ALSO ISSUED AS H. DOC. NO. 350,
90/2

PECAN BAYOU, TEXAS

LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY, DATED SEPTEMBER 20, 1966, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON PECAN BAYOU WATERSHED, COLORADO RIVER BASIN, TEXAS, REQUESTED BY A RESOLUTION OF THE COMMITTEE ON FLOOD CONTROL, HOUSE OF REPRESENTATIVES, ADOPTED OCTOBER 8, 1945

JULY 8, 1968.—Referred to the Committee on Public Works and ordered to be printed with illustrations

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U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1968

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ILLUSTRATIONS ACCOMPANYING THE REPORT OF THE DISTRICT ENGINEER

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Plate B. Existing, Investigated and Proposed Improvements.

LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY
WASHINGTON, D.C. 20310

July 1, 1968

Honorable John W. McCormack
Speaker of the House of Representatives
Washington, D. C. 20515

Dear Mr. Speaker:

I am transmitting herewith a favorable report dated 20 September 1966, from the Chief of Engineers, Department of the Army, together with accompanying papers and illustrations, on a review of the reports on Pecan Bayou Watershed, Colorado River Basin, Texas, requested by a resolution of the Committee on Flood Control, House of Representatives, adopted 8 October 1945.

The views of the Governor of Texas, the Departments of the Interior, Agriculture, Commerce, and Health, Education, and Welfare, the Public Health Service, and the Federal Power Commission are set forth in the inclosed communications, together with the replies of the Chief of Engineers to the Secretaries of the Interior and Agriculture.

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

Sincerely yours,

Stanley R. Resor
STANLEY R. RESOR
Secretary of the Army

1 Incl
Report

COMMENTS OF THE BUREAU OF THE BUDGET

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

June 26, 1968

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

Dear Mr. Secretary:

Mr. Alfred B. Fitt's letter of June 5, 1967, submitted the favorable report of the Chief of Engineers on Pecan Bayou Watershed, Colorado River Basin, Texas, requested by a resolution of the Committee on Flood Control, House of Representatives, adopted October 8, 1945.

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

Sincerely yours,

Carl H. Schwartz, Jr.

Carl H. Schwartz, Jr.
Director, Natural Resources
Programs Division

COMMENTS OF THE GOVERNOR OF TEXAS

JOHN CONNALLY

GOVERNOR OF TEXAS

August 12, 1966

Air Mail   Special Delivery

Lieutenant General William Cassidy
Chief of Engineers
United States Army Corps of Engineers
Washington, D. C.

Dear General Cassidy:

The Texas Water Development Board has distributed and discussed its preliminary Texas Water Plan at numerous locations throughout the State. The preparation of this Plan has included, in accordance with my request, consideration of projects proposed by or included in preliminary investigations of Federal agencies. A number of such project units are contained in the Corps of Engineers report titled "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas." Support for these project units in the Pecan Bayou Watershed was furnished the Board at its public hearing on the Colorado River Basin Plan on July 27, 1966.

In a letter dated November 30, 1965 to D. A. Williams, Administrator, United States Department of Agriculture, Soil Conservation Service, commenting upon a watershed work plan for the Upper Pecan Bayou Watershed developed pursuant to Public Law 86-468, I wrote that the Corps' Pecan Bayou project might be reconsidered by the State of Texas; such reconsideration would affect six of the structures proposed in the project of the Soil Conservation Service, and call for reconsideration of their work plan.

I am now advised that the Texas Water Plan will include the construction of the Lake Brownwood Protective Measures, the Brownwood Channel Improvements, and the Pecan Bayou Reservoir, substantially in accordance with the proposed plan outlined in your review report.

Following the consideration given these proposed projects by the Water Development Board, I request you submit your report on these above-named units to the Congress for its consideration at the earliest possible time.

With kindest regards,

Sincerely,

John Connally
Governor of Texas

TEXAS WATER DEVELOPMENT BOARD

August 12, 1966

Air Mail Special Delivery

Lieutenant General William Cassidy
Chief of Engineers
United States Army Corps of Engineers
Washington, D. C.

Dear General Cassidy:

A number of the projects proposed by the Corps of Engineers which are included in the Texas Water Plan have been mentioned in our recent discussions. This letter refers to those project units contained in the Corps of Engineers report titled "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas."

Actions by local entities during the processing of the Corps of Engineers report resulted in the non-federal construction of a dam and reservoir on Jim Ned Creek in the same area as one of the units proposed in your report. Accordingly it is requested that the portion of your recommendations pertaining to the proposed Coleman Reservoir be modified and that unit be deleted prior to submission of the report to Congress.

The Texas Water Plan includes the construction of the Lake Brownwood Protective Measures, the Brownwood Channel Improvements, and the Pecan Bayou Reservoir in accordance with the proposed plan and purposes described in the above-referenced report of the Corps of Engineers.

A Texas statute enacted in 1965 provides for the Water Development Board to be the State agency to cooperate with the Corps of Engineers in the planning of water resource development projects. That statute also authorized the Board to serve as State sponsor of a federal project, in whole or in part, to the extent that a local sponsor is not prepared to undertake sponsorship. The Board will act as State sponsor, to the extent local sponsors have not provided assurances, on the Lake Brownwood Protective Measures and the Pecan Bayou Reservoir.

Our agency desires to have your report submitted to Congress for their consideration at the earliest possible time. If information additional to that contained herein is needed, please contact me.

Very truly yours,

Joe G. Moore, Jr.

Joe G. Moore, Jr.
Executive Director
Texas Water Development Board

JGMjr:bj

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

May 28, 1965

Dear General Wilson:

This is in reply to your letter of March 17, 1965, transmitting for our comments a proposed report of the Chief of Engineers, together with the reports of the Board of Engineers for Rivers and Harbors, and of the District and Division Engineers, on a review of reports on Pecan Bayou Watershed, Colorado River Basin, Texas.

This Department is pleased to note that the proposed plan for the Pecan Bayou Watershed, Texas, provides for the conservation and development of fish and wildlife resources and gives adequate consideration to outdoor recreation.

The Bureau of Sport Fisheries and Wildlife advises that at least one of the proposed reservoirs may have value in carrying out the National migratory bird program. The available project information has not been detailed enough to permit the presentation of a specific plan or recommendation on this matter and the Bureau wishes to be afforded the opportunity to participate further in project planning to determine the advisability of establishing a National wildlife refuge in conjunction with the project.

The Bureau notes that your report independently evaluates benefits for fishing and hunting. Since the Bureau of Sport Fisheries and Wildlife is the Federal agency responsible for evaluating fish and wildlife resources, we believe that the more conservative evaluations furnished by the Bureau should be utilized in your economic analysis of the project. Your report further combines fish and wildlife benefits with those for general recreation. Fish and wildlife benefits are separate and distinct and readily identifiable from general recreational benefits. They are developed under separate legislative authorities, and should not be confused with general recreation opportunities in project reporting. Therefore, it is believed that the separation should be maintained in the economic analysis of the project. Your report shows benefits of $353,600 for fish and game harvest. This is in addition to visitor-day values for fishing and hunting, which are evaluated with other recreation activities. Assigning a value to the visitor-day involving a variety of recreational activities, including fishing and hunting, and assigning an additional harvest value to these same fishing and hunting activities is not in strict conformity with the procedure recommended in Senate Document No. 97, Supplement No. 1, "Evaluation Standards for Primary Outdoor Recreation Benefits."

Inasmuch as local interest would be required to pay an estimated $2,042,500 for first costs and $73,000 annually for operation, maintenance and replacement of recreation and fish and wildlife lands for enhancement, as provided for in the proposed Federal Water Project Recreation Act (H.R. 5269), we believe that the values for fish and wildlife should be separated from those for recreation so that those responsible for repayment would be aware of the charges to be imposed.

The Department recommends that your report be modified to include fish and wildlife benefits calculated in accordance with Administration policies and procedures and that costs and benefits for fish and wildlife enhancement be treated separately from those for general recreation.

The National Park Service advises that it is possible that the area involved contains archeological resources which should be salvaged. The Regional Director, Southwest Regional Office, National Park Service, P. O. Box 728, Santa Fe, New Mexico 87501, should be kept advised as to progress on the project in order to program and initiate such surveys, salvage, and preservation of historical and archeological evidence as may exist in accordance with provisions with the Act of June 17, 1960 (74 Stat. 220).

The opportunity of presenting our views is appreciated.

Sincerely yours,

Kenneth Holum

KENNETH HOLUM
Assistant Secretary of the Interior

Lt. General Walter K. Wilson, Jr.
Chief of Engineers
Department of the Army
Washington, D.C. 20315

LETTER TO THE SECRETARY OF THE INTERIOR

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20315

IN REPLY REFER TO
ENGCW-PD

30 June 1965

The Honorable Stewart L. Udall

The Secretary of the Interior

Dear Mr. Secretary:

This is in reply to a recent letter from the Assistant Secretary furnishing the comments of your Department on our Survey Report on Pecan Bayou Watershed, Colorado River Basin, Texas.

Fish and wildlife values totalling $279,000 annually and creditable to the proposed Pecan Bayou and Coleman reservoir projects are indicated in the report of the Bureau of Sports Fisheries and Wildlife which is appended to the report of the District Engineer. The report of the District Engineer shows fish and wildlife values estimated at $353,600 annually. I am of the opinion that both the foregoing estimates are conservative. The District Engineer's estimates of recreational use, including fishing and hunting, are based on experienced visitation at existing and comparable projects in the geographical region as determined from surveys, road checks, mechanical counters, and observations, and projected on a conservative basis for the life of the recommended projects. All such available data on existing projects in the Fort Worth District indicate the conservative nature of our pre-authorization and pre-project planning study estimates of benefits creditable to general and specialized recreation.

The combination of general recreation and fish and wildlife enhancement values, the latter of which is set forth as a special form of recreation in Supplement No. 1, Evaluation Standards for Primary Outdoor Recreation Benefits, is considered proper and in accordance with the language and intent of the proposed Federal Water Project Recreation Act. Accordingly, I do not believe that general recreation and the fish and wildlife enhancement benefits should be separated in the economic analysis in the subject report.

I believe the contention of the Assistant Secretary that our value of $353,600 is, in effect, a duplication and should be separated from general recreation results from a misunderstanding of the methodology employed by the District Engineer. While the noted value is set forth in the report of the District Engineer as a "harvest", it should not be construed as a commercial fishery, and if it were I would certainly agree that it should be separated. Actually, the annual value of $353,600 is simply the incremental value of hunting and fishing as a specialized recreation computed to be valued at $1.00 and $0.50, respectively, per visitor day, over and above the general recreation value of $0.50. Thus, specialized recreation from hunting and fishing is evaluated at $1.50 and $1.00 per user-day, respectively, and such values are below the range of from $2.00 to $6.00 suggested in Supplement No. 1.

As pertains to archeological values, the District Engineer will, pursuant to our policy, request the National Park Service to prepare a report on such values in the advance planning stage of the projects following authorization.

Sincerely yours,

(Signed)

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

COMMENTS OF THE DEPARTMENT OF AGRICULTURE

DEPARTMENT OF AGRICULTURE
WASHINGTON 25, D.C.

September 1, 1965

Honorable Stanley J. Resor
Secretary of the Army

Dear Mr. Secretary:

This is in reply to the Chief of Engineers' letter of March 17, 1965, transmitting for our review and comment his proposed review of reports on Pecan Bayou Watershed, Colorado River Basin, Texas.

The report recommends a plan of improvement for the Pecan Bayou providing for construction of (a) protective measures for Lake Brownwood Dam to establish a reconstructed project for purposes of flood control and water supply; (b) channel improvements on Pecan Bayou, Adams Branch, Tom Williams Branch, and Willis Creek for local flood protection at Brownwood, Texas; and (c) Coleman Reservoir on Jim Ned Creek and Pecan Bayou Reservoir on Pecan Bayou upstream from Lake Brownwood for purposes of flood control, water supply, water quality control, and fish and wildlife and recreation.

The report estimates the total first cost at $43,433,000, including a total Federal construction cost of $36,751,000, or a net Federal construction cost of $31,684,000 after reimbursement by local interests of $5,067,000 for project costs allocated to water supply; a non-Federal cost of $2,442,000 for lands, easements, rights-of-way, modification and relocation of roads, highway bridges, and related facilities as necessary for construction and operation of the Brownwood channel improvements; and a non-Federal cost value of $4,240,000 as credit for existing lands and existing useful facilities at Lake Brownwood essential to reconstruction and operation of Lake Brownwood. The estimated net annual cost to the United States is $192,200 for operation and maintenance. The benefit-cost ratio for the total plan is 2.3, based on annual benefits of $4,056,000 and annual charges of $1,761,500.

About half of the annual benefits will accrue to flood control. About 94 percent of the total flood control benefits are attributed directly to urban interests. Some benefits are expected to accrue throughout the 72,000-acre flood plain. The acquisition of lands for reservoir construction will amount to about 5,500 acres of cropland and 9,000 acres of range and pasture land.

There are no National Forests or National Grasslands in the area and effects of the project on non-Federal woodland would be insignificant.

The Jim Ned Creek Subwatershed Project was approved for operations on October 5, 1960, under the authority of the Flood Control Act of 1944. It was based on a subwatershed work plan developed by the Soil Conservation Service and the Central Colorado Soil Conservation District. A copy of this plan was transmitted to the Corps of Engineers and other agencies for review and comment prior to approval. No adverse comments were received. Of the 43 floodwater retarding structures planned for construction in this watershed project, 32 have been completed. The proposed Coleman Reservoir on Jim Ned Creek either would inundate or otherwise render ineffective four of the floodwater retarding structures which have been constructed in the Jim Ned Creek Subwatershed Project. These four structures represent a Federal investment of $923,683 in addition to the investments made by the local people.

During the field review of this report there was a rather complete discussion of this problem in an exchange of correspondence between personnel of the Soil Conservation Service and the Corps of Engineers. Reference was made to the interests of this Department in both the Jim Ned Creek watershed and the Pecan Bayou watershed. This is set forth in copies of the related correspondence included in Appendix VII of the report.

Department of Agriculture personnel have developed preliminary alternative plans to provide flood protection to the Pecan Bayou flood plain with or without the proposed Pecan Bayou Reservoir. Its plans for flood detention construction in this watershed are being held in abeyance pending further consideration of your proposal.

There has been considerable coordination at the field level between agencies of the two Departments since the field draft of this report was prepared. During its preparation we took advantage of every opportunity for field coordination of our planning activities and regret that this report indicates that these efforts were not fully effective. It is noted that the report recommends further coordination of planning activities by the Soil Conservation Service and the Corps of Engineers after authorization of the project and prior to construction of the Coleman Dam and Reservoir. The objective of these coordination efforts would be to evaluate a possible relocation of the Coleman Dam that might have less adverse effect upon the Jim Ned Creek Subwatershed Project than the site proposed in this report. We feel that this coordination should be effected during the development of this report and not delayed until after project authorization. We believe that we have made sufficient information available to the District Engineer for this to be accomplished.

It has just come to our attention that the City of Coleman is in the process of constructing a city reservoir on Jim Ned Creek upstream from the site proposed by the Corps of Engineers in this report. This action may alter completely this proposal as it affects Jim Ned Creek.

We appreciate the opportunity to review the report.

Sincerely yours,

John A Baker

JOHN A. BAKER
Assistant Secretary

DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

April 24, 1967

Honorable Stanley R. Resor
Secretary of the Army

Dear Mr. Secretary:

This is in reply to the Chief of Engineers' letter of December 19, 1966, transmitting for our review and comment his revised review report on Pecan Bayou Watershed, Colorado River Basin, Texas.

The Chief of Engineers' first report on improvements for the Pecan Bayou Watershed was provided to this Department with his letter of March 17, 1965. This report recommended a plan of improvement providing for the construction of: (a) protective measures for Lake Brownwood Dam to establish a reconstructed project for flood control and water supply; (b) channel improvements on Pecan Bayou, Adams Branch, Tom Williams Branch, and Willis Creek for local flood protection at Brownwood, Texas; and (c) Coleman Reservoir on Jim Ned Creek and Pecan Bayou Reservoir on Pecan Bayou upstream from Lake Brownwood for flood control, water supply, water quality control, fish and wildlife enhancement, and recreation.

The Department of Agriculture in its letter of September 1, 1965, to the Secretary of the Army commented on the proposed report. It was pointed out that the Jim Ned Creek Subwatershed project was approved for operation on October 5, 1960, under the authority of the Flood Control Act of 1944. This approval was based on a subwatershed work plan developed by the Soil Conservation Service and the Central Colorado Soil Conservation District. The proposed Coleman Reservoir would inundate or otherwise render ineffective four of the 32 completed floodwater retarding structures.

The revised report of the Chief of Engineers notes that local interests have now constructed a dam and reservoir on Jim Ned Creek in the general area of the Coleman Reservoir. In view of this construction, the Texas Water

Development Board requested that the proposed Coleman Reservoir be deleted from the recommended plan of improvement. Accordingly, the Chief of Engineers has deleted the recommendation for authorization of this reservoir in his revised report.

A subwatershed work plan for the Upper Pecan Bayou was approved on February 15, 1966, under authority of the 1944 Flood Control Act, as amended, and installation of the planned improvements has been initiated. Department of Agriculture personnel have assisted the local sponsoring organizations to develop alternative plans with or without the proposed Pecan Bayou Reservoir recommended in the Chief of Engineers' revised report. It does not appear, therefore, that the authorization of the Pecan Bayou will seriously affect the installation of the improvement measures contemplated in the subwatershed work plan.

The revised report of the Chief of Engineers also recommends "Brownwood Channel improvements for purposes of local flood protection along Pecan Bayou at Brownwood, Texas." The revised report also notes that detailed planning is now underway on a watershed work plan for Willis Creek and Adams Branch (including Tom Williams Branch) developed by the Soil Conservation Service and sponsoring local organizations. The report concludes that the improvement of these streams under this program precludes the need for the work contemplated in the original. Accordingly, the improvements proposed for these streams have been deleted from the revised report of the Chief of Engineers.

A subwatershed work plan for the "Brownwood Laterals" was approved on December 22, 1964, under the authority of the Flood Control Act of 1944, as amended. The sponsoring local organizations for this watershed work plan agreement are the Brown-Mills Soil Conservation District, the Brown and Mills Counties Commissioners' Courts, and the city of Brownwood.

The Brownwood Laterals watershed consists of that portion of the Pecan Bayou watershed between Lake Brownwood and the confluence of Blanket Creek, and Pecan Bayou. This watershed is located in the Colorado River Basin in Brown and Mills Counties, Texas. The watershed comprises an area of about 305 square miles.

The work plan proposes installing, in a 10-year period, an integrated program of land treatment and structural measures for the protection and development of the watershed. The principal objective is to provide flood protection to the agricultural lands and the urban areas of the cities of Brownwood and Early, Texas, which are subject to flood damages from Pecan Bayou and its tributaries.

The structural measures included in the plan consist of 8.15 miles of stream channel improvements and 27 floodwater retarding structures having a total sediment storage and floodwater detention capacity of 28,255 acre-feet.

This system of floodwater retarding structures will be required to afford the degree of flood protection to the flood plain lands and urban areas mutually agreed upon by the Soil Conservation Service and the sponsoring local organizations.

The stream channel improvement work includes about 3.44 miles on Willis Creek and 4.71 miles on Adams Branch. The improved channels functioning in conjunction with the floodwater retarding structures will provide flood protection for these respective urban areas of Brownwood from the 100-year frequency storm event. The terminations of the sections of channel improvements are at points where no additional damage will be caused downstream by the increased flow through the improved sections.

It appears that the installation of the improvements agreed to in the work plan developed by the sponsoring local organizations and the Soil Conservation Service functioning with those improvements recommended in the Chief of Engineers' report will provide an adequate level of flood protection for the city of Brownwood. Representatives of the Soil Conservation Service will be available to meet with those of the Corps of Engineers and the sponsoring local organizations for the purpose of coordinating the installation of the improvements.

Thank you for providing this report for our review.

Sincerely yours,

John A Baker

JOHN A. BAKER
Assistant Secretary

LETTER TO THE SECRETARY OF AGRICULTURE

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20315

IN REPLY REFER TO
ENGCW-PD

19 December 1966

The Honorable Orville L. Freeman

The Secretary of Agriculture

Dear Mr. Secretary:

In accordance with our usual procedure to insure coordination in the preparation of reports on water resource projects which affect the interests of the Department of Agriculture, a copy of the proposed report of the Chief of Engineers and pertinent papers on a review of reports on Pecan Bayou Watershed, Colorado River Basin, Texas, was furnished you on 17 March 1965 for your information and comment.

Subsequent to receipt of your comments on 1 September 1965, the Texas Water Development Board indicated that local interests have now constructed a dam and reservoir on Jim Ned Creek in the general area of the recommended Coleman Reservoir and, accordingly, the Board requested that this reservoir be deleted from the basin plan. A recent letter from the Governor of Texas requested that a report on the remaining items in the Corps of Engineers' plan be submitted to Congress for its consideration at the earliest possible time.

