Fork area upstream from Benbrook Dam to reflect rainfall records of recent years and also to reflect the effects of the authorized flood prevention and soil treatment program of the Soil Conservation Service.

e. Investigation of the feasibility of installing flood release facilities through Lake Worth Dam to provide positive control of the lake level to about four feet below spillway crest with a view to affording a measure of flood control during passage of minor flood flows.

44. Those proposals relating to the flood problem in the reach of the West Fork between the existing Fort Worth Floodway and Lake Worth Dam, including proposals in regard to new reservoir projects on Silver Creek and on the West Fork near Boyd, Texas, were considered in Part I of this report. The request for a reservoir on Big Fossil Creek was

discussed in a separate interim report covering that stream. As stated in paragraph 7b, the interior drainage improvements in item a(2) above were given consideration in House Document No. 242, 81st Congress, 1st Session, and were not found to be justified. Current investigations indicate that conditions within the interior drainage areas have not changed sufficiently to justify the addition of pumping plants. Consideration of the proposals contained in items c, d, and e above, including reconsideration of the Boyd Reservoir on the upper West Fork, will be included in the comprehensive survey report covering the Trinity River Basin, currently being prepared by the Fort Worth and Galveston Districts. Those proposals relating to a reservoir on Marys Creek and to the downstream and upstream extensions of the existing Fort Worth Floodway project on the West Fork and the Clear Fork, respectively, are considered herein.

WATER PROBLEMS

45. GENERAL.- The water problems in the areas investigated in and adjacent to the city of Fort Worth consist principally of the flooding of residential, commercial, and agricultural areas located within the flood plains of the West Fork and the Clear Fork of the Trinity River. These flood problem areas are located as follow: (a) the West Fork between Handley-Ederville Road at about river mile 541.6 and the downstream end of the existing Fort Worth Floodway channel improvement at river mile 551.5, just upstream from Riverside Drive, (b) Clear Fork between the upstream end of the existing Fort Worth Floodway at about river mile 1.6 and Benbrook Dam at about river mile 15.0, and (c) Marys Creek between its mouth and the investigated dam site at about river mile 7.7. Analyses of the flood problems within the investigated West Fork and Clear Fork reaches revealed that appreciable flood damages may result in the highly developed areas because of inadequate channel capacities to accommodate major flood flows originating on the contributing drainage areas. The Marys Creek reach was investigated to determine the overall benefits of a reservoir project on Marys Creek. This reservoir project was considered principally for the reduction of flood flows on the Clear Fork and for providing a source of additional water supply.

46. WEST FORK DOWNSTREAM FROM THE EXISTING FLOODWAY PROJECT.- The flood plain of the West Fork problem area is not at this time extensively developed and has not developed appreciably since authorization and initiation of construction of Benbrook Reservoir and the Fort Worth Floodway projects. The existing developments consist principally of business and industrial property, city and county improvements, including a sewage disposal plant, and a few inexpensive residential areas. The Fort Worth Planning Board is

considering an industrial development within a large undeveloped portion of this problem area and has requested that a plan of flood protection be investigated for the area. Preliminary planning for this development by the Board has not been initiated.

47. The nondamaging discharge in the West Fork problem area is about 20,000 second-feet, and the bankfull capacity is about 10,000 second-feet at the smallest section of the channel. The flood of April-June 1957, which had a peak discharge of about 26,800 second-feet at the West Fork gage in Fort Worth, caused only a moderate amount of damage in the West Fork flood problem area. The maximum flood of record for the West Fork problem area is the flood of May 1949, modified by Benbrook Reservoir. The estimated peak discharges for this flood, upstream and downstream from the mouth of Sycamore Creek (about river mile 549.9) are 36,000 and 45,000 second-feet, respectively. The flood plain of the West Fork problem area, based on the peak discharges of the maximum flood of record, is shown on plate 2.

48. CLEAR FORK.- The flood plain of the Clear Fork problem area has been extensively developed since authorization and initiation of construction of the Benbrook Reservoir and the Fort Worth Floodway projects. The flood plain developments are concentrated between the head of the Fort Worth Floodway project and the Southwest Loop 217 crossing, which is located just downstream from the mouth of Marys Creek at about river mile 10.4 on the Clear Fork. Existing developments within this reach, progressing downstream from the Southwest Loop 217, consist of the Convair recreational area, the Tanglewood residential area (including Mockingbird Lane Addition), the Colonial Country Club golf course area, the University Drive commercial area, and the Forest Park and Trinity Park recreational areas. Also within this reach are ten bridges of existing highways, roads, and railroads, and numerous crossings of existing urban utilities. The Tanglewood area (including the Mockingbird Lane Addition) is an expensive residential section on the right bank of the Clear Fork. For the area between the existing Tanglewood residential section and the Southwest Loop 217, local interests have completed final planning on a considerable amount of additional residential and commercial developments, certain portions of which are now under construction. The University Drive commercial area is a small, highly-developed area on the left bank of the Clear Fork, presently limited for future expansion by the existing Forest Park recreational areas and facilities. Between the Southwest Loop 217 and Benbrook Dam the flood plain of the Clear Fork is generally undeveloped except for a minor amount of agricultural improvements and activities. However, it is conceivable that the urban developments will be eventually extended by local interests to this area.

49. The bankfull capacity is about 8,000 second-feet at the smallest section of the channel in the Clear Fork problem area. However, the flood of April-June 1957, which had a peak discharge of 14,200 second-feet at the Clear Fork stream-gaging station at river mile 3.2, caused only a moderate amount of damage in the Clear Fork problem area. The maximum flood of record for the Clear Fork problem area is the flood of May 1949, modified by Benbrook Reservoir. The estimated peak discharges for the flood of record on the Clear Fork are about 26,000 second-feet on the Clear Fork below the mouth of Marys Creek and about 6,000 second-feet on the Clear Fork between the mouth of Marys Creek and Benbrook Dam. The flood plain of the Clear Fork problem area, based on the peak discharges of the maximum flood of record, is shown on plates 3, 9, 10, and 11.

50. MARYS CREEK.- The flood plain of Marys Creek downstream from the investigated dam site is generally undeveloped except for a few business and inexpensive residential properties, but additional residential properties are planned by local interests. The bankfull capacity is about 12,000 second-feet at the smallest channel section in the reach investigated and floods have caused only minor damage. The estimated peak discharge for the maximum flood of record (May 1949) increases from about 13,500 second-feet at the investigated dam site to about 20,500 second-feet at the mouth of Marys Creek. The flood plain for Marys Creek below the investigated dam site, based on the peak discharges of the maximum flood of record, is shown on plate 3.

SOLUTIONS CONSIDERED

51. GENERAL.- The improvements considered for resolution of the flood problems of the West Fork and Clear Fork reaches described in paragraph 45 were: (a) channel improvement works, (b) floodway improvements, consisting of channel improvements in conjunction with levees, appurtenant interior drainage facilities, and overbank fill areas, and (c) a reservoir on Marys Creek for flood control and water conservation purposes operating alone or in combination with floodway and channel improvements on the Clear Fork. In view of the magnitude of the potential flood problem, it was considered that any plan of improvement including channel improvement works and overbank fill areas should, as a minimum, provide protection against the maximum flood of record (May 1949 with a once-in-30-years frequency), modified by the Benbrook Reservoir. Accordingly, the channel improvement plans developed for this study were designed to confine the peak discharge of the maximum flood of record within the banks of the improved channels. The modified peak discharges of the maximum flood of record for the investigated problem areas are as follows: West Fork upstream and downstream from Sycamore Creek

(mile 549.9), 36,000 and 45,000 second-feet, respectively; Clear Fork, 26,000 second-feet below the mouth of Marys Creek and about 6,000 second-feet between the mouth of Marys Creek and Benbrook Dam; and Marys Creek, about 13,500 second-feet at the investigated dam site (mile 7.7) increasing to about 20,500 second-feet at the mouth of Marys Creek.

52. Since the channel improvement plans would provide only partial protection against the standard project flood, consideration was given to providing full protection against the peak discharges of the floodway design (standard project) floods by the addition of levees and overbank fill areas. The peak discharges for the floodway design and standard project floods (frequency of less than one occurrence per 100 years) for the various problem areas investigated are: 95,000 second-feet on the West Fork below the existing Fort Worth Floodway project; 75,000 second-feet on the Clear Fork below the mouth of Marys Creek;45,000 second-feet on the Clear Fork between the mouth of Marys Creek and Benbrook Dam; and 46,000 second-feet on Marys Creek from its mouth to the Texas and Pacific Railway bridge. Each of the possible solutions developed by means of the improvements in items (a), (b), and (c) above were studied sufficiently to determine its suitability and its economic merit. A summary of cost and benefits for investigated plans and improvements is presented in paragraph 67 and table 6.

53. In considering the various types of flood protection works, items (a) and (b) above, master floodway extension plans were developed for the West and Clear Forks problem areas being covered in this report. Even if not economically justified at this time, the overall master floodway plans will provide pertinent information on the magnitude and requirements of future protective works which will be helpful to local interests with respect to the establishment of building restriction limits and to the construction of future roads, bridges, utilities, and other urban developments within the subject problem areas.

54. SOLUTIONS CONSIDERED FOR THE WEST FORK.- To provide protection to the most highly developed portions of the problem area on the left bank of the West Fork, consideration was given to the feasibility of providing 27,800 feet of channel improvement (plan C) between the downstream limits (river mile 551.5) of the existing Fort Worth Floodway and river mile 545.8. A plan (floodway plan C) was also investigated to determine the feasibility of the addition of levees and appurtenant interior drainage facilities to the above channel improvement works to provide protection against discharges of the standard project flood. A lesser degree of protection by lower-height levees for this more-developed area was not considered advisable because of the catastrophic consequences that would result if floods of the standard project magnitude would occur. In addition, an investigation was made of the merits of extending the channel

improvement works downstream from mile 545.8 to mile 541.1 with and without a major cutoff between river miles 544.6 and 548.1 as suggested by local interests. Channel improvement works between river miles 551.5 and 541.1 (plan B), without the referenced cutoff, were found to be more economical. Studies were also made of the feasibility of the addition of levees and appurtenant interior drainage facilities between river miles 545.8 and 541.1. The channel improvement works and levees between river miles 551.5 and 541.1 are designated herein as master floodway plan B and are shown on plate 2. Cost and benefit data on the plans reported herein are contained in table 6. The annual charges for the various plans studied greatly exceeded the annual benefits. The most feasible plan for the West Fork (consisting of the channel improvements between river miles 551.5 and 545.8) has a benefit-cost ratio of only 0.3. Accordingly, additional improvements on the West Fork are not considered to be economically justified at this time.

55. SOLUTIONS CONSIDERED FOR THE CLEAR FORK.- The Tanglewood area and the area upstream therefrom on the right bank to the Southwest Loop 217, including the Convair recreational area, is a highly and rapidly developing residential area with some commercial developments. Because it is reasonable to expect future floods in the area to approach the magnitude of the standard project flood and in consideration of the catastrophic consequences that would obtain therefrom to life and property within the vicinity of the Tanglewood and Convair sections, it is considered essential and a necessity from a sound planning and engineering viewpoint to provide the referenced areas, as a minimum, protection against the floodway design and standard project flood discharges. On the other hand, as stated in paragraph 48, the remaining area downstream from the Tanglewood area to the head of the Fort Worth Floodway is principally a recreational area, containing the Colonial Club golf course and the Forest Park and Trinity Park recreational areas. Also, within this general reach is the University Drive commercial area, which is a small but highly-developed area along University Drive, presently limited for future expansion by the dedicated recreational areas. For these lesser developed and populated areas, it was concluded that the minimum desirable degree of protection to the areas subject to overflow should be against the maximum floods of record as modified by the Benbrook Reservoir. To accomplish the above degrees of protection, the basic plan of improvement considered for the Clear Fork included channel improvements between the existing Fort Worth Floodway and Southwest Loop 217 and levees for the protection of the Tanglewood and Convair areas (vicinity of miles 6.0 and 9.5, respectively).

56. One alignment was investigated in detail for the channel improvement and floodway extension works, but alternate considerations were given to sump capacities, pumping plants, levees, concrete

floodways, and overbank fill areas in lieu of levees. The channel improvements, levees, and overbank fill areas investigated are shown on plate 3. Profiles pertaining to the investigated improvements are shown on plates 13, 14, and 15.

57. The cost of hauling and disposing of the large amounts of excess materials from the channel excavation work is an important factor in the development of the most practical and economical plan of improvement for the Clear Fork problem area. Therefore, in lieu of certain levees and appurtenant interior drainage facilities, consideration was given to utilizing the excess materials from the channel excavation work for filling certain undeveloped areas to elevations about two feet above the floodway design water surface.

58. The study indicated that the most economical plans for the Clear Fork should include overbank fill areas 1, 2, 3, and 4, as shown on plate 3, in lieu of the levee within the highly-developed reach on the right bank between the Tanglewood residential and Convair recreational areas, the investigated levee for protection of the undeveloped areas along the left bank of the Clear Fork opposite and upstream from the Tanglewood area, and a levee for the protection of the partially developed industrial area on the right bank of the Clear Fork just below the East-West Freeway. The study also showed that the overbank fill areas considered herein are the most practical and economical method of disposing of fill material because significant additional haul cost would be required if the subject areas were not available. (See paragraphs 98 and 99 as to information furnished to local interests on this matter.)

59. The adoption of the overbank fill areas 1, 2, 3, and 4 resulted in the establishment of three principal plans of improvement as follows: plan A, the basic plan, consisting of channel improvement work between the existing Fort Worth Floodway project and Southwest Loop 217, the Tanglewood and Convair levees, and the overbank fill areas 1, 2, 3, and 4; plan B, consisting of plan A with the addition of the University Drive levee; and plan C, the master floodway plan, consisting of plan B with the addition of the channel improvement works and overbank fill areas for the protection of the agricultural and undeveloped areas along the 4.6-mile reach of the Clear Fork between the Southwest Loop 217 and the vicinity of Benbrook Dam, and the 1.3-mile reach of Marys Creek between its mouth and the Texas and Pacific Railway crossing.

60. ANALYSES OF CHANNEL AND FLOODWAY IMPROVEMENTS ON THE CLEAR FORK.- Economic and cost analyses indicate that the basic plan A, which provides a combination of full and partial flood protection for the 8.8-mile reach of the Clear Fork between the existing Fort Worth Floodway project and the Southwest Loop 217, is economically justified. The plan would provide full protection against the floodway design

discharge by means of levees for the Tanglewood residential and Convair recreational areas and by means of overbank fill areas for areas along the Clear Fork, including the right-bank area between the Tanglewood and Convair levees, the left-bank areas opposite the Tanglewood and Convair levees, and the right-bank area just below the East-West Freeway. The plan would provide partial flood protection by means of channel improvement works for the remaining areas of the 8.8-mile reach, including the University Drive commercial area, the Forest Park and Trinity Park recreational areas, and the Colonial Country Club golf course area. The analyses also indicated that the Tanglewood and Convair levees would be constructed at an estimated incremental annual cost of $44,800, would provide incremental annual flood control benefits of $57,000, and thus would have a favorable benefit-cost ratio of 1.3.

61. The analyses reveal that the addition of levees to plan A for the protection of the University Drive commercial area against the standard project flood is not justified. The cost of adding the University Drive levee, which includes such appurtenant works as levee sluices, a pumping plant, and the raising of the St. Louis, San Francisco, and Texas Railway bridge, the Texas and Pacific Railway bridge, the University Drive roadway and bridges, and the Rogers Avenue bridge, greatly exceeds the added benefits derived from such improvements and alterations.

62. The analyses also indicate that the further addition of channel improvements and overbank fill areas for protection of the agricultural and undeveloped areas of the Clear Fork and Marys Creek upstream from the Southwest Loop 217 against discharges of the standard project flood is not justified.

63. The investigations reveal that enlargement of the basic channel improvement works in plan A to provide protection for the University Drive commercial area and other areas downstream from the Tanglewood levee against a peak discharge having a frequency of occurrence of about once in 50 years is not economically justified. Discharge-frequency studies disclose that the design peak discharge of 26,000 second-feet adopted for the basic channel improvement works would recur on an average of about once in 30 years and that protection against a 50-year flood would require enlargement of the basic improved channel to contain a discharge of 36,000 second-feet. The residual damages within the problem areas downstream from the Tanglewood levee would be about $9,000 annually on the basis of the improved channel of plan A. The area which would be inundated by a discharge of 36,000 second-feet on the basis of improved conditions under plan A is shown on plate 9. Under these conditions, flood damages of about $138,000 would be experienced within the inundated area.

64. RESERVOIR ON MARYS CREEK.- Reservoir site studies indicated that the most practical and economical reservoir site on Marys Creek is located upstream from U. S. Highways 80 and 180. The reservoir site, with dam at creek mile 7.7, is located within a generally undeveloped area, where land-acquisition and relocation costs would be relatively inexpensive. Such a site, however, would control only about 41 percent (24 square miles) of the total Marys Creek drainage area. A reservoir site to control a larger portion of the Marys Creek drainage area was considered. However, the site investigations disclosed that a reservoir constructed further downstream, between U. S. Highways 80 and 180 and the mouth of Marys Creek, would be within an urban area, and thus would be extremely costly because of high land-acquisition and relocations costs.

65. A reservoir on Marys Creek, with dam at river mile 7.7, was investigated as follows: (a) A single purpose project for flood control; (b) a dual-purpose project for flood control and water conservation; (c) a multiple-purpose project for flood control, water conservation, and fish and wildlife; and (d) a multiple-purpose project for flood control, water conservation, fish and wildlife, and recreation. A summary of economic and cost analyses of the various Marys Creek Reservoir projects investigated on the basis of operating without the investigated floodway and channel improvement works on the Clear Fork is as follows:

Purpose	First Cost	Annual charges	Annual benefits	Benefit-cost ratio
FC	$5,620,000	$232,000	$279,500	1.2
FC, WC	7,262,000	315,500	361,700	1.1
FC, WC, FW	7,550,000	333,500	436,700	1.3
FC, WC, FW, R	7,800,000	350,100	586,700	1.7

The investigated Marys Creek Reservoir projects include 20,200 acre-feet of water conservation storage, sufficient to develop the maximum dependable yield of 3.45 second-feet, or about 2.23 million gallons daily, under existing watershed conditions. The water supply benefits of $82,200 are based on a unit value of raw water for industrial and municipal purposes of $0.101 per 1,000 gallons as estimated by the Department of Health, Education, and Welfare for this amount of dependable yield from alternative sources in the Fort Worth area. The fish and wildlife benefits of $75,000 annually are principally for sport fishing and are estimated on the basis of an annual visitation of 75,000 persons and a value of $1.00 per visitor-day. The general recreation benefits are based on an additional annual visitation of 300,000 persons and a value of $0.50 per visitor-day. The studies determined, however, that a flood control reservoir on Marys Creek, operating alone and controlling a drainage area of only 24 square miles, would not reduce appreciably the peak discharges of either the

TABLE 6

SUMMARY OF COST AND ECONOMIC STUDIES - SOLUTIONS CONSIDERED

Plan description	First cost	Annual charges: Incremental	Annual charges: Total	Annual benefits: Incremental	Annual benefits: Total	Benefit-cost ratio
		CLEAR FORK				
PLAN A (BASIC PLAN) - channel improvement, mile 1.6 to 10.4, Tanglewood and Convair levees, and overbank fill areas 1, 2, 3, and 4	$ 8,025,500	--	$402,700	--	$886,000	2.2*
PLAN B - plan A plus levee for University Drive	10,265,000	$113,900	516,600	$10,400	896,400	0.1**
PLAN C (MASTER PLAN) - plan B plus channel improvements upstream mile 10.4 and overbank fill areas adjacent thereto	12,747,100	113,500	630,100	20,700	917,100	0.2**
PLAN D - plan A plus Marys Creek Reservoir for flood control, water-conservation, fish and wildlife	14,584,100	294,700	697,400	173,900	1,059,900	0.6**
		WEST FORK				
PLAN C - channel improvements, mile 545.8 - 551.5	3,893,200	--	183,600	--	51,600	0.3*
FLOODWAY PLAN C - plan C plus levees	6,211,100	138,700	322,300	4,900	56,500	0.04**
PLAN B - plan C plus 5.7 additional miles channel improvement works, mile 541.1 - 551.5	7,117,000	138,900	322,500	18,700	70,300	0.1**
MASTER FLOODWAY PLAN B - plan B plus levees	10,334,700	218,500	541,000	31,700	102,000	0.1**

* Total

** Incremental

standard project flood or the maximum flood of record on the Clear Fork and, therefore, would not eliminate the need for floodway and channel improvements on the Clear Fork. The peak discharge of the standard project flood with only Benbrook Reservoir in operation would be about 75,400 second-feet at the Fort Worth gage. This would be modified to 68,000 second-feet by construction of Marys Creek Reservoir. The peak discharge of the 1949, or maximum flood of record, on Marys Creek at its mouth has been computed at 20,500 second-feet. Because of the magnitude of the uncontrolled area and the distribution of the 1949 storm below the Marys Creek Dam site, the peak discharge of 20,500 second-feet would be reduced to about 15,500 second-feet at the mouth of Marys Creek by construction of the dam. The peak discharges on the Clear Fork below the mouth of Marys Creek for the 1949 flood, as modified by Benbrook Reservoir only, would be about 21,000 second-feet just below the mouth of Marys Creek and about 26,000 second-feet at the Fort Worth gage. This flood would be further modified by construction of the Marys Creek Reservoir to about 17,000 and 22,000 second-feet below the mouth of Marys Creek and at the Fort Worth gage, respectively.

66. An analysis was made of a plan (plan D) involving the Marys Creek Reservoir as a last-added unit to plan A which is described in paragraphs 29 and 60 and is considered to be the most practicable plan for floodway and channel improvements for the Clear Fork. The investigation of plan D determined that a Marys Creek Reservoir project containing flood control storage would not reduce appreciably the cost of the required local flood protective works on the Clear Fork. The reservoir would reduce the cost of the channel improvement works, including principally the cost of channel excavation and of alterations to bridges, utilities, and channel dams, but would not reduce the design requirements and costs of the Tanglewood and Convair levee units included in plan A. The addition of the reservoir would reduce the annual cost of the channel improvement works of plan A by $29,000 in the segment upstream from Rogers Avenue and $9,800 in the segment downstream from Rogers Avenue. An analysis indicates that the reduction in costs of the above channel improvement segments would be greater than the corresponding annual flood prevention benefits which would be realized if the channel capacities are not reduced. The Marys Creek Reservoir, therefore, would be credited with the reduced annual cost of $38,800 for the channel works as well as incremental annual benefits of about $16,700 for prevention of damages in the Marys Creek flood plain. The incremental annual costs, benefits, and benefit-cost ratio between plans A and D, attributable to the investigated Marys Creek Reservoir as a last-added unit for flood control, water conservation, and fish and wildlife purposes, would be $294,700, $173,900, and 0.6, respectively, as shown in table 6. The addition of the recreation purpose to the Marys Creek Reservoir would increase the incremental benefit-cost ratio from 0.6 to 1.04. Since the ratio of benefits to costs for all project purposes other than recreation was determined to be only 0.6, the investigated reservoir project is not considered a justifiable undertaking at Federal expense. The studies indicate, also, that the

addition of the Marys Creek Reservoir unit as a second-added unit to the channel improvements of plan A, in lieu of the Tanglewood and Convair levees as second-added units, would not increase the incremental benefit-cost ratio of 0.6.

67. SUMMARY OF COSTS AND BENEFITS OF PLANS INVESTIGATED.- A summary of the first costs, annual charges, annual benefits, and benefit-cost ratios for the investigated plans and improvements on the West Fork and Clear Fork are shown in table 6.

