Also Issued as H. Doc. 276-89/1

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TRINITY RIVER AND TRIBUTARIES, TEXAS

LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY, DATED NOVEMBER 29, 1963, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A REVIEW OF THE REPORTS ON, AND A SURVEY OF THE TRINITY RIVER AND TRIBUTARIES, TEXAS, MADE PURSUANT TO SEVERAL CONGRESSIONAL AUTHORIZATIONS LISTED IN THE REPORT

IN FIVE VOLUMES

VOLUME I

AUGUST 25, 1965.—Referred to the Committee on Public Works and ordered to be printed with illustrations and appendixes

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U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1965

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Attachment - Information Required by Senate Resolution 148

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LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY
WASHINGTON, D.C. 20310

Honorable John W. McCormack August 17, 1965

Speaker of the House of Representatives

Dear Mr. Speaker:

I am transmitting herewith a favorable report dated 29 November 1963, from the Chief of Engineers, Department of the Army, together with accompanying papers and illustrations, on a review of the reports on, and a survey of the Trinity River and Tributaries, Texas, made pursuant to several Congressional authorizations listed in the report.

The views of the Governor of Texas and interested Federal agencies concerning the Chief of Engineers' proposals, together with certain replies by the Chief of Engineers, are inclosed.

In his 1963 report, the Chief of Engineers recommended that that comprehensive plan presented by the reporting officers, with certain modifications in detail, be approved as the plan for full development and beneficial public use of the water and related land resources of the Trinity River basin.

Specifically the Chief of Engineers recommended that existing and authorized projects for the Trinity River basin be supplemented by immediate authorization of local flood protection at five localities, four multiple-purpose reservoirs, water-conveyance facilities in connection with one of these reservoirs, and a multiple-purpose channel extending along the Trinity River from the Houston Ship Channel to Fort Worth, Texas, subject to certain requirements of local cooperation, all at estimated net costs to the United States of $737,607,000 for construction, and $6,007,000 annually for operation, maintenance, and replacements.

He further recommended that at such time as funds are requested for initiation of construction of features exclusively for navigation, the Chief of Engineers submit to the Congress an economic analysis of these features, with the explicit understanding that this analysis be based upon the best information then available of probable traffic on the waterway, the cost of constructing and operating it, and applicable land and water carrier costs and charges, and with the implicit understanding that construction funds would not be requested unless the analysis demonstrated that the project was economically justified.

The measures recommended by the Chief of Engineers for authorization at this time have been reviewed very carefully, taking into account the views expressed by all concerned parties both prior and subsequent to submission of his report. On the basis of this review, I am convinced that further analysis of the economics of measures exclusively related to navigation is essential if the joint goals of orderly and effective conservation, development and use of the water and related land resources of the basin are to be achieved, and that until such further analysis is performed, and reveals a favorable benefit-cost ratio for the navigation features, they should not be authorized by the Congress.

Early construction of upstream multiple-purpose reservoirs and local flood protection projects to meet the needs of specific localities, followed by improvement of the Trinity River channel for additional flood control, navigation (if found to be economically justified) and other purposes, will comprise a logical sequence of development, compatible with the substantial construction period required for a program of this magnitude and the need for restudy of the navigation purpose.

The Chief of Engineers has advised me that his recommended review of the navigation features of the Trinity basin plan would of course be made in accord with all policies and conditions then in effect. For example, the review would be based on a standard 50-year time period in lieu of the 100-year period used in the report. The use of the longer period in the Trinity report was unique. All other navigation projects recommended to the Congress before and after the Trinity study have been justified on the basis of no more than a 50-year period, and all projects now under study or planned for study will be justified on such a basis. Using the 50-year period and the interest rate and other policies applicable at the time, the benefit-cost ratio of the Trinity navigation features when the Chief of Engineers made his report was 0.74. I do not consider it appropriate to recommend to the Congress immediate specific authorization of projects which by standard methods of economic analysis are found not to be justified. Accordingly I recommend against present authorization of those features of the comprehensive plan which are exclusively related to the navigation purpose.

In the interest of efficient development of the water resources of the basin, the Corps of Engineers will initiate as soon as possible a re-evaluation of the navigation features of the plan making a maximum effort to complete this study within six months or at most one year from the date funds are made available for the study. I consider it reasonable that improvements for other purposes be constructed on a basis which would not be incompatible with possible ultimate adaptation to navigation needs.

In view of the foregoing I recommend immediate authorization of:

a. Local flood protection projects at five localities in accordance with the recommendations of the Chief of Engineers, at estimated costs to the United States of $36,829,000 for construction, and $70,000 annually for operation, maintenance, and replacements.

b. Lakeview, Roanoke, and Aubrey Reservoirs in general accordance with the recommendations of the Chief of Engineers, provided that prior to initiation of construction, local interests give assurances satisfactory to the Secretary of the Army that they will administer project land and water areas for recreation and fish and wildlife enhancement, and participate in the cost of development, operation, maintenance, and replacements for these purposes, in accordance with the Federal Water Project Recreation Act (PL 89-72). On this basis the ultimate costs to the United States for these reservoirs are estimated at $29,590,000 for construction and $118,000 annually for operation, maintenance, and replacements.

c. Tennessee Colony Reservoir and the water-conveyance facilities related thereto, in general accordance with the recommendations of the Chief of Engineers except for exclusion of facilities exclusively for navigation, provided that prior to initiation of construction, local interests give assurances satisfactory to the Secretary of the Army that they will administer project land and water areas for recreation and fish and wildlife enhancement, and participate in the cost of development, operation, maintenance, and replacements for these purposes, in accordance with the Federal Water Project Recreation Act cited above. On this basis the ultimate costs to the United States for these works are estimated at $62,000,000 for construction and $160,000 annually for operation, maintenance, and replacements.

d. A flood control channel extending generally along the Trinity River from the Houston Ship Channel to Fort Worth, Texas, to be constructed on a basis not incompatible with possible ultimate adaptation to navigation needs, at estimated costs to the United States of $210,000,000 for construction, and $900,000 annually for operation, maintenance, and replacements, depending upon the extent of such adaptation.

Summarizing, I recommend (a) immediate specific construction authorization of five local flood protection projects, four multipurpose reservoirs and a flood control channel, all on a basis not incompatible with future navigation development, and (b) authorization of a restudy of the navigation features to be completed before further action with respect to their authorization for construction.

The approximate aggregate cost of the foregoing, excluding the cost of the restudy, is currently estimated at $494,227,000, with a net Federal share of $338,419,000 and annual operation, maintenance and replacement Federal costs totalling $1,248,000.

I have discussed the foregoing recommendations with the Chief of Engineers and he concurs therein.

A summary of the views of the Bureau of the Budget follows:

"In summary, the Bureau of the Budget recommends authorization of those project features for flood protection, water supply, water quality, and recreation but not the navigation feature, due to the need for new data and the new criteria mentioned above. We have been impressed by the industrial growth in this region which has occurred since 1958. We recommend therefore that a restudy be completed giving appropriate consideration to further developments in the region affecting the economic feasibility of navigation; and we understand that construction undertaken before completion of the restudy will not preclude the addition of navigation to the overall plan. This restudy should be completed within six months but in no event in a longer time than one year."

The complete views of the Bureau of the Budget are attached.

Sincerely yours,

Stanley R. Resor

1 Incl
Report

STANLEY R. RESOR
Secretary of the Army

COMMENTS OF THE BUREAU OF THE BUDGET

EXECUTIVE OFFICE OF THE PRESIDENT
BUREAU OF THE BUDGET
WASHINGTON, D.C. 20503

Honorable Stanley R. Resor
Secretary of the Army
Washington, D. C. 20310

August 11, 1965

Dear Mr. Secretary:

This is in response to Mr. Joseph A. Califano's letter of February 25, 1964, transmitting a favorable report, in five volumes, of the Chief of Engineers on the Trinity River and Tributaries, Texas, and to Mr. Alfred B. Fitt's letter of June 4, 1965, submitting modifications which you have recommended and with which the Chief of Engineers concurs.

The Trinity River Basin covers approximately 18,000 square miles in eastern Texas. This area includes the expanding Dallas-Fort Worth urban-industrial complex; the rest of the basin is predominantly agricultural. The entire area is troubled by extreme variations in rainfall. For example, a prolonged drought between 1950 and 1957 was followed by severe flooding in 1957. The basin has problems with the quality as well as quantity of water. The development of the Trinity River for navigation has also been a subject of intense interest.

The modified recommendations represent a constructive proposal to overcome the area's water problems. The project consists of a number of features which will materially assist the further economic growth of this dynamic region. The headwater reservoirs--Lakeview, Aubrey, and Roanoke--and the five local protection projects all have good benefit-cost ratios, and their construction will alleviate pressing flood control, water supply, and water quality needs. Other major features proposed for authorization will permit orderly phased development of the basin's resources.

A project of this magnitude, complexity, and importance deserves the most careful consideration. The Bureau of the Budget has very carefully reviewed this project, taking into consideration additional information submitted by the Department of the Army and non-Federal organizations interested in the project. Our comments are based on that review.

PLAN OF DEVELOPMENT

The plan of development now proposed by you and the Chief of Engineers will permit an early start on upstream reservoirs to meet pressing water conservation needs and on flood protection projects in several urban areas. You also recommend immediate authorization of other major features discussed below. Construction schedules and final designs will be compatible with the long-range plans for development of the Trinity River. Studies necessary to develop such plans are recommended for authorization at this time.

The project would serve the following important purposes:

(a) Flood protection--The plan includes works to provide protection for four areas in the vicinity of Dallas-Fort Worth, the community of Liberty, and for the middle Trinity Basin.

(b) Water supply--Three headwater reservoirs--Lakeview, Aubrey, Roanoke--and a large mainstem reservoir--Tennessee Colony--are recommended for authorization to help provide a dependable yield for municipal and industrial water requirements. The plan would permit augmentation of upper basin supplies by pipeline transfer from the mid-basin Tennessee Colony Reservoir if it is decided that is the most feasible means for satisfying municipal and industrial water demands. The recommended combination of existing and proposed facilities is expected to satisfy, in large degree, projected municipal and industrial demands until about 2000-2010. Beyond the features now recommended for authorization, the plan considers later authorization of up to 13 additional reservoirs if needed.

(c) Water quality--The plan provides for interim storage of water in certain of the recommended reservoirs for releases to augment low stream flows. Such water releases will assist in eliminating septic conditions in the upper part of the river. Water quality storage is expected to be converted to municipal and industrial use as demands for the latter increase.

(d) Recreation--The proposed reservoirs together with recreation facilities will help satisfy the rapidly increasing demands for healthful outdoor recreation.

Given the vast scope and complexity of the project, it is expected that some adjustments and modifications of individual features will be required as planning progresses to a more detailed stage. In this connection, the Bureau of the Budget would expect that prior to any request for funds to construct projects including storage for water quality, the Department of the Army would resolve any problems which may arise in transferring the use of such storage to water supply. Steps also need to be taken to avoid future conflict between Federal and State views as to the highest economic use of water from the project and to assure repayment of water supply costs.

Total estimated cost of the project now recommended is $494 million, of which $338 million would be a Federal cost and $156 million would be non-Federal.

The Bureau of the Budget would have no objection to the authorization of the above described features.

NAVIGATION

The District and Division Engineers recommended the development of the Trinity River for navigation. You recommend that the navigation feature not be authorized at this time and the Chief concurs. Since navigation has been the subject of considerable interest, we believe it merits discussion here.

The navigation plan recommended by the District and Division Engineers consists of a 12 by 150-foot channel, along with 18 dams and 23 locks, running 370 miles from the Houston Ship Channel to Fort Worth. The channel would have an annual transportation capacity of about 20 million tons. Total allocated cost of these facilities was $515 million, of which $475 million would be Federal.

The Board of Engineers for Rivers and Harbors also recommended authorization of the navigation feature. The report of the Board noted, however, that "since modification of current and anticipated conditions may affect the evaluation of benefits for this work, the authorization should contain a proviso that at such time as the funds are requested for initiation of construction of features exclusively for navigation, the Chief of Engineers will submit to the Congress an economic analysis of these features." The Texas Water Commission, in a resolution dated August 2, 1963, commenting on the Trinity report stated that "concerning the multipurpose inland waterway; therefore, the Texas Water Commission specifically recommends that at such time as funds are requested for initiation of construction of features exclusively for navigation the Chief of Engineers will submit to the Congress an economic analysis of these features, with the understanding that this analysis be based upon the best information then available of probable traffic on the waterway, the cost of constructing and operating it, and applicable land and water carrier costs and charges."

The report of the Board of Engineers was based upon a 100-year period of analysis, whereas the period of analysis universally used on all other projects has never exceeded 50 years. Moreover, changes have been made in the basis for evaluating data on inland water-way projects since the report of the Board of Engineers and the original studies on this project. At the same time, more recent information on the growth of industry and freight traffic in the area suggests significant changes in the benefits originally assigned to the project. As a result, there is a need for further studies and evaluation of the data which results from these studies in order to determine the benefit-cost ratio of the navigation features of this project.

It is clear that a re-evaluation based upon up-to-date information and upon the new criteria which have been established since the original studies on the navigation features were undertaken cannot be concluded in time for the submission of this report. It is therefore the position

of the Bureau of the Budget that no recommendation be made at this time on navigation features. However, we believe the Corps should initiate an immediate re-evaluation of the benefit-cost ratio utilizing current information and policy standards, making the maximum effort to complete this study within six months or at the most one year. In the light of this recommended restudy, we suggest that planning for the non-navigation features be carried on in a way which does not preclude the later addition of navigation, if the study warrants.

In summary, the Bureau of the Budget recommends authorization of those project features for flood protection, water supply, water quality, and recreation but not the navigation feature, due to the need for new data and the new criteria mentioned above. We have been impressed by the industrial growth in this region which has occurred since 1958. We recommend therefore that a restudy be completed giving appropriate consideration to further developments in the region affecting the economic feasibility of navigation; and we understand that construction undertaken before completion of the restudy will not preclude the addition of navigation to the overall plan. This restudy should be completed within six months but in no event in a longer time than one year.

Sincerely,

Charles L. Schultze
Director

COMMENTS OF THE GOVERNOR OF TEXAS

EXECUTIVE DEPARTMENT
AUSTIN, TEXAS

JOHN CONNALLY
GOVERNOR

August 3, 1963

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

Dear General Wilson:

This has reference to your letter transmitting a copy of your proposed report entitled "Comprehensive Survey Report on Trinity River and Tributaries, Texas" for the written views and recommendations of this State.

At my request, the Texas Water Commission has reviewed this report, and pursuant to Article 7472e, has caused a public hearing to be held to receive the views of persons and groups who might be affected should this project be initiated and completed. The recommendations and comments of the Texas Water Commission, together with those of the Texas Highway Commission, the State Water Pollution Board, the Department of Health, and the Game and Fish Commission are attached hereto.

I concur fully in your proposed report and urge the authorization by the Congress of these projects in accordance with your recommendations.

Sincerely,

John Connally

John Connally

52-704 O-65 (Vol. I)—2

TEXAS WATER COMMISSION

AN ORDER approving the feasibility of the United States Army Corps of Engineers' Comprehensive Survey Report on Trinity River and Tributaries, Texas.

BE IT ORDERED BY THE TEXAS WATER COMMISSION:

Section 1. Statement of Authority. Article 7472e, Vernon's Annotated Civil Statutes of Texas, provides that upon receipt by the Governor of Texas of any engineering report submitted by a Federal Agency seeking the Governor's approval of a Federal Project, the Governor shall forthwith forward such report to the Texas Water Commission (successor to the Board of Water Engineers) for study and recommendations to the Governor as to the feasibility of the Federal Project, whereupon the Commission shall cause a public hearing to be held to receive the views of persons and groups who might be affected should the Federal Project be initiated and completed. After the Commission has heard all of the evidence both for and against the approval of such Federal Project, it shall enter its order either approving or disapproving the feasibility of the Federal Project, giving its reasons therefor in such order.

Section 2. Statement of Jurisdiction. (a) By letter dated June 28, 1963, the Honorable John Connally, Governor of Texas, requested the Texas Water Commission to review the report of the Chief of Engineers, U. S. Army, covering Trinity River and Tributaries, Texas, Project, entitled Comprehensive Survey Report on Trinity River and Tributaries, Texas, and to give him the Commission's recommendations as to the feasibility of the Federal Project. (b) In accordance with Article 7472e, and after due notice, the Commission caused a public hearing to be held on July 30, 1963, at 9:00 a. m., in the State Highway Department Auditorium, Austin, Texas, at which time all those interested or who may be affected should the project be initiated and completed were requested to come forward to give testimony, which hearing was continued through July 31, 1963.

Section 3. Determination of Feasibility. After studying the report and fully considering all the evidence, exhibits and opinions 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, and the recommendations of the Chief Engineer of the Texas Water Commission submitted in accordance with Article 7477(4)(g), the Texas Water Commission finds that the project, identified as Comprehensive Survey Report on Trinity River and Tributaries, Texas, is feasible and that the public interest will be served thereby.

Section 4. Reasons for Finding. In accordance with Section 4, Article 7472e, Commission consideration has been given, but not limited, to the following justifications:

(a) The Federal project, if constructed and prudently operated, will not detrimentally affect water users.

(b) The project would be in the public interest as it would provide for conserving flood waters for beneficial uses, reduce damages from floods in the basin, permit navigation of the Trinity River, and provide recreational and fish and wildlife benefits.

(c) The proposed project would develop the dam sites to the optimum potential for water conservation.

(d) The proposed Federal project would be an integral part of existing, under-construction and proposed reservoirs in the Trinity River Basin and would not conflict with any other water conservation activities.

(e) The multi-purpose project as proposed and presented to the Commission would protect the State's interest in its water resources.

(f) The proposed project is engineeringly practical.

Section 5. Recommendations. (a) The Commission concurs with the recommendations of the Board of Engineers for Rivers and Harbors and with those of General W. K. Wilson, Jr., Chief of U. S. Army Engineers, concerning the multi-purpose inland waterway; therefore, the Texas Water Commission specifically recommends that at such time as funds are requested for initiation of construction of features exclusively for navigation the Chief of Engineers will submit to the Congress

an economic analysis of these features, with the understanding that this analysis be based upon the best information then available of probable traffic on the waterway, the cost of constructing and operating it, and applicable land and water carrier costs and charges.

(b) The Commission also specifically concurs with the recommendations of the Board of Engineers for Rivers and Harbors and General Wilson, Chief of Engineers, to defer construction of the proposed water-conveyance facilities from proposed Tennessee Colony Reservoir to existing Benbrook Reservoir until further studies can be made of possible lower-cost, relatively short-term, interim measures. The Commission recommends that before such studies are concluded a determination be made and procedures established as to how facilities initially utilized for maintenance of water quality can be converted at a later date to water supply for municipal and other beneficial uses.

(c) The Commission recommends early consideration of the project by the United States Congress.

Section 6. Protection of Water Rights. Ownership by the State of Texas of the waters involved shall be fully recognized by all interested parties; and lawful rights to the use of such waters, vested pursuant to State law, shall be respected, protected and preserved.

Section 7. Transmittal. It is further ordered that a certified copy of this order be transmitted to the Governor.

Section 8. Effective Date. This order shall take effect and be in force on and after the 2nd day of August, 1963, the date of its passage, and it is so ordered.

SIGNED IN THE PRESENCE OF THE
TEXAS WATER COMMISSION

ATTEST:

Joe D. Carter, Chairman

Audrey Strandtman, Secretary

I certify that the foregoing order was adopted by the Texas Water Commission at a meeting held on the 2nd day of August, 1963, upon motion of Commissioner Beckwith, seconded by Commissioner Dent, Commissioner Dent voting "aye," Commissioner Beckwith voting "aye," and Chairman Carter voting "aye."

Audrey Strandtman, Secretary

COMMISSION
HERBERT C. PETRY, JR., CHAIRMAN
HAL WOODWARD
J. H. KULTGEN

TEXAS HIGHWAY DEPARTMENT

AUSTIN 14, TEXAS

STATE HIGHWAY ENGINEER
D. C. GREER

July 22, 1963

IN REPLY REFER TO
FILE NO. DCG

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

Dear Mr. Carter:

In accordance with the request from Governor Connally dated July 3, 1963 and your letter dated July 9, 1963, we have reviewed the "Comprehensive Survey Report on Trinity River and Tributaries, Texas" prepared by the U. S. Corps of Engineers, Ft. Worth and Galveston Districts, and the comments of the Chief of Engineers and the Board of Engineers for Rivers and Harbors.

As is the case in any project of this magnitude, serious conflicts of scheduling of construction as related to highway relocations and future planning are certain to develop. However, the report recognizes this problem and emphasizes the necessity of coordinating advance design and construction of the proposed projects with transportation relocations.

Our understanding of the report is that specific recommendations have been made for advance participation by the Federal Government in construction costs of highway relocations in the cases of Livingston Reservoir and Roanoke Reservoir which are to be built in the future. The remaining projects and related highway relocations covered by the report would be considered on an individual basis with the view toward the Corps of Engineers submitting separate reports on desirable participation to the Congress.

In addition, appropriate language has been incorporated in the report to provide for participation by the Federal Government in the construction costs for proposed future highway crossings of the Trinity River.

Thus, it is our belief that the report, in general, contains adequate provisions to both effect savings in public funds and to promote orderly development of the proposed projects and the related highway relocations.

We are attaching as a part of this letter a copy of the comments on the effect of the project on our highway system which was compiled during review. Each component project is covered individually with a brief project description and how it affects highways in the project area. Also included is a "Summary of Estimated Costs for Highway Relocations" covering both existing and proposed future highways.

As you know, the laws of the State of Texas impose upon this Department the responsibility for the construction and maintenance of a connected system of State Highways. To carry out this responsibility, the Highway Department has established this policy for guidance of those concerned with the construction of reservoir projects and other projects of improvement or development of streams and waterways:

1. Where existing highways and roads provide a satisfactory facility in the opinion of the Texas Highway Department and no immediate rehabilitation or reconstruction is contemplated, it shall be the responsibility of the participating agencies and/or local interests at their expense to replace the affected existing road facility in accordance with the current design standards of the Highway Department, based upon the road classification and the traffic needs.

2. Where no highway or road facility is in existence but where a route has been designated for construction across a proposed reservoir area or other project of improvement or development of streams and waterways, the Highway Department will bear the cost of constructing a satisfactory traffic facility across the proposed area, on line and grade for normal conditions of topography and stream flow. Any additional expense as may be necessary to construct the highway or road facility to line and grade to comply with

requirements of the proposed project shall be borne by the other participating agencies and/or local interests sponsoring the project.

We request that all agencies and local interests authorized to construct the projects envisioned by the Survey Report be informed of their responsibilities as set out above and required to budget funds for the rehabilitation or reconstruction of the affected highways. The Department is prepared to furnish detailed information in this regard upon request.

This letter constitutes the official statement of the Texas Highway Department on this matter. It is requested that the substance herein be placed in the record of the public hearing to be held in the Texas Highway Department Building in Austin on Tuesday, July 30, 1963 and subsequent public hearings or reports on the plan outlined in the "Comprehensive Survey Report on Trinity River and Tributaries, Texas".

Your courtesy in making the report available for our review and comments is appreciated.

Yours truly

D. C. Greer
State Highway Engineer

Comments on Highway Relocations in "Comprehensive Survey Report on Trinity River and Tributaries, Texas"

The "Comprehensive Survey Report on Trinity River and Tributaries, Texas" envisions a multiple purpose project consisting of a multiple purpose channel (including locks and dams), five flood control projects, four multiple purpose reservoirs, a national wildlife refuge and a water conveyance facility for water quality control. Each of the component projects is reported to be feasible both economically and from an engineering standpoint independent of the other projects.

Our review was confined to those sections of the report dealing with highway relocations. Consideration was given to both existing and future highways. Estimated costs shown in the report were checked only as to reasonableness in view of the fact that only limited information concerning the projects was available.

All costs shown in the report relative to highways are based on January, 1962 prices with an additional 25% applied for contingencies, engineering, design, supervision and administrative costs.

The report and subsequent recommendations by the Board of Engineers for Rivers and Harbors have recognized the possible construction of future highway crossings as well as existing structures. Though costs for adjustment or relocations of the future crossings necessitated by construction of the multiple-purpose project are not specifically shown in the report, appropriate language in Vol. IV, par. 69 concludes that the contingency item in the cost estimate is considered adequate to cover all bridges that might be built prior to the construction of the multiple-purpose channel. Specific recommendations have been made relative to advance participation in costs of relocations by the Corps of Engineers in the cases of the Livingston Reservoir and Roanoke Reservoir projects.

It is our understanding that the Texas Water Commission intends to consider the individual projects independently. Consequently, the following comments relative to highway relocations have been arranged by project in the order in which discussion will most likely develop at the hearing on July 30, 1963:

1. WEST FORK FLOODWAY

The plan of improvement for the West Fork of the Trinity River consists of a multiple purpose channel and floodway for navigation and flood control from the mouth of the West Fork in the Dallas Floodway upstream, a distance of 31 miles (approx.) to the end of the existing Ft. Worth Floodway.

There is no apparent relocation or adjustment of highways involved except for those relocations associated with the multiple purpose navigation channel.

2. ELM FORK FLOODWAY

The plan of improvement in the Elm Fork watershed extends along the main channel from its mouth upstream to Grapevine and Lewisville Dams. The project includes the following principal features:

(a) Realignment and enlargement of the Elm Fork Channel from Lewisville Dam outlet works channel downstream 7.5 miles to the mouth of Denton Creek.

(b) Clearing the existing Denton Creek Channel and flood plain to a width of 200 feet from Grapevine Dam outlet works channel downstream 7.0 miles to river mile 3.7, and realignment and enlargement of the channel from that point downstream about 1.9 miles to the Elm Fork.

(c) The realignment and enlargement of the Elm Fork channel from Denton Creek downstream to its confluence with the West Fork.

(d) The construction of a parallel levee system through the low areas. The floodway would have a minimum width of 1100 feet between centerlines of levees.

Relocation and/or adjustment of State Highway 114 in the vicinity of the proposed California Crossing Diversion Channel appears to be the only affected highway. Table 50 (Vol. IV, p. 149) of the report includes an estimated cost of $400,000 plus 25% contingencies or a total of $500,000 for accomplishing the required adjustments.

3. DALLAS FLOODWAY EXTENSION

An element of the multiple purpose channel and floodway for navigation and flood control in the Dallas area is the extension of the existing Dallas Floodway downstream to Five Mile Creek, including the lower end of White Rock Creek. Among the features included are the following:

(a) Realignment and enlargement of the Trinity River from about river mile 496.3 downstream to river mile 487.7.

(b) Realignment and enlargement of about 10.5 miles of tributary channels through the leveed areas.

(c) The construction of a parallel levee system consisting of about 10.2 miles of levee on the left bank, 14.6 miles of new levee on the right bank, and the rehabilitation on 0.6 miles of existing levee on the right bank. The floodway would have a minimum width of 2000 feet between centerlines of levees.

The Diversion Channel work on Five Mile Creek will require the relocation and/or alteration of the two bridges on IH 45 (US 75). Cost estimates shown in the report for accomplishing these modification of the highway facilities is $900,000 + 25% contingencies or a total of $1,125,000. Other crossings in the area will require reconstruction but these are associated with the navigation project.

4. DUCK CREEK CHANNEL IMPROVEMENT

The plan of improvement for Duck Creek consists of a channel improvement project along the main channel in the vicinity of Garland and includes the following features:

(a) Realignment and enlargement of 6.6 miles of Duck Creek channel including 0.58 mile of concrete gravity wall section.

(b) Modification of ten bridges. (City and County)

There does not appear to be any highway facilities which will require relocation or alteration.

5. LIBERTY LEVEE LOCAL PROTECTION

The plan of improvement in the vicinity of Liberty consists of levees with appurtenant interior drainage facilities extending along the left bank of the Trinity River.

There are no highways affected by this project.

6. LAKEVIEW RESERVOIR

The Lakeview dam site is located at river mile 7.2 on Mountain Creek in Dallas County about 3.1 miles above the existing Mountain Creek Dam. The Lakeview Dam site is just south of the city limit of Grand Prairie, about 14 miles from downtown Dallas and 22 miles from downtown Ft. Worth. The proposed reservoir would be constructed for flood control, water conservation, fish and wildlife, and general recreation purposes.

Construction of the project will require the relocations of 9.7 miles of highways. Highways involved would be FM 661 and FM 1382. Costs provided in the report for such relocations are $80,000 + 25% or a total of $100,000 for FM 661 and $500,000 + 25% or a total of $625,000 for FM 1382.

The cost for relocation of FM 1382 apparently is based upon the building of nine miles of new road along the eastern shoreline of the lake and then crossing the dam. Due to the fact that the existing Mountain Creek Lake extends to the foot of the proposed dam, it would appear difficult to find a more economical crossing to the west of the lakes which did not cross the dam.

However, it would appear that a route study would be desirable in the case of FM 1382 since a large section of this highway will be inundated in the area adjacent to its present chief source of traffic.

7. ROANOKE RESERVOIR (INCLUDING MODIFICATION OF GRAPEVINE RESERVOIR)

The Roanoke dam site is located at river mile 32.0 on Denton Creek, a tributary to the Elm Fork of the Trinity River. The dam site is located in Denton County, and the right abutment of the dam would be about one-half mile northwest of the town of Roanoke. The flood control storage provided in Roanoke Reservoir would permit

a reallocation of the storage in Grapevine Reservoir and increase that storage presently allocated to water conservation.

State Highway 114, FM Highway 156, and FM Highway 407 will require relocation or alteration. Total cost for such relocations including one county road is $3,200,000 + 25% for contingencies or a total of $4,000,000. A conservative estimate for accomplishing the required 12.1 miles of highway relocations excluding the county road would be $3,750,000.

The report also contains the following recommendation:

"That the Chief of Engineers be authorized to acquire an interest in the reservoir and dam site lands and to participate in construction or reconstruction of transportation and utility facilities for the Roanoke Project in advance of construction as required to preserve such areas from encroachment and to avoid increased costs for relocations. The interest in lands to be acquired would be the minimum necessary consistent with the objective of reservoir and dam site preservation. This authorization would enable the Chief of Engineers to cooperate with responsible local interests to keep lands on local tax rolls and to exercise control over development in the reservoir and dam site area until needed for project purposes."

This recommendation is in keeping with the policies outlined in Senate Document 97 approved by the President in May 1962 regarding project formulation and economic analysis of Federal-sponsored projects.

In addition to the aforementioned highways, the proposed location for IH 35W crosses the reservoir at a point approximately two miles upstream from the proposed dam. The report makes no mention of this highway and consequently makes no provision for any relocation or adjustment.

Investigation indicates that the present proposed grade line for the highway would need to be raised in excess of 30 feet for a distance of approximately four miles based on the reservoir map shown in the report.

Although adjustment of the proposed location to clear the flood control pool would be covered by the recommendation previously mentioned providing for advance participation in costs of relocations, consideration is being given to relocating the highway to reduce

the length of water crossing. Schematics for the present proposed location have been completed and surveys are 65% complete. A route hearing has not been held covering the section of road in question.

8. AUBREY RESERVOIR (INCLUDING MODIFICATION OF GARZA-LITTLE ELM RESERVOIR)

The Aubrey dam site is at mile 60.0 on the Elm Fork of the Trinity River in northeast Denton County. The site is between the towns of Sanger and Aubrey and is 30 river miles upstream from Lewisville Dam (Garza-Little Elm Reservoir). The primary purpose of the proposed reservoir is water conservation, but the included flood control storage in Aubrey Reservoir would permit a reallocation of storage in the Garza-Little Elm Reservoir and increase that storage presently allocated to water conservation.

State Highway 10, FM Highway 372, and FM Highway 455 will require relocation or alteration. The report does not indicate cost of such modification by individual highway but provides a total of $2,251,000 + 25% or $2,813,750 including a county road. A safe estimate would be about $2,750,000 for 16 miles of highways under jurisdiction of the Highway Department.

9. TENNESSEE COLONY RESERVOIR

The Tennessee Colony Dam site is located at river mile 339.2 on the Trinity River about 16 miles west of Palestine, Texas, and 7 miles southwest of Tennessee Colony. The proposed reservoir for navigation, flood control, water conservation, fish and wildlife, and recreation purposes will be located in Anderson, Freestone, Henderson, and Navarro Counties.

Tennessee Colony Reservoir will have a surface area of 73,540 acres at conservation pool and 119,500 acres at top of flood control pool. The Navigation Channel will be routed through the lake above the two locks provided at the dam site to accomplish a maximum total lift of 75 feet.

Construction of Tennessee Colony Reservoir will require relocation of 21 miles of highway. Highways involved are US 287, St 31, FM 488, and FM 321. Costs for the respective relocations or alterations are as follows:

US 287	-	$6,688,482 + 25%	-	$ 8,360,600
ST 31	-	2,075,000 + 25%	-	2,593,750
FM 488	-	2,127,580 + 25%	-	2,659,475
FM 321	-	New Road		275,000
				$13,888,825

The report recognizes the necessity of coordinating advance design and construction of the proposed project with transportation relocations. It should be pointed out in this connection that it is anticipated that Tennessee Colony Reservoir would be constructed prior to the proposed Richland Creek and Tehuacana Creek Reservoirs. The report provides for relocations into the latter two reservoir areas on this presumption. But the reservoir map shown in the report indicates US 287 also crossing the proposed Richland Creek Dam Site.

In view of this circumstance, it appears desirable that a route study be made to determine the most economical relocation to both reduce the length of water crossing and eliminate any future conflict with construction of the dam.

Relocation of FM 488 presents a problem in that the portion north of FM 246 would be entirely over water and adjacent to Richland Creek Dam. It would seem appropriate to abandon the portion of FM 488 mentioned and provide a connecting road between FM 246 and US 287 across the arm of Richland Creek Reservoir approximately three miles west of the dam. Adequate costs are included in the report to cover such relocation.

Relocation of FM 321 appears desirable in view of the fact that approximately five miles of the road will be affected as well as the area served near its present terminus. The possibility of a short connection to US 287 should be investigated as an alternative to adjusting the present location to accommodate the reservoir.

In any event, the costs included for relocating the affected highways appears to be adequate.

10. WATER CONVEYANCE FACILITIES FROM TENNESSEE COLONY RESERVOIR TO BENBROOK RESERVOIR

In order to facilitate pollution abatement along the Trinity River from Ft. Worth downstream to the vicinity of Rosser, Texas, a supply of fresh water of acceptable quality would be necessary at Ft. Worth. This water is available from Tennessee Colony Reservoir and will be delivered by pipeline to Benbrook Reservoir, 14 miles upstream from Ft. Worth on the Clear Fork of the Trinity River. This pipeline would be 84" in diameter and approximately 98 miles long with a total maximum pumping head of 825 feet. There would be one main pumping plant approximately 6 miles above Tennessee Colony Dam and three additional booster pumping stations spaced appropriately along the pipeline. The pipeline would terminate just past the Clear Fork eastern watershed divide and would discharge into an unnamed tributary of the Clear Fork that enters Benbrook Reservoir from the east about one mile upstream from the dam.

The pipeline would cross US 287, ST 31, US 75, ST 34, US 77, US 67, and IH 35. No specific item of cost is shown in the report for these highway alterations but there appears to be ample costs estimated per unit mile for the pipeline to include such alteration.

11. MULTIPLE PURPOSE CHANNEL FOR NAVIGATION AND OTHER PURPOSES FROM FT. WORTH TO THE HOUSTON SHIP CHANNEL.

The proposed multiple-purpose channel would begin at the Houston Ship Channel near Red Fish Bar, in Galveston Bay, follow the authorized channel to Liberty project through Trinity Bay and the Trinity River to the City of Liberty, and continue along the general course of the Trinity River to the Riverside Drive bridges in Ft. Worth, a total distance of about 370 miles. Spur channels would extend to turning basins at Dallas and Ft. Worth. The channel would pass through the Wallisville, Livingston and proposed Tennessee Colony Reservoirs.

All bridges over the proposed multiple-purpose channel would provide a minimum vertical clearance of 50 feet above the water surface elevation of the flood discharge that would not be exceeded over two percent of the time. All bridges below Dallas would have a minimum horizontal clearance of 250 feet between bridge fenders and all bridges above Dallas would have a minimum clearance of 225 feet between fenders. This will necessitate channel span lengths of 300 feet below Dallas and 275 feet above Dallas.

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There are 26 existing crossings of the Trinity River under the jurisdiction of the Texas Highway Department. Nineteen of these bridges will be raised to accommodate navigation at the existing channel crossing. The remaining crossings will be new structures due to the relocation of the channel across land.

The report also recognizes the possible construction of approximately 12 additional crossings within the next fifteen years and recommends consideration of each such crossing on an individual basis with the view to submitting separate reports on desirable participation to the Congress.

The report makes specific recommendations in the case of Livingston Reservoir for participation in the costs of highway relocations by the Federal Government in advance of the actual construction of the project. This is to be accomplished under measures provided in Senate Document 97 approved by the President on May 15, 1962.

In this connection, the Texas Highway Department has recently entered into an agreement with the City of Houston under the terms of which the Department is making a study to determine the most feasible and economical relocation of US 190 to accommodate the Livingston Reservoir planned by the City of Houston. The present study does not contemplate provisions for navigation clearances since the navigation project is not authorized.

Should the multiple-purpose channel be authorized by the Congress, grade changes at the channel would be necessitated. The aforementioned recommendation calling for advance participation in costs for the increased clearances would be applicable. However, no such participation in costs by the Chief of Engineers could be made without specific congressional appropriation. Thus, close coordination between the Highway Department and the Corps of Engineers would be required in order to prevent undue delay in the relocation of the affected highway.

The report emphasizes the importance of coordination of transportation construction and the construction of the proposed waterway and recommends exerting every effort to advance design and construction of the proposed works in phase with transportation relocations.

Refer to pages 10-11 for listing of affected existing highways and proposed future crossings.

Highway relocations necessitated by the multiple purpose channel with cost shown in the report (including 25% contingency item):

IH 10 (Eastbound)	$ 1,203,750.00
IH 10 (Westbound)	1,203,750.00
US 90 (Eastbound)	1,417,000.00
US 90 (Westbound)	1,417,000.00
St. 105	1,516,000.00
US 59	1,208,000.00
US 190	2,333,000.00
St. 19	1,338,750.00
St. 21	1,185,000.00
St. 7	1,116,000.00
US 79 & 84	1,453,000.00
St. 31	2,593,750.00
St. 1129	1,096,000.00
St. 34	1,186,000.00
St. Loop 12 (Eastbound)	1,816,000.00
St. Loop 12 (Westbound)	1,314,000.00
IH 45 (Northbound)	1,166,000.00
IH 45 (Southbound)	1,083,000.00
IH 35E	1,736,000.00
St. Loop 12	1,120,000.00
St. 360	885,000.00
*FM 157 (Northbound)	1,060,000.00
US Loop 820 (Northbound)	918,000.00
US Loop 820 (Southbound)	918,000.00
	$32,283,000.00

*The report should provide for a Southbound Lane on FM 157. However, such crossing would be covered by the language previously mentioned pertaining to future bridges.

PROPOSED CROSSINGS OF THE TRINITY RIVER WITHIN THE NEXT 15 YEARS

1. South of Liberty, connecting F.M. 563 and 1409 in the Moss Bluff Community north of proposed Wallisville Reservoir.

2. North of Liberty connecting F.M. 162 and 163 between Cleveland and Moss Hill. (Relocation of S.H. 105)

3. Southwest of Livingston connecting F.M. 1514 and 350 between Livingston and Cold Spring.

4. North of Oakhurst connecting F.M. 946, 980, and 355 between Oakhurst and Groveton.

5. Between Huntsville and Lovelady connecting F.M. 230 at Eastham Prison Farm and F.M. 247 north of Huntsville.

6. Between Centerville and Austonio connecting F.M. 1280 and 811.

7. Between Buffalo and Grapeland connecting F.M. 542 and 227 in Navarro Oil Field.

8. Below proposed Tennessee Colony Dam connecting F.M. 489, 645, and 320.

9. Northwest of Trinidad connecting F.M. 636 and S.H. 274 midway between S.H. 31 and F.M. 1129 in the vicinity of Bazette Oil Field east of Corsicana.

10. Between Ferris and Crandall connecting F.M. 780 and 148.

11. I.H. 635 (loop) northeast of Hutchins - Dallas County.

12. County Line Road - Dallas County - just east of and parallel to Tarrant County Line.

12 TENNESSEE COLONY NATIONAL WILDLIFE REFUGE

In connection with the Tennessee Colony Reservoir, the Bureau of Sport Fisheries and Wildlife recommends establishment of a National Wildlife Refuge to be located east of the Trinity River in Henderson and Anderson Counties. The proposed refuge would comprise about 21,000 acres located east of the proposed multiple-purpose channel between US Highway 287 on the south and State Highway 31 on the north. The refuge would extend about 9 miles along the river and average slightly less than 4 miles in width. This project will have no apparent effect on highways in the area.

*SUMMARY OF ESTIMATED COSTS FOR
HIGHWAY RELOCATIONS BY PROJECTS
(INCLUDES 25% CONTINGENCIES)

1.	West Fork Floodway	$ 0.00
2.	Elm Fork Floodway St. Hwy. 114	500,000.00
3.	Dallas Floodway Extension IH 45	1,125,000.00
4.	Duck Creek Channel Improvement	0.00
5.	Liberty Levee Local Protection	0.00
6.	Lakeview Reservoir 9.7 Miles (FM 661 & FM 1382)	1,125,000.00
7.	Roanoke Reservoir 12.1 Miles (St. 114, FM 156, & FM 407)	3,750,000.00
8.	Aubrey Reservoir 16.0 Miles (St. 10, FM 372, & FM 455)	2,750,000.00
9.	Tennessee Colony Reservoir 21.0 Miles (US 287, St. 31, FM 321, & FM 488)	13,888,825.00
10.	Water Conveyance Facility	0.00
11.	Multiple-Purpose Channel 26 Bridges (Existing)	32,283,000.00
12.	Tennessee Colony National Wildlife Refuge	0.00
		$55,421,825.00
	Estimated Costs covered by the Contingency Item to provide for Clearances for 12 proposed crossings within the next 15 years.	9,300,000.00
	Estimated Cost for FM 157 (Southbound) not included in report.	1,060,000.00
	Estimated Cost for IH 35W in Roanoke Reservoir	4,000,000.00
		$14,360,000.00

*Based on January 1962 Prices.

Texas Water Pollution Control Board

1100 WEST 49TH STREET
AUSTIN 5, TEXAS

July 24, 1963

Mr. Joe D. Carter, Chairman
Texas Water Commission
P. O. Box 2311, Capitol Station
Austin, Texas

Dear Mr. Carter:

In compliance with your request of July 9, 1963, we submit herewith our comments on the "Comprehensive Survey Report - Trinity River and Tributaries, Texas", prepared by the Corps of Engineers.

The area of interest of the Water Pollution Control Board with regard to the proposal under consideration is one primarily confined to the problems presented in striving to attain and maintain those water quality objectives in the river system to assure satisfactory conditions for the intended water uses. It is noted the report implies that, in addition to the navigational aspects of this project, municipal, industrial, and recreational water uses are anticipated. These comments, therefore, will be based upon the water quality criteria required for these water uses and will be confined to the main channel water quality, since, no doubt, statements by the cooperating state agencies on the Water Pollution Control Board - the State Game and Fish Commission, the State Water Commission, and the State Health Department - will reflect their interest in the entire project and, of course, these are also of interest and concern to the Water Pollution Control Board.

The effect of proposed navigation structures upon the flow characteristics of the river and the influence thereby imposed upon the natural stream recovery capabilities is a matter of concern. The retardation of stream flow due to such structures would no doubt tend to affect the rate of recovery of the stream from any imposed organic pollutional loads.

The Trinity River Report made by the State Health Department in 1960 revealed water quality conditions in the upper reaches to be materially affected by waste water discharges. There is no doubt that the organic load imposed upon this portion of the river could be reduced considerably with the provision of adequate maintenance of waste treatment plants and/or the provision of adequate treatment capacity for the waste loads produced. However, it is to be noted that, even with the fulfillment of these conditions, the volume and quality of the final effluent (as a result of "conventional" treatment processes) would not, by itself, be satisfactory to meet the water quality requirements for the water uses previously stated.

For the reason just mentioned, therefore, it appears that the proposal for flow augmentation for quality control purposes as included in the report has considerable merit. However, in an area where water is as limited in supply as it is in Texas, it seems appropriate to consider this practice on a "last resort" basis. As a suggestion, alternative plans which might be considered as a substitute for flow augmentation or as a means to reduce the volume of required water could include but would not be limited to:

a. Prohibit waste water discharges into the river system. This might possibly be accomplished by injection of wastes underground or by the collection and utilization of the waste waters in such a manner as to be kept out of the watercourse, possibly by application upon land.

b. Return, by pumping, of treated waste effluents to existing or planned impoundments where the influence of time of storage and dilution as provided in the reservoir would be adequate for the recovery of the effluents for reuse.

c. Reoxygenation of the river water by air diffusion or mechanical devices to assure desired water quality objectives being attained.

d. Provision of supplemental waste treatment devices or processes to produce higher quality effluents than presently possible with "conventional" methods.

e. Study of possible applications of results of current waste water research projects which might lead to a break-through in the science of treatment.

The basis for calculating the volume of augmentation water necessary to maintain optimum oxygen levels is well established by engineering research and has been proven in the field; however, there are other aspects which should be considered. One problem in this area is the potential build-up of nutritive and chemical constituents because of the inability of current treatment processes to adequately remove

these materials. It does seem logical, however, that if flow augmentation is incorporated in the overall plan, the volumetric requirements will increase proportionately with the population.

In view of the responsibility of the Water Pollution Control Board to issue permits for all waste discharges, the policies and procedures which would be established in carrying out flow augmentation in practice would be of utmost interest to the Board.

It is hoped these comments might be of some assistance to you in the preparation of your comments on this proposal, and if we can aid you further, please let us know.

Very truly yours,

D. F. Smallhorst
Executive Secretary

DFS:go

State of Texas
Department of Health

JAMES E. PEAVY, M. D.
COMMISSIONER

AUSTIN

July 24, 1963

Mr. Joe D. Carter, Chairman
Texas Water Commission
P. O. Box 2311, Capitol Station
Austin, Texas

Dear Mr. Carter:

In accordance with a request from the office of Governor Connally, I am enclosing herewith the following comments on the "Comprehensive Report on the Trinity River" as prepared by the Water Pollution Control Division of the Texas State Department of Health:

"In connection with the overall aspects of the "Trinity River Report" with reference to the State Department of Health report on the water quality conditions of the Upper Trinity Basin as compiled in 1960, it would appear that in order to utilize the Trinity River immediately below the Fort Worth-Dallas metropolitan complex for municipal, industrial, and recreational purposes, the following must first be accomplished:

1. All domestic sewage and industrial waste flows be continuously treated to the highest current degree of the art.

2. All domestic sewage effluent be continuously chlorinated and a chlorine residual of 0.5 ppm be attained after 20 minutes contact prior to discharge to the watercourse.

3. Even after the accomplishments of the above, additional stabilization must be accomplished because of the extremely high waste loadings in relation to the assimilative power of the river system. These considerations should include one or more of the following:

    a. Flow augmentation with pollution free dilution water. Based upon 90% removal by the waste treatment facilities, current estimates are that the release of dilution water required would be approximately 0.1 CFS per 1000 equivalent contributing population during the winter months and 0.2 CFS per 1000 contributing population equivalent during the summer months.

b. Artificial reaeration of the stream to supply predicted oxygen deficits.

c. The development of waste treatment facilities economically capable of producing much higher quality effluents. Especially is this true in relation to the removal of nitrogen, phosphorus and A.B.S. compounds.

With specific reference to the floodway proposals in the Dallas-Fort Worth area, additional clarification is necessary concerning modifications that might be required to various existing sewage treatment facilities to assure their continued operation, since this information was not covered in the Corps of Engineers' report as follows:

West Fork Floodway

1. Village Creek Plant, City of Fort Worth.
2. Riverside Plant, City of Fort Worth - Allocation of $5000.00 cited in report.
3. City of Arlington plant.
4. City of Hurst plant.
5. City of Haltom City plant.
6. Tarrant County Utility Co. #2 plant.

Elm Fork Floodway

1. Carrollton plant.

Dallas Floodway Extension

1. Hutchins plant. "

I sincerely trust these comments will prove helpful in the preparation of your evaluation of the "Trinity River Project".

Sincerely yours,

J. E. Peavy, M. D.
Commissioner of Health

GAME AND FISH COMMISSION

AUSTIN, TEXAS

July 26, 1963

Mr. Joe D. Carter, Chairman
Texas Water Commission
Austin, Texas

Dear Mr. Carter:

Reference is made to your letter of July 9, 1963, in which you informed the Texas Game and Fish Commission that the Texas Water Commission will conduct a public hearing on the U. S. Army Corps of Engineer's report, "Comprehensive Survey Report on Trinity River and Tributaries, Texas," beginning June 30, 1963. Your letter requested that this agency submit written views and comments on or before July 29, 1963.

The comments and views transmitted herewith are based upon a review of (1) Comprehensive Survey Report on Trinity River and Tributaries, Texas, by the Corps of Engineers, (2) Report of the U. S. Fish and Wildlife Service, Trinity River and Tributaries, Texas, to the Corps dated May 1962, and supplement dated November 8, 1962. Concurrence of this agency in the Fish and Wildlife Service reports was indicated in letters of April 20 and December 14, 1962, to Mr. John Gatlin, Regional Director, Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Albuquerque, New Mexico, (3) report of the Board of Engineers for Rivers and Harbors to the Chief of Engineers, Department of the Army dated March 14, 1963, and (4) report of General W. K. Wilson, Jr., Chief of Engineers, to the

Secretary of the Army.

The U. S. Fish and Wildlife Service report of May 1962, and the supplement dated November 8, 1962, include comprehensive information relative to anticipated benefits and harmful effects to fish and wildlife both with and without the project. Data submitted in these reports were from information supplied through cooperative efforts of personnel of the Texas Game and Fish Commission, and representatives of the Office of River Basin Studies, Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service. We understand copies of these reports are on file in the office of the Texas Water Commission. Since this agency has concurred in these reports, a repetition of the views and comments included will not be repeated in detail in this transmission. However, we believe some sections merit further comment.

Section 3, page 1 of the report by the Chief of Engineers to the Department of the Army states in part that:

> "After careful consideration of the reports of the District and Division Engineers, and the additional information presented by local interests, the Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the reporting officers..."

The language of this portion of this section is construed to imply that recommendations included in the report of Board of Engineers for Rivers and Harbors and the reports from the District and Division Engineers were accepted by the Chief of Engineers unless otherwise indicated.

Information and comments which follow are based upon this conclusion.

Comments and views of this agency are presented below in relation to anticipated effects of the project on wildlife, fresh water fish and marine species.

WILDLIFE

Gus Engeling Wildlife Management Area

The Texas Game and Fish Commission initiated a long-range program of land acquisition in 1945, aimed at providing an area of suitable size and wildlife habitat in each of the major ecological regions of the state. The primary objectives for purchase of these areas are (1) to provide suitable locations for research on wildlife species in the various major vegetative regions of the state and (2) to develop and initiate wildlife management techniques which can be demonstrated to landowners in the region represented. Game surpluses resulting from the Commission's programs on wildlife management areas are harvested by Texas sportsmen following an impartial selection of persons making application for hunting privileges.

Acquisition of the Gus Engeling Wildlife Management Area in Anderson County on Catfish Creek was begun in 1951 and has progressed at intervals since that time. The area now comprises 10,981.10 acres and is representative of a sizeable region in Texas extending from Guadalupe and Wilson Counties on the south to the Red River onthe north and from the eastern edge of the Blackland Prairie to the Pine-Hardwood region on the east. Some research results are applicable to the entire East Texas

Timberlands Resource Area (see attached map).

The Commission has requested relocation of the Engeling Area at project cost, since the proposed Tennessee Colony Reservoir will inundate sizeable areas along Catfish Creek and its tributaries. With the construction of this reservoir a considerable portion of the choice deer, turkey and squirrel habitat will be lost. A portion of the area will be separated from the remainder by the reservoir. Unrestricted public access to the property by way of the Catfish Creek arm of the lake will greatly decrease the wildlife and research values of adjacent uplands.

The Engeling Area was selected for purchase because it includes creek bottom and oak woodland upland in percentages considered typical of the type region. Elimination of the rich Catfish Creek bottomland game habitat will in effect nullify the purpose for which the area was purchased and developed. Research results obtained from the remaining upland will not be applicable elsewhere in the type region because the habitat from which data would be obtained will no longer be typical.

The Commission has requested mitigation values comparable to the total investment of this agency in the property, since with the construction of Tennessee Colony Reservoir, it will no longer be suitable for the purpose for which it was purchased.

Recommendation No. 8, which appears in Volume 5, page 25, Comprehensive Survey Report on Trinity River and Tributaries, Texas, by

"A specified amount of funds have been set up in the estimated project cost to provide for anticipated mitigated losses at this wildlife management area. The action and procedures taken will have to be developed between the Corps of Engineers and the Texas Game and Fish Commission during the advanced project planning state."

We conclude that provisions for relocation of the area have been approved by the Board of Engineers for Rivers and Harbors and by the Chief Engineer since no exceptions to the proposal appear in either of the reports by Rivers and Harbors to the Chief Engineer or his comments to the Secretary of the Army.

The purpose for presenting the matter here is to emphasize the need for relocation of this important wildlife research and demonstration area in which this agency has invested well in excess of one million dollars in research, development and land acquisition.

Recommendation

With completion of Tennessee Colony Reservoir and relocation of the Engeling Area, a sizeable portion of the present acreage included in the area might be used to advantage by the Corps for recreational purposes as indicated in Section 27, paragraph "f", page 19, of the report of March 14, 1963, to the Chief of Engineers by the Board of Engineers for Rivers and Harbors.

Substantial deer, squirrel and quail populations presently exist on the area and although deer and squirrel numbers will be materially reduced with the project, a sufficient number will remain to afford moderate hunting opportunity.

FRESH WATER FISHERIES

Paragraph 37, Volume 5, Appendix 5, of the Comprehensive Survey Report on the Trinity River and Tributaries, presents recommendations of the Fish and Wildlife Service and comments on these recommendations by the District Engineer.

The following observations are made relative to these numbered recommendations in reference to fresh water fisheries resources.

Recommendation No. 1 -- That fish and wildlife be included among the purposes for which project authorization is sought.

Comment -- This recommendation is concurred in and fish and wildlife have been included among the recommended project purposes.

Recommendation No. 2 -- That the Corps of Engineers provide access facilities for hunters and fishermen, as discussed in paragraphs 92 through 95 of the attached substantiating report, for Tennessee Colony Reservoir, Lakeview Reservoir, the multiple-purpose channel, and the Trinity River cut-offs.

Comment -- It is proposed that access and facilities for the hunters and fishermen be provided. The number, size, and location of areas selected for development for public facilities and types of facilities to be developed will depend on several factors such as topographic features of the land below and above the normal water levels, tree cover, etc. The areas are to be selected and a plan for developing each area will be accomplished during the detailed planning state.

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Recommendation No. 3 -- That 6 seining areas totaling 1,200 acres in Tennessee Colony Reservoir and 3 areas totaling 600 acres in Lakeview Reservoir be cleared to ground level of all stumps and other obstructions. Specific locations and dimensions of seining areas will be determined by the Texas Game and Fish Commission during more advanced project planning stages.

Comment -- This recommendation is supported by this agency.

Recommendation No. 4 -- That timber and brush clearing in Lakeview Reservoir be restricted to that required for seining areas, etc.

Comment -- The Commission will be pleased to work with the Corps in advanced stages of the project relative to this activity.

Recommendation No. 5 -- That passage lanes be cut through the densely timbered areas to the headwaters and upper reaches of coves in Tennessee Colony Reservoir to provide access to fishermen and hunters. Specific design of these passageways will be made by the Texas Game and Fish Commission during the advanced project planning stages.

Comment -- Consideration should be given to locating such passage lanes at sites recommended by the Texas Game and Fish Commission.

Recommendation No. 6 -- That Lakeview and Tennessee Colony be zoned to realize maximum fishing and hunting benefits and to reduce conflicts with other recreational uses.

Comment -- Zoning of reservoirs to avoid conflicting uses by fishermen and general recreationists are reservoir management problems and

will warrant consideration during detailed planning studies or when the projects are placed in operation. Zoning and all other regulations should be enforced by local peace officers or game wardens.

One additional item which causes concern is that of the pollution of the Trinity River in the 100-mile reach of the stream, below the confluence of Marine Creek and West Fork in Fort Worth, extending to Rosser. Conditions are generally septic and associated offensive odors persist. It is proposed by the Corps that the water quality will be improved by dilution and it is estimated that by the year 2070 adequate treatment facilities will be available to furnish excellent quality water. The 100-mile reach of the river is so badly polluted at the present time that a fishery is nonexistent. With adequate dilution a fishery can be developed.

It can be expected that the hazard due to pollution from industrial sources will be greatly increased with the construction of the navigation channel. This condition may have a tendency to nullify any benefits resulting from fresh water fishery in the presently septic 100-mile reach of the Trinity River from Fort Worth to Rosser as the result of the water quality control provision of the project.

Industrial pollution resulting from the navigation aspect of the project may also adversely affect valuable marine forms in Trinity Bay.

MARINE FISHERIES

The principal effect of the Trinity River and Tributaries Project on the marine fisheries is the possible loss of favorable habitat for some of

the important commercial species of Trinity and Galveston Bays. Such habitat loss would occur when the Trinity River flow into Trinity Bay would be less than 120,000 acre-feet per month during the period from March through October.

A reduction in river flow during this critical period could bring about an increase in the salinity of the bay water which would be unfavorable to the production of shrimp, oysters, crabs, and menhaden.

Likewise, a reduction of river flow would increase the hazard of pollution which threatens the sport as well as the commercial fishery. This hazard is expected to be further increased as the result of pollution resulting from spillage of crude oil and chemicals in the navigation channel should this phase of the project be completed.

The estimated average loss to the commercial fishery is $285,000 per year. This loss can be minimized by incorporation of Recommendation No. 9 of the U. S. Fish and Wildlife Service report of May 1962, on the project. This recommendation is:

> "That the regimen resulting from project operation provide for a mean monthly fresh-water discharge of 120,000 acre-feet, when available, into Trinity Bay during the period from March through October, to meet the requirements of estuarine fisheries."

It should be noted that the Board of Engineers for Rivers and Harbors has considered the comments of the U. S. Fish and Wildlife Service and believes that the project features recommended in the report would produce no significant adverse effects upon the marine commercial

fishery (paragraph 37, page 26 of the report to the Chief of Engineers, dated May 14, 1963).