The report of the Chief of Engineers has been revised to delete the Coleman Reservoir and I am transmitting herewith for your information and such comment as you may care to make four copies of the revised report on Pecan Bayou Watershed, Texas.

In view of the desirability of transmitting this report to Congress at an early date, I would appreciate receiving your comments as soon as possible.

Sincerely yours,

(Signed)

WILLIAM F. CASSIDY
Lieutenant General, USA
Chief of Engineers

1 Incl (4 cys)
CofEngrs rept
dtd 20 Sep 66

COMMENTS OF THE DEPARTMENT OF COMMERCE

THE UNDER SECRETARY OF COMMERCE
FOR TRANSPORTATION
WASHINGTON, D.C. 20230

June 22, 1965

Major General Robert G. MacDonnell
Acting Chief of Engineers
Department of the Army
Washington, D. C. 20315

Dear General MacDonnell:

Your proposed report to the Congress presenting the results of an investigation of the problems associated with the water and related land resources of the Pecan Bayou watershed with particular emphasis on flood protection for the City of Brownwood, Texas, was sent to this Department on March 17, 1965. You included with it the reports of the Board of Engineers for Rivers and Harbors, the District and Division Engineers, and requested our comments.

You recommend that the plan for enlarging Lake Brownwood authorized by the Flood Control Acts of 18 August 1941 and 22 December 1944 be deauthorized and that a multiple-purpose plan of improvement for the Pecan Bayou Watershed, Texas, be authorized to provide for construction of the following: (1) protective measures for Lake Brownwood Dam to provide a reconstructed project for purposes of flood control and water supply; (2) Brownwood channel improvements for purposes of local flood protection along Pecan Bayou, Adams Branch, Tom Williams Branch, and Willis Creek at Brownwood, Texas; and (3) Coleman Reservoir on Jim Ned Creek and Pecan Bayou Reservoir on Pecan Bayou upstream from existing Lake Brownwood for purposes of flood control, water supply, water quality control, and fish and wildlife and general recreation.

The assurances required of local interests prior to the initiation of construction are described. You report that the total first cost to the United States for these improvements is estimated to be $36,751,000. It is anticipated that this cost will be reduced through reimbursement by local participation in the cost of recreation and fish and wildlife enhancement based on presently planned level of development for these purposes, and by repayment of the construction cost allocated to water supply. Thus, the ultimate first cost to the United States is anticipated to be $29,641,500, and annual charges for maintenance, operation, and replacements are estimated to be $119,200 annually.

The Bureau of Public Roads notes that the construction of the channel improvements in the vicinity of Brownwood, Texas, will involve the reconstruction of a number of highway bridges and that the cost of this bridge reconstruction has been made a part of the local contribution to the project. As indicated in the District Engineer's report, Federal-aid highway funds cannot be used to finance any part of this work.

The Coast and Geodetic Survey notes that horizontal and vertical geodetic control exist throughout the project area and are considered adequate. The Survey assumes that the desirability of charting the proposed reservoirs will be investigated, and should there be a requirement for nautical charting, its services are available to your agency. At such time as a determination is made on these matters, it is requested that you communicate directly with the Coast and Geodetic Survey.

The Department of Commerce has no objections to your findings and recommendations, and appreciates the opportunity to comment on your report.

Sincerely yours,

Alan S. Boyd

COMMENTS OF THE DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
WASHINGTON

June 21, 1965

Dear Mr. Fitt:

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 Pecan Bayou watershed, Colorado River basin, Texas.

An investigation and report entitled "Water Resources Study, Pecan Bayou Watershed, Colorado River Basin, Texas" was prepared (October 1962) by the Water Supply and Pollution Control staff, Public Health Service, Department of Health, Education, and Welfare, Region VII, Dallas, Texas, in cooperation with the U. S. Army Engineer District, Fort Worth, Texas. The report noted that:

1. The Pecan Bayou watershed drains approximately 2,200 square miles to the Colorado River at mile 513. The proposed Pecan Bayou project consists of the reconstruction of Brownwood Dam at mile 52.0 on Pecan Bayou, construction of Pecan Bayou Reservoir at mile 100.8 on Pecan Bayou, and construction of Coleman Reservoir at mile 52.2 on Jim Ned Creek.

2. Water releases from storage in the proposed reservoirs would provide water quality control benefits throughout the Pecan Bayou watershed.

3. The water to be impounded in the proposed reservoir is of good quality; however, to assure maximum benefits for water quality control, suitable outlet structures should be provided for the selectivity of flow regulation releases.

On the basis of these investigations, we find that there is a need for flow regulation in releases for water quality control purposes below the Brownwood Reservoir amounting to 1.5 million gallons per day in the year 2020 and 2.1 million gallons per day in the year 2070. The need is based on present and future estimated population and industrial growth to year 2070 along Pecan Bayou below the point of storage.

The benefits resulting from this flow regulation for water quality control will be widely distributed along Pecan Bayou below the Brownwood Reservoir. The annual value of these benefits assignable to the storage in the Pecan Bayou and Coleman Reservoir projects is $46,700 and $41,100, respectively. This value is computed on the basis of providing adequate waste treatment at the source, before the discharge of wastes to the stream. It has been determined that pollution will exist in the river after such treatment and the flow regulation will, therefore, be needed to provide additional water quality control. Accordingly, it is our recommendation that storage for water quality control to the extent described above, be incorporated in the Pecan Bayou and Coleman Reservoir projects. The proposed streamflow regulation is not considered as a substitute for adequate treatment.

The detailed results of the investigations upon which the foregoing findings are based are contained in the aforementioned report entitled "Water Resources Study, Pecan Bayou Watershed, Colorado River Basin, Texas," a copy of which has already been transmitted to the U. S. Army Engineer District, Fort Worth, Texas.

We appreciate the opportunity accorded us of providing this information.

Sincerely yours,

James M. Quigley

James M. Quigley
Assistant Secretary

Mr. Alfred B. Fitt
Special Assistant to the Secretary
of the Army for Civil Functions
Washington, D. C.

COMMENTS OF THE PUBLIC HEALTH SERVICE

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
WASHINGTON, D.C. 20201

BUREAU OF STATE SERVICES

REFER TO:

April 13, 1965

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

Dear General Wilson:

This is in reply to General Graham's letter of March 17, 1965, requesting comments on the Report on Pecan Bayou Watershed, Colorado River Basin, Texas.

A Public Health Service report on water supply and water quality control prepared in October 1962 is appended to your report. Our recommendations have been taken into consideration in the formulation of this project.

We recommend that suitable outlet structures be provided in the dams so that releases can be selected to assure that good quality water is released for water quality maintenance.

Comments concerning Public Health safeguards against vector problems have been forwarded directly to the District Engineer.

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

Sincerely yours,

James B. Coulter

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

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

10 June 1965

Lieutenant General W. K. Wilson, Jr.
Chief of Engineers
Department of the Army
Washington, D. C. 20315

Reference: ENGCW-PD

Dear General Wilson:

This is in response to General Graham's letter of March 17, 1965, 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 Pecan Bayou, Texas.

The cited reports recommend that, in lieu of the authorized plan for enlargement of the existing Lake Brownwood, a multiple-purpose plan of improvement for the Pecan Bayou Watershed be authorized, including: (1) protective measures for Lake Brownwood dam to provide a reconstructed project for purposes of flood control and water supply; (2) channel improvements for purposes of local flood protection along Pecan Bayou and tributary streams at Brownwood, Texas; and (3) Coleman reservoir on Jim Ned Creek and Pecan Bayou reservoir on Pecan Bayou upstream from Lake Brownwood, for purposes of flood control, water supply, water quality control, fish and wildlife, and recreation. The total Federal construction cost is estimated as $36,751,000. After reimbursement by local interests for water supply and recreation, the net Federal construction cost is estimated to be $29,641,500. The benefit to cost ratio is shown as 2.3 to 1.0. No provisions are included in the project plans for hydroelectric power development.

The Commission has previously considered the hydroelectric power potential of the Lake Brownwood project. In its letter of March 27, 1950 to the Chief of Engineers, the Commission concluded that the small amount of power potential at that site would not be economically feasible of development.

The Commission staff has reviewed the cited reports and has further studied the power possibilities of the proposed improvements in the Pecan Bayou Watershed, Texas, using current costs and current power values. The staff studies show that development of hydroelectric power would not be economically feasible at any of the three dam sites, principally because of the low streamflow and relatively low heads available. If all of the dependable flows could be used for power purposes, continuous power outputs of only 100 kilowatts or less could be produced at each of the sites.

Based on its consideration of the reports of your Department and the studies of its own staff, the Commission concludes that the installation of hydroelectric power facilities would not be economically feasible at the Brownwood, Coleman, and Pecan Bayou reservoir projects.

Sincerely,

David S. Black

David S. Black
Acting Chairman

PECAN BAYOU, TEXAS

REPORT OF THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20315

IN REPLY REFER TO
ENGCW-PD

20 September 1966

SUBJECT: Pecan Bayou, 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, accompanied by the reports of the District and Division Engineers, in response to a resolution of the Committee on Flood Control of the House of Representatives, United States, adopted 8 October 1945. The report presents the results of an investigation of the problems associated with the water and related land resources of the Pecan Bayou watershed with particular emphasis on flood protection for the city of Brownwood, Texas.

2. The District and Division Engineers recommend that, in lieu of the authorized plan for enlargement of Lake Brownwood, a plan of improvement for the Pecan Bayou watershed be authorized to provide for construction of (a) protective measures for Lake Brownwood Dam to establish a reconstructed project for purposes of flood control and water supply; (b) channel improvements on Pecan Bayou, Adams Branch, Tom Williams Branch, and Willis Creek for local flood protection at Brownwood, Texas; and (c) Coleman Reservoir on Jim Ned Creek and Pecan Bayou Reservoir on Pecan Bayou upstream from Lake Brownwood for purposes of flood control, water supply, water quality control, and fish and wildlife and recreation. They estimate the total first cost at $43,433,000, including a total Federal construction cost of $36,751,000, or a net Federal construction cost of $31,684,000 after reimbursement by local interests of $5,067,000 for project costs allocated to water supply; a non-Federal cost of $2,442,000 for lands, easements, rights-of-way, modification and relocation of roads, highway bridges, and related facilities as necessary for construction and operation of the Brownwood channel improvements; and a non-Federal cost value of $4,240,000 as credit for existing lands and existing useful facilities at Lake Brownwood essential to reconstruction and operation of Lake Brownwood. They estimate the net annual cost to the United States at $192,200 for operation and maintenance. The benefit-cost ratio for the total plan is 2.3, based on annual benefits of $4,056,000 and annual charges of $1,761,500.

3. The Board concurs generally in the findings of the reporting officers and recommends authorization of the proposed improvements, subject to certain local cooperation requirements.

4. Subsequent to completion of the District and Division Engineers' reports, policies and procedures with respect to division of responsibility between Federal and non-Federal interests regarding recreation and fish and wildlife enhancement features of Federal multiple-purpose reservoirs entered a state of transition which culminated in P.L. 89-72, cited as the "Federal Water Project Recreation Act". Fundamentally, this Act provides for a substantial level of participation in the cost of development for recreation and fish and wildlife enhancement at multiple-purpose reservoir projects if non-Federal interests agree to administer project land and water areas for these purposes, bear not less than one-half of the separable project costs allocated thereto, and bear all the costs of operation, maintenance, and replacement of recreation and fish and wildlife lands and facilities. The Board's recommendations are consistent with the Act.

5. The proposed report of the Chief of Engineers, concurring generally in the views and recommendations of the Board with certain modifications, was submitted to the Governor of Texas and interested Federal agencies for comment in accordance with established procedures.

6. A recent letter from the Texas Water Development Board indicates that local interests have now constructed a dam and reservoir on Jim Ned Creek in the general area of the Coleman Reservoir which was recommended in our report. Accordingly, the Water Development Board requested that this unit be deleted from our recommendation. A subsequent letter from the Governor requested that a report on the other recommended items be submitted to the Congress for its consideration at the earliest possible time.

7. It also has come to our attention that detailed planning is now underway on a watershed work plan for Willis Creek and Adams Branch (including Tom Williams Branch) developed by the Soil Conservation Service and sponsoring local organizations. Improvement of these streams under that program precludes the need for the work thereon contemplated by the District Engineer.

8. Further consideration has been given to the advisability of Federal improvements in the Pecan Bayou Basin in the light of these recent developments. The items remaining in the District Engineer's plan of improvement after deletion of the Coleman Reservoir and channel

improvements on Willis Creek, Adams Branch, and Tom Williams Branch would constitute a very worthwhile investment with a benefit-cost ratio of about 2.3. Accordingly, I recommend:

a. That the plan for enlarging Lake Brownwood authorized by the Flood Control Acts of 18 August 1941 and 22 December 1944 be deauthorized and that a multiple-purpose plan of improvement for the Pecan Bayou Watershed, Texas, be authorized to provide for construction of the following:

(1) Protective measures for Lake Brownwood Dam to provide a reconstructed project for purposes of flood control and water supply;

(2) Channel improvements for purposes of local flood protection along Pecan Bayou at Brownwood, Texas; and

(3) Pecan Bayou Reservoir on Pecan Bayou upstream from existing Lake Brownwood for purposes of flood control, water supply, water quality control, and fish and wildlife and general recreation;

b. 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 cost to the United States of $24,861,000 for construction, provided 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 Lake Brownwood Dam protective measures:

(a) Retain ownership, maintain the project, and operate the flood-control features in accordance with flood regulations prescribed by the Secretary of the Army, and bear all annual maintenance and operation costs, subject to reimbursement by the Federal Government for annual maintenance and operation costs allocated to flood control;

(b) Hold and save the United States free from damages due to construction and operation of the project, including damages caused by flooding within the reservoir area; and

(c) Enter into a contract prior to initiation of the reconstruction work and in accordance with repayment provisions of the Water Supply Act of 1958, as amended, to reimburse the Federal Government for that portion of the construction costs allocated to water supply. Toward this amount, local interests would be given credit for the estimated value of existing lands and easements, and usable appurtenances at Lake Brownwood;

(2) With respect to the Pecan Bayou Channel improvements:

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

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

(c) Hold and save the United States free from damages due to construction of the project;

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

(e) Provide assurances that encroachments within the channels and rights-of-way will not be permitted;

(f) Provide without cost to the United States designated fill areas for the disposal of excess material from the channel excavation work, the areas to be within reasonable haul distance of the project (approximately 5 miles) or cost for excessive haul distance must be borne by local interests; and

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

(3) With respect to the Pecan Bayou Reservoir:

(a) Obtain without cost to the United States all water rights necessary for operation of the project in the interest of water supply, including water quality control; and

(b) Reimburse the United States for the project costs allocated to water supply, exclusive of water quality control, 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, and with such modification of the following presently estimated allocated water supply costs as may be necessary to reflect adjustments in the storage capacity for water supply and other purposes:

Water Supply Costs Allocated to Local Interests

Item	Pecan Bayou Reservoir
Construction costs	
Amount	$2,186,000
Percent	20.78
Annual maintenance and operating costs	
Amount	$ 19,500
Percent	18.22

(c) In accordance with the Federal Water Project Recreation Act cited in paragraph 4 above:

1. Administer project land and water areas for recreation and fish and wildlife enhancement;

2. Pay, contribute in kind, or repay, which may be through user fees, with interest, one-half of the separable costs of the Pecan Bayou reservoir allocated to recreation and fish and wildlife enhancement, the amount involved being currently estimated as $1,172,500;

3. Bear all costs of operation, maintenance, and replacements of recreation and fish and wildlife lands and facilities, the amount involved being currently estimated as $40,000;

Provided further that the sizing and responsibility for development, operation, maintenance, and replacement of the recreation and fish and wildlife enhancement features of the reservoir may be modified in accordance with the alternatives provided in the Federal Water Project Recreation Act cited above, depending upon the intentions of non-Federal interests regarding participation in the costs of these features at the time of reservoir construction and subsequent thereto, and that appropriate adjustments reflecting such modifications may be made in the allocation of costs to other project purposes.

9. The report as submitted by the District Engineer did not include a statement of intent by non-Federal interests for compliance with Section 2 of the Federal Water Project Recreation Act, adopted 9 July 1965. However, the above-mentioned letter from the Texas Water Development Board stated that the Board will act as State sponsor, to the extent local sponsors have not provided assurances, on the Lake Brownwood Protective Measures and the Pecan Bayou Reservoir.

10. The estimated ultimate cost to the United States for construction, after participation in the cost of recreation and fish and wildlife enhancement based on presently planned level of development for these purposes, and after repayment of the construction cost allocated to water supply, is $21,502,500. The estimated ultimate cost to the United States for maintenance, operation, and replacements is $70,500 annually.

11. I further recommend that following authorization of the Pecan Bayou Dam and Reservoir, detailed site investigations and design be made for the purpose of accurately defining the project lands required; that subsequently, advance acquisition be made of title to such lands as may be required to preserve the site against incompatible development; and that the Chief of Engineers be authorized to participate in the construction or reconstruction of transportation and utility facilities in advance of project construction as required to preserve such area from encroachment and avoid increased costs for relocations.

12. Use of the presently prescribed interest rate of 3-1/8 percent in computing annual charges and benefits would result in no appreciable change in the benefit-cost ratio.

William F. Cassidy

WILLIAM F. CASSIDY
Lieutenant General, USA
Chief of Engineers

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

ENGBR 19 February 1964

SUBJECT: Pecan Bayou, Texas

TO: Chief of Engineers
Department of the Army

1. Authority.--This report is in response to the following resolution adopted 8 October 1945:

> Resolved by the Committee on Flood Control of the House of Representatives, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report on Pecan Bayou, Texas, published as House Document No. 370, 76th Congress, First Session, with a view to determining whether any modifications of the recommendations contained therein with respect to flood protection for the town of Brownwood, Texas, are advisable at this time.

2. Watershed description.--The Pecan Bayou watershed is in the north-central part of the Colorado River basin, near the geographical center of the State of Texas. The watershed has an overall length of 85 miles, a maximum width of 40 miles, and a drainage area of 2,202 square miles. The mean annual precipitation over the watershed is about 27 inches, and varies from about 23 inches in the headwaters region to about 29 inches near the mouth. Snowfall is an insignificant portion of the total precipitation. Annual precipitation recorded at Brownwood has varied from a maximum of 46.00 inches in 1919 to a minimum of 10.86 inches in 1921.

3. Pecan Bayou flows about 144 miles southeasterly to its confluence with the Colorado River at mile 513.1. It drains an area of 1,544 square miles at Lake Brownwood Dam; and an area of 1,622 square miles at the Brownwood gage, about 10 miles downstream from Lake Brownwood Dam and within the eastern portion of the city of Brownwood. Jim Ned Creek, which drains an area of about 778 square miles, flows generally parallel and south of Pecan Bayou until its junction with Pecan Bayou within Lake Brownwood just upstream of the dam. The principal tributary of Jim Ned Creek is Hords Creek,

which flows through the city of Coleman, located about 13 stream miles downstream from Hords Creek Dam and Reservoir. Adams Branch and Willis Creek are right-bank tributaries of Pecan Bayou, flowing through the city of Brownwood and draining areas of about 26 and 27 square miles, respectively.

4. Economic development.--This report is concerned primarily with water problems and demands of a four-county area consisting of Brown, Callahan, Coleman, and Mills Counties. The geographic and economic center of this area is the city of Brownwood, about 125 miles southwest of Fort Worth, Texas. The population of the four-county area in 1960 was 49,582, of which about 50 percent was in Brown County. The principal urban centers in the watershed are the cities of Brownwood and Coleman, with 1960 census populations of about 17,000 and 6,400 persons, respectively. The population in the city of Brownwood represents about 67 percent of the total Brown County population. The principal manufacturing activities of the area consist of the manufacture of clothing, brick and tile, farm machinery, leather goods, oil refining, feed and cottonseed oil products, and the processing of foods, dairy products, meat, and poultry. Agriculture is of major importance and contributes substantially to the economy of the area. The principal farm crops are grain sorghums, oats, wheat, cotton, peanuts, rye, vetch, vegetables, and fruit. There is also a large production of pecans along the streams. Livestock raised in the area includes beef cattle, sheep, goats, hogs, and poultry. Considerable wool and mohair are produced. Mineral resources include oil, gas, brick clay, building stones, glass sand, and celestite, with some deposits of coal and dolomite.

5. Existing improvements.--The principal water resource developments involved on the Pecan Bayou watershed include such existing reservoirs as Lake Scarborough, Lake Brownwood, and the Federally constructed Hords Creek Dam and Reservoir project; existing channel improvements on Willis and South Willis Creeks at Brownwood; the authorized Lake Brownwood enlargement; and a potential flood-detention reservoir program by the Soil Conservation Service. Lake Scarborough is on Indian Creek, a tributary of Jim Ned Creek, about 4 miles north of the city of Coleman. The reservoir, completed in 1927, was constructed by the city of Coleman for municipal water supply. The storage capacity at the time of construction was 2,000 acre-feet. Lake Brownwood is impounded by a dam on Pecan Bayou at mile 57.1, a short distance below the confluence of Pecan Bayou and Jim Ned Creek. The dam was completed in 1932 by the Brown County Water Improvement District No. 1, at a cost of about $1,500,000. A distribution system for delivering water to lands within the district and to the city of Brownwood was completed in 1939 at an estimated cost of about $1,000,000.