PLAN OF IMPROVEMENT

68. PROPOSED PLAN OF IMPROVEMENT.- The proposed plan of improvement, which is the basic plan A previously described in paragraph 59 and discussed in paragraph 60, includes the following principal features and requirements:

a. The construction of about 6.5 miles of channel improvement by enlargement and realignment of the Clear Fork between West Lancaster Avenue, river mile 1.6, and the Southwest Loop 217 crossing, river mile 10.4.

b. The construction of about 3.2 miles of levee, including 900 feet of concrete floodwall, located along the right bank of the proposed enlarged and realigned channel, for the protection of the Tanglewood residential and Convair recreational areas.

c. The provision of appurtenant interior drainage facilities, consisting of three permanent sump areas to provide an aggregate storage capacity of about 109 acre-feet below damaging-stage elevations in the Tanglewood residential and Convair recreational areas, gate-controlled gravity sluices through the levees at each sump location, and 1.57 miles of diversion channels and appurtenant works provided in lieu of additional sump-storage facilities for interior drainage runoff.

d. The lengthening of four existing highway bridges and two railroad bridges, and the lengthening and raising of one existing highway bridge.

e. The filling of four overbank areas, amounting to a total area of about 500 acres, to elevations about two feet above the floodway design water surface by utilizing about 4,400,000 cubic yards of excess materials from the channel and sump excavation work.

f. The relocation and alteration of various urban utilities and of gas and oil lines of private companies.

g. The removal and reconstruction of 3 concrete channel dams existing on the Clear Fork.

h. The acquisition of rights-of-way, consisting of about 566 acres of land, for construction of the proposed excavated channels, levees, and permanent sump areas.

69. The details of the proposed plan of improvement, the locations of the principal existing utilities, and the area subject to flooding within the limits of the proposed plan of improvement are shown on plates 9 through 11. Pertinent data on the principal features and requirements of the proposed plan are shown in table 3, appendix III. Profiles of the proposed channel improvements, diversion channels, and levees are shown on plates 13, 14, and 15. Typical cross sections of the excavated channel, levees, sump areas, and the bridge profiles and alteration details are shown on plates 16, 17, and 18.

70. CHANNEL IMPROVEMENTS AND LEVEE.- Channel improvements on the Clear Fork would begin at the head of the existing channel improvement of the Fort Worth Floodway at West Lancaster Avenue and extend upstream about 34,200 feet to a point just downstream from the Southwest Loop 217 crossing. The channel would have side slopes of 1 vertical on 2.5 horizontal. The bottom widths of the improved channel, except at the transitions, would be 100 feet between West Lancaster Avenue and the St. Louis, San Francisco, and Texas Railway crossing and 150 feet from the St. Louis, San Francisco, and Texas Railway to the Southwest Loop 217, except for a 175-foot width in the reach between City Dam 2 and the Clear Fork Pumping Station in the University Drive commercial area. The Tanglewood and Convair levees would have side slopes of one vertical on 2.5 horizontal, a minimum top width of 14 feet, and a minimum berm width of 70 feet between the toe of the levees and the top of the channel slopes. The levees for the existing Fort Worth Floodway immediately downstream from the proposed floodway extension works have a minimum freeboard of 4 feet. Therefore, the proposed levees would have a minimum freeboard of 4 feet above the standard project flood discharge water-surface profile.

71. INTERIOR DRAINAGE FACILITIES.- Proposed interior drainage structures through the Tanglewood levee are a triple 5- by 5-foot gravity sluice structure to drain an area of 1.14 square miles and a single 4- by 4-foot gravity sluice structure to drain an area of 0.15

square mile. The proposed structure through the Convair levee would consist of a single 4- by 4-foot gravity sluice, draining an area of about 0.09 square mile. A Tanglewood diversion channel, confluent with the Clear Fork channel at the upstream corner of the Tanglewood levee, would extend 5,300 feet around the west loop of the levee to intercept the discharges from a Clear Fork tributary stream flowing through the Tanglewood residential area. The Convair diversion channel would extend from the Clear Fork channel about 3,000 feet along the west side of the Convair levee to intercept the discharges from a Clear Fork tributary area which would be blocked by construction of the levee. The proposed Tanglewood and Convair diversion channels, which would drain areas of about 4.7 and 4.6 square miles, respectively, would have side slopes of 1 vertical on 2.5 horizontal, and would have a bottom width of 20 feet. A low diversion dike and miscellaneous drainage ditches would be required in the Tanglewood area to insure storage of interior drainage runoff at different design water-surface levels in the two sump areas.

72. GENERAL HYDROLOGY AND HYDRAULICS.- Detailed hydrologic and hydraulic design data for the plan of improvement are given in appendices I and II and on plates 19 through 24. A summary of these details is given in paragraphs 73 through 75 while the principal physical features of the proposed plan of improvement are given in paragraphs 68 through 71.

73. DESIGN DISCHARGE CRITERIA FOR CHANNELS AND LEVEES.- The standard project storm for the proposed extension of the Fort Worth Floodway on the Clear Fork was centered over the entire Clear Fork drainage area upstream from the Fort Worth gaging station, near the head of the existing floodway project. The resultant standard project flood from this storm was routed through existing Benbrook Reservoir under the assumption that the May 1949 storm created the antecedent conditions. The resultant outflow routed through Benbrook Reservoir, when combined with inflow from the uncontrolled area between the Benbrook Reservoir and the Fort Worth Floodway project on the Clear Fork, produced a peak discharge of 75,400 second-feet at the head of the existing floodway project. This discharge is practically the same as the floodway design discharge of 75,000 second-feet previously adopted for design of the Clear Fork portion of the existing Fort Worth Floodway. The maximum flood of record (May 1949) on the Clear Fork at Fort Worth, as modified by Benbrook Reservoir, would have a peak discharge of 26,000 second-feet. This discharge was adopted for designing the improved channel on the Clear Fork. The standard project flood (75,000 second-feet) was adopted for developing backwater profiles and for establishing the grades of levees and overbank fill areas on the Clear Fork.

74. WATER-SURFACE PROFILES.- Backwater studies for the recommended floodway extension were based on the assumption that the flows

would be confined within the existing levee system from the Lancaster Avenue crossing to the St. Louis, San Francisco, and Texas Railway crossing. The recommended plan of improvement upstream from the St. Louis, San Francisco, and Texas Railway crossing includes channel improvements only, except for the four overbank fill areas and the two levees for protection of the Tanglewood residential and Convair recreational areas. However, the standard project flood discharge was assumed to be fully confined within a leveed system in order to establish the recommended levee grades. Under this plan, the levee freeboard would neither be adversely affected by any future levees, fills, or other encroachments outside the channel rights-of-way in the flood plain downstream from the recommended levees, nor would it be necessary to prohibit any future encroachment in the flood plain. This basis for establishing recommended levee grades was considered justified since an excess of material would also be available from the proposed channel excavation work and the required levee height could be accomplished at this time with only a slight increase in initial cost. The standard project flood discharge water-surface levee, under the improved conditions of the recommended plan and with the flood plain development as it existed in 1959, would be about 2.5 feet lower than that indicated for the recommended levee grades. Water-surface profiles for the standard project flood discharge of 75,000 second-feet (under both the recommended plan of improvement conditions and the fully-confined floodway conditions) and for the flood of record discharge (modified by Benbrook Reservoir) of 26,000 second-feet were developed using a roughness coefficient of 0.035 in the Manning formula for the improved channel and 0.080 for overbanks. The average velocities in the floodway would vary from 3.6 to 13.4 feet per second for the standard project flood and from 2.8 to 9.8 feet per second for the modified flood of record discharge. Riprap protection will be provided for the side slopes of the channel, levee, and overbank fill area at the confluence of the Tanglewood diversion channel and the Clear Fork. Plates 13 through 15 show the water-surface profiles for the Clear Fork under the recommended plan conditions and under the fully-confined floodway conditions. Plates 6 and 7 show the water-surface profiles under existing conditions.

75. DESIGN DISCHARGE CRITERIA FOR INTERIOR DRAINAGE.- The proposed gravity sluices for each interior drainage area have been designed to discharge runoff from 50-year all-season storm rainfall with free discharge at the outfall without exceeding the minimum damaging stage within the sump area. Sufficient sump capacity is available within the existing drainage ditches and the abandoned portions of the Clear Fork channel to control runoff from the 50-year storm coincident with gate closing stage for the individual sump areas.

COSTS, CHARGES, AND BENEFITS

76. FIRST COSTS AND ANNUAL CHARGES.- The estimates of first cost and annual charges for the proposed plan of improvement on the Clear Fork upstream from the existing Fort Worth Floodway project are summarized in table 7. The estimates are based on the January 1960 price level. A detailed estimate of first cost for the proposed plan on the Clear Fork is shown in appendix III.

77. FLOOD CONTROL BENEFITS FOR THE CLEAR FORK.- The total average annual damages in the flood plain of the Clear Fork of the Trinity River upstream from the existing Fort Worth Floodway are estimated at $374,900, based on the present state of development in the flood plain (including development under construction or for which final plans have been completed) and price levels of January 1960. The average annual damages for these stream limits under conditions as would be modified by the proposed plan of improvement are estimated to be $9,500 as shown on curve B, plate 25. These residual damages are principally in the area immediately upstream from the existing Fort Worth Floodway as indicated on plate 9, and include losses in connection with rides, roads, bridges, and picnicking facilities in the public recreation park, damages to utilities, streets and railroads, damages to commercial establishments in the vicinity of University Drive, and losses resulting from interruption to traffic and cost of policing activities. The resulting benefits from prevention of damages are $365,400. Based on trends of the past, it is logical to assume that development will continue in the flood plain even though flood protection is not provided. This probable future development has been evaluated in the economic base study shown in appendix V of this report. From paragraph 20 of this appendix, the annual benefits from the prevention of damages creditable to the improvement, including an allowance for future development, is estimated at $886,000.

78. As set forth in paragraph 21 of appendix V, it is determined that no significant amount of enhancement benefits would result from increased utilization of lands if the improvements should be constructed.

79. The total estimated average annual primary benefits creditable to the construction of the proposed plan of improvement on the Clear Fork are $886,000 for prevention of damages.

80. Secondary benefits to be realized by the proposed plan of improvement have not been included in the economic justification.

81. COMPARISON OF BENEFITS AND COSTS FOR THE CLEAR FORK.- The average annual benefits, the annual charges, and the ratio of benefits to charges for the proposed plan of improvement for the Clear Fork of the Trinity River, based on January 1960 price levels, are given below:

TABLE 7
FIRST COST AND ANNUAL CHARGES
PROPOSED PLAN OF IMPROVEMENT
CLEAR FORK OF TRINITY RIVER
(January 1960 Price Level)

Item	Costs
FIRST COSTS	
1. FEDERAL FIRST COST	
Railroad alterations	$ 118,800
Channel	3,696,400
Levee	449,900
a. Levee construction	(249,300)
b. Levee sluices	(49,900)
c. Sumps	(127,500)
d. Diversion channels	(23,200)
Engineering and design	420,300
Supervision and administration	462,600
Total Federal first cost	$5,148,000
2. NON-FEDERAL FIRST COST	
Lands and damages	$1,756,000
Alterations to highways, miniature railroad, and utilities	1,121,500
Total non-Federal first cost	$2,877,500
3. TOTAL ESTIMATED FIRST COST OF PROJECT	$8,025,500 (1)
ANNUAL CHARGES	
(Construction period - 36 months) (Amortization period - 50 years)	
(Interest rates - Federal, 2.625%; non-Federal, 5% lands, 3% other costs)	
1. FEDERAL INVESTMENT	
a. Federal first cost	$5,148,000
b. Preauthorization costs	12,500
c. Interest during construction on items a & b	203,200
Total Federal investment	$5,363,700
2. NON-FEDERAL INVESTMENT	
a. Non-Federal first cost	$2,877,500
b. Interest during construction	182,200
Total non-Federal investment	$3,059,700
3. FEDERAL ANNUAL CHARGES	
a. Interest on Federal investment	$ 140,800
b. Amortization of Federal investment	53,000
c. Maintenance and operation	None
Total Federal annual charges	$ 193,800
4. NON-FEDERAL ANNUAL CHARGES	
a. Interest on non-Federal investment	$ 129,600
b. Amortization of non-Federal investment	19,400
c. Maintenance and operation	59,900
Total non-Federal annual charges	$ 208,900
5. TOTAL ESTIMATED ANNUAL CHARGES	$ 402,700

(1) Exclusive of preauthorization cost of $12,500

Average annual benefits	$886,000
Annual charges	402,700
Ratio of benefits to charges	2.2 to 1

LOCAL COOPERATION

82. PROPOSED LOCAL COOPERATION.- The proposed plan of improvement for the Clear Fork is a local flood protection project subject to the requirements of local cooperation as generally specified for such projects. It is proposed to require local interests to participate in the project as follows:

a. Provide without cost to the United States all land, easements, and rights-of-way necessary for the construction, maintenance, and operation of the project, including those required for sump areas.

b. Provide without cost to the United States the designated fill areas of the project required for the disposal of excess materials from the channel excavation work.

c. Make any alterations to existing improvements which may be required for the construction of the project.

d. Hold and save the United States free from damages due to the construction of the project.

e. Prohibit encroachment in the sump areas and on the flood-carrying capacities of the improved channel and floodway works.

f. Maintain and operate all works after completion in accordance with regulations prescribed by the Secretary of the Army.

83. On March 2, 1960, representatives of the Tarrant County Water Control and Improvement District Number One and representatives of the City of Fort Worth attended conferences in the Fort Worth District office to discuss the proposed plan for protection of the subject problem area. These representatives indicated their general approval and support of the proposed plan.

84. The Tarrant County Water Control and Improvement District Number One, in its letter of April 25, 1960, stated that since it had assumed responsibility for providing the required items of local cooperation for the existing Fort Worth Floodway project, it considered the Improvement District the appropriate agency to assume a similar responsibility for the proposed channel improvement and floodway

extension works on the Clear Fork. Due to boundary limitations existing at the present time, the Improvement District stated that it is unable to pledge itself as the responsible agency for the proposed project at this time, but that at the proper time it will take the necessary steps to endeavor to extend its boundaries to embrace the entire area involved and qualify itself as the responsible local agency for the items of local cooperation established for the proposed project. Extension of the District's boundary will depend upon the results of an election to be held in the Fort Worth area. Previously, the Tarrant County Water Control and Improvement District Number One was successful in its endeavor to expand its boundaries to become the responsible local agency in connection with the construction of the existing Fort Worth Floodway project.

85. ALLOCATION OF COSTS.- The total cost of the proposed floodway extension project is estimated at $8,025,500, of which $5,148,000 is total Federal construction cost and $2,877,500 is total non-Federal cost, as shown on table 7.

COORDINATION WITH OTHER AGENCIES

86. NOTICE OF INITIATION OF STUDIES.- During the initiation of studies on the West Fork watershed, the regional office of other interested Federal agencies were advised by letter dated November 20, 1957, of the general investigations program for fiscal year 1958. In response to the above letter, the Federal agency comments, in general, included statements of interest in the investigations program and also presented available basic and general data. The Soil Conservation Service presented the only specific comments concerning the West Fork watershed, and reported that it had preliminary field data and preliminary work plan reports on the West Fork watershed.

87. PUBLIC HEARING.- Participation of other agencies in the public hearing is discussed in paragraph 42.

88. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE.- During the preparation of this report, the results of the investigations and studies made of the problem area were discussed with the Department of Health, Education, and Welfare, Dallas, Texas. In connection with the preparation of a survey report covering the Big Fossil Creek watershed, this agency made a water-value survey of the general Fort Worth area and furnished unit values of water to be utilized in estimating the municipal and industrial water-supply benefits which would be realized by construction of multiple-purpose reservoir projects. Since this information was applicable for the general Fort Worth area, the agency was not requested to make additional studies for the investigated Marys Creek Reservoir project.

89. U. S. SOIL CONSERVATION SERVICE.- During the subject investigation, the Soil Conservation Service was consulted with respect to its

authorized program on runoff and waterflow retardation and soil-erosion prevention on the West Fork watershed. The agency furnished information on cost and accomplishments of flood-prevention measures installed on the subwatershed upstream from the Benbrook Reservoir and Lake Worth. The existing and proposed improvements of the Soil Conservation Service on the West Fork watershed upstream from Fort Worth are briefly described in paragraphs 36, 37, and 38.

90. BUREAU OF SPORT FISHERIES AND WILDLIFE.- During the subject investigation, the proposed plan of improvement for the extension of the Fort Worth Floodway was discussed with a representative of the Bureau of Sport Fisheries and Wildlife, Fort Worth, Texas. The Bureau's representative stated that any adverse effects which the proposed plan of improvement will have on the fish and wildlife resources of the area will be of a minor nature.

91. REVIEW OF REPORT BY OTHER FEDERAL AGENCIES.- Copies of this report have been forwarded to the interested Federal agencies at regional level for their formal views and comments. Appendix IV of this report is reserved for copies of correspondence relative to coordination with other agencies, including their formal comments on this report. The comments are summarized briefly as follow:

a. The Bureau of Public Roads stated that the proposed project requires relocation and alterations to the West Lancaster Avenue bridge and the East-West Freeway bridge which were partially financed with Federal highway funds. They stated that the Texas State Highway Department has assumed the maintenance responsibility for these structures. They stated that governing regulations do not permit the expenditure of Federal-aid highway funds to defray any part of the alteration costs which local interests are required to assume as an item of local cooperation for the proposed project.

b. The Bureau of Reclamation stated that the proposed improvements will not adversely affect any existing or potential Bureau projects.

c. The Department of Health, Education, and Welfare stated that the proposed flood protection works will provide beneficial health measures by minimizing disease transmission, vector and rodent control problems, and by protecting water and waste treatment facilities.

d. The Federal Power Commission stated that the proposed channel and levee improvements do not lend themselves to adaptation for purposes of hydroelectric power development and will not affect any existing or potential hydroelectric resources.

e. The Bureau of Sport Fisheries and Wildlife stated that any adverse effects which the proposed plan of improvement may have on the fish and wildlife resources of the area will be of a minor nature. They stated that the Texas Game and Fish Commission has concurred in this conclusion.

f. The Geological Survey stated that although they have not made an analytical study regarding flood magnitudes and frequencies of the West Fork of the Trinity River and its tributaries, they believe that the Corps of Engineers' determination of the peak discharges for floodway design is reasonable, and possibly the discharges are lower than those which may occur under the most extreme conditions.

g. The National Park Service stated that the proposed improvements will not affect the interest of their agency.

h. The Soil Conservation Service provided current information regarding their authorized program on the West Fork watershed and suggested that certain statements contained in the report draft relative to constructed and planned flood-detention reservoirs be revised. Revised statements furnished by the Soil Conservation Service were incorporated in the report.

i. The Southwestern Power Administration stated that the proposed improvements will not affect the interest of their agency.

j. The Bureau of Mines stated that the current mineral industry of the Fort Worth area would not be adversely affected by the proposed construction work.

k. The Soil Conservation Service, AWR Basins Office, stated that the letter of May 19, 1960, from the State Conservationist, Temple, Texas, constitutes the comments of the Department of Agriculture on the report since the Forest Service has indicated that the project does not affect timbered lands.

DISCUSSION

92. GENERAL.- This report is Part II of two parts of a review of reports on the Clear Fork and West Fork watershed of the Trinity River Basin to consider flood control and allied improvements in the Fort Worth area. Part II considers the 9.4-mile reach of the West Fork from the downstream end of the Fort Worth Floodway to the Handley-Ederville Road, and the 13.4-mile reach of the Clear Fork between the existing Fort Worth Floodway project and Benbrook Dam. The completed Part I report, which considered the reach of the West Fork between the upstream end of the Fort Worth Floodway and Lake Worth Dam, recommended that the existing project for Trinity River, Texas, be modified to provide for the upstream extension of the Fort Worth Floodway on the West Fork to the vicinity of Lake Worth Dam. The improvements recommended in the Part I report were authorized for construction by the Flood Control Act approved July 14, 1960.

93. GEOGRAPHY.- The city of Fort Worth, located in Tarrant County in the upper Trinity River Basin, is centered at the confluence of the West Fork of the Trinity River and its principal tributary, the Clear Fork. The West Fork watershed has a total drainage area of about 3,502 square miles which is tributary to the head of the Trinity River at Dallas. The West Fork upstream from the mouth of the Clear Fork drains an area of about 2,096 square miles. The Clear Fork drains an area of about 531 square miles, and Marys Creek, one of its principal tributaries, drains an area of about 57 square miles.

94. EXISTING IMPROVEMENTS.- The principal existing improvements which related to the water problems of the Fort Worth area consist of the Fort Worth Floodway on the West and Clear Forks at Fort Worth and the Benbrook Reservoir on the Clear Fork upstream from Fort Worth constructed by the Federal Government for flood control and water conservation purposes; and in descending order on the West Fork upstream from Fort Worth, the Lake Bridgeport, Eagle Mountain Lake, and Lake Worth reservoirs constructed by local interests principally for water conservation purposes. These water conservation reservoirs serve, through use of surcharge storage, to reduce the peaks of floods originating on their respective drainage areas.

95. FLOOD PLAIN DEVELOPMENT.- The economic investigations and studies of the flood plains within the limits of the subject problem areas indicate that the value of physical properties is about $12,087,000 within the West Fork problem area below the existing Fort Worth Floodway project and about $32,487,000 within the Clear Fork problem area. The principal developments within the West Fork flood plain consist of business and industrial properties, and city and county improvements, including the sewage disposal plant. The principal developments within the Clear Fork flood plain are downstream from the Southwest Loop 217 and consist of an expensive residential section

in the Tanglewood area; the Convair recreational area; and business and industrial properties, city and county improvements, and municipal park and recreational facilities in the University Drive area. In addition, this reach of the Clear Fork will contain in the near future a considerable amount of residential and commercial developments for which local interests have completed final planning. It is probable that the urban developments will eventually be extended by local interests to the presently undeveloped areas of the Clear Fork upstream from the Southwest Loop 217. The flood plain of Marys Creek downstream from the investigated damsite is generally undeveloped except for a few business and residential properties. However, additional residential areas are being planned by local interests within this reach of Marys Creek.

96. FLOOD AREAS AND DAMAGES.- The April-June 1957 floods stressed the serious nature of the flood problems in the urban areas which have been developed extensively since the completion of Benbrook Reservoir and the Fort Worth Floodway projects. The problem area on the West Fork upstream from the Fort Worth Floodway project, which was covered in the Part I report, experienced a peak discharge of 19,200 second-feet (maximum flood of record) and extensive damages during these floods. The flood problem areas on the West Fork and Clear Fork being considered in this report experienced peak discharges of 26,800 and 14,200 second-feet, respectively, and only minor to moderate flood damages. The flood of May 1949, modified by Benbrook Reservoir, is considered to be the maximum flood of record for the subject West Fork and Clear Fork problem areas. A recurrence of the May 1949 storm would produce peak discharges of 36,000 and 45,000 second-feet on the West Fork problem area upstream and downstream from the mouth of Sycamore Creek, respectively; and 26,000 second-feet on the Clear Fork at the Fort Worth gage. Under the present conditions of flood plain development, such floods would cause damages estimated at about $560,000 in the West Fork problem area and about $4,286,000 in the Clear Fork problem area. The occurrence of the standard project storm would produce estimated peak discharges within the Fort Worth Floodway project of about 95,000 second-feet on the West Fork downstream from the mouth of the Clear Fork, 75,000 second-feet on the Clear Fork, and 50,000 second-feet on the West Fork upstream from the mouth of the Clear Fork. The standard project flood discharges are approximately the same as the adopted floodway design discharge capacities of the existing Fort Worth Floodway.

97. IMPROVEMENTS CONSIDERED.- During the report investigations, the following principal improvements were considered: (a) Channel improvement works to provide partial flood protection to the West Fork and Clear Fork flood problem areas by containing within the banks of the improved channels the peak discharges of the maximum flood of record; (b) floodway improvements, consisting of channel improvements in conjunction with levees, appurtenant interior drainage facilities,

and overbank fill areas, to provide full protection or a combination of full and partial flood protection against the peak discharges of the standard project floods and the maximum flood of record; and (c) a reservoir on Marys Creek for flood control and water conservation purposes operating alone or in combination with floodway and channel improvements on the Clear Fork.