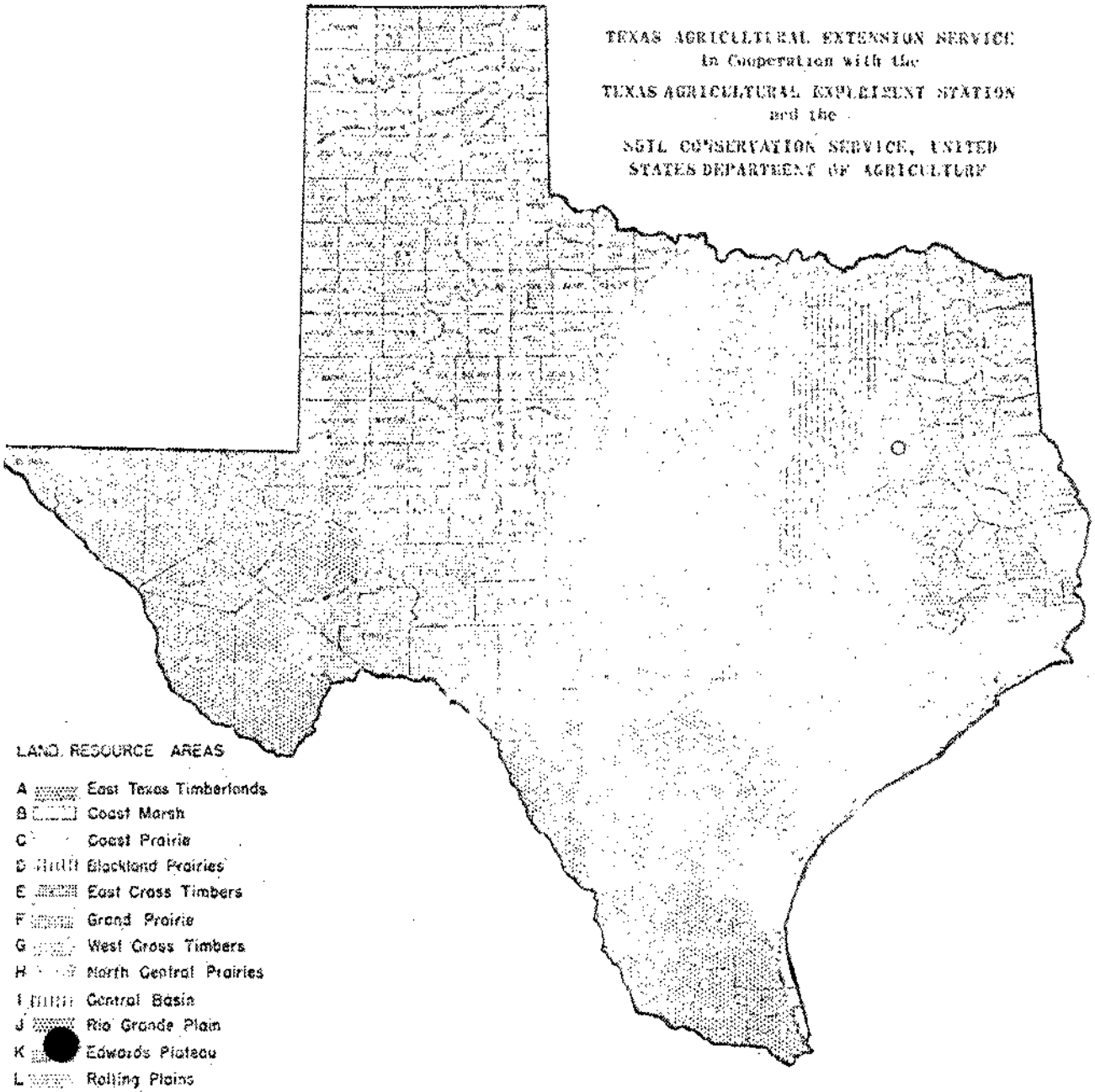
It is not entirely clear whether the Board believes that minimum river flow as requested would normally be available or if it considers the loss of the fishery habitat to be insignificant.

Sincerely yours,

H. D. Dodgen
Executive Secretary

HDD:EAW:em

Land Resource Areas of Texas



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

September 27, 1963

Dear General Wilson:

This is in reply to your letter of June 25, 1963, requesting our comments on reports on Trinity River and Tributaries. Your report proposes construction of four multiple-purpose reservoirs, a multiple-purpose channel for navigation, flood control, recreation, and fish and wildlife purposes from Trinity Bay to Fort Worth, Texas, five local flood protection projects, and water conveyance facilities in connection with one reservoir at a total estimated cost of $900,747,000. 13 additional reservoirs are contemplated in the long-range plan, but are not recommended for authorization at this time.

The plan presented is consistent with present plans of the Bureau of Reclamation for the Texas Basins Project and with the division of effort as agreed among the Bureau of Reclamation, the State of Texas, the Soil Conservation Service, and the Corps of Engineers.

We have several comments we believe are significant. However, these are not intended to be interpreted as an unfavorable recommendation for authorization.

The Fish and Wildlife Service is pleased to note your concurrence in most of the recommendations contained in its report of May 25, 1962. A supplement to this report was included in the District Engineer's report. Although the District Engineer did not comment on the specific recommendations contained in the supplement, he stated that "if the recommended elements of the plan are authorized by Congress, additional consideration will be given to the various recommendations of the Fish and Wildlife Service during advanced planning." Most of the recommendations contained in the supplement are similar to those in the report of May 25, 1962, and it is believed that they will be acceptable to you.

Your recognition of the importance of establishing a national wildlife refuge in connection with the Tennessee Colony Reservoir is appreciated. However, your concurrence in the Board's decision that the proposal for the refuge be considered separately from the reservoir is viewed with considerable disappointment. This Department firmly believes that opportunities for the development of national wildlife refuges created by the construction of water resource projects should be realized through project authorization and appropriations.

The national wildlife refuge recommended by the Fish and Wildlife Service would require the acquisition in fee title of only 600 acres of land in addition to the 20,400 acres of project land and water at the Tennessee Colony Reservoir. Since nearly all the land needed for the refuge would be acquired as a part of the project, this Department recommends that your report include acquisition of the 600 acres of land for the national wildlife refuge as an integral part of the project in accordance with paragraph 2.a of the Joint Policy of the Departments of the Interior and of the Army Relative to Reservoir Project Lands, approved February 16, 1962. The Fish and Wildlife Service will provide justification for the proposed national wildlife refuge and would be pleased to join the Corps of Engineers in testifying before Congress in support of this recommendation should it be desired.

In commenting on the recommendation of the Fish and Wildlife Service that the project be operated to allow for a mean monthly fresh-water discharge of 120,000 acre-feet into Trinity Bay during the period March through October, to meet the requirements of estuarine fishery resources, the District Engineer stated that "the Corps of Engineers has no control over the yield from the conservation storage of the reservoirs." Also, the Board of Engineers for Rivers and Harbors noted that "the project features recommended in the (comprehensive) report would produce no significant adverse effects upon the marine commercial fishery."

The Fish and Wildlife Service advises that significant losses to the marine commercial fishery would result in the absence of the fresh water discharges recommended in its report. Fresh-water inflows for the maintenance of fishery resources is as much a water requirement as that for navigation, industrial supply, etc., and should be provided for in the comprehensive planning for the development of all river basins. The Department therefore urges that every effort be made to provide for mean monthly fresh-water discharges into Trinity Bay as recommended by the Fish and Wildlife Service.

It is noted that the report of the District Engineer independently evaluates benefits for fish and wildlife about five times above the level evaluated in the report of the Fish and Wildlife Service. It appears that the explicit intent of the Congress, in amending the Fish and Wildlife Coordination Act in 1958, was to have the Service serve as the consulting agency on fish and wildlife matters concerning Federal water-resource developments. The use of fish and wildlife evaluations in lieu of those prepared by the Service evades the spirit and intent of this Act.

The Bureau of Outdoor Recreation is gratified with the consideration given in the report to recreation aspects. As indicated in the District Engineer's report the need for additional outdoor recreation facilities in this part of Texas is becoming more pressing each year. However, in contrast to the four reservoirs proposed for authorization the Bureau questions the suitability of the channel for general recreation use. According to

the District Engineer's report the quality of the water of the reservoirs will be favorable to recreation, but the channel waters may be murky. The compatibility of many types of outdoor recreation use and heavy barge traffic is questionable. In addition, it is not clear whether recreation lands and facilities will be provided commensurate with full recreation use. For these reasons, it is suggested that recreation not be treated as a primary purpose in the economic justification of the channel, but be handled as an incidental purpose if it is decided to build the channel on the basis of other benefits.

The report of the Bureau of Mines which is included in Appendix VIII to the District Engineer's report did not comment on the 13 reservoirs included in the long-range plan, but which are not recommended for authorization at this time. The Bureau advises that there are no mineral resources (including mineral fuels) of consequence involved at any of these sites.

The Frasch process operation of Texas Gulf Sulphur may possibly be involved in improvements required to maintain a 12-foot waterway in the Trinity River. This operation is on the top and flanks of a salt dome located near the east bank of the Trinity River at the south boundary of Liberty County. The sulfur occurs in a porous limestone formation 100 feet thick and at a depth of 750 feet. Wells are lost due to the caving of the ground which may affect the surface. The possibilities of such subsidence should be investigated before construction planning proceeds very far.

If the current real estate policy is followed so that the mineral resources and mineral producing and handling facilities are protected for continued operation and development, the Bureau of Mines does not object to authorization of the several projects proposed in the report. It is understood, of course, that some acquisition of mineral rights is often necessary under, or in the immediate vicinity of a structure. Such acquisition would be minimal and there would be no objection to such acquisition.

The need for geological studies is stressed by the United States Geological Survey for predicting construction problems that might be encountered as well as indicating areas of potential mineral production that would be submerged or withdrawn from exploration and development and turned to non-economic uses.

The cooperation of state and national agencies, oil and mining companies, institutions, societies, and informed individuals should be obtained in the gathering of information. General-purpose geologic maps of the entire basin would show the structure and the lithologic character of outcropping formations and would indicate the mineral and ground-water potential of the basin. Special-purpose maps would indicate both the areas where mineral deposits might be located and the areas most favorable or least favorable (such as areas susceptible to landslides and other failures) for construction.

Based on data contained in the District Engineer's report we find that there are no proposals which affect the marketing operations of hydroelectric power. However, it is suggested that in view of the extreme hydro power deficiency in this area, future planning should include studies of electric power, particularly, the possible use of the axial flow or bulb-type unit in connection with low-head installations. While not justified on an energy basis, the advantages of hydro installations for frequency regulation and emergency standby purposes may justify their installation. The Tennessee Colony Reservoir should be investigated further as to the possibility of a pump turbine installation of the pump-back type. As flows are diminished due to upstream use and impoundments, the power pool level may be raised if there is less need of flood control storage. The head is low, but the navigation structures may provide much of the after-bay construction and the cost of a pump turbine could be only a little higher than a conventional turbine.

We appreciate the opportunity of submitting our views and comments.

Sincerely yours,

Assistant Secretary of the Interior

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

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

IN REPLY REFER TO
ENGCW-PD

19 November 1963

The Honorable Stewart L. Udall

The Secretary of the Interior

Dear Mr. Secretary:

Reference is made to the recent letter from the Assistant Secretary of the Interior furnishing comments on our Comprehensive Survey Report on Trinity River and Tributaries, Texas.

The Fish and Wildlife Service in recommending a national wildlife refuge at Tennessee Colony Reservoir, indicated that specific boundaries of the refuge, as well as estimates of land acquisition and development and facilities costs, would be prepared by the Bureau of Sport Fisheries and Wildlife during advanced planning of the reservoir project. Section 3(c) of the Fish and Wildlife Coordination Act provides that before lands are acquired for fish and wildlife purposes, the probable extent of such acquisition shall be set forth, along with other data necessary for project authorization, in a report submitted to Congress. Accordingly, it is our position that all lands to be so acquired, in excess of lands or estate therein required for other project purposes, should be presented in such a way as to segregate clearly all such lands to be acquired and the authorities therefor; also, that when acquisition of lands is justified for fish and wildlife purposes, lands shall be shown separately in authorization reports to insure that the Congress has adequate information upon which to base a decision as to their inclusion in the project authorization. The Fish and Wildlife Service has not furnished sufficient information to meet the foregoing requirements in connection with its recommended national wildlife refuge at the proposed Tennessee Colony Reservoir. Nevertheless, I can assure you that the Corps of Engineers would have no objection to establishment of the refuge insofar as it would not conflict with operation of the project for other primary purposes, and provided its justification would be developed and defended by the appropriate agencies of the Department of the Interior.

With respect to fresh water discharges into Trinity Bay to meet the requirements of estuarine fishery resources, our studies have indicated that there is not sufficient water on a firm basis, beyond what is already

permitted or considered by local interests to be usable for future municipal and industrial purposes, to meet the Fish and Wildlife Service request that 960,000 acre-feet be discharged into Trinity Bay during the period of March through October annually. Accordingly, the Corps would not have sufficient control over the yield of the river to approve the Fish and Wildlife Service recommendation. The Corps will, however, make every reasonable effort to provide from projects under its jurisdiction the mean monthly fresh water discharges requested by the Service consistent with the priority of uses established by the State of Texas.

Our estimates of fish and wildlife benefits in the subject report are based essentially upon the visitation and participation experienced at existing comparable projects, with consideration being given to population density, predicted population increases during project life, and competition to be anticipated from existing and other proposed projects and facilities. The unit values we have applied to estimated visitor day use are in accordance with the Inter-agency Committee on Water Resources report dated 24 May 1960. We believe that our estimates are sound and realistic, and to not credit the project sufficiently with benefits of this type would in itself evade the spirit and intent of the Fish and Wildlife Coordination Act of 1958.

With respect to recreation usage of the proposed multiple-purpose channel, our experience on existing waterways indicates that the proposed waterway can be expected to attract visitors and recreationists for such specific purposes as sightseeing, boating for pleasure and sport, fishing, and water-skiing. Appropriate facilities would be developed along the channel to provide access, vehicle parking, boat launching and storage, and picnicking and camping.

The hydroelectric power potentialities at Tennessee Colony Reservoir and other elements of the proposed plan will be further considered and investigated in advanced planning of the various projects.

Your views and comments on our report are appreciated, and will accompany my report when it is submitted to the Congress.

Sincerely yours,

(Signed)

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

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:

September 24, 1963

Lieutenant General Walter K. Wilson, Jr.
Chief of Engineers
Department of the Army
Washington 20250, D. C.

Dear General Wilson:

This is in reply to General MacDonnell's letter of June 25, 1963, requesting comments on the U. S. Army Engineers' Report on the Trinity River and Tributaries, Texas.

The Public Health Service participated in the study upon which this report is founded, having prepared a report on needs for and value of water supply for municipal and industrial purposes and water quality control by flow regulation in the Trinity River Basin through the year 2070, included in Volume 3, Appendix II, as Exhibit 1.

While the Board of Engineers for Rivers and Harbors and the Chief of Engineers office recognize the need for water quality control and existing poor water quality conditions in the upper Trinity River basin, both recommend that the water conveyance facilities be deferred pending further study of alternatives. Our investigation included studies of three alternatives to the pipeline from Tennessee Colony Reservoir to Benbrook Reservoir, all of which were ruled out because of cost or inadequate water quality and quantity. Improvement and preservation of water quality in the Trinity River basin is included as an integral part of the water resource development plan presented in the Corps of Engineers report. The ultimate foreseeable development in the upper basin calls for the transfer of municipal and industrial water from the lower basin. The most economical source to supply this future need is Tennessee Colony. Its interim use for quality control is, therefore, the most feasible answer to the upper basin quality problem. We concur that these water conveyance facilities should be developed. If these facilities are not constructed in keeping with the overall plan, continued and more widespread degradation of water quality in the upper Trinity River basin will result.

The proposed water resource developments may create mosquito breeding places and intensify the problem unless steps are taken during planning and construction to avoid these hazards. Planning for these facilities should include an appraisal of the hazard by health officials and the incorporation of control measures in the design and operation.

The opportunity to review this report is appreciated. We stand ready to supply further consultation on your request.

Sincerely yours,

James B. Coulter

James B. Coulter
Acting Chief
Technical Services Branch
Division of Water Supply
and Pollution Control

COMMENTS OF THE DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
WASHINGTON

October 18, 1963

Dear Mr. Califano:

In accordance with Section 2(b) of the Federal Water Pollution Control Act, we are pleased to advise as follows on the need for and value of storage for water quality control in the Trinity River Basin Project:

A study was made and a report entitled "Water Resources Study, Trinity River Basin, Texas" was prepared during September 1962 by the Water Supply and Pollution Control staff, Public Health Service, Department of Health, Education, and Welfare, Region VII, Dallas, Texas.

On the basis of present conditions and projected population and industrial growth, we find that there is need for streamflow regulation for water quality control in the main stem of the Trinity River between Fort Worth, Texas and the Tennessee Colony reservoir site. The benefits from such regulation would be widely distributed.

The following table shows the value of storage for quality control. Since the quantities will vary with time, these values are calculated by decades until all water quality control storage is reallocated for municipal and industrial water supply.

Annual Benefits of Storage for Water Quality Control Purposes in Tennessee Colony and Aubrey Reservoirs

Year	Tennessee Colony Res.	Aubrey Res.
1970	$4,329,200	$1,085,200
1980	4,329,200	1,020,100
1985		965,800
1990	4,329,200	-0-
2000	4,329,200	
2010	4,329,200	
2020	4,329,200	
2030	1,931,800	
2040	-0-	

It is our recommendation that the interim storage for water quality control be incorporated in the Aubrey and Tennessee Colony Reservoirs and that the necessary appurtenances and conveyance facilities be provided.

The detailed findings on which these estimates are based are contained in the aforementioned report, copies of which have been transmitted to the U. S. Army Engineer Districts, Fort Worth and Galveston, Texas.

We appreciate the opportunity of providing this information.

Sincerely yours,

James M. Quigley
Assistant Secretary

Mr. Joseph A. Califano, Jr.
Special Assistant to the Secretary
of the Army for Civil Functions
Washington 25, D. C.

COMMENTS OF THE DEPARTMENT OF AGRICULTURE

DEPARTMENT OF AGRICULTURE
WASHINGTON 25, D.C.

October 24, 1963

Honorable Cyrus R. Vance
Secretary of the Army

Dear Mr. Secretary:

This is in reply to the Acting Chief of Engineers' letter of June 25, 1963, transmitting for our review and comment his proposed comprehensive survey report on the Trinity River and Tributaries, Texas.

The report presents a comprehensive plan for development to satisfy the present and projected needs for water supply and water quality, flood protection, navigation, recreation, and fish and wildlife in the Trinity River Basin. The specific projects recommended for authorization at this time consist of a multiple-purpose channel from the Houston Ship Channel to Fort Worth, including a series of navigation locks and dams; four multiple-purpose reservoirs--Roanoke (including modification of Grapevine Reservoir), Aubrey (including modification of Garza-Little Elm Reservoir), Lakeview, and Tennessee Colony with a wildlife refuge; water quality control distribution facilities from Tennessee Colony Reservoir to the existing Benbrook Reservoir; and five local flood protection projects--West Fork Floodway, Elm Fork Floodway, Dallas Floodway Extension, Duck Creek Channel Improvement and Liberty Local Protection.

Water requirements for irrigation potentialities of the basin are also included in the plan as is water needed to meet the cooling requirement for thermal electric power facilities which were determined to be the primary source of meeting future power needs of the area.

The construction cost for projects recommended for authorization is estimated to be about $911,000,000.

We note that comments of the Department of Agriculture agencies in the review of the report at field level have been considered in the final draft of the report. The report anticipates continuing development of the authorized Soil Conservation Service program in the Trinity River Basin on the basis of existing and authorized development under the Flood Control Act of 1944. This was considered by the Corps of Engineers and Soil Conservation Service in preparation of material for

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the U. S. Study Commission--Texas. If the projects recommended in the report are authorized, the Soil Conservation Service program will be reviewed and activities coordinated on the basis of the new improvements.

Since National Grasslands are involved in this program, the Forest Service and the Soil Conservation Service will cooperate in the review of plans where these lands are affected or where non-Federal woodlands are involved. Although portions of the Sam Houston and Davy Crockett National Forests and the Panhandle National Grasslands are within the boundaries of the Trinity River Basin, it appears that the improvement recommended in the report will have no significant impact on the administration of these lands.

There will obviously be an impact on State and private forest land as a result of the construction of the recommended measures. However, the report does not indicate that woodland values, lost by inundation of bottomland hardwood areas, have been recognized. On the other hand, the Director of the Texas Forest Service points out that marketing of both pine and hardwood stumpage may be facilitated if the recommended plan is authorized, since the timber products may be transported by barge to the pulp mills in Oklahoma, Georgia, and Florida via the coastal canal.

Annual benefits from the recommended projects are estimated in the report to be $63,200,000. Water supply, water quality control, navigation, fish and wildlife, and improvements for recreation are the major sources of benefits. While detailed information is not presented to determine agricultural benefits from reduction of damages, it appears that they constitute less than 5 percent of the total project benefits based on expected future development.

The report states that the Bureau of Reclamation has concluded that, since areas suited for irrigation lie in scattered tracts along the river, they are best suited for development by individual landowners rather than large-project type irrigation. Information available to this Department indicates that some irrigable areas are well adapted to multiple-purpose watershed development such as might be undertaken under the provisions of Public Law 566. Irrigation by local interests has been recognized as part of the comprehensive plan, and water requirements for future irrigation were included in the total water supply needs calculated for the basin.

We note that, although its inclusion has not been recommended, the installation of hydroelectric facilities at the Tennessee Colony Reservoir could produce power which would be economically justified. The comments of the Federal Power Commission indicate that this project could support a 15,000 KW installation. An REA-financed electric system has expressed interest in and could provide a market for reasonable cost power from this project. It is suggested that further investigation be undertaken at this time to plan for installation of such hydroelectric facilities.

The report of the U. S. Study Commission, Texas, indicated that there has been a progressive encroachment on the flood plain for both agricultural and non-agricultural purposes. The Commission report indicates that an exercise of foresight can minimize future flood damages. The Chief of Engineers' report does not indicate to what extent zoning restrictions or other measures were considered prior to the development of projections of the value of property in the flood plain.

The report recognizes that the construction of navigation dams on the river between Fort Worth and the Gulf may have a considerable impact upon agricultural production of adjacent lands, particularly in connection with drainage problems. If the proposed project is authorized, this Department recommends that careful consideration be given to the initiation of a joint study by the Corps of Engineers and the Department of Agriculture, similar to the study now underway on the Arkansas River, to determine the effects of such navigation developments on agricultural lands and recommend measures for the mitigation of adverse effects on crop production.

Since the report takes into account the present and future activities of this Department in the Trinity River Basin it appears that the proposed project would not adversely affect such activities. If the improvements recommended by the Chief of Engineers are authorized by the Congress, the concerned agencies of this Department will be pleased to consult with the Chief of Engineers prior to the initation of construction to consider such modifications as may be desirable.

We appreciate the opportunity to review the report.

Sincerely yours,

John A. Baker

John A. Baker
Assistant Secretary

COMMENTS OF THE DEPARTMENT OF COMMERCE

THE UNDER SECRETARY OF COMMERCE
FOR TRANSPORTATION
WASHINGTON 25, D.C.

September 30, 1963

Lieutenant General W. K. Wilson, Jr.
Chief of Engineers
Department of the Army
Washington, D. C. 20301

Dear General Wilson:

This is in response to General McDonnell's letter of June 25, 1963, requesting the views of the Department of Commerce on the proposed report of the Chief of Engineers relating to the Trinity River and Tributaries, Texas.

The views of the Area Redevelopment Administration, the Coast and Geodetic Survey, the Weather Bureau and the Bureau of Public Roads are transmitted herewith.

The Area Redevelopment Administration notes that the Tennessee Colony Reservoir and a large part of the navigation improvement recommended in the report will be located in areas presently designated as redevelopment areas and that area redevelopment benefits have been included in the economic analysis of the project by the Board of Engineers for Rivers and Harbors. The Area Redevelopment Administration suggests that early construction of the Tennessee Colony Dam and Reservoir and the navigation portions of the project would be of substantial value to economic redevelopment of the surrounding areas. The Area Redevelopment Administration will cooperate with your office to develop a mutually advantageous program for these features of the project.

The Coast and Geodetic Survey finds that sufficient primary horizontal and vertical geodetic control exists throughout the Trinity River and Tributaries area and could be extended locally to the various project sites. In the Tennessee Colony Reservoir area approximately seven control monuments will require relocation. This work is estimated to cost about $1,000. If additional control is required at any of the project sites, the Coast and Geodetic Survey would appreciate being advised so that cost estimates can be furnished. The Coast and Geodetic Survey also estimates that charting of this new waterway at 1:20,000 scale would cost about $75,000 and that charting of the waterway at 1:10,000 scale would cost about $100,000. The Coast and Geodetic Survey also suggests that there may be a need for making a circulation survey in Galveston Bay.

The Weather Bureau suggests that the type of evaporation pan used in obtaining the data for Table 10 on page 23 of Appendix II should be shown on the table. Such a note would explain the use of the 94 percent coefficient to convert pan data to reservoir evaporation. The Bureau also notes that the net reservoir evaporation (last column, Table 10) seems to be computed as the difference between rainfall and reservoir evaporation. The Weather Bureau points out that net reservoir evaporation is usually defined as reservoir evaporation minus effective rainfall, where effective rainfall is equal to rainfall minus runoff. The Weather Bureau also suggests that the report should contain additional discussion of the effect of increased net reservoir evaporation on the total water yield. This is especially pertinent in areas such as the Trinity Basin where the net reservoir evaporation losses might be quite significant.

The Bureau of Public Roads notes and endorses the recommendation that authority to acquire lands for the reservoirs in advance of construction should also include authority to participate in the cost of constructing and reconstructing transportation and utility facilities in advance of construction. This authority should be of inestimable value in the coordination of transportation improvements with waterway development.

The Bureau of Public Roads does not, however, agree with the recommendation that a proportional share of the cost of modifying existing bridges should be assigned to local interests in accordance with the provisions of the Truman-Hobbs Act. The improvement of the Trinity River for navigational purposes is, in effect, a basic change in the fundamental characteristic of the stream and is more analogous to the construction of a canal where no stream previously existed than it is to the improvement of a stream that was previously navigable by small commercial vessels to the standards required for the use of larger or a greater number of vessels. The Bureau of Public Roads, therefore, strongly suggests that the bridge alteration costs should be made a part of the project cost.

The Bureau of Public Roads also suggests that the previously mentioned recommendation that authority be granted for advance participation in the cost of constructing and reconstructing transportation facilities through lands needed for future reservoirs be made applicable to construction and reconstruction of transportation facilities crossing the alignment of the proposed Trinity River navigation channel. This is particularly important since the report recommends that improvement of the Trinity River be authorized subject to a further showing of the basic economy of the improvement prior to the appropriation of

funds for the construction of the improvement. Briefly, this amounts to a recommendation that the project be authorized and immediately placed in an inactive status, with no assurance that it would be constructed. Without the authority for advance participation in the additional cost of constructing these crossings to provide for navigation, the coordination of transportation development with waterway development in the Trinity River valley would be extremely difficult, if not impossible.

The Bureau of Public Roads also notes that the Corps report recognizes the cost of altering existing bridges but does not recognize the effect that the navigational improvement will have on the cost of future bridge construction. While this deficiency is partially rectified in the report of the Board of Engineers for Rivers and Harbors by the inclusion of an annual charge of $30,000 as an additional allowance for future bridge construction, the Bureau understands that the $30,000 annual charge is based on information indicating that nine additional crossings of the Trinity River will be built during the period 1967-1976 and that the incremental cost of providing the required navigational clearance at these crossings is $1,200,000. There appears to be some confusion on this point matter since information available to the Bureau of Public Roads indicates that the Texas Highway Department estimates that 12 new bridges would be built over the navigation channel during the next 15 years (1964-1978) and that the cost of providing the navigational clearance in the bridges would be $9,300,000.

Even the inclusion of this charge would not, however, fully recognize the effect of the navigational improvement on highway transportation costs. An annual charge based on the cost of constructing 12 new bridges in 15 years represents the effect of the navigational improvement on highway construction costs during only the next 15 years (1964-1978). The additional cost during the remaining study period, 1979-2074, has not been included. Although it is recognized that precise cost estimates are not available it would seem logical to assume that the annual costs during the later years would not be less than the costs estimated for the 1964-1978 period. It, therefore, seems appropriate to include an additional annual charge based on an additional highway construction cost of $620,000 per year as an estimate of the effect that the construction of the navigational improvement will have on highway construction costs during the later years of study.

Information available to the Bureau of Public Roads also indicates that the Texas Highway Department recommends that the cost of

altering existing roads and bridges be increased by $1,000,000 for the southbound lanes of Texas State Highway 157 at Mile 354 and by $4,000,000 for the realignment of Interstate Highway 35 in the Roanoke Reservoir area.

In addition to the preceding, the Bureau of Public Roads notes that the unit values per foot of lift (Appendix III, page 237) used in calculating the effect that the construction of the navigational improvement will have on the cost of operating passenger cars and trucks were obtained from the February 1955 edition of the Department of Commerce report titled "Navigational Clearance Requirements for Highway and Railroad Bridges". The unit values contained in that report have been modified considerably by later research on the subject. The revised unit values are contained in a Bureau of Public Roads circular memorandum dated April 4, 1960, copies of which were transmitted to the Corps of Engineers on or about that date. The revised unit values are .0004108 per foot for trucks (heavy vehicles with six or more tires). The Bureau of Public Roads suggests that the report be modified to take the change in the unit lift values into consideration and to include the increase in highway transportation costs due to the higher bridges necessary to provide navigational clearances for the estimated future traffic over these bridges.

General McDonnell's letter mentioned the contention of the Texas Railroad Association that implementation of the navigation recommendations in the proposed report would add to the "excess capacity problem" of the transportation industry. He requested our views on the relationship between the report recommendations and the general transportation policy, and, more specifically, the relationship of the recommendations to that portion of President Kennedy's transportation message of April 5, 1962 which dealt with the problem of excess capacity.

There are some serious differences between the transport savings data and waterway traffic forecasts contained in the proposed report of the Chief of Engineers and those in the report of the Texas Railroad Association on the proposed project. Because of the effect which resolution of these discrepancies might have upon the benefit/cost relationships, we are submitting them to further study. Our views on the benefit/cost aspects of the

navigation sector of the proposed project and our comment on the excess capacity problem will be transmitted to your office on or before October 15, 1963.

Sincerely,

Frank L. Barton

Frank L. Barton
Deputy Under Secretary for
Transportation (Operations)

THE UNDER SECRETARY OF COMMERCE
FOR TRANSPORTATION
WASHINGTON 25, D. C.

December 3, 1963

Lieutenant General W. K. Wilson, Jr.
Chief of Engineers
Department of the Army
Washington, D. C. 20301

Dear General Wilson:

This is in further reply to General MacDonnell's letter of June 25, 1963, requesting the views of the Department of Commerce on the proposed report of the Chief of Engineers relating to the Trinity River and Tributaries, Texas. In our letter of September 30, 1963, addressed to you, we submitted the views of the Area Redevelopment Administration, the Coast and Geodetic Survey, the Weather Bureau and the Bureau of Public Roads. At that time we indicated that we needed additional time in which to consider other aspects of the study.

General MacDonnell quoted the Texas Railroad Association as contending that implementation of the navigation recommendations would add to the transportation industry's excess capacity problem and that this would conflict with a principle as stated in the President's Message on Transportation of April 5, 1962. The President stated that investment or capacity should be neither substantially above nor substantially below the requirements for fast, safe and economical transportation services needed in a growing and changing economy to move people and goods, without waste or discrimination, in response to private and public demands at the lowest cost consistent with health, convenience, national security, and other broad public objectives.

The combination of existing rail and highway facilities and services provide adequate physical capacity to meet projected requirements, but physical capacity is only one criteria in the evaluation of the merits of this proposed project. Capacity also must be measured in terms of whether the present and prospective needs of the area will be met, at prices sufficiently economical to develop the maximum volume of traffic and to provide the type of service which will both meet requirements and stimulate economic expansion.

The Department of Commerce has reviewed the report of the Chief of Engineers, the material submitted by the Texas Railroad Association, the Trinity Improvement Association, and additional information supplied by consultants and other interested parties.

The Department has taken particular note of your ten point report to the Secretary of the Army and we concur in those conclusions and recommendations pertaining to the transportation aspects of the proposed Trinity River project.

Sincerely,

Clarence D. Martin, Jr.

LETTER TO THE SECRETARY OF COMMERCE

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

IN REPLY REFER TO
ENGCW-PD

19 December 1963

The Honorable Luther H. Hodges

The Secretary of Commerce

Dear Mr. Secretary:

Reference is made to letters from your Department dated 30 September 1963 and 3 December 1963, furnishing your views and comments on our comprehensive survey report on Trinity River and Tributaries, Texas.

With respect to comments of the Weather Bureau, the Bureau of Plant Industry evaporation pan was used at all precipitation stations throughout most of the period of record indicated in Table 10, appendix II. However, beginning in 1953 such pans have been gradually replaced by Young type pans at most stations. The coefficient of 94 percent is a weighted factor to convert pan evaporation for these two types of pans to evaporation from a reservoir surface. In the evaporation studies, adjustments for runoff at the individual reservoir sites were applied to the observed rainfall at the sites to obtain effective rainfall as defined in comments of the Weather Bureau. The effective rainfall was then deducted from gross reservoir evaporation to obtain net reservoir evaporation. Table 10 summarizes basic data for stations used in estimating evaporation at the several reservoirs and is not intended to present data for specific reservoirs.

The Bureau of Public Roads does not agree with our recommendation that a proportional share of the cost of bridge alterations over existing channels should be assigned to local interests in accordance with provisions of the Truman-Hobbs Act, and indicates that bridge alteration costs should be all Federal costs. The apportionment of project costs in the Trinity plan is complex since most elements of the plan would have multiple uses, and existing laws, policies, and procedures for cost sharing between Federal and non-Federal interests vary depending upon project purposes, types of development, and beneficiaries. The costs allocated to the navigation function were apportioned in accordance with Congressional policies expressed in legislation applicable to projects for general navigation. It is intended that the principles

contained in Section 6 of the Truman-Hobbs Act be used where applicable to ensure a fair and equitable apportionment of bridge alteration costs. Local interests sponsoring the recommended improvements have implied approval of the proposed cost sharing by furnishing satisfactory assurances that the requirements of local cooperation will be met.

Consideration was given in our report to recommending authority for advance participation in the cost of constructing and reconstructing transportation facilities crossing the alignment of the proposed multiple-purpose channel. The principal reason for not making that recommendation lies in the fact that feasibility studies of survey report scope are not sufficiently definitive to establish the exact locations of locks and dams, the alignments and locations of potential bridge crossings, nor bridge clearances needed to protect navigation requirements. We conclude that any advance participation of the nature suggested by the Bureau of Public Roads should be delayed at least until detailed design studies are made.

As discussed in appendix VI of our report, the 12 additional highway bridges planned by the Texas Highway Department are in its long-range plans and sufficient data are not available to us concerning locations, designs, and costs. However, certain assumptions were made, as follows: Nine of the 12 proposed bridges would be on new routes and would not supplant existing bridges; all bridges would accommodate 4-lane traffic; bridge construction would proceed at the rate of one per year beginning in 1967; and, the incremental added cost of the bridges chargeable to navigation would be 15 percent of the total cost below Dallas Floodway and 10 percent above that point. Based on these assumptions, the total estimated first cost of the nine bridges is estimated at $9,800,000 of which $1,220,000 would be chargeable to the navigation increment. Reduced to present worth and applied over the economic life of the project, the average annual equivalent charge would be about $30,000. We do not concur that the navigation features of the recommended plan should be assigned costs because of possible effects on highway construction costs to the year 2074. In developing the benefits creditable to navigation, no benefits are credited to potential barge traffic that could possibly be developed in the future but is currently unknown and would likely not move on an existing waterway. Likewise, it does not seem equitable that estimated construction costs should account for possible but unknown future effects on facilities beyond those that are existing, under construction, are being planned, or are otherwise subject to reasonable estimation.

It is recognized that the most recently published unit values were not used in our report in calculating the effect that construction of

high-lift bridges would have on the cost of operating passenger cars and trucks. However, changes in the report to reflect this minimal effect do not appear warranted.

Copies of your letters and this reply will accompany the report of the Chief of Engineers to Congress.

Sincerely yours,

(Signed)

R. G. MacDONNELL
Major General, USA
Acting Chief of Engineers

FEDERAL POWER COMMISSION
WASHINGTON 25, D.C. 20426

September 27, 1963

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

Reference: ENGCW:PD

Dear General Wilson:

This is in response to General MacDonnell's letter of June 25, 1963, inviting comments by the Commission relative to your proposed report and to the reports of the Board of Engineers for Rivers and Harbors and of the District and Division Engineers on the Trinity River and Tributaries, Texas.

The reports of your Department present a comprehensive plan of development for the Trinity River basin and recommend authorization of the following improvements from that plan: (1) Four multiple-purpose reservoirs -- Lakeview, Roanoke, Aubrey, and Tennessee Colony; (2) five local flood protection projects; and (3) a multiple-purpose channel extending along the Trinity River from the Houston Ship Channel to Fort Worth, Texas, for purposes of navigation, flood control, recreation, and fish and wildlife. No provisions for hydroelectric power development are included in any of the project plans. The reports give the estimated construction cost of the recommended improvements as $910,750,000. The recommendation is qualified in that further analyses of navigation will be submitted to the Congress when funds for construction of features exclusively for that purpose are requested.

The Commission staff has reviewed your Department's reports and has made studies of the possibilities of developing hydroelectric power at the recommended projects. These studies show that owing to the relatively low heads and flows available the firm power that could be produced at the three smaller of the proposed reservoirs would be very small even with the available conservation storage capacity used in the best interests of power. The estimated benefit-cost ratios of such power developments were found to be substantially below unity.

In the case of the larger proposed Tennessee Colony reservoir, an installation of about 15,000 kilowatts could generate an average of approximately 80,000,000 kilowatt-hours annually. Although the report

does not include firm operating criteria for the project, the staff studies indicate that the annual value of the power would be about equal to the annual cost of adding the power facilities. Further studies of this power possibility should be made at the project design stage.

The lifts at the proposed navigation dams range from 4 to 30 feet. A study was made of the power that could be produced at lock and dam No. 7 which has a 30-foot lift and regulates the runoff from more than 75 percent of the basin's drainage area. Using 1958 streamflow conditions and the estimated navigation requirements given in the report, it was estimated that an installation of 5,000 kilowatts could be made. However, using only the cost of specific power facilities, the benefit-cost ratio of such a development was found to be 0.6 to 1.

Based on its consideration of the reports of your Department and the studies of its own staff, the Commission concludes that, except for the proposed Tennessee Colony reservoir, the recommended improvements in the Trinity River basin would not provide opportunity for economical hydroelectric power development. The possibility of developing about 15,000 kilowatts of installed capacity at the Tennessee Colony project should be studied further at the project planning stage.

Sincerely,

Joseph C. Swidler
Chairman

TRINITY RIVER AND TRIBUTARIES, TEXAS

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
ENGCW-PD

29 November 1963

SUBJECT: Trinity River and Tributaries, 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 Trinity River and Tributaries, Texas, accompanied by reports of the District and Division Engineers, in response to resolutions of the Committee on Rivers and Harbors of the House of Representatives adopted 31 March 1944, 28 February 1945, and 30 November 1945; a resolution of the Committee on Public Works of the House of Representatives adopted 6 August 1948; and a resolution of the Committee on Public Works of the United States Senate adopted 20 January 1958; all as quoted in the District Engineers' report. It is also in review of reports on a survey of Trinity River, Texas, authorized by the River and Harbor Act approved 3 July 1958. Several interim reports recommending individual improvements have been previously submitted. This report considers a comprehensive plan for the development and control of the water and related land resources of the basin.

2. The Fort Worth and Galveston District Engineers and the Division Engineer find that, in the interests of comprehensive development and beneficial public use of the water and related land resources of the basin, the existing project for the Trinity River and Tributaries, Texas, should be modified to provide for a multiple-purpose channel for navigation, flood control, recreation, and fish and wildlife purposes from Trinity Bay to Fort Worth, Texas, four multiple-purpose reservoirs, five local protection projects, and water-conveyance facilities in connection with one reservoir, all as included in their comprehensive plan, at currently estimated net Federal costs of $775,796,000 for construction and $7,227,000 annually for maintenance, operation, and major replacements, subject to local cooperation and providing for certain ancillary authorities.

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3. After careful consideration of the reports of the District and Division Engineers, and the additional information presented by local interests, the Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the reporting officers, subject to an increase of $10,000,000 in the estimated Federal cost of construction; the provisions that at such time as funds are requested for initiation of construction of features exclusively for navigation the Chief of Engineers will submit to Congress an economic analysis of these features; that construction of the water-conveyance facilities be deferred until further studies can be made to determine if a more economical alternative should be authorized as an interim measure; and, subject to certain conditions of local cooperation.

4. The District and Division Engineers and the Board further recommend that the Congress consider recommendations of the Bureau of Sport Fisheries and Wildlife providing for land acquisition and use and operation of the Tennessee Colony Reservoir in support of a national wildlife refuge, insofar as there is no conflict with operation for other project purposes.

5. I concur in the view of the Board that the comprehensive plan developed by the District and Division Engineers is formulated to meet the needs of the Trinity River Basin area and provide suitable conditions for expansion of area activities.

6. Based on comparison of computed charges for transport by barge with charges or rates for movement by land carriers the Board has determined the benefit-cost ratio for the proposed navigation measures to be 1.13. In making this appraisal the Board took into account recent changes in land carrier charges for transporting certain commodities. The Board also considered the feasibility of appraising the economic justification of these measures by comparison of land and water carrier costs, concluding that the data available do not permit meaningful analysis on the latter basis.

7. I am mindful of the roles of land and water carrier costs and charges in determining the relative efficiency of various means of transportation and the movement of commerce, and of the effects of possible changes in these factors on the evaluation made by the Board. Accordingly, I concur in the recommendation of the Board that at such time as funds are requested for initiation of construction of features exclusively for navigation the Chief of Engineers will submit to the Congress an economic analysis of these features, with the understanding that this analysis be based upon the best information then available of probable traffic on the waterway, the cost of constructing and operating it, and applicable land and water carrier costs and charges.

8. The major facilities proposed by the District and Division Engineers and the Board for conveyance of water from Tennessee Colony Reservoir to Benbrook Reservoir are an important element of the Trinity River Basin plan in relation to current and long-range needs for water quality control and water supply. While I consider Federal construction of such major water-conveyance facilities to be appropriate in connection with Federal development of reservoir storage capacity to meet these needs, I believe that local interests should repay the cost of their construction and assume responsibility for their operation, maintenance, and replacement.

9. I note that the Board considers it advisable to defer construction of the proposed water-conveyance facilities until further studies can be made of possible lower-cost, relatively short-term, interim measures. I agree that such studies are desirable and consider it appropriate that they be made in connection with preconstruction planning of Tennessee Colony Reservoir. Nevertheless, in recognition of the local financial and operational responsibilities I have outlined above for the water-conveyance facilities which will meet needs on a long-term basis, I believe that decision as to when such facilities should be constructed should take into account the readiness of local interests to proceed. Decision on this basis should not preclude proper consideration of possible interim measures. Accordingly, I recommend construction of the water-conveyance facilities proposed by the District and Division Engineers and the Board, provided that prior to construction local interests give assurances satisfactory to the Secretary of the Army that they will repay the cost of construction of these facilities in general accordance with the repayment principles outlined in the Water Supply Act of 1958, as amended, and assume responsibility for their operation, maintenance, and replacement.

10. Subject to my views and recommendations stated above, I concur in the views and recommendations of the Board. On this basis the estimated net costs to the United States are $737,607,000 for construction and $6,007,000 annually for operation, maintenance, and replacements.

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 March 1963

SUBJECT: Trinity River and Tributaries, Texas

TO: Chief of Engineers
Department of the Army

AUTHORITY AND SCOPE

1. Authority.--This report is in response to resolutions of the Committee on Rivers and Harbors of the House of Representatives adopted 31 March 1944, 28 February 1945, and 30 November 1945; a resolution of the Committee on Public Works of the House of Representatives adopted 6 August 1948; and a resolution of the Committee on Public Works of the United States Senate adopted 20 January 1958; all as quoted in the District Engineers' report. It is also in review of reports on a survey of Trinity River, Texas, authorized by the River and Harbor Act approved 3 July 1958.

2. Scope.--The report considers the advisability of improvements to satisfy the present and projected needs for water supply and water quality control, flood protection, navigation, power, irrigation, drainage, recreation, and fish and wildlife in the Trinity River basin. It presents a comprehensive plan of development for a balanced program, consisting of projects proposed for immediate Federal authorization and others for long-range development, to provide the best combination of uses of the water and related land resources of the basin.

BASIN CHARACTERISTICS

3. Location and size.--The Trinity River basin is in eastern Texas. It contains 17,845 square miles, is about 360 miles long and has its maximum width of about 100 miles in the headwaters region above Fort Worth and Dallas. It drains into Trinity Bay, an arm of the Gulf of Mexico.

4. Basin description.--Topographically the basin is a gently sloping plain, varying from about 1,250 feet above sea level in the headwaters to sea level at Trinity Bay. In the upper reaches, the

surface is rolling and broken; below Fort Worth it is gently rolling to flat and is dissected by meandering and generally sluggish streams. The basin is predominantly agricultural, although about one-fourth, principally in the middle valley, is in forests.

5. River system.--Trinity River is formed at Dallas by the confluence of West Fork and Elm Fork. Throughout its course the river is tortuous. Its length, 505.5 miles, is about twice that of the valley. West Fork rises about 156 miles northwest of Fort Worth. In the 53-mile reach between that city and its junction with the Elm Fork at Dallas, the stream falls 120 feet. The elevation of the Trinity River at the junction of the West Fork and Elm Fork is 386 feet. Other tributaries are the East Fork, Cedar Creek, Richland Creek, and numerous smaller streams.

EXISTING AND PLANNED IMPROVEMENTS

6. Existing improvements.--In the basin, 24 major reservoirs, with individual conservation storage capacities of more than 5,000 acre-feet, are operational, under construction, or authorized. Among these are seven reservoirs, six Corps of Engineers' projects and one non-Federal project, which also provide flood-control storage. In addition, local interests have constructed 79 smaller reservoirs with a total of 41,000 acre-feet of conservation storage. Also, there are about 66,500 farm ponds with an average storage capacity of about 2 acre-feet. Existing Corps of Engineers' reservoirs are described on page 19 of the District Engineers' report and non-Federal reservoirs on page 20.

7. Soil Conservation Service.--The Soil Conservation Service has constructed four flood detention reservoirs in the Trinity River basin with individual storage capacities greater than 5,000 acre-feet. The Soil Conservation Service also has extensive programs underway in the basin for agricultural land treatment measures and for runoff and water flow retardation and soil erosion prevention. Prior to January 1961, the Soil Conservation Service had completed about 40 miles of channel improvements. It also has planned 1,200 floodwater retarding structures in the basin with a combined storage capacity of 1,300,000 acre-feet; of these, 288 have been constructed with a total storage capacity of 252,500 acre-feet, including 211,400 acre-feet for flood detention purposes.

8. Local flood protection.--Several local flood protection projects have been constructed by the Corps of Engineers in the Fort Worth-Dallas area and two additional projects have been authorized in the Fort Worth area. About 40 active organized levee districts maintain 341 miles of levees in both rural and urban areas.

9. Navigation.--The authorized Federal navigation project provides for a sea level channel 150 feet wide and 9 feet deep, below mean low tide, extending easterly from the Houston Ship Channel near Red Fish Bar to and along the east shore of Trinity Bay to Anahuac, Texas, thence generally following the natural Trinity River channel to and including a turning basin at Liberty, Texas, a distance of 48.9 miles. The portion of this project from the Houston Ship Channel to mile 23.2, about 1 mile below Anahuac, was completed in 1950.

GENERAL ECONOMY

10. Areas considered.--The economy of an area comprising 148 counties in Texas and 30 counties in Oklahoma influenced the planning considerations for navigation. Similarly, the economy of a 46-county area in and adjacent to the Trinity basin was taken into account in planning for water supply, recreation, and fish and wildlife. The economy of the local areas in and immediately adjacent to the flood plain was used in planning for flood-control improvements. The economic-base-study area, encompassing the areas considered for all purposes, covers 161,300 square miles and includes 183 counties in Texas and Oklahoma.

11. Population.--The 1960 population of the Trinity River basin was 1,895,000, of which about 80 percent was in the Fort Worth-Dallas complex. The population of Dallas and Tarrant Counties increased about 500 percent over the past 50 years. This increase was accompanied by a significant shift from a rural to an urban type economy in the upper basin. The middle basin has remained rural in character and has declined in population over the last half century. However, the District Engineers anticipate that with additional flood-control measures and the construction of a waterway, this area would change from predominantly agricultural to rural and urban with a resultant increase in population.

12. The population of the base-study area was 6,844,000 in 1960, about 4 percent of that of the United States. The population of the base-study area has increased at an average annual rate considerably greater than the national rate except for the decade from 1940 to 1950. From 1890 to 1960 the population of the base-study area increased at an average annual rate of 2.22 percent as compared with a rate of 1.50 percent for the United States.

13. Transportation facilities.--Seven major railroad systems provide a network of main lines and branches throughout eastern and southern Texas. North-south lines between the Fort Worth-Dallas and Houston areas do not closely parallel the Trinity River. Improved highways serve most of the basin. An extensive network of pipelines is used principally for gathering natural gas and crude oil and distributing them to refineries and shipping terminals along the Gulf Coast. The Fort Worth-Dallas complex, with a 1960 population of 1,657,000, is one of the largest urban-industrial areas in the United States that is not on a navigable waterway.

WATER RESOURCE PROBLEMS

14. Droughts.--The Trinity River basin has a recurring pattern of long to moderate droughts followed by periods of heavy rainfall. A prolonged drought throughout the basin during 1950-1957 was followed by severe floods in 1957. Droughts cause serious water shortages in the cities and towns which depend on the river for municipal and industrial water supplies and in the agricultural areas which are irrigated from the river. During the 1950-1957 drought, both Dallas and Fort Worth, as well as many smaller cities, were forced to curtail water use and seek temporary and expensive means of supplementing their water supplies. Dallas found it necessary to import low-quality water from the Red River basin as a temporary measure. As the population, industry, and the general economy of the basin expand, the water shortage problem will become more critical.

15. Water requirements.--Generally the water resources within the Trinity River basin are adequate to meet the water needs for the foreseeable future. The principal problems are distribution, water quality, and variability of flow. Total water use in 1958 was about 380 million gallons per day (mgd) of which 57 mgd was ground water for municipal and industrial purposes. The term "water supply," when used without qualification in this report, means water for municipal, industrial, domestic, and stock uses, and not for water quality control or navigation. The estimated water requirements of the basin and adjacent area for the years 2020 and 2070 are shown below:

Water Requirements
(Million gallons per day)

Sub-basin	Municipal and industrial	Non-municipal	Water quality control	Navigation	Irrigation	Exports	Total
			Year 2020				
Upper	1,513 (1)	15	80 (2)	0	69	0	1,677
Middle	227	3	0	0	65	0	295
Lower	340	2	0	57	222	840	1,461
Total	2,080	20	80	57	356	840	3,433
			Year 2070				
Upper	2,797	11	0	0	69	0	2,877
Middle	435	4	0	0	65	0	504
Lower	686	1	0	57	222	840	1,806
Total	3,918	16	0	57	356	840	5,187

(1) Includes 40 mgd for interim water quality control.
(2) 80 mgd for water quality control would be converted to water supply as the need develops.

16. Water quality.--The mineral quality of the water is good to very good except for the extreme lower portion of the river where salt water intrusion greatly reduces the quality during drought periods. The organic quality of the water can be classified as good above Fort Worth and below Livingston Reservoir. In the 100-mile reach of the river below the confluence of Marine Creek and West Fork in Fort Worth, extending to Rosser, conditions are generally septic and associated offensive odors persist.

17. Floods.--Approximately 1,550,000 acres of land are subject to flooding, of which more than 830,000 acres are along the main stream and lower reaches of the principal tributaries and the remaining 720,000 acres are along the headwater streams. These 720,000 acres are being considered for protection under programs of the Soil Conservation Service. Of the 830,000 acres on the main stream and principal tributaries, 225,000 acres will be afforded a high degree of flood protection by existing and authorized Corps of Engineers projects. The April-June 1957 flood, the most disastrous of record, caused damages estimated at $19,500,000 throughout the basin. The average annual damages on the 605,000 acres along the Trinity River and principal tributaries are estimated at $2,300,000 under 1960 conditions of flood plain protection and development.

18. Navigation.--The location, resources, and trends of economic development of the Trinity River basin are favorable to the generation of large volumes of commerce in bulk grains, manufactured products, and sand, gravel, and stone. An important grain-producing area lies north and northwest of the basin from which large quantities of export grain move by rail and truck to deep-water ports on the Gulf Coast. The industrial complexes of the Fort Worth-Dallas and Houston areas generate and receive large quantities of raw and semi-processed materials, manufactured products, bulk chemicals, petroleum, and petroleum products. The large deposits of stone, sand, and gravel in the basin would be extensively developed if low-cost barge transportation were provided.

19. Outdoor recreation.--Outdoor recreation facilities at the four Corps of Engineers reservoirs--Benbrook, Grapevine, Garza-Little Elm, and Lavon--attracted more than 8 million visitors in 1961 with almost 3 million engaging in sport fishing or hunting. It is estimated that by the year 2020 recreation facilities will be needed to accommodate about 38 million visitors and by the year 2070, about 78 million visitors. Any future impoundments will serve to satisfy a portion of the recreation needs.

20. Power.--The future power requirements of the basin are expected to be supplied from thermal sources by public and private utility companies. Studies also indicate that, under the most favorable conditions, only small amounts of hydroelectric power generation might be economically justified in the future. Cooling water requirements for projected thermal power generation are included in the comprehensive plan.

21. Drainage.--In a joint study by the Soil Conservation Service and the Corps of Engineers, it was found that drainage problems exist on about 14 percent of the total land area in the basin. It is estimated that drainage is feasible for about 449,000 acres, which includes 58,000 acres requiring on-farm improvements, 233,000 acres requiring group drainage, and 158,000 acres which would require improvement of the major outlets. Existing and foreseeable drainage needs may be met by existing programs of the Soil Conservation Service and by specific authorizations of Congress for major drainage improvements to be accomplished by the Corps of Engineers as specific needs develop.

22. Irrigation.--Irrigation is concentrated largely in the lower basin where water is diverted from the Trinity River for rice production; however, numerous small tracts scattered along

the Trinity River below Dallas and along several major tributaries are also irrigated by surface water. Ground water is similarly used for irrigation. As the irrigated areas are scattered along the river, they are generally best suited for development by individual landowners rather than by large project-type irrigation facilities. Future irrigation by local interests has been recognized in the comprehensive plan, which includes an allowance of 356 mgd for this purpose.

IMPROVEMENTS

23. Improvements desired.--Local interests desire Federal improvement of the Trinity River basin to include:

a. Reservoirs on the Trinity River and all major tributaries for flood control, water conservation, fish and wildlife conservation and recreation, and improvement of the river channel for flood control from Five Mile Creek to the mouth.

b. A barrier near the mouth of the river for water conservation and salinity control.

c. A waterway for barge navigation extending from the Houston Ship Channel to Fort Worth.

d. Extension of the Fort Worth Floodway upstream on the Clear Fork and downstream on the West Fork.

e. Floodways, including improved channels and levees, on the West Fork between Dallas and Fort Worth; on the Elm Fork from the mouth upstream to Grapevine and Garza-Little Elm Reservoir; and on Duck Creek through the city of Garland.

f. Extension of the Dallas Floodway downstream to White Rock and Five Mile Creeks.

g. Enlargement of Lavon Reservoir and downstream channel improvement on the East Fork, below the authorized Bardwell Reservoir on Waxahachie Creek, and on Town Branch through the city of Madisonville.

h. Rehabilitation of certain agricultural levees along the main stem, East Fork, and Richland and Chambers Creeks.

i. Levees along the left bank of Trinity River for flood protection to Liberty.

24. Improvements considered.--The District Engineers considered many plans for development, including a single-purpose flood-control channel, a single-purpose navigation channel, a combined multiple-purpose channel, 40 potential reservoir sites, and various local protection projects consisting of levees and channel rectification works. After detailed studies, the District Engineers selected a combination of improvements which they believe would reasonably satisfy in a timely sequence the major water-dependent needs of the basin more economically than any other combination.

FINDINGS OF REPORTING OFFICERS

25. Plan selected.--The plan selected by the reporting officers includes two categories of projects--those proposed for immediate Federal authorization and those in a long-range plan but not recommended for authorization at this time:

a. Immediate authorization.--Projects proposed for immediate Federal authorization are:

(1) A multiple-purpose channel from the Houston Ship Channel to Fort Worth to provide for barge navigation and with sufficient capacity to contain flood releases from upstream reservoirs and to partially control runoff downstream from the reservoirs;

(2) Four multiple-purpose reservoirs: Roanoke (including modification of Grapevine Reservoir) on Denton Creek, Aubrey (including modification of Garza-Little Elm Reservoir) on Elm Fork, Lakeview on Mountain Creek, and Tennessee Colony on Trinity River with water conveyance facilities connecting with the existing Benbrook Reservoir and contingent provisions for a wildlife refuge in connection with Tennessee Colony Reservoir; and

(3) Five local flood protection projects: West Fork Floodway, Elm Fork Floodway, Dallas Floodway Extension, Duck Creek Channel Improvement, and Liberty Local Protection Project.

b. Long-range plan.--Thirteen reservoir projects included in the long-range plan, but not recommended for authorization at this time, are described on page 73 of the District Engineers' report. When the needs develop to the extent that these projects are required, further investigations may be made to assure that the developments would serve all purposes found desirable and justified at that time.

26. Findings of reporting officers.--The Fort Worth and Galveston District Engineers and the Division Engineer find that modification of the existing project for the Trinity River and Tributaries, Texas, by construction of the facilities described below is economically justified and advisable, subject to certain conditions of local cooperation. The total estimated cost of the projects proposed for authorization is $900,747,000 for construction and $8,447,000 annually for operation, maintenance, and replacements. The net Federal costs are $775,796,000 for construction and $7,227,000 annually for operation, maintenance, and replacements. They estimate the benefit-cost ratio at 1.6. The individual units in the plan are described as follows:

a. Multiple-purpose channel.--The multiple-purpose channel for navigation, flood control, recreation, and fish and wildlife purposes would extend from the Houston Ship Channel in Galveston Bay, following the authorized "Channel to Liberty Project" to the city of Liberty, thence continue along the general course of the Trinity River to the Riverside Drive bridges in Fort Worth, a total distance of about 370 miles. The channel would provide a minimum depth of 12 feet below normal pool elevations and would have a minimum bottom width of 150 feet. It would have 17 gated navigation dams and one overflow navigation dam, in addition to the authorized Wallisville Dam, the Livingston Dam to be constructed by local interests, and the proposed Tennessee Colony Dam. Spur channels 12 feet deep and 150 feet wide extending to turning basins 400 feet square would be provided at Dallas and Fort Worth. The system would have 19 locks below Dallas, each having clear dimensions of 84 feet wide by 600 feet long, and 4 locks between Dallas and Fort Worth, each 56 feet wide by 400 feet long. The division of estimated costs, excluding the Tennessee Colony Reservoir reach, is tabulated below:

Item	Cost apportionment		Allocated cost ($1,000)
	Federal ($1,000)	Non-Federal	
Construction:			
Navigation	$427,590	$ 25,848	$453,438
Flood control	104,716	5,861	110,577
Recreation	4,723	--	4,723
Total	$537,029	$ 31,709	$568,738
Annual operation, maintenance, and replacements:			
Navigation and flood control	$ 3,591	$ 290	$ 3,881
Recreation	272	--	272
Total	$ 3,863	$ 290	$ 4,153

They estimate the annual charges for the navigation project at $23,713,000; and the average annual benefits at $32,073,000. The benefit-cost ratio is 1.4, based on a 100-year period of analysis;

b. Reservoirs.--The features of the four reservoirs recommended are as follows:

Name	Stream	Dam: Location	Dam: Ht. (ft)	Dam: Length (ft)	Storage in acre-feet: Sediment	Storage in acre-feet: Flood control	Storage in acre-feet: Conservation	Storage in acre-feet: Total
Lakeview	Mountain Creek	Mile 7.2	91	22,620	45,600	136,700	306,400	488,700
Aubrey	Elm Fork	Mile 60.0	116	13,660	37,800	258,300	603,800	899,900
Roanoke	Denton Creek	Mile 32.0	97	15,200	26,200	223,700	--	249,900
Tennessee Colony	Trinity River	Mile 339.2	114	29,500	190,000	2,144,300	1,032,500	3,366,800

The estimated costs, annual charges and benefits, and benefit-cost ratios for the four reservoirs recommended are as follows:

Costs, Benefits and Benefit-cost Ratios
($1,000)

Name	Item	Cost Apportionment		Allocated cost	Annual O. M. & R.		Benefits	Annual charges	BCR
		Federal	Non-Fed.		Federal	Non-Fed.			
Lakeview	Flood-control	$ 9,214	-	$ 9,214	$ 57	-	$ 1,391		
	Water supply (M. & I.)*	-	$ 14,960	14,960	-	$ 77	907		
	Recreation-F&WL	7,006	-	7,006	218	-	2,025		
		$ 16,220	$ 14,960	$ 31,180	$ 275	$ 77	$ 4,323	$ 1,372	3.2
Aubrey	Water supply	$ 8,591	$ 14,361	$ 22,952	$ 28	$ 47	$ 1,085		
	(M. & I.)*	-	(14,361)	(14,361)	-	(47)	-		
	(Quality control)	(8,591)	-	(8,591)	(28)	-	-		
	Recreation-F&WL	11,121	-	11,121	434	-	2,900		
		$ 19,712	$ 14,361	$ 34,073	$ 462	$ 47	$ 3,985	$ 1,624	2.5
Roanoke	Water supply (M. & I.)*	-	$ 14,997	$ 14,997	-	$ 42	$ 684		
	Recreation	$ 1,903	-	1,903	$ 36	-	150		
		$ 1,903	14,997	$ 16,900	$ 36	$ 42	$ 834	$ 624	1.3
Tennessee Colony	Navigation	$ 51,893	-	$ 51,893	$ 661	-	$ 2,951		
	Flood control	42,664	-	42,664	40	-	3,238		
	Water supply	54,598	$ 29,679	84,277	1,241	$ 281	5,590		
	(M. & I.)*	-	(29,679)	(29,679)	-	(281)	-		
	(Quality control)	(54,598)	-	(54,598)	(1,241)	-	-		
	Recreation-F&WL	14,948	-	14,948	579	-	4,050		
		$164,103	$ 29,679	$193,782	$2,521	$ 281	$15,829	$ 9,201	1.7

*Municipal and industrial.

c. Local protection.--The improvements recommended for local protection and the costs, annual charges and benefits, and benefit-cost ratios are shown in the following tabulations:

LOCAL PROTECTION FEATURES

Name	Stream	Length (miles)	Capacity (cfs)		Tributary channel (miles)	Levees (miles)	
			Channel	Floodway		Right bank	Left bank
West Fork Floodway	West Fork	31	30,000	95,000 to 160,000	16.7	10.6	34.0
Dallas Floodway Extension	Trinity River	9.7	-	163,800 to 174,600	10.5	15.2	10.2
Elm Fork Floodway	Elm Fork	21.8	10,000 to 15,000	58,000 to 61,000	11.2	15.9	24.8
	Denton Creek	8.9	7,000	-	-	-	-
Duck Creek Channel Improvement	Duck Creek	6.6	21,500 to 40,700	-	-	Walls 0.6	Walls 0.6
Liberty Levee	Trinity River	10.0	45,000	180,000	-	-	10.0

Costs, Annual Charges, Benefits, and Benefit-cost Ratios
($1,000)

Name	Construction Cost			O.M.&R.	Annual	Annual	
	Federal	Non-Fed.	Total	(Non-Fed.)	charges	benefits	BCR
West Fork Floodway	$10,719	$ 7,090	$17,809	$ 224	$ 808	$ 2,359	2.9
Dallas Floodway Extension	8,949	5,378	14,327	135	605	685	1.1
Elm Fork Floodway	11,191	5,632	16,823	173*	723	1,867	2.6
Duck Creek Channel Improvement	4,176	848	5,024	6	160	224	1.4
Liberty Levee	1,794	297	2,091	15	79	241	3.0

*Includes $70,000 Federal for portion related to reservoir releases.