Local flood-protection works, consisting of channel rectification and low levees on Willis and South Willis Creeks, were constructed in 1943 by the Department of the Army, with military funds, at an estimated cost of $84,578 for the purpose of relieving the aggravated flood conditions brought about by the construction of Camp Bowie. Construction of the Hords Creek Dam and appurtenant works was completed on 16 June 1948. The estimated cost of the project is $2,767,079, which includes $105,079 contributed by local interests.

6. The enlargement of Lake Brownwood, authorized by the Flood Control Acts of 18 August 1941 and 22 December 1944, was planned by the Corps of Engineers for purposes of flood control and additional water supply. Subsequent to authorization of this project, advanced planning studies for construction of the authorized enlargement were discontinued pending re-examination of the authorized plan and investigation of alternate upstream reservoir plans as requested by local interests.

7. The Soil Conservation Service has a potential flood-detention reservoir program on the Pecan Bayou watershed. This program includes 146 flood-detention reservoirs, of which 88 and 58 would be upstream and downstream from Lake Brownwood, respectively. As of 1 July 1962, 26 of the upstream reservoirs had either been constructed or were under construction.

8. Water resource problems.--Major floods originating on the Pecan Bayou watershed cause extensive flood damages to agricultural properties in the valleys of Pecan Bayou and its principal tributaries, and contribute to flood damages along the main stem of the Colorado River. The principal flood problem on the Pecan Bayou watershed is about 10 stream miles downstream from Lake Brownwood Dam at the city of Brownwood, where urban developments within the flood plains of Pecan Bayou and the tributary streams, Adams Branch and Willis Creek, are subject to appreciable damages from frequent floods. The flood plains investigated are along Pecan Bayou and Jim Ned Creek, along the Lake Brownwood shoreline, along Adams Branch and Willis Creek at the city of Brownwood, and along a 77.7-mile reach of the Colorado River. The investigated flood plain segments involve a total stream distance of 243 miles and a total area of 71,537 acres. The average annual damages within the investigated flood plains are estimated at $982,100.

9. In addition to the general flood problems on the Pecan Bayou watershed, there are important related problems at Lake Brownwood. The existing Lake Brownwood was constructed principally for water supply purposes, but because of its relatively narrow spillway and the resultant surcharge storage, it has been valuable in reducing flood

peaks and flood damages to the downstream area. Flood routing studies indicate that the existing spillway would not pass the standard project flood without utilizing practically all available freeboard of the existing dam, and that floods resulting from the transposed storm of 30 June-2 July 1932, or the design spillway storm would overtop the existing embankment. Field investigations, laboratory analyses, and studies determined that the safety factor of the existing embankment is below the minimum value considered adequate for an earthen structure; that there is no assurance the dam would not fail on recurrence of the maximum flood of record (July 1932). The failure of Lake Brownwood Dam would cause catastrophic conditions to the downstream areas along Pecan Bayou and at the city of Brownwood. The sudden release of impounded flood waters would create a flood wave which would inundate substantial portions of the agricultural flood plain and the business and residential areas of Brownwood. The flood wave would cause damages of several million dollars, and should it occur at night, would probably cause loss of life.

10. The water supply problems on the Pecan Bayou watershed involve consideration of additional surface water storage to meet existing and projected water supply requirements for municipal, industrial, irrigation, and water quality control uses. Upstream from Lake Brownwood, the city of Coleman has indicated an urgent need for additional water supply. The principal existing sources of water supply, which include Lake Brownwood, Hords Creek Reservoir, and ground water developments, amount to about 23.7 million gallons per day under projected conditions of watershed development. The existing sources are inadequate to meet the projected water supply requirements of the Pecan Bayou watershed subsequent to the year 1970. The total water requirements for domestic, municipal, industrial, irrigation, and water quality control purposes on the Pecan Bayou watershed are expected to increase from about 21.5 million gallons per day in 1960 to about 45.0 million gallons per day in 2070.

11. This report recognizes the possibility of the eventual construction of the Fox Crossing Dam and Reservoir on the Colorado River. The Fox Crossing Dam and Reservoir, a potential reservoir project included in the United States Study Commission plan and presently being investigated by the Corps of Engineers under comprehensive study of the Colorado River Basin, Texas, would inundate portions of the investigated flood plains along the Colorado River and along the lower Pecan Bayou. Thus, the analyses of the flood problems under projected conditions of flood plain development exclude the flood plain segments which would be subject to inundation by the potential Fox Crossing project. The benefits estimated for the proposed plan were determined on the basis that the existing watershed

improvements included the potential flood-detention reservoir system of the Soil Conservation Service, which would afford reductions in flood flows on Pecan Bayou and Jim Ned Creek.

12. Improvements desired.--Local interests have indicated a desire for the following improvements:

A local flood protection project for the city of Brownwood, to include such measures as channel straightening, diversions, enlargements of Pecan Bayou, Adams Branch, and Willis Creek, and small dams;

Construction of a permanent Lake Brownwood spillway with flood gates and protective measures within the existing spillway channel which erodes on passage of flood waters;

Construction of multiple-purpose reservoirs upstream from Lake Brownwood;

Retention of Lake Brownwood at its present size;

Continuation of the Brownwood irrigation project; and

Optimum water supply development.

In addition, the Texas Water Commission has publicly expressed its policy that all additional flood-control reservoirs 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 streams as necessary to meet the water requirements for municipal, industrial, and irrigation uses and for water quality control.

13. Plan of improvement.--The District Engineer finds that the comprehensive plan of development for the Pecan Bayou watershed should include the following improvements in lieu of the authorized plan for Lake Brownwood enlargement. The plan would operate in the interest of flood control, water supply, water quality control, fish-wildlife, and general recreation.

Lake Brownwood Dam protective measures, involving enlargement of the existing earth embankment, new outlet works, and erosion-control measures for the existing spillway, but with no increase in controlled reservoir storage;

Channel improvements in the city of Brownwood on the main stem of Pecan Bayou, Adams Branch, Tom Williams Branch, and Willis Creek;

Coleman Dam and Reservoir, involving an earth embankment at mile 52.2 on Jim Ned Creek, outlet works through the embankment, an excavated uncontrolled saddle spillway, and 240,900 acre-feet of controlled storage; and

Pecan Bayou Dam and Reservoir, involving an earth embankment at mile 100.8 on Pecan Bayou upstream from Lake Brownwood, outlet works through the embankment, an excavated uncontrolled saddle spillway, and 206,300 acre-feet of controlled storage.

The following tabulation gives pertinent data for the proposed plan:

Pertinent Data on Proposed Plan

RESERVOIRS

Item	Reconstructed Lake Brownwood	Coleman Reservoir	Pecan Bayou Reservoir	Total
Total controlled storage, acre-feet	124,600	240,900	206,300	571,800
Flood control		(92,100)	(102,700)	(194,800)
Water conservation	(91,600)	(138,500)	(93,500)	(323,600)
Sediment	(33,000)	(10,300)	(10,100)	(53,400)
Dependable water supply				
Million gallons daily	14.9	12.9	8.4	36.2
Cubic feet per second	23.0	20.0	13.0	56.0

CHANNELS

Item	Pecan Bayou	Adams Branch	Willis Creek
Channel improvements			
Length (main channel)			
Existing, miles	9.8	6.1	3.9
Improved, miles	7.3	2.9	3.0
Improved, feet			
Main channel	38,800	15,200	16,000
Cutoff channels	2,000 (WS)	1,100 (TWB)	-
Excavation, cubic yards	11,482,000	725,000	651,900
Side slopes	1 on 2-1/2	1 on 2-1/2	1 on 2-1/2
Average depth, feet	32	18	18
Bottom width, feet	300,25 (WS)	90,50,25 (TWB)	70,80,60,40
Clearing			
Maximum width, feet	550	300	250
Area, acres	413	40	69
Design capacity, 1,000 cubic feet per second	92.0	7.4 to 13.2	12.7 to 19.0

WS - West Slough
TWB - Tom Williams Branch

14. <u>Economic evaluation.</u>--Using July 1963 prices, the District Engineer estimates the total first cost of the Pecan Bayou plan at \$43,433,000, including a total Federal construction cost of \$36,751,000, or a net Federal construction cost of \$31,684,000 after reimbursement by local interests of \$5,067,000 for project costs allocated to water supply; a non-Federal cost of \$2,442,000 for lands, easements, rights-of-way, modification and relocation of roads, highway bridges, and related facilities as necessary for construction and operation of the Brownwood channel improvements; and a non-Federal cost value of \$4,240,000 as credit for existing lands and existing useful facilities at Lake Brownwood essential to reconstruction and operation of Lake Brownwood. The District Engineer estimates the total Federal annual maintenance and operation costs at \$210,000 or a total net Federal annual cost of \$192,200 for the three reservoirs, after reimbursement by Federal and non-Federal interests of reservoir project costs allocated to flood control and water supply, respectively. The total annual charges are estimated at \$1,761,500. He finds that prospective annual benefits, estimated at \$4,056,000 for flood control, water supply, water quality control, fish-wildlife and general recreation, justify the proposed work. The benefit-cost ratio is 2.3 based on a 100-year period of analysis. The economic evaluation of the proposed plan is summarized in the following tabulation:

Item	Reconstructed Lake Brownwood	Brownwood Channels	Coleman Reservoir	Pecan Bayou Reservoir	Total Recommended Plan
	Thousands of dollars				
First cost	7,300.0 (1)	13,723.0	11,890.0	10,520.0	43,433.0
Annual charges	286.4	523.9	496.3	454.9	1,761.5
Annual benefits	828.3	947.4	1,143.1	1,137.2	4,056.0
Benefit-cost ratio	2.9	1.8	2.3	2.5	2.3

(1) Includes proposed Lake Brownwood protective measures (3,060.0) and value of existing usable facilities (4,240.0).

The District Engineer recommends improvement to provide for the multi-purpose project in accordance with his plan, subject to certain local cooperation. The Division Engineer concurs.

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

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

16. Views.--The Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the reporting officers. The Board notes the deteriorated condition of the dam and spillway at Lake Brownwood. The growing water-management needs in the watershed warrant Federal participation in their development. The recommended improvements are economically justified.

17. The Board notes that recreation and fish and wildlife enhancement related to recreation have been included as a primary purpose of the reservoir improvements proposed by the District and Division Engineers. The standards heretofore in use by the Corps of Engineers encouraged non-Federal interests to operate, maintain, and expand project facilities for enhancement of the recreational resource and required them to bear all joint project costs allocated to recreation in excess of 25 percent of the total project cost. In applying these previously established standards for this report, the reporting officers found that none of the costs allocated to these purposes would be reimbursable.

18. Recently, the Bureau of the Budget has indicated that it would expect the agencies primarily concerned with water-resource development to follow the cost-sharing standards set forth for these purposes in H.R. 9032, a Bill proposed by the Administration, entitled "The Federal Water Project Recreation Act," and introduced in the Eighty-eighth Congress, first session, on 6 November 1963. Using the cost allocations previously prepared and applying the cost-sharing standards in accordance with H.R. 9032 the assignment of costs to local interests for recreation and fish and wildlife enhancement would be as follows:

Reservoir	Non-Federal share of cost for recreation and fish and wildlife enhancement: Percent of total initial construction cost	Non-Federal share of cost for recreation and fish and wildlife enhancement: Present estimate
Coleman	4.1	$ 490,000
Pecan Bayou	0.5	56,000

However, in view of the differences in cost apportionment contemplated by H.R. 9032 relating to the assignments of specific, joint, and other costs, additional refinements in the cost allocations may be required to provide for more equitable cost sharing.

19. The Pecan Bayou project is justified without recreational benefits, but the Coleman project, the one indicated by local interests as earliest needed for other purposes, is not. If the Pecan Bayou project is constructed

on that basis, the potential for recreation would be created but the necessary facilities for public use and safety would be omitted and constraints placed upon full realization of the project potentials. Inasmuch as the two projects are sponsored by the same group and will provide identical services, it is necessary that the same apportionment standards be applied to each.

20. The Board notes that the plan has been formulated over a period of years during which time it has been discussed with local interests on the basis of the then-current cost sharing criteria, including recreation features and requirements. On this basis, the report in general has the strong active support of the State and local interests. In view of this, and the additional fact that the recreation opportunities made available at the recommended projects would be widespread, the Board believes that local interests should not be required to bear the costs apportioned to them in accordance with the provisions of H.R. 9032.

21. Recommendations.--Accordingly, the Board recommends:

a. That the plan for enlarging Lake Brownwood authorized by the Flood Control Acts of 18 August 1941 and 22 December 1944 be deauthorized and that a multiple-purpose plan of improvement for the Pecan Bayou Watershed, Texas, be authorized to provide for construction of the following:

(1) Protective measures for Lake Brownwood Dam to provide a reconstructed project for purposes of flood control and water supply;

(2) Brownwood channel improvements for purposes of local flood protection along Pecan Bayou, Adams Branch, Tom Williams Branch, and Willis Creek at Brownwood, Texas; and

(3) Coleman Reservoir on Jim Ned Creek and Pecan Bayou Reservoir on Pecan Bayou upstream from existing Lake Brownwood for purposes of flood control, water supply, water quality control, and fish and wildlife and general recreation;

b. That the foregoing be accomplished with such changes and modifications as in the discretion of the Chief of Engineers may be advisable at estimated Federal costs as follows:

(1) Total Federal construction costs of $36,751,000, or a total net Federal construction cost of $31,684,000 after reimbursement by local interests of project costs allocated to water supply; and

(2) Total Federal annual maintenance and operation cost of $210,000, or a total net Federal annual cost of $192,200 after reimbursement by Federal and non-Federal interests of project costs allocated to flood control and water supply, respectively; and

c. 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 Lake Brownwood Dam protective measures:

(a) Retain ownership, maintain the project, and operate the flood-control features in accordance with flood regulations prescribed by the Secretary of the Army, and bear all annual maintenance and operation costs, subject to reimbursement by the Federal Government for annual maintenance and operation costs allocated to flood control;

(b) Hold and save the United States free from damages due to construction and operation of the project, including damages caused by flooding within the reservoir area; and

(c) Enter into a contract prior to initiation of the reconstruction work and in accordance with repayment provisions of the Water Supply Act of 1958, as amended, to reimburse the Federal Government for that portion of the construction costs allocated to water supply. Toward this amount, local interests would be given credit for the estimated value of existing lands and easements, and usable appurtenances at Lake Brownwood;

(2) With respect to the Brownwood channel improvements:

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

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

(c) Hold and save the United States free from damages due to construction of the project;

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

(e) Provide assurances that encroachments within the channels and right-of-way will not be permitted;

(f) Provide without cost to the United States designated fill areas for the disposal of excess material from the channel excavation work, the areas to be within reasonable haul distance of the project (approximately 5 miles) or cost for excessive haul distance must be borne by local interests; and

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

(3) With respect to the Coleman Reservoir and Pecan Bayou Reservoir units:

(a) Obtain without cost to the United States all water rights necessary for operation of the projects in the interests of water supply, including water quality control; and

(b) Reimburse the United States for the project costs allocated to water supply, exclusive of water quality control, 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, and with such modification of the following presently estimated allocated water supply costs as may be necessary to reflect adjustments in the storage capacity for water supply and other purposes:

Water Supply Costs Allocated to Local Interests

Item	Coleman Reservoir	Pecan Bayou Reservoir
Construction costs		
Amount	$ 2,880,900	$ 2,186,100
Percent	24.23	20.78
Annual maintenance and operating costs		
Amount	$ 21,300	$ 19,500
Percent	20.68	18.22

22. The Board further recommends that, following authorization of the Coleman and Pecan Bayou Dams and Reservoirs, detailed site investigations and design be made for the purpose of accurately defining the

project lands required; that subsequently, advance acquisition be made of title to such lands as may be required to preserve the sites against incompatible development; and that the Chief of Engineers be authorized to participate in the 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.

FOR THE BOARD:

R. G. MacDONNELL
Major General, USA
Chairman

96-452 O-68—4

REPORT OF THE DISTRICT ENGINEER

REVIEW OF REPORTS
ON
PECAN BAYOU WATERSHED
COLORADO RIVER BASIN, TEXAS

SYLLABUS

The District Engineer finds from his investigations of the Pecan Bayou watershed that: (a) the existing dam and spillway features at Lake Brownwood (a water-supply reservoir constructed by local interests) are in urgent need of repair and replacement to prevent failure of the dam and resultant catastrophic flood conditions and damages within the downstream areas, including the city of Brownwood; (b) that important flood problems exist within the city of Brownwood along Pecan Bayou, Adams Branch, and Willis Creek, within the shoreline area surrounding Lake Brownwood, and within the agricultural flood plains along Pecan Bayou and Jim Ned Creek; and (c) that an important water supply problem is evident, based on the need for additional sources of surface water supply to serve forecasted increases in population and municipal-industrial growth.

The District Engineer concludes that the principal flood and water supply problems of the Pecan Bayou watershed can best be solved by certain protective measures to the existing Lake Brownwood; by channel-improvement works along Pecan Bayou, Adams Branch, and Willis Creek in the urban Brownwood area; and by the construction of the Pecan Bayou and Coleman Reservoirs upstream from existing Lake Brownwood. He concludes further that there is an urgent need for these improvements and that they are fully justified for purposes of flood control, water supply, water quality control, and fish-wildlife and general recreation.

The District Engineer recommends that protective measures to provide a reconstructed Lake Brownwood for flood control and water supply be authorized generally as outlined in this report, in lieu of the authorized Lake Brownwood enlargement, at an estimated Federal construction cost of $3,060,000 and an allocated annual cost of $23,000 for flood-control maintenance and operation, subject to certain conditions of local cooperation, including the conditions that local interests be responsible for any project costs allocated to water supply and that they maintain and operate the project; that Brownwood channel improvements for the purpose of local flood protection at the city of Brownwood, be authorized generally as outlined in this report at an estimated Federal construction cost of $11,281,000 subject to certain conditions of local cooperation; and that the multiple-purpose Pecan Bayou and Coleman Reservoirs be authorized for construction at an estimated Federal construction cost of $22,410,000 and an estimated $210,000 annually for maintenance and operation, subject to the conditions that local interests reimburse the United States for the project costs allocated to water supply, exclusive of water-quality control.

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

December 31, 1963

SUBJECT: Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas

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

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

INTRODUCTION

1. AUTHORITY.- This review of reports on Pecan Bayou, Texas is submitted in compliance with instructions from the Chief of Engineers, dated October 19, 1945; pursuant to the following resolution by the Committee on Flood Control of the House of Representatives, adopted October 8, 1945.

"RESOLVED BY THE COMMITTEE ON FLOOD CONTROL OF THE HOUSE OF REPRESENTATIVES, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the report on Pecan Bayou, Texas, published as House Document No. 370, 76th Congress, First Session, with a view to determining whether any modifications of the recommendations contained therein with respect to flood protection for the town of Brownwood, Texas, are advisable at this time."

2. SCOPE.- This report presents the results of a comprehensive investigation of the problems associated with the water and related land resources of the Pecan Bayou watershed with particular emphasis on flood protection for the city of Brownwood, Texas. It presents a comprehensive plan for use and control of the runoff from Pecan Bayou and its tributaries which has been integrated with existing and proposed local and other Federal improvements and is in consonance with the overall planning of local, state, and Federal interests. The plan presented herein serves as a guide to the development and control of the watershed's water and related land resources and is based upon analysis of detailed technical data and investigations reported upon in the various appendixes of this report.

3. PURPOSE OF THE INVESTIGATION.- The Pecan Bayou watershed with a drainage area of 2,202 square miles is located in the north-central part of the Colorado River Basin. The water problems of this area have resulted primarily from the experienced extremes of runoff resulting from floods or extended periods of droughts without adequate existing control measures to conserve and regulate the water for beneficial use. The lack of adequate flood control and water conservation measures has created many social and economic problems within the watershed that have been the controlling and contributing factors which have prevented the progressive development of this area. The officials of local government and other agencies, having recognized the need for comprehensive and realistic planning to satisfy both the present and projected needs for the area, requested that this investigation be made.