98. Economic and cost analyses indicate that the following improvements are not economically justified: Channel and floodway improvements for protection of the West Fork downstream from the existing Fort Worth Floodway project; a levee for protection of the University Drive commercial area on the Clear Fork; channel improvements and overbank fill areas for protection of the Clear Fork and Marys Creek problem areas upstream from the Southwest Loop 217; and a reservoir on Marys Creek for flood control, water conservation, and fish and wildlife, operating in combination with floodway and channel improvements on the Clear Fork. The analyses indicate, however, that a plan of improvement providing a combination of full and partial flood protection for the 8.8-mile reach of the Clear Fork problem area between the head of the existing Fort Worth Floodway and the Southwest Loop 217 is economically justified. The plan of improvement, which is proposed in this report, would provide full protection against the standard project flood discharge of 75,000 second-feet for a highly developed area including the existing Tanglewood residential and Convair recreational areas and additional residential and commercial developments under construction of planned by local interests. Downstream from the Tanglewood residential section, the plan would provide protection against the peak discharge (26,000 second-feet) of the maximum flood of record for the University Drive commercial area, the Colonial Country Club golf course areas, and the Forest Park and Trinity Park recreational areas. The major features of the proposed plan consist of channel improvement works between the head of the existing Fort Worth Floodway and Southwest Loop 217, two levees for the protection of the Tanglewood residential and the Convair recreational areas, and the filling of four overbank areas. The levees and overbank fill areas would afford full flood protection against the floodway design discharge (75,000 second-feet), and the improved channel of the Clear Fork would contain within its banks the peak discharge (26,000 second-feet) of the maximum flood of record. Local interests have been advised that the disposal of the excess materials from the channel excavation work within the designated overbank fill areas prior to the construction of the planned residential and commercial developments is an important factor in the economic justification of the proposed plan of improvement. The necessity of hauling the excess materials to the general area above the Southwest Loop 217 would increase considerably the cost of the proposed project.

99. LOCAL COOPERATION.- Local interests representing the city of Fort Worth and the Tarrant County Water Control and Improvement District Number One have indicated their general approval and support

of the proposed plan for protection of the flood problem area on the Clear Fork. The Tarrant County Water Control and Improvement District Number One stated that since it is the local agency which has assumed the responsibility for providing the required items of local cooperation in connection with the construction and operation of the existing Fort Worth Floodway project, it is considered to be the appropriate agency to assume a like responsibility in connection with the proposed plan of improvement. Due to boundary limitations existing at the present time, the Improvement District stated that it is unable to pledge itself as the responsible agency for the proposed project at this time, but that at the proper time it will take the necessary steps to endeavor to extend its boundaries to embrace the entire area involved and qualify itself as the responsible local agency for the items of local cooperation established for the proposed project. In conjunction with the maintenance and operation requirements of the project, the responsible local agency will be required to prevent encroachments within the rights-of-way established for the proposed project, thus insuring that the project's floodway, channel, and sump capacities will not be reduced. Further, since extensive developments are being planned for certain undeveloped flood plain areas of the Clear Fork flood problem area, responsible local interests in the general area are being requested to consider the acquisition of additional lands required for the construction of future levees on the Clear Fork, or to exercise to the full extent of their legal capabilities the establishment of flood plain zoning and building restriction limits, as shown on plates 9, 10, and 11, to prevent development within the rights-of-way area required for future levee construction. Also, the report studies indicate that there are large areas of undeveloped land along the Clear Fork and Marys Creek upstream from the head of the recommended improvement. In order to preclude a future flood problem in this area, local interests should exercise to the full extent of their legal capabilities the establishment of flood plain zoning and building restrictions to prevent development in these unprotected areas. If these areas are to be developed, responsibility for protection should rest with the developers or other local interests.

100. SOIL CONSERVATION SERVICE.- The Soil Conservation Service, Department of Agriculture, has been authorized to undertake a program of runoff and waterflow retardation and soil erosion prevention on the upper Trinity River Basin, including the West Fork watershed. Construction of the items in the entire program would have only a minor effect on the requirements for the flood control improvements proposed in this report. However, in the interest of overall planning, the effects of any existing or definitely planned reservoir will be considered in the advance planning of the project improvements.

101. Additional information on recommended and alternative projects called for by Senate Resolution 148, 85th Congress, adopted January 28, 1958, is contained in attachment to this report.

CONCLUSIONS

102. CONCLUSIONS.- The District Engineer concludes:

a. That a potentially serious flood problem exists in the reach of the Clear Fork between the existing Fort Worth Floodway project and the Southwest Loop 217 where extensive residential and commercial developments are subject to frequent flood damage by major flood flows originating on the Clear Fork watershed.

b. That the most practical plan for the protection of this area is by modification of the existing project for Trinity River, Texas, to provide for the extension of channel improvement and floodway works on the Clear Fork upstream from the existing Fort Worth Floodway project.

c. That the proposed project is economically justified and is urgently needed to provide a combination of full and partial flood protection for the potentially serious flood problem area.

d. That the channel improvement and floodway extension plans investigated for the West Fork problem area between the existing Fort Worth Floodway project and the Handley-Ederville Road are not economically justified at this time.

e. That a levee for the protection of the University Drive commercial area, channel improvements and overbank fill areas for protection of the investigated flood problem areas upstream of Southwest Loop 217, and the investigated reservoir on Marys Creek for flood control, water conservation, and fish and wildlife purposes, operating as a part of the recommended channel and floodway improvements, are not economically justified at this time.

RECOMMENDATIONS

103. RECOMMENDATIONS.- The District Engineer recommends that the existing project for Trinity River, Texas, be modified to provide for the construction of channel improvement and floodway extension works on the Clear Fork between the existing Fort Worth Floodway project and the Southwest Loop 217 at an estimated total Federal construction cost of $5,148,000. The recommendation is subject to the provisions that no construction shall be undertaken until local interests have given assurances satisfactory to the Secretary of the Army that they will: (a) Provide without cost to the United States all land, easements, and rights-of-way necessary for the construction, maintenance, and operation of the project, including those required for sump areas; (b) provide without cost to the United States the

designated fill areas of the project required for the disposal of excess materials from the channel excavation work; (c) provide without cost to the United States all necessary relocation, alteration, or reconstruction of existing improvements, exclusive of railroad bridges, but including existing utility lines, street and highway bridges, channel dams, and recreational facilities (miniature railroad bridge and facilities); (d) hold and save the United States free from damages due to the construction of the project; (e) prohibit encroachment in the sump areas and on the flood-carrying capacities of the improved channel and floodway works; and (f) maintain and operate all works after completion in accordance with regulations prescribed by the Secretary of the Army.

WALTER J. WELLS
Colonel, CE
District Engineer

[First endorsement]

SWDGW-4
SUBJECT: Review of Report on Trinity River and Tributaries, Texas, Covering West Fork Watershed, Flood Protection - Fort Worth Area, Part II

United States Army Engineer Division, Southwestern, Dallas, Texas, August 17, 1960

TO: Chief of Engineers, Department of the Army, Washington, D.C.

I concur in the conclusions and recommendations of the District Engineer.

STANLEY G. REIFF
Colonel, CE
Division Engineer

APPENDIX I

HYDROLOGY

WEST FORK WATERSHED
FLOOD PROTECTION - FORT WORTH AREA
PART II

GENERAL

1. INTRODUCTION.- This appendix discusses hydrologic details of the proposed plans of improvement to prevent flooding in areas adjacent to the Clear Fork and the West Fork of the Trinity River. The proposed plans on the Clear Fork extend from the head of the existing Fort Worth Floodway upstream to Benbrook Dam and on the West Fork from the existing Fort Worth Floodway downstream to the vicinity of the mouth of Big Fossil Creek. The plans studied for the West Fork are not economically feasible while the plan of improvement on the Clear Fork is economically justified. Consequently, hydrologic features on the Clear Fork are discussed in more detail than on the West Fork.

2. EXISTING IMPROVEMENTS ON WEST FORK AND CLEAR FORK.- Existing improvements on the Trinity River watershed upstream from the existing Fort Worth Floodway consist of Benbrook and Weatherford Reservoirs on the Clear Fork and Bridgeport, Eagle Mountain, Lake Worth, and Amon Carter Reservoirs on the West Fork. Benbrook Reservoir has 170,350 acre-feet of flood-control storage between elevations 694.0 and 724.0. Storage between elevations 694.0 and 710.0 was provided for general flood control. Storage between elevations 710.0 and 724.0 (93,800 acre-feet) was provided specifically for protection of Fort Worth. Control of this storage is by a 100-foot wide notch in the spillway. Crest of this notch is at elevation 710.0. The width of the notch was established so that its design outflow, when combined with design inflow downstream from the reservoir, would not exceed the capacity of the Clear Fork portion of the Fort Worth Floodway. Generally the plan for regulation of Benbrook Reservoir provides that regulated releases from the flood-control storage will be limited to such rates that the total streamflow on the Clear Fork downstream from the reservoir and on the West Fork between the mouth of the Clear Fork at Fort Worth and the mouth of the Elm Fork at Dallas will not exceed 6,000 second-feet. The plans for the regulation of Benbrook Reservoir on the Clear Fork, Grapevine Reservoir on Denton Creek, and Lewisville Reservoir on Elm Fork provide that the total releases from the reservoirs, when combined

with uncontrolled flows below the dams, will produce a discharge not to exceed 13,000 second-feet on the Trinity River at Dallas. Weatherford Reservoir, near the town of Weatherford, and Amon Carter Reservoir, near the town of Bowie, were constructed by local interests to serve as sources of municipal water supply and will have little or no effect on flood control. The West Fork reservoirs have the following storage capacities at spillway crest (acre-feet): Bridgeport, 269,300; Eagle Mountain, 181,900; and Lake Worth, 33,700. The primary purpose of these reservoirs is to provide a source of water supply for the city of Fort Worth; therefore, the reservoirs are maintained at or near spillway crest. However, some flood protection to areas downstream from the reservoirs is afforded during floods that occur when reservoir storages are below spillway crest. The surcharge storage between spillway crest and top of gates amounts to 534,500 acre-feet at Lake Bridgeport and 458,000 acre-feet at Eagle Mountain Lake. Because of comparatively narrow spillways at these two reservoirs, the surcharge storage will reduce flood peaks even when the spillway crest elevation is exceeded. The existing Fort Worth Floodway, constructed by the Corps of Engineers, extends from about mile 551.5 to mile 564.7 on the West Fork and from the mouth of the Clear Fork upstream to approximately mile 1.6 on the Clear Fork. Design flood discharges for the existing floodway are as follow: (1) 75,000 second-feet on the Clear Fork; (2) 50,000 and 95,000 second-feet on the West Fork upstream and downstream from the mouth of the Clear Fork, respectively.

CLEAR FORK

3. PLAN OF IMPROVEMENT.- The extended drought during the period 1950 to 1957 created a misconception of the flood hazards and the degree of flood protection provided by Benbrook Reservoir in lowland areas adjacent to the Clear Fork, between the dam and the head of the existing Fort Worth Floodway. Consequently, extensive urban development was stimulated in the area, creating additional potential flood problems. Plans considered for protection to the problem areas on the Clear Fork were:

a. Extension of the existing Fort Worth Floodway by channel improvements, levees, and fill areas upstream to Benbrook Dam.

b. A reservoir on Marys Creek.

c. Various combinations of the foregoing plans.

After analyses of the various plans, it was concluded that the existing Fort Worth Floodway on the Clear Fork should be modified to provide for its upstream extension by channel improvements (to Southwest Loop 217) to pass the flood of record as modified by Benbrook Reservoir, 26,000 second-feet (see plate 19), and by the construction of levees in the

Tanglewood area and Convair area, and filling of low-lying areas to control the standard project flood (75,000 second-feet) from just upstream of Rogers Avenue to the Southwest Loop 217. Each interior drainage area created by construction of the proposed levees would be provided with gravity sluices and a sump with sufficient capacity to care for the 50-year all-season storm runoff and a sump with sufficient capacity to contain the runoff from a 50-year storm coincident with gate-closing stage. The recommended plan of improvement is shown on plates 9 through 11.

4. DRAINAGE AREAS.- Drainage areas and river miles at selected points on the Clear Fork of the Trinity River are shown in table 1, and a drainage area map of the entire West Fork watershed is shown on plate 4.

5. FREQUENCY OF FLOODING.- A continuous record of flows is available at the Fort Worth gage on the Clear Fork from March 1924 to date. These records do not reflect the effect of Benbrook Reservoir prior to its completion in September 1952. Therefore, it was necessary to adjust the records to the modification that would have resulted from operating the reservoir. Local flood hydrographs for the area between Benbrook Dam and the Fort Worth gage were constructed by the unit-hydrograph method, using available precipitation data and combined with Benbrook Reservoir releases for all floods since 1924.

6. The above study indicated that the two maximum floods during the period 1900 - 1959 at the Fort Worth gage on the Clear Fork were those of 1922 and 1949. Both of these floods produced a peak discharge of 26,000 second-feet at the gage when modified by Benbrook Reservoir. However, the center of the 1949 storm occurred just southeast of the uncontrolled area between Benbrook Dam and the Fort Worth gage. A transposition of this storm over the uncontrolled area (involving moving the storm center approximately 16 miles) produced a peak discharge of 42,600 second-feet as compared to the discharge of 26,000 second-feet produced by the storm in its actual position. In view of the proximity of the 1949 storm to the watershed, it is considered that a flood in the magnitude of that produced by the transposed storm could reasonably be expected to occur during the period of approximately 60 years covered by the discharge-frequency study. A discharge of 42,600 second-feet has, therefore, been inserted into the flood series for the 1949 flood.

7. To extend the discharge-frequency relationship to the standard project flood peak of 75,000 second-feet for use in economic studies, an analytical analysis of discharge frequency for natural flow at the Fort Worth gage was made using the method prescribed on page 18 of Leo R. Beard's "Statistical Methods in

Hydrology" (distributed with Civil Works Engineer Bulletin 52-24, dated August 26, 1952). The standard project flood was developed for natural flow for the 526 square miles drainage area above the Fort Worth gage. The frequency of the standard project flood peak, for the 526 square-mile area, was taken from the discharge-frequency curve for natural flow and assigned to the standard project flood peak of 75,000 second-feet as modified by Benbrook Reservoir. Assuming that flows at the Fort Worth gage would be applicable to the areas in which the proposed improvements would be made and considering historical floods since 1900, and the standard project flood, a discharge-frequency curve was constructed to evaluate flood damages in the problem areas on the Clear Fork. The discharge-frequency curve was constructed in accordance with graphical methods set forth on page 25 of the aforementioned publication.

8. RUNOFF COEFFICIENTS AND INFILTRATION INDICES.- Studies of initial losses and infiltration indices were made for the Clear Fork at Fort Worth and for Denton Creek near Roanoke in conjunction with the preparation of the definite project reports on Benbrook and Grapevine Reservoirs, and subsequent studies have been made for the April and May 1957 floods on the area of the Clear Fork between the Benbrook and Fort Worth gages. These studies were made in accordance with the method described in EM 1110-2-1405 and the results are presented in table 2. An initial loss of 0.50 inch was adopted for all drainage areas considered and an average infiltration index of 0.10 inch per hour was adopted for the area upstream from Benbrook Dam. However, as a result of continuing development within the areas to be protected, it was considered that a lower infiltration rate than indicated by table 2 should be adopted for such areas. Therefore, infiltration indices of 0.07 and 0.08 inch per hour were adopted for areas downstream from Benbrook Dam on the Clear Fork.

9. DESIGN STORM FOR THE FLOODWAY.- A standard project storm was determined for the watershed area of the Clear Fork upstream from the head of the existing Fort Worth Floodway (total drainage area 526 square miles). The standard project storm was determined in accordance with the procedure set forth in EM 1110-2-1411 (Civil Works Engineer Bulletin No. 52-8, dated March 26, 1952). Several transpositions of the standard project storm were considered:

a. With the storm centered upstream from Benbrook Reservoir.

b. With the storm centered over the uncontrolled area downstream from Benbrook Reservoir.

c. With the storm centered over the entire drainage area.

The most critical conditions within the problem area resulted from the storm being centered over the entire drainage area; therefore, this transposition was adopted. Rainfall was determined for two incremental areas: (1) upstream from Benbrook Dam (433 square miles) and (2) between the head of the existing Fort Worth Floodway and Benbrook Dam (93 square miles). The standard project storm rainfall and rainfall excess for the Clear Fork are shown in table 3.

10. UNIT HYDROGRAPH STUDIES.- Detailed hydrologic data are available for the floods resulting from the storms of April 26 and May 25-26, 1957, in the area of Clear Fork between the Benbrook and Fort Worth gages (drainage area 91 square miles). The rainfall and rainfall excess for the April storm were 3.98 and 2.48 inches, respectively. An analysis of the data for these storms indicated that a reasonably accurate reproduction of both hydrographs could be obtained by use of a synthetic one-hour unit hydrograph having a peak of 6,700 second-feet, a lag (t_p) of 5.5 hours, a C_t value of 0.96 and a C_p 640 value of 405. The reproduced hydrographs for the April and May 1957 floods on the 91 square-mile drainage area of the Clear Fork between Benbrook and Fort Worth gages are shown on plates 20 and 21, respectively. Other unit hydrograph studies were made in conjunction with the preparation of definite project and design memoranda reports on the upper Trinity River reservoirs and the Dallas and Fort Worth Floodways.

11. SYNTHETIC UNIT HYDROGRAPHS.- As a result of the unit hydrograph studies of April and May 1957 floods on Clear Fork, a C_t value of 0.96 and a C_p 640 value of 405 were adopted for construction of synthetic one-hour unit hydrographs for all incremental areas of the Clear Fork between Benbrook Dam and the head of the existing Fort Worth Floodway project. The 6-hour unit hydrograph used for the area on Clear Fork upstream from Benbrook Dam was based upon studies made in conjunction with the preparation of the definite project report for Benbrook Dam and Reservoir. Six-hour unit hydrographs were derived from the one-hour unit hydrographs when required. The time of concentration for some of the interior drainage areas was less than one hour; therefore, 1/2-hour unit hydrographs were used for these areas. The adopted unit hydrographs for the floodway and interior drainage areas are shown in tables 4 and 5, respectively.

12. DESIGN FLOOD FOR FLOODWAY.- That portion of the standard project flood hydrographs originating on each of the incremental areas on the Clear Fork was determined by applying the rainfall excess values of table 3 to the unit hydrographs of table 4. The

May 1949 flood was assumed to represent conditions antecedent to the standard project flood as indicated on plate 22. Under these antecedent flood conditions, Benbrook Reservoir was at elevation 706.8 or 3.2 feet below the crest of the notch at the beginning of the standard project flood. The flood when routed through Benbrook Reservoir and combined with inflow from the uncontrolled area downstream from the dam gave a peak discharge of 75,400 second-feet at the head of the existing Fort Worth Floodway. This compares favorably with the previously adopted 75,000 second-feet for that portion of the existing floodway on Clear Fork. A design flood of 75,000 second-feet has, therefore, been adopted. The standard project flood hydrograph for the Clear Fork together with inflow-outflow hydrographs for Benbrook Reservoir are shown on plate 22.

13. RAINFALL INTENSITY-DURATION.- The rainfall intensity-duration curve for the 50-year all-season rainfall at the U. S. Weather Bureau First Order Station at Fort Worth is shown on plate 23. This curve, based on a frequency analysis developed by the U. S. Weather Bureau and presented in Technical Paper No. 25, "Rainfall Intensity-Duration-Frequency Curves" (December 1955), has been used for the design of the interior drainage facilities in the problem areas of the Clear Fork. Also shown on plate 23 are the 50-year rainfall intensity-duration curves coincident with gate closing stage for interior drainage areas "B" and "C".

14. DESIGN STORM FOR INTERIOR DRAINAGE FACILITIES.- Urban development within the areas to be protected by levees under the various plans considered consists primarily of moderate to high-valued residential sections. There are no existing high-valued, concentrated, commerical, or industrial developments in the area. Criteria for design of interior drainage facilities in urban areas are set forth in a preliminary manuscript of EM 1110-2-1410 (Engineering Manual Civil Works Construction, Part CXIV, Chapter 10, dated August 1955, Subject "Interior Drainage of Leveed Urban Areas"). In accordance with information presented therein, the areas to be protected would be classified as Class U-2 (Urban, General). The storm resulting from 50-year rainfall has been adopted as the design storm for the studies made on interior drainage facilities in the problem areas.

15. An all-season storm rainfall of 50-year frequency (8.40 inches) was determined from the rainfall intensity-duration curve on plate 23 and distributed substantially in accordance with the criteria presented on plate 10 of EM 1110-2-1411. An initial loss of 0.50 inch and an infiltration index of 0.08 inch per hour were used in determining the rainfall excess. The rainfall and rainfall excess for the adopted 50-year interior drainage design storm are shown in table 6.

16. DESIGN FLOOD CRITERIA FOR INTERIOR DRAINAGE FACILITIES.- The interior drainage areas that will be created by construction of the proposed levees and the areas to be served by proposed diversion channels are shown on plates 9 through 11. The 50-year interior drainage design-flood hydrograph for each interior drainage area was obtained by applying rainfall-excess values to the unit hydrograph for the area. Rainfall and rainfall excess values for 50-year frequency are shown on table 6. Synthetic unit hydrographs for the recommended plan on Clear Fork are shown on table 5. The proposed gravity sluices for each area were then designed to pass the runoff from the design flood free discharge at the outfall without exceeding the minimum damaging stage within the sump area. The minimum sluice size adopted was 1 - 4' X 4' box for ease of maintenance and to generally correspond to sluice sizes in the existing Fort Worth Floodway. Sufficient sump capacity was provided in each interior drainage area to control the runoff from a 50-year storm which would occur coincident with stages in the Clear Fork that would block gravity drainage without exceeding minimum damaging stage within each individual sump area.

17. COINCIDENT 50-YEAR FREQUENCY FLOOD.- In the development of the coincident 50-year frequency flood, it was assumed that gate closing stage at each of the proposed sluices would occur when the river discharge reached the invert of the sluice. The river discharges at the sluice inverts of the interior drainage areas and the frequency of these discharges are shown in the following tabulation:

Area	River discharge at sluice invert (cfs)	Frequency of river discharge (years)
B	14,000	8
C	8,200	5
D	1,000	2

18. The flood hydrographs for the period 1900 - 1958 were used to determine when the discharges in the tabulation above would be equaled or exceeded. The rainfalls for the periods of assumed gate closure were determined and the rainfall intensity-duration curves shown on plate 23 were constructed for the coincident 50-year storm. An infiltration index of 0.08 inch per hour was applied to rainfall values taken from these curves. The resulting rainfall-excess for areas "B" and "C" were 1.10 and 1.92 inches, respectively. The existing sumps in areas "B" and "C" are capable of storing 1.02 and 1.94 inches of runoff, respectively. These capacities will be somewhat augmented by construction of diversion channels in the areas and are considered

adequate to store all of the runoff from the 50-year frequency coincident rainfall. The existing sump in area "D" has the capacity to store over 25 inches of runoff which is far in excess of any anticipated requirement. Table 7 summarizes pertinent data for each interior drainage area.

WEST FORK

19. PLAN OF IMPROVEMENT.- Minor urban development took place during the extended drought of 1950 to 1957 in the areas adjacent to the West Fork of the Trinity River downstream from the existing Fort Worth Floodway. This development increased the potential for flood damages in this area. The proposed plan for protection of the problem areas on the West Fork was the extension of the Fort Worth Floodway downstream from near Riverside Drive to near the mouth of Big Fossil Creek (Handley-Ederville Road). Three plans of channel alignment and levee systems were considered. None of the plans was found to be economically feasible.

20. DRAINAGE AREAS.- Drainage areas and river miles at selected points on the West Fork of the Trinity River are shown in table 1, and a drainage area map of the West Fork watershed is shown on plate 4.