27. Accomplishments of the basin plan.--

a. Water yield.--The four reservoir improvements recommended for authorization would provide a dependable water yield of 410.4 mgd during a critical drought period such as 1950-1957. The 19 reservoirs existing, under construction, and authorized, both Federal and non-Federal, together with importations from 2 reservoirs outside the basin would provide a dependable yield of 1,386.1 mgd. By using a nominal amount of return flow and ground water, the projected demands in all segments of the basin would be satisfied until about 2000 to 2010. An additional supply of approximately 1,640 and 3,390 mgd would then be required to satisfy the projected water requirements for the years 2020 and 2070, respectively. The water available, including that from the entire system of reservoirs in the basin plan, is shown in the following tabulation:

Reservoirs	Water yield (Million gallons per day)
Existing, under construction, or authorized	1,206.1
Importations	180.0
Sub-total	1,386.1
Recommended for authorization in this report	410.4
Sub-total	1,796.5
Potential long-range projects	680.4
Total	2,476.9

b. Anticipated water use.--Lakeview Reservoir would afford a source of water to satisfy the immediate needs of local interests. The water developed by the Tennessee Colony Reservoir would serve a dual purpose - initially 80 mgd would be used for water quality control in the upper basin and the remainder would be available for municipal and industrial uses in the middle basin. Increasing needs for municipal and industrial water in the upper basin will require later transfer of use of the Tennessee Colony water. It is anticipated that construction of the long-range reservoir projects in the middle basin will be phased with the transfer of Tennessee Colony water to serve the upper basin so that the demands of the middle basin will continue to be fully met. Initially most of the water developed by the Aubrey Reservoir would be used for water quality control. However, as the need for municipal and industrial water develops, a conversion from water quality control use would be made. There is no immediate demand for the additional water from the Roanoke Reservoir; however, it is considered that preservation of the site by acquisition at this time of the land required is desirable and economically justified. The project would not be constructed until the needs for the storage develop. The 13 potential projects included in the long-range plan to satisfy future requirements could be considered for authorization after further investigations to determine the full scope and purposes that would be justified at that time.

c. Water quality.--The water quality problem in the lower Trinity River resulting from intrusion of salt water from the Gulf will be eliminated by construction of the authorized Wallisville Reservoir Project. To eliminate the septic conditions in the upper Trinity River from Fort Worth to below Rosser, facilities consisting of storage space in the Aubrey and Tennessee Colony

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Reservoirs, plus a pipeline and appurtenances from Tennessee Colony Reservoir to the existing Benbrook Reservoir, would provide for interim water quality control. These facilities would be utilized for water quality control until the water supply requirements develop, at which time local interests would agree to contract to repay the remaining allocated costs. Projected water supply requirements indicate full conversion of the Aubrey Reservoir storage to water supply by about 1985, with conversion of the Tennessee Colony Reservoir storage and pipeline facilities to start about 2020.

d. Flood protection.--The improvements recommended for flood protection--Lakeview and Tennessee Colony Reservoirs, Multiple-purpose Channel, West Fork Floodway, Elm Fork Floodway, Dallas Floodway Extension, Duck Creek Channel Improvement, and Liberty Local Protection Project--would provide protection against standard project floods for urban areas, protection against floods having an estimated average frequency of occurrence of once in 100 years for leveed rural areas, and protection against floods having estimated frequencies of once in 6 to 10 years for the unleveed rural areas above Tennessee Colony Reservoir, and once in 60 to 90 years for those below. The recommended improvements would reduce the peak discharges of floods similar to the April-July 1957 flood from 26,800 to 15,100 cubic feet per second at Fort Worth, from 75,300 to 54,000 cubic feet per second at Dallas, and from 89,000 to 23,500 cubic feet per second at Romayor. In addition, the multiple-purpose channel would permit evacuation of flood-control storage in existing and proposed reservoir projects in a period of 30 to 40 days. The proposed Aubrey and Roanoke Reservoirs are not credited with flood reduction effects as the flood-control storage in these projects is an exchange for additional water supply storage in the existing Garza-Little Elm and Grapevine Reservoirs.

e. Navigation.--The recommended waterway would provide a minimum depth of 12 feet connected, through the Houston Ship Channel, with the Gulf Intracoastal Waterway and the extensive inland waterway system throughout the eastern and central United States. The waterway would afford low-cost water transportation to the Fort Worth-Dallas industrial complex, to the rural areas throughout the reaches of the Trinity River basin, and to the tributary trade area beyond the basin. Detailed investigation and studies show that if a waterway existed, large quantities of commodities consumed and produced in the basin would now move by barge because of net savings in transportation charges. The District Engineers estimate the prospective waterborne commerce at 8,800,000 tons in 1970 and 22,900,000 tons in 2020. The major commodities would be grain for

export from the upper tributary trade area, sand, gravel, and stone throughout the basin, and manufactured products to and from the Fort Worth-Dallas complex. The project would accommodate prospective commerce of 20,000,000 tons, estimated to develop by the year 2015, and is designed to permit future enlargement. The availability of barge transportation would accelerate expansion of the industrial economy in the Fort Worth-Dallas area, especially in the reach between the two cities, where existing and proposed floodways afford extensive open, flood-free land for industrial development. The availability of water supply and water transportation would encourage the rapidly growing Houston industrial complex to expand eastward along the lower Trinity River. In the retarded middle basin, the stimulus of ample water supply and flood-free conditions supplemented by low-cost barge transportation would stimulate development of the natural resources and establishment of major industrial plants.

f. Recreation and fish and wildlife.--The recreational and fish and wildlife facilities proposed for development in the reservoirs and the multiple-purpose channel would provide recreation opportunities for a total of 25.2 million visitors annually. About 16.4 million of these are expected to participate in general recreation activities, and 8.8 million in fishing and hunting. The estimated annual visitation at existing, authorized, and previously recommended Corps of Engineers' reservoir projects is 22.8 million. With the 25.2 million annual visitation at the projects recommended, this totals 48.0 million, which is about 60 percent of the recreation demand for the basin by year 2070. All of the project areas, both water surface and dry lands, would be available to the public for recreational and fish and wildlife purposes except for the area in the Tennessee Colony Reservoir which is recommended as a wildlife refuge by the Bureau of Sport Fisheries and Wildlife. The Bureau proposes to afford controlled public hunting and fishing at the refuge during periods when these activities would not interfere with wildlife conservation management.

28. Summary of costs and benefits.--The costs and benefits of the individual improvements recommended for Federal authorization, based on January 1962 prices, are summarized in Table 1.

TABLE 1

COSTS AND BENEFITS FOR TRINITY RIVER PLAN RECOMMENDED FOR AUTHORIZATION

BY THE REPORTING OFFICERS

Projects	Construction costs ($1,000)			Annual OM&R ($1,000)		Annual charges ($1,000)	Annual benefits ($1,000)						BCR
	Federal	Non-Federal	Total	Federal	Non-Federal		Navigation	Flood control	Water supply (1)	Recreation	Fish and wildlife	Total	
Multiple-purpose channel	537,029	31,709	568,738	3,863	290	23,713	24,002	4,696	-	1,625	1,750	32,073	1.4
Reservoirs													
Lakeview	16,220	14,960	31,180	275	77	1,372	-	1,391	907	975	1,050	4,323	3.2
Aubrey (2)	19,712	14,361	34,073	462	47	1,624	-	-	1,085	1,500	1,400(2)	3,985	2.5
Roanoke (3)	1,903	14,997	16,900	36	42	624	-	-	684	150	-	834	1.3
Tennessee Colony	164,103	29,679	193,782	2,521	281	9,201	2,951(4)	3,238	5,590(4)	1,950	2,100	15,829	1.7
Local protection													
West Fork (5)	10,719	7,090	17,809	-	224	808	-	2,359	-	-	-	2,359	2.9
Elm Fork	11,191	5,632	16,823	70	103	723	-	1,867	-	-	-	1,867	2.6
Dallas Floodway Extension	8,949	5,378	14,327	-	135	605	-	685	-	-	-	685	1.1
Duck Creek	4,176	848	5,024	-	6	160	-	224	-	-	-	224	1.4
Liberty levee (5)	1,794	297	2,091	-	15	79	-	241	-	-	-	241	3.0
Total	775,796	124,951	900,747	7,227	1,220	38,909	26,953	14,701	8,266	6,200	6,300	62,420	1.6

(1) Includes benefits from water quality control.
(2) Includes increased costs and benefits from modification of Garza-Little Elm Reservoir Project.
(3) Includes increased costs and benefits from modification of Grapevine Reservoir Project.
(4) Includes benefits for pipeline and navigation.
(5) Exclusive of multiple-purpose channel.

29. Recommendations of the reporting officers.--The District and Division Engineers recommend that the comprehensive plan be recognized as the plan for full development and beneficial public use of the water and related land resources of the Trinity River basin, and that the existing and authorized projects be supplemented to provide for:

a. A multiple-purpose channel for navigation, flood control, recreation, and fish and wildlife purposes extending along the Trinity River from the Houston Ship Channel to Fort Worth, Texas, including enlargement of the navigation lock authorized for construction in connection with the Wallisville Reservoir, and spur channels and turning basins in Dallas and Fort Worth.

b. Multiple-purpose reservoirs:

(1) Lakeview Reservoir for flood control, water supply, recreation, and fish and wildlife.

(2) Roanoke Reservoir (including modification of Grapevine Reservoir) for water supply, recreation, and fish and wildlife.

(3) Aubrey Reservoir (including modification of Garza-Little Elm Reservoir) for water supply, water quality control, recreation, and fish and wildlife.

(4) Tennessee Colony Reservoir for flood control, water supply, water quality control, navigation, recreation, and fish and wildlife conservation.

c. Local flood protection projects:

(1) West Fork Floodway between Dallas and Fort Worth.

(2) Elm Fork Floodway from its mouth to Denton Creek and upstream channel improvement.

(3) Dallas Floodway Extension extending downstream to Five Mile Creek.

(4) Duck Creek Channel Improvement between mile 10.4 and 17.5.

(5) Liberty Local Protection Project.

d. That the Chief of Engineers be authorized to acquire an interest in the reservoir and damsite lands and to participate in construction or reconstruction of transportation and utility facilities for the Roanoke Project in advance of construction as required to preserve such areas from encroachment and to avoid increased costs for relocations. The interest in lands to be acquired would be the minimum necessary consistent with the objective of reservoir and damsite preservation. This authorization would enable the Chief of Engineers to cooperate with responsible local interests to keep lands on local tax rolls and to exercise control over development in the reservoir and damsite area until needed for project purposes.

e. That the Chief of Engineers be authorized to participate in relocations in the Livingston Reservoir prior to the start of actual construction of the multiple-purpose channel when relocation of existing or construction of new highways, railroads, pipelines, and utility lines that would subsequently have to be modified for project purposes are undertaken by other agencies; provided that a net saving in cost of construction to the United States will result; and provided further that funds shall be expended only on those relocations required for project purposes.

f. That, prior to initiation of construction, responsible local interests give assurances satisfactory to the Secretary of the Army that they will assume the apportioned costs and other obligations specified.

30. The reporting officers also recommend that, in the interest of comprehensive planning and development of the water resources of the Trinity River basin, the Congress give careful consideration to the recommendations of the Bureau of Sport Fisheries and Wildlife providing for fee acquisition of about 600 acres of land immediately adjacent to the Tennessee Colony Reservoir at an estimated additional cost of $145,000, and should the acquisition of the additional lands be authorized, the Corps of Engineers be also authorized to make available to the Secretary of the Interior for a national wildlife refuge, about 20,400 acres of land within the Tennessee Colony Reservoir and the Chief of Engineers be authorized to operate the Tennessee Colony Reservoir in support of the wildlife refuge insofar as it does not conflict or interfere with the operations for other project purposes.

RESPONSE TO PUBLIC NOTICE

31. 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. Numerous communications were received, both from proponents of the plan and opponents of the navigation features. Four of the communications contained detailed information; two endorsed the comprehensive plan, and two protested the inclusion of navigation features and facilities. Careful consideration has been given to all communications received and special note has been taken of the following:

a. The Lubbock Chamber of Commerce, Lubbock, Texas, in opposing the navigation features of the project, states that they will be of no value to the city. It believes the channel will subsidize competition from the cities located thereon, prevent location of industry in Lubbock, and jeopardize future local investments. It recommends that the navigation features be found infeasible.

b. The Traffic Research Committee of the Texas Railroad Association, in opposing the navigation features, states that the reporting officers used unrealistically low interest rates in computing annual charges; used a period of 100 years for amortization and for projection of tonnage and benefits; failed to assign any reservoir storage costs to navigation (except for navigation facilities in the Tennessee Colony Reservoir); overstated tonnage and savings by failure to consider freight rate reductions since 1958 on important commodities; assumed 1970 as the first year of operation and projected 1958 tonnage and savings to that year; overstated tonnage for the base year of 1958; projected growth of tonnage and savings on too high a basis; computed savings inconsistently by using constructed costs plus profit for barges versus rates (i.e., charges paid by the shipper) for other forms of transportation; and subsequent to the public hearing at Fort Worth, Texas, on 20 December 1961, increased the estimated base-year tonnage without explanation. The Committee also advances the following reasons why the navigation improvements would be an economic waste: The Trinity River area is adequately served by existing forms of transportation; benefits, if any, to the Trinity Valley south of Dallas County, would be negligible; absence of water transportation has not retarded the growth of Dallas and Tarrant Counties--since 1940 they have experienced greater growth than the Texas Gulf Coast; and historical facts

do not support a contention that barge transportation on the Trinity River would create any substantial growth and development that would not otherwise occur.

c. The Trinity Improvement Association states in support of the recommended plan, that it is compatible with plans prepared by the United States Study Commission - Texas, the Trinity River Authority of Texas, the Texas Water Commission, and the various cities in the area. It believes that the benefits are ultra-conservative, the estimated costs are adequate, and the benefit-cost ratios are more than adequate to justify the plan as a whole, or by separate features. The Association points out that additional benefits could be allowed for area redevelopment, national defense, and increased tonnage and savings on sand and gravel and grain.

d. The Mid-Trinity Valley Association, Texas, states that the recommendations in the report will meet its needs and that they will support them to the utmost; that actual benefits to their section of the valley will materially exceed those reported; that the extent and variety of undeveloped natural resources have been under-valued; and the fact that 10 mid-Trinity counties have been designated for Area Redevelopment Administration assistance definitely increases the relative importance of the project and should be considered in the evaluation.

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

VIEWS

32. General.--The Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the reporting officers. Their comprehensive plan for development of the water resources of the Trinity River basin is formulated to meet the various needs and provide suitable conditions for expansion of the area activities. Provision of both reservoir storage and local works for flood control on the main stream and its tributaries would prevent a high percentage of the flood damages which would occur in the absence of flood-control measures. Progressive development is proposed in keeping with the increasing needs for improvement in the quality and quantity of the water supply available for municipal, industrial, and other uses. The limited water supply precludes the inclusion of facilities for development of hydroelectric power. Navigation facilities are proposed to provide

low-cost water transportation between the Houston and Fort Worth-Dallas metropolitan areas, near the extremities of the waterway, and improved access to the extensive mineral reserves in the middle basin. Irrigation and drainage improvements were considered by the reporting officers and the Board who concluded that these features are provided for under existing arrangements. The use of a 2-7/8 percent rate of interest, instead of the 3 percent in the report, for non-Federal investments, would not materially affect the benefit-cost ratios.

33. Consideration of local views.--The Board, in its review of the findings of the reporting officers, gave particular attention to all the views furnished to the Board by those opposing as well as those supporting the recommendations in the report. For all questions which would materially affect the economic justification of the project, special studies were conducted and adjustments made where appropriate.

34. Flood damage prevention.--Most of the residual flood damages after construction of the proposed projects would be along the main stem of the Trinity River between the Dallas Floodway Extension and the Tennessee Colony Reservoir and would result almost entirely from anticipated future development. The Board notes that prevention of residual damages is not economically feasible at the present time, but it is possible that future development in the area may be such that additional control may be required at a later date. Accordingly the Board suggests that local interests consider control of development in the fringe areas not fully protected by the proposed improvement.

35. Water-conveyance facilities.--The Board notes that more economical alternative means of providing water for water supply and water quality control needs appear to be available in the Fort Worth-Dallas area which, if properly controlled and integrated, could supply these needs for an estimated period of 20 years. The Board, therefore, believes that although water conveyance facilities from the Tennessee Colony Reservoir should be authorized at this time, their construction should be deferred until further studies can be made to determine if more economical alternatives should be authorized as interim measures.

36. Area redevelopment benefits.--Ten of the counties along the central portion of the channel now have the problem of unemployed labor. During construction and initial maintenance of the proposed works in this area, relief would be afforded in this

respect. Accordingly, the Board finds that the proposed multiple-purpose channel and Tennessee Colony Reservoir should be credited with average annual benefits estimated at $2,380,000 for serving this purpose. The Area Redevelopment Administration has expressed the view that this is a conservative estimate. Of this amount, $1,510,000 is creditable to the navigation facilities and the remainder to other purposes.

37. Recreation and fish and wildlife.--Additional water areas and the proposed navigation channel would be available for recreational use, including a route for boating activities extending from Fort Worth to the Gulf of Mexico. Conditions for the development of the fishery resources would in general be improved. The Board has considered the comments of the Fish and Wildlife Service and believes that the project features recommended in the report would produce no significant adverse effects upon the marine commercial fishery.

38. Navigation features.--The Board believes the estimated cost for the navigation channel should be increased by $10,000,000 to provide for longer guide walls at the locks. It increases the estimated annual carrying charges by $350,000 for this, and by $30,000 as an additional allowance for future bridges. With these changes, the incremental annual carrying charge for the navigation elements is $21,410,000. In recognition of the small economic advantage of the proposed 150-foot wide waterway over a waterway with a width of 200 feet, and also the fact that commerce is expected to develop in excess of capacity at about the mid-point of the project life, the need for authorization to modify the recommended width at a later date is probable. Consequently, in order to permit subsequent widening of the channel, the Board agrees with the reporting officers that the plan should provide for adequate horizontal clearances for bridges and utilities to accommodate a minimum channel width of 200 feet.

39. Navigation project life.--The Board's estimate of benefits is prepared on the basis that the earliest feasible date for completion of the waterway would be 1975. The anticipated rate of growth projected for the area indicates a commensurate increase in net benefits with time. By providing adequate maintenance and systematic replacements, as contemplated in the cost estimates in the District Engineers' report, the navigation facilities could be expected to have a physical life of at least 100 years. The commerce on which the navigation benefits are based is diverse and, with large traffic-generating regions at both ends of the waterway, can be expected to increase with further development of the area.

Hence, the Board's estimate of benefits is based on a useful life of 100 years from an estimated completion date of 1975.

40. Navigation analysis.--In the report, the transportation savings attributable to the waterway are premised on the reduced costs to the benefited shippers. This involves comparison of computed charges for transport by barge with the charges or rates for movement by land carriers. The Board has considered the feasibility of deriving these benefits by comparison of the land carrier costs with the estimated water carrier costs. It finds that the data available are inadequate for a meaningful comparison by this procedure, or to establish a meaningful relationship between costs and rates. The Board notes that all previous canalization projects have been authorized on the basis of rate comparisons. Almost without exception, projects so authorized have developed commerce greatly in excess of the expectations in the authorizing documents. Recent changes have been made in land carrier charges for transporting certain commodities and the Board has re-estimated the transportation savings taking into account these current rates. This results in some reduction in the prospective waterway commerce and savings from that found by the reporting officers. Other elements in its estimate of benefits include elimination of minor duplication of tonnages found in the report estimate, exclusion of soap and certain other doubtful commodities, and downward revision of projection factors for pipe and iron and steel scrap.

41. Navigation benefits.--The Board's evaluation of the waterway justification, with an estimated 1958 traffic of 5,200,000 tons, and based on current rates, is tabulated below:

Net annual transportation savings, if completed by 1975, and recreation and fish and wildlife benefits; after deduction of $170,000 which is the net result of adverse effects of navigation clearances on highway traffic and the increased benefits of advance replacement of future bridges	$22,590,000
Area redevelopment benefits	$ 1,510,000
Total annual benefits	$24,100,000
Total annual charges (incremental)	$21,410,000
B/C ratio	1.13

In view of the favorable benefit-cost ratio indicated above, the Board concludes that the navigation facilities should be authorized. However, since modification of current and anticipated conditions may affect the evaluation of benefits for this work, the authorization should contain a proviso that at such time as funds are requested for initiation of construction of features exclusively for navigation, the Chief of Engineers will submit to the Congress an economic analysis of these features.

42. Transportation capacity.--The waterway will supplement the existing transportation facilities by providing a means for moving bulk commodities more economically. In view of the stimulating effect of this upon the economy of the basin, the Board believes that provision of navigation facilities will tend to reduce any surplus capacity of existing carriers.

43. Separate construction.--The Board notes that a project for flood control, water supply, and water quality control is economically justified without navigation. If construction of the navigation features of the plan is delayed for any reason, and construction of the channel for flood control is initiated first, it is the opinion of the Board that the flood-control channel should be constructed along the same alignment as that required for navigation.

RECOMMENDATIONS

44. Accordingly, the Board recommends that the comprehensive plan presented by the reporting officers be approved as the plan for full development and beneficial public use of the water and related land resources of the Trinity River basin, and that the existing and authorized projects for the basin be supplemented to provide:

a. Local flood protection projects:

(1) West Fork Floodway

(2) Elm Fork Floodway

(3) Dallas Floodway Extension

(4) Duck Creek Channel Improvement

(5) Liberty Levee

b. Multiple-purpose reservoirs:

(1) Lakeview Reservoir for flood control, water supply, recreation, and fish and wildlife;

(2) Roanoke Reservoir (including modification of Grapevine Reservoir) for water supply and recreation;

(3) Aubrey Reservoir (including modification of Garza-Little Elm Reservoir) for water supply, water-quality control, recreation, and fish and wildlife;

(4) Tennessee Colony Reservoir (including water-conveyance facilities to Benbrook Reservoir) for flood control, water supply, water-quality control, navigation, recreation, fish and wildlife, and fish and wildlife conservation, provided that construction of the water-conveyance facilities be deferred until further studies can be made to determine if more economical alternatives should be authorized as interim measures; and

c. A multiple-purpose channel extending along the Trinity River from the Houston Ship Channel to Fort Worth, Texas, for purposes of navigation, flood control, recreation, and fish and wildlife, with minimum navigable dimensions of 12 feet by 150 feet, and with suitable locks and dams, including enlargement of the navigation lock authorized for construction in connection with the Wallisville Reservoir, spur channels, and turning basins in Dallas and Fort Worth, with the understanding that at such time as funds are requested for the initiation of construction of features exclusively for navigation, the Chief of Engineers will submit to the Congress an economic analysis of these features;

all to be accomplished generally in accordance with the plans of the District Engineers and with such modifications thereof as in the discretion of the Chief of Engineers may be advisable, at an estimated cost of $910,750,000 for construction and $8,447,000 annually for maintenance and operation, of which the currently estimated net Federal costs, inclusive of water-conveyance facilities to be provided later, are estimated at $785,800,000 and $7,227,000, respectively;

Provided that improvements at any of the localities mentioned above may be undertaken independently of the others whenever funds for that purpose are available and the prescribed local cooperation has been furnished;

Provided also that, prior to initiation of construction of each element, responsible local interests give assurances satisfactory to the Secretary of the Army that they will obtain without cost to the United States all water rights needed for storage and use of water for project purposes, resolve any conflicts in water rights necessary for effective operation of the project, use the water in a manner consistent with Federal and State laws, and hold and save the United States free from damages due to the storage and withdrawal of water by the users; and

Provided further that:

1. With respect to the Roanoke project, the Chief of Engineers be authorized to acquire for the United States an interest in the reservoir and damsite lands consistent with the objective of site preservation; to participate in construction or reconstruction of transportation and utility facilities in advance of project construction as required to preserve such areas from encroachment and avoid increased costs for relocations; and to cooperate with responsible local interests in keeping lands on local tax rolls and exercising control over developments in the reservoir and damsite area until needed for project purposes;

2. With respect to the proposed non-Federal Livingston Reservoir, the Chief of Engineers be authorized to participate in relocations in advance of the start of actual construction on the multiple-purpose channel project under the conditions specified by the reporting officers and in proportion to the Federal interest in the navigation channel in the reservoir;

3. Prior to initiation of construction, responsible local interests give assurances satisfactory to the Secretary of the Army that they will:

a. With respect to the West Fork Floodway, Elm Fork Floodway, Dallas Floodway Extension (except for the channel portions thereof), Duck Creek Channel Improvement, and Liberty Local Protection Project:

(1) Provide without cost to the United States all lands, easements, and rights-of-way necessary for construction, maintenance and operation of the project;

(2) Provide without cost to the United States all relocations of buildings and utilities, bridges (except railroad), sewers, pipelines, and any other alterations of

existing improvements which may be required for the construction of the project;

(3) Protect the channels, ponding areas, and other flood-control works from future encroachment or obstruction that would reduce their flood-carrying capacities and, if ponding areas and capacities are impaired, provide substitute storage or equivalent pumping capacity promptly without cost to the United States;

(4) Hold and save the United States free from damages due to the construction works;

(5) Maintain and operate all works after completion in accordance with regulations prescribed by the Secretary of the Army;

(6) Agree to publicize flood plain information in the community and area concerned and to provide this information to zoning and other regulatory agencies and public information media for their guidance and appropriate action;

b. With respect to Lakeview, Roanoke, Aubrey, and Tennessee Colony Reservoirs, pay the United States, in accordance with the provisions of the Water Supply Act of 1958, as amended, for the first costs and the annual operation, maintenance and replacement costs allocated to water supply storage, presently estimated as follows, with such modification in these amounts as may be necessary to reflect adjustments in the storage capacity for water supply and other purposes as determined by the Chief of Engineers:

Reservoir	Allocated cost to water supply storage			
	Construction costs		Annual O&M costs	
	Amount (dollars)	Percent	Amount (dollars)	Percent
Lakeview	14,960,000	47.98	77,000	21.81
Roanoke	14,997,000	88.74	42,000	53.53
Aubrey	14,361,000	42.15	47,000	9.25
Tennessee Colony	21,228,000	10.95	67,000	2.39

c. With respect to the water-conveyance facilities from Tennessee Colony Reservoir to Benbrook Reservoir, pay the United States, in accordance with the provisions of the Water Supply Act

of 1958, as amended, for that portion of the first costs and the annual operation, maintenance, and replacement costs allocated to water supply, as determined by the Chief of Engineers; and

d. With respect to the multiple-purpose channel:

(1) Provide the share apportioned to navigation of the actual Federal cost for all lands, easements, and rights-of-way required for construction and subsequent maintenance of the project and for aids to navigation upon the request of the Chief of Engineers, including suitable areas determined by the Chief of Engineers to be required in the general public interest for initial and subsequent disposal of spoil;

(2) Hold and save the United States free from damages due to construction, operation, and maintenance of the navigation works, including but not limited to those resulting from wave action and from changes in ground water levels;

(3) Provide a proportionate share of the cost of bridge alterations over existing channels in accordance with the principles of Section 6 of the Bridge Alteration Act (Truman-Hobbs) of 21 June 1940, as amended;

(4) Assume all obligations of owning, maintaining, and operating all railway and highway bridges altered or constructed as part of the multiple-purpose channel project, with such obligation for each bridge to be assumed by local interests upon final completion of alteration or construction of that bridge;

(5) Provide and maintain at local expense adequate public terminal and transfer facilities open to all on equal terms, and depths in berthing areas and local access channels serving the navigation channel commensurate with the depths provided in the related project areas;

(6) Provide the share apportioned to navigation of the actual Federal cost for alterations of sewer, water supply, drainage, pipelines, and other utility facilities;

(7) Protect the channels, ponding areas, and other flood-control works from future encroachment or obstruction that would reduce their flood-carrying capacities and if ponding areas and capacities are impaired provide substitute storage or equivalent pumping capacity promptly without cost to the United States.

45. The Board further recommends that, in the interest of comprehensive planning and development of the water resources of the basin, the Congress consider the recommendations of the Bureau of Sport Fisheries and Wildlife providing for fee acquisition of about 600 acres of land immediately adjacent to the Tennessee Colony Reservoir at an estimated additional cost of $145,000, and, should the acquisition of the additional lands be authorized, the Chief of Engineers be authorized to make available to the Secretary of the Interior, for a national wildlife refuge, about 20,400 acres of project land within the Tennessee Colony Reservoir area and to operate the reservoir in support of the wildlife refuge insofar as it does not conflict or interfere with the operations for other project purposes.

FOR THE BOARD:

R. G. MacDONNELL
Major General, USA
Chairman

52-704 O-65 (Vol. I)—8

REPORT OF THE DISTRICT ENGINEERS

COMPREHENSIVE SURVEY REPORT ON TRINITY RIVER AND TRIBUTARIES, TEXAS

SYLLABUS

The report presents a comprehensive plan of development for a balanced program to provide the best use or combination of uses of the water and related land resources of the Trinity River Basin, to meet all foreseeable short- and long-term needs, for the economic and social well being of all of the people.

The plan provides specific measures to satisfy the present and projected needs for water supply and water quality, flood protection, navigation, recreation, and fish and wildlife. The measures selected have been based on consideration of current and projected economic conditions. The projects recommended for authorization at this time consist of a multiple-purpose channel from the Houston Ship Channel to Fort Worth including a series of navigation locks and dams; four multiple-purpose reservoirs - Roanoke (including modification of Grapevine Reservoir), Aubrey (including modification of Garza-Little Elm Reservoir), Lakeview, and Tennessee Colony with a wildlife refuge; water quality control distribution facilities from Tennessee Colony Reservoir to the existing Benbrook Reservoir; and five local flood protection projects - West Fork Floodway, Elm Fork Floodway, Dallas Floodway Extension, Duck Creek Channel Improvement and Liberty Local Protection.

With respect to other purposes, land stabilization and drainage will be handled by existing programs and continuing Federal authorizations. Water requirements for irrigation potentialities of the basin are included in the plan as is water cooling requirement for thermal-electric power facilities which were determined to be the primary source of meeting future power needs of the area.

The total estimated construction cost of the projects recommended for authorization is $900,747,000 with an annual operation, maintenance and replacement cost of $8,447,000. The net Federal Government costs are $775,796,000 and $7,227,000, respectively. The total annual charges of the recommended projects are estimated at $38,910,000 and the total annual benefits are estimated at $62,420,000. The ratio of benefits to costs is 1.6.

U. S. ARMY ENGINEER DISTRICTS, FORT WORTH AND GALVESTON
CORPS OF ENGINEERS
FORT WORTH AND GALVESTON, TEXAS

June 30, 1962

SUBJECT: Comprehensive Survey Report on Trinity River and Tributaries, Texas.

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

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

INTRODUCTION

1. SCOPE.- This report presents the results of a comprehensive investigation of the problems associated with the water and related land resources of the Trinity River Basin. It defines a comprehensive plan for use and control of the flows of the Trinity River and its tributaries to the practical extent required to assure the economic and social well-being of the people of the region, state, and nation. The plan presented herein serves as a guide to the development and control of the basin's water and related land resources and is based upon analysis of detailed technical data and investigations reported upon in the various appendixes to this report. The elements of the plan recommended for authorization at this time were developed in consonance with the overall plan taking into consideration current and projected conditions and economic justification.

2. PURPOSE OF THE INVESTIGATION.- The Trinity River Basin, encompassing 17,845 square miles, extends southward through the eastern half of Texas from the Red River Basin on the north to Trinity Bay on the south. The large population centers of Dallas and Fort Worth are located in the upper portion of the basin. Houston, the largest city in Texas and a vital factor in the development of the lower Trinity River Basin, is located just west of the basin near the coast. Owing largely to the fortunes of strategic location and certain chains of

subsequent events, a phenomenal growth of population, industrialization and expansion of the general economy has been experienced in recent years by each of these large cities. Dallas and Fort Worth largely developed as the financial and marketing hub of the upper Trinity and surrounding area with a more recent trend to a rapidly expanding industrial economy. Houston and its adjacent area has been characterized by rapid industrial growth and development as a distribution center. The growth of Houston has been accelerated to a marked degree by the establishment of deepdraft navigation in the area and connection with the inland waterway system of the nation. The rapid economic growth of the cities has been characterized also by the vigorous and progressive enterprise of the people, coupled with outstanding leadership in all fields of endeavor. These human resources added to such natural advantages as mild climate, abundant rainfall, and strategic location with respect to natural resources, rich agricultural areas and established transportation routes insure the continued rapid development of these cities and surrounding areas for many years.

3. Although possessing many of the same advantages, the middle portion of the Trinity River Basin has not matched the development tempo of the upper and lower parts and has remained largely agricultural in character. A complete explanation of the comparatively slow progress of the middle basin would undoubtedly involve factors other than lack of water resource development. It is certain, however, that the absence of such development and the periodic recurrence of devastating floods and severe droughts have been major deterrents to general development.

4. Generally speaking, the total water resources within the Trinity River Basin is adequate to supply the water needs for the foreseeable future. The water problems arise mostly from the extremes experienced through floods and droughts and the inadequacy of existing control measures to conserve and regulate the water for beneficial use. The rapid growth of the Dallas-Fort Worth complex in the upper basin, and the Houston complex some 300 miles to the south, as well as the relatively slow development of the middle basin area, have generated many social and economic problems which demand attention. A number of such problems are related to development of water resources, including water supply, flood control, water transportation, hydroelectric power generation, drainage, irrigation, recreation, fish and wildlife, water quality control and other related purposes. Recognizing the necessity for comprehensive and realistic planning, with consideration of both the present and future demands, officials of local government and other agencies concerned with development of the Trinity River Basin requested that this investigation be made.

5. ARRANGEMENT OF REPORT.- The following sections of this report contain the results, conclusions and recommendations of the Fort Worth and Galveston District Engineers, based upon analysis of detailed

technical data and investigations reported upon in the following appendixes to this report:

Appendix I - Project Formulation
Appendix II - Hydrology, Hydraulic Design, and Water Resources
Appendix III - Navigation and Navigation Economics
Appendix IV - Flood Control Economics
Appendix V - Recreation and Fish and Wildlife
Appendix VI - Cost Estimates, Geology, and Design Information
Appendix VII - Economic Base Study
Appendix VIII - Comments of Other Agencies
Appendix IX - Resolutions, Public Hearing, Prior Reports

6. HISTORY OF INVESTIGATIONS.- Records show that the lower 300 miles of the Trinity River carried considerable navigation during the latter half of the nineteenth century, although its use was severely restricted by wide variations in stream flow. In 1902 Congress authorized a 6-foot navigation project to Dallas to be obtained by channel improvement and a system of 37 locks and dams. Seven of the locks and dams and one auxiliary dam had been completed by 1917 in several disconnected reaches. The difficulty of maintaining open river navigation between the widely separated navigation pools, led the Congress to abandon the project in 1922, except for the 41-mile reach from the mouth of the river to Liberty, Texas.

7. The most recent general study of the Trinity River Basin was completed in 1941 and is published as House Document No. 403, 77th Congress, 1st Session. That study analyzed the needs of the basin for flood control, navigation, and allied purposes. The report presented and recommended adoption of a basic plan of improvement for the Trinity River and Tributaries for flood control, navigation, and water conservation. The plan included five dam and reservoir projects designated as Grapevine, Benbrook, Aubrey, Lavon and Little Elm, modification of Garza Dam and Reservoir and modification of the levees and floodways at Fort Worth and Dallas for flood control and water conservation, and a 9-foot navigation channel extending up the Trinity River, by means of locks and dams, from the Houston Ship Channel in Galveston Bay to Fort Worth. The report recommended construction of the improvements found justified by conditions existing at that time, consisting of Benbrook, Little Elm and Grapevine Reservoirs, modification of Garza Dam, improvement of the levees and floodways at Fort Worth and Dallas and the lower 49 miles of the navigation channel from the Houston Ship Channel to Liberty. Construction of the recommended elements of the plan and of Lavon Reservoir for flood control

was authorized by the River and Harbor Act of March 2, 1945. Subsequently, the Garza-Little Elm Reservoir, impounded by the Lewisville Dam, was constructed in lieu of the separate projects for modifying Garza Dam and constructing Little Elm and Aubrey Reservoirs. Based on several subsequent studies and reports, Congress has authorized additional modifications of the project to provide conservation storage in Lavon Reservoir, construction of the Navarro Mills Reservoir on Richland Creek and Bardwell Reservoir on Waxahachie Creek for flood control and water conservation, additional improvement of the Dallas and Fort Worth Floodways and a local flood protection unit along Big Fossil Creek at the city of Richland Hills. All of these improvements are in the upper portion of the river basin in the general vicinity of Dallas and Fort Worth. Two recent investigations of additional flood problems in this area have been made. Separate reports have been submitted which recommend extension of the Fort Worth Floodway to provide protection along a reach of the Clear Fork, channel and levee improvement along the East Fork below Forney Dam site and enlargement of Lavon Reservoir for additional water supply and recreation.

8. An urgent problem of salt water intrusion from Trinity Bay into irrigation water pumped from the lower Trinity River led to a recent investigation of a proposed barrier dam and reservoir near the river mouth. A report, published in 1961 as House Document No. 215, 87th Congress, 1st Session, recommends construction of the multiple-purpose Wallisville Reservoir, at about river mile 4, for navigation, water supply, salinity control, fish and wildlife and recreational purposes. The reservoir, which would have a normal pool elevation of 4 feet above mean sea level, is designed to operate as a unit for water conservation with the Livingston Reservoir, which is under construction at about river mile 129, by the City of Houston and the Trinity River Authority of Texas.

9. Under authorities contained in the Flood Control Act of 1944 and the Watershed Protection and Flood Prevention Act of 1954, the Soil Conservation Service of the U. S. Department of Agriculture has made investigations and plans for land treatment, flood prevention and the conservation, development, utilization and disposal of excess water on many small watersheds in the Trinity River Basin. The Soil Conservation Service has formulated plans for extensive land treatment measures and about 1,200 floodwater detention structures in the small watershed areas, of which 288 are now constructed.

10. The Trinity River Authority of Texas, an agency created and organized under laws of the State of Texas, in 1958 adopted a master plan for development of the water resources of the Trinity River for all beneficial purposes, including barge navigation from the Houston Ship Channel to Fort Worth, and for additional flood control improvements. The master plan was modified to some extent by a supplemental report adopted in 1960.

11. The U. S. Study Commission - Texas, created in 1958 by an Act of Congress, inventoried the land and water resources of all major river basins in Texas, excepting the Sabine, Red, and Rio Grande, and formulated a comprehensive plan to meet the projected water needs within the study area to the year 2010. The Commission plan, published in 1962, presents for each major river basin, including the Trinity, a plan for use of existing physical features and the addition of numerous proposed and potential improvements to conserve and control the available water resources and supply the projected demands for the basin. The development plans are phased into two parts; the first would provide for projected needs to the year 1975, while the second considers projected additional needs to the year 2010. The Study Commission plan was designed as a framework to present general principles and features of an overall approach to land and water development problems for the state. The plan contemplates that detailed studies and plans would be made by the various local, State, and Federal agencies, within their fields of interest and responsibility, to develop the various features of the Study Commission plan. The comprehensive plan proposed in this report is in full consonance with the plan developed by the U. S. Study Commission - Texas for development of water resources in Texas.

12. Many other agencies have made investigations of water problems in the Trinity River Basin. The Cities of Dallas, Fort Worth and Houston have made extensive investigations and plans, particularly in the problem of water supply and flood control. Various other cities, towns and drainage districts have been concerned with water supply and flood control problems. The Bureau of Reclamation, U. S. Department of the Interior, is investigating the water resources of Texas in connection with studies of a long-range plan for transporting water from water surplus river basins in East Texas to areas of water deficiency in the central and southern parts of the state. This investigation will include consideration of available water resources in the Trinity River Basin. The Select Committee on National Water Resources, United States Senate, compiled extensive inventory data on water resources in the United States. Data pertinent to the Trinity River were published in 1960 as a portion of Committee Print No. 4, 86th Congress, 2nd Session. The Texas Water Commission in 1961 published a report entitled, "A Plan for Meeting the 1980 Water Requirements of Texas" which includes data pertinent to the Trinity River Basin requirements.

13. All of the investigations and reports described above were carefully reviewed and considered in developing the comprehensive plan presented in this report. The plan is compatible in all respects with the major objectives of the plans developed by the various agencies concerned with water resources problems in the Trinity River Basin.

14. AUTHORITY FOR THIS INVESTIGATION.- This report has been prepared in response to five separate resolutions of Congressional Committees requesting review of the report published as House Document No. 403, 77th Congress, 1st Session and other reports and an item in

Section 112 of the Rivers and Harbors Act, approved July 3, 1958. The authorizing resolutions include three adopted by the Committee of Rivers and Harbors of the House of Representatives on March 31, 1944, February 28, 1945, and November 30, 1945; one adopted by the Committee on Public Works of the House of Representatives on August 6, 1948 and one adopted by the Committee on Public Works of the United States Senate on January 20, 1958. The several resolutions and the pertinent section of the Rivers and Harbors Act of 1958 are given in full in Appendix IX.

15. PUBLIC HEARINGS.- The views of interested parties concerning improvements for development and use of water resources of the Trinity River Basin in the interests of navigation, flood control, water conservation, water quality control, drainage, irrigation, hydroelectric power, fish and wildlife, recreation and other purposes were obtained at eleven public hearings held at various cities and towns in the basin between 1946 and 1958. Prior to development of the comprehensive plan, nine hearings were held in the upper part of the basin in the general vicinity of Dallas and Fort Worth. Two hearings were held at Liberty, Texas, in the lower basin. The date, location and purposes covered by each public hearing are shown in Appendix IX. A subsequent public meeting was held at Fort Worth, Texas, to present the features of a preliminary plan to local interests.

16. The Trinity River Authority of Texas, prior to preparation of its Master Plan in 1958, held public hearings for each of the seventeen counties within its jurisdiction to determine the views of local interests with respect to improvements desired. The U. S. Study Commission - Texas in 1960 held public meetings in Huntsville and Corsicana to obtain the estimates of local interests concerning present and future water requirements throughout the basin.

17. Improvements desired.- Through the several public hearings and subsequent conferences and correspondence, local interests have expressed desires for a Federal improvement project for the Trinity River Basin to include specifically the following features:

a. Reservoirs on the Trinity River and all major tributaries for flood control, water conservation, fish and wildlife conservation and recreation, and improvement of the river channel for flood control from Five Mile Creek to the mouth of the river.

b. A salt water barrier near the mouth of the river for water conservation and salinity control.

c. A waterway for barge navigation to extend up the Trinity River from the Houston Ship Channel to Fort Worth.

d. Extension of the Fort Worth Floodway upstream on the Clear Fork and downstream on the West Fork.

e. Floodways, including improved channels and levees, on the West Fork between Dallas and Fort Worth, on the Elm Fork from the mouth upstream to Grapevine and Garza-Little Elm Reservoirs, and on Duck Creek through the City of Garland.

f. Extension of the Dallas Floodway downstream to the lower ends of White Rock and Five Mile Creeks.

g. Enlargement of Lavon Reservoir and channel improvement below Lavon Reservoir on the East Fork, below the authorized Bardwell Reservoir on Waxahachie Creek, and on Town Branch through the City of Madisonville.

h. Rehabilitation of certain agricultural levees along the main stem, East Fork, Richland and Chambers Creeks.

i. Levees along the left bank of the Trinity River for flood protection to Liberty.

18. The Texas Water Commission has publicly expressed its policy that all additional flood control reservoirs should include the maximum practicable water storage for water conservation, fish and wildlife and recreation, and that the stored water be used to supplement the low-water flows of the river as necessary to meet the water requirements for municipal, industrial and irrigation uses and for water quality control.

19. Because of an urgent need for several of the desired improvements, separate investigations and reports have been made on certain specific problems prior to this report. A number of improvements have been authorized or recommended as a result of separate reports, as described in paragraphs 7 and 8. The problem on Town Branch at Madisonville has been considered in the development of a planned system of small watershed improvements by the Soil Conservation Service. The remaining specific problems indicated by the expressed desires of local interests were considered in development of the comprehensive plan presented in this report.

20. The public meeting held at Fort Worth, Texas on December 20, 1961, to present features of a preliminary plan being considered for inclusion in this report was attended by about 1,400 persons, of whom 90 persons spoke in favor of the proposed improvement and 4 spoke in opposition. A total of 320 briefs were submitted with 274

favoring the improvement, 35 in opposition, 6 noncommittal and 5 in opposition to the previously recommended Wallisville Reservoir Project. Proponents of the plan included local officials from practically all cities, towns and counties in the Trinity River Basin, many civic organizations, representatives of businesses and industries, landowners and interested individuals. Proponents were practically unanimous in endorsing the navigation aspects, as well as the water supply, flood control and other features of the plan. Representatives of the Texas Water Commission stated that the distinct possibility of navigation of the Trinity River from the Houston Ship Channel to Fort Worth had been recognized in its long range planning and that other elements of the comprehensive plan were not in conflict with its plans. Opposition to the plan principally was from the Texas Railroad Association and from civic organizations representing several cities in West Texas, outside of the Trinity River Basin. The opposition was concerned with the navigation aspects of the improvement plan and no objections were expressed to other features or purposes of the plan other than those of landowners affected by the Wallisville Reservoir. A digest of the record of the public meeting is given in Appendix IX.

BASIN DESCRIPTION

21. GENERAL LOCATION AND SIZE.- The Trinity River Basin lies in the eastern half of the State of Texas. It is bounded on the north by the Red River Basin, on the east by the Neches and Sabine River basins, and on the west and south by the Brazos and San Jacinto River basins. The basin, as shown on figure 1, with an overall length of about 360 miles and a maximum width in the headwaters of about 100 miles, extends generally along a northwest-southeast axis from Archer County on the northwest to Chambers County and Trinity Bay on the southeast. The total drainage area of the basin is 17,845 square miles.

22. PHYSICAL CHARACTERISTICS OF THE BASIN.- The Trinity River Basin is relatively long and narrow and is shaped somewhat like a funnel, with its maximum width being located in the headwaters region above Dallas and Fort Worth. The topography of the basin, as shown on figure 2, is generally that of a gently sloping plain, varying in elevation from about 1,250 feet above sea level in the headwaters to sea level at the mouth in Trinity Bay. In the upper reaches, the topography is generally rolling and broken, while below Fort Worth, the topography ranges from gently rolling to flat. Practically all of the basin is located in the geologically recent, Coastal Plain Physiographic Province, which has weathered considerably and is characterized by meandering and generally sluggish streams. The Trinity River Basin is predominantly an agricultural area with about one-fourth of its area in the middle basin in forests. Except for cultivated areas and fringes of timber along the stream courses, the remainder of the basin generally is covered with native grasses, with some brush in the northwestern portion.

23. STREAMS.- The main stem of the Trinity River is formed at Dallas by the confluence of the West Fork and the Elm Fork at river mile 505.5. Throughout its length, the Trinity River follows a tortuous course, meandering from one side of the valley to the other for a distance of about two times the length of the general axis of the valley. The West Fork, about 209 miles long, rises in Archer County, near the town of Olney, and flows southeastward about 156 miles to Fort Worth, where it is joined by the Clear Fork; thence, easterly about 53 miles to its junction with the Elm Fork at Dallas. The Elm Fork rises in Montague County and flows in a general southeasterly and southerly direction about 119 miles to join the West Fork and form the Trinity River at Dallas. The East Fork, about 112 miles long, rises in Grayson County northeast of Dallas and flows southward to the Trinity River about 20 miles southeast of Dallas. Below the East Fork at river mile 385.5, the Trinity River is joined by the Cedar Creek tributary system from the northeast and at mile 372.4 by the Richland Creek tributary system from the west. Below mile 372.4, numerous smaller tributary systems enter the river from both sides, with

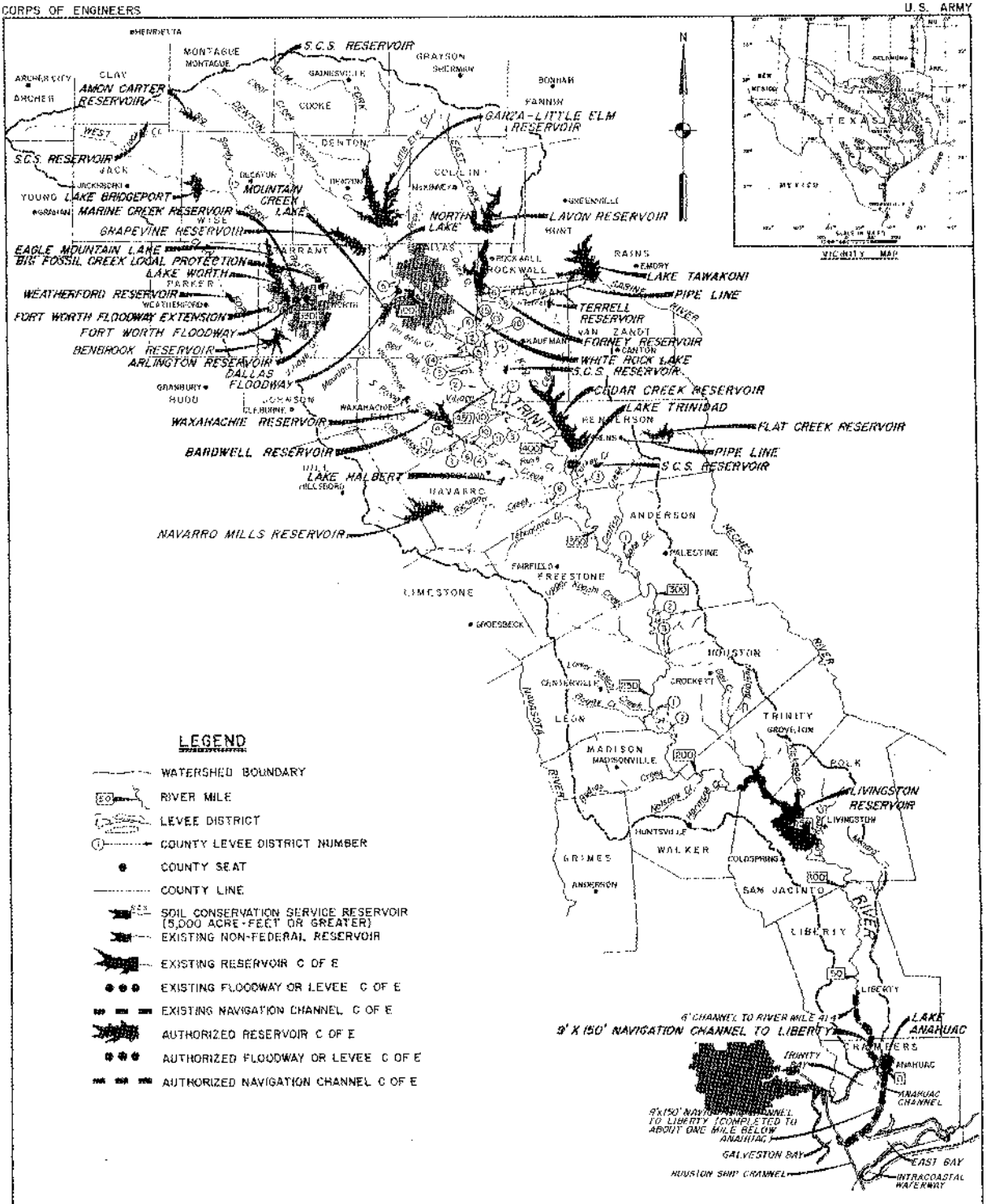


FIGURE 1

EXISTING AND AUTHORIZED IMPROVEMENTS

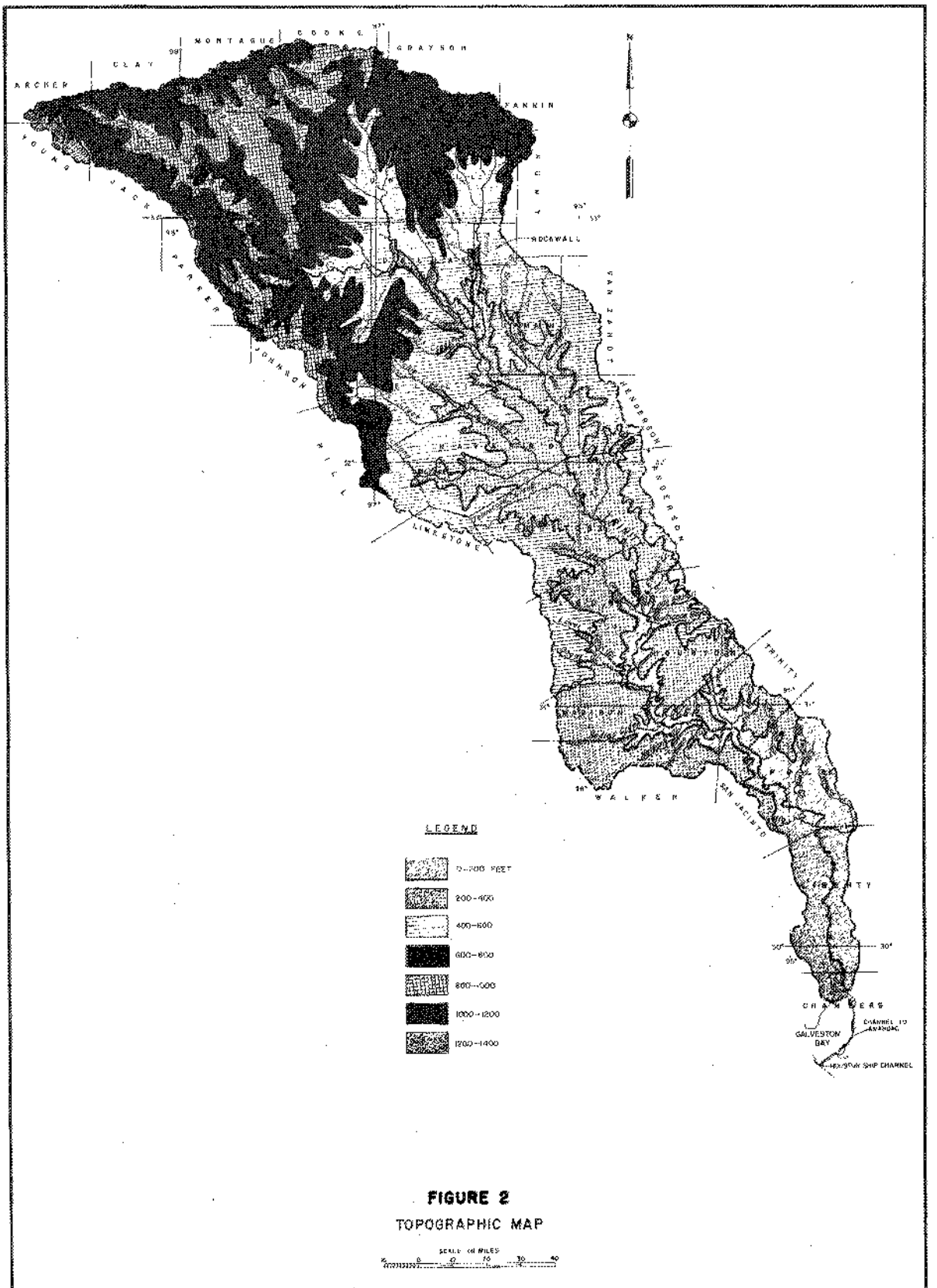


FIGURE 2

TOPOGRAPHIC MAP

the tributary lengths generally becoming shorter as the basin narrows to the south. The overall length of the river from its mouth in Trinity Bay to the headwater of the West Fork in Archer County is about 715 miles. Data pertinent to the Trinity River and its principal tributaries are shown in table 1 and scenes of the Trinity River channel are shown on figure 3.

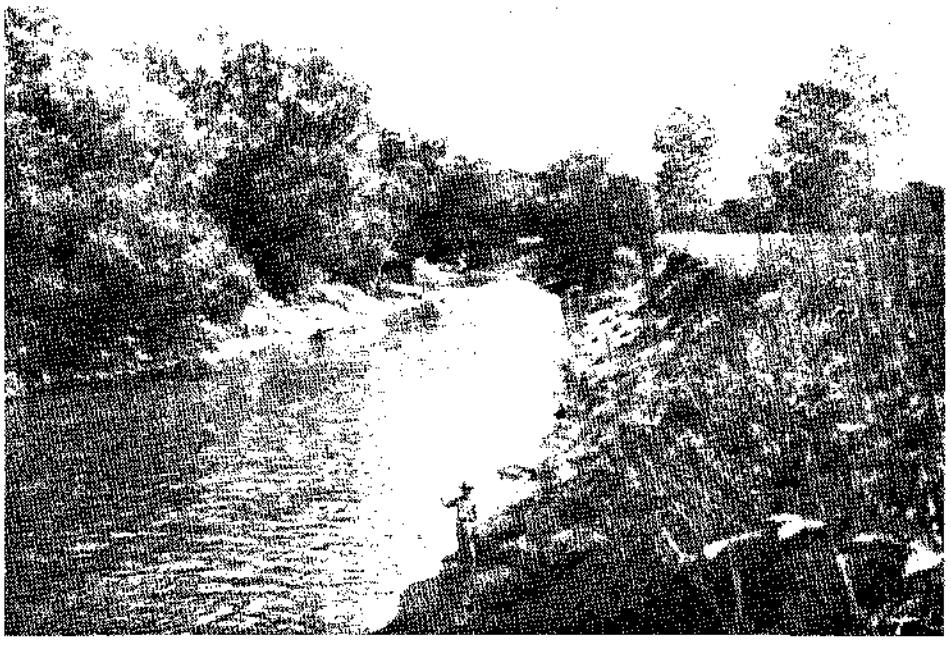
TABLE 1

STREAMS OF TRINITY RIVER BASIN

Stream	Confluence with parent stream (mi above mouth)	Length (river miles)	Approximate total fall (feet)	Drainage area (sq mi)
Trinity River (incl West Fork)	-	715	1,250	17,845
West Fork	505.5	209	864	3,502
Clear Fork	558.7	70	775	531
Big Fossil Creek	542.7	21	296	75
Village Creek	533.8	33	458	184
Mountain Creek	507.8	37	463	305
Elm Fork	505.5	119	864	2,578
Denton Creek	18.4	102	685	719
Little Elm Creek	39.4	41	348	262
Clear Creek	50.5	55	650	354
White Rock Creek	493.1	42	386	138
East Fork	459.8	112	566	1,309
Duck Creek	31.0	22	270	45
Cedar Creek	385.5	92	374	1,072
Richland Creek	372.4	97	630	1,990
Chambers Creek	14.2	107	603	1,072
Tehuacana Creek	347.2	42	297	432
Catfish Creek	339.6	37	303	305
Upper Keechi Creek	272.8	40	352	512
Lower Keechi Creek	240.5	29	341	192
Bedias Creek	207.9	35	282	603
White Rock Creek	169.9	35	318	518
Long King Creek	117.5	31	258	214

24. CLIMATOLOGY.- The climate over the basin is generally mild with the distinctive features of a large range of annual and daily temperatures. In summer, the days are usually hot and the nights moderately warm. Generally, the winters are moderate and snowfall and sub-freezing temperatures are rare in the lower basin near the Gulf but are experienced occasionally during the winter season in the more northerly parts of the basin.