4. ARRANGEMENT OF REPORT.- The following sections of this report contain the results and conclusions of the study and recommendations of the District Engineer, based upon analysis of detailed technical data and investigations reported upon in the following appendixes to this report:

Appendix I - Project Formulation, Analyses, Costs, and Cost Allocations

Appendix II - Foundations, Materials, and Soils

Appendix III - Hydrology, Hydraulic Design, and Water Resources

Appendix IV - Economic Studies

Appendix V - Recreation and Fish and Wildlife

Appendix VI - Reports of Other Federal Agencies

Appendix VII - Views and Comments of Other Agencies

5. HISTORY OF INVESTIGATIONS.- The most recent study submitted to Congress concerning the Pecan Bayou watershed was completed in March 1939 and is published as House Document No. 370, 76th Congress, 1st Session. The study was made in the interest of determining the needs for flood control, water conservation, and allied purposes on the Pecan Bayou watershed. The plan of improvement as presented in House Document No. 370 recommended the construction of the Hords Creek Reservoir on Hords Creek above the city of Coleman, Texas, and the enlargement of the existing Lake Brownwood. Construction of the Hords Creek Reservoir and the enlargement of the existing reservoir at Lake Brownwood were authorized by the Flood Control Acts approved August 18, 1941 and December 22, 1944. The Hords Creek Reservoir project became operational during April 1948. Subsequent to preparation of the report printed as House Document 370, 76th Congress, 1st Session, a report of survey scope entitled "Review of Reports on Pecan Bayou, Texas, Flood Protection, Brownwood, Texas," dated September 3, 1948

was prepared and submitted to the Office, Chief of Engineers through the Southwestern Division. The report, which contained a restudy of the authorized Lake Brownwood enlargement and studies of alternate reservoir plans and of Brownwood channel improvement plans, was returned to the district for revision in July 1954.

6. Under authorities contained in the Flood Control Act of 1944, 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 subwatersheds of the Pecan Bayou watershed. The Soil Conservation Service has formulated plans for extensive land treatment measures and for about 146 floodwater detention structures in the subwatersheds, 32 of which have been constructed.

7. The U. S. Study Commission - Texas, created in 1958 by an act of Congress, published a report in 1962 which presented a plan for use of existing physical improvements and proposed future improvements to conserve and control the available water resources and supply the projected demands for all the major river basins in Texas, except the Sabine, Red, and Rio Grande. The framework plan developed by the Study Commission for the Colorado River Basin includes a reservoir for flood control and water supply on Jim Ned Creek at the Camp Colorado site in consideration of the overall needs of the Pecan Bayou watershed.

8. Several other agencies have made investigations of the water problems in the Pecan Bayou watershed. The cities of Coleman and Brownwood have been particularly concerned about the flood control and water supply problems of the watershed. A number of investigations have been initiated and considerable interest expressed by local interests in an attempt to alleviate the various problems. 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 Pecan Bayou watershed requirements. A water supply plan presented in the report includes a reservoir on Jim Ned Creek at the Jim Ned Creek (Coleman) site.

9. The comprehensive plan presented in this report has been developed after fully considering all other investigations and reports described above. The plan is generally compatible with the major objectives of the plans and investigations developed by local interests and the various agencies concerned with water resources problems in the Pecan Bayou watershed and with the comprehensive aspect of the Colorado River studies now in progress.

10. PUBLIC HEARINGS AND IMPROVEMENTS DESIRED.- Public hearings were held at Ballinger, Texas, on May 22, 1962 in connection with the comprehensive plan of development for the Colorado River Basin, and at Brownwood, Texas, on September 11, 1946 in connection with the development of a plan of improvement for the Pecan Bayou watershed. At the public hearings, local interests stated their views with respect to improvements for flood control, water supply, and allied purposes.

11. The local interests through public hearings and various conference discussions have expressed the desire for a Federal improvement project on the Pecan Bayou watershed to include specifically the following features: (a) A local flood protection project for the city of Brownwood, Texas, to include such measures as channel straightening, diversions, and enlargements of Pecan Bayou, Adams Branch, and Willis Creek, and small dams; (b) Construction of a permanent Lake Brownwood spillway with flood gates and protective measures within the existing spillway channel for prevention of erosion by passage of floodwaters; (c) Construction of multiple-purpose reservoirs upstream from Lake Brownwood; (d) Retention of Lake Brownwood at its present size; (e) Continuation of the Brownwood irrigation project; and (f) Optimum water supply development.

11A. The Texas Water Commission has publicly expressed its policy that all additional flood control reservoirs in the State of Texas include the maximum practicable water storage for water conservation, fish-wildlife and general recreation, and that the stored water be used to supplement the low-water flows of the streams as necessary to meet the water requirements for municipal, industrial, and irrigation uses and for water quality control.

12. The plan of improvement proposed in this report was made known to responsible local interests and to the general public through the medium of the following: Conferences with responsible local interests on April 17, 1962 and January 29, 1963 at Fort Worth and on November 13-14, 1963 at Coleman and Brownwood; a public meeting held at Brownwood on June 7, 1962; and the public hearing held at Ballinger on May 22, 1962. The responsible local interests include governmental representatives of the cities of Coleman and Brownwood and of Coleman and Brown Counties, and representatives of the Central Colorado River Authority and the Brown County Water Improvement District No. 1. The conference and meetings of April 17, 1962, May 22, 1962, and June 7, 1962, were attended by representatives of the Texas Water Commission. Local interests of Brown and Coleman Counties, by letters dated June 13, 1962, indicated approval of the proposed plan and provided assurances of local cooperation; and by letters of November 14 and 15, 1963, reiterated the need and desire for the proposed plan of improvement. The public hearing held at Ballinger on May 22, 1962 in connection with the comprehensive Colorado River Basin study was attended by representatives from Coleman and Brown Counties. The reservoir projects selected for the water resources development on the Pecan Bayou watershed were shown on the display map used at the Ballinger, Texas, hearing. The Brown County Water Improvement District No. 1 presented a written public hearing statement which included comments on the plan of improvement selected for the Pecan Bayou watershed. The subject report and the proposed plan of improvement were presented on August 17, 1963 to interested Federal agencies and to certain State agencies for field-level review and comment.

WATERSHED DESCRIPTION

13. LOCATION AND SIZE.- The Pecan Bayou watershed is located in the north-central part of the Colorado River Basin, near the geographical center of the State of Texas. The Pecan Bayou watershed is bounded on the north and east by the Clear Fork and Leon River watersheds of the Brazos River Basin; and on the west and south by the small lateral tributary areas of the Colorado River. The watershed has an overall length of 85 miles, a maximum width of 40 miles, and a drainage area of 2,202 square miles. The watershed is pear-shaped and slopes generally from northwest to southeast. The watershed portion upstream from Lake Brownwood Dam possesses the maximum width and a 70-percent portion (1,544 square miles) of the total drainage area. The watershed includes portions of eight counties which are, in descending order, Taylor and Runnels, Coleman and Callahan, Brown and Eastland, and Mills and Comanche. The city of Brownwood in Brown County and the city of Coleman in Coleman County are the two largest urban centers on the watershed. The watershed is shown on plate A (adjacent to the rear cover of this report).

14. PHYSICAL CHARACTERISTICS OF THE WATERSHED.- The Pecan Bayou watershed lies principally within the Central Texas section of the Interior Plains physiographic province. The watershed portions which are upstream and downstream from approximately the Brown-Coleman County line are principally within the Rolling Plains and the North Central Prairies land-resource areas, respectively. The watershed is characterized by plateaus in maturity and later stages of erosion with areas of well-developed and rapid drainage and moderate relief ranging from relatively smooth plains to sharply eroded valleys. The watershed soils are sandy loams, clay loams, clays, and stoney soils, ranging from neutral to slightly calcareous or to slightly acid, and from dark brown to reddish brown or to grayish brown. The soils within the main stream valleys are alluvial. The watershed vegetation is principally grasses, mesquite, and scrub oak. The watershed elevations vary from about 2,350 feet above mean sea level along the head-water divide, about 14 miles south of Abilene, to about 1,160 feet at the confluence of Pecan Bayou with the Colorado River, about eight miles west of Goldthwaite.

15. GEOLOGY.- The watershed lies within outcrop of the Pennsylvanian, Permian, and Lower Cretaceous strata. The outcrops consist principally of clays, sands, shales, sandstones, limestones, conglomerates, marls, and gypsums.

16. STREAMS.- Pecan Bayou originates in the northwestern portion of Callahan County and flows a distance of about 144 miles in a generally southeasterly direction to its confluence with the Colorado River at mile 513.1. Throughout its length, Pecan Bayou follows a tortuous course and meanders from one side of the valley to the other for a distance of about 1.7 times the length of the general axis of the valley. Pecan Bayou

drains an area of 1,544 square miles at Lake Brownwood Dam; and an area of 1,622 square miles at the Brownwood gage which is located about ten stream miles downstream from Lake Brownwood Dam, and within the eastern portion of the city of Brownwood. Upstream from Lake Brownwood, the larger tributary streams are Jim Ned Creek, Hog Creek, Red River, Turkey Creek, and South and Middle Forks of Pecan Bayou. Downstream from Lake Brownwood Dam, the principal tributary streams are Blanket Creek and Brown Creek, as well as Adams Branch and Willis Creek which flow through the northern and southern portions of the Brownwood urban area, respectively.

17. Jim Ned Creek has a length of about 84 miles, rises in southeastern Taylor County, and flows in a southeasterly direction. It flows generally parallel to and south of Pecan Bayou until its junction with Pecan Bayou within Lake Brownwood just upstream from the dam. Jim Ned Creek drains an area of about 778 square miles, which is about equal to that drained by Pecan Bayou above the junction of the streams. Hords Creek is the principal tributary stream and is located wholly within Coleman County. Hords Creek flows generally eastward and through the city of Coleman, which is located about 13 stream miles downstream from Hords Creek Dam.

18. Adams Branch originates about five miles west of Brownwood and flows generally eastward, passing through the north portion and along the east edge of the city, to its confluence with Pecan Bayou at river mile 44.4. The watershed has a drainage area of about 26.0 square miles. Two principal tributaries which are confluent within the Brownwood urban area, are Tom Williams Branch with a drainage area of 4.4 square miles and West Slough with a drainage area of 8.4 square miles.

19. Willis Creek originates about five miles southwest of Brownwood and flows generally north and then east, passing through the southern portion of Brownwood, to its confluence with Pecan Bayou at river mile 42.7. The watershed has a drainage area of 27.0 square miles. One principal tributary which is confluent within the Brownwood urban area, is South Willis Creek with a drainage area of 11.5 square miles.

20. Pertinent stream data, including drainage areas, stream lengths, channel capacities for Pecan Bayou and its principal tributaries, are shown in table 1.

21. CLIMATOLOGY.- The Pecan Bayou watershed has a generally mild climate with the distinctive feature 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; however, freezing temperatures and snowfall are occasionally experienced during the passage of cold high-pressure air masses from the northwestern polar regions and the continental western highlands.

TABLE 1

PHYSICAL CHARACTERISTICS
PECAN BAYOU AND TRIBUTARIES

Stream	Confluence with parent stream (mi. above mouth)	Length (river miles)	Approximate total fall (feet)	Drainage area (sq. mi.)
Pecan Bayou	513.1	144	840	2,202
Brown Creek	4.2	12	476	111
Blanket Creek	13.8	29	520	198
Willis Creek	42.7	10	270	27
Adams Branch	44.4	13	330	26
Jim Ned Creek	57.5	84	902	778
Hords Creek	26.8	41	684	149
Hog Creek	67.8	16	320	101
Red River	73.2	21	412	73
Turkey Creek	80.2	23	544	80

Section of Stream (mile to mile)	Average streambed slope (ft./mile)	Prevailing channel capacity (cfs)
Pecan Bayou		
0.0 to 18.0	2.9	30,000
18.0 to 44.0	2.9	13,000
44.0 to 57.1	3.8	12,000
57.1 to 68.1	(Lake Brownwood)	
68.1 to 97.5	4.9	13,000
97.5 to 102.8	3.9	10,000
Jim Ned Creek		
0.0 to 9.5	(Lake Brownwood)	
9.5 to 18.5	8.9	20,000
18.5 to 52.2	6.6	10,000
Willis Creek		
0.00 to 2.6	12.7	6,000
2.6 to 4.2	14.1	4,300
4.2 to 6.1	13.1	2,300
Adams Branch		
0.0 to 2.5	9.4	5,000
2.5 to 4.0	4.0	1,800
4.0 to 6.2	15.2	2,500

22. The mean annual temperature for the watershed is about 65 degrees Fahrenheit. Temperatures have ranged from a maximum of 114 degrees to a minimum of minus 6 degrees. January, the coldest month, has an average minimum daily temperature of about 33 degrees. August, the warmest month, has an average maximum daily temperature of about 97 degrees. The average length of the growing season is about 235 days.

23. The mean annual precipitation over the Pecan Bayou watershed is about 27 inches, and varies from about 23 inches in the headwaters region to about 29 inches near the mouth. Snowfall is an insignificant portion of the total precipitation. Annual precipitation recorded at Brownwood has varied from a maximum of 46.00 inches in 1919 to a minimum of 10.86 inches in 1921.

24. The average annual runoff measured on Pecan Bayou at Brownwood averages about 1.37 inches, but annual extremes of 6.02 and 0.04 inches have been experienced during the period of record.

25. FLOODS AND DROUGHTS.- The amounts of average annual precipitation and runoff indicate that the Pecan Bayou watershed receives a substantial amount of fresh water through rainfall and runoff. However, the extremes in rainfall and runoff -- too much or too little -- have caused flood and water-supply problems on the watershed. The history of the watershed shows a recurring pattern of long to moderate droughts and periods of heavy rainfall. The most severe drought period, based on dependable yield studies made for the various reservoir projects investigated, extended from November 1942 through April 1955. The maximum drought period was interspersed with local and widespread storms, such as the July 1945 flood on Adams Branch and Willis Creek at Brownwood, and the Pecan Bayou and Adams Branch floods in June 1951, and terminated by the flood of April-May 1956.

26. Maximum flood discharges experienced on the Pecan Bayou watershed are as follows: September 1900, 100,000 second-feet on Pecan Bayou upstream from the confluence with Jim Ned Creek, and 150,000 second-feet on Pecan Bayou at Brownwood; July 1932, 187,000 second-feet on Jim Ned Creek with total inflow of 235,000 second-feet into Lake Brownwood; April-May 1956, 25,100 second-feet on Hords Creek at Coleman; and July 1945, 12,000 second-feet on Adams Branch at Brownwood, and 17,800 second-feet on Willis Creek at Brownwood.

27. Lake Brownwood has modified all floods originating upstream from the dam since early 1932 and Hords Creek Reservoir has modified all floods originating on Hords Creek upstream from the dam since 1948. Because Lake Brownwood was just completed and empty at the time, the peak outflow from Lake Brownwood during the July 1932 flood was only about 13,300 second-feet. It is estimated that the peak outflow from Lake Brownwood would have been about 61,000 second-feet during the

July 1932 flood if the conservation pool had been full to the top of the spillway crest. The peak discharge for the 1956 flood on Hords Creek at Coleman was 25,100 second-feet. It is estimated that the 1956 peak discharge at Coleman would have been about 40,000 second-feet if Hords Creek Reservoir had not existed.

ECONOMIC DEVELOPMENT

28. INTRODUCTION.- This study is concerned primarily with water problems and needs of a four-county area consisting of Brown, Callahan, Coleman, and Mills Counties. The geographic and economic center of this area is the city of Brownwood, about 125 miles southwest of Fort Worth, Texas. The economy of this area has a direct effect on planning for the project purposes of flood control, water supply, water quality control, and fish-wildlife and general recreation.

29. The lack of adequate control of the waters of the Pecan Bayou watershed has resulted in a sequence of extremes from water shortages to floods, and these extremes have had a great effect on the economy of the four-county area. Damages to urban property, farms, homes, and industries from floodwaters along Pecan Bayou and its principal tributaries, including a small portion of the Colorado River affected by flood flows from the Pecan Bayou watershed, average almost $550,000 annually under present conditions of watershed improvements and development. Surface and ground water resources of the watershed furnish an average of about 45 million gallons of water daily for use in homes, offices, factories, and on farms. The surface waters also provide for recreational uses. The unregulated flows from the watershed result in a waste of water resources which can be expected to be more serious in the future because of increased population.

30. POPULATION.- The population of the four-county area in 1960 was 49,582, of which 23,345, or about 47 percent was urban. In the 50 years from 1910 to 1960 there was a definite decline in total population; whereas, urban population more than doubled. In common with most agricultural areas, changes in farm methods, increased mechanization, and improved transportation have resulted in a decrease in rural population. Projection of the four-county total population shows an increase to 57,700 in 1970, and to 64,500 in 2020, due to continued growth of the urban areas. The following tabulation shows the historical and projected data for total, urban and rural, population of the study area and the computed average annual rates of increase for the intervals:

POPULATION

	Urban		Rural		Total	
Year	Number Inhabitants	Avg Ann Percent Change	Number Inhabitants	Avg Ann Percent Change	Number Inhabitants	Avg Ann Percent Change
1910	10,013		58,207		68,220	
		+2.24		-0.74		-0.11
1940	19,452		46,562		66,014	
		+0.92		-2.83		-1.41
1960	23,345		26,237		49,582	
		+3.33		-0.37		+1.53
1970	32,400		25,300		57,700	
		+0.59		-0.38		+0.22
2020	43,400		21,100		64,500	

31. An estimate of the population of Texas counties in 1962 was made by the Population Research Center, Department of Sociology, University of Texas and published in the April 1963 issue of the Texas Business Review, a monthly summary by the Bureau of Business Research, the University of Texas. The estimated population of the four-county area in 1962 from this source is 51,756. This would indicate an average annual rate of growth of 2.16 percent, nearly one and one-half times the 1.53 percent rate used in the period 1960 to 1970. Even though the validity of the estimate is not questioned, the population projection has not been changed. It is believed the secular trend will approach the lower rate of increase used in the projection above.

32. PERSONAL INCOME.- Personal income is considered to be the most comprehensive measure of economic activity available in this study since it maintains a close and generally constant relationship with the gross national product. In 1960, the 49,600 residents of the study area received income of $76,651,000. This is $1,550 per person, about two-thirds of the average per capita income for the nation as a whole.

33. MANUFACTURING.- The principal manufacturing activities of the area consist of oil refining, the manufacture of clothing, brick and tile, farm machinery, leather goods, feed and cottonseed oil products, and the processing of foods, dairy products, meat and poultry. The total value added by manufacture in the four-county area in 1960 is estimated at $8,470,000, of which $7,150,000 was in Brown County.

34. AGRICULTURE.- Agriculture is of major importance and contributes substantially to the economy of the area. The principal farm crops grown

are grain sorghums, oats, wheat, cotton, peanuts, rye, vetch, vegetables, and fruit. There is also a large production of pecans along the streams. Livestock raised in the area include beef cattle, sheep, goats, hogs, and poultry. Production of wool and mohair is of major importance.

35. Within the four-county study area in 1959, crops were harvested from about 219,500 acres, of which 2,600 acres were irrigated and 216,900 acres were dry farmed. The value of production on the irrigated land averaged $56.10 per acre, 2.4 times the average value of production on the dry land. It is estimated that the area irrigated from ground water and from surface water supplies will increase to 6,000 acres by the year 2020.

36. NATURAL RESOURCES.- In relation to future needs, water is the most important natural resource of the area. Principal mineral resources include oil, gas, brick clay, building stone, glass sand, and celestite, with some deposits of coal and dolomite. The fish and wildlife resources of the water proper are important primarily as the basis for sport hunting and fishing and other outdoor recreation.

37. GENERAL.- The principal water resource developments involved in the Pecan Bayou watershed studies include the following: Existing reservoirs such as Lake Scarborough, the Federally-constructed Hords Creek Reservoir project, and Lake Brownwood; the authorized Lake Brownwood enlargement; channel improvements on Willis and South Willis Creek at Brownwood, Texas; and a potential flood-detention reservoir program by the Soil Conservation Service. Descriptions of the above developments are presented in the following paragraphs. The existing developments on the watershed and at Brownwood are shown on plates A and B (adjacent to the rear cover of this report).

38. LAKE SCARBOROUGH.- Lake Scarborough is located on Indian Creek, a tributary of Jim Ned Creek, about 4 miles north of the city of Coleman. The reservoir, completed in 1927, was constructed by the city of Coleman for municipal water supply. The storage capacity at time of construction was 2,000 acre-feet. The water from Lake Scarborough is filtered, and then delivered to Coleman through a 10-inch pipe line. Lake Scarborough, which is served by a drainage area of about 12 square miles, provides a negligible amount of water supply, and proved to be inadequate for the water supply needs of the Coleman area. Thus, the city of Coleman acquired the water supply storage in the Hords Creek Reservoir project prior to its construction.

39. HORDS CREEK RESERVOIR.- The Hords Creek Reservoir, authorized by the Flood Control Acts of August 18, 1941 and December 22, 1944, is an existing Corps of Engineers project constructed for purposes of flood control, water supply, and recreation. Construction of the Hords Creek Dam and appurtenant works was completed on June 16, 1948. The estimated project first cost, as of 1962, is $2,767,079. The city of Coleman has contributed $105,079 for the water conservation cost in accordance with the provisions for local cooperation. The average annual maintenance and operation costs for the last five years is $49,334. Since its completion, Hords Creek Reservoir has prevented total flood damages estimated to be $662,000. The project, which has a water surface area of about 510 acres at top of water conservation pool, has been valuable for fish-wildlife and recreational purposes, serving an average visitation of 250,000 persons during 1961 and 1962. The project provides a dependable water supply yield of about 1.07 cfs (cubic feet per second), or 0.7 mgd (million gallons per day).