21. FREQUENCY OF FLOODING.- A continuous record of flows is available on the West Fork at the Fort Worth gage from 1920 to date. The observed flows do not reflect the effects of the reservoirs upstream from Lake Worth, Lake Bridgeport (completed in April 1932) and Eagle Mountain Lake (completed in February 1934) on the West Fork and Benbrook Reservoir on the Clear Fork (completed in September 1952). It was, therefore, necessary to adjust the records to reflect the modification that would have resulted from operation of these reservoirs. Local flood hydrographs for the areas downstream from the reservoirs were constructed by the unit hydrograph method and combined with modified flows at the Fort Worth gage on the West Fork to obtain peak discharges for floods during the period of record. Historical floods since 1900 were considered in the construction of discharge-frequency curves for the West Fork within the problem area. The discharge-frequency curves on the West Fork were constructed in accordance with graphical methods set forth on page 25 of Leo R. Beard's "Statistical Methods in Hydrology" (distributed with Civil Works Engineer Bulletin 52-24, dated 26 August 1952).

22. RUNOFF COEFFICIENTS AND INFILTRATION INDICES.- Initial losses and infiltration indices as adopted for the Clear Fork as discussed in paragraph 8 were also adopted for the West Fork.

23. DESIGN FLOOD FOR FLOODWAY.- The design flood for that portion of the Fort Worth Floodway on the West Fork downstream from the mouth of Clear Fork was 95,000 second-feet, as determined in connection with

the definite project studies for the Fort Worth Floodway project. Based on actual storm occurrences, the maximum six-hour periods of rainfall for the West Fork flood and the Big Fossil flood would be coincident. The West Fork flood hydrograph (with allowance for travel time) was combined with the hydrograph for Big Fossil Creek with a resulting peak discharge of 117,700 second-feet on the West Fork downstream from the mouth of Big Fossil Creek. The adopted design-flood hydrographs on the West Fork upstream and downstream from the mouth of Big Fossil Creek are shown on plate 24.

24. SYNTHETIC UNIT HYDROGRAPHS.- Studies of the April and May 1957 floods on the Big Fossil Creek watershed (a small watershed just northeast of Fort Worth) indicate C_t and C_p 640 values of 0.90 and 420, respectively. As a result of the studies made on Clear Fork, discussed in paragraph 11, and studies on Big Fossil Creek, a C_t value of 0.93 and a C_p 640 value of 413 were adopted for construction of synthetic one-hour unit hydrographs for interior drainage areas on the West Fork. Six-hour unit hydrographs were derived from one-hour unit hydrographs when required. The time of concentration for some of the interior drainage areas was less than one hour; therefore, 1/2-hour unit hydrographs were used for these areas.

25. INTERIOR DRAINAGE FACILITIES.- Design criteria for interior drainage facilities on the West Fork were the same as discussed for the Clear Fork in paragraphs 13 through 16.

TABLE 1

DRAINAGE AREAS AND MILEAGES

Point of measurement	Drainage area (square miles)		River mile above mouth
	Component	Total	
Clear Fork Trinity River			
Source	0	0	88.7
Benbrook Dam	433	433	15.0
Above gage near Benbrook	2	435	12.1
Above mouth of Marys Creek	6	441	10.7
Below mouth of Marys Creek	57	498	10.7
Fort Worth gage	28	526	3.2
Confluence with West Fork	5	531	0.0
West Fork Trinity River			
Source	0	0	692.0
Bridgeport Dam	1114	1114	626.2
Eagle Mountain Dam	860	1974	583.3
Lake Worth Dam	95	2069	572.1
Above confluence with Clear Fork	27	2096	558.7
Below confluence with Clear Fork	531	2627	558.7
Fort Worth gage		2627	558.6
Above mouth of Big Fossil Creek	91	2718	542.7
Below mouth of Big Fossil Creek	75	2793	542.7
Above mouth of Village Creek	11	2804	533.8
Below mouth of Village Creek	184	2988	533.8
Grand Prairie gage	82	3070	515.1
Above mouth of Mountain Creek	112	3182	507.8
Below mouth of Mountain Creek	310	3492	507.8
Above Elm Fork of Trinity River	10	3502	505.5

TABLE 2

INFILTRATION AND RUNOFF DATA

Date of storm	Rainfall (inches)	Runoff (inches)	Initial loss (inches)	Infiltration index (inch/hour)	Runoff (percent)	Conditions preceding storm
			Clear Fork at Fort Worth - Drainage area = 526 sq. mi.			
May 12-13, 1930	4.62	0.86	2.00	0.45	18.6	Dry - light rain May 2-10
Jan 21-22, 1932	2.12	0.72	0.40	0.09	34.0	Moist - moderate rain January 3-16
May 17-18, 1935	3.14	1.37	0.70	0.23	43.6	Moist - heavy rain May 14-15
Jan 23, 1938	1.66	0.58	0.40	0.14	35.0	Moist - moderate rain January 20-22
May 4-5, 1941	1.71	0.43	0.45	0.10	25.1	Moist - moderate rain May 1-3; April relatively wet
May 18-19, 1942	3.14	1.16	0.60	0.19	36.9	Moist - moderate rain May 6-8 and 14; April relatively wet
June 14-15, 1942	2.49	0.37	1.10	0.38	14.9	Dry - light rain June 5-8
Feb 17-21, 1945	2.48	1.04	0.50	0.11	41.9	Moist - heavy rain February 12; light rain February 11 and 13
April 26, 1957*	3.98	2.48	0.50	0.10	62.3	Moist - light to moderate rain April 19-25
May 25-26, 1957*	4.08	3.46	0.10	0.10	84.8	Moist - heavy rain May 23-24; light rain May 22
			Denton Creek near Roanoke - Drainage area = 621 sq. mi.			
July 1-3, 1940	3.16	0.95	1.00	0.20	30.1	Dry - light rain June 28; light rain June 24
June 9-10, 1941	4.41	2.47	0.65	0.15	56.0	Dry - light rain June 6; no rain June 3-6; May below normal
April 19, 1942	3.07	1.61	0.45	0.15	52.5	Moist - heavy rain April 6-8; light rain April 12-14
April 24, 1942	3.03	1.65	0.45	0.11	54.5	Moist - heavy rain April 23; heavy rain April 19
May 18-19, 1942	2.27	0.88	0.55	0.20	39.7	Dry - light rain May 14; no appreciable rain April 24-May 18
June 14-15, 1942	1.97	0.65	0.70	0.25	33.0	Dry - no rain June 11-13; light rain June 8-10; moderate rain June 6-7
March 24-25, 1943	3.11	0.70	0.60	0.15	22.5	Dry - no rain Mar 14-23; moderate rain Mar 12; no rain Feb 2-Mar 11

* Between Benbrook and Fort Worth gages - D. A. = 91 sq. mi.

TABLE 3

RAINFALL AND RAINFALL-EXCESS FOR
THE STANDARD PROJECT STORM
CLEAR FORK

Time in 6-hour periods	Above & below Benbrook Dam: Rainfall (inches)	Loss (inches)	Rainfall-Excess (inches)	Between Benbrook Dam & Ft Worth Gage: Rainfall (inches)	Loss (inches)	Rainfall-Excess (inches)
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.1	0.1	0.0	0.1	0.1	0.0
3	0.3	0.3	0.0	0.3	0.3	0.0
4	0.1	0.1	0.0	0.1	0.1	0.0
5	0.2	0.2	0.0	0.2	0.2	0.0
6	0.4	0.4	0.0	0.4	0.4	0.0
7	1.5	0.6	0.9	1.4	0.4	1.0
8	0.2	0.2	0.0	0.2	0.2	0.0
9	1.0	0.6	0.4	1.0	0.4	0.6
10	2.2	0.6	1.6	2.1	0.4	1.7
11	8.7*	0.6*	8.1*	8.2*	0.4*	7.8*
12	1.5	0.6	0.9	1.4	0.4	1.0
13	0.1	0.1	0.0	0.1	0.1	0.0
14	0.1	0.1	0.0	0.1	0.1	0.0
15	0.5	0.5	0.0	0.5	0.4	0.1
16	0.1	0.1	0.0	0.1	0.1	0.0
Total	17.0	5.1	11.9	16.2	4.0	12.2
Time in 1-hour periods						
1	0.5	0.1	0.4	0.5	0.07	0.4
2	0.7	0.1	0.6	0.7	0.07	0.6
3	1.2	0.1	1.1	1.1	0.07	1.0
4	4.8	0.1	4.7	4.5	0.07	4.4
5	1.0	0.1	0.9	0.9	0.07	0.8
6	0.5	0.1	0.4	0.5	0.07	0.4
Total	8.7	0.6	8.1	8.2	0.4	7.8

*Distribution of maximum 6-hour rainfall and rainfall-excess period.

TABLE 4

SYNTHETIC UNIT HYDROGRAPHS FOR FLOODWAY
CLEAR FORK

Above Benbrook Dam		Between Benbrook Dam and Fort Worth Gage					
	6-hour		6-hour	1-hour		6-hour	1-hour
Time in 2-hour periods	unit hydro-graph	Time in 1-hour periods	unit hydro-graph	unit hydro-graph	Time in 1-hour periods	unit hydro-graph	unit hydro-graph
1	820	1	10	50	26	660	580
2	4060	2	180	1020	27	630	550
3	13130	3	520	2050	28	600	520
4	14310	4	1120	3990	29	570	490
5	14030	5	1970	5130	30	540	460
6	13520	6	3090	6700	31	500	430
7	13180	7	4060	5840	32	480	400
8	12800	8	4720	5020	33	440	370
9	12000	9	5080	4200	34	420	340
10	9500	10	5070	3540	35	380	310
11	6700	11	4710	2950	36	360	280
12	4600	12	3980	2360	37	320	250
13	3200	13	3320	1840	38	300	220
14	2300	14	2690	1250	39	260	180
15	1700	15	2160	1030	40	230	160
16	1350	16	1730	930	41	200	120
17	1060	17	1380	860	42	170	90
18	880	18	1120	830	43	140	60
19	720	19	950	800	44	110	40
20	620	20	870	770	45	80	20
21	540	21	820	740	46	60	0
22	480	22	780	710	47	40	
23	430	23	760	680	48	20	
24	400	24	720	650	49	10	
25	370	25	690	610	50	0	
26	340						
27	310						
28	0						

TABLE 5

SYNTHETIC UNIT HYDROGRAPHS FOR
INTERIOR DRAINAGE FACILITIES

Time in 1/2-hour periods	Discharge in second-feet				
	Area A* 1-hour unit hydrograph	Area B 1-hour unit hydrograph	Area C 1/2-hour unit hydrograph	Area D 1/2-hour unit hydrograph	Area E* 1-hour unit hydrograph
1	125	90	32	12	150
2	318	260	105	99	330
3	545	405	37	5	550
4	825	260	16	0	825
5	1000	168	4		990
6	840	116	0		840
7	660	77			815
8	510	48			480
9	390	28			370
10	300	14			275
11	220	5			200
12	150	0			140
13	90				80
14	47				40
15	20				15
16	10				0
17	0				

*Diversion channel.

TABLE 6

DESIGN STORM RAINFALL AND RAINFALL-EXCESS
FOR INTERIOR DRAINAGE FACILITIES
50-YEAR FREQUENCY

For use with 1-hour unit hydrograph:				For use with 1/2-hour unit hydrograph							
Time in 1-hour periods	Rain-fall (in)	Loss (in)	Re (in)	Time in 1/2-hour periods	Rain-fall (in)	Loss (in)	Re (in)	Time in 1/2-hour periods	Rain-fall (in)	Loss (in)	Re (in)
1	0.08	0.08	0	1	0.04	0.04	0	25	0.13	0.04	0.09
2	0.08	0.08	0	2	0.04	0.04	0	26	0.15	0.04	0.11
3	0.08	0.08	0	3	0.04	0.04	0	27	0.22	0.04	0.18
4	0.08	0.08	0	4	0.04	0.04	0	28	0.26	0.04	0.22
5	0.08	0.08	0	5	0.04	0.04	0	29	0.45	0.04	0.41
6	0.08	0.08	0	6	0.04	0.04	0	30	0.65	0.04	0.61
7	0.16	0.08	0.08	7	0.04	0.04	0	31	1.02	0.04	0.98
8	0.18	0.08	0.10	8	0.04	0.04	0	32	2.18	0.04	2.14
9	0.21	0.08	0.13	9	0.04	0.04	0	33	0.42	0.04	0.38
10	0.25	0.08	0.17	10	0.04	0.04	0	34	0.32	0.04	0.28
11	0.18	0.08	0.10	11	0.04	0.04	0	35	0.20	0.04	0.16
12	0.16	0.08	0.08	12	0.04	0.04	0	36	0.18	0.04	0.14
13	0.28	0.08	0.20	13	0.08	0.04	0.04	37	0.04	0.04	0
14	0.48	0.08	0.40	14	0.08	0.04	0.04	38	0.04	0.04	0
15	1.10	0.08	1.02	15	0.09	0.04	0.05	39	0.04	0.04	0
16	3.20	0.08	3.12	16	0.09	0.04	0.05	40	0.05	0.04	0.01
17	0.74	0.08	0.66	17	0.11	0.04	0.07	41	0.06	0.04	0.02
18	0.38	0.08	0.30	18	0.10	0.04	0.06	42	0.06	0.04	0.02
19	0.08	0.08	0	19	0.13	0.04	0.09	43	0.06	0.04	0.02
20	0.09	0.08	0.01	20	0.12	0.04	0.08	44	0.06	0.04	0.02
21	0.12	0.08	0.04	21	0.09	0.04	0.05	45	0.05	0.04	0.01
22	0.12	0.08	0.04	22	0.09	0.04	0.05	46	0.05	0.04	0.01
23	0.10	0.08	0.02	23	0.08	0.04	0.04	47	0.05	0.04	0.01
24	0.09	0.08	0.01	24	0.08	0.04	0.04	48	0.04	0.04	0
Total	8.40	1.92	6.48						8.40	1.92	6.48

TABLE 7

INTERIOR DRAINAGE - PERTINENT DATA

Area designation	B	C	D
Drainage area (acres)	727	96	60
Damaging state (ft-msl)	568.0	564.0	595.0
Proposed gravity sluices:			
No. and size	3 - 5'x5'	1 - 4'x4'	1 - 4'x4'
Invert elevation (ft-msl)	554.0	550.0	577.0
Storage at damaging stage:			
Existing (acre-feet)	62	15.5	123
Proposed (acre-feet)	62	15.5	31
Peak inflow (cfs)	1531	285	222

APPENDIX II

HYDRAULICS
WEST FORK WATERSHED
FLOOD PROTECTION - FORT WORTH AREA
PART II

GENERAL

1. GENERAL.- Studies were made to determine the hydraulic characteristics under existing conditions and various plans of improvement on the West Fork of the Trinity River downstream from the existing Fort Worth Floodway and on the Clear Fork of the Trinity River and Marys Creek upstream from the existing Fort Worth Floodway. The following paragraphs describe the hydraulic studies made on the West Fork, Clear Fork, Marys Creek, and their principal tributaries.

WEST FORK

2. WATER-SURFACE PROFILES - EXISTING CONDITIONS.- Hydraulic computations were made to establish water-surface profiles under existing conditions on the West Fork of the Trinity River from the Handley-Ederville Road crossing (river mile 541.6) to the Chicago, Rock Island, and Pacific Railroad crossing (downstream limits of the existing floodway levees). A rating curve was developed for the West Fork immediately downstream from the Handley-Ederville Road crossing by correlating backwater computations with high water marks from the U. S. Geological Survey gage at Grand Prairie, Texas (river mile 515.1). The rating curve was used to obtain a starting elevation and to develop a water-surface profile under existing channel and valley conditions for the design discharge of 117,700 second-feet to the confluence of Big Fossil Creek and the West Fork and 95,000 second-feet from that point to the Chicago, Rock Island, and Pacific Railroad crossing. Water surface profiles were developed based on Manning's formula, in accordance with paragraph 10 of EM 1110-2-1409, 7 December 1959. The mean of the conveyances of the two end sections in each reach were used in computing the backwater curves. A similar profile was developed for the flood of record discharge (modified by Benbrook Reservoir) of 45,000 second-feet to the confluence of Sycamore Creek and the West Fork and 36,000 second-feet from that point to the Chicago, Rock Island, and Pacific Railroad crossing. Roughness coefficients for use in the Manning formula were computed to vary from 0.040 to 0.045 in the existing channel and to vary from 0.070 to 0.100 for the overbank, based on observed flood data. Plate 5 shows the water-surface profiles under existing conditions.

3. RECOMMENDED PLAN OF IMPROVEMENT.- Based on the estimated costs and benefits involved, it was recommended that no improvement be accomplished on the West Fork downstream from the existing floodway.

4. MASTER PLAN OF IMPROVEMENT.-

a. Channel.- A master plan of improvement (plan B) was studied, as shown on plates 2 and 3. This plan included channel enlargement and realignment of the West Fork from a point 1,575 feet downstream from the Handley-Ederville Road crossing to the downstream limits of the existing floodway, 1,450 feet upstream from Riverside Drive. The excavated channel in the West Fork would be generally trapezoidal in shape and have a bottom width of 200 feet (depressed 1.0 foot at the center), and side slopes of 1 vertical on 2.5 horizontal. The channel would have a uniform bottom grade, would be realigned and cutoffs made as necessary. A 1,575-foot-long transition downstream from the Handley-Ederville Road crossing would connect the improved channel with the existing river channel. A 4-foot-deep pilot channel, having a 20-foot bottom width and 1 vertical on 2 horizontal side slopes, would extend from the downstream limits of the floodway extension to the existing pilot channel at the Chicago, Rock Island, and Pacific Railroad crossing. Table 2 shows control grades, including channel grades, and water surface levels for the improved channels for the master plan.

b. Levees.- The levees for the existing Fort Worth Floodway immediately upstream from the master plan of extension have a minimum freeboard of 4 feet. Levees generally along both banks of the improved channel would therefore be designed to provide a minimum freeboard of 4 feet above standard project flood discharge levels. All levees would be provided with a minimum top width of 16 feet with 1 on 2.5 side slopes. Emergency control structures and seepage collars would be provided, as required, for all existing utility lines wherever they cross the floodway levees.

5. WATER-SURFACE PROFILES - MASTER PLAN.- Backwater studies for the master plan of the floodway extension were based on the assumption that the flow would be confined within levees, having a distance between centerlines of levees varying from a minimum of 600 feet to a maximum of 1,000 feet. This would permit additional levees or future development in the remaining flood plain without encroachment on the capacity of the designed flood plain. Water surface profiles for the design flood discharge (117,700 and 95,000 second-feet, below and above Big Fossil Creek, respectively) and the flood of record, modified by Benbrook Reservoir (45,000 and 36,000 second-feet, below and above Sycamore Creek, respectively) were developed for the improved floodway, using roughness coefficients of 0.035 in the Manning formula for the channel and 0.080 for the overbank (berms between channel and levees). For the design discharge, the

average velocity would vary from 4.1 to 7.3 feet per second. Plate 12 shows the water-surface profiles of the West Fork of the Trinity River under improved conditions.

6. BRIDGE IMPROVEMENTS.- Table 2 shows low steel elevations for existing bridges and the low steel elevations that would be required in conformance with the master plan (plan B) for the floodway extension. All bridges would provide a minimum freeboard of 3 feet between low steel and the design water surface level.

7. TRIBUTARY CHANNEL IMPROVEMENTS.- Channel improvements for the lower reaches of Little and Big Fossil Creeks and Sycamore Creek are included in the master plan.

a. Little and Big Fossil Creeks.- The channel improvements on Little and Big Fossil Creeks would join the left bank of the West Fork about 4,460 feet upstream from the Handley-Ederville Road crossing. The portion of the improved channel on Big Fossil Creek would have 2,600 feet of 150-foot wide channel similar to the improved main river channel with the exception of the pilot channel. The portion of the improved channel on Little Fossil Creek would have a 50-foot bottom width and extend from the Chicago, Rock Island, and Pacific Railroad crossing to a point about 1,450 feet downstream from the crossing. Both channels would have uniform bottom grades between control-grade elevations. A levee would be constructed on the right bank of the channel to provide a minimum freeboard of 4 feet above design discharge water-surface level.

b. Sycamore Creek.- The channel improvement on Sycamore Creek would join the right bank of the West Fork about 2,600 feet downstream from the Riverside Drive crossing. The improved channel would have a bottom width of 50 feet and would extend about 3,000 feet to the Texas and Pacific Railway crossing. The channel would have uniform bottom grades with control grades as shown on table 2. Levees would be constructed on both sides of the channel from the upstream side of the Dallas-Fort Worth Turnpike crossing to the Texas and Pacific Railway crossing to provide a minimum freeboard of 4 feet above the design water-surface level. To provide a reasonable degree of protection to the developed areas adjacent to Sycamore Creek, the peak discharge resulting from 50-year storm rainfall on Sycamore Creek was assumed to occur coincident with the standard project flood discharge on the West Fork of the Trinity River. This resulted in a total peak discharge of 100,300 second-feet in the West Fork immediately downstream from the mouth of Sycamore Creek.

8. ALTERNATE PLANS STUDIED.- Alternate plans were studied in conjunction with the master plan (plan B). Plan A is identical to the master plan with the exception of a major cutoff between West Fork river miles 544.6 and 548.1. Plan C improvement would begin at West Fork river mile 545.8 and would be identical in alignment and bottom grades to the master plan (plan B) from there upstream to the Chicago, Rock Island, and Pacific Railroad crossing. Channel-improvement-only plans A, B, and C were initially investigated. These plans would provide partial flood protection by containing the peak discharges of the maximum flood of record (modified by Benbrook Reservoir) within the banks of the improved channel.

CLEAR FORK

9. WATER-SURFACE PROFILES - EXISTING CONDITIONS.- Hydraulic computations were made to establish water-surface profiles under existing conditions on the Clear Fork of the Trinity River from Lancaster Avenue crossing to Benbrook Dam. A rating curve (see plate 26) was developed for the Clear Fork of the Trinity River at the Lancaster Avenue crossing (river mile 1.64) by backwater computations, which were correlated with high water marks from the U. S. Geological Survey gage at Fort Worth, Texas (West Fork river mile 564.7). This rating curve was used to obtain a starting elevation and to develop a water-surface profile under existing channel and valley conditions for the standard project flood design discharge of 75,000 second-feet to the confluence of Marys Creek and the Clear Fork and 45,000 second-feet from that point to Benbrook Dam. A similar profile was developed for the flood-of-record discharge (modified by Benbrook Reservoir) of 26,000 second-feet and 6,000 second-feet for the corresponding reaches. Based on observed flood data, the roughness coefficients for use in the Manning formula varied from 0.040 to 0.050 for the existing channel and from 0.060 to 0.100 for the overbank. Plates 6 and 7 show the water-surface profiles under the existing conditions. Table 1 shows the average channel velocities and the head losses through the bridges and at the channel dam structures for the standard project flood (in the fully confined floodway) and the flood of record (modified by Benbrook Reservoir).

10. RECOMMENDED PLAN OF IMPROVEMENT.-

a. Channel.- The recommended plan of improvement, shown on plates 9 through 11, includes channel enlargement and realignment of the Clear Fork of the Trinity River from Lancaster Avenue crossing to the Southwest Loop 217. The improved channel would be trapezoidal in shape with 1 on 2.5 side slopes. It would have a bottom width of 100 feet from West Lancaster Avenue to the St. Louis, San Francisco, and Texas Railway. From the St. Louis,

San Francisco, and Texas Railway to a point just downstream from the Southwest Loop 217, the improved channel would have a bottom width of 150 feet, except for a 175-foot bottom width between City Dam 2 and the City Pump Station. Transitions would be provided at the St. Louis, San Francisco, and Texas Railway crossing, between the Vickery Boulevard crossing and the City Dam, between the City Pump Station and a point approximately 100 feet upstream therefrom, and at the upstream end of the proposed improved channel, just downstream from the Southwest Loop 217 crossing. The improved channel would provide for realignment of the existing channel and would have uniform bottom grades between control points. Table 2 shows control grades, including channel grades, and water-surface levels for the improved channel. The recommended channel would generally contain the flood of record (modified by Benbrook Reservoir) within the channel banks upstream from the St. Louis, San Francisco, and Texas Railway crossing.

b. Channel dams.- The three channel dams replacing existing structures on the Clear Fork would be similar to the channel dam rebuilt at the intersection of the Clear and West Forks of the existing Fort Worth Floodway. The hydraulic features of the reconstructed dams would be developed in connection with the definite planning studies on this project.

c. Levees.- The recommended plan of improvement would provide levees around the Tanglewood residential area and the Convair recreational area on the right bank of the Clear Fork, as shown on plates 10 and 11. The levees for the existing Fort Worth Floodway immediately downstream from the proposed floodway extension works with a minimum freeboard of 4 feet. Therefore, the proposed levees would have a minimum freeboard of 4 feet above the standard project flood discharge water-surface profile. The proposed levees would have a minimum top width of 14 feet with 1 on 2.5 side slopes, and a minimum berm width of 70 feet between the levee toe and top of channel excavation. A typical section is shown on plate 16. Emergency control structures and seepage collars would be provided, as required, for all existing utility lines wherever they cross the proposed floodway levees.