25. The mean annual temperature over the basin is about 66 degrees and varies from about 69 degrees in the lower part of the basin to about 64 degrees in the headwaters. Between July, the warmest month, and January, the coldest month, the mean monthly temperatures vary by about 35 degrees. Temperature extremes have ranged from about 112 degrees to minus 8 degrees in the northern part of the basin and from about 108 degrees to 8 degrees in the southern part.



TRINITY RIVER - BELOW DALLAS

TRINITY RIVER - VICINITY OF ROMAYOR, TEXAS

FIGURE 3

26. The mean annual precipitation over the basin averages about 38 inches and varies from about 27 inches in the northwestern extremity of the basin to about 51 inches at the lower end. An isohyetal pattern of mean annual precipitation over the basin is shown on figure 4. The annual runoff in the basin is influenced directly by the pattern of annual rainfall and increases generally from the headwaters to the mouth. The variation in annual runoff in various parts of the basin and a comparison with runoff for several selected floods of record are shown on figure 5.

27. Floods and droughts.- The statistics of mean annual precipitation, which are obtained by averaging the records over long periods of time, show that, on the whole, the Trinity River Basin receives a generous supply of fresh water through rainfall. The water problems, however, arise not from the averages but from the extremes. The history of the basin shows a recurring pattern of long to moderate droughts and periods of heavy rainfall, sometimes torrential in character. This is illustrated by the prolonged drought experienced throughout the basin during the years 1950-1957, followed by severe floods in 1957. The rainfall records for Fort Worth are typical for this period. Fort Worth has a normal annual rainfall of 33.7 inches. During the six full years, 1951 through 1956, the annual rainfall ranged from 18.6 inches to 25.2 inches and averaged 22.4 inches. The accumulated deficiency during the period was over 68 inches. The drought was broken by heavy rainfall which began in April 1957 and extended into the early part of June and totaled 28.8 inches. Similar heavy rainfall over much of the basin caused the largest volume of runoff during any similar period for which records are available. Grapevine, Benbrook and Garza-Little Elm Reservoirs had been completed during the drought years but only small amounts of water had been impounded. At the beginning of the rainfall period, storage was low in many of the older water conservation reservoirs in the upper basin. Had it not been for these circumstances, record breaking flood peak discharges would have occurred throughout the basin.

28. The drought periods cause serious shortages of water to the cities and towns which depend upon the river for municipal and industrial water supplies. Diminished water supplies also cause hardships throughout the rural areas of the basin. During the 1950-1957 drought, both Dallas and Fort Worth, as well as many smaller cities, were forced to curtail water use and seek temporary means of supplementing their water supplies. Dallas found it necessary to import low quality water from the Red River Basin as a temporary measure. On the other hand, during periods of heavy rainfall, vast quantities of unregulated water flow wastefully and often destructively down the river in floods and are lost in the Gulf of Mexico. If the Trinity River Basin is to reach its full potential of development, this destruction and waste cannot be tolerated. As the basin develops and population, industry and agriculture expand, more and more water will be needed and protection must be provided for the ever expanding developments. The answer lies in

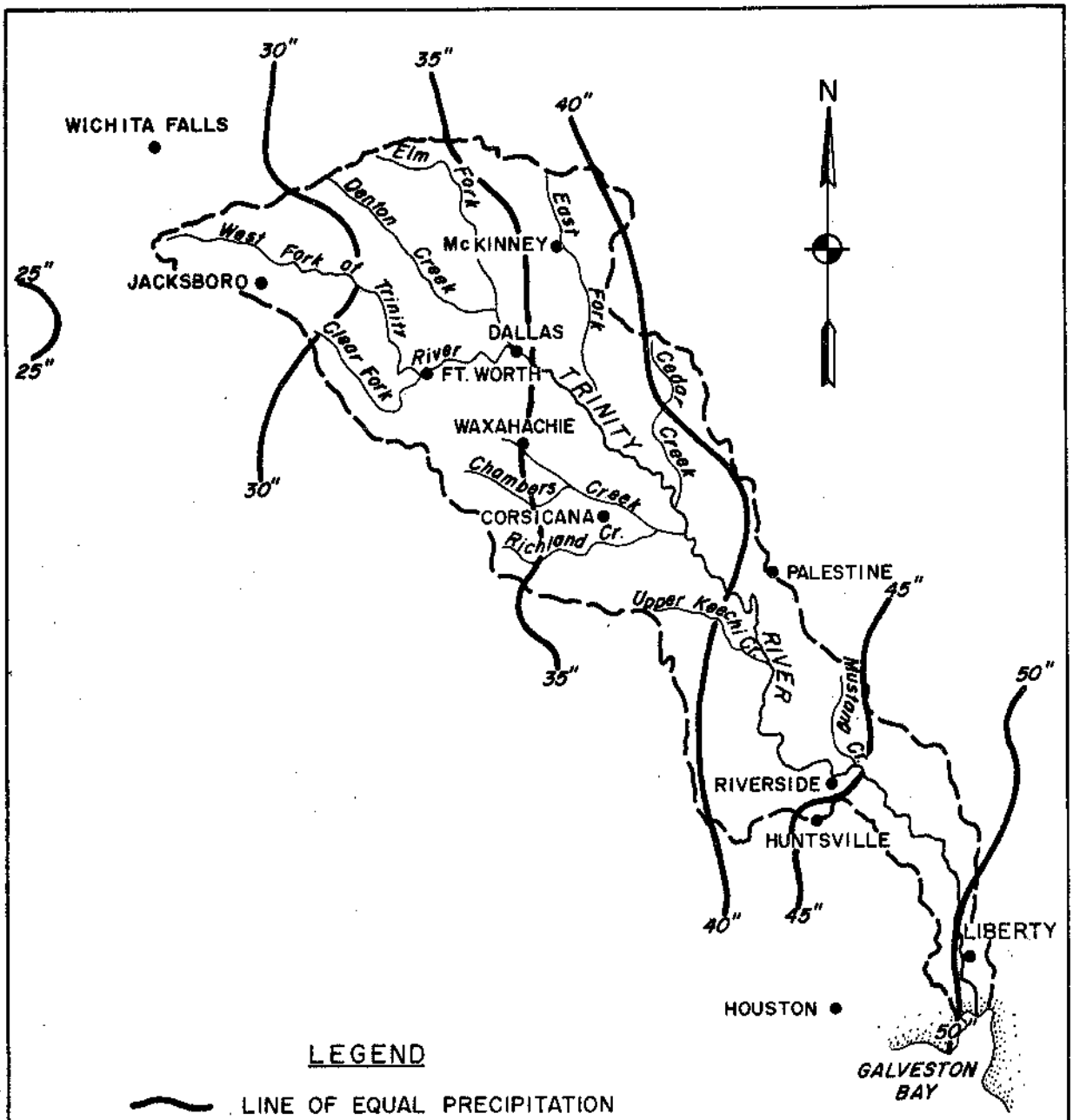


FIGURE 4

TRINITY RIVER

MEAN ANNUAL PRECIPITATION

SCALE IN MILES

0 20 40 60

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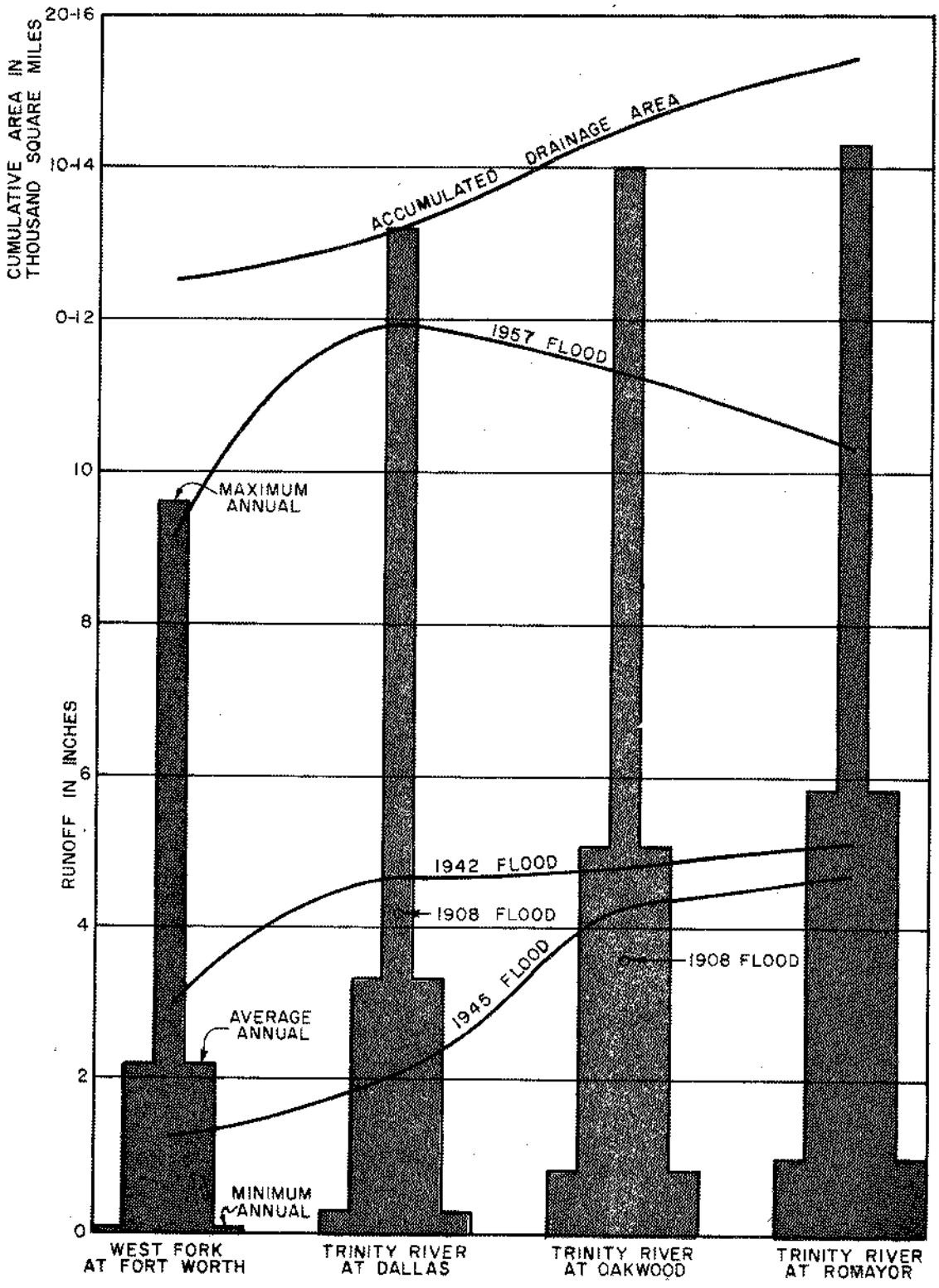


Notes:

All data observed except 1957 flood data and maximum annual data which have been corrected for reservoir storages.

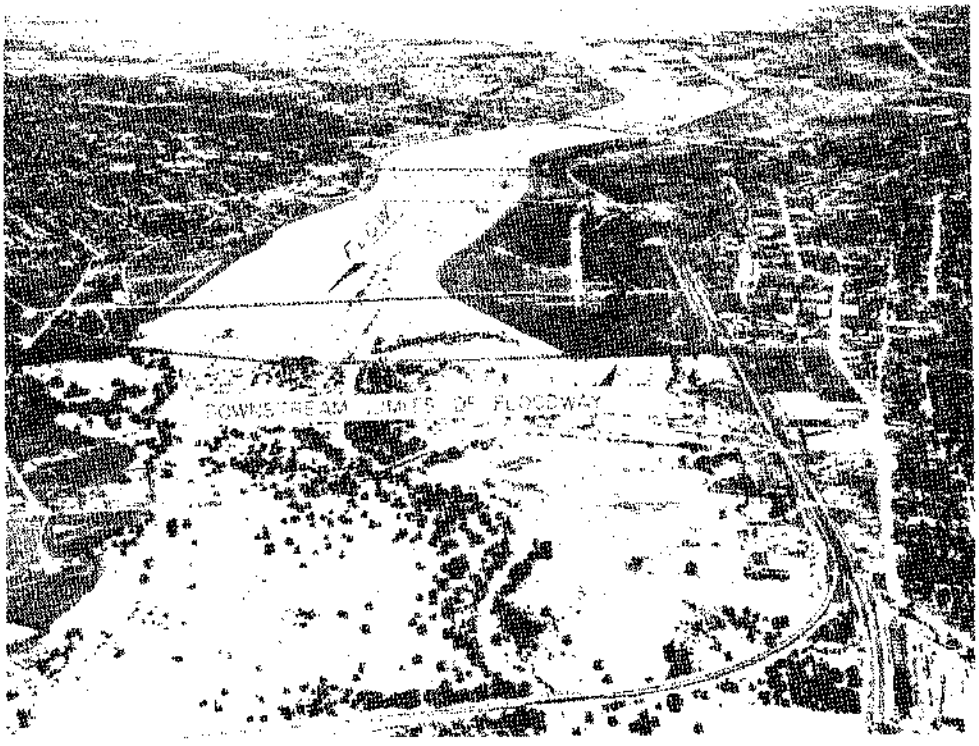
FIGURE 5

TRINITY RIVER BASIN

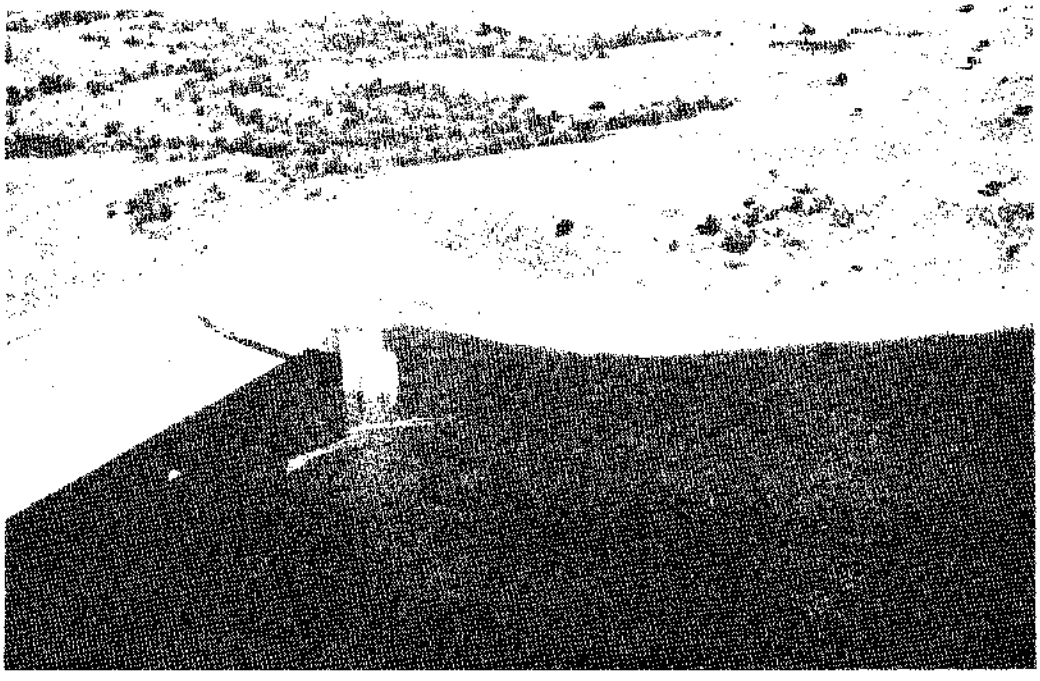
RUNOFF DATA

controlling and regulating the river so that, to the maximum extent practicable, the flood waters can be stored and conserved for beneficial use, and providing facilities to assure protection against floods.

29. EXISTING IMPROVEMENTS.- The residents of the Trinity River Basin have for many years been cognizant of their many water problems as evidenced by the construction of the first major water supply reservoir, White Rock Lake, by the City of Dallas in 1911 and the organization of the first levee improvement district in 1909. Subsequent to those dates many facilities, both single and multiple-purpose, and both Federal and non-Federal, have been constructed in an attempt to cope with the ever increasing water problems of the basin. At the present time there are 24 major reservoirs, either operational, under construction or authorized, which contain conservation storage capacity and have individual total storage capacity of more than 5,000 acre-feet. Six of these reservoirs are Corps of Engineers projects which provide flood control storage. One of the 18 non-Federal reservoirs also provides storage specifically for flood control. The locations of these reservoirs are shown on figure 1 and data pertinent thereto are shown in tables 2 and 3. Scenes typical of projects constructed by the Corps of Engineers are shown on figure 6. The Soil Conservation Service has constructed four flood detention reservoirs with individual storage capacities greater than 5,000 acre-feet. In addition, the Soil Conservation Service has an extensive program underway in the basin for agricultural land treatment measures and a program for runoff and water flow retardation and soil erosion prevention. Prior to January 1961, the Soil Conservation Service had completed about 40 miles of channel improvements and constructed 288 floodwater retarding structures, which provide total storage capacity of 252,500 acre-feet, including 211,400 acre-feet for flood detention purposes. There are 79 smaller conservation reservoirs in the basin with individual total storage capacities of less than 5,000 acre-feet constructed by local interests. These reservoirs provide a total of about 41,000 acre-feet of conservation storage. In addition, for rural and agricultural purposes, there are about 66,500 farm ponds with an average storage capacity of about two acre-feet. About 40 active organized levee districts in the basin have concerned themselves with the water problems for about 50 years and presently maintain approximately 341 miles of levees to alleviate flooding in both rural and urban areas. The Corps of Engineers has constructed local flood protection projects in the Dallas-Fort Worth area and has been authorized to construct two additional local flood protection projects in the Fort Worth area. The Corps also has an existing and authorized navigation project in the lower Trinity River and in Trinity and Galveston Bays.



DALLAS FLOODWAY, FLOOD OF APRIL 1942



BENBROOK RESERVOIR AT CONSERVATION LEVEL

FIGURE 6

TYPICAL CORPS OF ENGINEERS PROJECTS IN THE TRINITY RIVER BASIN

TABLE 2

PERTINENT DATA
CORPS OF ENGINEERS RESERVOIRS

Item	Benbrook	Grapevine	Garza Little Elm	Lavon	Navarro Mills	Bardwell
Status	In operation	In operation	In operation	In operation	Under construction	Advance planning
Stream	Clear Fork	Denton Creek	Elm Fork	East Fork	Richland Cr.	Waxahachie Cr.
Location (river mi)	15.0	11.7	30.0	55.9	63.9	6.0
Dreinage area (sq mi)	433	694	1658	777	316	171
Type of dam	Earth fill	Earth fill	Earth fill	Earth fill	Earth fill	Earth fill
Max. height of dam (feet above streambed)	130	137	125	69	82	68
Surface area-top of conservation pool (acres)	3,770	7,380	23,470	11,080	5,070	2,660
Storage capacity (acre-feet)						
Flood control	170,350 (1)	238,250	513,400	275,600	143,200	79,600
Conservation	72,500	161,250	436,000	100,000	53,200	29,500
Sediment	15,750	36,000	53,500	47,800	15,800	8,700
Total	258,600	435,500	1,002,900	423,400	212,200	117,800
Dependable yield (2)	6.5	18.1	86.0	35.5	18.1	4.2

(1) At elev. 724.0 (crest of uncontrolled spillway); 76,550 ac.-ft. at elev. 710.0 (notch crest)

(2) Million gallons per day based on maximum drought period of record and 2020 conditions of basin development.

TABLE 3

PERTINENT DATA
NON-FEDERAL RESERVOIRS
(With Capacities Greater Than 5000 Acre-Feet)

Name	Ownership	Location		Drainage area above dam (sq mi)	Storage capacity in acre-feet				Year constructed
		Stream	River mile		Sediment	Conservation	Flood-control	Total	
Amon Carter	City of Bowie	Big Sandy Cr.	31.0	103	5,100	14,800	0	19,900	1956
Bridgeport	Tarrant County WCID No. 1	West Fork	626.2	1114	37,700	233,200	0	270,900	1932
Eagle Mountain	Tarrant County WCID No. 1	West Fork	583.3	1974	39,100	143,500	0	182,600	1934
Lake Worth	City of Ft. Worth	West Fork	572.1	2069	2,100	31,600	0	33,700	1913
Marine Creek	Tarrant County WCID No. 1	Marine Cr.	4.7	10	450	3,350	11,600	15,400	1957
Weatherford	City of Weatherford	Clear Fork	39.8	106	6,300	13,100	0	19,400	1956
Arlington	City of Arlington	Village Creek	8.0	136	10,100	35,600	0	45,700	1957
Mountain Creek	Dallas Power & Light Co.	Mountain Cr.	4.1	289	20,000	4,200	0	24,200	1936
North Lake	Dallas Power & Light Co.	So. Fork, Grapevine Creek	0.5	2.3	1,100	16,000	0	17,100	1957
White Rock	City of Dallas	White Rock Creek	12.0	99	7,400	4,900	0	12,300	1911
Trinidad	Texas Power & Light Co.	(1)	--	--	0	6,200	0	6,200	1925
Livingston (2)	City of Houston and Trinity River Authority	Trinity River	129.2	16,606	51,600	1,698,400	0	1,750,000	(2)
Anahuac	Chambers Liberty Counties Navigation Dist.	(3)	--	129	0	35,300	0	35,300	1953
Forney (2)	City of Dallas	East Fork	31.8	1074	24,000	466,000	0	490,000	(2)
Terrell	City of Terrell	Muddy Cedar Cr.	9.8	13	1,200	7,100	0	8,300	1956
Cedar Creek (2)	Tarrant County WCID No. 1	Cedar Creek	11.1	1013	70,900	608,000	0	678,900	(2)
Waxahachie	Ellis County WID No. 1	So. Prong, Waxahachie Cr.	0.5	31	2,100	11,400	0	13,500	1957
Halbert	City of Corsicana	Elm Creek	0.7	12	1,170	6,250	0	7,420	1924
					280,320	3,338,900	11,600	3,630,820	

Notes: (1) Off-channel reservoir, on left bank of Trinity River just upstream from mouth of Cedar Creek.

(2) Under construction.

(3) Off-channel reservoir, Turtle Bay.

REGIONAL ECONOMIC DEVELOPMENT

30. INTRODUCTION.- This study is concerned primarily with water problems and demands that can be solved by the construction of water resource improvements located within the Trinity River Basin. While the economy of the areas physically subject to flood damages and drainage problems has the greatest influence in planning solutions for these problems, the economy of additional areas outside of the basin affects planning for such purposes as municipal and industrial water supply, recreation, fish and wildlife, and navigation. The extent of the area varies with each purpose and is limited by the practical and economic aspects of the purpose served. The economy of a large segment of the area extending many miles beyond the Trinity River Basin influenced planning for extension of a navigable waterway to the Dallas-Fort Worth area because the agricultural products grown in the area, such as wheat, would be expected to move over the waterway in barges. Figure 7 shows the several economic areas which were taken into account in the formulation of the comprehensive plan for the Trinity River Basin. This figure shows that the economy of a total area comprising 148 counties in Texas and 30 counties in Oklahoma influenced the planning considerations for navigation. Similarly, the economy of a 46-county area in and adjacent to the Trinity Basin was taken into account in planning for water supply, recreation and fish and wildlife problems that might be solved by projects considered in this report. The economy of the area in and immediately adjacent to the flood plain was used in planning for flood control improvements. The area selected for the economic base study encompassed the areas considered for all purposes, covers 161,300 square miles and includes 183 counties in Texas and Oklahoma.

31. The lack of adequate control of the waters of the Trinity River Basin has resulted in a disheartening pattern of extremes from floods to droughts which have been dominating factors on the economy of the region. Floods not only have caused high damages to heavily populated metropolitan areas in the upper and lower regions of the basin but have also greatly retarded the economic development of the middle and lower sections of the basin. Damages to homes, farms and industries from floodwaters along the Trinity River and main tributaries average about 3 million dollars annually under present conditions of watershed improvement and development. Surface and ground water resources of the basin furnish about 306 and 72 million gallons, respectively, of water daily for use in homes, farms, offices, factories and other institutions. The surface waters also provide for recreation, rice irrigation in the adjacent coastal area and general small-scale irrigation throughout the entire basin, navigation in the lower reaches of the Trinity River and commercial fishing in Trinity Bay and marshlands adjacent to the Gulf. The unregulated flows and unintegrated

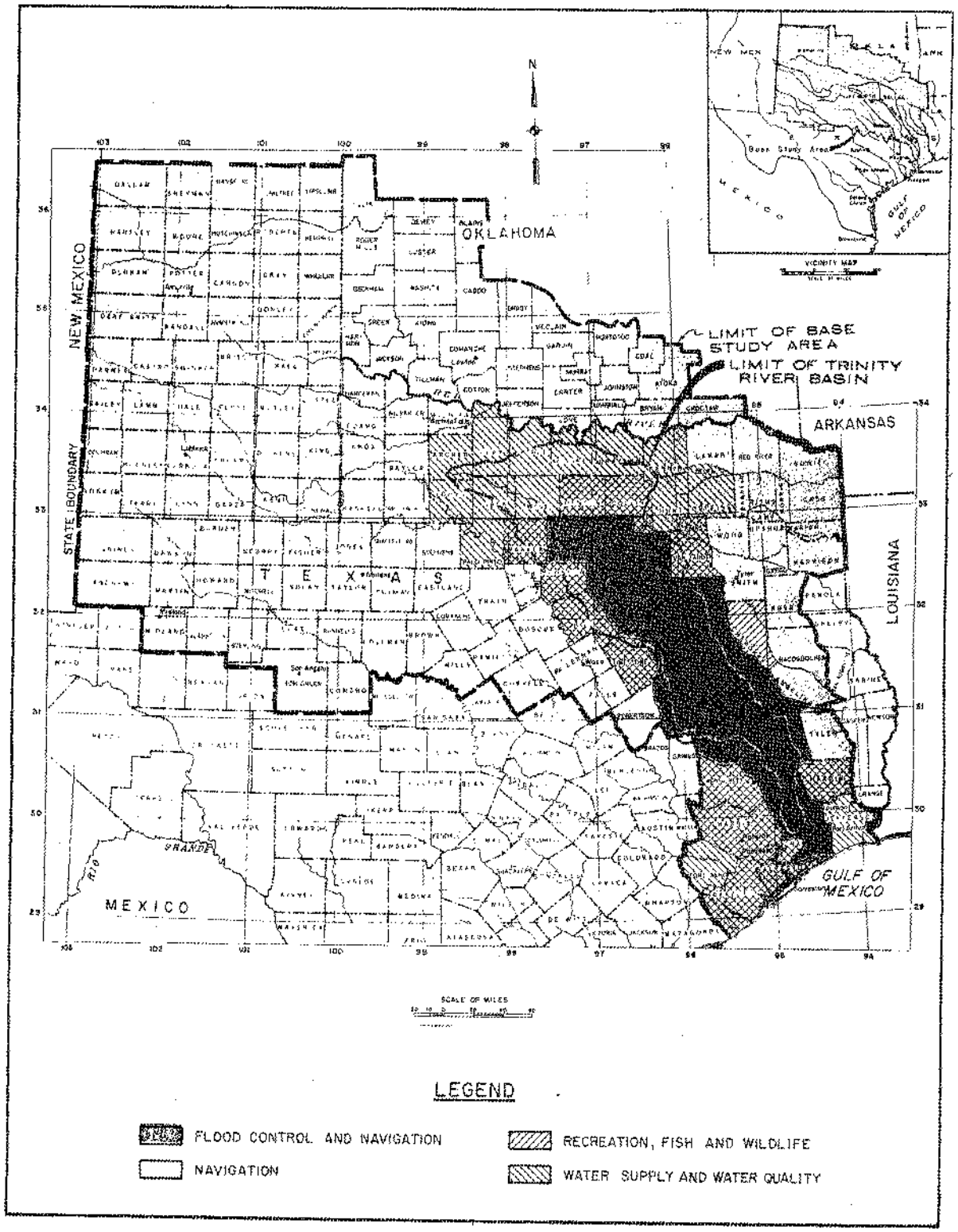


FIGURE 7. AREAS PERTINENT TO PROJECT PURPOSES

treatment of water problems have allowed the waters of the Trinity River, so urgently needed for the economy of the region, to waste to the Gulf and result in serious water shortages such as was experienced during the extended drought period of 1950-1957. Also, the waste effluent of rapidly growing municipal and industrial areas in the Dallas-Fort Worth complex has over-taxed the efficiency of the Trinity River to maintain a relatively "clean stream" of acceptable water quality.

32. POPULATION.- The Trinity River Basin population in 1960 was 1,895,000, of which about 80 percent is located in the Dallas-Fort Worth complex. The tremendous increase in population for Dallas and Tarrant Counties of about 500 percent over the past 50 years has been accompanied by a significant shift from rural to urban type economy in the upper basin. The middle area of the basin has remained rural in character and shows a decline in population for the last half century. However, it is anticipated with additional flood control measures and the construction of a waterway, the character of that area would change from predominantly agricultural to both rural and urban with resultant increase in population.

33. The metropolitan area of Houston is located just west of the Trinity River Basin near its mouth and has a large influence on water resource requirements for the lower basin. The population of Houston has shown an even more spectacular growth than the Dallas-Fort Worth area during the last 50 years and Houston is now the largest city in the State. The growth of the Houston industrial complex is continuing at a rapid rate and there is no doubt that this growth would extend into the lower Trinity Basin if the threat of flood damages were removed and other benefits of water resource regulation were made available.

34. The population of the base study area was 6,844,000 in 1960, or about 4 percent of the total United States population. A comparison of the growth rates given on figure 8 shows that the population of the study area has had an average annual rate of increase considerably greater than the national rate, except for the decade from 1940 to 1950. During the 70-year period from 1890 to 1960 the base study area's average annual population growth rate was 2.22 percent compared to the United States rate of 1.50 percent.

35. Projection of the basin population shows a rise from 1.9 million in 1960, to 2.4 million in 1970, to 5.9 million in 2020, and to 11.3 million in 2070. The population of the base study area is projected to increase from 6.8 million in 1960, to 8.1 million in 1970, to 18.6 million in 2020, and to 35.6 million in 2070. The projected average annual increase for the basin of 1.6 percent and for the base study area of 1.5 percent both are above the national average of 1.4 percent.

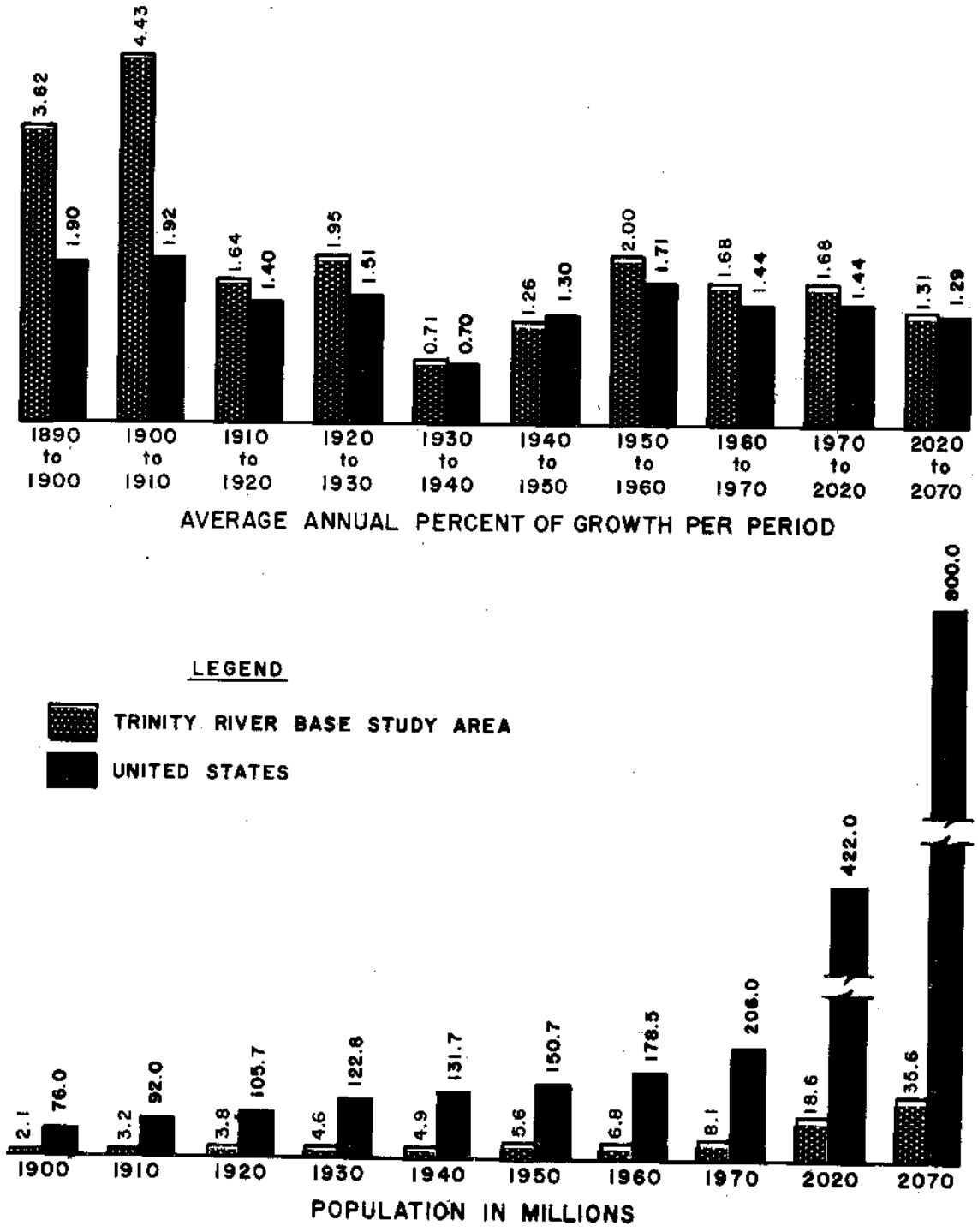


FIGURE 8

POPULATION GROWTH AND FUTURE PROJECTIONS

36. PERSONAL AND PER CAPITA INCOME.- Personal income is the most comprehensive available measure of economic activity and bears a close and generally constant relationship with the gross national product over the long run. At the national level it has been found that personal income exhibits the same 3 percent average annual growth rate that characterizes the long range trend of gross national product. In 1960, the 1.9 million residents of the basin and the 6.8 million residents of the base study area received $4.1 billion and $13.7 billion of personal income, respectively. On the basis of a per capita total this amounted to $2,170 for the basin and $2,015 for the base study area. While these amounts are slightly below the average for the nation as a whole, the annual rates of increase for personal income in the base study area have been greater than the annual increase in the national average during the period 1940-1960 as shown on figure 9.

37. MANUFACTURING.- The growth of manufacturing has been more rapid than that of any other economic development in the region and has been brought about by changing market demands, rapid technological improvements, increasing mobility of people and goods, and wartime emergencies. Many raw materials of the basin are adaptable to industrial needs but those coming from mining and agricultural activities have the biggest role in the area economy. The current trend is toward increased chemical processes in manufacturing as compared to the mechanical processes used in the past. The principal raw materials which are easily adaptable to use in the chemical industries are oil, gas, lignite, cotton, grain sorghums, and forest products.

38. The growing industrial development is evidenced in the value added by manufacturing, which, in the basin, jumped from $224 million in 1939 to $1.5 billion in 1960 and, in the base study area, rose from $841 million to $4.5 billion during the same period. The four largest industry groups in the region are chemical, petroleum, transportation equipment, and food products. The chemical industry is one of the newest and fastest growing and the abundance of raw materials available for petrochemical development indicates that it will continue to grow in the future. The petroleum refining and chemical manufacturing industries are concentrated in the Houston and Beaumont-Port Arthur area. The transportation vehicle and equipment industry is concentrated in the military aircraft factories in the Dallas-Fort Worth complex and constitutes 40 percent of the value added by manufacture for Dallas-Tarrant Counties. The production of food and kindred products is also one of the region's leading industries and some of the largest establishments are found in the larger population centers of Houston, Dallas, and Fort Worth.

39. Textile mill products, while not relatively important at the present time, give indications of becoming a large industry in the future. The production of wearing apparel and related products

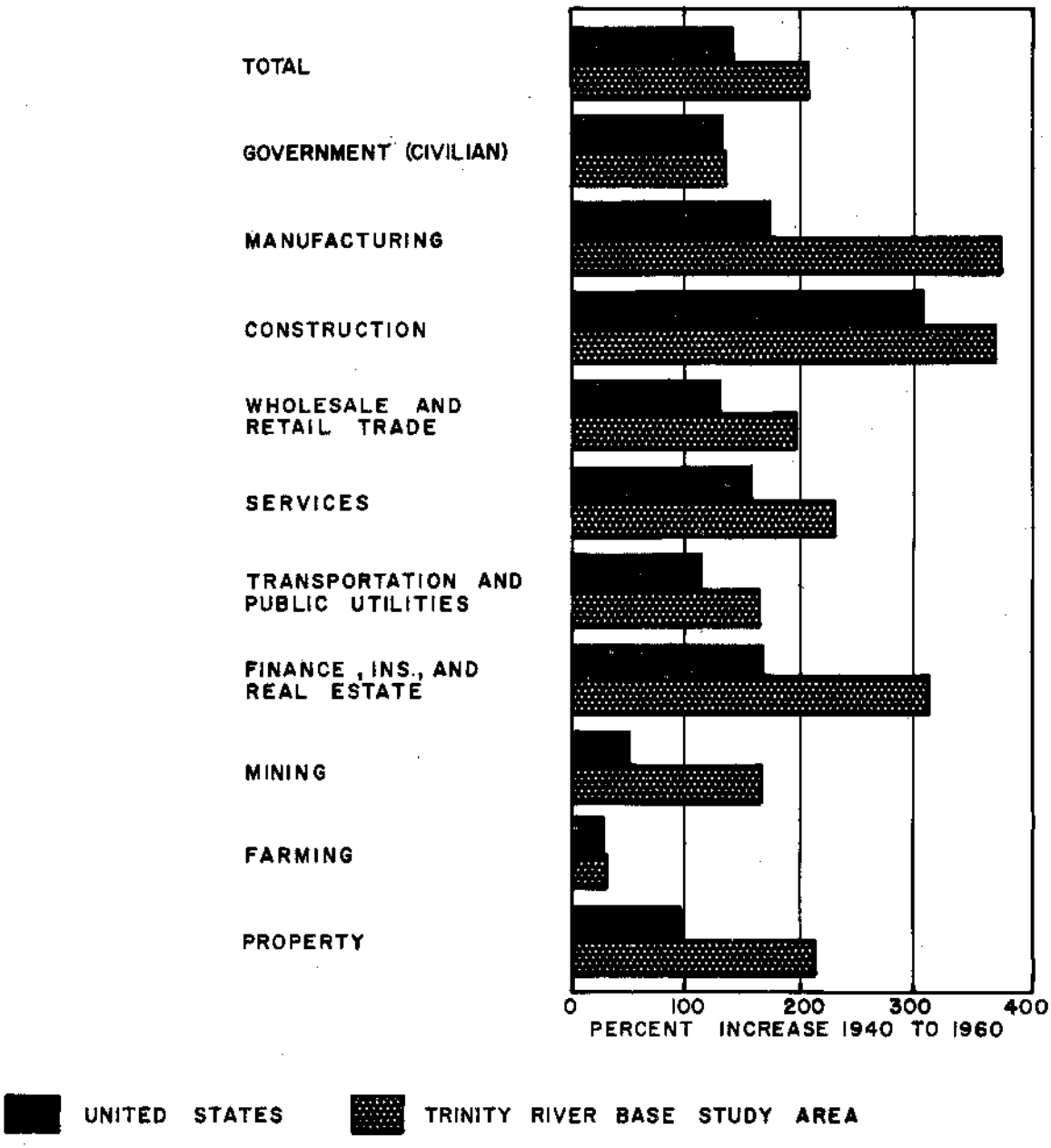


FIGURE 9

ECONOMIC TRENDS IN UNITED STATES AND TRINITY RIVER BASE STUDY AREA

has grown rapidly, with its greatest concentration in Dallas. The lumber and wood products industry is located principally in the East Texas forest area and is expected to grow rapidly on a sustained basis in the future due to good forest management practices. Printing and publishing is probably the most widely distributed industry in the region and Dallas is the leading city in the state in volume of business. Other significant industries include stone, clay, and glass products, leather and leather goods, primary metals, and machinery manufacturing.

40. The manufacturing establishments of the three largest cities, Houston, Dallas, and Fort Worth are such that manufacturers produce about 60 percent of the base study area's total value added. The construction of the Houston Ship Channel, which was completed about 1920, has made Houston one of the nation's major seaports and Texas' largest city. Today there are 108 industrial plants located in the Houston area with numerous others planned. Dallas and Fort Worth have numerous large industries for manufacturing airplanes, airmotive equipment, and heavy machinery. One important difference between the two large metropolitan complexes is that the Dallas-Fort Worth area lacks water transportation. The same opportunity for additional expansion and growth which developed in the Houston area would exist for the entire Trinity Basin if water transportation were made available. The 370 miles from Fort Worth to the Houston Ship Channel, as a navigable waterway for barges carrying bulky, heavy freight would attract numerous industries and act as the key to greater growth than inland Texas has ever experienced. A breakdown of the value added by manufacture during 1958 for various industries in Dallas, Fort Worth and Houston is given in figure 10.

41. POWER.- The growth of electric generating capacity in Texas is the fastest of any state in the nation. The tremendous increase in power production within the base study area is evidenced by the increase from 1.7 billion kilowatt hours in 1937 to an estimated 14.4 billion kilowatt hours in 1960 which is a total increase of about 750 percent. Comparable figures for the United States show an expansion from 180 billion kilowatt hours to 850 billion kilowatt hours in 1960 or a total increase of 370 percent.

42. AGRICULTURE.- Although rapid industrialization is taking place, agriculture is still of major importance, contributing substantially to the national production and economy. Farms, ranches, and woodlands occupy 88,372,000 acres, or about 138,100 square miles of the base study area. Total cropland is slightly over 32,000,000 acres of which 14 percent is irrigated. Figure 11 gives the breakdown of agricultural land use within the base study area.

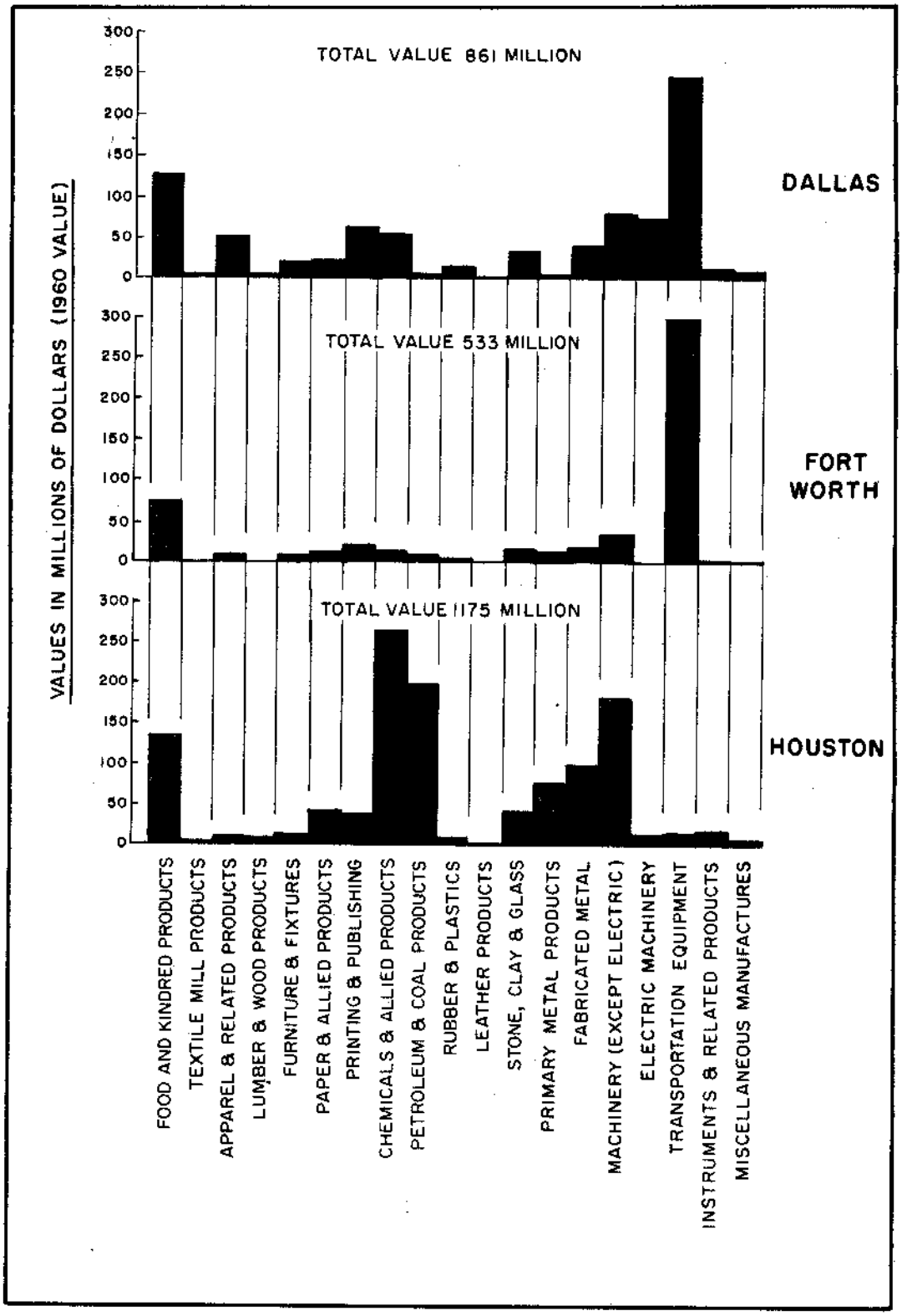


FIGURE 10. VALUE ADDED BY MANUFACTURE IN 1958
DALLAS, FORT WORTH, HOUSTON

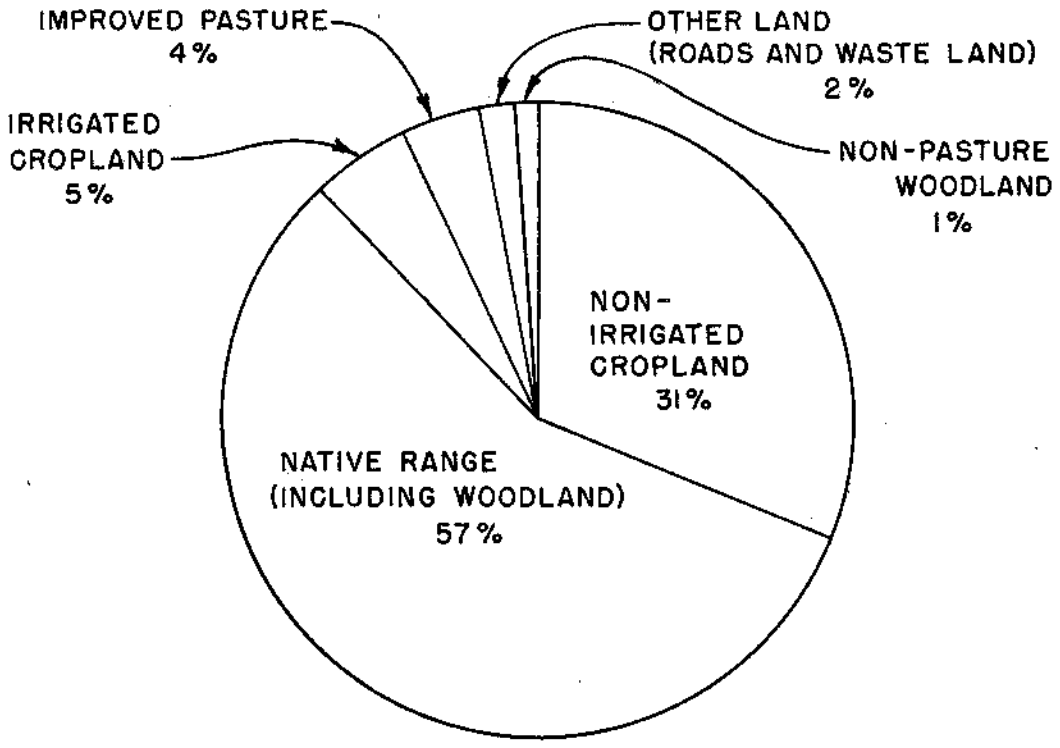


FIGURE 11

TRINITY RIVER BASE STUDY AREA AGRICULTURAL LAND USE
88,372,000 ACRES

43. A wide range of climatic and soil conditions provides an environment favorable for the production of most of the economically important crops and livestock. About 3.4 million bales of cotton, representing almost one-quarter of the Nation's cotton, is produced in the study area. Grain sorghum is grown in large quantities and production within the base study area represents 37 percent of the United States total. Large amounts of wheat grown in the Texas and Oklahoma areas lying north and west of the basin move to the Dallas-Fort Worth area and southward to the Gulf coast ports for export. Other important crops include rice, oats, and vegetables. Cattle raising is the main livestock enterprise, but sheep and goats are also raised in large quantities. The value of farm production in the base study area in 1959 and the production in the base study area as a percent of the United States production are given in figure 12.

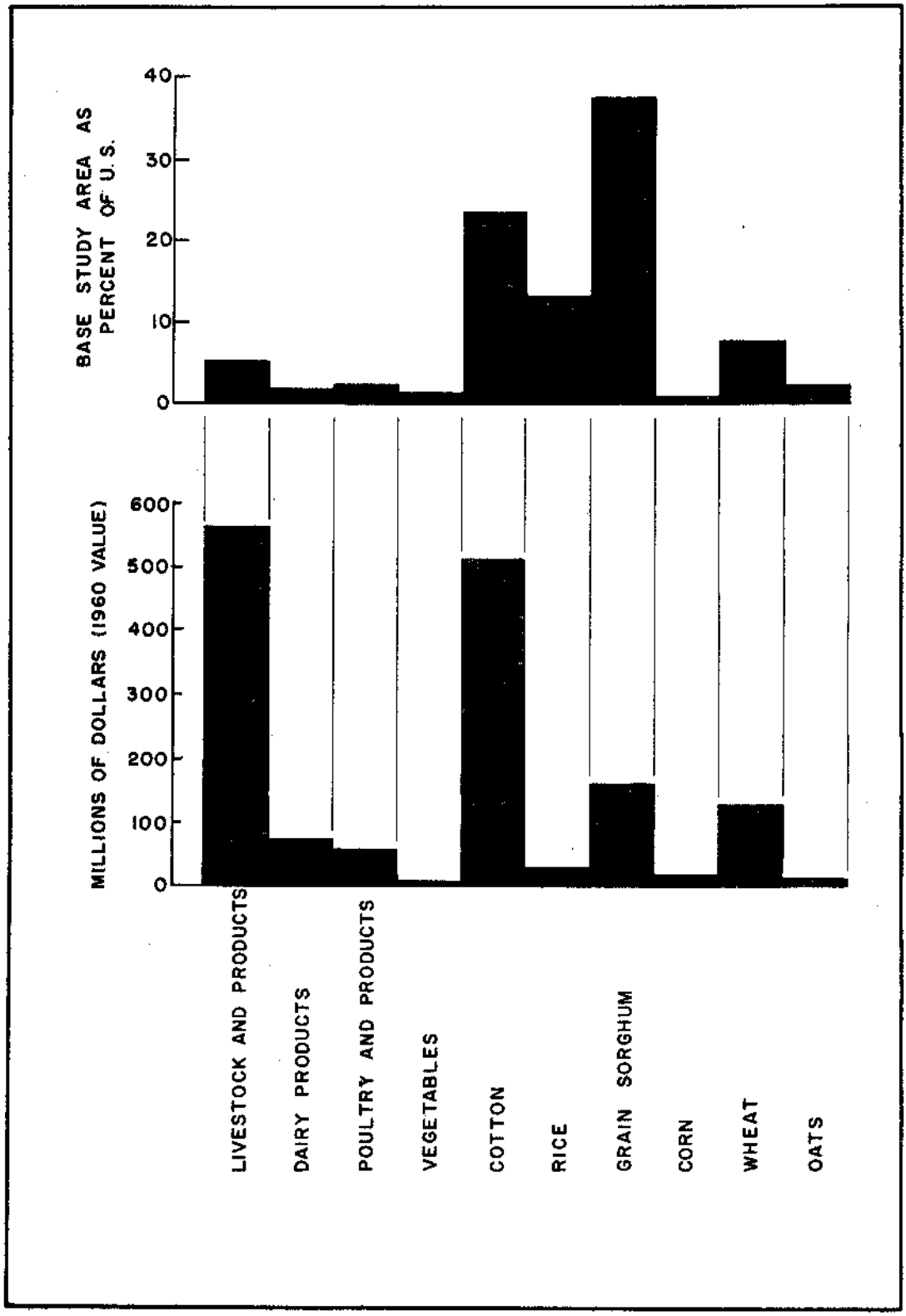


FIGURE 12

VALUE OF FARM PRODUCTION IN THE BASE STUDY AREA - 1959

44. TRANSPORTATION.- The urbanization and growth of any area is directly dependent upon adequate and economical transportation. Without transportation, the growth of cities and the concentration of industry and manufacturing would be limited by the ability to derive a food supply for inhabitants and all other basic necessities for the general economy from the immediate locality. The cost of transportation is an integral part of the cost of production and the free exchange of goods and products can be effected only to the extent that efficient and economical transportation is available.

45. There are five significant modes of transport for intercity freight in the United States. Statistics show that, in 1958, railroads carried about 46 percent of all intercity freight, with the remainder being divided among highways, 21 percent; inland waterways, 16 percent; oil pipelines, 17 percent; and airlines, a small fraction of one percent. Based on the forecasted growth of the gross national product and a continuation of the present relationship between the gross national product and intercity freight traffic, it has been estimated that, by 1980, the United States will need a transportation system having a capacity, in ton-miles of about double the nation's present freight traffic. By the year 2000, freight traffic is estimated to be at least four times the present volume.

46. Although, at this time, railroads generally are operating at less than physical capacity, the emergency demands of World War II strained the freight-carrying capacity of the railroads to the utmost. Since World War II, the use of improved rolling stock and more efficient operating practices have increased the total freight carrying capacity of the main lines and there is little doubt that at this time, the railroads could absorb a considerable increase in freight volume with little increase in track mileage. However, with the projected future demands for intercity transportation, it is not likely that this condition, in general, will endure beyond the next few years.

47. The Trinity River Basin and adjacent areas are served by the facilities of seven major railroad systems, which provide a network pattern of main lines with feeder and distributor branches throughout the eastern and southern parts of Texas. The north-south main lines provide connections between the central transcontinental routes of the Union Pacific system and the southern transcontinental routes of the Southern Pacific and Atchison, Topeka and Santa Fe systems. Generally, the north-south main lines extend southward from St. Louis, Kansas City, Wichita and Denver, converge on the Dallas-Fort Worth area and, following various routes through central and eastern Texas, continue southward to Houston and Galveston and southwestward to Waco, Austin, San Antonio and the Rio Grande Valley. The north-south lines between the Dallas-Fort Worth and Houston areas do not closely parallel the Trinity River and, in the middle basin area, are located somewhat to the east and west of the basin proper.

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48. A network of improved highways provides facilities for motor transport to most of the Trinity River Basin. However, as with the rail lines, the main north-south highways skirt the middle basin area without extending deeply into the basin proper. The highway facilities are being augmented at this time by construction of an elaborate system of modern highways, through the Interstate Highway program. As with the railroads, motor freight carriers could move larger amounts of freight than they are now moving, although the joint use of the highways by motor trucks and private automobiles presents serious problems in traffic control and highway construction and maintenance as the total volume of traffic increases.

49. Motor freight traffic undoubtedly will continue to increase; however, this means of transportation is not truly competitive for mass shipments of bulk commodities at lowest cost. The prime advantage of truck transport lies in the rapid and flexible movement of small units of individual shipments. The low ratio of load to power required for movement results in a high unit cost of transportation and precludes effective competition in the market for mass transportation of bulky low-value items.

50. Air freight is of little significance in the overall pattern of intercity freight transportation. The advantage of air freight lies in ultra-rapid movement of small, lightweight items. The movement of freight by air will continue to increase, perhaps at a greater rate than by other modes of transport. However, it is equally certain that the limitations of size, weight and high cost will preclude the movement of any significant portion of the total intercity freight by air.

51. In analyzing the overall transportation requirements, pipelines can be considered only to the extent that movement of liquid or gaseous commodities are involved. An extensive network of pipelines extends in and through the Trinity River Basin. The pipelines principally are for gathering and distributing natural gas or for gathering and transporting crude oil to refining centers and shipping terminals along the Gulf Coast. Some of the pipelines are used for moving liquid refined products from refineries to distribution centers. Pipelines will remain an important factor in transportation of liquid petroleum commodities; however, being limited to the movement of liquids, they can be assigned only a small field of application in satisfying the general mass transportation demands.

52. Demand for mass transportation.- For the most part, the demand for low-cost, mass transportation must be met either by rail or waterway transport. Each of these means has its inherent advantages and, where both can be provided, together offer the most efficient and economical mass transportation facilities known today. Railroad

transport offers rapid service at relatively low cost for a wide range of freight. It is relatively free of topographical limitations and, with the extensive rail network already in existence, serves thousands of different points throughout the nation. Comparatively small units of freight can be efficiently handled. However, for movement of large volumes of freight at extremely low cost, waterway transportation is clearly superior. No other form of transportation can approach its high ratio of load to power required for movement, nor its low cost per ton for movement of those commodities for which it is suited. Many types of industry are dependent on mass transportation at the lowest possible cost, and it is a well demonstrated fact that such industries will concentrate in localities having water transportation. This is illustrated by the tremendous industrial developments in recent years along the modern inland waterways of the Ohio River Valley, the lower Mississippi Valley and Gulf Intracoastal and connecting waterways in Louisiana and Texas. Such industrial developments lead to a general expansion of the economy in the surrounding areas and generate additional traffic for the waterway, railroad and highway truck transport. It is significant that virtually all major industrial areas of the United States are served by water transportation. With a population in 1960 of about 1,657,000, the Dallas-Fort Worth complex is the largest urban-industrial area in the United States that is not located on a navigable waterway.

53. ROLE OF NATURAL RESOURCES IN THE ECONOMY.- The change in the economy of the region surrounding the Trinity River from frontier subsistence to a growing urban-industrial complex has occurred largely since the Reconstruction period following the Civil War and is due, in large part, to the vast and varied resources of the region. The first of several economic stages was the colonial era of cotton and cattle, which was an energetic period of rapidly advancing frontier, gathering momentum with the westward push of the railroads. The second stage, that of forest and mineral exploitation, began near the turn of the century and continued a rapid increase until about 1940. This middle period of development of the natural resources augmented by World War II brought about the next major period of advancement, that of industrialization and urbanization, which is of utmost importance today. The relationship that exists between the natural resources and the continued economic growth and development of the region is described in subsequent paragraphs.