40. The Hords Creek Dam is located at river mile 27.8 on Hords Creek, about 13 stream miles west of Coleman, Texas. The project provides substantial flood protection for the valley area below the dam and is a source for municipal water supply for the city of Coleman. The dam is an earth-filled embankment which is 6,800 feet long, including an uncontrolled 500-foot-wide broadcrested spillway, and water-supply appurtenances consisting of an approach channel, intake structure, and a 24-inch water line through the dam. The reservoir,

when completed, had a total capacity of 49,290 acre-feet at maximum design water surface, of which 2,860 acre-feet was allocated to sediment storage, 5,780 acre-feet to water conservation storage, 16,670 acre-feet to flood control storage, and 23,980 acre-feet to surcharge storage.

41. LAKE BROWNWOOD.- Lake Brownwood is impounded by a dam on Pecan Bayou at mile 57.1, a short distance below the confluence of Pecan Bayou and Jim Ned Creek. The drainage area above the dam is about 1,544 square miles. The dam, which was completed in 1932 by the Brown County Water Improvement District No. 1, at a cost of about $1,500,000, impounds water for the following purposes: irrigating lands in the lower Pecan Bayou Valley; providing municipal water supply for the city of Brownwood; affording partial flood protection to the lower valley, including the city of Brownwood, by reducing the magnitude of flood peaks originating above the dam; and providing recreational opportunities. A distribution system for delivering water to lands within the irrigation district and to the city of Brownwood was completed in 1939 at an estimated cost of about $1,000,000.

42. The existing Lake Brownwood has an estimated total storage capacity of 130,000 acre-feet, based on 1960 storage conditions. The total storage is below top of water conservation level, elevation 1425.0. The storage is impounded by an earth-fill embankment about 1,500 feet long with top at elevation 1450. Its maximum height is about 117 feet and it has a crown width of 20 feet. The embankment includes: two 9-foot conduits through the base of the dam near the center for drawing down the reservoir during emergencies, and a 5-foot conduit near the south end of the dam for releasing water into the irrigation system. An uncontrolled spillway is located in a saddle about 2,000 feet north of the dam and consists of a cut through the saddle. The spillway has a width of about 480 feet. The concrete sill crest is at elevation 1425. The Brown County Water Improvement District No. 1 has had to make major repairs on the conduits and conduit-gate structure and does not now utilize the existing Broome gates at the intake ends of the 9-foot conduits, but uses 24-inch outlets, which bypass the Broome gates, for regulating the lake level. The reduction in discharging capacity of the outlet results in more frequent use of the existing spillway.

43. Lake Brownwood is operated by the Brown County Water Improvement District No. 1 under the laws of Texas for purposes of municipal and industrial water supply, irrigation, flood control, and recreation. The principal purpose for which Lake Brownwood was constructed is water supply. Lake Brownwood affords water supply for the cities of Brownwood, Bangs, Santa Anna, and Early for municipal and industrial purposes and water supply for irrigating about 5,000 acres of arable land within the boundaries of the District. The District constructed the following: (a) water supply outlets through the embankment; (b) a main concrete-lined canal, 15 miles long and of 77 second-feet initial capacity, leading from the water supply outlet to the vicinity of Brownwood to supply irrigation water to the District lands and water supply to the city;

(c) a lateral system, comprised of 13 miles of concrete-lined canals and about 41 miles of pipe line to distribute the irrigation supply; and (d) municipal-supply treatment facilities which include two filtration plants with a combined maximum capacity of 5.5 million gallons daily and two concrete ground storage reservoirs having total capacity of 2,000,000 gallons. The water supply for Bangs is conveyed by a pipe line owned by the city of Bangs. The city of Santa Anna contracted with the District for water supply and constructed necessary diversion and conveyance works to obtain its water supply from Lake Brownwood. The Brown County Water Improvement District No. 1 comprises about 14,000 acres of land within its boundaries, including the urban area of the city of Brownwood. In addition to serving about 5,000 acres of arable land within the District boundaries, the District, at times, sells water to irrigate portions of about 1,500 acres outside the District boundaries. Crops grown within the District boundaries are wheat, corn, forage and grain sorghums, oats, barley, cotton, alfalfa, bermuda, orchards, and vegetables. The method of irrigation is by flooding, utilizing generally the border system and to a small extent the sprinkler system. The arable land irrigated within the District averaged about 3,600 acres between 1953 and 1963. The average withdrawal from Lake Brownwood by the District for all purposes is about 23,000 acre-feet per year.

44. The existing Lake Brownwood is also valuable for recreational activities. Commercial, private, and state park recreational facilities within the Lake Brownwood shoreline area, including lands, has a present estimated value of about $22,000,000. Much of the area around Lake Brownwood has been developed for cabin, cottage, lodge encampment, commercial recreational businesses, and permanent homesites. The area provides many cabins and camping areas, swimming areas, fishing and boating docks, and boathouses. The shoreline area is undergoing extensive subdivision and the amount of recreational improvements is expected to increase considerably in the future. The Lake Brownwood shoreline area includes the Lake Brownwood State Park area. The State Park area involves an area of about 500 acres and includes cabin areas, playground areas, and facilities for boating, fishing, swimming, picnicking, and dancing. Lake Brownwood has a normal water surface area of about 7,500 acres and a shoreline distance of about 90 miles. The number of permits for boating and fishing exceeds 200,000 annually. The National Parks Service estimates the number of visitors to the State Park area to be about 100,000 annually. The total average annual visitation to Lake Brownwood is conservatively estimated to be at least 750,000 annually.

45. Problems exist at Lake Brownwood due to the inadequacy of the existing dam and spillway. The existing embankment lacks sufficient height and structural stability. The spillway channel is undergoing deterioration

due to erosive action of spillway discharges. Failure of the existing embankment under extreme flood conditions would cause catastrophic conditions within the downstream area. The problems at Lake Brownwood are presented in paragraphs 60 and 61 under the discussion of water problems.

46. LAKE BROWNWOOD ENLARGEMENT.- The enlargement of Lake Brownwood, authorized by the Flood Control Acts of August 18, 1941 and December 22, 1944, was adopted by the Corps of Engineers for purposes of flood control and additional water supply. Subsequent to authorization of this project, advanced planning studies for construction of the authorized enlargement were initiated. However, the advanced planning studies were discontinued pending reexamination of the authorized plan and investigation of alternate projects under authority of congressional resolution cited in paragraph 1 of this report. The authorized Lake Brownwood enlargement has an approved first cost of $15,200,000 which was estimated in 1954 and based on price levels at that time. Based on studies contained in this report, the estimated first cost of the Lake Brownwood enlargement would be about $43,700,000. The difference in the above cost estimates are due principally to increased real estate values within the shoreline area resulting from subdivision of lands and development of homesites and recreational establishments and facilities during the past 10 years.

47. The authorized Lake Brownwood Dam site is located at river mile 57.1 on Pecan Bayou, about 10 stream miles north of Brownwood, Texas. The authorized project would provide substantial flood protection to the valley of Pecan Bayou downstream from the dam, including the city of Brownwood, would aid in the reduction of flood damages along the Colorado River, and would also provide additional conservation storage. The project includes provisions for raising and strengthening the existing dam, and for improving the existing spillway, including installation of spillway gates and protection against further deterioration of the spillway channel. The Lake Brownwood enlargement, as set forth in the project document, would include 116,000 acre-feet of water conservation storage and 238,000 acre-feet of flood control storage. The project was adopted by Congress subject to the provision that the local agency owning and controlling Lake Brownwood would permit the United States to utilize, without cost, the existing dam, reservoir, appurtenant works, any of its lands needed for the construction and operation of the enlarged dam and spillway, and that the local agency would maintain and operate the enlarged reservoir upon completion in accordance with regulations prescribed by the Secretary of the Army.

48. FLOOD-PROTECTIVE WORKS AT BROWNWOOD.- Local flood-protection works, consisting of channel-rectification work and low levees (3 to 5 feet in height) on Willis and South Willis Creeks, were constructed in 1943 by the Department of the Army, with military funds, for the purpose of relieving the aggravated flood conditions brought about by the construction of Camp Bowie (see plate B adjacent to the rear cover of this report). These works were constructed in accordance with recommendations made by the Corps of Engineers in "Supplemental Report on Floods in Willis Creek Valley below Camp Bowie, Texas, dated

March 1, 1943, which estimated the cost of this work at $84,578. The report contained the following provisions of local cooperation: That the affected property owners furnish free of cost to the Government certain necessary rights-of-way and spoil-disposal areas and execute waivers of claims for past and future damages, all in consideration of the Government performing the proposed construction work. These flood-protection works consisted of the following:

a. Increasing the channel capacity of South Willis Creek to 5,000 second-feet from the junction with Willis Creek to Stephen F. Austin Boulevard in Camp Bowie (mile 0.9).

b. Increasing the channel capacity of Willis Creek to 8,000 second-feet from about 0.6 mile below Austin Avenue (mile 2.3) to the junction with South Willis Creek (mile 2.6).

c. Constructing a new bridge over South Willis Creek at Fourth Street (mile 0.4).

d. Raising and lengthening the existing bridge over Willis Creek at Austin Avenue (mile 2.3).

e. Constructing low levees along the frontage of the more highly developed property so as to provide a reasonable degree of protection against floods of about 7,500 second-feet in South Willis Creek and 12,000 second-feet in Willis Creek. The levees were constructed about 3.5 feet above design water surface at the following locations:

(1) Along the left bank of South Willis Creek from a point about 300 feet above the junction with Willis Creek to Stephen F. Austin Boulevard (mile 0.9).

(2) Along the right bank of Willis Creek and South Willis Creek from Austin Avenue (mile 2.3) to about Third Street (mile 0.3). The low levees were constructed from the spoil material obtained from the channel excavation.

f. Filling the abandoned portions of the creek channels and raising the banks of the channel in the several locations where the banks were below the grade of the design water surface. This work was done with the spoil materials obtained from the channel excavation.

49. The adequacy of these flood-protection works has been tested only once. This was during the flood of July 7, 1945, which was caused by intense rainfall over the watershed. Local residents stated that Willis Creek attained the highest stage known. The water surface, according to one observer, reached within about 18 inches of the top of the levees at a point 500 feet above Austin Avenue. The improvements on

South Willis Creek and on Willis Creek below the confluence of these two streams functioned as designed and the damages in the improved area were slight.

50. SOIL CONSERVATION SERVICE PROGRAM.- The Soil Conservation Service has investigated a potential flood-detention-reservoir program on the Pecan Bayou watershed. The potential program is covered in the Report of the U. S. Study Commission - Texas, dated March 1962. The potential program includes 146 flood-detention-reservoirs, of which 88 and 58 reservoirs would be located upstream and downstream from Lake Brownwood, respectively. The Soil Conservation Service, under authority noted in paragraph 6, has prepared definite work plans for construction of 55 reservoirs upstream from Lake Brownwood, 12 of which are on the Turkey Creek subwatershed, and 43 reservoirs are on the Jim Ned Creek subwatershed.

51. The 12 planned flood-detention-reservoirs on the Turkey Creek subwatershed have an estimated total Federal construction cost of $820,400; and would provide a total storage of 12,100 acre-feet, of which 10,780 acre-feet is for flood detention and 1,320 acre-feet is reserved for sedimentation purposes. As of July 1, 1962, six of these reservoirs have either been constructed or were under construction, at an estimated total Federal construction cost of $388,700; and include a total storage of 6,200 acre-feet, of which 5,430 acre-feet is for flood detention and 770 acre-feet is for sedimentation. Participation of local interests in the above reservoirs consists of furnishing the required lands.

52. The 43 planned flood-detention reservoirs on the Jim Ned Creek subwatershed have an estimated total Federal construction cost of $3,804,500; and would provide a total storage of 80,000 acre-feet, of which 73,500 is for flood detention and 6,500 acre-feet is for sedimentation. As of July 1, 1962, 26 of these reservoirs have either been constructed or were under construction, at an estimated total Federal construction cost of about $2,085,500; and include a total storage of 49,590 acre-feet, of which 46,900 acre-feet is for flood detention and 2,690 acre-feet is for sedimentation.

53. In addition to the above flood-detention structures, the Soil Conservation Service is participating in land-treatment measures consisting of cover cropping, contour farming, terracing, diversion construction, and fertilizing, all of which serve to reduce runoff velocity, erosion damage, and sediment yield.

WATER PROBLEMS

54. INTRODUCTION.- The aim of river-basin and watershed programs is to satisfy human needs and provide solutions to the various water problems. A basic principle in this investigation is that the water- and related land-resource developments have value only to the extent that they are needed. The magnitude of the demands for water resources development and control in the Pecan Bayou watershed 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 should be planned to assure a balanced program of resource development. In the overall evaluation of the demands of water resources, including resolution of the various water problems, 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.

55. Because the existing dam at Lake Brownwood lacks sufficient height and structural stability, it is probable that the existing embankment would fail during extreme flood conditions. In order to analyze Lake Brownwood in the proper perspective, the flood control and water supply problems on the Pecan Bayou watershed have been analyzed under conditions which assume that Lake Brownwood is non-existent.

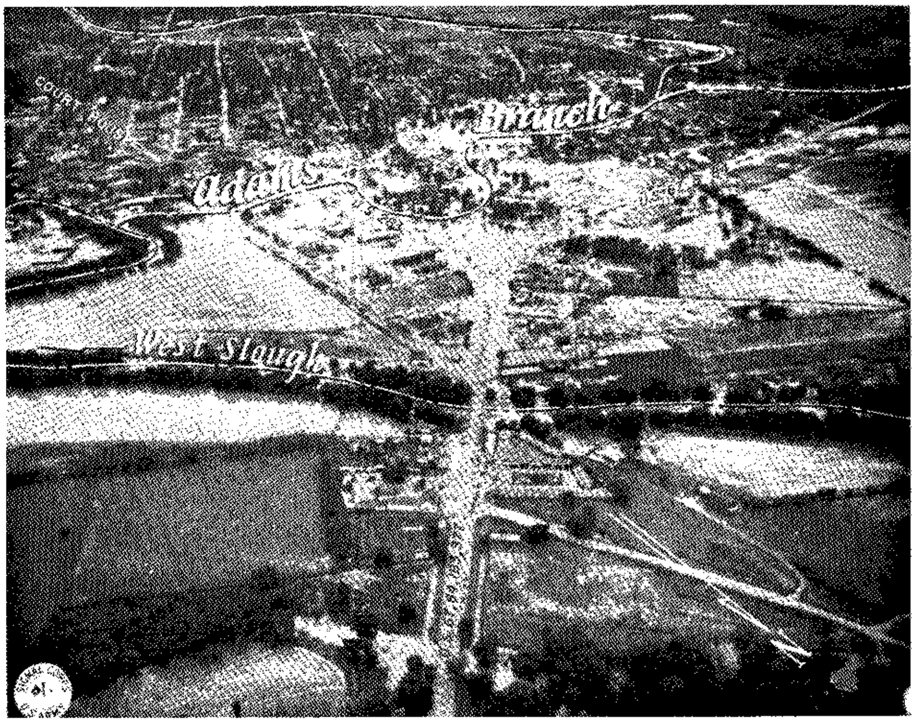
56. FLOOD PROBLEMS.- Flood problems exist on the Pecan Bayou watershed as the result of frequent heavy storm rainfall and inadequate channel capacities. Major floods originating on the watershed cause extensive flood damages to agricultural properties in the valleys of Pecan Bayou and its principal tributaries, and contribute to the amount of flood damages along the main stem of the Colorado River. The principal flood problem on the Pecan Bayou watershed is located about 10 stream miles downstream from Lake Brownwood Dam at the city of Brownwood, Texas where urban developments within the flood plains of Pecan Bayou and the tributary streams, Adams Branch and Willis Creek, are subject to appreciable damages from frequent floods. The flood conditions at Brownwood are illustrated in figure 1. Also, the Lake Brownwood shoreline area, experiencing rapid subdivision and development within and above the flood easement area, is a potentially serious flood problem area. The economic studies indicate that substantial increases in the amount of development within the investigated flood plain segments of the Pecan Bayou watershed are to be anticipated during the next century. The Soil Conservation Service has planned a system of flood-detention reservoirs on the Pecan Bayou watershed. The program would provide substantial flood protection to the tributary streams. However, additional flood control measures are needed to reduce anticipated flood damages along the main-stem streams of Pecan Bayou and Jim Ned Creek under existing and projected conditions of flood plain development.

57. The flood plains investigated for the purposes of this report are located along Pecan Bayou and Jim Ned Creek, along the Lake Brownwood shoreline, along Adams Branch and Willis Creek at the city of Brownwood, and along a 77.7-mile reach of the Colorado River. As previously stated, the analyses of the flood problems are based on the conditions that Lake Brownwood is non-existent. The flood plain areas investigated in detail for this report consist of areas subject to overflow from the maximum floods of record which would occur under the conditions as modified by a potential flood-detention reservoir program of the Soil Conservation Service and by the existing Hords Creek Reservoir. The investigated flood plain segments involve a total stream distance of 243.0 miles and a total area of 71,537 acres. The flood plains are devoted principally to agricultural activities, but involve urban developments at Brownwood, numerous transportation and distribution facilities, and oil-field activities upstream from Lake Brownwood.

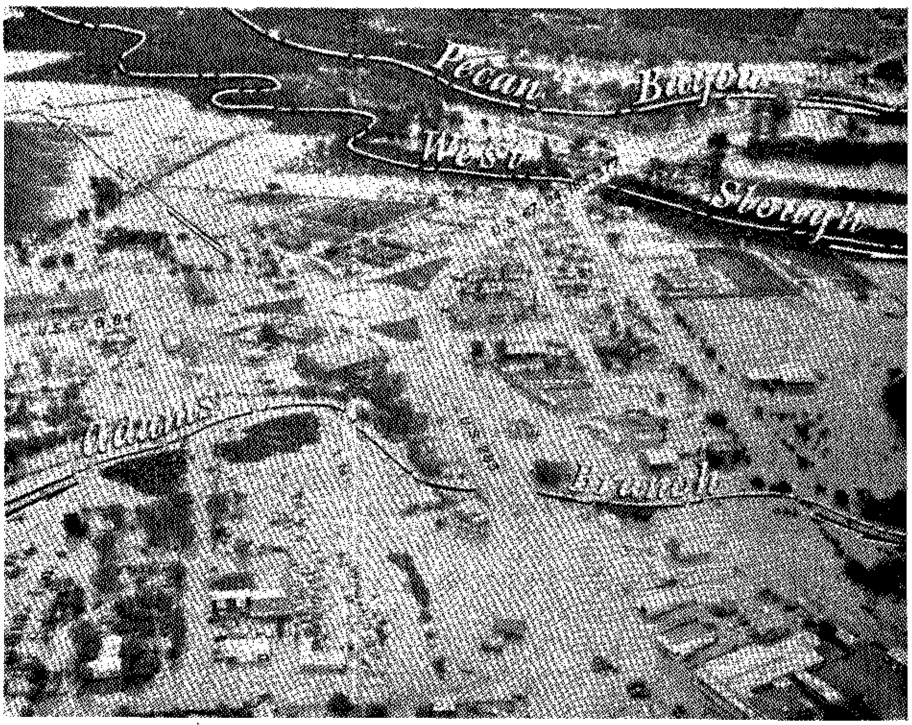
58. The seriousness of existing and potential flood problems on the Pecan Bayou watershed specifically within the investigated flood plains and within the Brownwood urban area, are indicated by the value of physical property damages to be expected from recurrence of the maximum floods, and average annual damages. Economic studies indicate that there will be considerable population and property expansion in the Pecan Bayou watershed within the next century. The projection of economic trends within the investigated flood plains and at urban Brownwood indicates that the value of physical property and flood damages will increase as shown in figure 2. Based on the existence of such flood control developments as Hords Creek Reservoir and a potential system of flood detention reservoirs of the Soil Conservation Service, the average annual damages within the investigated flood plains, are estimated to be $982,100, assuming 1960 conditions of flood plain development; and $2,328,500, assuming projected conditions of flood plain development during the period 1970-2070.

59. The above analyses of the flood problem recognizes the possibility of the eventual construction of the Fox Crossing Reservoir on the Colorado River. The Fox Crossing Reservoir, a potential reservoir project included in the U. S. Study Commission plan and presently being investigated by the Corps of Engineers under comprehensive study of the Colorado River Basin, Texas, would inundate portions of the investigated flood plains along the Colorado River and along the lower Pecan Bayou. Thus, the analyses of the flood problems under projected conditions of flood plain development from 1970 to 2070, as presented above, exclude the flood plain segments which would be subject to inundation by the potential project.