11. WATER-SURFACE PROFILES - RECOMMENDED PLAN.- Backwater studies for the recommended floodway extension were based on the assumption that the flows would be confined within the existing levee system from the Lancaster Avenue crossing to the St. Louis, San Francisco, and Texas Railway crossing. The recommended plan of improvement upstream from the St. Louis, San Francisco, and Texas Railway crossing includes channel improvements only, except for the four overbank fill areas and the two levees for protection

of the Tanglewood residential and Convair recreational areas. However, the standard project flood discharge was assumed to be fully confined within a leveed system to establish the recommended levee grades. Under this plan, the levee freeboard would not be adversely affected by any future levees, fills, or other encroachments outside the channel rights-of-way in the flood plain downstream from the recommended levees. Nor would it be necessary to prohibit any future encroachment in the flood plain. This basis for establishing recommended levee grades was considered justified since an excess of material would also be available from the proposed channel excavation work and the required levee height could be accomplished at this time with only a slight increase in initial cost. The standard project flood discharge water-surface level, under the improved conditions of the recommended plan and with the flood plain development as it existed in 1959, would be about 2.5 feet lower than that indicated for the recommended levee grades. Water surface profiles for the standard project flood discharge of 75,000 second-feet (under both the recommended plan of improvement conditions and the fully-confined floodway conditions) and for the flood of record discharge (modified by Benbrook Reservoir) of 26,000 second-feet were developed using a roughness coefficient of 0.035 in the Manning formula for the improved channel and 0.080 for overbanks. The average velocities in the floodway would vary from 3.6 to 13.4 feet per second for the standard project flood and from 2.8 to 9.8 feet per second for the modified flood of record discharge. Plates 13 through 15 show the water-surface profiles for the Clear Fork under the recommended plan conditions and under the fully-confined floodway conditions.

12. BRIDGE IMPROVEMENTS.- Table 2 shows low steel elevations that would be required in connection with the channel improvement and floodway extension works. All bridges would provide a minimum freeboard of 3 feet between low steel elevation and the modified flood of record water surface, except the Bryant-Irvin Road bridge which would provide a 3-foot freeboard above the floodway design discharge water surface. The Bryant-Irvin Road crossing would conform to design discharge criteria, since it is immediately downstream from the recommended Convair levee. The remaining bridges would be in areas not to be provided with levee protection. With the exception of the East-West Freeway, they would conform to flood of record discharge criteria since the valley areas would be inundated during extreme floods. Should levees be provided in these areas in the future, it would be necessary to raise the bridges to conform to design discharge criteria and to compensate for the elimination of the valley conveyance. Drift accumulation was not considered a problem since a major portion of the drainage area is urban and there are no heavily wooded areas in the flood plain. In addition, floods on the Clear Fork watershed are generally of short duration, further reducing the problem. Bridge pier foundation protection would be provided, as required, where the channel would be excavated. No

additional protection from scour was considered necessary since, with the exception of University Drive and Rogers Avenue bridge crossings where existing piers and abutments would be modified in the enlarged channel section, the improved channel would not materially increase the average bridge velocity for the standard project flood discharge over the velocity under existing conditions. Bridge profiles and modifications are shown on plates 16 through 18.

13. DIVERSION CHANNELS.- A diversion channel, as shown on plate 11, would join the Clear Fork on its right bank about 10,900 feet upstream from the Rogers Avenue crossing and would intercept runoff from about 4.7 square miles. The channel would have a length of 5,300 feet with the upstream 400 feet being a transition from improved to natural channel. The west portion of the Tanglewood levee would be constructed on the right bank of the diversion channel and would provide a minimum freeboard of 4 feet above the design discharge water-surface level. A diversion channel, as shown on plate 11, would also be provided where the Convair recreation area levee crosses an existing creek which drains an area of about 4.57 square miles. The channels would have bottom widths of 20 feet and side slopes of 1 on 2.5. The channels would have uniform bottom grades with control grades as shown in table 2.

14. MASTER PLAN OF IMPROVEMENT.- The channel size and alignment for the master plan are identical to those of the recommended plan of improvement. The master plan of improvement would further include a 200-foot channel for the Clear Fork to the confluence with Marys Creek, a 200-foot channel to Rall Dam (river mile 12.60), and a 100-foot channel to the Benbrook Dam spillway discharge channel, as well as a 100-foot channel on Marys Creek to the Texas and Pacific Railway. Also, an additional levee at University Drive, and overbank fill areas along both sides of the Clear Fork and Marys Creek were included in the master plan.

15. INTERIOR DRAINAGE.- Runoff from a total area of 1.29 square miles behind the recommended Tanglewood levee and 0.09 square miles behind the Convair recreational area levee would be collected in sumps and conveyed through the levee by gravity sluices. Table 7, appendix I, shows pertinent data for these sluices including location, size, control elevations, drainage area, and design discharges. The sluice structures would be similar to those in the existing Fort Worth Floodway. Details of the structures will be prepared in connection with definite planning studies. The sluices were designed to pass the 50-year frequency peak discharges from the interior areas with no other flow in the Clear Fork channel and utilizing available sump capacities. Sufficient sump capacity would be available to store the interior runoff during periods of high water in the main channel without exceeding the minimum damaging elevation. A

concrete retaining wall would be provided along Mockingbird Lane, and a 4- by 4-foot sluice draining the area would be located in the concrete wall.

MARYS CREEK

16. WATER-SURFACE PROFILE - EXISTING CONDITIONS.- Hydraulic computations were made to establish water-surface profiles under existing conditions on Marys Creek from its confluence with the Clear Fork of the Trinity River to the dam site investigated at Marys Creek river mile 7.69. The water-surface level at the mouth of Marys Creek for a total discharge of 75,000 second-feet was computed to be at elevation 612.5. A backwater curve was then developed for Marys Creek from its mouth to river mile 7.69 for a discharge of 75,000 second-feet in the Clear Fork downstream from Marys Creek, coincident with a discharge of 46,000 second-feet in Marys Creek at its mouth and 27,000 second-feet at river mile 7.69. A similar curve was developed for a total discharge of 26,000 second-feet in the Clear Fork downstream from Marys Creek, coincident with discharges on Marys Creek of 20,500 second-feet at the mouth and 13,500 second-feet at river mile 7.69. Roughness coefficients for use in the Manning formula were computed to be 0.040 for the existing channel and 0.080 for the overbank. Plate 8 shows the water surface profiles developed for Marys Creek under existing channel and valley conditions. Tailwater rating curves to be used in spillway and outlet works design were developed for the investigated dam sites.

17. DAM SITES.- Possible dam sites were investigated at Marys Creek river miles 7.29 and 7.69. Ogee spillways, 850 feet long at crest elevation 794.0 and 800 feet long at crest elevation 807.0, respectively, would be required to pass the design flood discharges at the two dam sites in conjunction with a 13-foot-diameter outlet works conduit. No dams have been recommended for Marys Creek.

TABLE 1

CHANNEL VELOCITIES AND BRIDGE LOSSES
FORT WORTH FLOODWAY EXTENSION

Location of structure	Approx. channel station	75,000 cfs design flood		26,000 cfs modified flood of record	
		Average velocity (ft/sec)	Bridge or dam loss (ft)	Average velocity (ft/sec)	Bridge or dam loss (ft)
W. Lancaster Br.	-20+40	2.99 / 3.07	0.04	5.11 / 4.95	0.10
St.L.& S.F.Ry.Br.	0+00	5.32 / 5.29	0.11	8.38 / 8.12	0.25
T.& P.Ry.Dam	28+20	4.59 / 4.47	0.06	7.18 / 6.25	2.37
E.-W.Freeway Br.	40+25	8.72 / 8.67	0.13	6.66 / 6.64	0.17
Vickery Blvd.Br.	41+75	11.64 / 11.47	0.38	6.66 / 6.58	0.16
Channel Dam No.2	45+00	9.07 / 8.39	1.88	6.57 / 4.95	3.70
T.& P.Ry.Br.	45+65	7.90 / 7.77	0.23	4.98 / 4.91	0.09
City Pump Plant	48+00	8.23	--	4.97	--
Univ. Dr. Br.	83+65	9.97 / 9.82	0.28	7.02 / 6.93	0.18
Rogers Ave.Br.	94+44	10.67 / 10.43	0.32	7.32 / 7.24	0.19
Confl.,Div.Ch.	201+90	13.00	--	9.77	--
Chan.Dam #4	235+00	13.11 / 8.59	4.73	9.81 / 5.42	9.00
Bryant-Irvin Rd.	270+60	12.73	0.00	7.60 / 7.49	0.20
End Channel	319+70	10.55	--	7.67	--
S.W.Loop Br.	321+60	5.86 / 5.39	0.61	5.91	0.00
Confl.,Marys Cr.	332+20	11.81	--	7.00	--

TABLE 2

CONTROL GRADES
FORT WORTH FLOODWAY EXTENSION

Location or structure	Approx. channel station (feet)	Design discharge (cfs)	Improved channel grade (ft msl)	Improved channel bottom width (feet)	Design water surface (ft msl)	Flood of record* water surface (ft msl)	Low steel		Remarks
							Existing (ft msl)	Required (ft msl)	
WEST FORK (MASTER PLAN ONLY)									
Begin channel improvement	0+00	117,700	455.00	Natural	-	-	-	-	Existing channel
End transition	15+75	117,700	456.57	200	506.05	498.04	-	-	
Handley-Ederville Road	15+75	117,700	456.57	200	506.05	498.04	495.7	509.1	Bridge
Grade Control Point	100+00	95,000	464.50	200	507.92	498.68	-	-	
First Street	224+00	95,000	472.55	200	512.37	501.57	507.2	515.4	Bridge
Grade Control Point	261+80	95,000	475.00	200	513.58	502.75	-	-	
Grade Control	311+80	95,000	480.25	200	516.36	504.90	-	-	
Beach Street	321+80	95,000	480.50	200	516.89	505.56	523.1	519.9	Bridge
Riverside Drive	365+80	95,000	481.62	200	520.17	507.65	523.7	523.2	Bridge
Begin Present Floodway	385+00	95,000	482.11	200	520.75	508.18	-	-	
CRI&P Railroad	415+79	95,000	485.70	200	522.53	509.18	-	-	End levee improvement
LITTLE & BIG FOSSIL CREEKS DIVERSION									
Begin channel improvement on Big Fossil	0+00	55,030	466.00	150	506.80	-	-	-	Diversion channel stationing
End improvement Big Fossil	26+00	55,030	475.00	150	506.95	-	-	-	Diversion channel stationing
Begin improvement Little Fossil	0+00	10,600	488.80	50	506.96	-	-	-	Diversion channel stationing
End improvement Little Fossil	14+50	10,600	490.80	50	507.00	-	-	-	Diversion channel stationing
SYCAMORE CREEK DIVERSION									
Begin improvement	-10+00	22,000	481.96	50	519.70	-	-	-	Diversion channel stationing
Toll Road	0+00	22,000	490.00	50	519.70	-	528.5	522.7	Bridge
Lancaster Avenue	13+50	22,000	496.00	50	519.76	-	517.4	522.8	Bridge
End improvement	20+00	22,000	497.00	50	519.80	-	-	-	

*As modified by Benbrook Reservoir

TABLE 2 (CONT'D)

Location or structure	Approx. channel station (feet)	Design discharge (cfs)	Improved channel grade (ft msl)	Improved channel bottom width (feet)	Design water surface (ft msl)	Flood of record* water surface (ft msl)	Low steel: Existing (ft msl)	Low steel: Required (ft msl)	Remarks
CLEAR FORK (FULLY-CONFINED FLOODWAY)									
Lancaster Avenue	-20+40	75,000	519.50	100	550.53	540.0	566.0	543.0**	Bridge
StLS&T Railway	0+00	75,000	520.00	150	552.47	546.40	551.0	549.4**	Bridge
Channel Dam	28+20	75,000	524.24	150	555.45	547.95	-	-	Dam #A, Crest Elev. 536.0
East-West Freeway	40+25	75,000	526.05	150	556.20	548.30	561.0	551.4**	Bridge
Vickery Blvd.	41+75	75,000	526.27	150	556.35	548.50	559.7	551.6**	Bridge
Channel Dam	45+00	75,000	526.76	175	559.22	550.67	-	-	Dam #2, Crest Elev. 541.6
T&P Railway	45+65	75,000	526.86	175	559.62	550.78	565.8	553.8**	Bridge
City Pumping Plant	48+00	75,000	527.21	175	559.97	550.89	-	-	Intake structure
University Drive	83+65	75,000	532.56	150	563.03	552.52	560.7	555.5**	Bridge
Rogers Avenue	94+44	75,000	534.18	150	564.40	553.50	562.2	556.4**	Bridge
Grade Control Point	126+97	75,000	539.07	150	568.56	556.50	-	-	
Channel Dam	235+00	75,000	560.63	150	591.80	584.60	-	-	Dam #4, Crest Elev. 575.5
Bryant-Irvin Road	270+60	75,000	567.86	150	595.31	586.16	598.0	591.2	Bridge
End Recommended Improvement	319+70	75,000	577.53	150	605.07	592.73	-	-	
Southwest Loop	321+60	75,000	578.0	250(Exist)	606.58	593.96	-	-	Existing channel
CLEAR FORK (MASTER PLAN)									
Upstream Southwest Loop	321+60	75,000	578.10	250	607.19	-	616.2	611.2	Existing bridge FM 217
Confluence Marys Creek	332+20	75,000	579.49	200	607.38	-	-	-	
Rall Dam	416+40	45,000	592.71	200	613.26	-	-	-	
Upstream Rall Dam	416+40	45,000	592.71	200	617.56	-	-	-	

* As modified by Benbrook Reservoir

** Three feet above flood-of-record (modified) water surface level for recommended plan only.

APPENDIX III

SUPPLEMENTAL DATA - PROPOSED PLAN OF IMPROVEMENT

TABLE 1
DETAILED ESTIMATE OF FIRST COST
PROPOSED PLAN OF IMPROVEMENT
CLEAR FORK OF TRINITY RIVER
(January 1960 Prices)

Item	Unit quantity	Unit cost	Quantity	Cost
1. Federal first cost				
(02.0) Railroad alterations				
(1) St. L & S.F.bridge	L.S.	--		$ 18,500
(2) T&P bridge	L.S.	--		80,500
Subtotal				$ 99,000
Contingencies, 20% ±				19,800
Total - railroad alterations				$ 118,800
(09.0) Channel				
(1) Care of water during construction	L.S.	--		$ 21,500
(2) Clearing	Acre	$150.00	236	35,400
(3) Excavation, common	C.Y.	0.35	3,534,600	1,237,110
(4) Excavation, rock	C.Y.	1.25	1,316,000	1,645,000
(5) Slope protection, sodding	Acre	300.00	84	25,200
(6) Slope protection,riprap	C.Y.	6.00	12,900	77,400
(7) Slope protection, bedding	C.Y.	5.00	4,900	24,500
(8) Concrete walls, protect existing pump plant	L.S.	--		14,200
Subtotal				$3,080,310
Contingencies, 20% ±				616,090
Total - channel				$3,696,400
(11.0) Levees				
a. Levee and floodwall				
(1) Clearing	Acre	$150.00	30	$ 4,500
(2) Grubbing	Acre	150.00	22	3,300
(3) Stripping	C.Y.	0.35	62,200	21,770
(4) Compacted fill	C.Y.	0.07	270,542	18,938
(5) Slope protection, sodding	Acre	300.00	22	6,600
(6) Concrete (wall)	C.Y.	40.00	2,880	115,200
(7) Reinforcing steel (wall)	Lb.	0.13	288,000	37,440
Subtotal - levee constr.				$ 207,748
Contingencies, 20% ±				41,552
Total - levee and floodwall				$ 249,300

TABLE 1
DETAILED ESTIMATE OF FIRST COST
(CONT'D)

Item	Unit quantity	Unit cost	Quantity	Cost
b. Levee sluices				
(1) Excavation, structural	C.Y.	$ 1.50	3,050	$ 4,575
(2) Backfill, structural	C.Y.	1.00	1,850	1,850
(3) Concrete	C.Y.	40.00	325	13,000
(4) Reinforcing steel	Lb.	0.13	35,462	4,610
(5) Riprap	C.Y.	6.00	145	870
(6) Bedding	C.Y.	5.00	47	235
(7) Miscellaneous metals	Lb.	0.50	780	390
(8) Flap gates 5'x5'	Each	1,250.00	3	3,750
(9) Flap gates 4'x4'	Each	800.00	2	1,600
(10) Sluice gates, stems headstands 5'x5'	Each	2,500.00	3	7,500
(11) Sluice gates, stems headstands 4'x4'	Each	1,600.00	2	3,200
Subtotal - levee sluices				$ 41,580
Contingencies, 20%				8,320
Total - levee sluices				$ 49,900
c. Sump and drainage ditches				
(1) Clearing	Acre	$ 150.00	35	$ 5,250
(2) Excavation (ditches)	C.Y.	0.35	288,500	100,975
Subtotal - sump and drainage ditches				$ 106,225
Contingencies, 20%				21,275
Total - sump and drainage ditches				$ 127,500
d. Diversion channels				
(1) Clearing	Acre	$ 150.00	24	$ 3,600
(2) Excavation, unclass.	C.Y.	0.35	40,543	14,190
(3) Slope protection, sodding	Acre	300.00	5	1,500
Subtotal - diversion channels				$ 19,290
Contingencies, 20%				3,910
Total - diversion channels				$ 23,200
Total - levees				$ 449,900
(30.0) Engineering and design				$ 420,300
(31.0) Supervision and administration				$ 462,600
Total estimated Federal construction cost				$5,148,000

TABLE 1
DETAILED ESTIMATE OF FIRST COST
(CONT'D)

Item	Unit quantity	Unit cost	Quantity	Cost
2. Non-Federal first cost				
a. Lands and damages				
(1) Fee simple lands and improvements				$1,517,900
(2) Administrative costs				9,000
Subtotal - lands and damages				$1,526,900
Contingencies, 15%±				229,100
Total - lands and damages				$1,756,000
b. Relocations and alterations				
(1) Bridges and roads				
Park drives	L.S.			$ 5,000
East-West Freeway	L.S.			1,000
Vickery Blvd.	L.S.			72,000
University Drive (bridge)	L.S.			123,500
New bridges (Tanglewood ares)	L.S.			40,000
Rogers Avenue	L.S.			30,000
Bryant-Irvin Road	L.S.			30,000
Miniature railroad	L.S.			18,000
Subtotal				$ 319,500
Contingencies, 20%±				63,900
Total - bridges and roads				$ 383,400
(2) Utilities				
20" water pipeline	L.S.			$ 4,500
12" H.P.pipeline (gas)	L.S.			10,000
16" water pipeline	L.S.			15,000
60" raw water pipeline	L.S.			50,000
Sanitary sewers	L.S.			75,000
Subtotal				$ 154,500
Contingencies, 20%±				30,900
Total - utilities				$ 185,400
(3) Channel dams	L.S.			$ 460,540
Contingencies, 20%±				92,160
Total - channel dams				$ 552,700
Total - relocations and alterations				$1,121,500
Total - non-Federal first cost of project				$2,877,500
3. Total - estimated first cost of project				$8,025,500 (1)

(1) Exclusive of preauthorization cost of $12,500

TABLE 2

DELETED FROM REPORT

TABLE 3
PERTINENT DATA
PROPOSED PLAN OF IMPROVEMENT
CLEAR FORK OF TRINITY RIVER

LOCATION		
Stream	Clear Fork of Trinity River	
River-mile limits	1.6 to 10.4	
DRAINAGE AREAS (Clear Fork)		
Above Benbrook Dam, square miles	433	
Above Southwest Loop 217, square miles	498	
Above Fort Worth gage, square miles	526	
Above existing Fort Worth Floodway on Clear Fork, square miles	529	
Interior drainage area diverted by proposed Tanglewood diversion channel, square miles		4.69
proposed Convair diversion channel, square miles		4.57
Interior drainage area contributing to proposed permanent sump areas (Tanglewood), square miles		1.29
proposed permanent sump area (Convair), square miles		0.09
STANDARD PROJECT DATA (Storm centered on area)		
Above Fort Worth gage on Clear Fork		
Above Benbrook Dam		
Storm rainfall, inches	17.0	
Storm duration, hours	96	
Flood volume, inches	11.9	
Flood volume, acre-feet	274,800	
Peak inflow, second-feet	145,500	
Peak outflow, second-feet	69,000	
Maximum reservoir elevation, feet msl	732.0	
Between Benbrook Dam and Fort Worth gage		
Storm rainfall, inches	16.2	
Storm duration, hours	96	
Flood volume, inches	12.2	
Flood volume, acre-feet	60,500	
Peak discharge at Fort Worth gage, second-feet	75,400	
Adopted design discharge for proposed floddway, second-feet	75,000	
Flood of record at Fort Worth gage (modified by Benbrook Dam), second-feet	26,000	

TABLE 3
PERTINENT DATA
(CONT'D)

DESIGN FLOOD CRITERIA (Interior drainage)

Storm rainfall, inches (50-year all-season)		8.40
Storm duration, hours		24
Flood volume, inches		6.48
Storm rainfall, inches (coincident 50-year)	Area "B"	Area "C"
	1.71	2.94
Storm duration, hours	12	24
Flood volume, inches	1.10	1.92

Interior drainage area	Peak discharge (second-feet)	Flood volume (acre-feet)
A (Tanglewood diversion channel)	4,400	1,620
B	1,531	394
C	285	52
D	222	31
E (Convair diversion channel)	4,320	1,580

CHANNEL IMPROVEMENT (Enlargement & realignment)

Clear Fork Channel (river miles 1.6 to 10.4)	
Length of existing channel before improvement, miles	8.8
Length of improved channel, miles	6.5
(Station -22+40 to 319+70), feet	34,210
Side slopes of excavated channel	1 on 2.5
Average depth of excavated channel, feet	24.2
Channel excavation, cubic yards	5,180,000

Bottom widths of excavated channel, feet:

Station limits	Bottom width
-22+40 - -3+00	100
-3+00 - 0+00	Transition
0+00 - 41+75	150
41+75 - 45+00	Transition
45+00 - 49+50	175
49+50 - 51+50	Transition
51+50 - 319+70	150

Location of bridges over improved channel, station:

West Lancaster	-20+40
St. Louis, San Francisco, and Texas Railway	0+00
East-West Freeway	40+25

TABLE 3
PERTINENT DATA
(CONT'D)

Location of bridges over improved channel, stations: (Cont'd)	
Vickery Boulevard	41+75
Texas and Pacific Railway	45+65
Miniature Railroad	83+05
University Drive	83+65
Rogers Avenue	94+44
Bryant-Irvin Road	270+60
Southwest Loop 217	321+60
LEVEE	
Freeboard, minimum above design water surface, feet	4
Length of Tanglewood levee, right bank, feet (includes 900-foot floodwall)	13,000
Length of Convair levee, right bank, feet	3,860
Crown width of levee, feet	14
Minimum berm width, feet	70
Side slopes of levee	1 on 2.5
Average height of Tanglewood levee, feet	11.0
Average height of Convair levee, feet	10.7
Compacted fill, cubic yards (Tanglewood levee)	208,000
Compacted fill, cubic yards (Convair levee)	65,540
INTERIOR DRAINAGE FACILITIES	
Diversion channel (Tanglewood levee):	
Contributing drainage area, acres & square miles	3,005 & 4.69
Length of excavated channel, miles (station 0+00 to 53+00), feet	1.0 5,300
Bottom width of excavated channel, feet	20
Side slopes of excavated channel	1 on 2.5
Average depth of excavated channel, feet	13.2
Channel excavation, cubic yards	26,400
Diversion channel (Convair levee):	
Contributing drainage area, acres & square miles	2,927 & 4.57
Length of excavated channel, miles (station 0+00 to 30+00), feet	0.57 3,000
Bottom width of excavated channel, feet	20
Side slopes of excavated channel	1 on 2.5
Average depth of excavated channel, feet	13.0
Channel excavation, cubic yards	14,143