54. Timber.- Most of the heavily timbered areas in the region are located in 43 counties in eastern Texas and 17 counties in eastern Oklahoma, of which three of the Oklahoma counties and 34 of the Texas counties are in the base study area. Timber interests first undertook large-scale operations in forest exploitation toward the end of the 19th century and by 1907, more than two billion board feet were being removed annually, mainly from the East Texas forest area. The tremendous

lumbering operations during the early part of this century caused rapid depletion of the forest reserves and brought about the establishment of a conservation program in 1915 by the Texas State Department of Forestry (later changed to Texas Forest Service). The conservation program assured adequate forest reserves and during the period from 1915 to 1958 lumber production for the State of Texas averaged a billion board feet. Today timber is being grown more rapidly in the East Texas Forest Region than it is being harvested, and has been established as an important permanent resource. The extensive East Texas Forest Region covers the lower and a portion of the middle Trinity River Basin as shown on figure 13. The commercial forest land in the base study area and the amount of growing stock and saw timber volume is given in table 4.

TABLE 4

COMMERCIAL FORESTS IN TRINITY RIVER BASE STUDY AREA
1953-1956

Item	Unit	TEXAS		OKLAHOMA	
		34-County Total	Percent of State Total	3-County Total	Percent of State Total
Land area	acre	17,935,500	10.6	1,473,300	3.3
Commercial forest	acre	9,471,300	77.8	744,000	13.2
Growing stock:					
Softwood	(1)	34,351,200	71.4	25,200	0.4
Hardwood	(1)	32,841,600	78.0	1,950,000	19.8
All species	(1)	67,192,800		1,975,200	
Saw timber volume:					
Softwood	(1)	12,576,500	71.6	7,800	0.4
Hardwood	(1)	7,341,900	75.9	414,900	20.5
All species	(1)	19,918,400	73.1	422,700	10.5

(1) Thousand board feet.

FIGURE 13

EAST TEXAS FOREST REGION

55. Minerals.- About 30 different minerals are produced on a commercial scale in Texas and Oklahoma, most of which are found in the basin. However, the production of crude petroleum and natural gas overshadows all other minerals in importance. The first commercial petroleum production of importance in Texas came from discovery of oil at Corsicana in 1894. Since then oil exploration has expanded rapidly throughout the Southwest. Texas currently produces about 40 percent of the total production of crude oil in the United States as shown on figure 14. In 1959, crude oil production within the base study area in Texas was about 620 million barrels and in Oklahoma 90 million barrels which constituted about 28 percent of the national output.

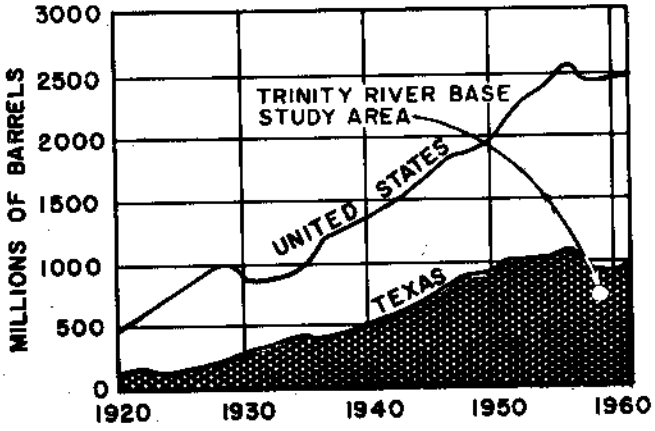


FIGURE 14

CRUDE OIL PRODUCTION

56. The future of oil production in the region is, of course dependent on the recoverable reserves. Most of the available data on petroleum futures is based on the ratio of proven reserves to production and tends to present a conservative outlook on the estimates of ultimate production from United States reserves, both known and prospective. Although a reserve-production ratio decline has actually occurred over the past six-year period, it should be noted that there has been some increase in total national reserves, with Texas reserves remaining about steady through 1960. In late 1960, a new major discovery was made on the James Reef in the Fairway Field which is located within the basin in Henderson and Anderson Counties, Texas. Although the limits of the Fairway Field have not been fully established, it was evident, by the end of 1961, that the field is a major producing field, with a potential recovery presently estimated to exceed one-half billion barrels. New discoveries such as this, together with advanced technology in oil discovery and production permit an optimistic forecast for the possibility of future oil production. The relationship of crude oil production and reserves in Texas as a percent of the United States is shown on figure 15.

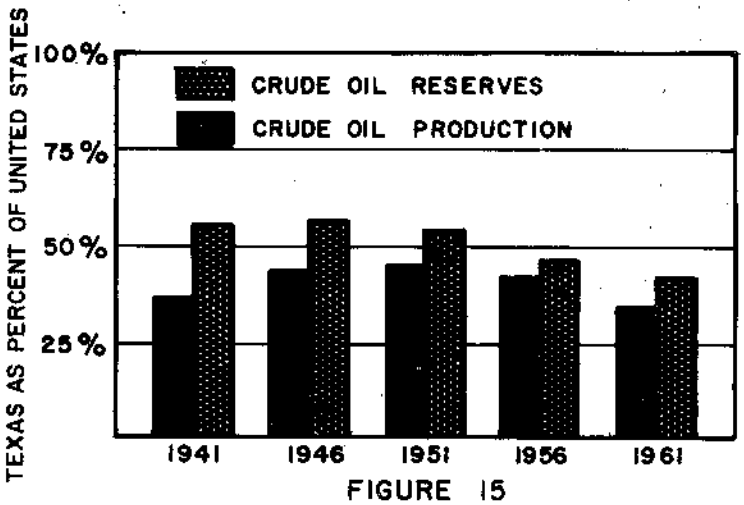


FIGURE 15

PETROLEUM PRODUCTION AND RESERVES

57. Natural gas is considered as the world's best domestic and industrial fuel, and in recent years it has been increasingly used as a raw material for a wide variety of products of the modern chemical industries. Although natural gas resources are widely distributed throughout the southwest region, gas in commercial quantities

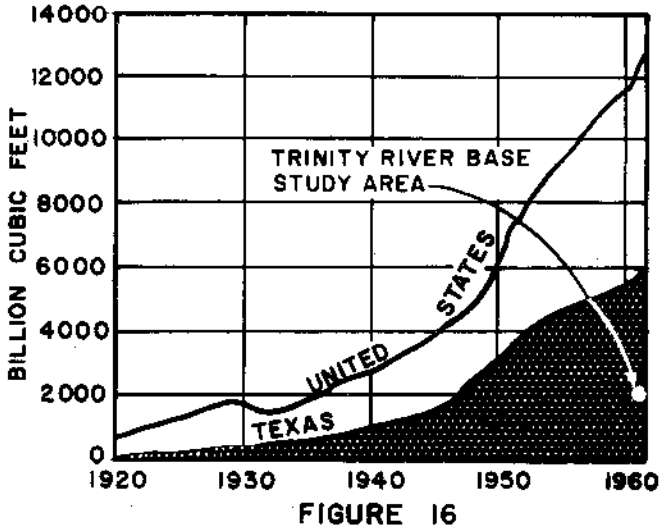


FIGURE 16

NATURAL GAS PRODUCTION

is not as widely found as crude oil. Natural gas production in the State of Texas and the United States from 1920-1961 are shown on figure 16. In 1961, natural gas production within the base study area was about two trillion cubic feet and constituted 16 percent of the production for the United States.

58. In addition to supplying natural gas to more than half of the United States, the State of Texas has nearly one-half of the nation's proven reserves of this mineral. The American Gas Association Committee on Natural Gas Reserves reported that estimated proven recoverable reserves of natural gas in the United States totaled 262.2 trillion cubic feet at the end of 1959, increasing 8.5 trillion cubic feet during the year. The larger gains were reported in Texas and Louisiana, where increases of 4.3 and 3.8 trillion cubic feet, respectively, are shown.

59. Natural gas liquids are also produced in large quantities in the base study area. Liquid gas products, whether obtained from natural gas or processing in refineries, are defined by the Bureau of Mines as natural and finished gasolines, ethane, propane, butane, isobutane, etc. The base study area's production was over 100 million barrels of natural gas liquids in 1959 and is second only to crude oil production in total monetary value of minerals. The American Gas Association Reserves Committee estimated recoverable reserves of natural gas liquids in the United States at the end of 1959 of 6,522 million barrels which was an increase of 362 million barrels or 6 percent over the previous year. The State of Texas, including the offshore area in the Gulf, accounted for 53 percent of the total estimated reserves.

60. Other minerals available in commercially significant quantities from the region are sand and gravel, stone, lignite, common salt, clay, iron ore, and sulphur. The reserves of sand, gravel, and stone (mostly limestone) in the basin are virtually unlimited. Some of the beds of limestone are known to be several hundred feet thick. In the base study area during 1958, 660,000 tons of limestone were used in the manufacture of lime. There are an estimated 20 billion tons of recoverable lignite in the base study area, a large part of which is located within, or adjacent to, the basin. The principal use of this fuel at present is for a 240,000 KW steam-electric plant which furnishes power to an aluminum reduction plant located just west of the basin in Milam County, about 100 miles northwest of Houston. Utilization studies indicate that not only will lignite be used for future power production but also in the chemical, wood preservation, and refining industries. An estimated 72 billion tons of salt are located in salt domes in 9 counties within the base study area. Most of these counties are located within the middle portion of the basin, the average distance from the salt domes to the Trinity River being 33 miles. Iron ore is located mainly in the middle section of the basin and adjacent base study area to the east. Iron ore production in Texas since 1955 has not been disclosed by the Bureau

of Mines. In 1955 about 875,000 long tons were produced, all from strip mines in the base study area. Total recoverable reserves of iron ore, based on the best available information, is estimated at about 175 million tons containing 40 to 50 percent iron. Sulphur is produced in large quantities from four deposits in the base study area, one of which, the Moss Bluff Dome, is located on the Trinity River in Liberty County. Sulphur production in Texas during 1959 was over one-half of the national total.

61. Water.- In relation to future needs, water is the most important natural resource of the area. The residents of the southwest region made a rather late start toward conserving their water resources. Like most frontier people, they took an adequate water supply for granted and, only with the rapid growth of urban population in the last 20 years, has there been a realization that an adequate future water supply was one of the area's big problems. A critical drought, which occurred in this area during the period 1950-1957, caused restriction on uses of water in about one-half the incorporated cities and towns in Texas and demonstrated the seriousness of the water problem. The Trinity River Basin has less length and drainage area than several other Texas river basins, but due to the moderate to heavy rainfall occurring over its drainage area, the flow near its mouth is exceeded only by the Sabine and Neches Rivers. In addition to surface waters, a large portion of the basin is underlain by great natural underground water reservoirs. These ground water supplies have played a tremendous part in the economic development of the area, furnishing water for municipal and industrial needs and irrigation. The five major sources of underground water are the aquifers of the Trinity, Paluxy, and Woodbine sands; the Carrizo Sand and Wilcox group; the Gulf Coast aquifer; the Ogallala Formation; and the Alluvial deposits.

62. The development of water as a natural resource will continue to be a major requirement in providing for the rapid growth and industrial activity of the area. About two million residents of the Trinity River Basin are currently withdrawing approximately 300 million gallons a day from ground and surface water sources to satisfy their needs. As the population continues to expand along with higher living standards during the next century, ever greater demands will be placed on the water resources of the basin.

63. Maintenance of water quality and reduction of stream pollution are essential elements in the future use of water as a natural resource. With the future large expansion of population and industrial activity and the resultant increased waste loads, more attention must be directed to the maintenance of acceptable water quality, either through direct reduction of waste loads or by dilution

from increased stream flow. Failure to recognize and cope with the water quality problems could well result in a barrier to full development of the economic potential of large sections of the basin.

64. Fish and wildlife.- The fish and wildlife resources of the basin proper are important primarily as a basis for hunting, fishing and other outdoor recreation. The commercial fish harvest from the Trinity River is not large. However, flow from the river into Trinity Bay tends to maintain a proper salinity balance with ocean water and create a favorable habitat for various species of commercially important marine life found in the coastal bays and offshore waters of the Gulf. Of the marine products taken by commercial fisheries, shrimp has the largest monetary value but menhaden, a fish used for meal and oil, is the greatest in volume, with about 100 million pounds harvested in 1959. Although fish and wildlife resources, in some of their original locations and native habitat, have declined considerably since the early pioneers settled in Texas, various changes during recent years have contributed to increase the game and fish life. The raising of stock and growing feed crops on the larger, more productive farms, and the practice of allowing large acreages of marginal lands to revert to native vegetation have contributed to providing a much better wildlife habitat. Also the many reservoirs built in the Trinity River Basin during the past 30 years have provided not only increased fishing opportunity but also new habitat for both fish and migratory birds. Future economic and social factors in the area will impose an increasing demand on the fish and wildlife resources and require expanded measures for their conservation and propagation.

65. Recreation.- Because of a favorable climate for outdoor activity during much of the year and due to the tremendous economic growth, the use of water and land resources is becoming increasingly important for development of outdoor recreation opportunities. Provisions for outdoor recreation in the region vary from local facilities such as municipal playgrounds and parks, museums, and stadiums to resource-based recreation areas, selected for their superior natural features, such as National and State Parks and Monuments. However, in this report, the emphasis is placed on water-oriented recreation areas because it is inherent in river basin planning and development.

66. The development of water and related land resources for recreation not only fulfills a need for the social well being of the people but it also contributes to the future economic growth in the local areas where this development takes place. There is substantial demand for water-based recreation facilities, particularly in the upper Trinity Basin near the Dallas-Fort Worth complex. It is anticipated that the expansion in recreational facilities and opportunities for commerce as a result of the development of water resources, together with favorable labor and raw materials supplies, will attract industry and investment in many forms to the area.

Recreation associated with major water resources projects attracts outside investment in a number of ways. Particularly significant are the following:

a. Recreation attracts visitors who in the aggregate spend large sums at lakeshore resorts and service establishments.

b. Recreational visitation induces private investors to put money into overnight accommodations, marinas, and other recreation-related sales and service facilities.

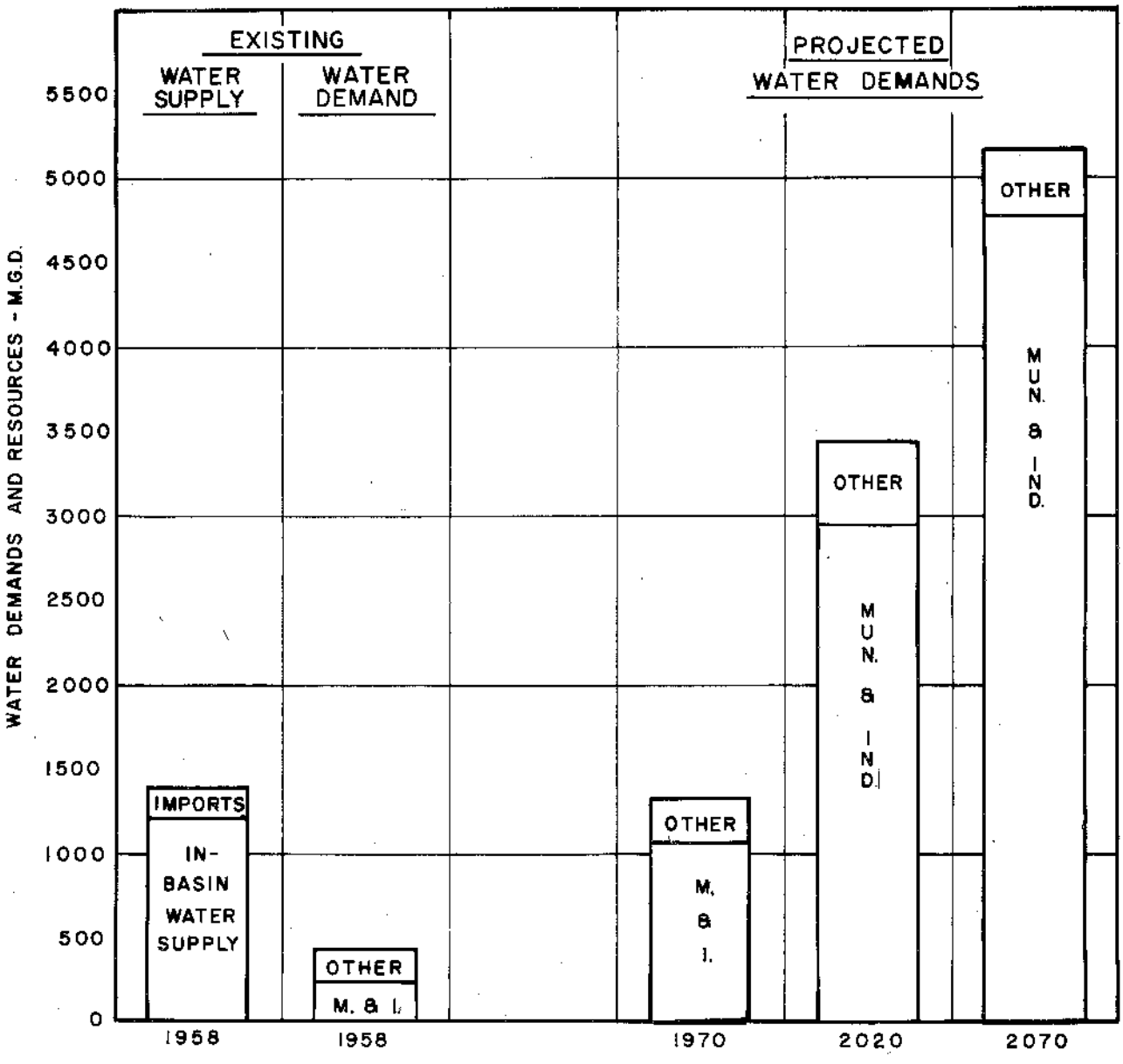
c. Recreational aspects of projects attract newcomers to the reservoir area who construct homes and cabins for themselves on or near the shore lines.

d. Industry is attracted to an area because of the favorable recreational opportunities afforded its employees, even though the industry itself may not be a heavy water user.

RELATION OF THE ECONOMIC DEVELOPMENT TO THE WATER AND RELATED LAND RESOURCES OF THE BASIN

67. INTRODUCTION.- The ultimate aim of river basins programs, in common with all other productive activity, is to satisfy human needs and improve the economic and social well-being of all the people. A basic principle in this investigation is that the water and related land resources development have value only to the extent that they will be needed. The previous section has shown that a portion of the Trinity River Basin is rapidly developing into one of the major urban-industrial areas of the United States. Other areas of the basin and adjacent study area, although potentially favorable for development, have been retarded because of various factors, some of which are water associated. The magnitude of the demands for water resources development and control in the Trinity River Basin is based on the past and present uses as related to the economic activities of the study area and the broad projections of future economic growth. The development and control of the water and related land resources that would contribute to the area's growth and anticipated economy were planned to assure a balanced program of resource development. In the over-all evaluation of the demands on water resources, consideration was given to all available information on present and projected needs as developed by the State of Texas and other Federal agencies, the wishes of local interests as expressed at public hearings, and the directives from Congress for this investigation.

68. DOMESTIC, MUNICIPAL, AND INDUSTRIAL WATER SUPPLY.- The projected widespread increase in population and industrial expansion must of necessity be closely supported by a water supply that is not only sufficient in quantity, but suitable in quality and at a reasonable cost. In the Trinity Basin, the principal problems in meeting these requirements are supplies, distribution, water quality, and variability of flow, all of which will become more acute as the population and economy grow. Water supply in the basin can be a problem if water resources are not developed sufficiently in advance to satisfy projected needs and becomes an acute situation when the demands exceed the available resources. In the Trinity River Basin, as shown on figure 17, about 235 million gallons of water per day were used in 1958 for municipal and industrial purposes. It is anticipated that this requirement will multiply many times in the future. For instance, by year 2020 the requirements will be more than 12 times the 1958 use and by year 2070 the need will have increased to more than 20 times the 1958 use. It is estimated that existing and under-construction water resource developments for municipal and industrial purposes, including present ground water usage and importations and assuming the Soil Conservation Service program in operation, will produce about 1.4 billion gallons of water per day. These supplies are more than



NOTE:
REQUIREMENTS FOR IRRIGATION, NAVIGATION AND WATER QUALITY CONTROL INCLUDED AS "OTHER."

FIGURE 17

TRINITY RIVER BASIN

EXISTING AND PROJECTED WATER DEMANDS

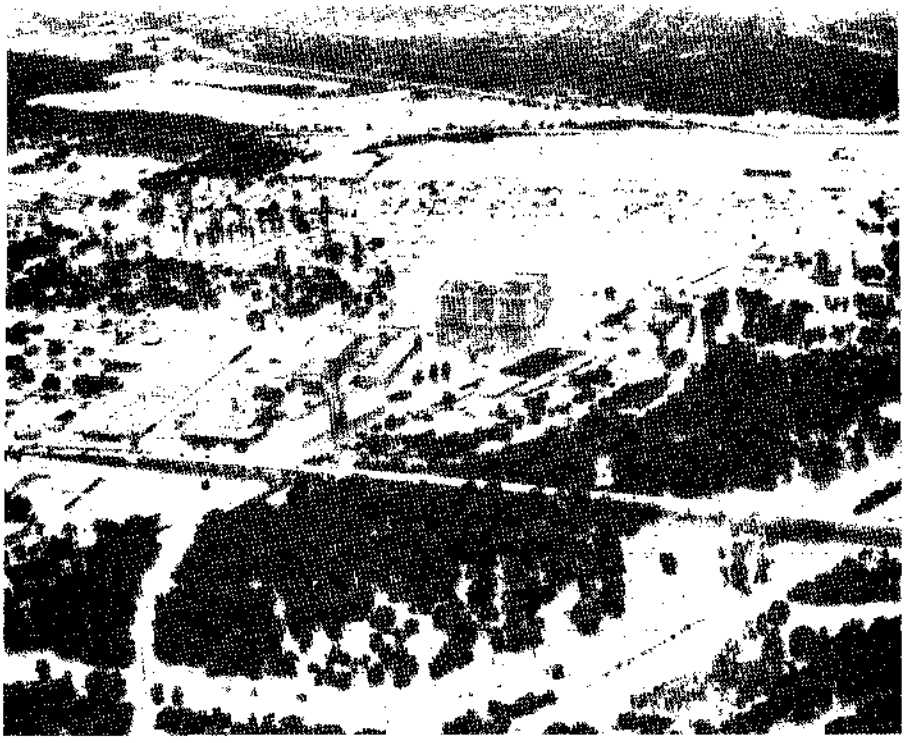
adequate to satisfy the projected municipal and industrial demands in the upper and lower basin until about the year 1970. As the need arises in certain areas to satisfy the increasing population and industrial expansion, additional successive increments of water resources can be developed. These developments may include additional reservoir projects in the basin, more efficient use of return flow, increased ground water use, and additional importations.

69. FLOOD CONTROL.- The Trinity River Basin, like many others in the State of Texas and throughout the country, experiences at various intervals the natural phenomena of floods -- too much water. This problem dates back to the earliest settlements located on the level flood plains along the main stem and principal tributaries. Many of the early settlers built small levees to protect their property but invariably the levees were overtopped. Later, local organized groups in the form of levee districts, and finally the Federal Government took an interest in the flood problem and their efforts have grown until flood control has become one of the major public works activities. The battle between man and streams for possession of flood plain lands has been long and costly. There are many influencing factors which contribute to the complexity of the problem, such as: the unrelenting efforts of man to wrest valley lands from the streams to which, under the laws of nature, they belong; the attractiveness of the flood plain which causes man to overlook or ignore the threat of flood damage and use this area for homes, industry, and agriculture, the lesser cost of building on relatively flat valley bottoms and partial protection from flooding which encourages greater use and development of the flood plain. Flood scenes in the Trinity River Basin are shown on figures 18 and 19.

70. There are many areas throughout the Trinity River Basin with an abundance of natural resources and development opportunities, such as the middle section, which have only limited development primarily because these areas are subject to frequent flooding. These areas will prosper only when the flood problems have been eliminated. An outstanding example of what may be achieved by elimination of a flood threat and through planning foresight and personal initiative can best be demonstrated by what has taken place at Dallas, where an agricultural area in a relatively few years has been converted into a tremendous industrial development.

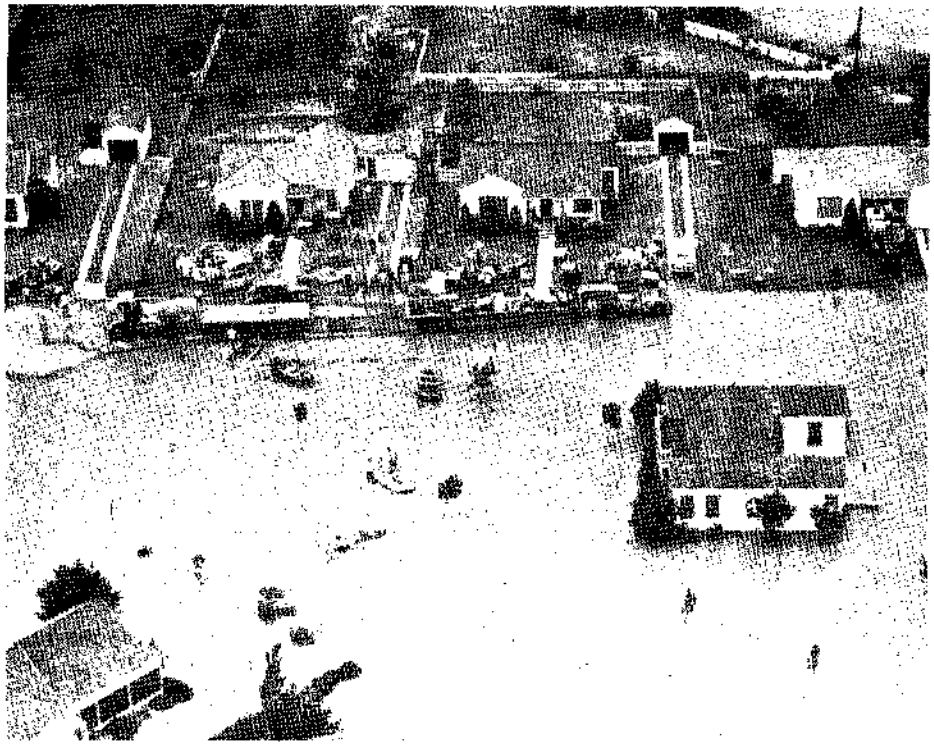
71. In the Trinity River Basin there are about 1,550,000 acres of land subject to being flooded, of which over 830,000 acres are situated along the main stem and lower reaches of the principal tributaries and the remaining 720,000 acres are in the headwater tributary streams. The 720,000 acres subject to flooding on the headwater tributaries will be considered for protection under the runoff and waterflow retardation and soil erosion prevention programs of the Soil Conservation Service. Of the 830,000 acres subject to flooding on the main stem and principal tributaries, about 225,000 acres are, or will be, afforded a high

FLOOD OF APRIL-JUNE 1957 ON
RICHLAND CREEK NEAR CORSICANA, TEXAS



1949 FLOOD ON THE CLEAR FORK AT FORT WORTH

FIGURE 18



WEST FORK TRINITY RIVER – MAY 1949

BIG FOSSIL CREEK—APRIL-JUNE 1957

FIGURE 19. URBAN FLOOD SCENES
VICINITY OF FORT WORTH, TEXAS

degree of flood protection by existing, authorized, and previously recommended Corps of Engineers projects. Flood protection to the remaining 605,000 acres of flood plain is considered in this report. This flood plain consists of 586,400 acres of agricultural land and 18,600 acres of urban and suburban development. The annual value of crops produced in the flood plain under present conditions amounts to about $17,250,000. The total value of physical property in this flood plain is about 327 million dollars under present conditions of basin development. With the projected widespread increase in population, industrial expansion, and service facilities, this value is expected to increase without additional flood control works, to about 1, 3.5, and 5.4 billion dollars in 1970, 2020, and 2070, respectively, as shown on figure 20.

72. In the basin a number of multiple-purpose reservoir and local flood protection projects, as shown on figure 1, have been constructed over a period of years in an attempt to alleviate the flood problem on the main stem and principal tributaries. Many of these improvements such as the reservoir projects on the West Fork of the Trinity River and numerous levee projects in the upper basin have been developed by local interests for flood protection. The value of such flood protective works was demonstrated by the 1957 flood, during which Corps of Engineers projects alone prevented damages estimated at about 85 million dollars. The April-June 1957 flood, which caused flooding throughout the entire Trinity River Basin, resulted from a series of storms which occurred over a period of about three months. This flood was one of the most damaging in the history of the basin and caused damages estimated at $19,500,000. Economic studies indicate a tremendous population and industrial expansion in the Trinity River Basin during the next century. Based on this projected growth, a recurrence of the April-June 1957 flood, with existing and authorized protection, would cause damages estimated as follows:

Date	Estimated Damage (Dollars)
1960	15,200,000
2020	163,600,000
2070	251,100,000

73. The average annual damages on the Trinity River and principal tributaries under 1960 conditions of flood plain protection and development are estimated to be about $3,000,000. The average annual damages on the 605,000 acres of flood plain studied in this report under 1960 conditions of economic development based on existing, authorized, and previously recommended flood-control projects are estimated to be about $2,300,000 as shown on figure 21.

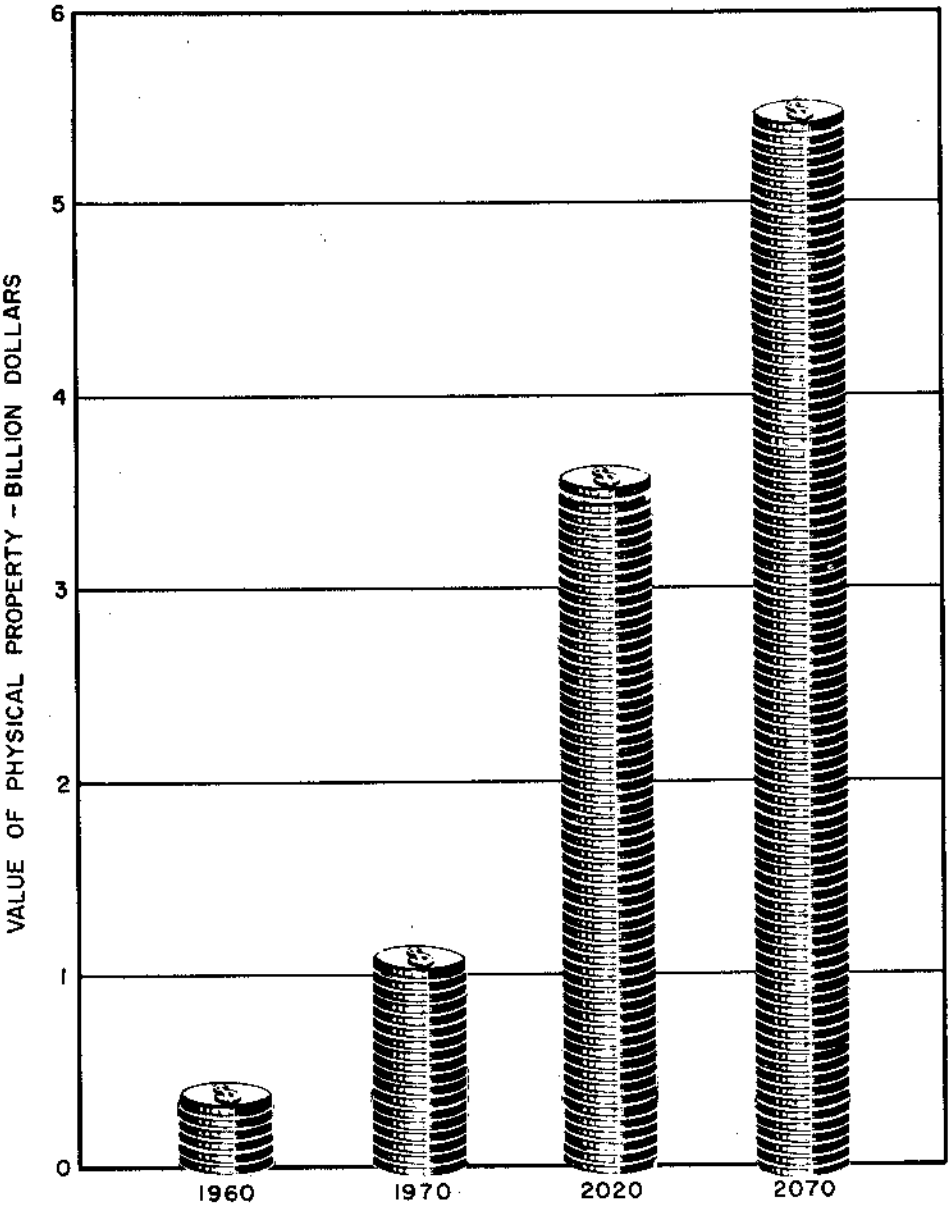


FIGURE 20

VALUE OF PHYSICAL PROPERTY IN FLOOD PLAIN
UNDER 1960 FLOOD-CONTROL PROJECT DEVELOPMENT
MAIN STEM & PRINCIPAL TRIBUTARIES

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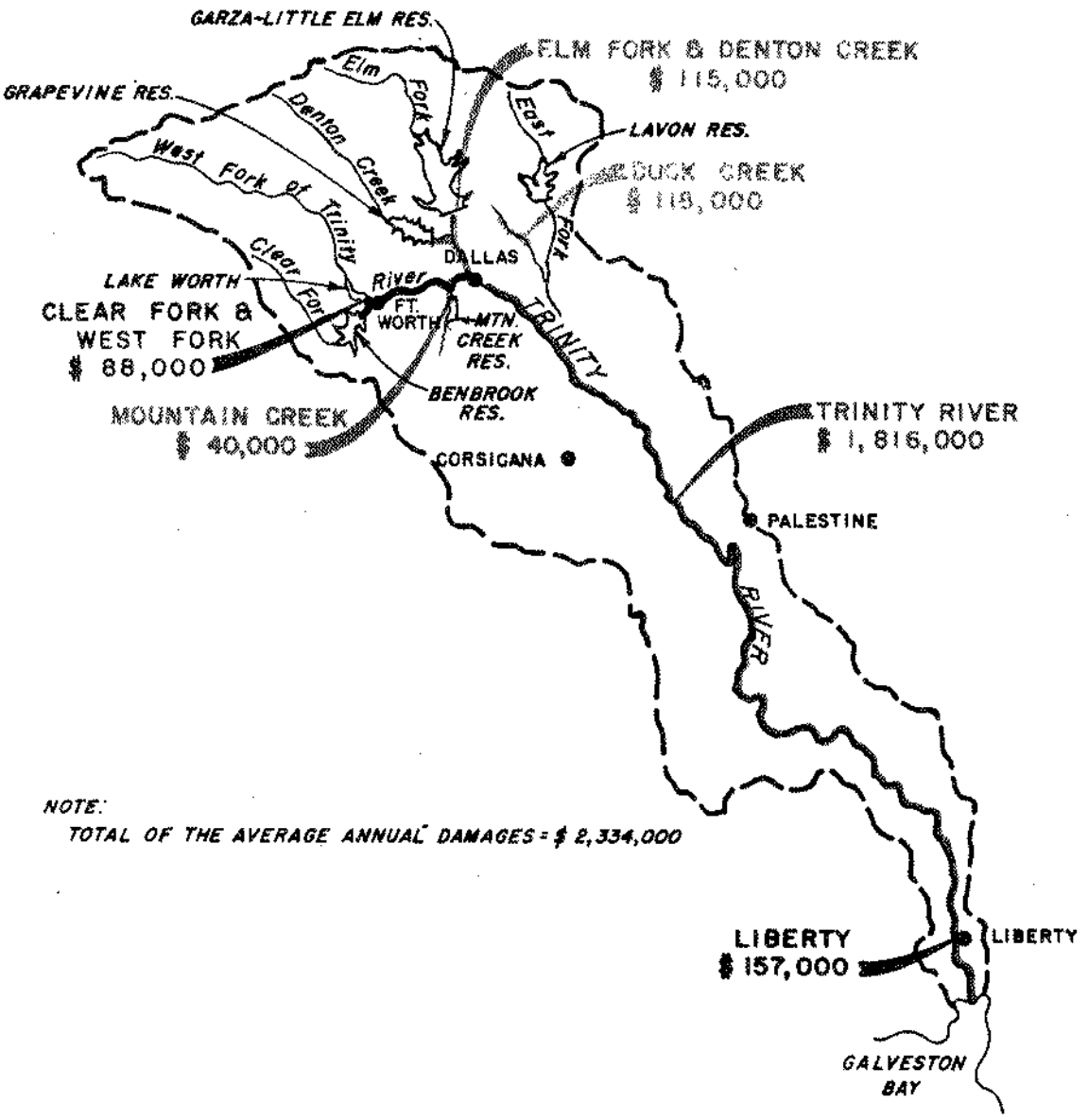


FIGURE 21

AVERAGE ANNUAL FLOOD DAMAGES

UNDER 1960 FLOOD-CONTROL PROJECT AND ECONOMIC DEVELOPMENT

MAIN STEM AND PRINCIPAL TRIBUTARIES

74. The present and future flood problems of the basin may be most effectively prevented by protective measures, such as reservoirs, local flood protection projects, channel improvement works, levee systems with appurtenant interior drainage facilities, and land treatment and water retardation programs. The flood control effectiveness of these works of improvement would be enhanced tremendously through the flood forecasting and improved flood warning systems of the U. S. Weather Bureau and flood plain information studies of the Corps of Engineers.

75. NAVIGATION.- The economic development of an area is greatly stimulated by a complete transportation complex that includes all forms of transportation including navigation. The need for a navigable waterway is dependent upon sufficient volume of those commodities that can be moved at a savings by this form of transportation. The prime requisite for efficiency in barge transportation is consolidation of large volumes of freight at one point. Waterway service is generally restricted to a fairly limited range of commodities which are mostly bulky and, in many instances unprocessed items, which constitute well over half of the total goods moving in the United States. Bulk grains, metal ores and manufactured products, thermal energy fuels and unprocessed non-metallic minerals are typical commodities particularly adaptable to low-cost waterway transportation. Waterway transportation offers the only feasible method of transporting some of the enormous and complex mechanisms that are being assembled and must be transported long distances in the country's rapidly expanding scientific development. The location, resources and trends of economic development of the Trinity River Basin are favorable to the generation of large volumes of commerce in these commodities. The nation's principal grain belt lies to the north and northwest of the basin. A continuous flow of export grain moves southward by rail and truck to deepwater ports on the Gulf Coast. The industrial complexes of the Dallas-Fort Worth and Houston areas generate large movements in both directions of raw and semi-processed materials, manufactured products, bulk chemicals, petroleum and petroleum products. Water transportation would make the extensive deposits of lignite and coal in the basin available to supply the demands of Texas and the Nation for energy as fossil fuels become more competitive with petroleum, natural gas and other forms of energy. There are large deposits of stone, sand and gravel in the basin that, with low-cost barge transportation, would be extensively developed and worked for outside markets. In view of the superiority of water transportation for some elements of the mass transportation market, an objective evaluation was made of the need, prospective use and economic feasibility of the waterway.

76. Potential use of waterway.- To evaluate the potential commerce for a navigable Trinity River Waterway, a field canvass and traffic survey was made of a 178-county area in Texas and Oklahoma. The traffic area was delineated after study and analysis of the existing tariff rates and points of origin and destination for movement of selected commodities, known to be adaptable to barge movement and susceptible to routing, either wholly or in part, on the proposed Trinity River Waterway. The field canvass, completed late in 1958, was made by traffic and transportation

specialists and included personal interviews and correspondence with about 2,000 potential shippers and receivers throughout the traffic area. The survey also included a canvass of major shippers presently using the extensive inland waterway system, with which the proposed Trinity River Waterway would connect at the Houston Ship Channel. The principal coastal and inland waterways of the eastern United States are shown on figure 22. The growth of commerce on Texas waterways between 1950 and 1959 is shown on figure 23. It is pertinent to note that the growth experienced by the Gulf Intracoastal Waterway traffic increased by over 50 percent in the decade from 1950 through 1959. Similar increases were evidenced in the barge traffic of the major deepwater ports of Texas.

77. The traffic survey developed a total of 114 separate commodities in 10 major classifications that were adaptable to waterborne commerce and moving in the traffic area in sufficient amounts to warrant consideration as potential commerce. The potential in 1958 for barge movement of these commodities if a navigable waterway existed from the Houston Ship Channel to Fort Worth was estimated at 45 million tons annually.

78. Prospective commerce.- The 1958 potential of 45 million tons was subjected to a rigorous screening out of those commodities that would not move on the waterway. Certain potential commerce was eliminated for one or more reasons, including the following: apparent duplication of tonnages reported by shippers and receivers; excessive circuity of routing; not adaptable to barge transportation because of special handling requirements, insufficient total volume shipped or necessity for small, frequent shipments; more probable movement on other waterways and little or no savings by water transportation because of existing tariff rate consideration or comparatively large transfer and handling costs. The residual potential commerce then was subjected to a rate analysis process. Special studies of the prospective movement of sand, gravel, stone and grain were made. Of the 45 million tons of potential 1958 commerce, 38,078,000 tons were eliminated to leave a total of 6,922,000 tons of prospective commerce that would move by barge if an improved channel existed along the river. The commerce considered to be presently prospective comprises 42 commodities in 9 major classification groupings and is shown by direction of movement in table 5.

79. Of the 42 commodities included in the nine classes of accepted prospective commerce, the principal ones are 2,210,000 tons of downbound grain (item 2); 2,934,000 of sand, gravel and stone moving in both directions (included in item 6); 709,000 tons of upbound iron and steel articles, and 314,000 tons of downbound iron and steel scrap (included in item 7). These commodities comprise about 89 percent of the total prospective commerce. About 19 percent of the total upbound commerce would originate on the Ohio and Upper Mississippi River inland waterways system, 10 percent would originate on the Gulf Coast at and east of New Orleans, with the remainder originating along the Texas coast and the Trinity River. Most of the downbound commerce would terminate along the Gulf Coast west of New Orleans, either for domestic use or for export through the deepwater ports of Houston and Galveston.

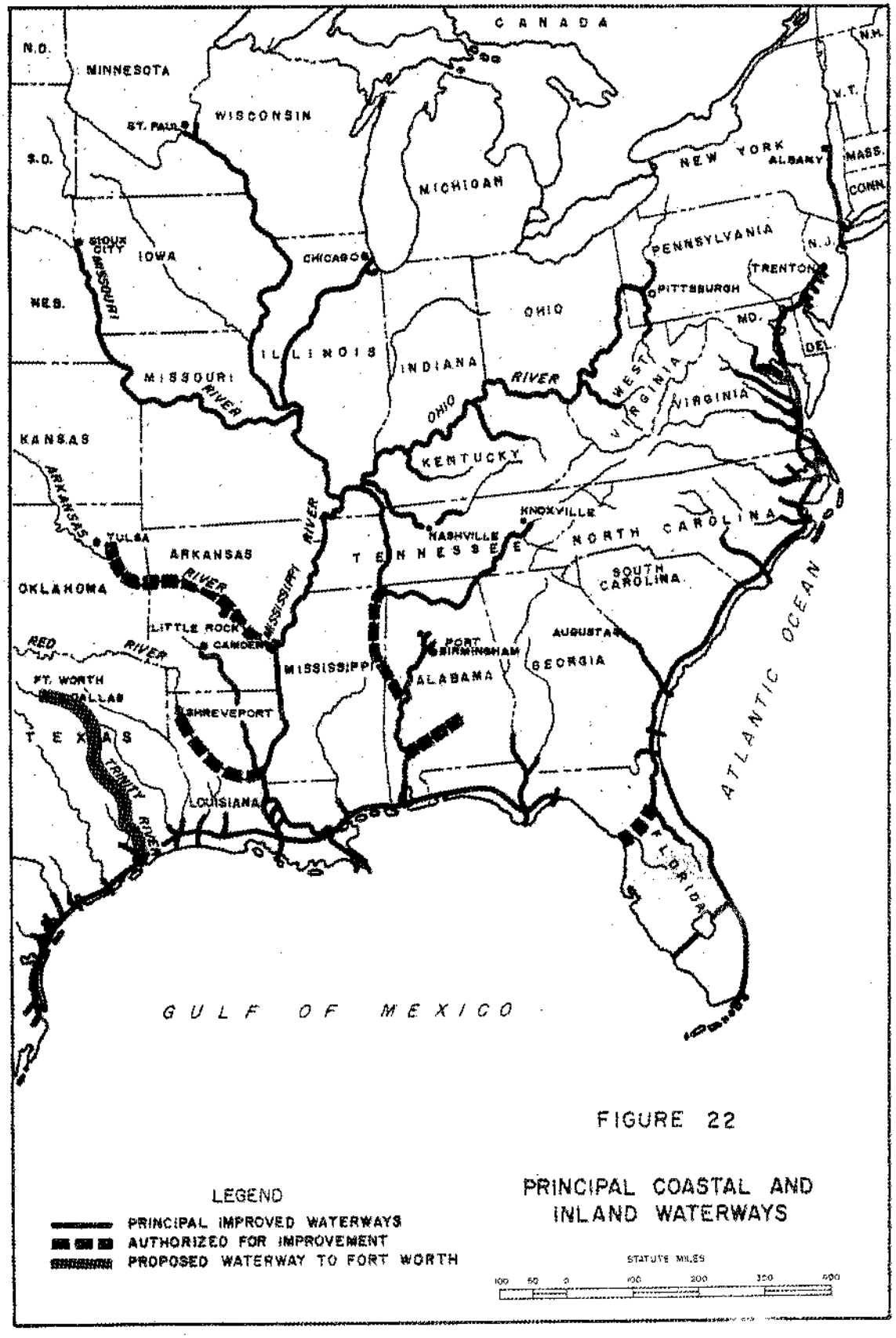


FIGURE 22

PRINCIPAL COASTAL AND INLAND WATERWAYS

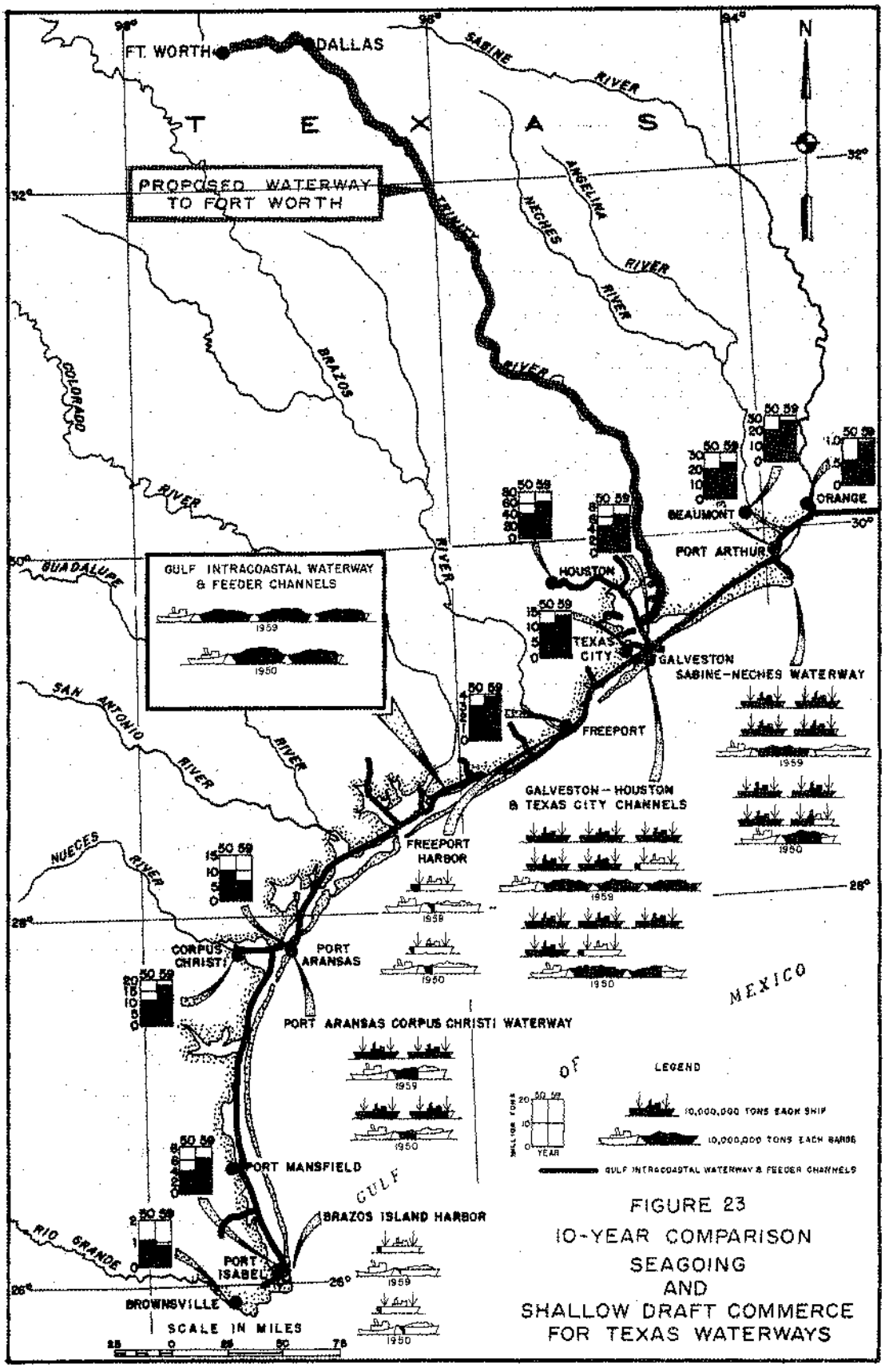


FIGURE 23
10-YEAR COMPARISON
SEAGOING
AND
SHALLOW DRAFT COMMERCE
FOR TEXAS WATERWAYS

TABLE 5

1958 PROSPECTIVE WATERWAY COMMERCE
BY MAJOR CLASSES OF COMMODITIES

Item	Class of Commodity	Annual prospective waterway commerce		
		Upbound (tons)	Downbound (tons)	Total (tons)
1	Animal & animal products, inedible	62,000	-	62,000
2	Vegetable food products & beverages	-	2,210,000	2,210,000
3	Vegetable products, inedible, except fiber & wools	121,000	-	121,000
4	Textile fibers & manufactures	6,000	2,000	8,000
5	Wood & paper	153,000	-	153,000
6	Non-metallic minerals	1,171,000	1,838,000	3,009,000
7	Metals & manufactures, except machinery & vehicles	712,000	365,000	1,077,000
8	Chemicals & related products	166,000	113,000	279,000
9	Miscellaneous	3,000	-	3,000
	Totals	2,394,000	4,528,000	6,922,000

80. Projected prospective commerce.- The anticipated expanding economy of the basin would increase the prospective commerce on the waterway and in turn would be accelerated by the availability of water transportation. In order to estimate the prospective waterborne commerce over the life of the project, an extensive study was made of the basic economy of the basin and its future development. Basic economic factors closely related to the commodities comprising the waterway traffic were selected and the history and growth of these factors were projected over the life of the project. Indicators were developed from the projections of these growth factors and applied to the related groups of commodities in the 1958 commerce to determine the projected waterway commerce. The total prospective commerce so developed for the proposed waterway to Fort Worth amounts to 8,828,000 tons in 1970, 22,903,000 tons in 2020, and 72,080,000 tons in 2070.

81. The Trinity Improvement Association in 1957 completed a preliminary survey of prospective barge commerce for a modern, canalized waterway extending in the Trinity River from the Houston Ship Channel to Fort Worth. The Association found prospective commerce of 8,270,000 tons upbound and 5,669,000 tons downbound, or a total prospective movement of 13,939,000 tons annually. The prospective commerce developed by the Association comprised 10 general classes of commodities and more than 75 separate commodities.

82. At the public hearing held in Fort Worth, Texas, on

December 20, 1961, when features of the preliminary plan then being considered for inclusion in this report were presented to local interests, representatives of the Texas Railroad Association spoke in opposition to the proposed navigation improvement and gave the Association's estimates of prospective commerce on the proposed waterway. Assuming the waterway had been in existence during the year 1959 and that prospective commerce was fully developed, the Association estimated that the commerce would have totaled 2,587,000 tons. This prospective commerce comprises twelve commodities, ten of which are included in and account for 91 percent of the total prospective commerce developed for this report. The three largest items in each estimate account for about 72 percent of the difference. Of these the Association allowed 66 percent of the sand and gravel, 26 percent of the grain and 22 percent of the iron and steel,except pipe, for a total of 2,446,000 tons compared to 5,586,000 tons. For the 50-year period 1971-2020, the Association estimates an average annual prospective commerce of 5,751,000 tons. Assuming a uniform annual increase from 1959 this estimate would result in about 9,900,000 tons of commerce in 2020 or about 45 percent of the estimate developed in this report.

83. IRRIGATION.- The development of the basin has progressed from an agrarian beginning to the present economy which includes substantial urbanization and industrialization. During the next century, the projected development of the basin will have a marked effect on the agricultural economy of the basin. Irrigation is one of the many resource development opportunities which will be used to increase future food and fiber production. In the Trinity River Basin and adjacent coastal area, about 68,000 acres of land were irrigated in 1958 with a total water use of about 165,000 acre-feet. Present surface-water irrigation is concentrated largely in the lower basin where water is diverted from the Trinity River for rice production. There is some additional surface water irrigation on numerous small tracts scattered along the Trinity River below Dallas and along several tributaries. In addition to the surface-water irrigation there is some ground-water irrigation in the lower portion of the basin and on small, scattered tracts throughout the basin.

84. Based on the projected population and industrial expansion and increased water demands in the Trinity River Basin, it is believed that irrigation in the future will remain about the same except along the Trinity River below Dallas. A study of available land resources revealed that about 42,000 acres between Dallas and the Tennessee Colony Reservoir site; about 49,000 acres between that site and the Livingston Reservoir; and about 80,000 acres in the lower basin and in the adjacent coastal area for a total of 171,000 acres are physically suitable for sustained permanent-type irrigation and production of agricultural crops and have been considered in the overall plan of development for the basin. The projected water requirements for irrigation of these areas are 356 million gallons per day or about 399,100 acre-feet per year.

85. Existing appropriative water rights and permits provide for the future irrigation of 80,000 acres in the lower basin and adjacent coastal area. However, in the interest of developing the remaining 91,000 acres of land along the Trinity River, consideration was given to Federal project-

type facilities. From a study of these areas, the Bureau of Reclamation concluded that since the areas lie in scattered tracts along the river, they are best suited for development by individual landowners rather than large project-type irrigation. However, information furnished by the Soil Conservation Service indicates that some irrigable areas are well-adapted to small project-type development under Public Law 566, as amended. The municipal and industrial return flows from the Fort Worth-Dallas area will provide a large sustained flow that will be physically accessible to landowners desiring to irrigate holdings along the main stem. Irrigation by local interests has been recognized as a part of the comprehensive plan and water requirements of 356 million gallons per day were included in the determination of the total water supply needs of the basin.

86. RECREATION.- The demands for outdoor recreation have greatly accelerated in recent years. Much of this recreation activity is concerned with the use and enjoyment of our water resources. Regardless of the measure used -- number of visitors to Federal and State recreation areas, number of fishing license holders, number of outboard motors in use -- it is clear that Americans are seeking the outdoors as never before. Water is a key factor of recreational development and serves as a magnet since both urban and rural areas show a strong urge for water-oriented recreation.

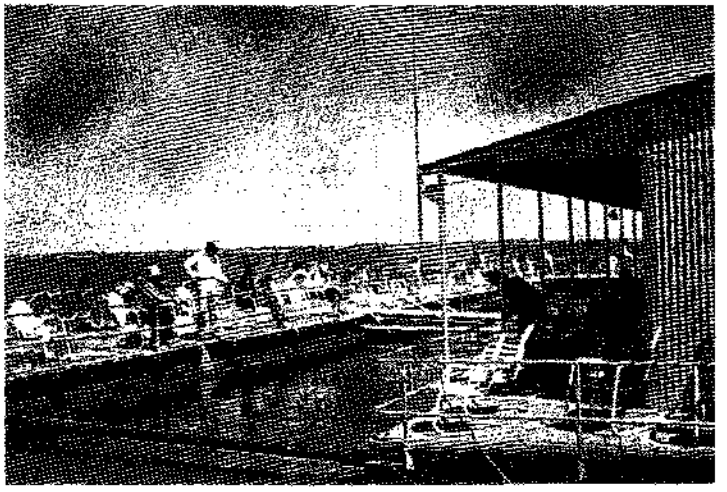
87. The general public through a better standard of living and by education and participation has found that outdoor recreation produces many benefits -- it provides healthful exercise necessary for individual physical fitness; it promotes mental health; it offers spiritual values -- for being in the outdoors can be a deeply moving experience; it is valuable for education in the world of nature; and it satisfies simple recreational needs whether they be a path to walk along, an attractive road for a drive, a place to swim, or a shady spot for a picnic.

88. The national trend of water-oriented recreational demands and activities is reflected in the Trinity River Basin. In the general area of the Fort Worth-Dallas-complex, a number of major reservoirs have outdoor recreational opportunities available. Visitor statistics are available for the four Corps of Engineers reservoirs, Benbrook, Grapevine, Garza-Little Elm, and Lavon, where the general public has free access to Federally provided outdoor recreation facilities. These reservoirs attracted over eight million visitors in 1961, with almost three million engaging in sport fishing or hunting. Scenes of general recreational activities at Corps of Engineers projects are shown on figure 24.

89. With the rapid increase in population accompanied by more leisure time and money to spend on recreation and better travel facilities, a tremendous increase in the demand for recreational facilities will occur, as shown on figure 25. By year 2020 recreational facilities will be needed to accommodate about 38 million visitors and by year 2070 about 78

PICNICKING - LAVON RESERVOIR

BOAT STORAGE - GRAPEVINE RESERVOIR



FISHING BARGE - GARZA-LITTLE ELM RESERVOIR

BOATING - GARZA-LITTLE ELM RESERVOIR

FIGURE 24
RECREATION AT CORPS OF ENGINEERS PROJECTS

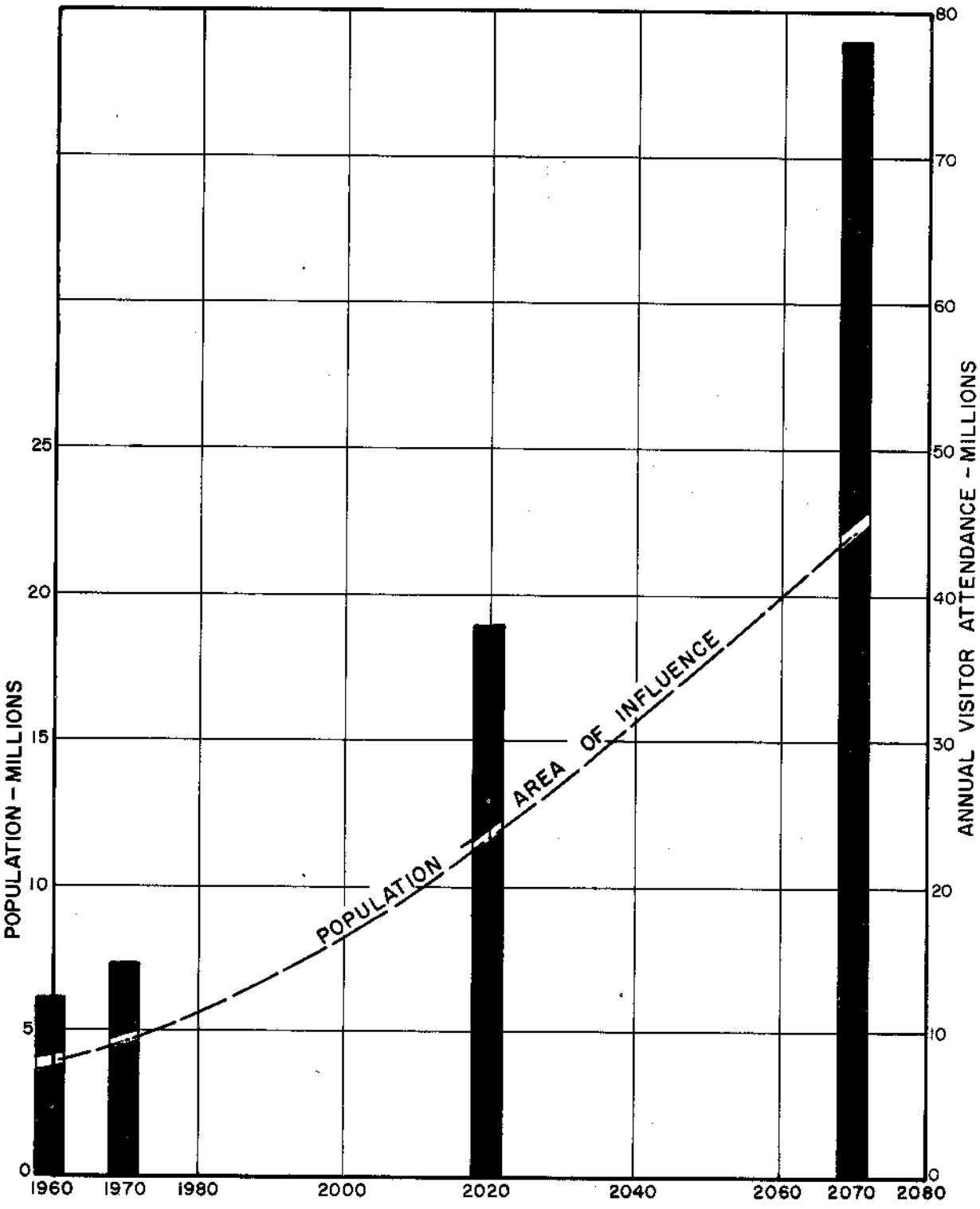


FIGURE 25

WATER BASED
RECREATION DEMANDS

million visitors. Of the total visitors participating in water-oriented activities, about 65 percent will be engaged in general recreation and about 35 percent in fish and wildlife recreation. The comprehensive plan will include development of the natural resources of each project in the interest of satisfying the projected recreational needs.