60. LAKE BROWNWOOD DAM PROBLEMS.- In addition to the general flood problems on the Pecan Bayou watershed, there are important related problems at Lake Brownwood. The existing Lake Brownwood was constructed principally for water supply purposes, but because of its relatively narrow spillway and the resultant surcharge storage, it has been valuable in reducing flood peaks and flood damages to the downstream area. However, the design of the existing

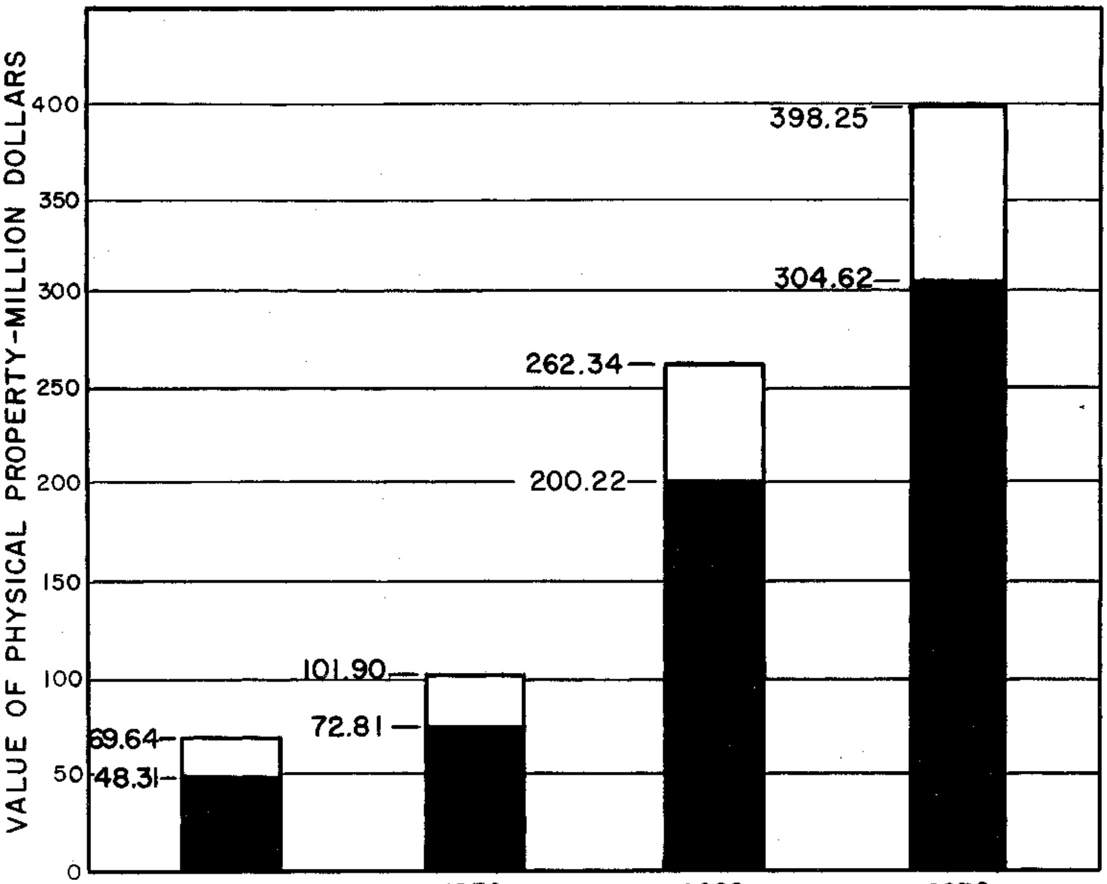


FLOOD ON ADAMS BRANCH-1945
AT BROWNWOOD, TEXAS

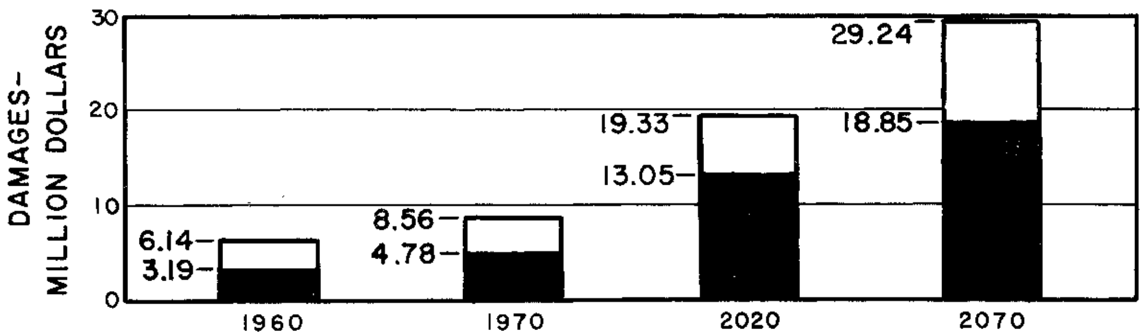


FLOOD ON ADAMS BRANCH AND PECAN BAYOU-MAY 1956
AT BROWNWOOD, TEXAS

FIGURE 1



VALUE OF PHYSICAL PROPERTY IN FLOOD PLAIN



ESTIMATED DAMAGES ON RECURRENCE OF MAXIMUM FLOODS

TOTAL FLOOD PLAINS INVESTIGATED

(BROWNWOOD URBAN AREA INCLUDED)

UNDER 1960 FLOOD CONTROL CONDITIONS AND EXISTING AND PROJECTED FLOOD PLAIN DEVELOPMENTS

FIGURE 2

dam and spillway at Lake Brownwood is not considered adequate for safe operation. Flood routing studies indicate that the existing spillway would not pass the standard project flood without utilizing practically all available freeboard of the existing dam, and that floods resulting from the transposed storm of June 30-July 2, 1932, and the spillway design storm would overtop the existing embankment. Field investigations, laboratory analyses, and studies determined that the safety factor of the existing embankment is below the minimum value considered adequate for an earthen structure; that there is no assurance the dam would not fail on recurrence of the maximum flood of record (July 1932); and that strengthening measures, such as grouting and additional compacted fill, are needed to insure its stability. In addition, new outlet works are needed to replace the virtually inoperative existing facilities, and erosion-control measures are needed to prevent deterioration of the spillway channel. Scenes of the dam and spillway channel are shown in figures 3 and 4.

61. The failure of Lake Brownwood Dam would cause catastrophic conditions to the downstream areas along Pecan Bayou and at the city of Brownwood. The sudden release of impounded flood waters would create a flood wave which would inundate substantial portions of the agricultural flood plain, the irrigable lands, and the business and residential areas of Brownwood. The flood wave would cause damages of many million dollars; and should it occur at night, would probably cause considerable loss of lives. Failure of Lake Brownwood Dam would result in loss of at least 95 percent of water supply now available on the Pecan Bayou watershed. Such loss would cause considerable hardship to water users on the watershed, particularly in the Brownwood urban area and the existing irrigation district. Also, failure of Lake Brownwood Dam would result in loss of water surface area which affords considerable recreational opportunities and enjoyment and which has stimulated appreciable private, commercial, and state-park developments within the general shoreline area. The seriousness of a Lake Brownwood Dam failure and the resulting flood damages and losses with respect to lives, property, water supply, and recreation establishes an urgent need for remedial measures at Lake Brownwood.

62. WATER SUPPLY PROBLEMS.- The water supply problems on the Pecan Bayou watershed involve consideration of additional surface water storage to meet existing and projected water supply requirements for municipal, industrial, irrigation, and water quality control uses. Upstream from Lake Brownwood, the city of Coleman has indicated a need for additional water supply storage space. The existing sources of surface water supply afforded by Lakes Brownwood and Scarborough and the existing Hords Creek Reservoir project are inadequate to meet the projected water supply requirements of the Pecan Bayou watershed beginning during the period 1970-1980, particularly for Coleman and smaller cities in the upper portion of the watershed.

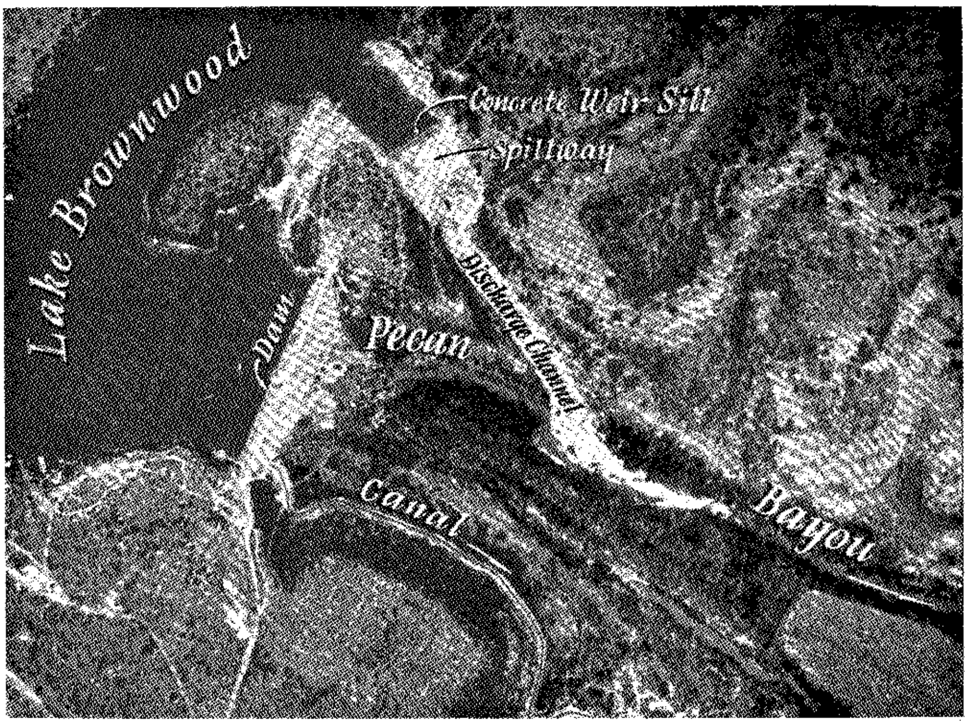
63. The total water requirements for the Pecan Bayou watershed are expected to increase from about 21.5 million gallons per day (mgd) in year 1960 to about 23.5 mgd in year 1970, to about 25.5 mgd in year 1980, about 34.3 mgd in year 2020, and about 45.0 mgd in year 2070. The increasing water supply requirements of the Pecan Bayou watershed, including those for municipal and industrial, irrigation, and water quality control purposes, are illustrated in figure 5.

64. The principal existing sources of water supply will produce a total dependable water-supply yield of about 23.7 mgd under projected conditions of watershed development, including a potential Soil Conservation Service program. The principal existing dependable sources of water supply on the Pecan Bayou watershed include those from existing Lake Brownwood (22.6 mgd), Hords Creek Reservoir (0.7 mgd), and groundwater developments (.4 mgd). The existing sources are adequate for present-day needs, although they are not located to efficiently serve the needs of all areas on the watershed.

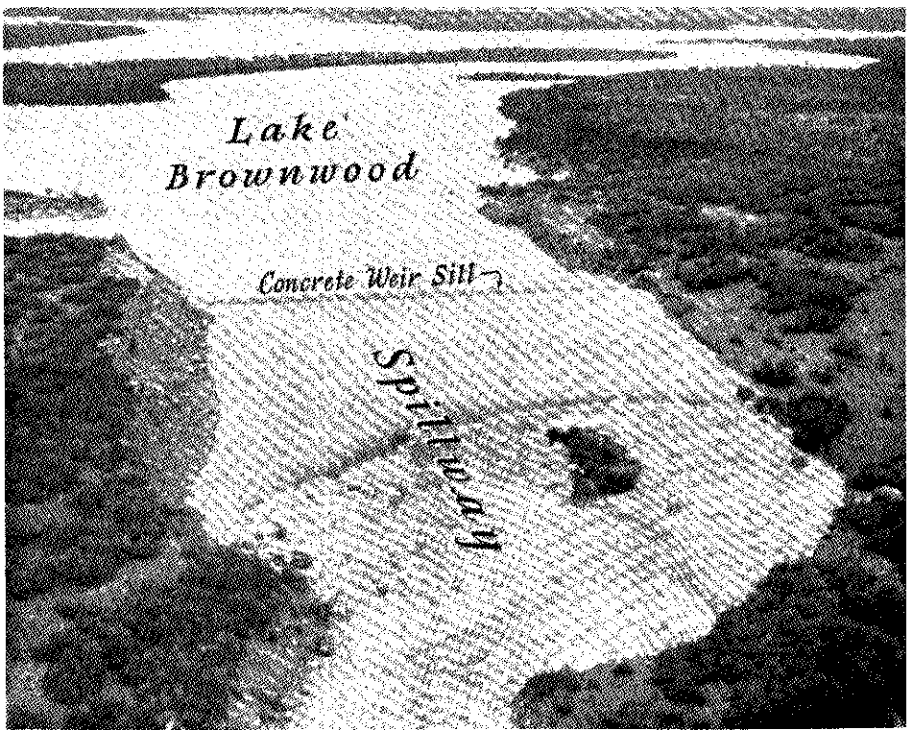
65. The anticipated needs for municipal and industrial, irrigation, and water quality control purposes, based on information contained in the U. S. Public Health Service report, are discussed in the following subparagraphs.

a. Domestic, municipal, and industrial.- The expected increase in total water requirements on the Pecan Bayou watershed would be attributable principally to increases in population and to municipal and industrial expansions. The domestic, municipal, and industrial requirements (including non-municipal and thermal-power generation) are expected to increase from 5.6 mgd in year 1960 to about 7.6 mgd in year 1970, about 9.5 mgd by year 1980, about 18.0 mgd by year 2020, and about 28.1 mgd by year 2070. The municipal requirements would be the principal component, increasing from 4.2 mgd in year 1960 to about 5.0 mgd by year 1970, about 6.6 mgd by year 1980, about 11.8 mgd by year 2020, and about 19.5 mgd by year 2070. As the water needs arise in certain areas because of increasing population and municipal and industrial expansions, additional successive increments of water supply resources can be developed, such as those from new reservoirs, greater use of return flows, and increased ground water use.

b. Irrigation.- The investigation of the water supply problems included consideration of the existing and potential water requirements for irrigation. In the vicinity of Brownwood and within the limits (as outlined on plates A and B, adjacent to the rear cover of this report) of the Brown County Water Improvement District No. 1, there are 5,000 acres of irrigation lands. The water requirement for irrigating the 5,000 acres of land is estimated to be a dependable water supply of about 14.8 mgd, or 16,500 acre-feet per annum. The Bureau of Reclamation stated that there are additional lands acceptable for project-type irrigation on the watershed. The lands investigated by

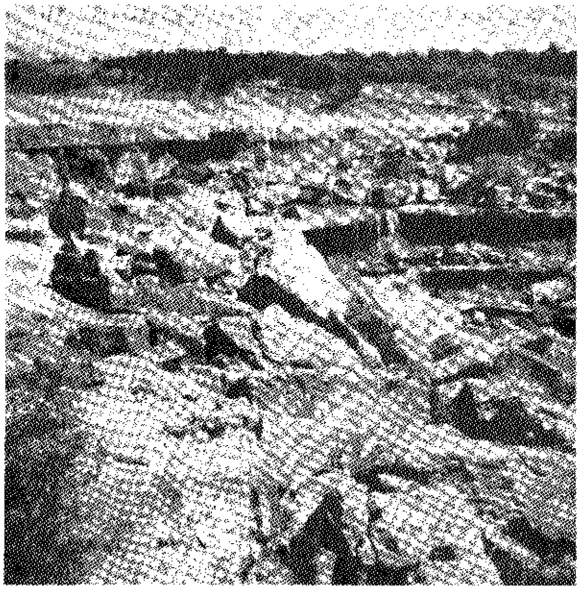


AERIAL VIEW OF LAKE BROWNWOOD DAM AND SPILLWAY

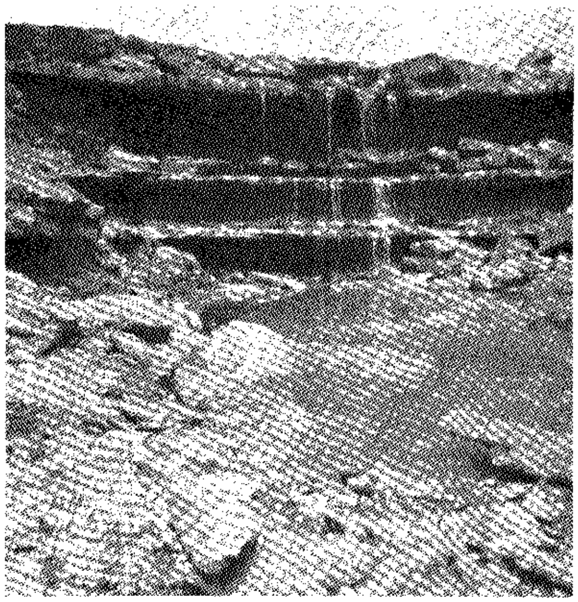


LAKE BROWNWOOD SPILLWAY - MAY 1956
SURCHARGE STORAGE 60,000 AC. FT.

FIGURE 3

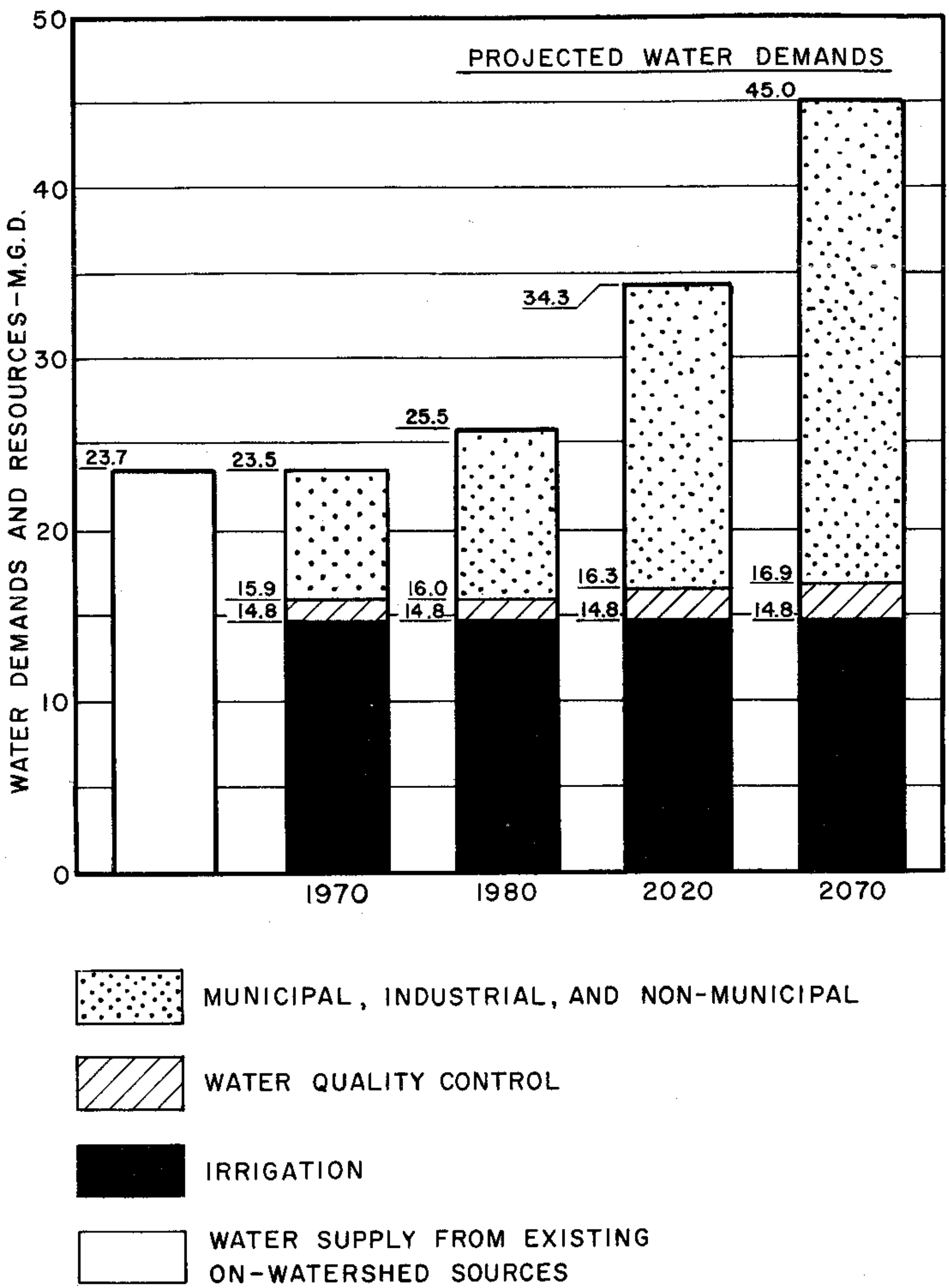


Existing Lake Brownwood spillway area. Looking north from a point on right abutment and approximately 550 feet downstream of concrete weir sill.



Existing Lake Brownwood spillway area. View looking northwest from approximate center of gulch.