TABLE 3
PERTINENT DATA
(CONT'D)

Diversion channel (Convair levee): (Cont'd)

Drainage area and sump	Area: Square miles	Area: Acres	Damaging stage: elevation (ft msl)	Sump capacity (acre-feet): Existing	Sump capacity (acre-feet): Proposed	Levee sluices: No. Req'd	Levee sluices: Size (feet)	Levee sluices: Invert el.
A	4.69	3,005	None required (proposed Tanglewood diversion channel)					
B	1.14	727	568.0	62	62	3	5x5	554.0
C	0.15	96	564.0	15.5	15.5	1	4x4	550.0
D	0.09	60	595.0	123	31	1	4x4	577.0
E	4.57	2,927	None required (proposed Convair diversion channel)					

UTILITY ALTERATIONS

20 in. water pipeline (lowering required)
12 in. high pressure gas line (alteration for river crossing required)
16 in. water pipeline (lowering required)
60 in. raw water pipeline (relocation required)
Sanitary sewers (relocation required)

CHANNEL DAMS

T&P Dam, Texas and Pacific Railway existing channel dam (removal of existing structure required and replacement in improved channel at station 28+20)
Dam 2 (removal of existing structure required and replacement in improved channel at station 45+65)
Dam 4 (removal of existing structure required and replacement in improved channel at station 235+00)

FILL AREAS

Area number	Area (acres)	Fill material (cu. yd.)	Average depth (feet)
1	24.0	266,000	5.0
2	156.0	905,000	4.0
3	192.0	2,326,700	7.0
4	126.0	950,200	5.0

TABLE 3
PERTINENT DATA
(CONT'D)

BRIDGE ALTERATIONS	
St. Louis, San Francisco, and Texas Railway, provide foundation protection to one pier; add two timber trestle spans	
East-West Freeway, retaining wall required at right bank abutment	
Park drives, approximately 6,000 feet of park drives to be relocated	
Vickery Boulevard, provide foundation protection, add one span	
Texas and Pacific Railway, provde foundation protection, add three timber trestle spans	
Miniature Railroad, provide foundation protection and lengthen bridge, relocate about two miles of track	
University Drive, lengthen both bridges	
Rogers Avenue, lengthen bridge	
Bryant-Irvin Road, lengthen bridge and raise approaches	
RIGHTS-OF-WAY	
Fee simple acquisition (for excavated channel, berms, levees, and sumps), acres	488
City owned, acres	78
Total, acres	566

APPENDIX IV

VIEWS AND COMMENTS OF OTHER AGENCIES

WEST FORK WATERSHED
FLOOD PROTECTION - FORT WORTH AREA

PART II

FEDERAL POWER COMMISSION
REGIONAL OFFICE
300 WEST VICKERY BOULEVARD - SUITE 2127
FORT WORTH 4, TEXAS

May 9, 1960

The District Engineer
U. S. Army Engineer Office
Corps of Engineers
P. O. Box 1600
Fort Worth 4, Texas

Dear Sir:

Receipt is acknowledged of your letter of April 29, 1960, forwarding a copy of your report of April 1960 entitled "Review of Reports on Trinity River and Tributaries, Texas, Part II, Covering the West Fork Watershed, Flood Protection, Fort Worth Area" for our review and comments.

In our review of the report, primary attention was given to the effect of the recommended improvements on any potential hydroelectric resources in the Trinity Basin. We find that the particular modifications recommended for the Clear Fork tributary consisting of channel improvements and floodway extension works above the existing Fort Worth Floodway project would not be adaptable to the purposes of hydroelectric power development and would not affect any existing or potential hydroelectric power resources in the basin.

The opportunity to review this unit of your report for the West Fork Watershed of the Trinity Basin is appreciated. It is to be noted that our comments are prepared at field level and are not to be construed as an official expression of the Federal Power Commission.

Sincerely yours,

Edgar S. Coffman
Regional Engineer

By /s/ Lenard B. Young
Acting

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
Region Three
Santa Fe, New Mexico

In Reply Refer To:
L7423

May 9, 1960

Walter J. Wells, Colonel, CE
District Engineer
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth, Texas

Dear Colonel Wells:

We have reviewed the draft copy (serial number 60) of Part II, your "Review of Reports on Trinity River and Tributaries, Texas, Covering the West Fork Watershed, Flood Protection, Fort Worth Area," dated April 1960, as requested by your letter of April 29.

The National Park Service has no direct interest in the project, and we have no comment on the report.

The opportunity to review the report and your cooperation in keeping us informed on your water resources development program is appreciated.

Sincerely yours,

/s/ George W. Miller

George W. Miller
Assistant Regional Director

UNITED STATES
DEPARTMENT OF THE INTERIOR
SOUTHWESTERN POWER ADMINISTRATION
POST OFFICE DRAWER 1619
TULSA 1, OKLAHOMA

May 11, 1960

District Engineer
U. S. Army Engineer District,
Fort Worth
P. O. Box 1600
Fort Worth, Texas

Dear Sir:

Thank you for your letter of April 29, 1960, file SWFGP, enclosing Part II, Review of Reports on Trinity River and Tributaries, Texas, Covering the West Fork Watershed, Flood Protection, Fort Worth Area, serial number 64, and a set of revised pages and plates for insertion in Part I.

The proposed measures outlined in this report will not affect the interests of this Administration.

We appreciate being kept informed of proposed investigations.

Sincerely,

/s/ James V. Alfriend

For Douglas G. Wright
Administrator

U. S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
REGION SIX

Austin, Texas
May 12, 1960

Colonel Walter J. Wells
District Engineer
Corps of Engineers
Fort Worth, Texas

Dear Colonel Wells:

Receipt is acknowledged of your letter dated April 29, 1960 with a draft copy of Part II "Review of Reports on Trinity River and Tributaries, Texas, Covering the West Fork Watershed, Flood Protection, Fort Worth Area," dated April 1960.

The report has been reviewed with considerable interest. The original construction of two of the bridges which will be affected by the proposed work, the West Lancaster Street Bridge and the East West Freeway Bridge were partially financed with Federal highway funds. The Texas Highway Department has assumed the maintenance responsibility for these structures.

In accordance with our governing regulations Federal-aid highway funds cannot be made available to relieve local interests of their agreed or required responsibility to adjust highway facilities as a condition to the construction of the Flood Protection project.

The Southwest Loop 317 which is outside the limits of the proposed project is also on a Federal-aid highway system and was partially financed with Federal-aid highway funds. The future proposed Interstate Highway Loop 820 will also cross southwest or upstream from the Loop 317 structures. Although the exact location and details of these structures have not yet been determined, it is possible that the proposed channel improvement project may result in some additional benefits to the highway project. The Texas Highway Department has the primary responsibility for the location and the design of this new highway facility.

We shall be pleased to cooperate in the development of the proposed flood control project to the extent permitted by regulations. The opportunity to review the draft copy of the report is appreciated.

Very truly yours,

/s/ J. M. Page

J. M. Page
Division Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
REGION IV

DIVISION OF
MINERAL RESOURCES

ROOM 206 FEDERAL BUILDING
BARTLESVILLE, OKLAHOMA

May 12, 1960

Colonel Walter J. Wells, CE
District Engineer
U. S. Army Engineer District
Fort Worth
P. O. Box 1600
Fort Worth, Texas

Dear Colonel Wells:

Please refer to file No. SWFGP, your letter of April 29, 1960, to Robert S. Sanford, Bureau of Mines, Region IV, Bartlesville, Oklahoma.

We have reviewed the draft copy (Serial Number 75) of Part II of "Review of Reports on Trinity River and Tributaries, Texas, Covering the West Fork Watershed, Flood Protection, Fort Worth Area", dated April 1960.

As we interpret the report, the main objective of the program is flood protection for a more or less suburban area at Fort Worth, Texas. Such protection would be accomplished by modification of the existing project for Trinity River, Texas, to provide for the extension of channel improvement and floodway works on the Clear Fork upstream from the existing Fort Worth Floodway project. The estimated total Federal cost would be $4,921,400.

The current mineral industry of the area would not be adversely affected by the proposed construction work.

Sincerely yours,

/s/ H. F. Robertson

H. F. Robertson
Mining Engineer

Copy to: Leon Dupuy, Special Assistant for Mineral Resources Studies of River Basins, Washington, D. C.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
REGIONAL OFFICE, REGION 5
P. O. BOX 1609
AMARILLO, TEXAS

IN REPLY
REFER TO: 5-730

May 13, 1960

Colonel Walter J. Wells
District Engineer
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth, Texas

Dear Colonel Wells:

Your April 29, 1960, letter (file SWFGP) transmitting for our review and comments a draft copy, in final form, of your Part II of "Review of Reports on Trinity River and Tributaries, Texas, Covering the West Fork Watershed, Flood Protection, Fort Worth Area," dated April 1960, is appreciated.

The report has been reviewed in this office, and the office of the Area Engineer, Austin, Texas. This letter includes the comments of both the Regional and Area offices.

The proposed works would not adversely affect any existing or potential Bureau projects, and we have no objection thereto.

Your courtesy in providing our offices an opportunity to review and comment on your report is appreciated.

Sincerely yours,

/s/ John R. Thompson

Acting Regional Director

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE
Ninth Floor - 1114 Commerce
Dallas 2, Texas

PUBLIC HEALTH SERVICE

May 16, 1960

District Engineer
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth, Texas

Dear Sir:

The comments which we made on Part I of "Review of Reports on Trinity River and Tributaries, Texas, Covering West Fork Watershed, Flood Protection---Fort Worth Area" also apply to Part II.

The partial solution of flood problems through construction of floodway and channel improvement works on the Clear Fork will be beneficial public health measures. The reduction of floods will minimize disease transmission, vector and rodent control problems. Protection to water and waste treatment facilities will also be beneficial.

We appreciate the opportunity to review the report.

Sincerely yours,

/s/ Jerome H. Svore

JEROME H. SVORE
Regional Program Director
Water Supply and Pollution
Control

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

P. O. Box 417
Temple, Texas
May 19, 1960

Colonel Walter J. Wells
District Engineer
U. S. Corps of Engineers
100 West Vickery Boulevard
P. O. Box 1600
Fort Worth 4, Texas

Dear Colonel Wells:

Thank you for the opportunity to review the final draft of Part II of your "Review of Reports on Trinity River and Tributaries, Texas, Covering the West Fork Watershed, Flood Prevention, Fort Worth Area," dated April 1960. As a result of the completed review, the following comments are presented for your consideration.

Paragraph 36, page 16 - It is stated that the total Federal obligations under the authorized program (USDA-SCS) for the Upper Trinity River Basin through June 30, 1957, amounted to $17,296,881, based on information presented at the hearings for fiscal year 1959, held by the House subcommittee of the Committee on Appropriations, 85th Congress, 2d Session. Paragraph 28, page 11 of Part I of the report dated July 1959, stated the Federal obligation to be $14,518,668 through June 30, 1957, quoting the same hearings as the source of information. Information at this office indicates the latter amount ($14,518,668) as stated in Part I to be correct.

Paragraph 38, page 16 - The following statement is suggested as a substitute for the paragraph now appearing. "The Soil Conservation Service has planned 33 additional flood detention reservoirs under the authorized program on the planned subwatersheds above Eagle Mountain Lake and Benbrook Reservoir at an estimated Federal construction cost of approximately $1,436,760. The planned structures would provide a total storage of 40,273 acre-feet, including 34,134 acre-feet for flood detention and 6,139 acre-feet for sediment."

We would like also to acknowledge receipt of the revised sheets and plates sent with your letter of April 29, 1960, for insertion in our copy of Part I of the report forwarded for our review and comment with your letter of July 15, 1959.

The continued courtesy in providing draft copies of your reports for review by the Soil Conservation Service is appreciated. It is hoped that the comments presented above will be helpful.

Very truly yours,

/s/ H. N. Smith

H. N. Smith
State Conservationist

U. S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
100 WEST VICKERY BOULEVARD
FORT WORTH 4, TEXAS

ADDRESS REPLY TO:
DISTRICT ENGINEER
U. S. ARMY ENGINEER DISTRICT, FORT WORTH
P. O. BOX 1600
FORT WORTH, TEXAS
REFER TO FILE NO. SWFGP

23 May 1960

Mr. H. N. Smith, State Conservationist
U. S. Soil Conservation Service
P. O. Box 417
Temple, Texas

Dear Mr. Smith:

This is in reply to your letter of 19 May 1960 which contained the comments of your office on the draft copy of our "Review of Reports on Trinity River and Tributaries, Texas, Covering West Fork Watershed, Flood Protection - Fort Worth Area, Part II," dated April 1960.

The subject report is being revised in accordance with the information and suggested revisions contained in your letter.

The comments contained in your letter with regard to the subject report are appreciated.

Sincerely yours,

WALTER J. WELLS
Colonel, CE
District Engineer

Copy furnished:
Head, Engineering and
Watershed Planning Unit
Soil Conservation Service
U. S. Department of Agriculture
P. O. Box 1898
Fort Worth, Texas

John A. Short, River Basin Representative
Soil Conservation Service
U. S. Department of Agriculture
15th and Quebec Streets
Tulsa 12, Oklahoma

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO

ADDRESS ONLY THE
REGIONAL DIRECTOR
2-RBS

SOUTHWEST REGION
(REGION 2)
ARIZONA
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
UTAH
WYOMING

May 19, 1960

AIRMAIL-SPECIAL DELIVERY

District Engineer
Corps of Engineers, U. S. Army
P. O. Box 1600
Fort Worth, Texas

Dear Sir:

Two copies of a draft of our proposed report on "The Review of Reports on Trinity River and Tributaries, Texas, Covering West Fork Watershed, Flood Protection, Fort Worth Area, Part II," are enclosed in response to your letter of April 29, 1960.

Although this report has not had the formal concurrence of the Texas Game and Fish Commission, we do not expect any material change in the wording of the draft. As soon as we have the concurrence of the Texas Game and Fish Commission, we will release the report in final form.

Sincerely yours,

/s/ Carey H. Bennett, Chief

Carey H. Bennett, Chief
Division of Technical Services

Enclosures (2)

cc: Executive Secretary, Texas Game and Fish Commission, Austin, Texas
Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Fort Worth, Texas

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO

ADDRESS ONLY THE
REGIONAL DIRECTOR
2-RBS

SOUTHWEST REGION
(REGION 2)
ARIZONA
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
UTAH
WYOMING

May 19, 1960

AIRMAIL

Mr. Howard D. Dodgen, Executive Secretary
Texas Game and Fish Commission
Walton State Building
Austin 1, Texas

Dear Mr. Dodgen:

Two copies of a review draft report on the Corps of Engineers "Review of Reports on Trinity River and Tributaries, Texas, Covering West Fork Watershed, Flood Protection, Fort Worth Area, Part II" are enclosed for your review and concurrence.

We presume that Field Supervisor Degani has discussed this metropolitan area project with personnel of your field staff, and we cannot foresee any adverse problems which this project may cause. Since the Corps of Engineers has expressed an early need for our report, we expect to release the report in final form as soon as we have your letter of concurrence.

Sincerely yours,

Carey H. Bennett, Chief
Division of Technical Services

Enclosures (2)

cc: District Engineer, Corps of Engineers, U. S. Army, Fort Worth, Texas
Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Fort Worth, Texas, w/c of draft

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO

District Engineer
Corps of Engineers, U. S. Army
P. O. Box 1600
Fort Worth, Texas

Dear Sir:

In response to your letter of April 29, 1960, file SWFGP, the following comments constitute our report on "The Review of Reports on Trinity River and Tributaries, Texas, Covering West Fork Watershed, Flood Protection, Fort Worth Area, Part II," dated April 1960.

We notice that the proposed plan of improvement includes channel improvement on about 8.8 miles of the Clear Fork between West Lancaster Avenue and the Southwest Loop 217 crossing, construction of about 3.2 miles of levee including 900 feet of concrete floodwall located along the right bank of the proposed enlarged and realigned channel, appurtenant interior drainage facilities, filling in of four overbank areas, removal and reconstruction of three concrete channel dams on the Clear Fork, modification of five highway bridges and two railroad bridges, and relocation and alteration of urban and private utilities.

Any adverse effects which the proposed plan of improvement may have on fish and wildlife resources of the area would be minor. This conclusion has been concurred in by the Texas Game and Fish Commission, as indicated by Assistant Director J. R. Singleton of the Division of Wildlife Restoration in his letter of May 25, 1960.

Sincerely yours,

/s/ John C. Gatlin

John C. Gatlin
Regional Director

Copies (10)

Distribution:
(2) Executive Secretary, Texas Game and Fish Commission, Austin, Texas
(2) Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Fort Worth, Texas

UNITED STATES
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
AWR Basins Office
Agricultural Office Building, 15th and Quebec
Tulsa 12, Oklahoma
May 23, 1960

District Engineer
U. S. Army Corps of Engineers
100 West Vickery Blvd.
Fort Worth, Texas

Dear Sir:

You have received a letter dated May 19, 1960, from Mr. H. N. Smith, State Conservationist, Texas, submitting some comments on your review of reports on Trinity River and Tributaries, Texas, covering the West Fork watershed Flood Prevention, Fort Worth area.

This letter constitutes the comments of the Department of Agriculture on the report since the Forest Service has indicated that the project does not affect timber lands.

Yours very truly,

/s/ John A. Short

John A. Short
River Basin Representative

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
SOUTHWEST FIELD COMMITTEE, REGION SIX
807 Brazos Street
Austin 14, Texas

May 25, 1960

District Engineer
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth, Texas

Dear Sirs:

The Corps of Engineers' report, Serial No. 71, entitled "Review of Reports on Trinity River and Tributaries, Texas covering West Fork Watershed Flood Protection - Fort Worth Area, Part II", transmitted with your letter of April 29, 1960, has been reviewed by this office.

It is apparent that all available historical data on rainfall and runoff have been utilized in the analytical studies.

The Geological Survey has not made detailed analytical studies of past and possible flood-flow magnitudes and frequencies of the West Fork of Trinity and its tributaries in the Fort Worth area. Flood reports prepared by the Geological Survey such as that for the flood of May 17, 1949 at Fort Worth, Tex. and other peak flood determinations show that the peak discharge selected for your design operation is reasonable and in all probability the designed discharge is lower than that which may occur under the most extreme conditions.

Thanks for giving me an opportunity to review this report.

Very truly yours,

/s/ Trigg Twichell

Trigg Twichell

cc: General Staff Committee (5)

APPENDIX V

ECONOMIC BASE STUDY

WEST FORK WATERSHED
FLOOD PROTECTION - FORT WORTH AREA

PART II

APPENDIX V

ECONOMIC BASE STUDY
WEST FORK WATERSHED
FLOOD PROTECTION - FORT WORTH AREA
PART II

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APPENDIX V

ECONOMIC BASE STUDY

WEST FORK WATERSHED
FLOOD PROTECTION - FORT WORTH AREA

PART II

INTRODUCTION

1. PURPOSE.- The purpose of the economic base study is to determine the probable future development in the area subject to flooding which is to be used in estimating the damage prevention benefits creditable to the proposed plan of improvement. This development and future growth is that which would be anticipated without any further flood control improvements in operation. Two methods of estimating the flood plains future growth have been employed herein. One method involves economic projections of Tarrant County such as population growth, value added by manufacture, labor force, and wholesale and retail sales. The other method employs a more direct approach, whereby a development sequence of the actual flood plain lands is contemplated and average annual damages estimated thereon.

TARRANT COUNTY - FUTURE GROWTH

2. POPULATION TRENDS.- During the period 1910 to 1960 the population of Tarrant County has increased 382 percent, a growth far greater than that of the State of Texas, the Southwest region, and the United States. An indication that this growth has occurred at a more accelerated rate during the last 20 years is shown by the fact that the growth during the first 30 years of the period (1910-1940) was only 108 percent.

3. The Fort Worth National Bank and the Texas Electric Service Company, in a report entitled "Population and Growth Trends of the Fort Worth Metropolitan Area, 1950-2000," dated June 1958, made the following estimates for Tarrant County:

Year	Population
1970	880,000
1980	1,186,000
1990	1,491,000
2000	1,718,000

A projection of the trend indicated above results in an estimated population of 1,875,000 for Tarrant County in 2010.

4. The Urban Land Institute, an independent, nonprofit research organization incorporated in 1936 under the laws of the State of Illinois, has published a monograph by Dr. Jerome P. Pickard, Director of Research of Hammer and Company Associates, economic and business consultants of Atlanta and Washington. This publication, dated 1959, indicated the following population estimates for Tarrant County:

Year	Population
1980	1,129,000
2000	1,681,000

A projection of the above trend results in an estimated population of 1,850,000 for Tarrant County in 2010.

5. The Select Committee on National Water Resources of the United States Senate in its Committee Print No. 5, entitled "Water Resources Activities in the United States, Population Projections and Economic Assumptions," dated 1960, indicated the following population estimates for Tarrant County:

Year	Population
1970	850,000
1980	1,220,000
2000	2,262,000

The above figures are based on an average of series II and series IV fertility assumptions (a measure of birth performance which takes account of birth rates by age of women) and an average of interstate migration assumptions 1 and 2. A projection of the above indicated trend results in an estimated population of 2,560,000 for Tarrant County in 2010.

6. The U. S. Study Commission - Texas has prepared preliminary population projections for the use of the Commission staff and the various collaborating agencies. These projections indicate an estimated population of 1,885,000 for Tarrant County in 2010.

7. An average of the four estimated populations as indicated above results in an estimated population for Tarrant County of about 2,040,000 in 2010. The actual 1960 population for Tarrant County is 523,452. Using the actual 1960 population of 523,452 as a base of 100, and the estimated population of 2,040,000 for 2010, the index for the year 2010 would be 390, or a factor of 3.90.

8. VALUE ADDED BY MANUFACTURE.- There are two areas in Texas which will contain the major future industrial growth, the Houston-Beaumont area and the Dallas-Fort Worth area; therefore, the values

used in this report should be considered as the minimum limits of growth, assuming an adequate water supply.

9. Studies currently underway in connection with the comprehensive report on the Trinity River and tributaries, Texas, indicate that the value added by manufacture in Tarrant County in the year 2010 will be about $3,360,000,000. Using an estimated value of $460,000,000 in 1960 as a base of 100, and the estimated value of $3,360,000,000 for 2010, the index for 2010 would be 730, or a factor of 7.30. Based on current trends in the area being studied on the Clear Fork, it has been determined that future development in the flood plain will be largely residential and commercial. For this reason it has been considered appropriate to use only one-half the anticipated rate of growth for the county, and an adjusted factor of 3.65 has been used for the Clear Fork flood plain.

10. WHOLESALE SALES.- Based on studies by the Bureau of the Census, wholesale sales projected in current dollars gives an estimated value of $1,750,000,000 for the year 2010. Using an estimated value of $730,000,000 in 1960 as a base of 100, the index for 2010 would be 240, or a factor of 2.40.

11. RETAIL SALES.- Based on a projection approximated with wholesale sales as a pattern, but with the further consideration that retail sales will probably increase more rapidly than wholesale sales in the latter part of the period due to the dominance of Dallas in the wholesale activity of Tarrant County, an estimated value of $1,750,000,000 for retail sales by the year 2010 has been determined. Using an estimated value of $630,000,000 in 1960 as a base of 100, the index for 2010 would be 278, or a factor of 2.78.

12. LABOR FORCE.- Based on data from the Texas Employment Commission, the Bureau of the Census, and other sources, the labor force projection for Tarrant County by the year 2010 is estimated at 583,000. Using an estimated figure of 208,000 in 1960 as a base of 100, the index for 2010 would be 280, or a factor of 2.80.