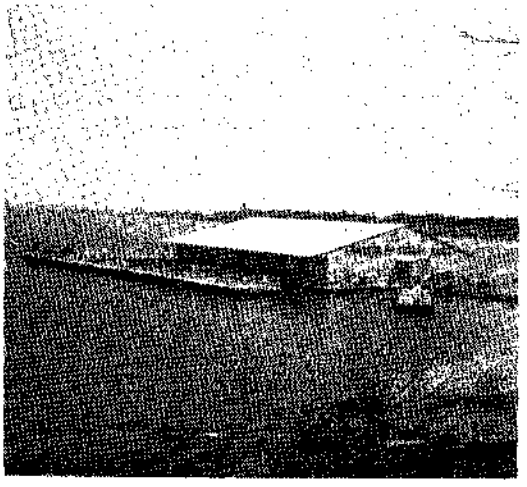
90. FISH AND WILDLIFE.- Fish and wildlife are living natural resources of the Trinity River Basin and, like other living things, they are initially associated with the land and water. A great deal is at stake in the preservation and development of our fish and wildlife resources since they are vitally important to our economy and way of living. The recreational value of fish and wildlife is of profound significance to the well-being of people, possibly even more so than the food value of this resource. In our way of life, we no longer have to hunt and fish for food, but the pleasure and sport of hunting and fishing are widely enjoyed. In an age of hustle and bustle, where the effects - both physical and emotional - from the stress of modern-day living are reflected in our daily lives, it has been stated that "fishing and hunting in the outdoors are better antidotes for modern-day stresses than the use of tranquilizer pills." The opportunity to hunt and fish will not automatically remain, and fish and wildlife resources must be considered in the overall planning for the basin. Fishing scenes on Corps of Engineers projects in the Trinity River and adjacent basins are shown on figures 26 and 27.

91. In the State of Texas and especially in the Trinity River Basin, based on statistical data compiled by the Corps of Engineers, indications are that the percentage of Texans who hunt and fish is about 10 percent higher than the national average. In the Fort Worth-Dallas complex, fishing and hunting privileges are generally available to the public on the four major reservoirs constructed by the Corps of Engineers. It has been determined that about 35 percent of the visitors to these reservoirs was either fishermen or hunters. Based on this percentage, the potential fisherman-hunter visitor attendance to projects within the basin will be about 13 million by year 2020 and about 27 million by year 2070. The projected demands for hunting and fishing opportunities generated by the growing population have been considered as an important element in the comprehensive basin plan since it is considered desirable to satisfy these requirements to the maximum extent practicable.

92. WATER QUALITY CONTROL.- The quality of water is of critical concern in planning for the use of this resource, since toxic or obnoxious pollutants may render the water unfit for human consumption and chemical or mineral pollutants may render it unsuitable for industrial and agricultural purposes. The natural pollutants of dissolved chemicals and suspended sediments are augmented by municipal sewage and industrial effluents. Water pollutants may be classified according to eight general categories: (1) sewage and other oxygen demanding wastes, (2) infectious

BENBROOK

LAVON



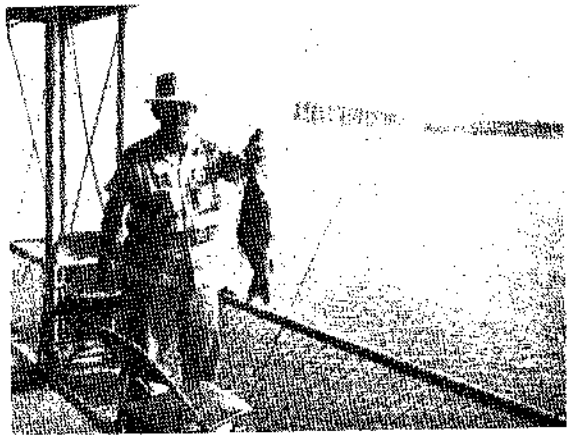
GARZA – LITTLE ELM

GRAPEVINE

FIGURE 26

FISHING AT CORPS OF ENGINEERS PROJECTS
TRINITY RIVER BASIN

DAM B



WHITNEY

DAM B

DAM B

FIGURE 27

FISHING AT CORPS OF ENGINEERS PROJECTS

agents, (3) plant nutrients, (4) organic chemical exotics, (5) other mineral and chemical substances, (6) sediments, (7) radioactive substances, and (8) heat. Although each of the above may not be an influencing factor at the present time, it is recognized that they can cause problems of great concern and will increase manyfold in the future. Quality analysis by the U. S. Public Health Service is based on broad parameters which are currently available for evaluation of present and future stream conditions. Total dissolved solids projections have been employed to characterize the effects of stable pollutants (those constituents which are not utilized or reduced by stream environment). Dissolved oxygen content is applied as a measure of unstable pollutants (those constituents which decay and act on, or are acted on, by the stream environment). Mineral content and suspended sediment are measured in parts per million of the pollutant in the water supply.

93. There is justifiable concern over the widespread and perhaps serious increase in the water quality problems resulting from the large increase of population in the Trinity River Basin. The basin population was about two million in 1960, with a projected increase to about six million by 2020 and over eleven million by 2070. A large portion of the increase will occur in the upper section of the basin.

94. The mineral quality of the Trinity River Basin can be presently described as good to very good except for the extreme lower portion of the basin in the coastal region where intrusion of salt water from the Gulf of Mexico has frequently increased dissolved solids concentrations to as much as 1,000 parts per million. The construction of the previously recommended Wallisville Reservoir will eliminate the salt water intrusion problem on the lower basin since it will act as a barrier. As development proceeds, however, waste loads will increase; demand on water will become more prevalent; and increased concentrations of mineral solids can be expected throughout the basin.

95. Above Fort Worth and below Livingston Reservoir, the organic quality of the water can be classified as good. Below the confluence of Marine Creek with the West Fork in Fort Worth and downstream to Rosser in Kaufman County, conditions in the river are generally anaerobic and associated offensive odors persist. Downstream from Rosser, sufficient tributary dilution and reaeration occur, almost overcoming the effect of the organic pollution upon reaching Livingston Reservoir. Since the 100-mile reach of the river from the vicinity of Fort Worth to below Rosser is septic at the present time and this condition will continue in view of the projected growth and development of the area, remedial measures for water quality control are urgently needed in the interest and well-being of the people.

96. SOIL CONSERVATION SERVICE PROGRAM.- The Soil Conservation Service is fully cognizant of the effect of land and water resources

on the present and future agricultural economy of the basin and is actively engaged under authority of the Flood Control Act of 1944 (PL 534, 78th Congress, 2d Session) in the development of work plans and the implementation of a Watershed Improvement Program for the reduction of flood damages and the preservation of agricultural resources. The program generally consists of two major phases of construction - the land treatment measures and the structural measures for flood prevention, sediment control, and water management.

97. An evaluation of the economic trends indicates that there is a general increase in urban expansion underway and a shift in total employment from agricultural to non-agricultural. With the population projections and urban expansions, more land would be shifted to non-farm uses which would result in less total land remaining for agriculture. It therefore becomes a significant factor that the present land and water resources must be developed for maximum utilization.

98. The Corps of Engineers and the Soil Conservation Service have for a number of years been actively engaged in developing plans and projects which are complementary in the interest of a fully developed comprehensive plan. Although considered on a comprehensive watershed basis, the Soil Conservation Service has generally concentrated its activities on the headwater tributaries, whereas, the Corps of Engineers has confined its activities to the main stem and principal tributaries. The coordinated activities of these agencies will continue to contribute to the sound economic growth and well being of the basin.

99. The Soil Conservation Service estimates the total average annual floodwater, sediment, flood plain erosion, and indirect damages in the headwater tributary areas, under present conditions of flood plain development, to be about $7,300,000. In the interest of the preservation and maximum utilization of the natural resources of the basin and to sustain the agricultural economy, the Service, in cooperation with 27 Soil Conservation Districts in the basin, has underway an effective land treatment program based on the use of agricultural land within its capabilities and its treatment in accordance with its needs. The Soil Conservation Service has prepared a number of work plans on selected subwatersheds of the Trinity River Basin in accordance with the desires of, and in cooperation with, local interests based on the needs of the basin. As a result of these work plans the Soil Conservation Service

as of January 1961 had completed about 40 miles of channel improvements and the construction of 288 floodwater retarding structures. These structures have a total storage capacity of 252,500 acre-feet, with 41,100 acre-feet for sediment storage and 211,400 acre-feet of flood detention storage.

100. The U. S. Study Commission - Texas with the realization of the tremendous projected growth in population and industrial expansion and the impact of these developments on the land and water resources and agricultural economy requested the Soil Conservation Service to develop a preliminary plan for upstream flood prevention and water resources development in the Trinity River Basin. This basin plan which includes both existing and proposed improvements indicated that soil conservation measures were justified in 26 subwatersheds comprising 21 percent of the basin and that a total of 1200 floodwater retarding structures with a total capacity of about 1,300,000 acre-feet should be provided at an estimated cost of about 61 million dollars. In addition the plan provides for about 400 miles of channel improvement at an estimated cost of about 14 million dollars or a total structural cost of about 75 million dollars.

101. POWER.- The growth of electric-generating capacity in Texas is the fastest of any state in the nation. The Fort Worth-Dallas area is the second most densely populated and industrialized area in the State of Texas and utilizes a significant percentage of the total power generated in the state. In the Trinity River Basin upstream from Trinidad where the Fort Worth-Dallas area is the hub of activities for steam-electric-generating capacity there are nine major plants with an installed net capability of over 2 million kilowatts. Through the interconnected systems of the Texas Utility Company the net capability of these plants is about 3,700,000 kilowatts. The future power needs of the Trinity River Basin can best be illustrated by what has happened during the past ten years as reported by the Texas Utility Company which services most of the Trinity River Basin. The net generating capability has increased from about one to four million kilowatts; the energy sales have grown from about 4 billion to nearly twelve billion kilowatt hours; the peak load has increased from less than one million to about three million kilowatts; and the investment in plant, property, and equipment has increased from over three hundred million to over nine hundred million dollars. The impact of the population and industrial expansion and ever-increasing demand for additional power is quite evident at the present time since substantial enlargements are presently underway at several of the existing plants.

102. Consideration was given to the development of hydroelectric power, including the use of pumped storage. The low topographic relief of the Trinity Basin is not favorable for either conventional or pump-storage projects. The requirements for use of the water resources

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for other higher priority purposes precludes development of water specifically for hydroelectric power generation or its use for power generation in conjunction with other purposes. Studies indicated that, under the most favorable conditions, hydroelectric power generation in small amounts might be economically justified in the future.

103. Power planning for the future.- The future power requirements of the basin are expected to be supplied by the utility companies as the needs develop. This conclusion is based on the progressive developments which have taken place during recent years where the Texas utility companies have pioneered in gas fired, outdoor-type generating plants with their lower construction costs and the use of progressively larger generating units which incorporate the latest refinements in operating economy. If gas becomes too expensive or is more valuable for other purposes, there are large sources of lignite and coal in the Trinity River Basin that are available for power generation. Improvement of the Trinity River would afford low cost barge transportation for the movement of coal and lignite for thermal power generation and other uses. The most recent step which has been taken to assure Texans an adequate, dependable electric power supply at the lowest possible cost is the initiation of construction of a new interconnected super-transmission line. Four Texas utilities have joined to build the southwest's largest transmission line which will extend from the Red River to Houston, and west to the Permian Basin oil fields of West Texas as shown on figure 28. This 345,000-volt transmission line will link together six and one-half million kilowatts of electric power from the 27 steam-electric-generating plants of the four companies. It will be six times greater in electric power capacity than any other line now in operation in the Southwest and will form one of the largest and strongest reservoirs of power in the United States. Construction of the new "super power highway" will result in greater security of electric service throughout the area served because generating capability available in one area can be transmitted to other areas in the event of an emergency, or should a disaster cripple any local power system. Also, it will make additional power available to meet future power requirements of a number of REA Co-operatives. Since the interconnected companies will be able to install even larger generating units than those now in use, greater flexibility will be realized as to when additional generating equipment will be installed because of the ability to exchange power between systems. Consumptive water use for cooling requirements for projected thermal power generation in the basin is provided in the comprehensive plan.

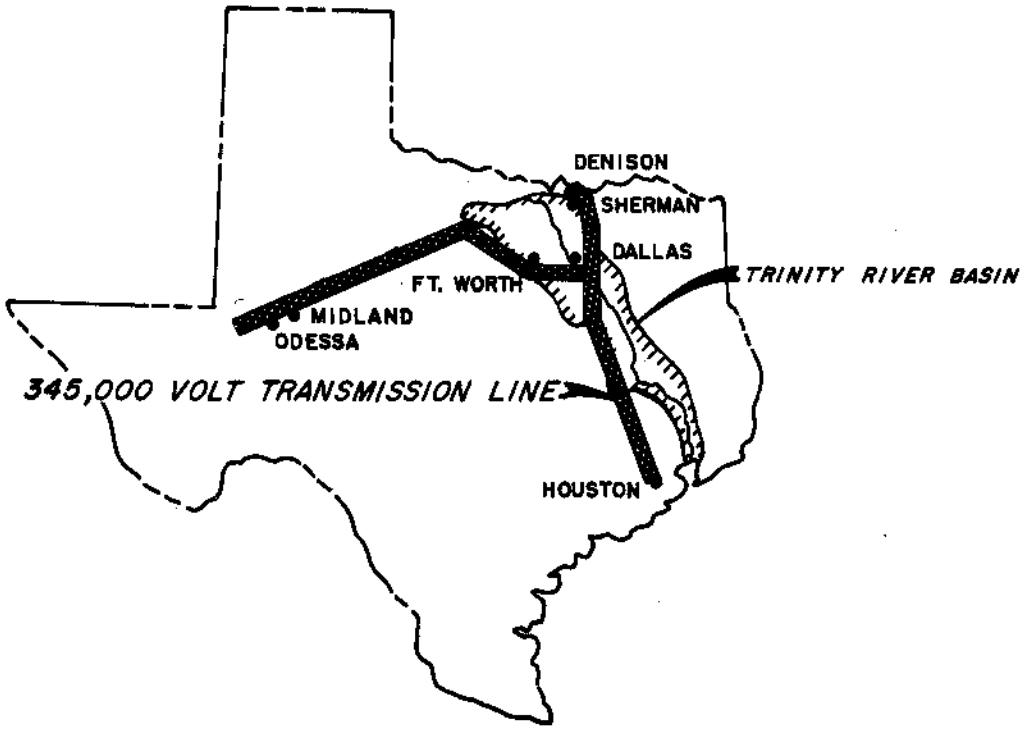

FIGURE 28

104. DRAINAGE.- The lack of adequate drainage restricts the optimum use of considerable acreage of agricultural lands in the Trinity River Basin. The Soil Conservation Service and the Corps of Engineers studied the magnitude of this problem in 1961 in connection with the U. S. Study Commission - Texas investigation. It was found that a drainage problem existed on about 1,570,000 acres, or 14 percent of the total land area in the basin. In addition, about 375,000 acres, mostly in Chambers and Liberty Counties, located just outside the basin near the mouth of the river have drainage problems. Within the basin, the slowly drained areas are relatively narrow bands paralleling the river and its principal tributaries.

105. The heavy black clay soils of the bottom lands have low permeability and are frequently inundated. Various obstructions, such as sediment, natural levees or flood debris, often block small tributary channels as well as the network of old river channels. Such obstructions cause ponding of floodwaters or runoff for extended periods and frequently result in high water tables. Local

drainage efforts in some parts of the basin have aggravated the drainage problem in downstream areas. At some points, drainage is blocked or slowed by roads and railroads. In most of the valley, the topography is virtually flat and runoff from higher lands concentrates in the numerous swales and pocket areas and creates high water tables. Most crops can tolerate only limited periods of waterlogging or inundation, usually not over 24 to 30 hours. The Coastal Prairie land used for rice production in Chambers and Liberty Counties just outside of the basin accounts for practically all of the slowly drained land that is now under cultivation.

106. Lands feasible for drainage.- Of the total land within the drainage problem areas of the basin, it was estimated that about 37,000 acres are now adequately drained and that drainage is feasible on about 449,000 additional acres, making a total of 486,000 acres or 31 percent of the total problem areas that has been or could be adequately drained. Of the 449,000 acres feasible for drainage, about 233,000 acres would require group drainage consisting of a system of lateral ditches to collect and carry farm drainage to the natural streams that usually serve as major outlets and about 158,000 acres would require improvement of the major outlets.

107. It is inevitable that many developments associated with industrialization, housing, commercial enterprise, and recreation will be made on lands now classed as agricultural, including some of the drainage problem areas. Such developments will remove these lands from the problem field of agricultural drainage but may intensify the drainage problem. With the construction of buildings, driveways, streets, sidewalks and other non-permeable areas of urban development, the more rapid runoff of rainfall frequently creates drainage problems in the areas of low elevation. Generally, the local communities and agencies of local government provide facilities for adequate drainage of problem areas within their jurisdiction.

108. Plans for future drainage.- Adequate surface drainage of agricultural wetlands requires a complete on-farm system of drains usually accompanied by construction of a group lateral collection and disposal system and enlargement and improvement of the major outlets. Generally, individual landowners are expected to provide the on-farm system. Local or state government agencies are expected to carry out detailed overall planning and provide the lateral collection and disposal system. The Soil Conservation Service upon request, may provide technical and financial assistance in planning and installation of works of improvement. With the specific authorization of Congress, the Corps of Engineers can plan and construct major outlet improvements in cooperation with local interests. As local drainage facilities are improved by local farmer groups and under Soil Conservation Service programs, it is probable that some of the major drainage

outlets will also require improvement. As such problems develop, it is expected that Congress, in accordance with established policy, will authorize the Corps of Engineers to investigate the individual problems and to plan and construct any necessary improvements. Although major drainage improvements are not proposed in this report, all proposed improvement works, including the navigation locks and dams, were planned with drainage in mind, so that the projects would not be detrimental to drainage and, wherever possible, would provide improved drainage conditions.

109. PLANNING CONSIDERATIONS.- The basic objective in the formulation of a plan of development for the Trinity River Basin is to provide the best use, or combination of uses, of the water and related land resources of the basin to meet all foreseeable short- and long-term needs. In planning for the best use of water and related land resources for a balanced program, the overriding determinant is the economic and social well-being of all of the people and the achievement of satisfactory levels of living. The development and control of water resources are planned on a fully comprehensive basis to include adequate supplies of water for municipal, agricultural, and industrial use; water quality facilities and controls to assure water of suitable quality for all purposes; water navigation facilities for needed transportation service; flood control measures; hydroelectric power; irrigation; drainage; watershed protection and management; outdoor recreation; and fish and wildlife protection and enhancement. Plan formulation studies require the consideration of all water problems and the interrelation of all purposes and projects to develop fully the potential of the basin.

110. Broad principles used in accomplishing the above are (a) that the elements of the plan for further control and development of the water resources of the basin would be integrated into the existing system so as to provide a balanced program; (b) that there is not a more economical means, evaluated on a comparable basis, of accomplishing the same purpose or purposes; (c) that the scale of development of each project be such as to provide the maximum excess benefits over costs insofar as practicable; and (d) that the adopted plan be capable of further expansion, as future conditions require such expansion. In addition to these broad principles, certain basic planning and design considerations for individual purposes are used in defining the final comprehensive plan of development. The more important of these basic planning and design considerations and objectives are: (1) that protection of urban areas against the standard project flood be provided if economically feasible; (2) that rural areas be afforded flood protection against a recurrence of the 50-year flood; (3) that navigation facilities should be provided in consonance with the pattern of existing and future economic development of the basin; (4) that full cognizance be given to the long-range waterflow retardation and land conservation program of the Soil Conservation Service; (5) that reservoir capacity for supplies of water be in consonance with the State of Texas' expressed policy for maximum practical development of the water resources of individual river basins; (6) that planning for supplies of water be in full agreement with existing water rights and priorities of use established by the State of Texas; (7) that future demands for supplies of water in the Trinity River Basin be satisfied insofar as practicable from

"in-basin" resources; and (8) that planning for water quality recognize the pollution problems associated with existing and future development and provide necessary measures to protect the health and welfare of the people.

111. DEVELOPMENT OF THE PLAN.- Several basic types of water control measures are considered in planning the development of the water and related land resources of the Trinity River Basin. Improvement measures include: (1) major impoundments of runoff for regulation and use in the general areas of need and to control flood flows and reduce damages in downstream areas; (2) land treatment measures, including detention structures and small impoundments in headwater and tributary reaches, to reduce flood flows and provide small pools of water for localized uses; (3) improvement of stream channels or construction of channels, ditches, and pipelines for such purposes as increasing the flood-carrying capacity of streams, providing channels adequate for navigation, draining agricultural wetlands, and providing carrying systems for transporting water to points of need; (4) levees, floodwalls, bank protective works, and other training measures to direct the flow of water for local flood protection and preserve the integrity of design flow channels; (5) locks and dams to create slackwater pools for barge navigation and provide a means of lifting and lowering vessel traffic to overcome the natural gradient of the river; (6) facilities for supplementing the available supply of surface water, such as development of ground water resources and importation of water from adjacent river basins; and (7) lands and facilities adjacent to water areas for public recreation and preservation and enhancement of fish and wildlife resources.

112. Many improvements for developing water resources in the basin have been constructed in past years by both Federal and non-Federal interests as shown on figure 1. The improvements have included all of the basic types listed above. Generally, however, the existing and under-construction facilities satisfy an immediate and, often localized, specific need. A comprehensive development plan must first weigh the effects of existing, under-construction, and definitely planned improvement measures against the total needs for all purposes; then, insofar as practicable, provide for additional improvements or modifications of existing facilities required to bring the overall program into balance and satisfy the present and future needs in the most economical manner.

113. EXISTING, UNDER-CONSTRUCTION, AND AUTHORIZED IMPROVEMENTS.- The existing Corps of Engineers reservoir program comprises six major projects, including four completed, one under-construction, and one authorized for construction. The Soil Conservation Service reservoir program provides for construction of 1,200 small flood detention

reservoirs in headwater and tributary areas, together with land treatment measures. A total of 288 small reservoirs have been completed, with the remainder to be completed before 2020. There are 107 reservoirs of all sizes that have been constructed or are under construction in the basin by various state and local government agencies and private concerns, including 18 which have storage capacities in excess of 5,000 acre-feet. The cities of Dallas and Terrell have made permanent arrangements with the Sabine River Authority for importing water from the Tawakoni (Iron Bridge) Reservoir on the Sabine River. The City of Athens has made similar arrangements for importing water from the Flat Creek Reservoir on the Neches River Basin. Imports from these sources are included as part of the comprehensive plan and are expected to total 172 million gallons per day in 2020 and 180 million gallons per day in 2070. The ground water resources within the basin were developed in 1958 to the extent of providing about 72 million gallons per day.

114. The Corps of Engineers reservoirs primarily provide flood control and water conservation storage, although two provide storage for navigation water and all of the completed reservoirs provide recreational facilities. For the most part, the non-Federal reservoirs provide water conservation storage; however, they are also used extensively for recreational purposes. Total storage available in all of the existing, under-construction, and authorized reservoirs is about 7.3 million acre-feet, about equally divided between the Federal and non-Federal reservoirs.

115. Three existing and authorized Corps of Engineers local flood protection projects will provide flood protection to portions of the cities of Fort Worth, Richland Hills, and Dallas. These projects include about 23 miles of improved channels and about 45 miles of levees, which form floodways through parts of the cities. In addition, 38 agricultural levee districts, organized under state laws, have flood protection levees in operation along the Trinity River and tributaries. There was no coordinated plan for these levees and they vary in height and size and afford varying degrees of protection to the lands protected. From time to time many of these agricultural levees have been damaged by major floods and have been restored by the Corps of Engineers under emergency flood damage repair authority.

116. The authorized project for navigation on the Trinity River provides for a 9x150-foot channel extending from the Houston Ship Channel through Galveston and Trinity Bays and the Trinity River to Liberty, Texas, a total distance of about 49 miles. The 23-mile reach extending through the bays from the Houston Ship Channel to Anahuac has been constructed but not maintained for several years. The channel was not extended into the Trinity River because of salt water intrusion problems. The existing Anahuac Channel is being maintained to provide navigation from Galveston Bay to the lower reaches of the Trinity River. The recently submitted report recommend-

ing construction of the Wallisville Reservoir also recommends a navigation lock at the dam and immediate construction of the authorized project channel upstream to mile 33.8 to connect with a spur channel owned by the Texas Gulf Sulphur Company.

117. PROJECTS RECENTLY RECOMMENDED IN SEPARATE REPORTS.- Because of urgent problems in local areas, separate reports have been submitted previously recommending enlargement of the Lavon Reservoir, near Dallas, and construction of the Wallisville Reservoir, near the mouth of the Trinity River. The Lavon enlargement would provide over 262,000 acre-feet of additional storage capacity for water conservation and recreational purposes. The recommended Wallisville Reservoir would serve several purposes, including prevention of salinity intrusion into irrigation water pumped from the lower river, water conservation, navigation, recreation, and fish and wildlife conservation. For water conservation the reservoir would be operated in combination with the Livingston Reservoir which is now under construction. Extension of the Fort Worth Floodway for a distance of about 8 miles on Clear Fork and channel improvement and rehabilitation of local levees along a 32-mile reach on East Fork have also been recommended in previously submitted reports.

118. ADDITIONAL IMPROVEMENTS REQUIRED.- The analysis of capabilities of existing, under-construction, and definitely planned improvements for development of water resources with respect to satisfying the existing and projected needs of the basin showed that additional improvements would be required. The analysis indicated serious deficiencies in satisfying both the immediate and long-range needs for flood control, navigation, and conservation of water for municipal and industrial water supply including water quality, recreation, fish and wildlife, power, drainage and irrigation. A comprehensive plan of development was prepared to include measures that would satisfy all of the foreseeable deficiencies. Irrigation development has been recognized in the proposed plan by inclusion of 356 MGD for irrigation requirements. No specific provisions for drainage are provided in the comprehensive plan although considerable work of this character is expected to be initiated by local interests with possible assistance from the Soil Conservation Service as the area develops. As this phase of development progresses, it is anticipated that studies by the Corps of Engineers will be authorized to investigate the necessity and justification of Federal participation in the construction of major drainage outlet facilities. The power requirements of the basin are expected to be generally supplied by the utility companies from thermal power generation as the need develops. Industrial water supply provided in the plan would include 570 MGD in the year 2020 for cooling requirements for the increased power generation. On this basis, improvements for irrigation, drainage, and power are not considered further in the comprehensive plan.

119. The remaining purposes to be satisfied in the comprehensive plan would require additional improvements to bring the overall system into balance and meet the present and future water and related land resources needs to the maximum practicable extent. The proposed additional improvements are separated into two categories: (1) projects in the long-range plan but not recommended for authorizations at this time, and (2) projects proposed for immediate Federal authorization, hereinafter referred to as the "Projects Recommended for Authorization." The projects included in the long-range plan, but not recommended for authorization at this time, comprise 13 reservoir projects required to satisfy the projected water requirements of the basin. It is probable that further developments may indicate needs for local adjustment or supplements to the comprehensive plan which, for the most part, can be accomplished with no loss in overall efficiency. It is anticipated that as the water requirements develop to the extent that these projects are required, further investigation will be made to assure that the developments would serve all purposes found desirable and justified at that time. The projects recommended for authorization are those improvements which, for various reasons, were found to be needed now and which, as a result of detailed analyses, were determined to be economically justified.

120. The projects in the comprehensive plan are shown on plate 1 and are summarized in tables 6 and 7. Table 6 presents pertinent data for reservoir projects in the plan and table 7 presents data for other improvements.

TABLE 6

COMPREHENSIVE PLAN - RESERVOIRS

Name	Owner	Location: Stream	Location: Mile	Total drainage area above (sq mi)	Total storage capacity (acre-feet)	Dependable yield in year 2020 MGD(1)	Purpose(2)
EXISTING, UNDER CONSTRUCTION AND AUTHORIZED							
FEDERAL RESERVOIRS							
Bonbrook	Corps of Engineers	Clear Fork	15.0	433	258,600	6.5	FC-Con-Nav-R-F&W
Grapevine	Corps of Engineers	Denton Creek	11.7	694	435,500	18.1	FC-Con-Nav-R-F&W
Garza-Little Elm	Corps of Engineers	Elm Fork	30.0	1,658	1,002,900	86.0	FC-Con-R-F&W
Lavon	Corps of Engineers	East Fork	55.9	777	423,400	35.5	FC-Con-R-F&W
Navarro Mills(3)	Corps of Engineers	Richland Creek	63.9	316	212,200	18.1	FC-Con-R-F&W
Bardwell(3)	Corps of Engineers	Waxahachie Creek	6.0	171	117,800	4.2	FC-Con-R-F&W
1,200 Small detention res(4)	Soil Conservation Serv.	(Headwater & tributary areas throughout basin)		3,679(4)	1,301,966(4)	0	FC
NON-FEDERAL RESERVOIRS(5)							
Amon Carter	City of Bowie	Big Sandy Creek	31.0	103	19,900	0	Con
Bridgeport	Tarrant Co. WC&ID #1	West Fork	626.2	1,114	270,900	50.4	Con
Eagle Mountain	Tarrant Co. WC&ID #2	West Fork	583.3	1,974	182,600	17.5	Con
Lake Worth	City of Fort Worth	West Fork	572.1	2,069	33,700		Con
Marine Creek	Tarrant Co. WC&ID #1	Marine Creek	4.7	10	15,400	0	FC-Con
Weatherford	City of Weatherford	Clear Fork	39.8	106	19,400	0.6	Con
Arlington	City of Arlington	Village Creek	8.0	136	45,700	5.8	Con
Mountain Creek	Dallas P&L Co.	Mountain Creek	4.1	289	24,200	0	Con
North Lake	Dallas P&L Co.	So. Fork - Grapevine Cr.	0.5	2.3	17,100	0	Con
White Rock	City of Dallas	White Rock Creek	12.0	99	12,300	1.9	Con
Forney(3)	City of Dallas	East Fork	31.8	1,074	490,000	58.8	Con
Tawakoni (Iron Bridge)(6)	Sabine River Authority	Sabine River	-	-	-	174.0	Con
Terrell	City of Terrell	Muddy Cedar Creek	9.8	13	8,300	0.6	Con
Trinidad	Texas P&L Co.	(7)	-	-	6,200	0	Con
Cedar Creek(3)	Tarrant Co. WC&ID #1	Cedar Creek	11.1	1,013	678,900	173.2	Con
Waxahachie	Ellis Co. WID #1	So. Prong - Waxahachie Cr.	0.5	31	13,500	1.9	Con
Halbert	City of Corsicana	Elm Creek	0.7	12	7,420	0	Con
Flat Creek (8)	City of Athens	Flat Creek	-	-	-	6.0	Con
Livingston (3)	Trinity River Authority	Trinity River	129.2	16,606	1,750,000	670.9	Con
Anahuac	Chambers & Liberty Co. Nav. Dist.	(9)	-	129	35,300	13.4	Con
RECOMMENDED FOR FEDERAL AUTHORIZATION IN PREVIOUSLY SUBMITTED REPORTS							
Lavon (enlargement)(10)	Corps of Engineers	East Fork	55.9	777	685,700	42.7(11)	FC-Con-R-F&W
Wallisville(12)	Corps of Engineers	Trinity River	3.9	17,760	55,700	(13)	Con-Nav-S-R-F&W
RECOMMENDED FOR FEDERAL AUTHORIZATION IN THIS REPORT							
Lakeview	Corps of Engineers	Mountain Creek	7.2	272	488,700	30.4	FC-Con-R-F&W
System (Roanoke	Corps of Engineers	Denton Creek	31.4	604	249,900	23.9(14)	FC-R-F&W
System (Grapevine	Corps of Engineers	Denton Creek	11.7	-	-		FC-Con-Nav-R-F&W
System (Aubrey	Corps of Engineers	Elm Fork	60.0	682	899,900		FC-Con-R-F&W-Q
System (Garza-Little Elm	Corps of Engineers	Elm Fork	30.0	-	-	65.3(15)	FC-Con-R-F&W
Tennessee Colony	Corps of Engineers	Trinity River	339.2	12,687	3,366,800	290.8	FC-Con-Nav-R-F&W-Q
RECOMMENDED FOR INCLUSION IN LONG RANGE PLAN BUT NOT FOR AUTHORIZATION AT THIS TIME							
Boyd	-	West Fork	604.7	1,707	639,200	31.7	(16)
Richland Creek	-	Richland Creek	5.2	714	1,045,200	169.3	(16)
Tehuacana	-	Tehuacana Creek	11.2	356	295,300	56.9	(16)
Upper Keechi	-	Upper Keechi Creek	11.0	486	134,500	54.3	(16)
Hurricane	-	Hurricane Bayou	7.0	91	151,900	17.5	(16)
Lower Keechi	-	Lower Keechi Creek	8.9	162	173,000	25.2	(16)
Bedias	-	Bedias Creek	19.2	327	376,700	94.4	(16)
Harmons	-	Harmons Creek	10.5	47	79,100	16.8	(16)
Gail	-	Gail Creek	25.3	91	169,900	31.0	(16)
Mustang	-	Mustang Creek	23.7	84	157,700	25.2	(16)
Caney	-	Caney Creek	7.7	74	135,600	25.2	(16)
Long King	-	Long King Creek	22.9	57	186,200	34.9	(16)
Capers Ridge	-	Trinity River	63.0	17,436	841,500	98.0	(16)

(1) Areal or primary yield in million gallons per day based on a recurrence of the 1950-1957 drought period under 2020 conditions of watershed development. For the projects where zero yield is shown these projects have been designed for watershed conditions other than year 2020 and for a period of runoff less critical than the recurrence of the 1950-1957 drought. (Does not include return flow)

(2) FC - Flood control
Con - Water supply
Nav - Navigation
R - Recreation
S - Salinity intrusion control
F&W - Fish and wildlife conservation
Q - Water quality control

(3) Under construction or authorized

(4) Totals for 1,200 reservoirs - 288 constructed, including 4 of greater than 5,000 acre-feet storage capacity.

(5) Only those reservoirs with total storage of 5,000 acre-feet or greater are listed.

(6) Import from Sabine River Basin for City of Dallas.

(7) Off-channel on left bank of Trinity River above mouth of Cedar Creek

(8) Import from Neches River Basin for City of Athens

(9) Off-channel - Turtle Bay

(10) Report not printed at this time

(11) Net increase in yield resulting from increased conservation storage

(12) House Doc. 215, 87th Cong., 1st Sess.

(13) Included with yield of Livingston

(14) Increase in yield as a result of exchange of storage with Roanoke

(15) Increase in yield from the Garza-Little Elm - Aubrey system

(16) Conservation with probable flood control and other purposes

TABLE 7

COMPREHENSIVE PLAN - OTHER IMPROVEMENTS

Project	Location: Stream or locality	Location: Mile to Mile		Type of improvement	Remarks
EXISTING, UNDER CONSTRUCTION AND AUTHORIZED					
LOCAL FLOOD PROTECTION PROJECTS					
Federal					
Fort Worth Floodway	Clear Fork	0	1.6	Channel improvement & levees	Existing
	West Fork	564.7	570.4	Channel improvement & levees	Authorized
	West Fork	551.3	564.7	Channel improvement & levees	Existing
Big Fossil Creek Floodway (City of Richland Hills)	Big Fossil Creek	0	3.3	Channel improvement & levees	Authorized
Dallas Floodway	Elm Fork	0	3.5	Channel improvement & levees	Existing
	West Fork & Trinity River	497.4	508.7	Channel improvement & levees	Existing
Non-Federal					
Agricultural levees	Trinity River and tributaries	-	-	Levees	Existing - 38 active local levee districts
FEDERAL NAVIGATION PROJECTS					
Trinity River, Channel to Liberty (9x150-foot channel)					
Houston Ship Channel to Anahuac	Galveston & Trinity Bays	0(1)	23.2(1)	Channel improvement	Constructed - not maintained
Anahuac to Liberty	Trinity River	23.2(1)	48.9(1)	Channel improvement	Authorized
RECOMMENDED FOR FEDERAL AUTHORIZATION IN PREVIOUSLY SUBMITTED REPORTS					
LOCAL FLOOD PROTECTION PROJECTS					
Fort Worth Floodway	Clear Fork	1.6	10.4	Channel improvement & levees	
East Fork Channel Improvement	East Fork	0	31.8	Channel improvement & levee rehab.	
RECOMMENDED FOR FEDERAL AUTHORIZATION IN THIS REPORT					
MULTIPLE-PURPOSE CHANNEL IMPROVEMENT					
Houston Ship Channel to Fort Worth	Trinity River & West Fork	0	369.8(2)	Channel enlargement, rectification, & navigation locks and dams	For navigation, flood control, recreation, and fish and wildlife
LOCAL FLOOD PROTECTION PROJECTS					
West Fork Floodway	West Fork	505.5	551.5	Channel improvement & levees	To connect Fort Worth & Dallas Floodways
Elm Fork Floodway	Elm Fork	0	29.4	Channel improvement & levees	Lower end connects with Dallas Floodway
	Denton Creek	0	11.1	Channel improvement & levees	
Dallas Floodway Extension	Trinity River	487.7	498.1	Channel improvement & levees	Downstream extension to Five-Mile Cr.
Duck Creek Channel Improvement	Duck Creek	10.4	17.5	Channel improvement	
Liberty Local Protection Project	Trinity River	34	44.5	Levees	

(1) Channel mile
(2) Channel mile - natural river mile 551.5

PROJECTS RECOMMENDED FOR AUTHORIZATION

121. INTRODUCTION.- To satisfy the existing and immediately prospective needs for additional flood protection, navigation, water supply including water quality, recreation, and fish and wildlife, a number of improvements are proposed for immediate authorization and construction. A multiple-purpose channel improvement is proposed from the Houston Ship Channel to Fort Worth to provide for barge navigation and to provide sufficient channel capacity to contain flood discharge releases from flood control storage in upstream reservoirs and partial control of runoff downstream from the reservoirs. A system of dams would provide a series of slackwater pools and navigation locks would lift and lower vessel traffic between these pools. The navigation pools would afford recreation and fish and wildlife benefits. Four reservoirs are proposed consisting of Roanoke (including modification of Grapevine) on Denton Creek, Aubrey (including modification of Garza-Little Elm) on Elm Fork, Lakeview on Mountain Creek, and Tennessee Colony on the main stem of the Trinity River with a wildlife refuge in Tennessee Colony and water quality control distribution facilities from Tennessee Colony Reservoir to the existing Benbrook Reservoir. In conjunction with the multiple-purpose channel improvement, levee improvements are proposed to extend and connect the Fort Worth and Dallas Floodways on the West Fork and to extend the Dallas Floodway downstream to Five Mile Creek, and to provide flood protection to the City of Liberty, Texas. Levees and channel improvements are proposed on Elm Fork to provide a floodway extending from its mouth upstream to about Carrollton, with improved channels extending further upstream to the Garza-Little Elm Reservoir and on Denton Creek to Grapevine Reservoir. A channel rectification project is proposed on Duck Creek for the protection of the City of Garland.

122. MULTIPLE-PURPOSE CHANNEL.- The proposed multiple-purpose channel would begin at the Houston Ship Channel, near Red Fish Bar, in Galveston Bay, follow the authorized Channel to Liberty project through Trinity Bay and the Trinity River to the City of Liberty, and continue along the general course of the Trinity River to the Riverside Drive bridges in Fort Worth, a total distance of about 370 miles. Spur channels would extend to turning basins at Dallas and Fort Worth. The channel would pass through the Wallisville, Livingston, and proposed Tennessee Colony Reservoirs.

123. It was determined early in the investigation that with a joint-use channel for flood control and navigation, the requirements for flood control would generally establish the final channel dimensions. The minimum dimensions of the channel for navigation are a depth of 12' and bottom width of 150' in the reach below Dallas, and a depth of 12' and width of 125' between Dallas and Fort Worth. As shown in table 8, the bottom widths and depths for the multiple-purpose channel required for

conveyance of the recommended channel capacity for flood control are generally in excess of the navigation requirements cited above. The proposed channel alignment provides for numerous cutoffs across natural bends of the river and for numerous straightened and rectified reaches of the channel. This realignment was generally dictated by requirements for navigation. The overall distance from the mouth of the river to Fort Worth along the improved channel would be about 345 miles, compared with the natural river distance of 552 miles. The plan and profile of the proposed multiple-purpose channel are shown on plate 2.

TABLE 8

DIMENSIONS AND CAPACITY OF MULTIPLE-PURPOSE TRINITY RIVER CHANNEL

Channel mile		Length	Bottom	Depth	Recommended operating discharge	Recommended channel capacity
From	To	(miles)	width(ft)	(ft)(1)	(cfs)	(cfs)
0.0	28.30	28.30	150	13.3	Tidal pool	
			Wallisville Reservoir			
35.50	43.50	8.00	300	27.0	35,000	45,000
43.50	55.70	12.20	350	30.0	35,000	45,000
55.70	74.85	19.15	200	34.0	35,000	45,000
74.85	100.88(2)	26.03	150	40.0	35,000	45,000
			Livingston Reservoir			
147.92	234.60(3)	86.68	150	45.0	35,000	45,000
			Tennessee Colony Reservoir			
274.51	293.00	18.49	200	25.0	25,000	32,000
293.00	304.00	11.00	150	28.0	25,000	32,000
304.00	331.31	27.31	150	26.0	20,000	27,000
331.31	337.30	5.99	150	26.0	20,000	25,000
337.30	342.51	5.21	150	26.0	12,000	15,000
342.51	360.17	17.66	200	26.0	12,000	15,000
360.17	367.83	7.66	150	26.0	12,000	15,000
367.83	369.78	1.95	200	26.0	12,000	15,000

(1) Approximate depth of channel below top of river bank.
(2) Upper end of flood release discharge channel at the Livingston spillway basin.
(3) Upper end of flood release discharge channel at the Tennessee Colony spillway basin.

124. The multiple-purpose channel also provides 17 gated navigation dams and one overflow navigation dam in addition to the Wallisville, Livingston and Tennessee Colony Dams to provide slackwater pools for navigation. In conjunction with this system of dams, 23 locks would be required for passage of traffic. Tandem locks at Livingston and Tennessee Colony to accommodate the high lifts account for the two additional locks. The 19 locks located below the Dallas terminus would have clear basins 84 feet wide by 600 feet long. This size lock was selected as most efficient to lock the average barge tow of three barges and one towboat that would be necessary to carry the prospective commerce on this section of the waterway, together with pleasure craft, and which would have a minimum water requirement. The four locks between Dallas and Fort Worth would have clear basins 56 feet wide by 400 feet long. This size lock would accommodate the two barge tows necessary to carry the prospective commerce above Dallas and would involve a minimum demand on the available water supply in this reach. All of the gated navigation dams would consist of non-submersible tainter gates, 40 feet long, with sills set at the bottom elevation of the multiple-purpose channel at each dam site. The number of gates at each dam was determined by the capacity of the channel at that point. The proposed locations and pertinent data for the navigation locks and dams are shown in table 9.

TABLE 9

PERTINENT DATA CONCERNING SYSTEM OF LOCKS AND DAMS
PROPOSED FOR THE MULTIPLE-PURPOSE
TRINITY RIVER CHANNEL TO FORT WORTH, TEXAS

Location Lock and Dam (1)	Proposed lock: Lock No	Normal Pool elev (2): Lower	Upper	Lift (feet)	Proposed dam: Elevation: 2 percent flow (3)	Sill elevation(2)	Number & size of gates
28.30	1	0	4	4	5.0	-16.0	4-40X21
47.45	2	4	16	12	17.0	-13.0	7-40X31
59.08	3	16	36	20	37.0	3.5	6-40X34.5
74.85	4	36	60	24	61.0	26.0	6-40X36
98.00	5A	60	101	41	(4)		
99.20	5B	101	131	30	(4)		
147.92	6	131	138	7	139.0	96.0	5-40X44
183.92	7	138	168	30	169.0	126.0	5-40X44
207.55	8	168	192	24	193.0	152.0	5-40X42
217.95	9	192	210	18	211.0	166.0	6-40X46
233.00	10A	210	235	25	(5)		
233.61	10B	235	262.5	27.5	(5)		
258.91	11	262.5	270	7.5	(6)		
274.51	12	270	284	14	286.0	258.0	5-40X28
286.64	13	284	308	24	309.0	278.0	6-40X32
298.38	14	308	326	18	327.0	302.0	5-40X26
306.31	15	326	344	18	345.0	322.0	5-40X24
311.25	16	344	356	12	357.0	331.0	5-40X27
317.81	17	356	372	16	373.0	344.0	5-40X30
331.31	18	372	396	24	397.0	363.5	5-40X34.5
342.51	19	396	424	28	425.0	402.0	6-40X24
351.91	20	424	452	28	451.0	426.0	6-40X28
360.17	21	452	480	28	481.0	451.0	6-40X31

(1) Distance in channel miles from the Houston Ship Channel.
(2) Elevation in feet above mean sea level.
(3) Elevation of two percent flood discharge (regulated) in feet above mean sea level.
(4) Livingston Reservoir spillway controls river flows passing locks 5A and 5B.
(5) Tennessee Colony Reservoir spillway controls river flows passing locks 10A and 10B.
(6) Notched overflow spillway at Lock No. 11.

125. All locks except Nos. 5A, 6, 10B and 11 and the Wallisville Reservoir lock would have massive concrete gravity-type walls founded on piling and would have concrete paved floors in the lock basin. Locks Nos. 5A, 6, 10B and 11 would be of concrete "U-Frame" type construction and would rest directly upon a natural foundation. The Wallisville Reservoir lock would provide a lock chamber, 84 feet wide by 600 feet long, in lieu of the 56 x 400-foot lock recommended in the plan for the Wallisville Reservoir project, contained in House Document No. 215, 87th Congress, 1st Session. The lock would have massive concrete gravity-type walls founded on wood piling, with a paved earth basin and timber mooring walls throughout the basin. All lock gates would be of the miter type except the sector gates at Wallisville. The sills would be set a minimum of 15 feet below normal pool elevations. Lock and Dam No. 3 would be located a short distance below the site of the proposed Capers Ridge Reservoir dam and could serve as part of the lock system for passing the dam when it is constructed. Except for the tandem locks required to pass the Livingston and Tennessee Colony dams, the shortest travel distance between locks would be about 5 miles and the longest would be about 49 miles in the Livingston Reservoir.

126. Bridges, highways, railroads and utilities.- All bridges over the proposed multiple-purpose channel would provide a minimum vertical clearance of 50 feet above the water surface elevation of the regulated flood discharge that would not be exceeded over two percent of the time. All bridges below Dallas would have a minimum horizontal clearance of 250 feet between bridge fenders and all bridges above Dallas would have a minimum clearance of 225 feet between fenders. All bridges extending across floodway projects would have a minimum vertical clearance of three feet above the design flood discharge water surface elevation of the floodway. High-level fixed bridges are proposed for all highways crossing the navigation channel. A total of 44 new and modified high-level highway bridges would be required, including the bridges on U. S. Highway 190 crossing the Livingston Reservoir and those on U. S. Highway 287 and State Highway 31 crossing the Tennessee Colony Reservoir. In addition to the high level bridges crossing the navigation channel, a new bridge to replace the existing First Street bridge and modification of the Beach Street and the two Riverside Drive bridges in Fort Worth would be required to provide adequate floodway clearances in the proposed floodway reach upstream from the Fort Worth navigation terminus. Vertical lift bridges are proposed for all railroad crossings of the multiple-purpose channel. A total of 13 new or modified railroad bridges would be required to provide for navigation on the project channel, including modification of the St Louis - Southwestern Railway crossing the Tennessee Colony Reservoir, four new life bridges over land-cut channel sections and eight modifications of existing railroad bridges.

127. The multiple-purpose channel would require the relocation of 111 pipelines of various sizes, ranging from 3 inches to 30 inches in diameter; 31 electric power transmission lines; 17 communication lines; 6 water lines ranging from 24 inches to 72 inches in diameter; and 6 sewer lines ranging from 18 inches to 84 inches in diameter.

128. Public-use areas.- The plan for the multiple-purpose channel improvement provides for the development of 31 public-use areas to be located adjacent to the channel. The proposed development includes twenty-one 50-acre sites, one 75-acre site and nine 125-acre sites with necessary access and internal roads, requiring a total land area of about 2,600 acres.

129. Aids to navigation.- The Commander, Eighth Coast Guard District, New Orleans, Louisiana, estimated the number and cost of aids to navigation for the multiple-purpose channel to Fort Worth. Generally, the aids would include single pile day beacons along the channel and radar-reflecting buoys in the Livingston and Tennessee Colony Reservoirs.

130. Lands required.- Lands required for the multiple-purpose channel include rights-of-way for the channel, lock and dam sites, access roads and public-use areas; spoil areas for maintenance and construction of the project and damages for severed lands that would be isolated by the channel. Channel rights-of-way include areas to be excavated and a 50-foot berm on each bank of the channel. Spoil area requirements are based on the assumption that dragline-excavated material will be spoiled to an average height of 15 feet and hydraulically excavated material will be spoiled to an average height of 5 feet. The land area requirements for the proposed multiple-purpose channel improvement total 45,400 acres, including 4,200 acres in fee simple for lock and dam sites, access roads and public use areas and 41,200 acres in easements for channel excavation, spoil disposal areas and severed lands.

131. LAKEVIEW RESERVOIR.- The Lakeview dam site is located at river mile 7.2 on Mountain Creek, about 3.1 miles above the existing Mountain Creek Dam. The reservoir would be formed by an earth-fill dam with a maximum height of 91 feet above the streambed and a total length of 22,620 feet, including a concrete spillway 136 feet long. The spillway, with a net opening of 120 feet and located in a saddle on the right abutment, would be a gate-controlled, ogee, flip-bucket type with three 40 by 28-foot tainter gates. The outlet works would consist of one 12-foot diameter conduit controlled by two $5\frac{1}{2}$x12-foot gates.

132. The reservoir would have a total controlled storage of 488,700 acre-feet and a water surface area of 15,650 acres at elevation 528.0, the top of the flood control pool. At elevation 518.0, the top of the conservation pool, the reservoir would have an area of 12,300

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acres and a storage capacity of 349,500 acre-feet. The total allowance for a 100 year accumulation of sediment would be 45,600 acre-feet. The total conservation storage would be sufficient to provide a dependable yield of 30.4 million gallons per day under 2020 conditions of watershed development during a recurrence of the severest drought of record. Land requirements for construction of the dam and operation of the reservoir for the several purposes would be about 19,600 acres in fee simple and 800 acres in flowage easements. Additional lands required in fee simple for public use and access would be about 760 acres.

133. Construction of the Lakeview Reservoir would require relocation of 9.7 miles of farm to market highways, 12.0 miles of county roads, 1.5 miles of railroad, 1.5 miles of pipelines, 33.0 miles of telephone lines and 40.4 miles of electric power and distribution lines. There are no known cemeteries or significant mineral deposits in the proposed reservoir area. Portions of two unincorporated sub-divisions are located within the limits of the proposed reservoir.

134. TENNESSEE COLONY RESERVOIR.- The Tennessee Colony dam site is located at river mile 339.2 on the Trinity River, about 16 miles west of Palestine, Texas. The reservoir would lie in parts of Anderson, Freestone, Henderson and Navarro Counties. The dam would be an earthfill structure with maximum height above the streambed of 114 feet and a total length of 29,500 feet, including a controlled concrete spillway 520 feet long. The concrete ogee spillway, located in a natural saddle near the left abutment, would be controlled by 11 tainter gates, each 40 feet wide and 35 feet high, providing a total net width of opening of 440 feet. The outlet works would consist of four sluices in the spillway piers, each 3 feet by 6 feet, with power operated slide gates. Navigation locks numbered 10-A and 10-B would be located near the right abutment of the dam.

135. The reservoir would have a total controlled storage of 3,366,800 acre-feet and a water surface area of 119,500 acres at elevation 285.0, the top of the flood control pool. At elevation 262.5, the top of the conservation pool, the reservoir would have an area of 73,540 acres and a storage capacity of 1,193,000 acre-feet. The total allowance for a 100-year accumulation of sediment would be 190,000 acre-feet. The total conservation storage is estimated to have a dependable yield of 290.8 million gallons per day under 2020 conditions of watershed development during a recurrence of the severest drought of record.

136. Initially the water conservation storage would serve in a dual capacity to provide dilution water for water quality control and to supply yield for municipal and industrial purposes in the middle basin. Eighty million gallons per day would be used for water quality requirements in the West Fork of the Trinity River. The water from Tennessee Colony would be conveyed about 98 miles to Benbrook Reservoir

through an 84-inch diameter pipeline with appurtenant pumping facilities. Benbrook Reservoir would be used for reregulation of this water without requirement for reallocation of or encroachment on existing storage allocations. Use of the storage capacity in Tennessee Colony and the pipeline facilities initially allocated to water quality control would be converted to municipal and industrial use in the upper basin as the needs for water supply develop and local interests contract for repayment of the remaining cost of the storage capacity and pipeline facilities. The remaining yield in Tennessee Colony of 210.8 million gallons per day would be used initially to meet the needs of the middle basin with gradual conversion to municipal and industrial uses in the upper basin as the needs develop and additional projects are constructed in the middle basin. Ultimately the total yield from Tennessee Colony would be used for municipal and industrial uses in the upper basin.

137. In connection with the Tennessee Colony Reservoir, the Bureau of Sport Fisheries and Wildlife recommends establishment of a National Wildlife Refuge to be located east of the Trinity River in Henderson and Anderson Counties. The proposed refuge would comprise about 21,000 acres located east of the proposed multiple-purpose channel between U. S. Highway 287 on the south and State Highway 31 on the north. The refuge would extend about 9 miles along the river and would average slightly less than 4 miles in width. The Bureau recommends, in accordance with the provisions of Public Law 85-624, 85th Congress, approved August 12, 1958, that the Corps of Engineers be authorized to acquire about 600 acres of land, in addition to about 20,400 acres required for other purposes of the reservoir, and to make the total 21,000 acres available to the Secretary of the Interior for refuge use, as provided for in Section 3 of the Fish and Wildlife Coordination Act cited above. The Bureau proposes to manage the refuge to provide controlled public hunting and to permit fishing at periods when it would not interfere with wildlife management.

138. Land requirements for construction of the dam and operation of the reservoir for the several purposes would be about 166,244 acres in fee simple and about 7,000 acres of flowage easements. Additional lands acquired in fee simple for public use and access would be about 1,907 acres. An additional 600 acres is recommended by the Bureau of Sport Fisheries and Wildlife for acquisition in fee simple for the proposed National Wildlife Refuge.

139. Construction of the Tennessee Colony Reservoir would require relocation of 21 miles of highways, 10 miles of county roads, 1.8 miles of railroads, 44 miles of pipelines and 21 miles of electric power lines. There are no known cemeteries in the proposed reservoir area. An allowance has been made for mineral subordination of known mineral deposits including the Cayuga oil field near Trinidad in the headwater area of the reservoir and three other small producing fields.

140. AUBREY RESERVOIR (INCLUDING MODIFICATION OF GARZA-LITTLE ELM RESERVOIR).- The Aubrey dam site is at mile 60.0 on the Elm Fork of the Trinity River in northeast Denton County. The site is between the towns of Sanger and Aubrey and is 30 river miles upstream from the Lewisville Dam (Garza-Little Elm Reservoir). The reservoir would be formed by an earth-fill dam with a maximum height of about 116 feet above the streambed and a total length of about 13,660 feet, including a concrete spillway 424 feet long. The spillway, with a net controlled opening of 360 feet located on the right bank, would be a concrete ogee section with nine 40 by 35-foot tainter gates. The outlet works would consist of two 36-inch diameter conduits through the spillway piers controlled by power operated slide gates.

141. The reservoir would have a total controlled storage of 899,900 acre-feet and a water surface area of 30,750 acres at elevation 635.0, the top of the flood control pool. At elevation 625.5, the top of the conservation pool, the reservoir would have an area of 24,340 acres and a storage capacity of 639,000 acre-feet. The total allowance for a 50-year accumulation of sediment would be 37,800 acre-feet. The flood control storage in the Aubrey Reservoir would permit a reallocation of storage in the Garza-Little Elm Reservoir to increase the storage presently allocated to water conservation in that reservoir. Under 2020 conditions of watershed development and recurrence of the severest drought of record, the dependable yield of the proposed Aubrey and Garza-Little Elm Reservoir system would be 151.3 million gallons per day, or an increase of 65.3 million gallons per day over that of the Garza-Little Elm Reservoir alone. The water conservation storage would serve in a dual capacity, operating initially to provide dilution water for water quality control, with gradual conversion to municipal and industrial use as those needs develop. Land requirements for construction of the Aubrey Dam and operation of the reservoir would be about 37,700 acres in fee simple and 1,500 acres in flowage easements. Additional lands acquired in fee simple for public use and access in the Aubrey and Garza-Little Elm Reservoirs would be about 4,200 acres.

142. Construction of the Aubrey Reservoir would require relocation of 16 miles of highways, 6 miles of county roads, 5 miles of railroads, 1 mile of pipeline, 10 miles of telephone lines and 12 miles of electric power lines. There are no known cemeteries or significant mineral deposits in the proposed reservoir area.

143. ROANOKE RESERVOIR (INCLUDING MODIFICATION OF GRAPEVINE RESERVOIR.- The Roanoke dam site is located at stream mile 32.0 on Denton Creek, about one mile northwest of the town of Roanoke. The dam would be near the upper limits of the existing Grapevine Reservoir. The reservoir would be formed by an earth-fill dam with a maximum height of about 97 feet above the streambed and a total length of about 15,200 feet, including a concrete spillway 328 feet long and two dikes. The spillway, with a net controlled opening of 280 feet, would be a concrete

ogee section with seven 40 by 35-foot tainter gates. The outlet works would consist of one 15-foot diameter conduit controlled by three 4.5 by 15-foot power operated slide gates.

144. The reservoir would have a total controlled storage of 249,900 acre-feet, including 223,700 acre-feet for flood control and 26,200 acre-feet sediment reserve. At elevation 619.0, the top of the flood control pool, the reservoir would have a water surface area of 9,720 acres. The reservoir would be operated for flood control only and no permanent impoundment of water would be made since impoundment in this reservoir would reduce the total yield of the watershed because of evaporation from the increased exposure of water surface. The flood control storage provided in Roanoke Reservoir would permit reallocation of storage in the existing Grapevine Reservoir to increase the conservation storage from the existing total of 161,250 acre-feet to a new total of 372,200 acre-feet. The dependable yield of Grapevine Reservoir, under 2020 conditions of watershed development and recurrence of the severest drought of record, would be increased from 18.1 million gallons per day to 42 million gallons per day. Land requirements for construction of the Roanoke Dam and operation of the reservoir for flood control would be about 710 acres in fee simple and about 11,990 acres of flowage easements. An additional 1100 acres of land, 600 acres converted from easement to fee and 500 acres in fee, would be acquired at the Grapevine Reservoir for public use and access.

145. Construction of the Roanoke Reservoir would require relocation of 12.1 miles of highways, 1 mile of county road, 4.5 miles of railroads, 5 miles of pipelines, 10 miles of telephone lines and 15 miles of electric power lines. There are no known cemeteries or significant mineral deposits in the proposed reservoir area.