FIGURE 4



PECAN BAYOU WATERSHED

EXISTING AND PROJECTED WATER DEMANDS

FIGURE 5

the Bureau are 11,000 acres along Pecan Bayou downstream from Lake Brownwood and 5,000 acres along Jim Ned Creek downstream from the Coleman Dam site. The Bureau states, however, that crops which can be irrigated in their investigated Brownwood irrigation project are not of a particularly high value, and that acceptability of new lands for irrigation under present economic conditions would be dependent on the costs of reservoir storage and distribution.

c. Water quality control.- The natural quality or existing sources of surface water supply on the Pecan Bayou watershed are generally acceptable for municipal and industrial uses after conventional treatment. The ground water supplies are extremely hard and highly mineralized. The full utilization of all water resources for municipal, industrial, agricultural, and recreation purposes will require control of pollution throughout the area. Studies indicate that organic pollution in the lower 33-mile reach of Pecan Bayou exceeds the assimilative capacity of the stream and will require release of water from storage to maintain an acceptable oxygen balance in the stream. Based on allowance for natural flows that can be expected to occur in the streams and on hydrologic conditions expected to reoccur on an average of once in 10 years, the average water requirements for maintaining adequate water quality control would increase from about 1.1 mgd in year 1960 to about 1.2 mgd by year 1980, about 1.5 mgd by year 2020, and about 2.1 mgd by year 2070.

66. HYDROELECTRIC POWER AND NAVIGATION.- Investigations indicate that the development of hydroelectric power on the Pecan Bayou watershed is not economically attractive. The high unit cost of power capacity, the low flow of the stream, and the lack of adequate regulatory storage combine to support this conclusion. For comparable reasons, navigation of Pecan Bayou itself is not an attractive venture. Water to serve any potential navigation project on the Colorado River could best be obtained from storage in main-stem reservoirs.

67. 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. The general public has found that outdoor recreation produces many benefits -- it provides healthful exercise necessary for individual physical fitness; it promotes health; it is valuable for education in the world of nature; and it satisfies simple recreational needs.

68. FISH AND WILDLIFE.- Fish and wildlife are living natural

resources 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. The opportunity to hunt and fish will not automatically remain, and fish and wildlife resources must be considered in the overall planning for the watershed.

69. GENERAL.- Various water-resource developments on the Pecan Bayou watershed have been constructed or planned by both Federal and non-Federal interests for purposes of water supply, prevention of flood damages, and fish-wildlife and general recreation. The improvements developed by local interests include Lake Scarborough, Lake Brownwood, and various small water-supply reservoirs. The projects developed by the Federal Government include the Hords Creek Reservoir, the authorized (but not constructed) Lake Brownwood enlargement, the potential Soil Conservation Service program, and the existing channel and levee improvements on Willis and South Willis Creeks at Brownwood. A comprehensive plan of development must first weigh the effects of existing and planned improvement measures against the total needs for all purposes; then, insofar as practicable, provide for additional improvements or modifications of existing facilities as required to bring the overall program into balance and satisfy the present and future needs in the most economical manner.

70. OBJECTIVES.- The basic objective in the formulation of a plan of development for the Pecan Bayou watershed is to provide the best use, or combination of uses, of the water and related land resources of the watershed to meet all foreseeable short- and long-term needs. Plan formulation studies require the consideration of all water problems and the interrelation of all purposes and projects to develop fully the potentials of the watershed, to add impetus to economic development, and to enhance the conditions of health and welfare of the people.

71. After adequate analyses of the water problems and consideration of views expressed by various interested agencies and individuals, plans of improvement were formulated and investigated with a view to achieving the following principal objectives: (a) to provide structural modifications at Lake Brownwood to prevent an embankment failure and the resultant catastrophic conditions which would involve enormous flood damages and loss of lives, property, water supply facilities, and recreation values; (b) to provide adequate flood protection to the city of Brownwood; (c) to provide substantial reductions in flood damages within all or portions of the investigated flood plains; (d) to provide maximum economical water supply development to serve projected populations and urban developments and to meet the projected water supply needs for municipal, industrial, agricultural, irrigation, and water quality control uses on the Pecan Bayou watershed, and if possible, a portion of such requirements for the upper Colorado River and adjacent Brazos River areas; and (e) to provide for the development of the fish-wildlife and general recreation potentials of the Pecan Bayou watershed.

72. PLANNING CONSIDERATIONS.- Broad principles used in accomplishing the above objectives are (a) that the elements of any plan for further control and development of the water resources of the Pecan Bayou watershed provide a balanced program, which would be compatible with existing

improvements on the watershed, including a potential Soil Conservation Service program, and with potential projects and developments being considered for the Colorado River Basin; (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 developments 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.

73. INVESTIGATED GENERAL PLANS.- The most favorable general plans of improvement formulated and investigated for the Pecan Bayou watershed for purposes of flood control, water supply, stream-quality control, and fish-wildlife and general recreation involved unit improvements, in sequence of importance, as follows: (a) protective measures for Lake Brownwood Dam; (b) channel improvements on Pecan Bayou, Adams Branch, and Willis Creek at the city of Brownwood; (c) enlargement of Lake Brownwood, or as alternates, upstream two-reservoir systems, consisting of one reservoir on Pecan Bayou at either the Burkett or Pecan Bayou sites and one reservoir on Jim Ned Creek at either the Camp Colorado or Coleman sites. Plans involving enlargement of Lake Brownwood would incorporate necessary protective measures for Lake Brownwood Dam. The location of the investigated units are shown on plates A and B (adjacent to the rear cover of this report).

74. Engineering and economic studies established (a) that Lake Brownwood protective measures are urgently needed to protect the city of Brownwood against catastrophic flood conditions resulting from failure of the existing embankment and to insure continued operation of Lake Brownwood as a valuable unit for existing municipal, industrial, and irrigation water supply purposes and for affording appreciable reductions in the magnitudes of Pecan Bayou flood discharges; (b) that channel improvements on Pecan Bayou, Adams Branch, and Willis Creek are the best means of affording substantial protection to the city of Brownwood against separate and coincident floods on these streams; and (c) that the addition of reservoirs to the above measures would increase the degree of protection at Brownwood against Pecan Bayou floods, would afford appreciable reductions in flood flows and damages within the rural areas, would afford a substantial increase in dependable water supply yield above that provided by existing sources, and would provide for additional development of the fish-wildlife and general recreation potentials on the Pecan Bayou watershed.

75. The plan of improvement determined to be most comprehensive and favorable for the Pecan Bayou watershed involves the construction of Lake Brownwood protective measures, Brownwood channel improvements, and the Coleman and Pecan Bayou Reservoirs.

PLAN OF IMPROVEMENT

76. PROPOSED PLAN.- The plan of improvement proposed for the Pecan Bayou watershed would be constructed in lieu of the authorized plan for Lake Brownwood enlargement, and would operate for purposes of flood control, water supply, water quality control, and fish-wildlife and general recreation. The proposed plan would involve the following units operating during the period 1970 through 2070.

a. Lake Brownwood Dam protective measures, involving a new earth embankment, new outlet works, and erosion-control measures for the existing spillway, but no increase in controlled reservoir storage.

b. Brownwood channel improvements, involving (1) about 38,800 feet of improved channel on Pecan Bayou at Brownwood with designed channel capacity of 92,000 second-feet, and 2,000 feet of diversion channel from West Slough to Pecan Bayou; (2) about 11,600 feet of improved channel on Adams at Brownwood with design channel capacities of 13,200 and 7,400 second-feet downstream and upstream from the confluence with Tom Williams Branch, 3,600 feet of diversion channel from Adams Branch to Pecan Bayou with capacity of 13,200 second-feet, and 1,100 feet of diversion channel from Tom Williams Branch to Adams Branch with capacity of 5,800 second-feet; and (3) 16,000 feet of improved channel on Willis Creek at Brownwood with designed channel capacities of 19,000 and 12,700 second-feet, downstream and upstream from the confluence with South Willis Creek, respectively.

c. Coleman Dam and Reservoir, involving an earth embankment at mile 52.2 on Jim Ned Creek, outlet works through the embankment, an excavated uncontrolled saddle spillway, and 240,900 acre-feet of controlled storage.

d. Pecan Bayou Dam and Reservoir, involving an earth embankment at mile 100.8, on Pecan Bayou upstream from Lake Brownwood, outlet works through the embankment, an excavated uncontrolled saddle spillway, and 206,300 acre-feet of controlled storage.

77. The general locations of the proposed improvements are shown on plates A and B (adjacent to the rear cover of this report).

78. LAKE BROWNWOOD PROTECTIVE MEASURES.- The Lake Brownwood protective measures would establish a reconstructed Lake Brownwood capable of safe operation and having a useful life of at least 100 years. Pertinent data on the earth embankment, outlet works, existing spillway, spillway design flood, reservoir storages, surface areas, and land requirements for the dam, are shown in table 2.

79. The new embankment would be constructed approximately 800 feet downstream from the existing embankment, and would have sufficient height and strength to withstand spillway design flood conditions. The existing embankment would be partially removed.

80. New outlet works for the reconstructed project would be located through the right-bank portion of the new embankment. The outlet works would afford releases from storage such as the passage of minor flood flows, and would reduce usage of and erosive action within the existing spillway channel. Also, separate outlet works to serve the existing water supply and irrigation system would be constructed through the right-bank portion of the new embankment.

81. The spillway erosion-control measure would reduce erosion and deterioration within the existing spillway channel. The spillway work would provide principally for construction of concrete curtain walls to protect the exposed alternate layers of shale and limestone at the dropoff areas; the disposal of loose boulders and rubble within the spillway channel just downstream from the dropoff areas; and utilization of such material as protection stone along the abutments of the concrete weir sill and for filling deep gouges within the spillway channel. The total accumulative length of the various concrete curtain wall segments would be about 1,500 linear feet, with heights varying from about 4 to 19 feet.

82. The Lake Brownwood protective measures do not involve additional controlled storage capacity, and thus, would not require modification of existing developments or acquisition of additional lands within the general reservoir area. The reservoir storages, as reflected in table 2, represent storage conditions for reconstructed Lake Brownwood during the 100-year period from 1970 to 2070 with the proposed Coleman and Pecan Bayou Reservoirs in operation. The total controlled storage of 124,600 acre-feet for sediment and water supply would provide a dependable water supply yield of about 22.6 mgd (or 35.0 cfs) without the proposed Coleman and Pecan Bayou Reservoirs and about 14.9 mgd (or 23.0 cfs) with the proposed upstream reservoirs, based on recurrence of the maximum drought conditions (November 1942 through April 1955). Sediment storage of 33,000 acre-feet would allow for deposition of sediment for a 100-year period under conditions of the proposed plan of improvement and of projected upstream development.

83. BROWNWOOD CHANNEL IMPROVEMENTS.- The proposed Brownwood channel improvement project, which involves Pecan Bayou, Adams Branch, and Willis Creek at Brownwood, provide for realignment and enlargement of existing channels, as well as diversion channels from West Slough to Pecan Bayou, Adams Branch to Pecan Bayou, and Tom Williams Branch to Adams Branch. Pertinent data on drainage areas, channel dimensions and lengths, rights-of-way, and alterations are presented in table 3.

84. The channel improvement work along Pecan Bayou would extend from stream mile 37.8 to mile 47.6. The improvement would increase the minimum channel capacity from about 12,000 cfs to a within-banks capacity of about 92,000 cfs in the reach extending from a point just downstream of the mouth of Willis Creek to the head of the channel improvement.

TABLE 2

PERTINENT DATA
EXISTING AND PROPOSED RESERVOIRS
PECAN BAYOU WATERSHED

Item	Existing Reservoir: Lake Brownwood	Proposed Reservoirs: Reconstructed Lake Brownwood	Proposed Reservoirs: Pecan Bayou Reservoir	Proposed Reservoirs: Coleman Reservoir
DRAINAGE AREA				
Square miles	1,544	1,544	316	287
SPILLWAY DESIGN FLOOD				
Peak inflow, cfs	708,300	676,200	317,500	307,100
Volume, acre-feet	1,605,800	1,613,600	406,100	371,100
Volume, inches	19.50	19.60	24.10	24.24
Peak outflow, cfs	(1)	352,800 (2)	184,200 (2)	202,800 (2)

RESERVOIR	Lake Brownwood Elev.(3) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Reconstructed Lake Brownwood Elev.(3) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Pecan Bayou Reservoir Elev.(3) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Coleman Reservoir Elev.(3) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
Top of dam	1450.0	--	--	--	1469.0	--	--	--	1676.0	--	--	--	1812.0	--	--	--
Maximum design water surface	(1)	--	--	--	1464.1	30,600	812,100	9.86	1670.4	12,010	379,700	22.53	1806.3	7,360	382,000	24.96
Top flood control pool and spillway crest	--	--	--	--	--	--	--	--	1653.0	8,030	206,300	12.24	1784.0	5,430	240,900	15.74
Top conservation pool	1425.0	7,570	124,600	1.51	1425.0	7,570	124,600	1.51	1637.0	5,150	102,000	6.05	1764.0	3,930	147,600	9.64
Sediment storage	1425.0	--	49,700	0.60	1425.0	--	33,000	0.40	1653.0	--	10,100	0.60	1784.0	--	10,300	0.67
Sediment storage	--	--	--	--	--	--	--	--	1637.0	--	8,500	0.50	1764.0	--	9,100	0.59

Item	Lake Brownwood	Reconstructed Lake Brownwood	Pecan Bayou Reservoir	Coleman Reservoir
STORAGE SUMMARY				
Flood control, ac-ft	--	--	102,700	92,100
Water conservation, ac-ft	74,900	91,600	93,500	138,500
Sediment, ac-ft	49,700	33,000	10,100	10,300
Total	124,600	124,600	206,300	240,900
DAM				
Type	Earth fill	Earth fill	Earth fill	Earth fill
Total length, feet	2,060	2,330 (5)	15,500 (4)	16,660
Embankment section:				
Type	Compacted earth fill	Compacted earth fill	Compacted earth fill	Compacted earth fill
Total length, feet	1,580	1,850	14,700 (4)	16,060
Height above streambed, feet	110	129	107	156
Freeboard, feet	(1)	4.9	5.6	5.7
Crown width, feet	20	20	20	20
Side slopes:				
Upstream	1 on 2 & 1 on 3	1 on 2-1/2 & 1 on 3-1/2	1 on 2-1/2 & 1 on 3-1/2	1 on 2-1/2 & 1 on 3-1/2
Downstream	1 on 2	1 on 2-1/2 & 1 on 3	1 on 2-1/2 & 1 on 3	1 on 2-1/2 & 1 on 3
Spillway section:				
Type	Broadcrested	Broadcrested	Broadcrested	Broadcrested
Gross length, feet	480	480	800	600
Net length, feet	480	480	800	600
Spillway discharge, cfs:				
Maximum design water surface	(1)	349,300	173,200	192,500
OUTLET WORKS				
Type	Gate-controlled conduit	Gate-controlled conduit	Gate-controlled conduit	Gate-controlled conduit
Number of conduits	2	1	1	1
Dimensions	9' horseshoe shaped	10' diameter	16' diameter	14' diameter
Invert elevation, feet	1330.0	1342.0	1588.0	1672.0
Control	2 - 24" outlets, usable	2 - 5' x 10' tractor-type gates	3 - 5' x 16' slide gates	3 - 4'2" x 14' slide gates
OUTLET WORKS (for irrigation)				
Type	Conduit	Conduit	--	--
Dimensions	5' diameter	5' diameter	--	--
Invert elevation, feet	1406.0	1406.0	--	--
Control	Gate	Gate	--	--
RELOCATIONS				
County roads, miles	--	--	5.6	5.2
Power lines, miles	--	--	13.3	7.3
Telephone lines, miles	--	--	25.0	8.3
Pipe lines, miles	--	--	None	1
Cemeteries	--	--	1	1
LANDS				
Dam and reservoir				
Clearing, acres	--	--	1,335	1,019
Land acquisition:				
Fee simple, acres	7,570	7,720	10,000	6,550
(Top control elevation)	(1425.0)	(1425.0)	(1658.0)	(1789.0)
Flood easements, acres	4,250 (1425.0 - 1435.0)	4,250 (1425.0 - 1435.0)	1,100	700
Recreation				
Clearing, acres	--	--	1,600	1,200
Land acquisition:				
Fee simple above general taking limits, acres	--	--	550	550

(1) Embankment will be overtopped
(2) Includes discharge through outlet works as follows: 3,500 cfs (Reconstructed Lake Brownwood); 11,000 cfs (Pecan Bayou Reservoir); 10,300 cfs (Coleman Reservoir)
(3) All elevations refer to mean sea level
(4) Includes 5,400' dike on right bank
(5) Includes 480-foot spillway

TABLE 3

PERTINENT DATA
PROPOSED BROWNWOOD CHANNEL IMPROVEMENT
PECAN BAYOU WATERSHED

Item	Pecan Bayou	Adams Branch	Willis Creek
1. IMPROVEMENTS			
River mile limits, main stem	PB 37.8 - PB 47.6	AB 3.0 - AB 6.1	WC 0.0 - WC 3.9
River mile limits, cutoff	WS 1.5 - PB 47.5	AB 3.0 - PB 46.9	
River mile limits, cutoff		TWB 0.3 - AB 4.0	
2. DRAINAGE AREA			
Head of improvement, sq. mi.	1,621.0	8.6	11.2
3. DESIGN DISCHARGE, CFS	92,000	Below TWB - 13,200 Above TWB - 7,400	Below SWC - 19,000 Above SWC - 12,700
4. CHANNEL IMPROVEMENTS			
Existing length (main channel), mi.	9.8	6.1	3.9
Improved length (main channel), mi.	7.3	2.9	3.0
Improved length, feet			
Main channel	38,800	15,200	16,000
Cutoff channels	2,000 (WS)	1,100 (TWB)	--
Excavation, c.y.	11,482,000	725,000	651,900
Side slopes	1 on 2-1/2	1 on 2-1/2	1 on 2-1/2
Average depth, feet	32	18	18
Bottom width, feet	300, 25 (WS)	90, 50, 25 (TWB)	70, 80, 60, 40
Clearing			
Maximum width, feet	550	300	250
Area, acres	413	40	69
5. RIGHTS-OF-WAY			
Land area, acres	500	112	100
Maximum width, feet	550	300	250
6. BRIDGE ALTERATIONS			
Bridges - highways and streets	3	8	2
Bridges - railroads	1	3	-
Channel dams	1	-	-
Utilities, pipelines	Misc.	Misc.	Misc.

Legend:
AB - Adams Branch
PB - Pecan Bayou
SWC - South Willis Creek
TWB - Tom Williams Branch
WC - Willis Creek
WS - West Slough

85. The channel improvement work along Adams Branch would provide for a diversion channel from stream mile 3.0 on Adams Branch to the improved Pecan Bayou channel and the improvement of Adams Branch from mile 3.0 to mile 6.1, just upstream from the Gulf, Colorado and Santa Fe Railway bridge. The channel improvements would increase the minimum capacity from about 1,800 cfs to about 13,200 cfs downstream from the new confluence with Tom Williams Branch and from about 2,500 cfs to about 7,400 cfs upstream from the confluence.

86. The channel improvement work along Willis Creek would extend from the mouth to stream mile 3.9, a point about 2,900 feet upstream from the Fourth Street bridge. The channel improvements would increase the existing minimum capacity from about 6,000 cfs to about 19,000 cfs in the reach downstream from the confluence with South Willis Creek and from 2,300 cfs to 12,700 cfs upstream from the confluence. At certain locations within the lower reach, the side slopes of the improved channel will require riprapping to protect against the higher streamflow velocities.

87. COLEMAN AND PECAN BAYOU RESERVOIRS.- The proposed Coleman and Pecan Bayou Reservoirs would be located upstream from Lake Brownwood. The Coleman Dam site on Jim Ned Creek and the Pecan Bayou Dam site on Pecan Bayou are about 14 miles and 17 miles, respectively, generally north of the city of Coleman. Pertinent data on earth embankments, outlet works, spillways, reservoir storages, surface areas, land requirements, spillway design floods, and relocations are presented in table 2.

88. The proposed reservoirs would contain sufficient flood storage to control 50-year-frequency floods originating above the dam sites; and sediment storage to permit sediment deposits for a period of 100 years. Water conservation storage of 138,500 acre-feet in the Coleman Reservoir and 93,500 acre-feet in the Pecan Bayou Reservoir would develop total dependable water supply yields at the sites of about 12.9 mgd (20 cfs) and 8.4 mgd (13 cfs), respectively, based on maximum drought conditions (November 1942 through April 1955). Sediment storages of 10,300 acre-feet in the Coleman Reservoir and 10,100 acre-feet in the Pecan Bayou Reservoir would allow for deposition of sediment for a 100-year period under conditions of projected upstream development.

89. The Coleman and Pecan Bayou Reservoirs would be provided with sufficient facilities such as lands, access roads, parking areas, boat ramps, and picnic areas to serve the fishing, hunting and general recreation activities. A zoning plan will be developed during the advanced planning stage to insure adequate use of the reservoir lands and waters for these activities.

PHYSICAL EFFECTS OF THE PLAN

90. GENERAL.- The proposed plan is designed to satisfy various water and related land resource needs of the Pecan Bayou watershed. The plan involves a correlation of the existing and proposed improvements to efficiently serve present and future needs.