13. ECONOMIC DEVELOPMENT.- The economic development of Tarrant County, as well as the development of the Clear Fork flood plain, is progressing at a rapid rate. The combined area of Tarrant and Dallas Counties, which includes the cities of Fort Worth and Dallas, is the center of a rapidly expanding industrial and commercial complex of which the flood plain of Clear Fork is a part. As a result of this obvious rapid progress, it has been determined that an accelerated growth curve would be the most representative of the growth trends of the area.

14. DEVELOPMENT FACTORS.- All of the factors determined in paragraphs 2 through 12 above are summarized as follows:

Item	Factor
Population trend	3.90
Value added by manufacture	3.65
Wholesale sales	2.40
Retail sales	2.78
Labor force	2.80

The geometric mean is an accepted means of averaging rates of change or index numbers expressed as percentages of a base. This method therefore has been used to determine the average of the above factors as follows:

Average factor = $\sqrt[5]{3.90 \times 3.65 \times 2.40 \times 2.78 \times 2.80} = \sqrt[5]{265.93} = 3.06$

This factor, less the factor of 1.00 assumed for 1960 conditions, gives an additional growth factor of 2.06. Adjusting this factor on the basis of a 50-year project, a 2-5/8 percent interest rate, and an accelerated growth curve results in an adjusted average annual equivalent factor of 1.45 (.704 x 2.06 = 1.45). Adding this amount to the factor of 1.00 for 1960 conditions as described above gives a total adjusted average annual equivalent factor of 2.45.

15. AVERAGE ANNUAL BENEFITS.- The average annual benefits from prevention of damages under 1960 prices and conditions are estimated in paragraph 77 of the report to be $365,400 for the area affected by the proposed plan of improvement. Average annual benefits under 2010 conditions of development are obtained by multiplying the average annual benefits of $365,400 under 1960 conditions by the adjusted average annual equivalent factor of 2.45, the resulting benefits being $895,200.

FLOOD PLAIN LANDS - FUTURE GROWTH

16. INVESTIGATIONS BASED ON ANTICIPATED DEVELOPMENT.- The portion of the flood plain of the Clear Fork upon which the benefits are based is being developed very rapidly at the present time. This high rate of growth is due to several factors. Its geographical location is such that the business section of Fort Worth is readily accessible. This accessibility is further augmented by the modern expressways and adequate thoroughfares which serve the area. Its desirability is increased by the existing housing development through which expensive homes have been constructed and others are being planned in the general area. Other favorable features are the extensive parks and recreational facilities in the general vicinity.

17. A thorough study of the entire flood plain being investigated was made to determine the areas that were likely to be developed by the year 2010 even though flood control were not provided. A field reconnaissance of these areas was made, and developers active in the vicinity were interviewed to determine the type of improvement most likely to be constructed in the flood plain. A tabulation showing

the value of physical property existing in the flood plain at the present time (1960), the value of physical property expected to be added by the year 2010, and the total value of physical property expected within the flood plain by the year 2010 (based on 1960 price levels) is given below:

Item	1960	Added by 2010	Total 2010
Residential property	$14,573,000	$21,180,000	$35,753,000
Business and industrial property	8,883,000	17,000,000	25,883,000
Recreational facilities (private)	1,058,000	500,000	1,558,000
Schools	505,000	500,000	1,005,000
City property			
Parks	2,392,000	500,000	2,892,000
Streets and bridges	1,531,000	500,000	2,031,000
Sewage system	813,000	200,000	1,013,000
Water supply system	842,000	200,000	1,042,000
Local utilities	416,000	175,000	591,000
State highways	847,000	--	847,000
Railroads	113,000	50,000	163,000
Undeveloped land	514,000	100,000	614,000
Total	$32,487,000	$40,905,000	$73,392,000

18. These improvements were then assumed to be in place, and hypothetical discharge-damage curves were constructed based on estimated 2010 development. In this connection, it was necessary to consider not only the increase in the amount of property in the flood plain but also an increase in the ratio of damages to total value of the property. This increase is due to several factors. As development continues, it is considered logical to assume that it will extend farther into the flood plain where the depth of flooding will be greater and moving floodwaters will have higher velocities. Also, the present trend is toward construction of one-story residences with "built-in" or fixed installation of kitchen appliances, heating and air conditioning equipment, and other expensive electrical appliances. All of these factors were considered in constructing the discharge-damage curve referred to above.

19. The discharge-damage curve thus obtained was then applied to the existing discharge-frequency curve shown on plate 25A of the report and a damage-frequency curve was constructed. From this curve the average annual benefits from damages prevented, based on 2010 conditions, were found to be $1,091,100. The benefits of $365,400 under 1960 conditions had previously been determined in paragraph 77 of the report. This amount subtracted from the $1,091,100 given above shown an increase of

$725,700 due to increased development between 1960 and 2010. This amount was then adjusted on the basis of a 50-year project, a 2-5/8 percent interest rate, and an accelerated growth curve to obtain the annual equivalent benefits of $510,900 (.704 x $725,700 = 510,900). This amount was then added to the benefits of $365,400 for 1960 conditions to obtain average annual benefits of $876,300 under anticipated 2010 development conditions.

SUMMARY

20. SELECTION OF DAMAGE PREVENTION BENEFITS.- In comparing the amount of $876,300 as determined in paragraph 19 with the amount of $895,200 as estimated in paragraph 15, there is found a difference of only 2.2 percent. Therefore, it is considered appropriate to adopt an average of $886,000 as the annual benefits from the prevention of damages creditable to the improvement.

21. LAND ENHANCEMENT CONSIDERED.- As indicated above, available information indicates that intensive development of the flood plain being studied will continue even if flood control improvements are not provided. Therefore, if the proposed improvements should be constructed, no significant amount of enhancement benefits would result from increased utilization of lands within the flood plain, including those land areas set forth in the proposed plan of improvement on the Clear Fork for the disposal of excess channel-excavation materials.

22. UNIVERSITY DRIVE LEVEE.- The development factor is not applicable to the University Drive area due to the fact that a large portion of the area that would be protected by the levee consists of land now occupied by a city park and is not susceptible to extensive damage. Furthermore, it is highly improbable that this condition will change since the area is dedicated as a park and in the event it is no longer used for this purpose, title for the land will revert to the original owners. It is considered unlikely that the city will be willing to relinquish the land for any higher order of use under these conditions.

23. CLEAR FORK ABOVE SOUTHWEST LOOP 217.- Application of neither of the foregoing methods of development projection will result in justification of improvements in the area of the flood plain above Southwest Loop 217. The existing average annual damages under 1960 conditions are less than $300 and application of any reasonable development factor would not be sufficient to result in any significant benefits. An investigation was made based on anticipated development similar to that described in paragraph 19 above. This resulted in average annual damages of $84,900 in the year 2010. This amount adjusted on the basis of a 50-year project, a 2-5/8 percent interest rate, and a deferred growth factor gives an annual equivalent benefit of $20,700.

24. MARYS CREEK RESERVOIR.- Construction of a single-purpose project for flood control only on Marys Creek in addition to the recommended channel and levee improvements of plan A would not be justified by the application of either of the methods of development projection used on the Clear Fork. The flood plain of Marys Creek is considered to be less desirable for future development than the Clear Fork area. However, in order to make a very optimistic evaluation of the area, the same development factor of 2.45 as used on the Clear Fork has been applied to the Marys Creek flood plain. The estimate of damages prevented under 1960 conditions of $6,800 in the Marys Creek flood plain would thus be increased to $16,700. Construction of the Marys Creek Reservoir would have the additional effect of reducing damages in the University Drive area by $3,000, if the channel capacity is not reduced, thereby resulting in total incremental benefits from the reservoir in the amount of $19,700.

FLOOD PROTECTION - FORT WORTH AREA, PART II
WEST FORK OF TRINITY RIVER, TEXAS

INFORMATION CALLED FOR BY
SENATE RESOLUTION 148, 85TH CONGRESS
ADOPTED 28 JANUARY 1958

1. Authority.- The following information is furnished in response to Senate Resolution 148, 85th Congress, Second Session, adopted 28 January 1958.

2. Flood problem.

a. The principal and most urgent flood problem in the Fort Worth area consists of the flooding of residential, commercial, and agricultural development within the flood plains of the West Fork and the Clear Fork of the Trinity River. The areas investigated are located as follows:

(1) The West Fork flood plain between the Handley-Ederville Road at about river mile 541.6 and the downstream end of the existing Fort Worth Floodway channel improvement at river mile 551.5 just upstream from Riverside Drive.

(2) The Clear Fork flood plain between the upstream end of the existing Fort Worth Floodway at about river mile 1.6 and Benbrook Dam at about river mile 15.0.

(3) The Marys Creek flood plain between the mouth of the creek and the investigated dam site at about mile 7.7.

b. The developments in these areas are located principally within the corporate limits of Fort Worth. Problem area (1) contains four street or highway crossings, partially developed business and industrial property, a few inexpensive residential areas, and the Fort Worth sewage treatment plant. Problem area (2) contains six street or highway crossings, three railroad crossings, numerous urban utility crossings, Convair recreational area, the Tanglewood residential section, the Colonial Country Club golf course area, the highly developed University Drive commercial area, and the Forest Park and Trinity Park recreational areas. In the area between the existing Tanglewood residential section and the Southwest Loop 217, planning has been completed on additional residential and commercial development, a portion of which is now under construction. Between the Southwest Loop 217 and Benbrook Dam the flood plain is generally undeveloped except for minor agricultural improvements. Problem area (3) is generally undeveloped except for minor business and residential property; however, additional residential development is being planned by local interests.

3. Recommended plan of improvement.- The recommended plan of improvement, described as plan A in the basic report, provides for the upstream extension of channel and floodway improvements on the Clear Fork between the existing Fort Worth Floodway project (mile 1.6) and the Southwest Loop crossing (mile 10.4). The proposed project would provide a combination of full and partial flood protection against the peak discharges of the standard project floods and maximum flood of record to the 8.8-mile reach of the Clear Fork problem area and would consist of the following principal items of work: The construction of about 6.5 miles of channel improvement by enlargement and realignment of the Clear Fork between West Lancaster Avenue, river mile 1.6, and the Southwest Loop 217 crossing, river mile 10.4; the construction of about 3.2 miles of levee, including 900 feet of concrete floodwall, located along the right bank of the proposed enlarged and realigned channel, for the protection of the Tanglewood residential and Convair recreational areas; the provision of appurtenant interior drainage facilities, consisting of three permanent sump areas to provide an aggregate storage capacity of about 109 acre-feet below damaging-stage elevations in the Tanglewood residential and Convair recreational areas, gate-controlled gravity sluices through the levees at each sump location, and 1.57 miles of diversion channels and appurtenant works provided in lieu of additional sump-storage facilities for interior drainage runoff; and the filling of four overbank areas, amounting to a total area of about 500 acres, to elevations about two feet above the floodway design water surface by utilizing about 4,400,000 cubic yards of excess materials from the channel and sump excavation work. Local interests would be required to comply with all of the requirements as generally set forth for local-protection type projects. These requirements are (1) provide without cost to the United States all land, easements, and rights-of-way necessary for the construction, maintenance, and operation of the project, (2) provide without cost to the United States the fill areas required for disposal of excess materials from the channel excavation, (3) make any alterations and relocations to existing improvements required for the construction of the project, (4) hold and save the United States free from damages due to the construction of the project, (5) prohibit encroachment in the sump areas and on the flood-carrying capacities of the improved channel and floodway works, and (6) maintain and operate all works after completion in accordance with regulations prescribed by the Secretary of the Army.

4. Project costs and economic analysis.- The total first cost of the project, exclusive of the cost of preauthorization studies ($12,500), is estimated at $8,025,500 on the basis of January 1960 prices, of which $5,148,000 is the Federal construction cost and $2,877,500 is the non-Federal cost for lands and for alterations to channel dams, bridges, and utilities. The estimated annual cost shown in the basic report is $402,700, of which $342,800 is for interest and amortization computed on the basis of 2.625 percent

for Federal costs, 5.0 percent for lands, and 3.0 percent for other project costs, and a 50-year economic life; and $59,900 is for annual maintenance and operation by local interests.

5. Benefits and benefit-cost ratios.- The total benefits credited to the project are estimated to amount to $886,000, all for the prevention of flood damages. The benefit-cost ratio on the basis of a 50-year economic life is 2.2 to 1, as shown in the basic report. Analysis on the basis of a 100-year economic life indicates a decrease in the annual costs to $345,000 and an increase in the benefit-cost ratio to 2.6 to 1.

6. Physical feasibility and provisions for future needs.- The proposed project (plan A) was found to be the most practical and only economically justified plan and will provide a combination of full and partial flood protection for the problem area on the Clear Fork. It will provide full protection against the standard project flood discharge of 75,000 second-feet for the Tanglewood residential and Convair recreational areas and the four overbank fill areas, and partial flood protection for the balance of the 8.8-mile reach of the Clear Fork by containing within the banks of the improved channel the peak discharge of 26,000 second-feet of the maximum flood of record (May 1949), modified by Benbrook Reservoir.

7. Master floodway extension plans developed for the West Fork and Clear Fork problem areas being covered in this report were not found to be economically justified at this time; however, these plans will provide pertinent information on the magnitude and requirements of future protective works which will be useful to local interests in the establishment of building restriction limits and in the construction of future roads, bridges, utilities, and other urban developments in the problem area.

8. The nature of the flood control problem in the Fort Worth area is not conducive to the development of an upstream reservoir since there would be no appreciable reduction in the peak discharges of the standard project flood or the maximum flood of record on the Clear Fork and, therefore, would not eliminate the need for upstream extension of the existing Fort Worth Floodway project. Consideration was given to a multiple-purpose reservoir on Marys Creek at creek mile 7.7 for flood control, water conservation, fish and wildlife, and recreation purposes. The studies indicated, however, that the reservoir project,as a last-added unit to the proposed floodway and channel improvement works of plan A, would not be a justified undertaking at Federal expense since the incremental benefit-cost ratio of the reservoir project for the flood control, water conservation, and fish and wildlife purposes, exclusive of the recreation function, was only 0.6. However, with the recreation function added, the incremental benefit-cost ratio increased to 1.04.

9. Extent of interest in project.- Local interests represented by the Tarrant County Water Control and Improvement District Number One and the City of Fort Worth have indicated their general approval and support of the proposed project, and no objections are known to exist. The above local interests have been advised that an upstream multiple-purpose reservoir for flood control and water conservation purposes considered in the plans for the protection of the subject flood problem areas was not found to be practical or economically justified at this time. The Tarrant County Water Control and Improvement District Number One stated that at the proper time it will take the necessary steps to endeavor to extend its boundaries to embrace the entire area involved and qualify itself as the responsible local agency for the items of local cooperation established for the proposed project. Previously, this agency was successful in extending its boundaries to become the responsible local agency in connection with the construction, maintenance, and operation of the existing Fort Worth Floodway project.

10. Alternative projects.- In accordance with the requests made by local interests at the public hearing, the following additional plans and improvements were investigated for resolution of the flood problems on the West Fork and Clear Fork:

a. Channel improvement for the West Fork problem area downstream from the existing Fort Worth Floodway project consisting of plans A, B, and C. Channel improvement plans A and B extend from a point about 1,575 feet downstream of the Handley-Ederville Road upstream to the existing Fort Worth Floodway project. Plan A consists of 39,400 feet of channel improvement and, as suggested by local interests, includes a major cutoff between river miles 544.6 and 548.1. Plan B, consisting of 43,600 feet of channel improvement, is essentially the same as plan A, but the major cutoff is excluded. Channel improvement plan C, which is essentially the upstream portion of plan B, was established to protect the most highly developed portion of the problem area on the left bank of the West Fork. Plan C begins at about river mile 545.8 and consists of about 27,600 feet of channel improvement.

b. Floodway plans for the West Fork consisting of master floodway extension plans A and B and floodway plan C were developed for the West Fork problem area by the addition of levees and appurtenant interior drainage facilities. The floodway plans would provide full protection for most of the flood plain against the floodway design or standard project flood discharge.

c. Channel improvement and floodway plans investigated for the Clear Fork, in addition to the basic plan A, consist of plan B which includes plan A with the addition of the University Drive commercial area levee; and plan C, the master floodway plan, which includes plan B with the addition of the channel improvement works and overbank

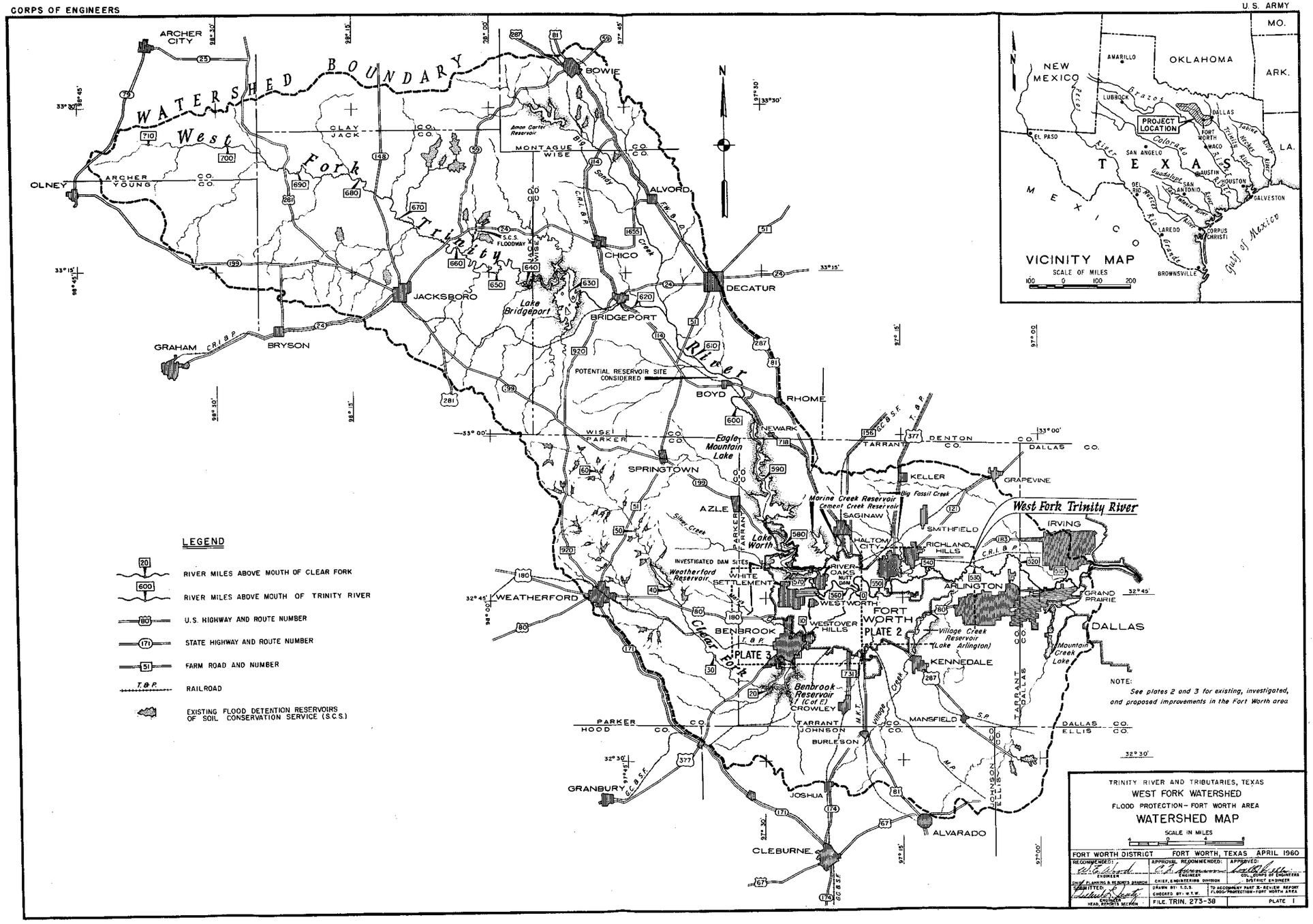
fill areas for the problem reach of the Clear Fork upstream from Southwest Loop 217 to Benbrook Dam and a 1.3-mile reach of Marys Creek.

d. Marys Creek Reservoir for flood control, water conservation, fish and wildlife, and recreation purposes was investigated as an added unit to the local flood protection measures of plan A on the Clear Fork. The investigations included full consideration to the maximum potential development of water conservation in a multiple-purpose reservoir at the Marys Creek site.

Economic and cost studies determined that the additional improvements described in items a and b are not economically justified. As explained in paragraph 8, item c (the Marys Creek Reservoir) was not found to be a justified undertaking at Federal expense since the incremental benefit-cost ratio for the flood control, water conservation, and fish and wildlife functions, exclusive of recreation, was only 0.6. The economic analyses of costs and benefits for items a, b, and c were based on a 50-year economic life and interests rates of 2.625 percent for Federal costs, 5.0 percent for lands, and 3.0 percent for other project costs. It was also determined that, on the basis of a 100-year economic life, the economic merits of the additional improvements in items a and b would not substantially change. In the case of the Marys Creek Reservoir, however, the incremental benefit-cost ratio of 0.6 described above would increase to 0.7 on the basis of a 100-year amortization period, and thus, the investigated reservoir project would not be considered a justified Federal undertaking, even though the recreation function would increase the incremental benefit-cost ratio to 1.2.

CORPS OF ENGINEERS

U. S. ARMY



LEGEND

- 20 — RIVER MILES ABOVE MOUTH OF CLEAR FORK
- 600 — RIVER MILES ABOVE MOUTH OF TRINITY RIVER
- 80 — U.S. HIGHWAY AND ROUTE NUMBER
- 171 — STATE HIGHWAY AND ROUTE NUMBER
- 51 — FARM ROAD AND NUMBER
- T&P — RAILROAD
- EXISTING FLOOD DETENTION RESERVOIRS OF SOIL CONSERVATION SERVICE (S.C.S.)