146. LOCAL FLOOD PROTECTION PROJECTS.- In addition to flood control protection provided by the multiple-purpose channel improvement and the reservoir projects, it was found necessary and economically justified to afford protection from the standard project flood to 5 urban localities by means of local flood protection projects. It was found necessary, also, to improve the channels below the Garza-Little Elm and Grapevine Reservoirs to provide channel capacities consistent with a sound flood control regulation plan that would allow emptying the reservoir flood storage pools within periods ranging from 30 to 40 days. The local protection projects would include the appurtenant facilities and necessary measures to preserve the drainage of protected areas and carry drainage water through the levees. Such facilities and measures include permanent ponding areas, gated gravity sluices and conduits, enlargement and realignment of tributary channels through the leveed areas, and filling of some low areas with excess excavated materials from channel improvements. Also included in the local protection projects are alteration or reconstruction of bridges crossing

the floodway to provide adequate clearances and necessary alteration or relocation of highways, streets, railroads, pipelines and utility lines.

147. West Fork Floodway.- The proposed West Fork Floodway improvement would extend about 31 channel miles up the West Fork to connect and provide a floodway from the upper end of the Dallas Floodway at Elm Fork to the lower end of the Fort Worth Floodway. The channel improvement in this reach would consist of the multiple-purpose channel for navigation, flood control and other purposes. Levees would provide a floodway width varying from about 1,000 feet to 3,000 feet. About 8,430 acres of land would be required for rights-of-way for the proposed improvements.

148. Elm Fork Floodway.- The proposed Elm Fork Floodway would connect with the Dallas Floodway at the confluence of Elm Fork and West Fork. Channel rectification and enlargement and a leveed floodway to afford standard project flood protection would be provided from the Dallas Floodway upstream along Elm Fork to the mouth of Denton Creek, a distance of about 14.3 channel miles. Channel rectification and enlargement only would extend from that point upstream along Elm Fork to the Lewisville Dam outlet works and upstream along Denton Creek to the outlet works of the Grapevine Dam to provide adequate channel capacity for the proper regulation of those projects for flood control. The total improved length along Elm Fork would be about 21.8 miles and along Denton Creek about 8.9 miles. The floodway along Elm Fork would have a minimum width between levees of about 1,100 feet. About 3,400 acres of land would be required for rights-of-way for the proposed improvements.

149. Extension of Dallas Floodway.- The proposed downstream extension of the Dallas Floodway would provide additional floodway length of about 9.7 miles along the Trinity River and would terminate at the mouth of Five Mile Creek. The channel improvement would comprise the multiple-purpose channel in this reach. Levees would provide a minimum floodway width of about 2,000 feet. About 4,030 acres of land for rights-of-way would be required for the proposed improvements.

150. Duck Creek Channel Improvement.- A reach of Duck Creek between stream miles 10.4 and 17.5 at Garland, Texas, would be realigned and enlarged to provide sufficient within-banks capacity to contain the standard project flood. About 190 acres of rights-of-way would be required for construction of the improved channel and disposal of the excavated materials.

151. Liberty Local Protection Project.- About 10 miles of levees would be provided along the left bank of the Trinity River in conjunction with the multiple-purpose channel to protect the City of Liberty, Texas. The levees along the river would be located from 600 to 6,000 feet from the multiple-purpose channel and would protect areas on the north and

south of the city. About 6 miles of the levees would be constructed by controlled spoiling of hydraulically dredged material from the multiple-purpose channel. Two pumping stations with capacities of 40,000 and 150,000 gallons per minute would be provided for interior drainage of the north and south leveed areas, respectively, during periods of high river stages. About 560 acres of rights-of-way would be required for construction of the levees and about 500 acres of flowage easements would be required for ponding areas for interior drainage. Relocation or alteration of 9 oil pipelines, one sewer line and one telphone line would be required.

PHYSICAL EFFECTS OF THE PLAN

152. INTRODUCTION.- The physical effects of the comprehensive plan of development were evaluated to determine the ability of all elements of the plan to satisfy various water and related land resource needs of the Trinity River Basin. It has been pointed out in previous sections of this report that provision of works of improvement for certain needs such as land stabilization, drainage measures, irrigation and power will be handled through existing programs, separate authorizations or by other alternative means such as thermal-electric generating plants for power development. The results of the evaluation of the physical effects of the plan for satisfying the residual needs are summarized in the paragraphs below.

153. WATER SUPPLY.- The projected water supply requirements for the Trinity River Basin to satisfy the needs for municipal, industrial, non-municipal use, water quality control, navigation, irrigation, and exportation have been estimated to be 3,433 million gallons per day by year 2020 and 5,187 million gallons per day by year 2070, as shown in table 10.

TABLE 10

WATER REQUIREMENTS
(Million Gallons Per Day)

Sub-basin	Municipal and Industrial	Non-Municipal	Water quality control	Navigation	Irrigation	Export(3)	Total
			Year 2020				
Upper	1,513(1)	15	80(2)	0	69	0	1,677
Middle	227	3	0	0	65	0	295
Lower	340	2	0	57	222	840	1,461
Total	2,080	20	80	57	356	840	3,433
			Year 2070				
Upper	2,797	11	0(2)	0	69	0	2,877
Middle	435	4	0	0	65	0	504
Lower	686	1	0	57	222	840	1,806
Total	3,918	16	0	57	356	840	5,187

(1) Includes 40 MGD yield from Aubrey Reservoir for interim use as water quality control.
(2) 80 MGD for water quality control would be converted to water supply as the need develops.
(3) Export to the City of Houston in accordance with the provisions of Permit 1970.

154. The existing, under construction, and authorized reservoirs with storage for water supply for municipal and industrial purposes together with the importations would produce a water supply of 1,343.4 million gallons per day. The Roanoke (including modification of Grapevine Reservoir), Aubrey (including modification of Garza-Little Elm Reservoir), Lakeview, and Tennessee Colony multiple-purpose reservoir projects which are recommended for authorization in this report plus the previously recommended enlargement of Lavon Reservoir would produce a water supply of 453.1 million gallons per day. Thirteen additional potential reservoir projects have been recommended for inclusion in the long-range plan of development for the Trinity River Basin primarily in the interest of water supply. These reservoirs were formulated on the basis of developing the surface water resources of the Trinity River Basin to the maximum practical extent. The construction of the long-range projects has been considered as a phase development which would be coordinated with the needs of the basin in such a manner as to permit timely construction to provide additional water supply as the needs develop. The thirteen potential reservoirs would produce a water supply of 680.4 million gallons per day. The system of reservoirs included in the comprehensive plan together with importations would furnish a water supply of 2,476.9 million gallons per day as summarized below and as shown in table 11.

Reservoirs	Water Supply (Million gallons per day)
Existing, Under construction, Authorized	1,163.4
Importations	180.0
Previously recommended for authorization	42.7
Recommended for authorization in this report	410.4
Sub-Total	1,796.5
Potential long-range projects	680.4
Total	2,476.9

TABLE 11

PRIMARY RESERVOIR YIELDS

(million gallons per day)(1)

Reservoir project	Imports	Upper basin: Federal	Upper basin: Non-Federal	Middle basin: Federal	Middle basin: Non-Federal	Lower basin: Federal	Lower basin: Non-Federal	Total
EXISTING, UNDER CONSTRUCTION AND AUTHORIZED								
Benbrook		6.5						
Grapevine		18.1						
Garza-Little Elm		86.0						
Lavon		35.5						
Navarro Mills		18.1						
Bardwell		4.2						
Bridgeport			50.4					
Eagle Mtn & Lake Worth			17.5					
Weatherford			0.6					
Arlington			5.8					
White Rock			1.9					
Forney			58.8					
Tawakoni (Iron Bridge)	174.0							
Terrell			0.6					
Cedar Creek			173.2					
Waxahachie			1.9					
Flat Creek	6.0							
Livingston						670.9		
Anahuac						13.4		
Total	180.0	168.4	310.7			684.3		1,343.4
RECOMMENDED FOR FEDERAL AUTHORIZATION IN PREVIOUSLY SUBMITTED REPORTS								
Lavon (enlarged)		42.7						
Wallisville						(4)		
Total		42.7						42.7
RECOMMENDED FOR FEDERAL AUTHORIZATION IN THIS REPORT								
Lakeview		30.4						
Roanoke-Grapevine		23.9(2)						
Aubrey-Garza-Little Elm		65.3(3)						
Tennessee Colony		290.8						
Total		410.4						410.4
RECOMMENDED FOR INCLUSION IN LONG RANGE PLAN BUT NOT FOR AUTHORIZATION AT THIS TIME(5)								
Boyd			31.7					
Richland Creek			169.3					
Tehuacana			56.9					
Upper Keechi				54.3				
Hurricane				17.5				
Lower Keechi				25.2				
Bedias				94.4				
Harmons				16.8				
Gail				31.0				
Mustang				25.2				
Caney				25.2				
Long King						34.9		
Capers Ridge						98.0		
Total		257.9		289.6		132.9		680.4
Total by basins	180.0	1,190.1		289.6		817.2		2,476.9

(1)Based on recurrence of 1950-1957 critical dry period under 2020 conditions of watershed development.
(2)Increase yield as a result of exchange of storage with Roanoke.
(3)Increase yield from the Aubrey-Garza-Little Elm system.
(4)Included with yield of Livingston.
(5)Authorization studies will be required to determine the extent of Federal participation.

155. Water supply from reservoirs which are existing, under construction, authorized, and recommended for authorization in this report together with a nominal use of ground water and return flow would satisfy the projected demands in all segments of the basin until about year 2000 to 2010. An additional supply of approximately 1,640 and 3,390 million gallons a day would be required to satisfy the projected water requirements for years 2020 and 2070, respectively. An analysis of the available water supply in the basin from additional reservoirs in the long range plan, ground water and return flow revealed that the potential of these resources may be sufficiently developed to satisfy the additional requirements of the basin to year 2070. Unquestionably the expansion of ground water use beyond the present 72 million gallons per day, the use of return flows, and construction of additional reservoirs will progressively increase throughout the projected period of basin development. Other than to conclusively establish the fact that ultimate water requirements will necessitate the maximum practical development of these resources to meet in-basin demands, no definitive basis is available to predict just when the development of these resources would be scheduled. Also water from alternative sources of supply in adjacent basins to the north and east could be imported if in the future local interests or the State decided to utilize such resources rather than to use in-basin resources. Generally, the development and use of these water resources will progress in consonance with changing economic conditions and areal development of the basin and with the distribution, availability and quality of these water resources.

156. Development of the Lakeview Reservoir project would afford a source of water supply to satisfy the immediate needs of local interests. The water supply of 291 million gallons per day from the Tennessee Colony Reservoir would serve a dual purpose - initially, 80 million gallons would be used for water quality control in the upper basin and the remaining 211 million gallons per day would be available as a source of municipal and industrial water supply for the middle basin. As the need for municipal and industrial water supply increases in the upper basin, the entire 291 million gallons per day of the Tennessee Colony water supply will be converted to serve these needs. It is anticipated that construction of the eight long-range reservoir projects in the middle basin would be phased with the gradual transfer of the Tennessee Colony water supply with construction of certain projects starting around the turn of the century so that the demands of the middle basin may continue to be fully satisfied. Initially the water supply from the Aubrey Reservoir would be used in the interest of water quality control. However, as the need for municipal and industrial water supply develops, a conversion from water quality control to water supply for municipal and industrial use would be made. There is no immediate demand for the additional water supply provided by the Roanoke Reservoir; however, it is considered that preservation of this project by acquisition of the land required at this time is desirable and economically justified. The actual project would not be constructed until the needs for the storage developed. The 13 potential projects

included in the long range plan to satisfy future requirements would be considered for authorization after detailed investigations to determine the full scope and purposes that would be justified at that time.

157. EFFECTS ON WATER QUALITY.- The water quality problem in the lower Trinity River resulting from intrusion of salt water from the Gulf will be eliminated by construction of the Wallisville Reservoir Project which has been recommended by a separate report. An element in the projects recommended herein for authorization is storage space in Tennessee Colony Reservoir and pipe line facilities from the reservoir to the existing Benbrook Reservoir for ultimate water supply. These facilities will be utilized initially for water quality control until the water supply requirements develop and local interests contract to repay the remaining costs of the facilities. The water supply storage in the Aubrey Reservoir will also be operated initially for water quality control under similar conditions. Projected water supply requirements indicate full conversion of the Aubrey Reservoir storage to water supply by about 1985, with conversion of the Tennessee Colony Reservoir and pipe line facilities to start about 2020. The facilities provided for interim use for water quality control would eliminate the septic conditions from Fort Worth to below Rosser and maintain satisfactory water quality for a considerable period in the future. It is obvious that with the projected development of the area and the conversion of interim water quality control facilities to water supply, the problems of water quality will increase. Since the water designated for interim use for quality control is provided for ultimate water supply, no provision for equivalent water quality control is required as a prerequisite for conversion to water supply. However, it is anticipated that maintenance of a satisfactory quality of water will be made possible by expected future developments in increased efficiency in treatment of water pollution.

158. EFFECT OF PLAN FOR NAVIGATION.- The recommended plan includes facilities for barge navigation from the Houston Ship Channel in Galveston Bay to Fort Worth, Texas. Through the Houston Ship Channel, connection is afforded to the Gulf Intracoastal Waterway and the extensive inland waterway system throughout the eastern and central United States. The waterway would afford low-cost water transportation to the Dallas-Fort Worth industrial complex, to the rural areas throughout the reaches of the Trinity River Basin, and the tributary trade area beyond the basin. Detailed investigation and studies show that if a waterway presently existed, large quantities of commodities consumed and produced in the basin would now move by barges, because of net savings in transportation costs. The prospective waterborne commerce is estimated at 8,800,000 tons in 1970 and 20,000,000 tons in 2020. The major commodities would be grain for export from the upper tributary trade area, sand, gravel, and stone throughout the basin and manufactured articles to and from the Dallas-Fort Worth complex. The navigation project would accommodate the prospective waterborne commerce that would develop to the year 2020, and is designed to permit expansion to provide greatly increased capacity as the prospective commerce increases to 72,000,000

tons in the year 2070. The availability of barge transportation would accelerate expansion of the industrial economy in the Dallas-Fort Worth area, especially in the reach between these two cities, where existing and proposed floodways afford extensive flood-free land for industrial plant location. The rapidly growing Houston industrial complex would take advantage of the water supply and water transportation and expand eastward into the lower Trinity. In the presently retarded middle basin the stimulus of ample water supply and flood-free conditions supplemented by low cost barge transportation would assure realization of the potential development of the natural resources and undoubtedly would result in establishment of major industrial plants.

159. FLOOD PROTECTION.- The projects recommended for authorization for flood protection are Lakeview and Tennessee Colony Reservoirs, Multiple-Purpose Channel, West Fork Floodway, Elm Fork Floodway, Dallas Floodway Extension, Duck Creek Channel Improvement, and Liberty Local Protection project. The effect of these projects would be to afford a high degree of flood protection along the Trinity River and major tributaries. These projects would provide standard project flood protection in the urban areas, greater than 100-year protection in leveed rural areas, 6 to 10 year protection in the unleveed rural areas above Tennessee Colony, and 60 to 90 year protection in the unleveed rural area below Tennessee Colony. In addition, the multiple-purpose channel would provide channel capacities consistent with a sound flood control regulation plan that would permit evacuation of flood control storage in existing and proposed reservoir projects in a period of 30 to 40 days and constitutes a fundamental and inseparable part of the reservoir system. The reduction in peak discharges of the proposed flood control improvements at various locations along the Trinity River for the floods of April-July 1942, February-May 1945, and April-July 1957 are shown in table 12. The modified discharges include the effects of all projects cited above plus the effects of the continuing program of the Soil Conservation Service. There are no flood reduction effects credited to the proposed Aubrey and Roanoke Reservoirs since the flood control impoundments in these projects are on an exchange of storage basis for additional water supply storage in the existing Garza-Little Elm and Grapevine Reservoirs.

TABLE 12

FLOOD CONTROL EFFECTS OF THE PLAN

Date of flood and location	Peak discharges (cfs)			
	Actual	Modified by existing & authorized facilities	Proposed channel capacities	Modified by projects recommended for authorization
Flood of April-July 1942				
W. Fork Trinity R. at Fort Worth	23,700	16,400	95,000(1)	13,200
Trinity River at Dallas	111,000	53,000	226,000(2)	48,000
Trinity River at Rosser	133,000	93,000	32,000	82,300
Trinity River at Oakwood	153,000	93,500	45,000	35,000
Trinity R. at Riverside	121,000	74,700	45,000	35,000
Trinity R. at Romayor	111,000	69,600	45,000	36,500
Flood of Feb-May 1945				
W. Fork Trinity R. at Fort Worth	31,200	15,600	95,000(1)	14,900
Trinity River at Dallas	52,900	35,600	226,000(2)	26,200
Trinity River at Rosser	66,600	53,200	32,000	44,500
Trinity R. at Oakwood	140,000	123,000	45,000	35,000
Trinity R. at Riverside	116,000	103,800	45,000	36,000
Trinity R. at Romayor	106,000	93,000	45,000	38,000
Flood of April-July 1957				
W. Fork Trinity R. at Fort Worth	58,800(3)	26,800	95,000(1)	15,100
Trinity River at Dallas	222,000(3)	75,300	226,000(2)	54,000
Trinity River at Rosser	142,000(3)	56,000	32,000	29,800
Trinity R. at Oakwood	137,100(3)	81,300	45,000	27,300
Trinity R. at Riverside	130,500(3)	91,000	45,000	29,300
Trinity R. at Romayor	125,900(3)	89,000	45,000	23,500

(1) Fort Worth Floodway capacity.
(2) Dallas Floodway capacity.
(3) Estimated actual discharge without effects of existing Corps of Engineers Reservoirs.

160. OTHER PHYSICAL EFFECTS OF PLAN.- The recreational and fish and wildlife facilities proposed for development in the reservoirs and the Multiple Purpose Channel would provide recreation opportunities for a total of 25,200,000 visitors annually. Of this total visitation, about 16.4 million visitors are expected to participate in general recreation activities and 8.8 million visitors in fishing and hunting. The estimated annual visitation at existing, authorized and previously recommended Corps of Engineers reservoir projects is 22,800,000. This visitation together with the 25,200,000 annual visitation at the projects recommended in this report totals 48,000,000 which is about 60% of the recreation demand for the basin by year 2070. All of the project areas, both water-surface and dry lands, would be available to the public for recreational and fish and wildlife purposes except for the area in the Tennessee Colony Reservoir recommended as a wildlife refuge by the Bureau of Sport Fisheries and Wildlife. The Bureau proposes to manage the refuge to provide controlled public hunting and fishing at periods when these activities would not interfere with wildlife conservation management.

ECONOMIC EVALUATION OF PROJECTS RECOMMENDED FOR AUTHORIZATION

161. GENERAL.- Economic evaluations were made of projects recommended for authorization at this time. The projects were appraised to assure that: (a) project benefits exceed costs; (b) each separable unit or purpose provides benefits at least equal to its cost; (c) each element of the plan provides the maximum net benefits consistent with development of a balanced plan; and (d) there is no more economical means, evaluated on a comparable basis, of accomplishing the same purpose or purposes. The project costs and benefits were estimated on the basis of January 1962 price level.

162. COSTS.- The first costs comprise all initial expenditures for physical construction of the project, including lands and damages, relocations, reservoir clearing, engineering and design, and supervision and administration. The first costs and annual charges for all projects recommended for authorization are shown in table 13. The annual charges include interest and amortization of the investment at a Federal interest rate of 2-7/8 percent and a non-Federal interest rate of 3 percent for a 100-year period, operation and maintenance charges, and annual equivalent cost of major replacements.

163. BENEFITS.- Benefits which would accrue from the projects recommended for authorization have been estimated on the basis of a useful project life of 100 years. The benefits which are expected to accrue from future flood plain development, future use of water supplies, and future savings in transportation costs have been reduced to an average annual equivalent value by compound interest methods. The estimates of average annual benefits for the projects recommended for authorization are described below and are shown in table 13 by projects and purposes.

164. Reduction in flood damages.- The average annual benefits for flood damage reduction accruing to the various projects were determined by use of discharge-damage and discharge-frequency relations with allowances to reflect: (1) economic trends and future development in the flood plain during the period 1970 to 2070 and (2) the effects of existing, under-construction, authorized and previously recommended flood control works. On this basis the average annual damages of $15,430,000 would be reduced by the recommended projects to $1,060,000 for a benefit of $14,370,000. Additional average annual benefits in the amount of $331,000 would also accrue to the plan from the increased net return from a higher order of use of flood plain lands. The total average annual flood-control benefits resulting from the projects recommended for authorization are $14,701,000.

165. Water supply and water quality control.- Benefits for supplies of water were computed on the basis of the cost of providing the same quantity and quality of water by the cheapest alternative means. The estimated cost of the alternative means was based on non-Federal financing and interest rates for existing private and publicly owned projects. The benefits credited to the four reservoir projects which contain conservation storage (water supply and water quality control), were based on the cost of the most economical alternative single-purpose conservation facilities, including the pipeline from Tennessee Colony and amount to $8,266,000.

166. Navigation.- The multiple-purpose channel would develop navigation benefits from a savings in transportation cost of the prospective commerce between the Houston Ship Channel and Fort Worth. The survey of prospective barge commerce on the waterway indicated a total potential of about 6.9 million tons in 1958, which would increase to 22.9 million tons in 2020 and about 72.1 million tons in 2070. However, the operating capacity of the system of locks for handling vessel traffic would limit total commerce on the waterway to about 20 million tons annually. It is estimated that this volume would be reached in the year 2015 and benefits were computed on total annual commerce of 20 million tons for each year thereafter to the year 2070. Gross average annual equivalent benefits from savings in transportation costs were estimated at $27,074,000 annually for the period of analysis 1970-2070. However, increased operating costs would be incurred by vehicular traffic using the high-level fixed bridges crossing the navigation channel and a benefit would accrue to the project from the advance replacement of the reconstructed bridges. The costs to vehicular traffic were estimated and reduced to an average annual equivalent value of $323,000. The average annual equivalent benefit from advance replacement of existing bridges was estimated at $202,000. The net annual benefit from the navigation project is estimated at $26,953,000.

167. Recreation.- Benefits for general recreation were computed on the basis of estimated annual attendance at each project locality, using a unit value per visitor-day. A weighted average value of $0.50 per visitor-day was applied equally to all projects for a variety of general recreational activities including picnicking, swimming, boating, camping, sightseeing, nature study, and other outdoor pursuits. The total general recreational benefits for all projects were estimated at $6,200,000.

168. Fish and wildlife.- Benefits for fish and wildlife were computed on the basis of estimated annual attendance at each project locality using a constant unit value per visitor-day. A value of $1.00 per visitor-day was applied equally to all projects for the sports hunting and fishing afforded by the projects. Although it is recognized that the projects would have additional value as commercial fisheries and for fish and wildlife conservation purposes, a specific benefit has not been evaluated. Fish and wildlife benefits in the amount of $6,300,000 will accrue to the projects recommended for authorization.

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169. ECONOMIC JUSTIFICATION.- Estimates of annual charges and benefits and ratios of benefits to costs in table 13 show that the annual benefits would exceed the annual costs for the projects considered individually and as a system.

170. Intangible benefits.- The projects recommended for authorization have been justified entirely by monetary benefits. These projects would also provide important intangible benefits in economic and social terms to the Trinity River Basin, the state of Texas, the Region and the Nation. The recommended projects would significantly increase the economic efficiency of the basin and the adjacent areas. Unemployment would be appreciably alleviated in certain areas, particularly in the middle basin of the Trinity where small areas of chronic unemployment exists. Also under utilization of resources in a large segment of the middle basin would be activated and developed, and stabilization of production and personal income and quality of work and services would be greatly improved. The flood control effects of the projects would reduce the threat to lives and stabilize the economy of the areas subject to flood and adjacent areas. Water quality control features would greatly improve the health and general welfare of the people, the recreation and fish and wildlife aspect of the projects would make an important contribution to the social well being of a large segment of the population. The water supply and navigation features of the recommended projects would directly stimulate the economy of the Trinity River Basin and large areas adjacent thereto. These intangible benefits have not been evaluated in monetary terms. However, the effect of intangible benefits were carried to the point where it was apparent that their inclusion would not make any new project eligible for recommendation for authorization. These studies were advanced, however, to the point where it was clearly evident that these intangible benefits are of major significance and would add materially to justification of the projects recommended for authorization.

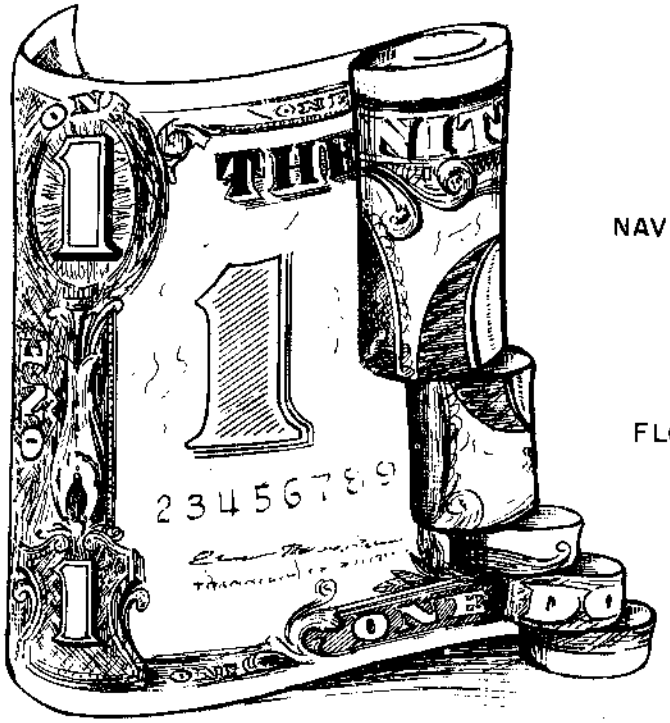
TABLE 13

FIRST COST, ANNUAL CHARGES, ANNUAL BENEFITS AND BENEFIT-COST RATIOS
PROJECTS RECOMMENDED FOR AUTHORIZATION
(in thousands of dollars)

Item	Multiple-Purpose Chan, Locks and Dams	Lakeview Reservoir	Tennessee Colony Reservoir	Elm Fork Floodway	West Fork Floodway	Dallas Floodway Extension	Duck Creek Channel	Aubrey Reservoir	Roanoke Reservoir	Liberty Local Protection	Total Recommended Plan
First Cost	568.738	31,180	193,782(1)	16,823	17,809	14,327	5,024	34,073	16,900	2,091	900,747
Annual Charges	23,713	1,372	9,201(1)	723	808	605	160	1,624	624	79	38,909
Annual Benefits											
Navigation	24,002		2,951(1)	-	-	-	-	-	-	-	26,953
Flood Control	4,696	1,391	3,238	1,867	2,359	685	224	-	-	241	14,701
Water Supply and Water Quality	-	907	5,590(1)	-	-	-	-	1,085	684	-	8,266
Recreation	1,625	975	1,950	-	-	-	-	1,500(2)	150 (3)	-	6,200
Fish and Wildlife	1,750	1,050	2,100	-	-	-	-	1,400(2)	-	-	6,300
Total	32,073	4,323	15,829	1,867	2,359	685	224	3,985	834	241	62,420
Benefit-Cost Ratio	1.4	3.2	1.7	2.6	2.9	1.1	1.4	2.5	1.3	3.0	1.6

(1) Includes costs and benefits for pipeline and navigation.
(2) Includes increased benefits at the Garza-Little Elm reservoir project.
(3) Includes increased benefits at the Grapevine reservoir project.

171. COST ALLOCATION TO PROJECT PURPOSES.- Cost allocations for multiple-purpose projects were made to determine the equitable distribution of the costs to each project purpose. All reservoir project costs were allocated by the separable costs-remaining benefits method using an amortization period of 100 years and an interest rate of 2-7/8 percent. Project costs for Aubrey and Roanoke Reservoirs were not considered allocable to flood control but rather to water supply and recreation - fish and wildlife since an exchange of equivalent storage for flood control was made between Aubrey and Garza-Little Elm and Roanoke and Grapevine projects. Allocation of total costs of Aubrey and Roanoke Reservoirs, including modifications and additions of recreation and fish and wildlife facilities in Garza-Little Elm and Grapevine, were made by the separable costs-remaining benefits method for the purposes of water supply and recreation - fish and wildlife. The costs allocated in this manner for the four reservoir projects are summarized in table 14. Although the Multiple Purpose Channel was formulated by the incremental method, a cost allocation between purposes was made by allocating all specific costs to purposes served with the remaining joint costs distributed to flood control and navigation purposes on a fair share basis in proportion to their benefits. Only specific costs were allocated to recreation - fish and wildlife features of the multiple-purpose channel. Since the local protection projects were solely for flood control, no cost allocation was necessary. Figure 29 graphically shows the distribution to project purposes of the total cost of all of the projects recommended for authorization in this report.



NAVIGATION 53¢

FLOOD CONTROL 24¢

WATER SUPPLY 7¢

WATER QUALITY CONTROL 9¢

RECREATION - FISH & WILDLIFE 7¢

FIGURE 29

COSTS ALLOCATED TO PURPOSES

TABLE 14

ALLOCATION OF COSTS

Project & Purpose	First Cost	Annual Charges	Annual Benefits	B/C Ratio
	$	$	$	
Lakeview Reservoir:				
Flood control	9,213,700	358,100	1,391,000	3.9
Water supply	14,960,200	566,300	907,300	1.6
Recreation - fish & wildlife	7,006,100	447,600	2,025,000	4.5
Total	31,180,000	1,372,000	4,323,300	3.2
Aubrey Reservoir: (1)				
Water supply	22,951,600	826,550	1,085,200	1.3
Municipal & industrial	(14,360,800)	(517,150)	(679,000)	(1.3)
Quality control	(8,590,800)	(309,400)	(406,200)	(1.3)
Recreation - fish & wildlife	11,121,400	797,850	2,900,000	3.6
Total	34,073,000	1,624,400	3,985,200	2.5
Roanoke Reservoir: (2)				
Water supply	14,997,100	526,100	683,700	1.3
Recreation	1,902,900	97,700	150,000	1.5
Total	16,900,000	623,800	833,700	1.3
Tennessee Colony Reservoir:				
Flood control	42,663,600	1,492,800	3,238,000	2.2
Water supply	84,277,300	4,192,900	5,589,600	1.3
Municipal & industrial	(29,679,200)	(1,262,300)	(1,975,400)	(1.6)
Quality control	(54,598,100)	(2,930,600)	(3,614,200)	(1.2)
Navigation	51,893,000	2,427,600	2,951,000	1.2
Recreation - fish & wildlife	14,948,100	1,088,100	4,050,000	3.7
Total	193,782,000	9,201,400	15,828,600	1.7

(1) Includes costs and benefits of the modification of Garza-Little Elm project.
(2) Includes costs and benefits of the modification of Grapevine project.

172. APPORTIONMENT OF COSTS AMONG INTERESTS.- The apportionment between Federal and non-Federal interests of construction costs and annual operation, maintenance, and replacement costs is shown in table 15. Existing laws, policies, and procedures for apportionment of costs of public works among the various users, interests, and agencies that will contribute to the cost of the project differ with project purposes, types of development, and beneficiaries. The apportionment of costs is discussed in the following paragraphs.

173. Flood control.- Costs allocated to flood control are apportioned between Federal and non-Federal interests in accordance with the general policy given in the Flood Control Act of 1936 (Public Law 738, 74th Congress), as subsequently amended. All costs allocated to flood control features of the reservoirs and multiple-purpose channel are apportioned to the Federal Government because of the widespread and general benefits associated with the flood control effects of these projects and because the channel is a necessary and inseparable adjunct to the reservoirs for efficient and effective flood-control regulation. Costs for the local flood protection projects are assigned to the Federal Government except for the costs of lands, easements, rights-of-way and relocations (excluding railroads) and the annual operation, maintenance, and replacement costs, all of which are the responsibility of local interests.

174. Navigation.- Costs allocated to navigation are apportioned between Federal and non-Federal interests in accordance with Congressional policies expressed in legislation applicable to projects for general navigation. The Federal Government will bear the construction costs associated with navigation in the multiple-purpose channel, including navigation locks and dams and construction of bridges in new land cuts. The costs of bridge alterations over existing channels will be apportioned between Federal and non-Federal interests in accordance with the principles of Section 6 of the Bridge Alteration Act (Truman-Hobbs) of June 21, 1940, as amended. Non-Federal interests will bear a fair share of the costs of all lands, easements, rights-of-way and relocations (except bridges) for the multiple-purpose channel allocated in proportion to the benefits credited to the various purposes. The costs of maintenance dredging of the channel and operation and maintenance of the locks and dams will be borne by the Federal Government. The costs of operation and maintenance of all bridges are the responsibility of non-Federal interests.

175. Water supply and water quality control.- Costs allocated to storage for water quality control have been apportioned to the Federal Government, in accordance with the Water Pollution Control Act of 1948, as amended. All costs allocated to water supply for municipal and industrial uses are the responsibility of non-Federal interests, in accordance with the provisions of the Water Supply Act of 1958, (Public Law 500, 85th Congress), as amended. The provision for water supply

includes both that needed for immediate use (present demand storage) and for future use (future demand storage). Payment of first costs allocated to present demand storage will be made by non-Federal interests starting at the time water is available for delivery and payment of costs incurred for future demand storage need not be made by non-Federal interests until use is initiated. No interest will be charged on the investment costs for future water supply until use is initiated, but such interest-free period shall not exceed ten years. Operation and maintenance costs associated with the water supply for municipal and industrial uses are apportioned to local interests.

176. Recreation-fish and wildlife.- Recreation-fish and wildlife encompasses both general recreation and fish and wildlife recreation, which are considered to be project purposes of the recommended projects and which is in consonance with Senate Document 97, 87th Congress, 2d Session. Costs allocated to recreation-fish and wildlife are recommended as a Federal cost since the allocated costs for recreation-fish and wildlife for each project in the recommended plan fall within the criteria established by the Chief of Engineers that Federal costs include all specific costs plus joint costs not to exceed 25 percent of the total project cost.

TABLE 15

APPORTIONMENT OF COSTS

Project	First Cost			: Operation, Maintenance & Replacement Costs		
	Federal	Non-Federal	Total	: Federal	Non-Federal	Total
	$	$	$	$	$	$
Multiple-Purpose Channel	537,029,000	31,709,000	568,738,000	3,863,000	290,000	4,153,000
Reservoirs:						
Lakeview	16,220,000	14,960,000	31,180,000	275,000	77,000	352,000
Aubrey (1)	19,712,000	14,361,000	34,073,000	462,000	47,000	509,000
Roanoke (2)	1,903,000	14,997,000	16,900,000	36,000	42,000	78,000
Tennessee Colony	164,103,000	29,679,000	193,782,000	2,521,000	281,000	2,802,000
Local Protection:						
West Fork (3)	10,719,000	7,090,000	17,809,000	-	224,000	224,000
Elm Fork	11,191,000	5,632,000	16,823,000	70,000	103,000	173,000
Dallas Floodway Extension (3)	8,949,000	5,378,000	14,327,000	-	135,000	135,000
Duck Creek	4,176,000	848,000	5,024,000	-	6,000	6,000
Liberty Levee (3)	1,794,000	297,000	2,091,000	-	15,000	15,000
Total	$775,796,000	$124,951,000	$900,747,000	$7,227,000	$1,220,000	$8,447,000

(1) Including modification of Garza-Little Elm Reservoir.
(2) Including modification of Grapevine Reservoir.
(3) Exclusive of multiple-purpose channel.

LOCAL COOPERATION

177. PROPOSED LOCAL COOPERATION.- The projects recommended for authorization for the Trinity River Basin include a multiple-purpose channel, four multiple-purpose reservoirs, and five local flood protection projects. The proposed requirements of local cooperation are discussed in the subsequent paragraphs.

178. Multiple-Purpose Channel.- The proposed requirements of local cooperation for the Multiple-Purpose Channel are as follows:

a. Provide the share apportioned to navigation of the actual cost to the United States for all lands, easements, and rights-of-way, required for construction and subsequent maintenance of the project and for aids to navigation upon request of the Chief of Engineers, including suitable areas determined by the Chief of Engineers to be required in the general public interest for initial and subsequent disposal of spoil;

b. Hold and save the United States free from damages due to construction of works for navigation and from damages to real estate (land and improvements) resulting from dredging, changes in ground water level and wave action caused by operation and maintenance of the project;

c. Provide a proportionate share of the cost of bridge alterations over existing channels in accordance with the principles of Sec. 6 of the Bridge Alteration Act (Truman-Hobbs) of June 21, 1940, as amended;

d. Assume all obligations, owning, maintaining and operating all railway and highway bridges altered or constructed as part of the multiple-purpose channel project, with such obligation for each bridge to be assumed by local interests upon final completion of alteration or construction of that bridge;

e. Provide and maintain at local expense adequate public terminal and transfer facilities open to all on equal terms; provide and maintain without cost to the United States depths in berthing areas and local access channels serving the navigation channel commensurate with the depths provided in the related areas;

f. Provide the share apportioned to navigation of the actual cost to the United States for alterations of sewer, water supply, drainage, pipeline, and other utility facilities;

g. Obtain without cost to the United States any water rights that may be found necessary for operation of the project in the interest of navigation; and

h. Provide a cash contribution of 5.58 percent of the actual Federal cost of construction which includes items (a), (c), and (f) above. The cash contribution apportioned to local interests is currently estimated at $31,709,000.

179. Reservoirs.- The proposed requirements of local cooperation for the multiple-purpose reservoirs are as follows:

a. Provide the share of the cost of the reservoirs allocated to municipal and industrial water supply in accordance with the provisions of the 1958 Water Supply Act, as amended. These costs for each reservoir are currently estimated as follows:

Reservoir	Cost (in thousands of dollars)	
	Construction	Annual O&M
Lakeview	14,960	77
Roanoke-Grapevine	14,997	42
Aubrey-Garza-Little Elm (1)	14,361	47
Tennessee Colony (1)	29,679	281

(1) Excludes cost allocated to water quality control during interim use.

b. Obtain without cost to the United States all water rights necessary for operation of the project in the interest of water supply.

180. Local flood protection projects.- The projects recommended for authorization also include as local flood protection projects the West Fork Floodway; Elm Fork Floodway; Dallas Floodway Extension; Liberty Local Protection Project; and Duck Creek channel. The requirements of local cooperation for participation in these works of improvement except for the channel portion of the West Fork Floodway, Elm Fork Floodway, and Dallas Floodway Extension projects are as follows:

a. Provide without cost to the United States all lands, easements, and rights-of-way necessary for construction, maintenance and operation of the projects;

b. Provide without cost to the United States all relocations of buildings and utilities, bridges (except railroad), sewers, pipelines, and any other alterations of existing improvements which may be required for the construction of the project;

c. Provide assurances that encroachment on improved channels and floodways or ponding areas will not be permitted, and that, if ponding areas and capacities are impaired, substitute storage capacity or equivalent pumping capacity will be provided promptly without cost to the United States;

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

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

f. Agree to publicize flood plain information in the community and area concerned and to provide this information to zoning and other regulatory agencies and public information media for their guidance and appropriate action.

181. LOCAL COOPERATION OFFERED.- The President of the Trinity Improvement Association and Chairman of the Executive Committee of the Trinity River Authority of Texas by letters dated October 2,1961 and August 9, 1962, and informal discussion, has stated that it is the intent of these organizations to sponsor the projects recommended for authorization in this report and to undertake to comply singularly or jointly on items of cooperation required of local interests.

COORDINATION WITH OTHER AGENCIES

182. INITIATION OF STUDIES.- The study on the Trinity River Basin was initiated during the fall of 1957. The regional offices of other interested Federal agencies and the State of Texas were advised of this action by letter dated November 20, 1957. In response to the letter, the Federal agencies, in general, indicated an interest in the study, offered information on available basic and general data, and requested that copies of the report be submitted for field-level review and comment.

183. U. S. PUBLIC HEALTH SERVICE.- Estimates of the water supply needs and values for various purposes have been coordinated with the Public Health Service. On the basis of this coordination, the Public Health Service prepared a report presenting its determinations of the value of additional water supply that would result from construction of the Lakeview, Tennessee Colony, Roanoke, and Aubrey Reservoirs; results of water quality studies; problems concerning, and need for, pollution abatement; and water requirements for years 2020 and 2070. This report has been included as a part of Appendix II.

184. BUREAU OF SPORT FISHERIES AND WILDLIFE.- The Bureau of Sport Fisheries and Wildlife, U. S. Department of the Interior, was consulted regarding the fish and wildlife aspects of the recommended plan of development. The Bureau, in cooperation with the Bureau of Commercial Fisheries and the Texas Game and Fish Commission, prepared a report on the fish and wildlife aspects of the Lakeview and Tennessee Colony Reservoirs and the multiple-purpose channel. In accordance with the recommendations made in the report by the Bureau of Sport Fisheries and Wildlife, provisions have been incorporated in the plan for the Tennessee Colony Reservoir for development of a wildlife refuge. This agency report has been included as part of Appendix V.

185. NATIONAL PARK SERVICE.- The National Park Service, Department of the Interior, was requested to evaluate the recreational aspects and potentialities of the recommended Lakeview and Tennessee Colony Reservoirs and the multiple-purpose channel. A representative of the National Park Service prepared a report which contained an appraisal of the recreational potential and estimated monetary evaluation of the recreational benefits, which has been included as a part of Appendix V.

186. U. S. BUREAU OF RECLAMATION.- The Bureau of Reclamation, Department of the Interior, was consulted during the progress of the report studies to determine if there was a need and justification for the inclusion of irrigation storage space as a Federal purpose in any of the recommended reservoir projects in the Trinity River Basin.

Studies by the Bureau revealed that lands suited for irrigation can best be developed by individual land owners rather than by project-type facilities. Therefore, the reservoir projects recommended for authorization do not provide any storage space specifically allocated for irrigation purposes. The Bureau also has underway an investigation entitled, "Texas Basin Project," dealing with the water resources of the Texas streams that flow into the Gulf of Mexico. In this connection, consideration is being given to a system of canals, natural channels and appurtenant control structures to serve as a system for conveyance of water southwesterly along the Gulf Coast to water deficient areas. A storage reservoir on the lower Trinity River is indicated as a part of the Bureau plan. An analysis of the projected water requirements for the Trinity River Basin and of measures recommended to satisfy these requirements, as developed in this report, discloses that water for that purpose would not be available for export from the basin.

187. U. S. SOIL CONSERVATION SERVICE.- During investigation for this report and the report prepared for the U. S. Study Commission - Texas, numerous conferences were held which involved members of the Fort Worth and Galveston Districts and members of the Soil Conservation Service. Many problems associated with hydrology, hydraulics, economics, drainage, design, integrated river basin planning, and other related items were discussed. Engineering data made available as a result of these conferences generally served as the basis for an integrated and complementary plan of water resources development for the Trinity River Basin.

188. FEDERAL POWER COMMISSION.- The Fort Worth regional office of the Federal Power Commission was requested to prepare estimates of power and energy values for the potential development of hydroelectric power at the Lakeview and Tennessee Colony Reservoir projects, based on January 1962 price levels. These values were used in studies to determine the economic justification for including hydroelectric power as a specific purpose in these projects.

189. BUREAU OF PUBLIC ROADS AND TEXAS HIGHWAY DEPARTMENT.- The Bureau of Public Roads and the Texas Highway Department were contacted during the progress of the study so that the future plans of these agencies may be fully integrated into the overall comprehensive plan of development. All highway relocations and related activities in the plan of development have been accomplished generally in accordance with the policies and procedures of the Bureau of Public Roads and the Texas Highway Department.

190. TEXAS WATER COMMISSION.- During the investigation for this report and the report prepared for the U. S. Study Commission - Texas, many conferences and informal discussions were held with various representatives of the Texas Water Commission. Basic data, agency procedures, project formulation, coordination of the Corps of Engineers' plan with

that developed by the Commission and the Trinity River Authority, and many other engineering and policy matters were discussed. Engineering data compiled and reports published by the Commission were used in connection with the basin studies.

191. U. S. STUDY COMMISSION - TEXAS.- In the process of developing the report of the U. S. Study Commission - Texas, separate plans for each of the eight basins were prepared for incorporation into an integrated overall plan for the entire area. The Corps of Engineers was assigned the formulation of preliminary plans for four of the basins including the Trinity River. In the development of these plans for the Commission certain basic hydrologic, economic, and other data were computed by the U. S. Bureau of Reclamation, Soil Conservation Service, other Federal agencies, and State agencies. Much of the data prepared for the U. S. Study Commission - Texas has been used by the Corps of Engineers in the development of the comprehensive plan for the Trinity River Basin. The proposed Trinity River Basin plan is in full consonance with the U. S. Study Commission - Texas plan.

192. REVIEW OF REPORT BY OTHER AGENCIES.- Copies of this report have been forwarded to the interested Federal agencies at field level and the Texas Water Commission for their preliminary views and comments. Letters from these agencies containing their comments and replies where appropriate are presented in Appendix VIII of this report. The comments are summarized briefly in the following subparagraphs.

a. U. S. Public Health Service.- The Public Health Service, by letter dated August 9, 1962, stated that minor inconsistencies between data contained in the Corps report and their report which is included as Exhibit 1, Appendix II, had been resolved and offered no further comment.

b. Bureau of Sport Fisheries and Wildlife.- The comments of the Corps of Engineers on the recommendations contained in the Bureau of Sport Fisheries and Wildlife report are contained in Appendix V. The Bureau of Sport Fisheries and Wildlife, by letter dated August 3, 1962, expressed their disappointment with our decision that the proposal for a national wildlife refuge should be considered separately from the reservoir project. Studies have shown that the refuge as proposed by the Bureau of Sport Fisheries and Wildlife is a separable economic component which could be included or excluded from the overall development without affecting the justification of the other purposes of the reservoir and it was concluded that the Fish and Wildlife Service and the Department of the Interior would be the agencies responsible for providing necessary detail and specific technical support for the refuge, as may be necessary. The Bureau of Sport Fisheries and Wildlife stated that they stand ready to support the proposal before Congress or at such times and places as are appropriate. The Bureau also noted a wide variance between the fish and wildlife benefits estimated by them and the Corps of Engineers. The Corps estimates of benefits are based on experienced visitor use at comparable operating Corps reservoirs throughout the area and are considered conservative. In developing the estimates, consideration was

given to present population density, predicated population increases during project life, and competition to be satisfied from existing and other proposed reservoirs.

c. National Park Service.- The National Park Service, by letter dated August 3, 1962, stated that they had reviewed the report and had no comment.

d. U. S. Bureau of Reclamation.- The Bureau of Reclamation, by letter dated August 17, 1962, stated that the report is of interest in connection with their Texas Basin Project Study and that they had no comments to offer at field level.

e. U. S. Soil Conservation Service.- By letter dated August 13, 1962, the Soil Conservation Service proposed certain comments and revisions which have been included in the report. The Soil Conservation Service stated that with consideration of their comments, they felt that the treatment of agricultural phases and recognition of Soil Conservation Service programs, together with coordination of activities of our respective agencies, was presented adequately in the report.

f. Federal Power Commission.- The Federal Power Commission by letter dated August 16, 1962, expressed their opinion that facilities for generation of power should not be recommended at this time at any of the projects proposed. However, they further stated that power potentialities in the Tennessee Colony Project should be restudied during preconstruction planning.

g. Bureau of Public Roads.- The Bureau of Public Roads in their letter dated July 30, 1962, stated that the basic regulations of the Bureau will not permit the use of Federal-aid highway funds to relieve local interests of their obligations concerning highway and bridge relocations and alterations incurred as a result of construction of the recommended projects.

h. Bureau of Mines.- The comments by the Bureau of Mines in their letter dated August 20, 1962, were that it does not object to Federal authorization for the recommended projects provided that mineral resources and mineral producing and handling facilities are protected for continued operation and development.

i. U. S. Geological Survey.- The U. S. Geological Survey, by letter dated August 29, 1962, stated that the comprehensive report anticipates major future water use and water control needs and offered no objection to the projects proposed in the report.

j. Southwestern Power Administration.- By letter dated August 29, 1962, the Southwestern Power Administration stated that a

review of the pertinent portions of the report indicate that the interests of the Administration would not be affected by the proposed improvements.

k. Texas Water Commission.- The Commission furnished comments on the draft of the report and two conferences were held with staff personnel of the Commission and the Corps of Engineers to consider various aspects of the report. Subsequent revisions have been made in the report as a result of these considerations. In their letter of September 11, 1962, the Commission concluded to withhold its formal comments pending the public hearing to be held in accordance with Article 7472e, Vernon's Civil Statutes of Texas.

DISCUSSION AND CONCLUSIONS

193. DISCUSSION.- The economic situation in the Trinity River Basin can be described as a vigorous, expanding business and industrial complex in the upper portion of the basin and in the area along the Gulf coast that compares favorable with other urbanized areas of equal size in the United States. In the remaining portions of the basin the opposite exists with the generally agricultural economy either stationary or declining. The areas of vigorous growth are expected to continue to grow. The remaining areas have a vast potential for economic growth that requires only the control of frequent long duration floods, the provision of regulated water supplies, and a water transportation system.

194. The comprehensive plan of development for the water and related land resources of the Trinity River Basin gives full recognition of the needs that must be satisfied to provide unimpeded development in the upper basin and coastal area and to stimulate the great economic development that is possible in the middle and lower basins. Basic in any planning is the scheduling of projects for orderly development of an area, and it became evident early in the studies that a flood control channel was required now as a basic part of the established flood control program of reservoirs and floodways, as well as for any new flood control projects. It also became apparent that modification of this channel to provide water navigation was practical and vital to the economic development of the basin and the region. In addition to the multiple-purpose channel, immediate needs and justification were found for the development of additional facilities for flood control, water supply, water quality control, recreation and fish and wildlife. This led to the development of the projects recommended for authorization, all of which are integral parts of the comprehensive plan and are economically justified individually and as a system. The magnitude of the resources of the Trinity River Basin in relation to the immediate and long-range needs of the area was not conducive to alternative plans of in-basin development if maximum practical satisfaction of all of the needs were to be met.

195. The projected water supply to satisfy the needs by the year 2070 for municipal and industrial use, non-municipal use, water quality control, navigation, irrigation, and including exportation to the City of Houston would require the full development of the water resources of the basin. The plan for development of the water resources was formulated to operate within the framework of permits issued by the Texas Water Commission to local interests and permit 1970 granted jointly to the City of Houston and the Trinity River Authority. Studies showed that additional supplies from surface water resources obtained by the development of the four reservoirs recommended for authorization in this report and the phased development of the thirteen long-range reservoir projects together with the maximum practical development of

ground water, and the use of return flow would be required to satisfy fully the projected water supply needs of the basin by 2070. Studies also revealed that the Tennessee Colony and Aubrey Reservoirs could be scheduled for construction, so that interim use of the water supply could be made to satisfy immediate and near future water quality requirements to eliminate the septic conditions in the Trinity River from Fort Worth to below Rosser. Accordingly, pipe line facilities from the Tennessee Colony Reservoir to the existing Benbrook Reservoir were provided and a yield of 80 million gallons of water per day from Tennessee Colony and 40 million gallons of water per day from Aubrey Reservoir would be utilized initially for water quality control. The pipe line facilities and reservoir storage used for water quality control would be converted to fulfill municipal and industrial water needs as they develop and local interests contract to repay the remaining costs of the facilities. The facilities utilized on an interim basis for water quality control are provided to satisfy ultimate water supply requirements and conversion to this purpose places no obligation on those contracting for the facilities to provide replacement water quality control measures. Prior to construction of Aubrey Reservoir (including modification of Garza-Little Elm), arrangements for operation and future conversion of these projects would be made with the cities of Dallas and Denton which have contracts with the United States for existing conservation storage in Garza-Little Elm Reservoir and hold permits from the State of Texas for the water use. With respect to water quality it is anticipated that as conversion is made to water supply the maintenance of a good quality of water will be made possible by expected future developments in increased efficiency in treatment of water pollution.

196. In the formulation of the plan for meeting the water supply demands in the basin, it was recognized that the people who will ultimately require additional water resources may prefer to import water rather than to develop in-basin resources such as ground water and return flow. In such a situation the available water resources within the basin may not be fully utilized. Importation of water from other areas would not alter the need for or the economic justification of the projects recommended for authorization in this report. As the needs arise in the future, studies can be made to determine the best solution of the several alternatives then existing.

197. The navigation features of the multiple-purpose channel were designed to accommodate efficiently the size and type of equipment expected to carry the prospective commerce on the waterway during the immediately foreseeable future. The water requirements necessary to operate the navigation facilities would be satisfied by return flows and existing navigation storage and no additional storage is required for this purpose. On the basis of the projected increases in commerce and on the expected pattern of distribution of the commodities and movements of tows, it was found that the capacity

of the locks in the reach immediately below Dallas would be reached by the expected traffic in the year 2015. Considerable increase in the carrying capacity of the waterway, however, could be realized by rearrangement of tows being locked through the restrictive locks and by some restriction on movement of pleasure craft. The waterway navigation facilities were found to be economically justified at this time on the basis of reaching a maximum capacity through the year 2020. Further increase in capacity could be obtained by construction of additional locks and eventually by widening of the channel. Since the initial development was found to be economically justified as a unit and on the basis of the projections of commerce, enlargement would not be needed until 2020, there is no justification in the public interest for constructing a larger waterway at this time. However, the plan recommended herein is designed so that enlargement of the waterway to accommodate the projected commerce can be provided as the need arises and the cost of the added works is found justified.

198. The pattern of economic growth in the area of the Roanoke Reservoir indicates that extensive development can be expected to take place before the project will be required for water supply. Such development, if not limited, could preclude the construction of the reservoir because of high cost of lands, relocations and damages. It was found desirable and economically justified to obtain an interest in the necessary lands in advance of construction so as to preserve the dam site and reservoir from encroachment. A minimum interest in the lands consistent with the objective of site and reservoir preservation would be obtained. Prior to construction, tenancy would be preserved where practical with development for recreation and fish and wildlife on areas where outright purchase was necessary. Measures are also provided for advance participation in construction or reconstruction of transportation facilities to minimize costs for relocations.

199. Construction of the multiple-purpose channel recommended for authorization in this report would likely extend over a number of years in the future. In the interim, construction of Livingston Reservoir by the City of Houston is scheduled to be initiated in the immediate future. Construction of that reservoir will require relocation of transportation and utility lines which would have to be subsequently further modified when the multiple-purpose channel is constructed. If the Federal Government were to participate in such relocations, significant saving in cost to the United States would be realized. The savings in public funds as well as the avoidance of added inconvenience to transportation traffic occasioned by separate relocations, would warrant the expenditure of Federal funds in advance of start of overall construction of the multiple-purpose channel. Measures are recommended herein for advance participation in relocations on Livingston Reservoir to avoid increased costs.

200. Economic growth will continue along the proposed alignment of the multiple-purpose channel and adjacent to the local protection projects in advance of construction. Rapid acceleration and expansion

of transportation and utility facilities normally accompany a growing economy. The time-sequence of the expanding transportation and utility work should, insofar as practicable, be phased with the design and construction of the proposed waterway and local protection works. Every effort should be made to advance design and construction of the works proposed herein in phase with transportation and utility relocations to effect savings in public funds and to minimize adverse effects on the orderly development of the basin. If the recommended projects are authorized, participation by the United States in such undertakings should be coordinated with local interests on an individual basis with the view to submitting to Congress separate reports on desirable participation.

201. The needs for flood control, navigation, and water quality control are immediate and it is anticipated that projects involving these purposes would be initiated soon after authorization. In scheduling the accomplishment of individual units of the program, consideration would be given to the requirements for all purposes, with particular attention given to provision of water supply storage in order to meet the projected needs as they develop. Since construction by the Corps of Engineers is determined by appropriation of funds by Congress no assurance can be given herein that Federal construction would be undertaken in accordance with a particular schedule. Under these circumstances, it should not be construed that Federal authorization would constitute a preemption of a site or would prohibit development of a site by local interests if water supply needs develop in advance of Federal appropriations for a project.

202. Additional information on recommended projects called for by Senate Resolution 148, Eighty-fifth Congress, adopted January 28, 1958, is contained in an attachment to this report. (Appendix I)

203. CONCLUSIONS.- The comprehensive basin plan provides for the development of the water and related land resources to meet the immediate and long range needs. The projects recommended for authorization and immediate construction are those found necessary for the orderly development of the water and related land resources consistent with the present and projected economic conditions of the Trinity River Basin. The projects are consistent with the comprehensive plan for basin development and are multiple purpose in scope. They are well justified both individually and as a system and each purpose served by the projects is fully justified. Projects recommended for inclusion in the long range plan but not recommended for authorization at this time would only be considered for Federal participation after detailed studies are made to develop the full comprehensive requirements of each project and its justification. The comprehensive basin plan including the projects recommended for authorization and immediate construction is in full consonance with the recommendations of the U. S. Study Commission Texas which contemplates that their plan be followed as a flexible framework guide in detailed planning for subsequent survey reports for project authorization by appropriate Federal agencies.

204. RECOMMENDATIONS.- On the basis of the studies and conclusions made for this report, it is recommended that the comprehensive plan be recognized as the plan for the full development and beneficial public use of the water and related land resources of the Trinity River Basin and that the existing, under construction, authorized, and previously recommended projects for the Trinity River Basin be supplemented to provide:

a. A multiple-purpose channel extending along the Trinity River from the Houston Ship Channel to Fort Worth, Texas, including enlargement of the navigation lock previously recommended for construction in connection with the Wallisville Reservoir and spur channels and turning basins in Dallas and Fort Worth.

b. Multiple-purpose reservoirs:

(1) Lakeview Reservoir
(2) Roanoke Reservoir (including modification of Grapevine Reservoir)
(3) Aubrey Reservoir (including modification of Garza-Little Elm Reservoir)
(4) Tennessee Colony Reservoir

c. Local flood protection projects:

(1) West Fork Floodway
(2) Elm Fork Floodway
(3) Dallas Floodway Extension
(4) Duck Creek Channel Improvement
(5) Liberty Local Protection Project

d. That the foregoing be accomplished with such changes and modifications as in the discretion of the Chief of Engineers may be advisable, at an estimated total construction cost of $900,747,000 and $8,447,000 annually for maintenance and operation. The net cost to the Federal Government for construction and the annual maintenance and operation cost are estimated at $775,796,000 and $7,227,000, respectively.

e. That the Chief of Engineers be authorized to acquire an interest in the reservoir and dam site lands and to participate in construction or reconstruction of transportation and utility facilities for the Roanoke Project in advance of construction as required to preserve such areas from encroachment and to avoid increased costs for relocations. The interest in lands to be acquired would be the minimum necessary consistent with the objective of reservoir and dam site preservation. This authorization would enable the Chief of Engineers to cooperate with

responsible local interests to keep lands on local tax rolls and to exercise control over development in the reservoir and dam site area until needed for project purposes.

f. That the Chief of Engineers be authorized to participate in relocations in the Livingston Reservoir in advance of the start of actual construction on the multiple-purpose channel project, when relocation of existing or construction of new highways, railroads, pipelines, and utility lines that would subsequently have to be modified for project purposes, are undertaken by other agencies; provided that a net saving in cost of construction to the United States will result; and provided further that funds shall be expended only on those relocations required for project purposes.

g. That, prior to initiation of construction, responsible local interests give assurances satisfactory to the Secretary of the Army that they will:

(1) With respect to the multiple-purpose channel:

(a) Provide the share apportioned to navigation of the actual Federal cost for all lands, easements, and rights-of-way required for construction and subsequent maintenance of the project and for aids to navigation upon the request of the Chief of Engineers, including suitable areas determined by the Chief of Engineers to be required in the general public interest for initial and subsequent disposal of spoil;

(b) Hold and save the United States free from damages due to construction of navigation works and from damages to real estate (land and improvements) resulting from dredging, changes in ground water level and wave action caused by operation and maintenance of the project;

(c) Provide a proportionate share of the cost of bridge alterations over existing channels in accordance with the principles of Section 6 of the Bridge Alteration Act (Truman-Hobbs) of June 21, 1940, as amended;

(d) Assume all obligations, owning, maintaining and operating all railway and highway bridges altered or constructed as part of the multiple-purpose channel project, with such obligation for each bridge to be assumed by local interests upon final completion of alteration on construction of that bridge;

(e) Provide and maintain at local expense adequate public terminal and transfer facilities open to all on equal terms; provide and maintain without cost to the United States depths in berthing areas and local access channels serving the navigation channel commensurate with the depths provided in the related areas;

(f) Provide the share apportioned to navigation of the actual Federal cost for alterations of sewer, water supply, drainage, pipelines, and other utility facilities;

(g) Obtain without cost to the United States any water rights that may be found necessary for operation of the project for navigation;

(h) Provide a cash contribution of 5.58 percent of the actual Federal cost of construction which includes items (a), (c), and (f) above. The cash contribution is presently estimated at $31,709,000.