TRINITY RIVER AND TRIBUTARIES, TEXAS

WEST FORK WATERSHED

FLOOD PROTECTION - FORT WORTH AREA

WATERSHED MAP

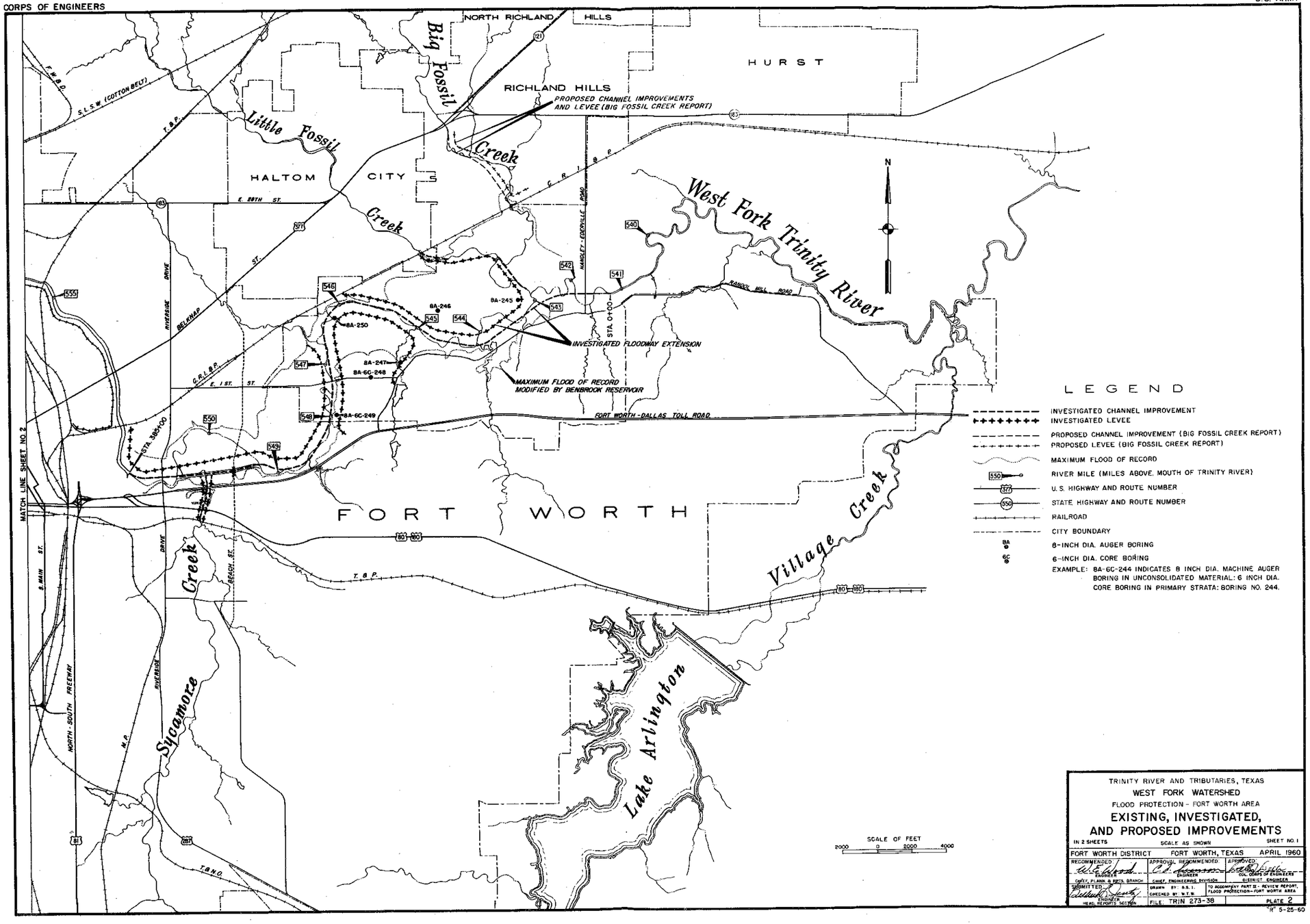
SCALE IN MILES 4 0 4 8

FORT WORTH DISTRICT	FORT WORTH, TEXAS APRIL 1960	
RECOMMENDED: Chief, Planning & Reports Branch	APPROVAL RECOMMENDED: Chief, Engineering Division	APPROVED: Col., Corps of Engineers, District Engineer
SUBMITTED: Chief, Reports Section	DRAWN BY: T.C.S. CHECKED BY: W.T.W.	TO ACCOMPANY PART II - REVIEW REPORT FLOOD PROTECTION - FORT WORTH AREA
	FILE: TRIN. 273-38	PLATE 1

85717 O - 62 (Face blank p. 124) No. 1

CORPS OF ENGINEERS

U.S. ARMY



LEGEND

- INVESTIGATED CHANNEL IMPROVEMENT
- INVESTIGATED LEVEE
- PROPOSED CHANNEL IMPROVEMENT (BIG FOSSIL CREEK REPORT)
- PROPOSED LEVEE (BIG FOSSIL CREEK REPORT)
- MAXIMUM FLOOD OF RECORD
- RIVER MILE (MILES ABOVE MOUTH OF TRINITY RIVER)
- U.S. HIGHWAY AND ROUTE NUMBER
- STATE HIGHWAY AND ROUTE NUMBER
- RAILROAD
- CITY BOUNDARY
- 8A — 8-INCH DIA. AUGER BORING
- 6C — 6-INCH DIA. CORE BORING

EXAMPLE: 8A-6C-244 INDICATES 8 INCH DIA. MACHINE AUGER BORING IN UNCONSOLIDATED MATERIAL; 6 INCH DIA. CORE BORING IN PRIMARY STRATA: BORING NO. 244.

TRINITY RIVER AND TRIBUTARIES, TEXAS
WEST FORK WATERSHED
FLOOD PROTECTION - FORT WORTH AREA

EXISTING, INVESTIGATED, AND PROPOSED IMPROVEMENTS

IN 2 SHEETS — SCALE AS SHOWN — SHEET NO. 1

FORT WORTH DISTRICT — FORT WORTH, TEXAS — APRIL 1960

RECOMMENDED	APPROVAL RECOMMENDED	APPROVED
ENGINEER	ENGINEER	COL. CORPS OF ENGINEERS
CHIEF, PLANS & REPTS. BRANCH	CHIEF, ENGINEERING DIVISION	DISTRICT ENGINEER

SUBMITTED: ENGINEER, HEAD, REPORTS SECTION

DRAWN BY: B.S.I.
CHECKED BY: W.T.H.
FILE: TRIN 273-38

TO ACCOMPANY PART II - REVIEW REPORT, FLOOD PROTECTION - FORT WORTH AREA

PLATE 2

"R" 5-25-60

85717 O - 62 (Face blank p. 124) No. 2

CORPS OF ENGINEERS

U.S. ARMY

LEGEND

- PROPOSED CHANNEL IMPROVEMENT (CLEAR FORK TRINITY RIVER)
- PROPOSED LEVEE (CLEAR FORK TRINITY RIVER)
- INVESTIGATED CHANNEL IMPROVEMENT
- INVESTIGATED LEVEE
- PROPOSED CHANNEL IMPROVEMENT (WEST FORK TRINITY RIVER-PART 1 REPORT)
- PROPOSED LEVEE (WEST FORK TRINITY RIVER-PART 1 REPORT)
- MAXIMUM FLOOD OF RECORD
- EXISTING LEVEE-FORT WORTH FLOODWAY
- RIVER MILE (MILES ABOVE MOUTH)
- PROPOSED LEVEE SLUICE
- PROPOSED FILL AREA (1 THROUGH 4)
- PROPOSED BRIDGE ALTERATIONS:
  - (A) EXTEND BRIDGE, ADD PROTECTIVE WORKS
  - (B) ADD PROTECTIVE WORKS
  - (C) EXTEND BRIDGE
  - (D) RAISE AND EXTEND BRIDGE

NOTE: SEE LEGEND ON PLATE 2 FOR BORINGS AND GENERAL ITEMS

Lake Worth

West Fork Trinity River

CARSWELL AIR FORCE BASE

RIVER OAKS

PROPOSED FLOODWAY EXTENSION (PART I REPORT)

FORT WORTH FLOODWAY (EXISTING)

NUTT DAM

WESTWORTH

WHITE SETTLEMENT

Branch

Farmers

Marys Creek Reservoir Site (Investigated)

SPILLWAY

TOP DAM EL 820

Kings Brook

WESTOVER HILLS

MAXIMUM FLOOD OF RECORD MODIFIED BY BENBROOK RESERVOIR

INVESTIGATED UNIVERSITY DRIVE LEVEE AND FLOODWALL

CRAWFORD LEVEE

STA. 0+00 T&P DAM

STA. 22+40 BEGIN PROPOSED CHANNEL EXCAVATION

INVESTIGATED LEVEE

CITY DAM 2

PROPOSED CHANNEL IMPROVEMENT

CAMP BOWIE

EAST - WEST FREEWAY

FORT WORTH

CITY DAM 3

INVESTIGATED LEVEE

PROPOSED CONCRETE FLOODWALL

PROPOSED TANGLEWOOD LEVEE

PROPOSED DIVERSION CHANNEL

CITY DAM 4

MAXIMUM FLOOD OF RECORD MODIFIED BY BENBROOK RESERVOIR

INVESTIGATED LEVEE

South Marys Creek

Marys Creek

COMPUTED WATER SURFACE MAXIMUM FLOOD OF RECORD

STA. 319+70 END PROPOSED CHANNEL EXCAVATION

INVESTIGATED CHANNELS

INVESTIGATED FILL AREAS

PROPOSED CONVAIR LEVEE AND DIVERSION CHANNEL

SOUTHWEST LOOP 217

Walnut Creek

T & P.

ALEDO ROAD

BENBROOK

RALL DAM

Clear Fork Trinity River

Benbrook Reservoir

COUNTY

PARKER

TARRANT

SCALE OF FEET

2000 0 2000 4000

MATCH LINE SHEET NO. 1

TRINITY RIVER AND TRIBUTARIES, TEXAS

WEST FORK WATERSHED

FLOOD PROTECTION - FORT WORTH AREA

EXISTING, INVESTIGATED, AND PROPOSED IMPROVEMENTS

IN 2 SHEETS | SCALE AS SHOWN | SHEET NO. 2

FORT WORTH DISTRICT | FORT WORTH, TEXAS | APRIL 1960

RECOMMENDED: Chief, Plans & Data Branch

APPROVAL RECOMMENDED: Chief, Engineering Division

APPROVED: For the Chief of Engineers, District Engineer

CHECKED BY: Head, Reports Section

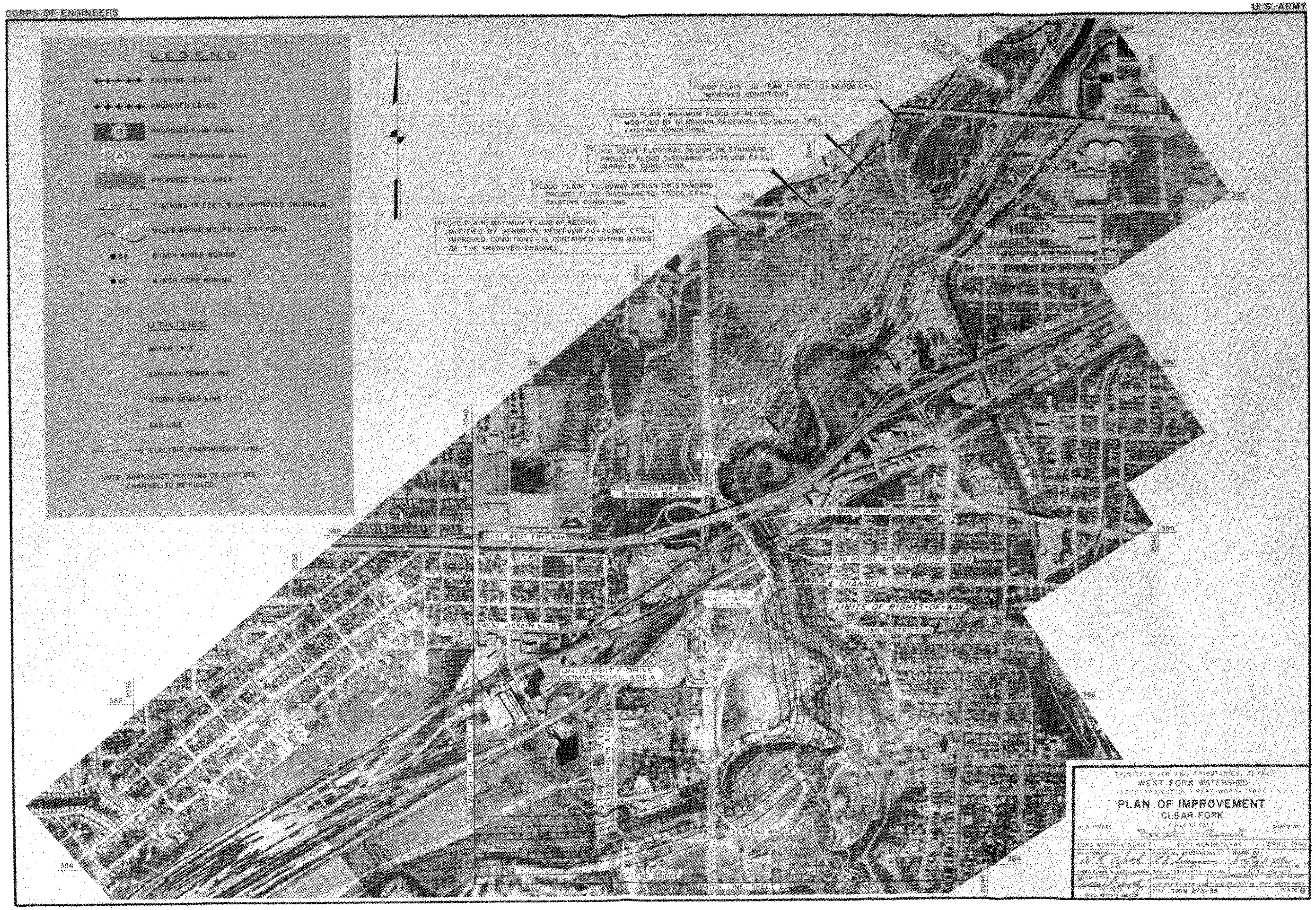
DRAWN BY: B.B.H. | CHECKED BY: W.T.W.

TO ACCOMPANY PART II - REVIEW REPORT, FLOOD PROTECTION - FORT WORTH AREA

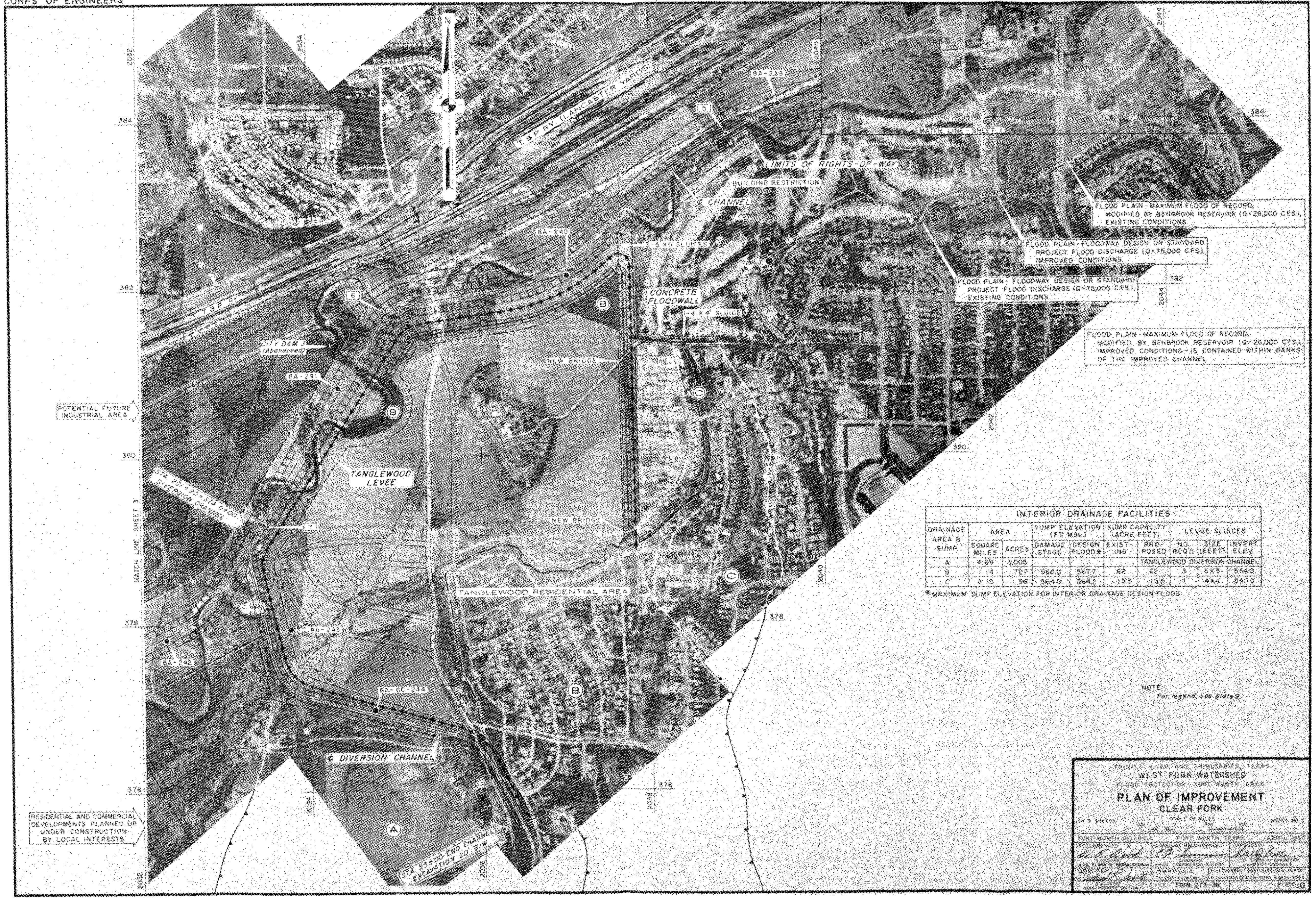
FILE: TRIN 273-38 | PLATE 3

"R" 5-25-60

85717 O - 62 (Face blank p. 124) No. 3


CORPS OF ENGINEERS
U.S. ARMY
LEGEND
EXISTING LEVEE
PROPOSED LEVEE
PROPOSED SUMP AREA
INTERIOR DRAINAGE AREA
PROPOSED FILL AREA
STATIONS IN FEET, ℄ OF IMPROVED CHANNELS.
MILES ABOVE MOUTH (CLEAR FORK)
8 INCH AUGER BORING
6 INCH CORE BORING
UTILITIES
WATER LINE
SANITARY SEWER LINE
STORM SEWER LINE
GAS LINE
ELECTRIC TRANSMISSION LINE
NOTE: ABANDONED PORTIONS OF EXISTING CHANNEL TO BE FILLED.
FLOOD PLAIN - 50-YEAR FLOOD (Q=36,000 C.F.S.) IMPROVED CONDITIONS
FLOOD PLAIN - MAXIMUM FLOOD OF RECORD, MODIFIED BY BENBROOK RESERVOIR (Q=26,000 C.F.S.) EXISTING CONDITIONS
FLOOD PLAIN - FLOODWAY DESIGN OR STANDARD PROJECT FLOOD DISCHARGE (Q=75,000 C.F.S.) IMPROVED CONDITIONS
FLOOD PLAIN - FLOODWAY DESIGN OR STANDARD PROJECT FLOOD DISCHARGE (Q=75,000 C.F.S.) EXISTING CONDITIONS
FLOOD PLAIN - MAXIMUM FLOOD OF RECORD, MODIFIED BY BENBROOK RESERVOIR (Q=26,000 C.F.S.) IMPROVED CONDITIONS - IS CONTAINED WITHIN BANKS OF THE IMPROVED CHANNEL.
EXTEND BRIDGE, ADD PROTECTIVE WORKS
ADD PROTECTIVE WORKS (FREEWAY BRIDGE)
EAST WEST FREEWAY
EXTEND BRIDGE, ADD PROTECTIVE WORKS
EXTEND BRIDGE, ADD PROTECTIVE WORKS
℄ CHANNEL
LIMITS OF RIGHTS-OF-WAY
BUILDING RESTRICTION
WEST VICKERY BLVD.
UNIVERSITY DRIVE COMMERCIAL AREA
EXTEND BRIDGES
EXTEND BRIDGE
MATCH LINE, SHEET 2
WEST FORK WATERSHED
PLAN OF IMPROVEMENT
CLEAR FORK
FORT WORTH, TEXAS
FILE TRIN 273-38
9

CORPS OF ENGINEERS U.S. ARMY



INTERIOR DRAINAGE FACILITIES

DRAINAGE AREA & SUMP	AREA		SUMP ELEVATION (F.T. MSL)		SUMP CAPACITY (ACRE FEET)		LEVEE SLUICES		
	SQUARE MILES	ACRES	DAMAGE STAGE	DESIGN FLOOD*	EXIST-ING	PRO-POSED	NO. REQ'D	SIZE (FEET)	INVERT ELEV.
A	4.69	3,005				TANGLEWOOD DIVERSION CHANNEL			
B	1.14	727	566.0	567.7	62	62	3	6X5	556.0
C	0.15	96	564.0	564.2	15.5	15.0	1	4X4	560.0

*MAXIMUM SUMP ELEVATION FOR INTERIOR DRAINAGE DESIGN FLOOD

WEST FORK WATERSHED

PLAN OF IMPROVEMENT

CLEAR FORK

TRIN 273-36

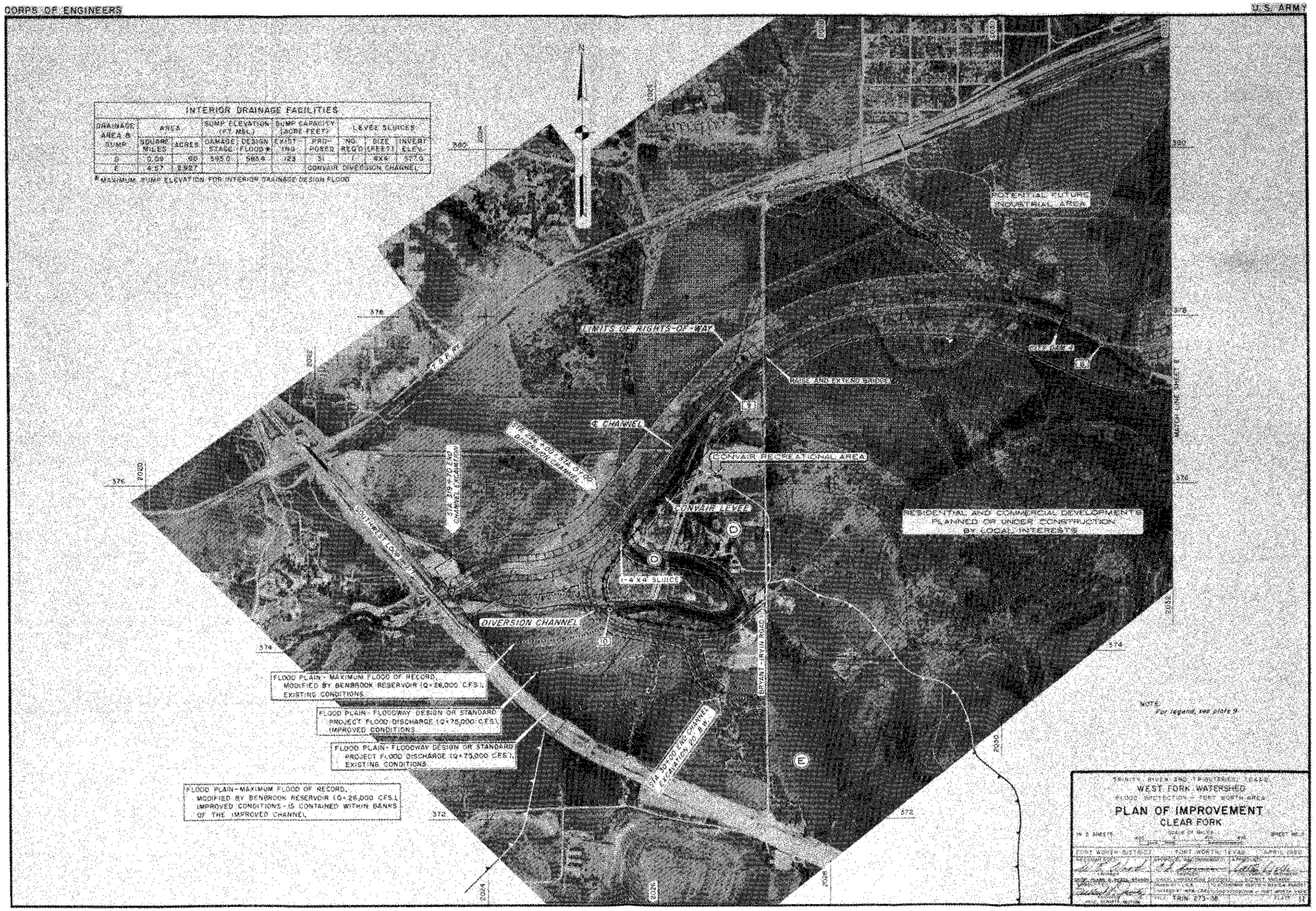
CORPS OF ENGINEERS

U.S. ARMY

INTERIOR DRAINAGE FACILITIES

DRAINAGE AREA & SUMP	AREA		SUMP ELEVATION (FT MSL)		SUMP CAPACITY (CUBIC FEET)		LEVEE SLUICES		
	SQUARE MILES	ACRES	DAMAGE STAGE	DESIGN FLOOD*	EXISTING	PROPOSED	NO. REQ'D	SIZE (FEET)	INVERT ELEV.
D	0.59	80	595.0	583.8	123	31	1	4X4	577.0
E	4.57	2927			CONVAIR DIVERSION CHANNEL				

*MAXIMUM SUMP ELEVATION FOR INTERIOR DRAINAGE DESIGN FLOOD



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