(2) With respect to Lakeview, Roanoke, Aubrey and Tennessee Colony Reservoirs:

(a) Reimburse the United States for the water supply storage in the project on terms which will permit paying out the costs allocated thereto as determined by the Chief of Engineers, in accordance with the provisions of the Water Supply Act of 1958, as amended; such costs presently estimated as shown below:

	Allocated costs to water supply			
	Construction costs		Annual O&M costs	
Reservoir	Amount (dollars)	Percent	Amount (dollars)	Percent
Lakeview	14,960,000	47.98	77,000	21.81
Roanoke	14,997,000	88.74	42,000	53.53
Aubrey	14,361,000	42.15	47,000	9.25
Tennessee Colony	29,679,000	15.32	281,000	10.04

with such modification in these amounts as may be necessary to reflect adjustments in the storage capacity for water supply and other purposes, except that these costs and percentages may be revised in the preconstruction planning stage; and

(b) Obtain without cost to the United States all water rights necessary for operation of the project in the interest of water supply.

(3) With respect to West Fork Floodway, Elm Fork Floodway, Dallas Floodway Extension (except for the channel portions thereof),

Duck Creek Channel Improvement, and Liberty Local Protection Project:

(a) Provide without cost to the United States all lands, easements, and rights-of-way necessary for construction, maintenance and operation of the project;

(b) Provide without cost to the United States all relocations of buildings and utilities, bridges (except railroads), sewers, pipelines, and any other alterations of existing improvements which may be required for the construction of the project;

(c) Provide assurances that encroachment on improved channels and floodways or ponding areas will not be permitted; and that, if ponding areas and capacities are impaired, substitute storage capacity or equivalent pumping capacity will be provided promptly without cost to the United States;

(d) Hold and save the United States free from damages due to the construction works;

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

(f) Agree to publicize flood plain information in the community and area concerned and to provide this information to zoning and other regulatory agencies and public information media for their guidance and appropriate action.

205. It is also recommended that, in the interest of comprehensive planning and development of the water resources of the Trinity River Basin, the Congress give careful consideration to the recommendations of the Bureau of Sport Fisheries and Wildlife providing for fee acquisition of about 600 acres of land immediately adjacent to the Tennessee Colony Reservoir at an estimated additional cost of $145,000, and should the acquisition of the additional lands be authorized, the Corps of Engineers be also authorized to make available to the Secretary of the Interior for a national wildlife refuge, about 20,400 acres of land within the Tennessee Colony Reservoir and authorize the Chief of Engineers to operate the Tennessee Colony Reservoir in support of the Wildlife refuge insofar as it does not conflict or interfere with the operations for other project purposes.

JAMES S. MAXWELL
Lt Col, CE
District Engineer
Galveston District

R. P. WEST
Colonel, CE
District Engineer
Fort Worth District

[First endorsement]

SUBJECT: Comprehensive Survey Report on Trinity River and Tributaries, Texas

United States Army Engineer Division, Southwestern, Dallas, Texas, September 19, 1962.

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

I concur in the conclusions and recommendations of the District Engineers, Fort Worth and Galveston Districts.

C. H. DUNN
Brigadier General, USA
Division Engineer

TRINITY RIVER AND TRIBUTARIES, TEXAS
COMPREHENSIVE SURVEY REPORT

INFORMATION REQUIRED 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, 1st Session, adopted January 28, 1958.

2. WATER PROBLEMS.- The principal water problems in the Trinity River Basin are those associated with navigation of the Trinity River from the Houston Ship Channel to Fort Worth, flood control, and an adequate water supply for municipal and industrial purposes. In addition, there are problems associated with pollution control, particularly along the main course of the Trinity River between Fort Worth and Trinidad. Also, there are problems associated with the provision of recreational facilities on the proposed reservoirs and along the navigation pools in order to satisfy the anticipated needs and demands for water-related recreation activities. The economic studies of the basin show that the water problems will become more acute with the expected growth and development, particularly in the Fort Worth-Dallas area.

3. NAVIGATION PROBLEMS.- The major water problem relative to navigation on the Trinity River is providing the water requirements at the controlling locks necessary for lockage of floating craft and at the same time supplying sufficient water to meet the estimated losses in the pools formed by the navigation locks and dams.

4. FLOOD PROBLEMS.- The control of floods is one of the major problems in the basin. Although Corps of Engineers' reservoirs and floodway projects in operation in the upper basin are credited with preventing over $87,000,000 in damages during the 1957 (April-June, and October-November) floods, the almost $20,000,000 in damages which were experienced during these floods clearly show the need for additional flood control works in the upper basin and in improved and developed areas in the remainder of the basin not presently afforded protection. The approximate $20,000,000 in flood damages which were experienced during the 1957 floods would be multiplied many-fold under conditions of growth and development forecast for the next 50 years. Under projected conditions of watershed development, the area along the West Fork between Fort Worth and Dallas, the area along the Elm Fork downstream from the mouth of Denton Creek, and the area along the main stem of the Trinity downstream from Dallas to Five Mile Creek will all

experience accelerated urban and industrial growth. The urban area along Duck Creek in Garland and in the vicinity of Liberty in the lower basin will also experience growth and expansion. The remaining flood problem areas along the Trinity River downstream from Five Mile Creek are rural in character.

5. WATER SUPPLY PROBLEMS.- Associated with the anticipated population growth and urban and industrial expansion are the needs for adequate water supply facilities and development of the surface and ground water resources of the basin to their fullest practicable potential. The projected requirements for the year 2020 to satisfy navigation, municipal and industrial, irrigation, water quality control, and exportation uses total 3,433 million gallons per day, and the projected water requirements for the year 2070 to satisfy these uses total 5,187 million gallons per day.

6. RECOMMENDED PLAN OF DEVELOPMENT.- In the main report, the District Engineers recommend that the plan presented in House Document 403, Seventy-seventh Congress, first session, and as modified by subsequent interim reports and authorizations, be expanded to meet the changing conditions in the Trinity River Basin. Units of the plan recommended for authorization in this report are shown in green on the attached plate, and consist of the following features:

a. Multiple-purpose channel for navigation and flood control.- The proposed navigable waterway would extend from Fort Worth to a junction with the Houston Ship Channel in Galveston Bay. The plan provides for terminals at Fort Worth and Dallas, 19 navigation locks with chambers 84 feet wide by 600 feet long on the channel downstream from Dallas, and 4 navigation locks with chambers 56 feet wide by 400 feet long on the channel upstream from the Dallas terminus to the Fort Worth terminus. In addition to the reservoir dams there are eighteen navigation dams which provide slackwater pools for navigation. Channel requirements for navigation are a minimum depth of 12 feet and bottom widths of 150 feet downstream from Dallas and 125 feet upstream from Dallas. The rectified channel for flood control has its upstream limit at the beginning of the existing Fort Worth Floodway and joins the navigation channel at the entrance to the Fort Worth terminus and proceeds along a common alignment with the navigation channel to the river's mouth. The channel design provides sufficient capacity to contain operational flood control releases from existing and proposed reservoirs, supplemented by local runoff. Bottom widths required for the combined use, navigation and flood control, channel vary from 150 to 300 feet.

b. Lakeview Reservoir.- The Lakeview dam site is located at river mile 7.2 on Mountain Creek in Dallas County. The proposed reservoir would be formed by an earth dam with a maximum height above streambed of about 91 feet, and a total length of about 22,620 feet including a

136 foot concrete spillway controlled by three 40 by 28 foot tainter gates. The reservoir will have a total controlled storage of 488,700 acre-feet and an area of 15,650 acres at elevation 528.0, top of gates or top of flood control pool. The total storage includes 136,700 acre-feet for flood control, 306,400 acre-feet for water conservation and 45,600 acre-feet for sediment reserve. The 306,400 acre-feet of conservation storage provides a net yield of 47 cubic feet per second or 30.4 million gallons daily under 2020 conditions of watershed development during a recurrence of the 1950-1957 drought period.

c. Aubrey Reservoir.- The Aubrey dam site is located at river mile 60.0 on the Elm Fork of the Trinity River in Denton County. The proposed reservoir would be formed by an earth dam with a maximum height of about 116 feet above streambed and a length of about 13,660 feet including a 424-foot concrete spillway controlled by nine 40 x 35 foot tainter gates. The reservoir would have a total controlled storage capacity of 899,900 acre-feet and an area of 30,750 acres at elevation 635.0 top of flood control pool. The total controlled storage includes 37,800 acre-feet for sediment reserve, 603,800 acre-feet for water conservation, and 258,300 acre-feet for flood control. The flood-control storage in Aubrey Reservoir would permit the reallocation of the storage in the existing downstream Garza-Little Elm Reservoir and increase that storage presently allocated to water conservation purposes. Under 2020 conditions of watershed development and a recurrence of the 1950-1957 drought period, the dependable yield from the Aubrey-Garza-Little Elm system is estimated to be 151.3 million gallons per day, or 65.3 million gallons per day more than would be produced by Garza-Little Elm Reservoir alone.

d. Roanoke Reservoir.- The Roanoke dam site is located at river mile 32.0 on Denton Creek in southwest Denton County. The proposed reservoir would be formed by an earth dam having a maximum height of about 97 feet above streambed and a total length of about 15,200 feet including two dikes and a 328-foot concrete spillway controlled by seven 40 x 35 foot tainter gates. The reservoir would have a total controlled storage capacity of 249,900 acre-feet and an area of 9,720 acres at elevation 619.0 top of flood control pool. There would be 223,700 acre-feet of flood-control storage and 26,200 acre-feet of storage for sediment reserve. The flood control storage in Roanoke Reservoir would permit a reallocation of the storage in the existing Grapevine Reservoir and increase that storage presently allocated to water conservation purposes. With the reallocation of storage, under 2020 conditions of watershed development and a recurrence of the 1950-1957 drought period, the Grapevine Reservoir would yield about 42 million gallons per day or an increase of 23.9 million gallons per day over that which would be produced by Grapevine Reservoir without the increased conservation storage.

e. Tennessee Colony Reservoir.- The Tennessee Colony dam site is located at river mile 339.2 on the Trinity River about 16 miles west of Palestine, Texas. The principal structure consists of an earth fill dam with a maximum height of 114 feet above streambed and a total length of 29,500 feet including a 520-foot concrete spillway controlled by eleven 40 x 35-foot tainter gates. The reservoir will have a total controlled storage of 3,366,800 acre-feet and an area of 119,500 acres at elevation 285.0, top of spillway gates or top of flood control pool. The total storage includes 2,144,300 acre-feet for flood control, 1,032,500 acre-feet for water conservation and 190,000 acre-feet for sediment reserve. The 1,032,500 acre-feet of conservation storage is estimated to provide a yield of 450 cubic feet per second or 290.8 million gallons daily under 2020 conditions of watershed development during a recurrence of the 1950-1957 drought period. The gated spillway of Tennessee Colony dam would control the river discharges passing the 84 x 600-foot locks, 10B located in the dam, and 10A located about 0.6 of a mile downstream.

f. West Fork Floodway.- The West Fork Floodway project consists of a component part of the multiple purpose channel for navigation and flood control, and a floodway from the mouth of the West Fork in the Dallas Floodway, upstream a distance of about 31 channel miles to the beginning of the existing Fort Worth Floodway. Flood control features include the following items:

(1) Realignment and enlargement of the channel to provide bottom widths varying from 150 to 200 feet.

(2) Enlargement and realignment or diversion of avout 16.74 miles of tributary channels through leveed areas.

(3) A parallel levee system consisting of about 34.0 miles of levee along the left bank, 9.1 miles of new levee and rehabilitation of 1.5 miles of existing levee on the right bank. The floodway varies in width from 1,000 feet to 3,000 feet between centerline of levees. Floodway capacity varies from about 95,000 to 160,000 cubic feet per second. Levees have 1 on 2.5 side slopes with a 10-foot crown width and will provide 4 feet of freeboard above the design water surface.

(4) The provision of gravity interior-drainage facilities, modification of 14 main stem and 5 tributary channel bridges, construction of one road, and filling of eight areas outside proposed leveed areas.

g. Elm Fork Floodway.- The Elm Fork Floodway project extends along the Elm Fork from its mouth to Lewisville Dam and along Denton Creek from its mouth to Grapevine Dam and includes the following items:

(1) Rectification of the Elm Fork channel from Lewisville Dam to mouth of Denton Creek. The 50-foot bottom width channel will provide a discharge capacity of 10,000 cubic feet per second.

(2) Clearing 7.0 miles of channel and flood plain, and realignment and enlargement of the lower 1.9 miles of Denton Creek to its mouth to provide a channel capacity of 7,000 cubic feet per second.

(3) Rectification of 14.3 miles of Elm Fork Channel from the mouth of Denton Creek downstream to the West Fork to provide a 100-foot bottom width channel with a discharge capacity of 15,000 cubic feet per second.

(4) Enlargement and realignment of about 11.2 miles of tributary channels through leveed areas.

(5) A parallel levee system of about 24.8 miles along the left bank, 14.1 miles of new levee and rehabilitation of 1.8 miles of existing levee on the right bank, with minimum floodway width of 1,100 feet between centerline of levees. The floodway capacity varies from 58,000 to 61,000 cubic feet per second. Levees have 1 on 2.5 side slopes with a 10-foot crown width, and will provide 4 feet of freeboard above the design water surface.

(6) The provision of gravity interior drainage facilities, modification of 18 bridges and construction of two streets, filling of four areas outside proposed leveed areas, and relocation of utility lines.

h. Dallas Floodway Extension.- The Dallas Floodway Extension project includes a component part of the multiple purpose channel for navigation and flood control, improvement of the lower portion of White Rock Creek, and a floodway downstream from the Dallas Floodway to Five Mile Creek. Flood control features include the following items:

(1) Rectification of the Trinity River to provide a 150-foot bottom width channel with a capacity of 35,000 cubic feet per second.

(2) Enlargement and realignment or diversion of about 10.5 miles of tributary channels through leveed areas.

(3) A parallel levee system of about 10.2 miles of left bank levee, and 14.6 miles of new levee and rehabilitation of 0.6 mile of existing levee on the right bank. The main stem floodway is to have a minimum width of 2,000 feet between centerline of levees. Floodway capacity varies from 163,800 to 174,600 cubic feet per second. Levees have 1 on 2.5 side slopes with a 10-foot crown width and will provide 4 feet of freeboard above the design water surface.

(4) The provision of gravity interior-drainage facilities, modification of 13 bridges, filling of one area outside the proposed leveed areas, and relocation of utility lines.

i. Duck Creek Channel.- The plan of improvement for Duck Creek consists of a channel improvement project along the main channel in the vicinity of Garland, Texas, from creek mile 10.38 to mile 17.53. The project includes the following features:

(1) Realignment and enlargement of about 6.6 miles of Duck Creek Channel including 0.58 mile of concrete gravity wall section, to provide sufficient capacity to contain discharges varying from 21,500 cubic feet per second at the upstream end to 40,700 cubic feet per second at the downstream end of the project.

(2) The modification of 10 bridges, and alteration and relocation of utility lines.

j. Liberty Local Protection.- The plan of improvement in the vicinity of Liberty, Texas, in addition to the multiple-purpose channel along the Trinity River, includes construction of about 53,500 feet of levee and provision of appurtenant interior drainage facilities consisting of permanent sump areas, gated gravity drains and two pump stations.

k. Pipeline.- In order to facilitate pollution abatement along the Trinity River from Fort Worth downstream to the vicinity of Rosser, Texas, a supply of about 80 million gallons of water per day of acceptable quality would be necessary at Fort Worth. This water is available from Tennessee Colony Reservoir and would be delivered by pipe line to Benbrook Reservoir, 14 miles upstream from Fort Worth on the Clear Fork of the Trinity River. The use of Benbrook Reservoir for terminal storage will enable the pipe line to be sized for average demand rather than for a higher peak demand and will also enable the regulation of the flows in the river in contrasting periods of drought and excessive runoff. The water from Tennessee Colony Reservoir would be conveyed to Benbrook Reservoir through an 84-inch pipe line. The pipe line would be approximately 98 miles long and there would be 4 pumping stations - a main station at the Tennessee Colony Reservoir intake and 3 booster stations along the pipe line.

7. PROJECT COSTS.- The total estimated first cost of the projects in the recommended plan of development to be authorized at this time for the Trinity River Basin, based on January 1962 prices is $900,746,400. The first cost operation and maintenance costs and annual charges for the units in the plan are shown in table 1.

8. ECONOMIC ANALYSES.- The annual charges, annual benefits and and benefit-cost ratios for 100-year economic life and 50-year economic life for the recommended plan of development and for each unit in the plan are shown in table 2.

TABLE 1

FIRST COST, OPERATION AND MAINTENANCE, AND ANNUAL CHARGES
PROJECTS IN RECOMMENDED PLAN OF DEVELOPMENT

Project	First Cost			Operation, Maintenance and Replacement			Annual Charges		
	Federal	Non-Federal	Total	Federal	Non-Federal	Total	Federal	Non-Federal	Total
Multiple-Purpose Channel	$537,029,100	$31,708,600	$568,737,700	$3,863,200	$289,900	$4,153,100	$22,311,900	$1,400,600	$23,712,500
West Fork Floodway	10,719,000	7,090,000	17,809,000	(1)	224,000	224,000	346,200	461,900	808,100
Elm Fork Floodway	11,191,000	5,632,000	16,823,000	70,000	103,000	173,000	431,400	292,000	723,400
Dallas Floodway Extension	8,949,000	5,378,000	14,327,000	(1)	135,500	135,500	289,000	315,900	604,900
Duck Creek Channel	4,176,000	848,000	5,024,000	0	6,000	6,000	127,600	32,800	160,400
Liberty Local Protection	1,794,000	296,700	2,090,700	0	15,000	15,000	54,800	24,400	79,200
Sub total	573,858,100	50,953,300	624,811,400	3,933,200	773,400	4,706,600	23,560,900	2,527,600	26,088,500
Reservoirs									
Lakeview Reservoir			31,180,000			351,300			1,372,000
Aubrey Reservoir (Including modification of Garza-Little Elm Reservoir)			34,073,000			509,000			1,624,400
Roanoke Reservoir (Including modification of Grapevine Reservoir)			16,900,000			78,000			623,800
Tennessee Colony Reservoir			193,782,000			2,801,700			9,201,400
Reservoir			(137,138,000)			(1,367,400)			(6,037,200)
Pipe line			(56,644,000)			(1,434,300)			(3,164,200)
Sub total			275,935,000			3,740,000			12,821,600
Total Plan			$900,746,400			$8,446,600			$38,910,100

(1) Included in multiple-purpose channel

TABLE 2

ANNUAL CHARGES, ANNUAL BENEFITS
AND BENEFIT-COST RATIOS
100-YEAR AND 50-YEAR ECONOMIC LIFE

Project	ANNUAL CHARGES ($1000)			AVERAGE ANNUAL BENEFITS ($1000)						BENEFIT-COST RATIO
	Interest and Amortization	Operation and Maintenance	Total	Flood Control	Water Conservation Municipal and Industrial	Water Conservation Quality	Navigation	Recreation	Total	
MULTIPLE-PURPOSE CHANNEL										
100-year life	19,559.4	4,153.1	23,712.5	4,695.8	-	-	24,002.0	3,375.0	32,072.8	1.4
50-year life	24,289.0	4,083.4	28,372.4	3,825.1	-	-	23,078.0	1,890.0	28,793.1	1.0
LAKEVIEW RESERVOIR										
100-year life	1,020.7	351.3	1,372.0	1,391.0	907.3	-	-	2,025.0	4,323.3	3.2
50-year life	1,268.4	349.9	1,618.3	1,197.9	907.3	-	-	1,417.5	3,522.7	2.2
AUBREY RESERVOIR										
100-year life	1,115.4	509.0	1,624.4	-	679.0	406.2	-	2,900.0	3,985.2	2.5
50-year life	1,386.0	508.0	1,894.0	-	635.2	450.0	-	2,090.0	3,175.2	1.7
ROANOKE RESERVOIR										
100-year life	545.8	78.0	623.8	-	683.7	-	-	150.0	833.7	1.3
50-year life	678.2	77.0	755.2	-	683.7	-	-	150.0	833.7	1.1
TENNESSEE COLONY RESERVOIR (1)										
100-year life	6,399.7	2,801.7	9,201.4	3,238.0	1,975.4	3,614.2	2,951.0	4,050.0	15,828.6	1.7
50-year life	7,952.5	2,798.7	10,751.2	2,496.8	1,335.9	4,253.7	2,422.0	2,632.5	13,140.9	1.2
WEST FORK FLOODWAY (2)										
100-year life	584.1	224.0	808.1	2,359.4	-	-	-	-	2,359.4	2.9
50-year life	722.4	224.0	946.4	1,971.4	-	-	-	-	1,971.4	2.1
ELM FORK LOCAL PROTECTION										
100-year life	550.4	173.0	723.4	1,866.7	-	-	-	-	1,866.7	2.6
50-year life	681.2	173.0	854.2	1,670.4	-	-	-	-	1,670.4	2.0
DALLAS FLOODWAY EXTENSION (2)										
100-year life	469.4	135.5	604.9	685.0	-	-	-	-	685.0	1.1
50-year life	580.8	135.5	716.3	665.6	-	-	-	-	665.6	0.9
DUCK CREEK CHANNEL IMPROVEMENT										
100-year life	154.4	6.0	160.4	224.4	-	-	-	-	224.4	1.4
50-year life	191.4	6.0	197.4	187.8	-	-	-	-	187.8	1.0
LIBERTY LEVEE										
100-year life	64.2	15.0	79.2	240.9	-	-	-	-	240.9	3.0
50-year life	79.6	15.0	94.6	198.3	-	-	-	-	198.3	2.1
TOTAL PLAN										
100-year life	30,463.5	8,446.6	38,910.1	14,701.2	4,245.4	4,020.4	26,953.0	12,500.0	62,420.0	1.6
50-year life	37,829.5	8,370.5	46,200.0	12,213.3	3,562.1	4,703.7	25,500.0	8,180.0	54,159.1	1.2

(1) Includes pipe line and navigation in reservoir reach.
(2) Exclusive of multiple-purpose channel.

9. PHYSICAL FEASIBILITY AND PROVISION FOR FUTURE NEEDS.- The proposed plan of development, as presented in paragraph 6 above, was found to be the most favorable and practical means of meeting the navigation, flood control, water supply, water quality control, and recreation problems in the Trinity River Basin. The multiple-purpose channel design is the result of combining the need to increase the discharge capacity of the channels downstream from flood control reservoirs with the need to provide a channel for navigation and effects considerable saving in cost to both purposes. The Fort Worth-Dallas metropolitan area is one of the largest in the country without water transportation, and the studies of the problem determined that it is both physically and economically feasible to provide it. Adequate recreation facilities to meet the anticipated needs of the general public will be provided along the pools formed by the navigation locks and dams. The flood control feature of the multiple-purpose channel must be included in the flood control plan for the basin and provides the most effective means of reducing the remaining flood damages below the flood control reservoirs. It not only increases the operational effectiveness of the reservoirs, it also increases the operational effectiveness of the levee sluices along the channel. With the addition of the flood control features of the Lakeview and Tennessee Colony Reservoirs to the existing and authorized flood control plan, the increased channel capacity provides adequate flood protection to the rural areas along the channel.

a. A regional analysis of flood control storage requirements in the Trinity River Basin indicated that the Lakeview and Tennessee Colony Reservoirs should have sufficient flood storage capacity to regulate the 50-year flood from their watershed areas to non-damaging proportions downstream. The flood control storage provided in existing reservoirs on other sub-watersheds is adequate when considered in conjunction with the proposed increased channel capacities downstream from these reservoirs. The selected capacity for the Lakeview and Tennessee Colony Reservoirs is sufficient to control the floods of record and the volume of flood control storage provided approximates that which is required to control floods of 50-year frequency.

b. In determining the conservation storage capacity that should be provided in the reservoirs, cognizance was taken of the State's expressed policy for maximum practical development of the water resources of the Texas river basins. Studies of the Lakeview Reservoir indicated that conservation storage capacity of 306,400 acre-feet should be provided which will develop all the water resources of the watershed above the dam site. In the interest of developing a multiple-purpose reservoir at the Tennessee Colony site, which was limited by the town of Trinidad, it was possible to provide 1,032,500 acre-feet of conservation storage capacity, a portion of which would be used to provide dilution water for water quality control on an interim

basis. To further meet the water needs of the upper basin, studies indicated that reservoirs at the Aubrey and Roanoke sites, with an exchange of storage between the Garza-Little Elm and Grapevine Reservoirs, respectively, would provide additional conservation yield. The additional yield of 65.3 million gallons per day of the Aubrey-Garza-Little Elm system would provide dilution water for water quality control purposes on an interim basis. The additional yield of the Roanoke-Grapevine system of 23.9 million gallons per day would not be needed immediately; consequently, it is recommended that construction of this reservoir be deferred until the need becomes apparent. In connection with the reservoirs, adequate recreation facilities are included to meet the needs of the anticipated visiting public.

c. To alleviate the pollution problem that exists in the Trinity River, particularly in the reach from Fort Worth to Tennessee Colony Reservoir, dilution water can be provided from the Tennessee Colony and Aubrey Reservoirs on an interim basis until this water is needed for municipal and industrial purposes. It is anticipated that sewage treatment plants and procedures will improve with time and that when the water from these reservoirs will be needed for municipal purposes, it will no longer be needed for water quality control. Water from the Tennessee Colony Reservoir will be pumped through an 84-inch pipe line to Benbrook Reservoir from which it will be released for quality control purposes. The pipe line also would be used on an interim basis and eventually be converted to municipal and industrial use.

d. The flood plain areas along the West Fork between Fort Worth and Dallas, along the Elm Fork downstream from Denton Creek, along the Trinity River downstream from the Dallas Floodway to Five Mile Creek, and along the left bank of the Trinity River in the vicinity of Liberty, would not be afforded sufficient protection from floods by increasing channel capacities with or without the addition of upstream flood control reservoirs. These areas are considered to be urban in character and should be provided with protection from floods resulting from the standard project storm. These units, with levees to standard project design, are both physically and economically feasible. Protection of the area along Duck Creek in Garland, from floods of standard project magnitude, by means of a channel enlargement project, is both physically and economically feasible.

e. The above mentioned projects are predicated on present needs and anticipated future developments. All the projects are both physically and economically feasible. Should future developments occur in a pattern much different than that now expected, additional projects may be added to the proposed plan to meet these needs.

10. EXTENT OF INTEREST IN THE PLAN OF IMPROVEMENT.- A public hearing was held in Fort Worth, Texas, on December 20, 1961 by the Corps of Engineers. Principal features of the recommended plan of improvement for the Trinity River Basin were presented at this hearing. The widespread interest in the plan of improvement was evidenced by the attendance of approximately 1400 persons. Oral testimony was given by 97 of those present and of these, 90 were in favor of the proposed plan of improvement, four were opposed, and three spoke in opposition to the Wallisville Reservoir project which was not a project for consideration at this hearing. The opposition to the plan of improvement was principally from the Texas Railroad Association and from civic organizations from West Texas cities outside the Trinity River Basin. The opposition centered mainly against the barge navigation feature of the improvement plan and no objections were made to the proposed flood control and water conservation features of the plan. A total of 320 briefs were submitted prior to, during and subsequent to the hearing for incorporation in the record of the public hearing. Of these briefs, 274 were in favor of the plan, 35 were in opposition, six were noncommital and five were concerned with the above mentioned Wallisville Reservoir project.

a. The President of the Trinity Improvement Association and Chairman of the Executive Committee of the Trinity River Authority of Texas, by letter dated October 2, 1961, furnished the following general assurances of local cooperation:

"The Trinity Improvement Association and the Trinity River Authority of Texas desire to, at this time, express in general their approval of the proposed plan of improvement developed by the District Engineer for the Trinity River, Texas. * * * *

"It is considered that the Trinity River Authority of Texas will be the agency designated by the State Board of Water Engineers, (now Texas Water Commission) with which the Corps of Engineers should negotiate in matters concerning conservation storage in any of the proposed new reservoirs in the Trinity River watershed and should negotiate in matters pertaining to local flood protection improvements.

"It is the intent of the Trinity Improvement Association to sponsor the navigation and local flood protection projects which are included in the project. There is an expressed willingness on the part of the Association Board of Directors and the Trinity River Authority of Texas to undertake to comply singularly and/or jointly on all of the usual items of cooperation generally required of local interests in accordance with existing Federal laws and the Corps of Engineers regulations in connection with * * * * the plan * * * *."

Also by letter dated August 9, 1962, the assurances of local cooperation were extended to include those units added to the plan of development subsequent to the letter dated October 2, 1961.

b. The desires of local interests relative to deferment of payment for the cost of any portion of the storage space for future water supply, as set forth by the Water Supply Act of 1958, are not known at this time.

11. ALLOCATION OF COSTS.- The results of the cost allocation studies of the recommended Lakeview, Aubrey, Roanoke, and Tennessee Colony Reservoir projects by the Separable Costs-Remaining Benefits method and by other methods called for in Senate Resolution 148, based on economic lives of 100 years and 50 years, are presented in tables 3 through 6, respectively. Costs allocated to water conservation for muncipal and industrial purposes are the responsibility of local interests. Costs allocated to water quality control were made on the basis of use for this purpose and are the responsibility of the Federal Government. The full local cooperation requirements for the recommended reservoir improvements provide that prior to construction, local interests give assurances satisfactory to the Secretary of the Army that they will obtain all the necessary water rights and contribute the part of the total first cost of the projects and the annual cost of operation, maintenance, and replacements allocated to water conservation for municipal and industrial purposes. As presently estimated, the costs allocated to water conservation which would be the responsibility of local interests for the reservoirs recommended for authorization at this time are shown in the following tabulation.

Reservoir	Allocated First Cost	Allocated Annual Operation, Maintenance and Replacement Costs
Lakeview	$14,960,200	$ 76,600
(% of total)	(47.98)	(21.81)
Aubrey	14,360,800	47,080
(% of total)	(42.15)	(9.25)
Roanoke	14,997,100	41,750
(% of total)	(88.74)	(53.53)
Tennessee Colony	29,679,200	281,300
(% of total)	(15.32)	(10.04)

TABLE 3

ALLOCATION OF COSTS
LAKEVIEW RESERVOIR
(SENATE RESOLUTION 148)
(In thousand dollars)

Item	Separable Costs Remaining Benefits Method	Use of Facilities Method	Priority of Use Method	Incremental Cost Method
	ECONOMIC LIFE OF 100 YEARS			
Allocations to flood control				
First cost	$ 9,213.7	$ 8,652.4	$ 8,487.2	$14,315.0
(%)	(29.55)	(27.75)	(27.22)	(45.91)
Annual cost of operation, maintenance, and replacement	$ 56.5	$ 44.8	$ 95.6	$ 65.4
(%)	(16.08)	(12.75)	(27.22)	(18.62)
Allocations to water conservation				
First cost	$14,960.2	$17,264.4	$11,489.8	$11,603.0
(%)	(47.98)	(55.37)	(36.85)	(37.21)
Annual cost of operation, maintenance and replacement	$ 76.6	$ 91.5	$ 129.5	$ 70.9
(%)	(21.81)	(26.05)	(36.85)	(20.18)
Allocations to recreation				
First cost	$ 7,006.1	$ 5,263.2	$11,203.0	$ 5,262.0
(%)	(22.47)	(16.88)	(35.93)	(16.88)
Annual cost of operation and maintenance	$ 218.2	$ 215.0	$ .26.2	$ 215.0
(%)	(62.11)	(61.20)	(35.93)	(61.20)
	ECONOMIC LIFE OF 50 YEARS			
Allocations to flood control				
First cost	$ 9,232.4	$ 8,649.3	$ 8,244.0	$14,315.0
(%)	(29.61)	(27.74)	(26.44)	(45.91)
Annual cost of operation, maintenance, and replacement	$ 55.5	$ 44.0	$ 92.5	$ 64.0
(%)	(15.86)	(12.57)	(26.44)	(18.29)
Allocations to water conservation				
First cost	$14,978.9	$17,267.5	$11,131.3	$11,603.0
(%)	(48.04)	(55.38)	(35.70)	(37.21)
Annual cost of operation, maintenance, and replacement	$ 76.4	$ 90.9	$ 124.9	$ 70.9
(%)	(21.84)	(25.98)	(35.70)	(20.26)
Allocations to recreation				
First cost	$ 6,968.7	$ 5,263.2	$11,804.7	$ 5,262.0
(%)	(22.35)	(16.88)	(37.86)	(16.88)
Annual cost of operation and maintenance	$ 218.0	$ 215.0	$ 132.5	$ 215.0
(%)	(62.30)	(61.45)	(37.86)	(61.45)

TABLE 4

ALLOCATION OF COSTS
AUBREY RESERVOIR
(SENATE RESOLUTION 148)
(In thousand dollars)

Item	Separable Costs Remaining Benefits Method	Use of Facilities Method	Priority of Use Method	Incremental Cost Method
ECONOMIC LIFE OF 100 YEARS				
Allocations to water conservation				
First cost				
Municipal and industrial	$14,360.8	$15,000.4	$10,214.2	$15,167.0
(%)	(42.15)	(44.02)	(29.98)	(44.51)
Water quality	$ 8,590.8	$ 8,973.4	$ 6,110.2	$ 9,073.0
(%)	(25.21)	(26.34)	(17.93)	(26.63)
Annual cost of operation, maintenance, and replacement				
Municipal and industrial	$ 47.08	$ 60.1	$ 152.6	$ 60.1
(%)	(9.25)	(11.81)	(29.98)	(11.81)
Water quality	$ 28.17	$ 35.1	$ 91.3	$ 35.9
(%)	(5.53)	(7.05)	(17.93)	(7.05)
Allocations to recreation				
First cost	$11,121.4	$10,099.2	$17,748.6	$ 9,833.0
(%)	(32.64)	(29.64)	(52.09)	(28.86)
Annual cost of operation and maintenance	$ 433.75	$ 413.0	$ 265.1	$ 413.0
(%)	(85.22)	(81.14)	(52.09)	(81.14)
ECONOMIC LIFE OF 50 YEARS				
Allocations to water conservation				
First cost				
Municipal and industrial	$13,433.6	$14,031.9	$10,015.4	$14,187.7
(%)	(39.43)	(41.18)	(29.39)	(41.64)
Water quality	$ 9,518.0	$ 9,941.9	$ 7,096.1	$10,052.3
(%)	(27.93)	(29.18)	(20.83)	(29.50)
Annual cost of operation, maintenance and replacement				
Municipal and industrial	$ 43.5	$ 55.6	$ 149.3	$ 55.6
(%)	(8.57)	(10.94)	(29.39)	(10.94)
Water quality	$ 30.9	$ 39.4	$ 105.8	$ 39.4
(%)	(6.08)	(7.76)	(20.83)	$ (7.76)
Allocations to recreation				
First cost	$11,121.4	$10,099.2	$16,961.5	$ 9,833.0
(%)	(32.64)	(29.64)	(49.78)	(28.86)
Annual cost of operation and maintenance	$ 433.6	$ 413.0	$ 252.9	$ 413.0
(%)	(85.35)	(81.30)	(49.78)	(81.30)

TABLE 5

ALLOCATION OF COSTS
ROANOKE RESERVOIR
(SENATE RESOLUTION 148)
(In thousand dollars)

Item	Separable Costs Remaining Benefits Method	Use of Facilities Method	Priority of Use Method	Incremental Cost Method
	ECONOMIC LIFE OF 100 YEARS			
Allocations to water conservation				
First cost	$14,997.1	$15,330.0	$13,670.4	$15,505.0
(%)	(88.74)	(90.71)	(80.89)	(91.75)
Annual cost of operation, maintenance, and replacement	$ 41.75	$ 53.0	$ 63.1	$ 51.0
(%)	(53.53)	(67.95)	(80.89)	(65.38)
Allocations to recreation				
First cost	$ 1,902.9	$ 1,570.0	$ 3,229.6	$ 1,395.0
(%)	(11.26)	(9.29)	(19.11)	(8.25)
Annual cost of operation and maintenance	$ 36.25	$ 25.0	$ 14.9	$ 27.0
(%)	(46.47)	(32.05)	(19.11)	(34.62)
	ECONOMIC LIFE OF 50 YEARS			
Allocations to water conservation				
First cost	$14,998.8	$15,330.0	$13,820.8	$15,505.0
(%)	(88.75)	(90.71)	(81.78)	(91.75)
Annual cost of operation, maintenance, and replacement	$ 40.8	$ 52.0	$ 63.0	$ 50.0
(%)	(52.99)	(67.53)	(81.78)	(64.94)
Allocations to recreation				
First cost	$ 1,901.2	$ 1,570.0	$ 3,079.2	$ 1,395.0
(%)	(11.25)	(9.29)	(18.22)	(8.25)
Annual cost of operation and maintenance	$ 36.2	$ 25.0	$ 14.0	$ 27.0
(%)	(47.01)	(32.47)	(18.22)	(35.06)

TABLE 6

ALLOCATION OF COSTS
TENNESSEE COLONY RESERVOIR
(SENATE RESOLUTION 148)
(In thousand dollars)

Item	Separable Remaining Benefits Method	Use of Facilities Method	Priority of Use Method	Incremental Cost Method
	ECONOMIC LIFE OF 100 YEARS			
Allocations to flood control				
First cost	$42,663.6	$52,181.0	$28,881.3	$56,380.0
(%)	(22.02)	(26.93)	(14.90)	(29.10)
Annual cost of operation, maintenance and replacement	$ 40.3	$ 106.2	$ 288.0	$ 94.7
(%)	(1.44)	(3.79)	(10.28)	(3.38)
Allocations to water conservation				
First cost				
Reservoir - municipal and industrial use	$21,227.9	$19,299.9	$17,013.9	$16,070.7
Pipe line - municipal and industrial use	8,451.3	8,451.3	8,451.3	8,451.3
Total	$29,679.2	$27,751.2	$25,465.2	$24,522.0
(%)	(15.32)	(14.32)	(13.14)	(12.65)
Reservoir - water quality control	$ 6,405.4	$ 5,823.7	$ 5,133.9	$ 4,849.3
Pipe line - water quality control	48,192.7	48,192.7	48,192.7	48,192.7
Total	$54,598.1	$54,016.4	$53,326.6	$53,042.0
(%)	(28.17)	(27.88)	(27.52)	(27.37)
Annual cost of operation, maintenance, and replacement				
Reservoir - municipal and industrial use	$ 67.3	$ 39.3	$ 169.6	$ 48.1
Pipe line - municipal and industrial use	214.0	214.0	214.0	214.0
Total	$ 281.3	$ 253.3	$ 383.6	$ 262.1
(%)	(10.04)	(9.04)	(13.69)	(9.36)
Reservoir - water quality control	$ 20.3	$ 11.8	$ 51.2	$ 14.5
Pipe line - water quality control	1,220.3	1,220.3	1,220.3	1,220.3
Total	$ 1,240.6	$ 1,232.1	$ 1,271.5	$ 1,234.8
(%)	(44.28)	(43.98)	(45.38)	(44.07)
Allocations to navigation				
First cost	$51,893.0	$47,751.5	$58,832.2	$47,755.0
(%)	(26.78)	(24.64)	(30.36)	(24.64)
Annual cost of operation, maintenance and replacement	$ 660.5	$ 643.1	$ 586.6	$ 643.1
(%)	(23.57)	(22.95)	(20.94)	(22.95)
Allocations to recreation				
First cost	$14,948.1	$12,081.9	$27,276.7	$12,083.0
(%)	(7.71)	(6.23)	(14.08)	(6.24)
Annual cost of operation and maintenance	$ 579.0	$ 567.0	$ 272.0	$ 567.0
(%)	(20.67)	(20.24)	(9.71)	(20.24)

TABLE 6 (CONTINUED)

ALLOCATION OF COSTS
TENNESSEE COLONY RESERVOIR
(SENATE RESOLUTION 148)
(In thousand dollars)

Item	Separable Costs Remaining Benefits Method	Use of Facilities Method	Priority of Use Method	Incremental Cost Method
	ECONOMIC LIFE OF 50 YEARS			
Allocations to flood control				
First cost	$44,405.3	$52,181.0	$34,106.2	$56,380.0
(%)	(22.91)	(26.93)	(17.60)	(29.09)
Annual cost of operation, maintenance, and replacement	$ 47.0	$ 105.4	$ 339.3	$ 93.3
(%)	(1.68)	(3.77)	(12.12)	(3.33)
Allocations to water conservation				
First cost				
Reservoir - municipal and industrial use	$21,179.0	$18,199.5	$18,606.9	$15,154.4
Pipe line - municipal and industrial use	-0-	-0-	-0-	-0-
Total	$21,179.0	$18,199.5	$18,606.9	$15,154.4
(%)	(10.93)	(9.39)	(9.60)	(7.82)
Reservoir - water quality control	$ 8,057.9	$ 6,924.1	$ 7,079.0	$ 5,765.6
Pipe line - water quality control	56,644.0	56,644.0	56,644.0	56,644.0
Total	$64,701.9	$63,568.1	$63,723.0	$62,409.6
(%)	(33.39)	(32.80)	(32.89)	(32.21)
Annual cost of operation, maintenance and replacement				
Reservoir - municipal and industrial use	$ 68.2	$ 36.7	$ 185.2	$ 45.5
Pipe line - municipal and industrial use	-0-	-0-	-0-	-0-
Total	$ 68.2	$ 36.7	$ 185.2	$ 45.5
(%)	(2.44)	(1.31)	(6.62)	(1.63)
Reservoir - water quality control	$ 25.9	$ 14.0	$ 70.4	$ 17.3
Pipe line - water quality control	1,434.3	1,434.3	1,434.3	1,434.3
Total	$ 1,460.2	$ 1,448.3	$ 1,504.7	$ 1,451.6
(%)	(52.17)	(51.75)	(53.76)	(51.87)
Allocations to navigation				
First cost	$47,765.2	$47,751.5	$50,933.1	$47,755.0
(%)	(24.65)	(24.64)	(26.28)	(24.64)
Annual cost of operation, maintenance and replacement	$ 641.3	$ 641.3	$ 506.7	$ 641.3
(%)	(22.91)	(22.91)	(18.11)	(22.91)
Allocations to recreation				
First cost	$15,729.7	$12,081.9	$26,412.8	$12,083.0
(%)	(8.12)	(6.24)	(13.63)	(6.24)
Annual cost of operation and maintenance	$ 582.0	$ 567.0	$ 262.8	$ 567.0
(%)	(20.80)	(20.26)	(9.39)	(20.26)

Local cooperation requirements further provide that local interests be permitted to contribute their share of the construction (a) in a lump sum prior to initiation of construction, (b) in annual amounts during the period of construction, proportional to the annual Federal appropriations for construction or (c) in equal annual payments, including interest during construction and interest on the unpaid balance, within the economic life of the project but in no event to exceed 50 years from the date on which the project is first available for storage of water for any purpose. Also, that local interests be permitted to contribute their share of the annual cost of operation, maintenance, and replacements (a) on an annual basis as these costs are incurred or (b) in one lump sum on a present-worth basis.

12. REPAYMENT ARRANGEMENTS.- Possible repayment arrangements for the water-supply provisions in the recommended Lakeview and Tennessee Colony Reservoirs are described in paragraph 11 above.

13. ALTERNATE PROJECTS.- There is no feasible alternative to any of the units in the comprehensive plan of development for the Trinity River Basin that would provide the same degree of effectiveness. Studies were made of each unit in the plan to determine the project dimensions that would result in the maximum excess benefits over costs. However, project dimensions were adjusted, where necessary, to make each unit compatible with the overall plan for the basin, and to afford the project areas the degree of flood protection warranted.

a. Studies were made of the navigation problem including several channel alignments and bottom widths, with both 9 and 12 foot depths, and various lock chamber sizes to determine the project that would return the most benefits over cost. In conjunction with these studies was the problem of channel discharge capacity which must be increased for efficient operation of the flood control feature of the existing and proposed flood control reservoirs in the basin and to permit proper operation of the levee sluices of each of the many leveed areas below the reservoirs. These studies resulted in the proposed multiple-purpose channel project which meets the increased channel capacity requirements for flood control purposes and the requirements for the most feasible navigation project.

b. Preliminary studies of many potential reservoir sites for flood control, water conservation, and allied purposes determined that the Lakeview, Aubrey, Roanoke, and Tennessee Colony Reservoirs were the only economically feasible reservoir projects to be included in those recommended for authorization at this time. There are no other practical or economically feasible projects which could accomplish these purposes to the same degree as would these reservoirs. Other dam sites were investigated on Mountain Creek for the Lakeview Reservoir and the site selected was made on the basis of the one which

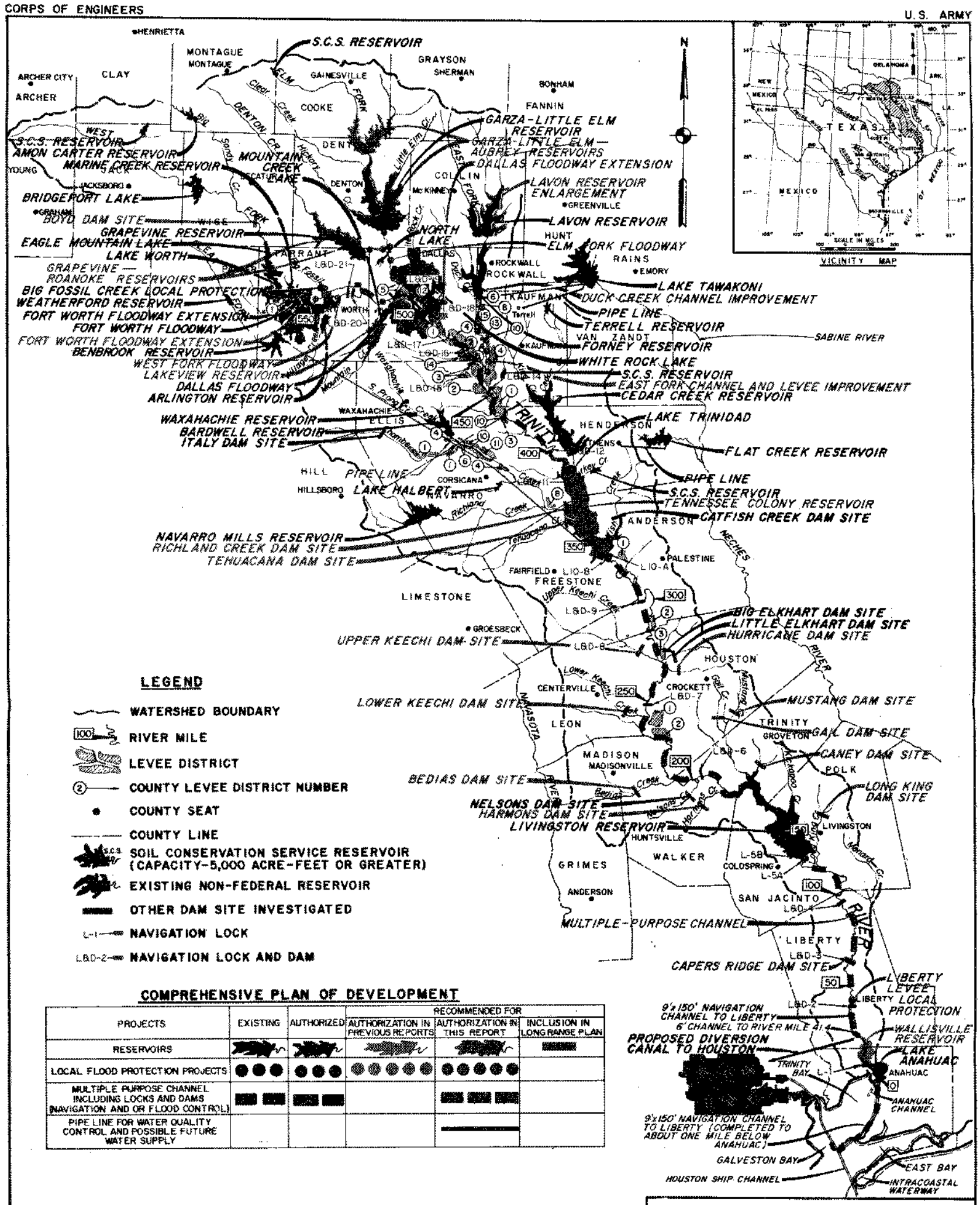
would return the most excess benefits over costs. Other sites were also investigated for the Tennessee Colony Reservoir and the one selected exerted the greatest flood control, being below the major tributaries of Richland, Chambers, and Cedar Creeks. This site was also within a reasonable distance for pumping water upstream to the metropolitan areas of Dallas and Fort Worth. Relocation costs for sites further downstream would increase due to the producing oil fields in the area and the cost of pumping water upstream would increase also, all of which precluded consideration of any site further downstream.

c. Studies of the local protection projects on the West Fork, Elm Fork, Dallas Floodway Extension, and at Liberty included a determination of the size channel rectification project which would realize the maximum excess benefits over costs. The degree of flood protection afforded by such projects was not considered adequate for these areas. Further studies were made varying the channel and floodway widths, with the addition of levees to standard project design, to determine the dimensions of such a project which would return the greatest net benefits. These areas could not feasibly be protected from floods resulting from the standard project storm by any other means than by the addition of levees. Additional flood control storage upstream from these areas could reduce levee heights but the subsequent saving in construction cost would be insufficient to justify the construction of additional reservoirs. Studies of the local protection project on Duck Creek at Garland, Texas, included the investigation of a reservoir as well as a channel rectification project to protect the area from the flood of record. It was determined that the channel project to afford this degree of protection would realize more net benefits than would the reservoir project. However, this is an urban area and this degree of protection was not considered adequate; consequently, the channel rectification project dimensions were altered to afford this area protection from floods resulting from the standard project storm. There are no other feasible means of affording this area the degree of protection warranted than the channel rectification project.

d. The principal stream pollution problem in the Trinity River Basin is in the main stem from Fort Worth to the vicinity of Rosser. There is no water available for quality control upstream from Fort Worth. Therefore, the first stage of development to meet this requirement is a pipe line from Tennessee Colony Reservoir to Benbrook Reservoir to provide the necessary dilution water. The water in both the Tennessee Colony and Aubrey Reservoirs will be available for dilution purposes on an interim basis until this water is needed for municipal and industrial purposes.

CORPS OF ENGINEERS

U.S. ARMY



LEGEND

- WATERSHED BOUNDARY
- RIVER MILE
- LEVEE DISTRICT
- COUNTY LEVEE DISTRICT NUMBER
- COUNTY SEAT
- COUNTY LINE
- SOIL CONSERVATION SERVICE RESERVOIR (CAPACITY-5,000 ACRE-FEET OR GREATER)
- EXISTING NON-FEDERAL RESERVOIR
- OTHER DAM SITE INVESTIGATED
- NAVIGATION LOCK
- NAVIGATION LOCK AND DAM

COMPREHENSIVE PLAN OF DEVELOPMENT

PROJECTS	EXISTING	AUTHORIZED	RECOMMENDED FOR: AUTHORIZATION IN PREVIOUS REPORTS	RECOMMENDED FOR: AUTHORIZATION IN THIS REPORT	RECOMMENDED FOR: INCLUSION IN LONG RANGE PLAN
RESERVOIRS	▬	▬	▬	▬	▬
LOCAL FLOOD PROTECTION PROJECTS	●●●	●●●	●●●●●	●●●●●	
MULTIPLE PURPOSE CHANNEL INCLUDING LOCKS AND DAMS (NAVIGATION AND OR FLOOD CONTROL)	▬▬	▬▬		▬▬▬	
PIPE LINE FOR WATER QUALITY CONTROL AND POSSIBLE FUTURE WATER SUPPLY				▬	

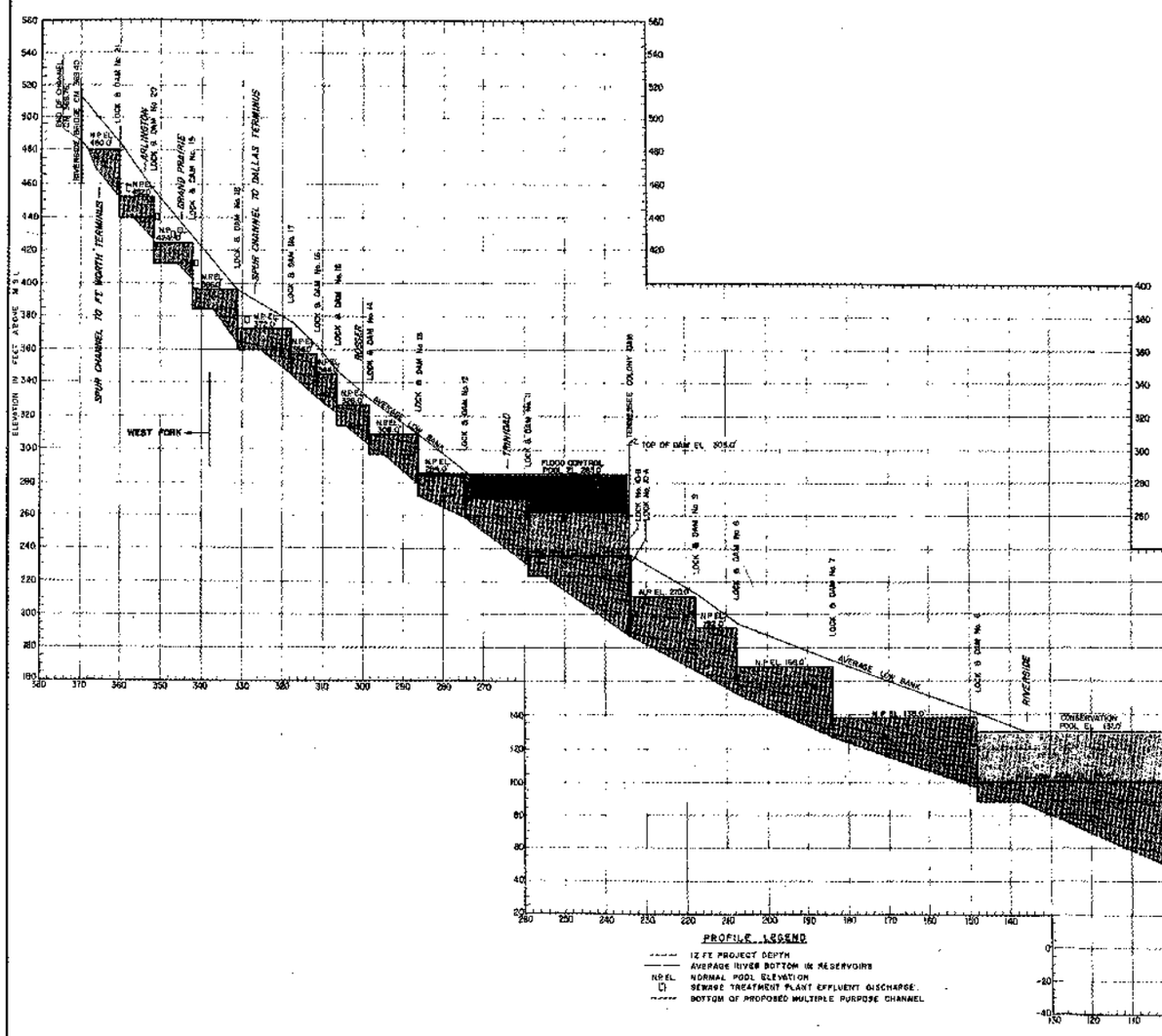
SCALE IN MILES
5 0 5 10 15 20 25

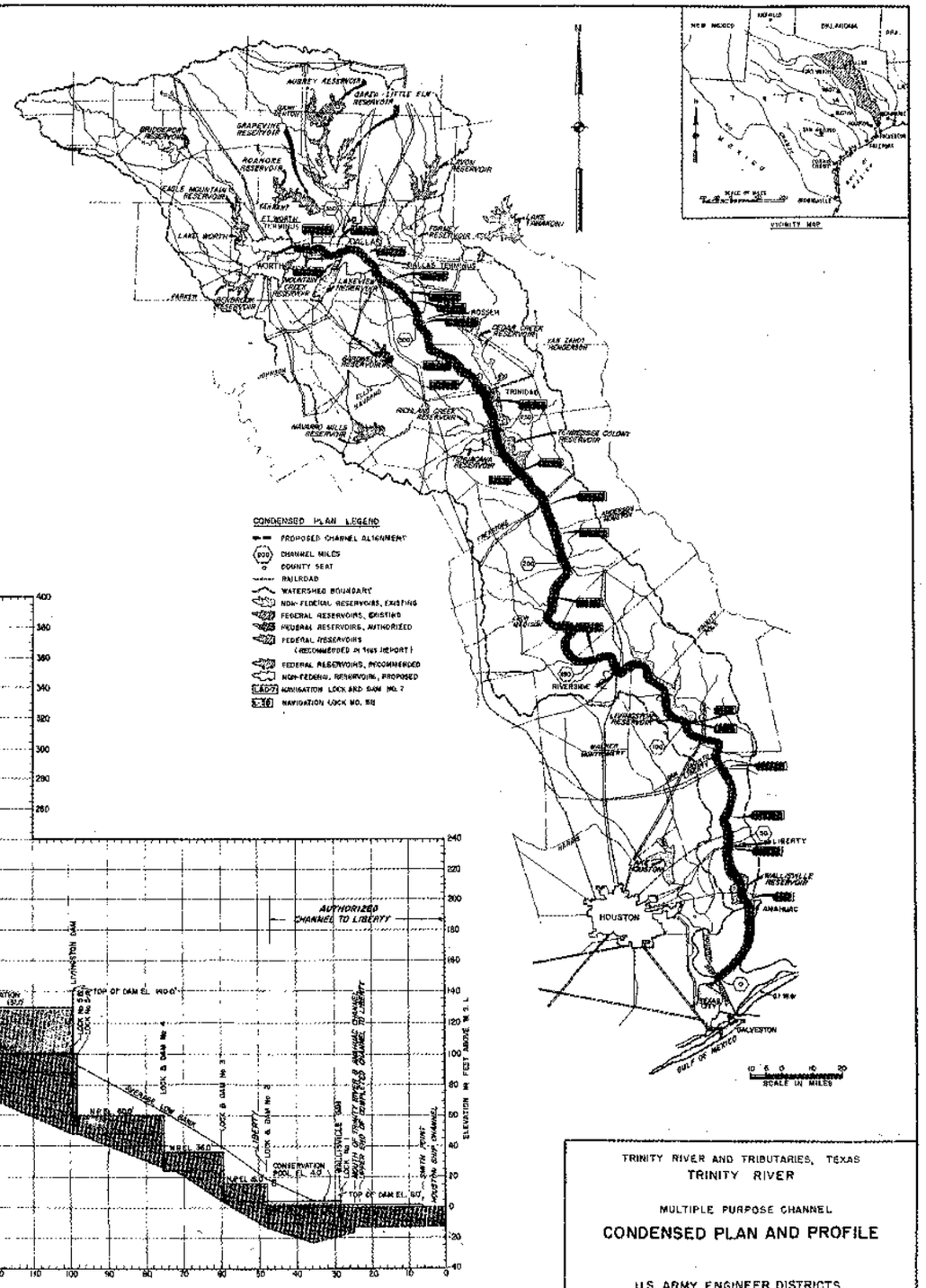
TRINITY RIVER AND TRIBUTARIES, TEXAS
TRINITY RIVER

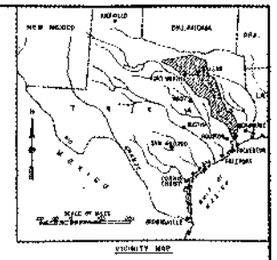
COMPREHENSIVE PLAN OF DEVELOPMENT

U.S. ARMY ENGINEER DISTRICTS, FORT WORTH AND GALVESTON

PLATE I







TRINITY RIVER AND TRIBUTARIES, TEXAS

TRINITY RIVER

MULTIPLE PURPOSE CHANNEL

CONDENSED PLAN AND PROFILE

U.S. ARMY ENGINEER DISTRICTS,

FORT WORTH AND GALVESTON

PLATE 2

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