91. FLOOD CONTROL.- The proposed Lake Brownwood protective measures are urgently needed to prevent possible failure of the existing dam under extreme flood conditions, and thus, to prevent catastrophic flood conditions and loss of lives within the downstream area. Protective measures would extend the useful life of Lake Brownwood and insure its continued operation as an effective means in reducing flood peaks and damages within the downstream area, even though controlled flood storage space is not specifically dedicated.

92. The proposed Brownwood channel improvement project, operating with reconstructed Lake Brownwood but without the proposed Coleman and Pecan Bayou Reservoirs, would provide about 100-year frequency flood protection to a substantial portion of the existing and future Brownwood urban area. As indicated in the next paragraph, the degree of flood protection at Brownwood against Pecan Bayou flood flows would be further increased by the addition of the Pecan Bayou and Coleman Reservoirs.

93. The proposed Coleman and Pecan Bayou Reservoirs would provide for the control of 50-year-frequency floods originating upstream from the respective dam sites, and thus, would afford general reduction in flood flows and damages along Pecan Bayou and Jim Ned Creek, including the Lake Brownwood shoreline area and Pecan Bayou at Brownwood. The addition of these units would increase the flood protection in urban Brownwood along Pecan Bayou from 100-year to about 180-year frequency.

94. Based on projected conditions of flood plain development with Hords Creek Reservoir and the potential system of Soil Conservation Service reservoirs as the only existing improvements, the addition of the proposed plan of improvement, including a reconstructed Lake Brownwood, would eliminate about 85 percent of the aggregate average annual damages within the total flood plains investigated for this report.

95. Based on projected condition of flood plain development with Hords Creek Reservoir, the potential system of Soil Conservation Service reservoirs, and a reconstructed Lake Brownwood in operation, the degree of flood protection within the improved reaches of Pecan Bayou, Adams Branch, and Willis Creek at Brownwood as afforded by the successive addition of the proposed Brownwood channel improvements and the proposed Coleman Reservoir-Pecan Bayou Reservoir combination, is reflected in the following tabulation:

Item	Pecan Bayou	Adams Branch	Willis Creek
	WITH BROWNWOOD CHANNEL IMPROVEMENTS		
a. Std proj flood discharge, cfs	171,200	21,100	37,000
b. Design channel capacity, cfs	92,000	13,200	19,000
c. Degree of protection, percent of standard project flood	53.7	62.6	51.4
d. Average annual damages, dollars	474,400	294,600	42,500
e. Annual damages prevented, percent	91.8	99.9	99.9
f. Flood protection frequency	100-yr	100-yr	100-yr
	WITH BROWNWOOD CHANNEL IMPROVEMENTS AND COLEMAN AND PECAN BAYOU RESERVOIRS		
a. Std proj flood discharge, cfs	133,200	21,100	37,000
b. Design channel capacity, cfs	92,000	13,200	19,000
c. Degree of protection, percent of standard project flood	69.1	62.6	51.4
d. Average annual damages, dollars	474,400	294,600	42,500
e. Annual damages prevented, percent	95.7	99.9	99.9
f. Flood protection frequency	180-yr	100-yr	100-yr

96. WATER SUPPLY.- The proposed plan of improvement will assist substantially in meeting the overall water supply needs of the Pecan Bayou watershed during the period 1970 through 2070. Water supply of 14.8 mgd (or 16,500 acre-feet per annum) is needed to irrigate 5,000 acres of existing arable lands within the boundaries of the Brown County Water Improvement District No. 1. Based on projections of population and urban developments, the municipal and industrial water supply needs on the Pecan Bayou watershed will increase from about 6.3 mgd in year 1970 to about 26.6 mgd in year 2070. Completion of a reconstructed Lake Brownwood would insure continued use of the principal source of water supply on the Pecan Bayou watershed for municipal, industrial, nonmunicipal, and irrigation purposes. The existing available water supplies in the Pecan Bayou watershed, consisting of Hords Creek Reservoir, developed ground water sources, and a reconstructed Lake Brownwood, would provide an aggregate dependable supply of about 23.7 mgd. The existing supply is adequate to meet the water requirements of the watershed as a whole to about year 1970, but the supply sources are not located to efficiently serve the increasing needs of areas upstream from Lake Brownwood, such as the city of Coleman.

97. The proposed plan of improvement tentatively provides for completion and operation of the Coleman and Pecan Bayou Reservoirs by year 1970, or at such time that additional water supply is needed. The proposed Coleman and Pecan Bayou Reservoirs would provide for the maximum

economical development of the water supply resources of the Pecan Bayou watershed upstream from the respective dam sites. The proposed Coleman and Pecan Bayou Reservoirs together with return flows into Lake Brownwood resulting from water supply utilized from the Coleman and Pecan Bayou Reservoirs would provide additional total dependable water supply yields of about 15.8 mgd in year 2020 and 17.7 mgd in year 2070. The aforementioned total existing and proposed water supply sources would provide sufficient dependable supply to meet projected total needs of 40.8 mgd in year 2050, or to meet about 92 percent of the projected total watershed requirements to year 2070. The construction of the Coleman and Pecan Bayou Reservoirs would not completely solve, but would lessen, the problems of distribution within the upper Pecan Bayou watershed. Because of the distribution problem and the increasing water needs of the city of Coleman and other upstream areas, construction of the Coleman Reservoir will be required in the near future.

98. Water quality control is an important purpose in the proposed plan. Based on recommendations of the U. S. Public Health Service, the plan of improvements provides an average water supply of about 2.1 mgd for water quality control. Such provision will afford continuous or occasional releases from reservoir storage to effectively reduce concentration of pollutants within the lower 33-mile reach of Pecan Bayou. The proposed plan predicates releases from the Coleman and Pecan Bayou Reservoirs, with regulation from reconstructed Lake Brownwood.

99. A complete water plan for the Pecan Bayou watershed to year 2070 would require use of return flows entering Lake Brownwood, additional ground-water development, and imports from reservoirs being investigated on the main stem of the Colorado River. Water-use plans for the Pecan Bayou watershed within Brown, Coleman, and Callahan Counties for years 2020 and 2070 are suggested in the U. S. Public Health Service report. A summary presenting in million gallons per day the aggregate water supply needs for the tri-county area of Callahan, Coleman, and Brown Counties and the sources to meet the needs is as follows:

Item	1970	1980	2020	2070
	Water Supply Requirements			
Municipal and industrial	6.3	8.2	16.3	26.6
Non-municipal	1.3	1.3	1.7	1.5
Irrigation	14.8	14.8	14.8	14.8
Water quality control	1.1	1.2	1.5	2.1
Total	23.5	25.5	34.3	45.0
	Existing Sources			
Hords Creek Reservoir	0.7	-	-	-
Lake Brownwood	22.6	-	-	-
Ground water	0.4	-	-	-
Total	23.7	-	-	-
	Existing, Proposed, and Other Sources			
Hords Creek Reservoir	0.7	0.7	0.7	0.7
Lake Brownwood	14.9	14.9	14.9	14.9
Return flows into Lake Brownwood	1.0	1.3	2.5	4.2
Coleman Reservoir	12.9	12.9	12.9	12.9
Pecan Bayou Reservoir	8.4	8.4	8.4	8.4
Ground water	0.4	0.4	2.0	2.0
Imports	0.0	0.0	0.0	1.9
Total	38.3	38.6	41.4	45.0

100. OTHER PHYSICAL EFFECTS.- The Pecan Bayou area is fortunately endowed with recreational areas and facilities at Lake Brownwood and Hords Creek Reservoir. A reconstructed Lake Brownwood would insure continued use of existing private, commercial, and state-park recreational facilities within the Lake Brownwood shoreline area. Hords Creek Reservoir and reconstructed Lake Brownwood would continue to serve a current visitation estimated to be at least 1,000,000 persons annually. The fish-wildlife and general recreation facilities proposed for development in Coleman and Pecan Bayou Reservoirs would accommodate projected public recreational needs. The upstream reservoirs would provide recreational opportunities for an expected average annual visitation of 2,000,000 persons during the period 1970-2070. Of this total, about 1,300,000 visitors are expected to participate in general recreation activities and about 700,000 visitors in fishing and hunting. The proposed plan will actually accommodate a larger visitation than those estimated since the estimates are not based on saturated reservoir surface conditions.

101. The proposed plan, including channel improvements and regular maintenance in urban Brownwood, will have notable value in the esthetic effect it provides by improved appearance. The Coleman and Pecan Bayou Reservoirs will give definite impetus toward further development of the immediate areas for public use.

ECONOMIC EVALUATION OF PROPOSED PLAN

102. GENERAL.- Economic evaluations were made of projects recommended for authorization. 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 the July 1963 level.

103. As previously stated, existing Lake Brownwood is considered a hazard to the downstream area, including the Brownwood urban area. Failure of the existing embankment would cause catastrophic conditions resulting in enormous damages and loss of lives. On the basis of the hazardous condition, reconstruction of Lake Brownwood is justified without consideration of monetary benefits. However, a monetary evaluation of costs and benefits for the flood control and water supply function shows that reconstruction of Lake Brownwood is fully justified. In order to make an economic analysis and evaluation of an overall reconstructed Lake Brownwood project, the estimated construction-cost value of existing usable facilities at Lake Brownwood was added to the estimated cost of the proposed Lake Brownwood protective measures.

104. 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 4. The annual charges for the proposed plan include interest and amortization of Federal and non-Federal investments at an interest rate of 3.0 percent for a 100-year period, operation and maintenance costs, and annual equivalent costs of major replacements.

105. 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 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 4 by projects and purposes.

a. 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 relationships. The average annual damages of $982,100 under 1960 conditions of economic development in the flood plain would be reduced by the recommended flood-control projects to $230,000 for benefits of $752,100. An allowance to reflect the economic trends and future development anticipated in the flood plain during the period 1960 to 2070 would increase these flood-control benefits to a total of $2,027,600.

b. Water supply and water quality control.- Benefits for water supply were computed on the basis of the cost of providing the same quantity and quality of water by 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. Coleman and Pecan Bayou Reservoirs have been credited with water supply benefits of $425,000 and water quality control benefits of $58,800, a total of $483,800. Additional water supply benefits of $191,000 have been credited to the proposed reconstructed Lake Brownwood project, resulting in total water supply and water quality control benefits of $674,800.

c. Recreation.- Benefits for recreation were computed on the basis of estimated annual attendance of 1,000,000 visitor-days at each project locality, using a weighted average value of $0.50 per visitor-day for a variety of recreational activities including picnicking, swimming, boating, camping, sightseeing, fishing, hunting, and other outdoor pursuits. Total benefits from these recreational activities are estimated at $1,000,000. Recreational benefits for fisherman's catch and hunter's bag were computed on the basis that 35 percent of the total visitation would be for the purpose of fishing and hunting, 34.65 percent for the purpose of fishing and 0.35 percent for the purpose of hunting. It was estimated that each visit for fishing would yield a fish harvest value of $0.50, and each visit for hunting would yield a game harvest value of $1.00, a total of $353,600. The total recreational benefits for Pecan Bayou and Coleman Reservoirs are estimated at $1,353,600.

106. ECONOMIC JUSTIFICATION.- Estimates of annual charges and benefits and ratios of benefits to costs in table 4 show that the annual benefits would exceed the annual costs for the projects considered individually and as a system. The economic justification of Reconstructed Lake Brownwood is based on annual benefits solely for flood control and water supply. As indicated in paragraph 44, Lake Brownwood is also valuable for recreational activities. The recreational activities are under non-Federal control. Although not utilized for economic justification, it is estimated that a Reconstructed Lake Brownwood project would provide significant average annual recreational benefits over the life of the project and further enhance the benefit-cost ratio. The projects recommended for authorization have been justified entirely by monetary benefits. The projects would also provide important intangible benefits to the economy of the area and to the state. Unemployment in the area would be appreciably alleviated, the flood control effects of the projects would reduce the threat to lives and stabilize the economy of the area subject to flooding, the recreation and fish and wildlife aspect of the projects would improve the social well-being of a large segment of the population, and the water supply features would stimulate the economy of the area. Although these intangible benefits have not been evaluated in monetary terms, it is evident that they are of major significance and would add materially to justification of the projects recommended for authorization.

TABLE 4

FIRST COST, ANNUAL CHARGES, ANNUAL BENEFITS AND BENEFIT-COST RATIOS
PROJECTS RECOMMENDED FOR AUTHORIZATION
PECAN BAYOU WATERSHED
(Costs and benefits in thousand dollars)
(July 1963 price level)
(Interest rate, 3% - Amortization period, 100 yrs)

Item	Reconstructed Lake Brownwood	Brownwood Channels	Coleman Reservoir	Pecan Bayou Reservoir	Total Recommended Plan
FIRST COST	7,300.0(1)	13,723.0	11,890.0	10,520.0	43,433.0
ANNUAL CHARGES	286.4	523.9	496.3	454.9	1,761.5
ANNUAL BENEFITS					
Flood control	637.3	947.4	207.2	235.7	2,027.6
Water supply	191.0	--	229.7	195.3	616.0
Water quality control	--	--	29.4	29.4	58.8
Recreation	--	--	676.8	676.8	1,353.6
Total - Benefits	828.3	947.4	1,143.1	1,137.2	4,056.0
BENEFIT-COST RATIO	2.9	1.8	2.3	2.5	2.3

(1) Includes proposed Lake Brownwood protective measures (3,060.0) and value of existing usable facilities (4,240.0)

LOCAL COOPERATION

107. PROPOSED LOCAL COOPERATION.- The local cooperation required for the proposed protective measures at Lake Brownwood would be as follows:

a. Retain ownership, maintain the project, and operate the flood control features in accordance with regulations prescribed by the Secretary of the Army, and bear all annual maintenance and operation costs, subject to reimbursement by the Federal Government for annual maintenance and operation costs allocated to flood control;

b. Hold and save the United States free from damages due to construction and operation of the project, including damages caused by flooding within the reservoir area;

c. Enter into a contract prior to initiation of the reconstruction work and in accordance with repayment provisions of the Water Supply Act of 1958, as amended, to reimburse the Federal Government for that portion of the construction costs allocated to water supply. Toward this amount, local interest would be given credit for the estimated value of existing lands and easements and usable appurtenances at Lake Brownwood.

108. The proposed Brownwood channel improvement project for the Brownwood area along Pecan Bayou, Adams Branch, and Willis Creek is a local protection plan, and is subject to the requirements of local cooperation as generally specified for local flood protection projects. It is proposed to require local interests to participate in the channel improvement plan as follows:

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

b. Provide without cost to the United States all relocations and alterations of roads and bridges (except for railroads) and of all building structures, pipelines, sewers, channel dams, and utilities made necessary by construction of the channel work.

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

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

e. Provide assurances that encroachment within the channels and rights-of-way will not be permitted.

f. Provide without cost to the United States designated fill areas for the disposal of excess materials from the channel excavation work, the areas to be within reasonable haul distance of the project (approximately 5 miles), or cost for the excessive haul distance must be borne by local interests.

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

109. Local cooperation requirements with respect to the Pecan Bayou and Coleman Reservoirs are:

a. Local interests will enter into a contract prior to initiation of construction to reimburse the United States for the project costs allocated to water supply, exclusive of water quality control, in accordance with provisions of the Water Supply Act of 1958, as amended;

b. Obtain without cost to the United States all water rights necessary for operation of the projects in the interest of water supply, including water quality control.

110. The cities of Brownwood and Coleman, Brown County and Coleman County Commissioners Courts, the Brown County Water Improvement District No. 1, and the Central Colorado River Authority indicated approval of the proposed plan of improvement and proposed action to establish, under the laws of the State of Texas, an agency to qualify as the responsible agency with which the Federal Government could negotiate in regard to the necessary items of local cooperation. Letters from local interests providing assurances of local cooperation are discussed in paragraphs 12 and 128, and are presented in appendix VII.

111. COST ALLOCATION TO PROJECT PURPOSES.- Cost allocation studies were made for each reservoir unit in the proposed plan to determine the equitable distribution of the costs to be chargeable to each project purpose. The allocation of reservoir project costs to the various purposes was based on the Separable Cost-Remaining Benefits method. The total overall costs of a reconstructed Lake Brownwood project, consisting of the costs of the proposed Lake Brownwood protective measures and the estimated cost of useful existing Lake Brownwood facilities, were allocated to purposes of flood control and water supply. The total costs of the proposed Coleman and Pecan Bayou Reservoirs were allocated to purposes of flood control, water supply, water quality control, and recreation (including fish-wildlife recreation and harvest). A summary of cost allocation for reservoir units is presented in table 5. The proposed Brownwood channel improvements are solely for local flood protection purposes, and thus, cost allocation studies were not required.

112. APPORTIONMENT OF COSTS AMONG INTERESTS.- The construction cost and the annual maintenance and operation cost of each unit of the proposed plan were apportioned to Federal and non-Federal interests in accordance with existing laws, policies, and procedures. A summary of cost apportionments is presented in table 6.

113. The 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. The costs of the reconstructed Lake Brownwood and the Pecan Bayou and Coleman Reservoirs which are allocated to the flood control function are apportioned to the Federal Government because of the widespread and general nature of the benefits associated with the flood control effects of the reservoir units. The costs of the Brownwood channel improvements are shared by Federal and non-Federal interests. The costs of the channel improvement works associated with the items of local cooperation, such as the costs of rights-of-way and relocations (excluding railroads), and of annual maintenance and operation, are the responsibility of local interests.

114. Costs allocated to water quality control in the Pecan Bayou and Coleman Reservoirs have been apportioned to the Federal Government, in accordance with provisions of the Water Pollution Control Act of 1948, as amended. Costs allocated to water supply for other purposes in the reconstructed Lake Brownwood and in the Pecan Bayou and Coleman Reservoirs 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 of water supply includes both that needed for immediate use (present

demand storage) and for future use (future demand storage). Payment of first cost 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.

115. In the case of the reconstructed Lake Brownwood project, the construction cost allocated to water supply does not exceed the estimated value of useful existing Lake Brownwood facilities which have been credited to local interests. Thus, the total estimated construction costs for the proposed protective measures would be borne by the Federal Government. However, local interests would be required to bear the annual maintenance and operation costs allocated to water supply.

116. Costs allocated to recreation (including fish-wildlife recreation and harvest) in regard to the Pecan Bayou and Coleman Reservoirs are recommended as Federal costs because the benefits are widespread and general in nature.

TABLE 5

PROPOSED LAKE BROWNWOOD, PECAN BAYOU, AND COLEMAN RESERVOIRS
PECAN BAYOU WATERSHED
SUMMARY OF COST ALLOCATION STUDIES
(ALLOCATED COSTS AND PERCENTAGES)
(Interest rate, 3% - Amortization period, 100 yrs)

Item	Reconstructed Lake Brownwood	Coleman Reservoir	Pecan Bayou Reservoir
	PERTINENT DATA		
Total project first cost (dollars)	7,300,000	11,890,000	10,520,000
Total project annual charges (dollars)	286,400	496,300	454,900
Total controlled storage, acre-feet	124,600	240,900	206,300
Flood control storage, acre-feet	--	(92,100)	(102,700)
Water conservation storage, acre-feet	(91,600)	(138,500)	(93,500)
Sediment storage, acre-feet	(33,000)	(10,300)	(10,100)
Dependable water supply yield at site			
Water supply, cfs - (mgd)	23 - (14.87)	18.4 - (11.89)	11.4 - (7.37)
Water quality control, cfs - (mgd)	--	1.6 - (1.03)	1.6 - (1.03)
Total at site (1)	23 - (14.87)	20.0 - (12.92)	13.0 - (8.40)
Benefits (dollars)	828,300	1,143,100	1,137,200
Flood control (dollars)	(637,300)	(207,200)	(235,700)
Water conservation (dollars)	(191,000	(229,700)	(195,300)
Water quality control (dollars)	--	(29,400)	(29,400)
Fish-wildlife & general recreation (dollars)	--	(676,800)	(676,800)
	FLOOD CONTROL ALLOCATIONS (2)		
Annual charges	$ 145,300 (50.73)	$ 139,300 (28.07)	$ 139,100 (30.58)
Construction costs	3,698,200 (50.66)	3,576,500 (30.08)	3,429,500 (32.60)
Annual maintenance and operation cost	23,000 (51.11)	21,000 (20.39)	25,700 (24.02)
Construction cost per acre-foot	--	38.83	33.39
	WATER SUPPLY ALLOCATIONS (2)		
Annual charges	141,100 (49.27)	116,600 (23.49)	91,800 (20.18)
Construction cost	3,601,800 (49.34)	2,880,900 (24.23)	2,186,100 (20.78)
Annual maintenance and operation cost	22,000 (48.89)	21,300 (20.68)	19,500 (18.22)
Construction cost per acre-foot	39.32	25.95	31.23
Cost per 1000 gallons	0.0260	0.0269	0.0341
	WATER QUALITY CONTROL ALLOCATIONS (2)		
Annual charges	--	26,000 (5.24)	18,600 (4.09)
Construction cost	--	680,100 (5.72)	459,700 (4.37)
Annual maintenance and operation cost	--	3,500 (3.40)	3,400 (3.18)
	FISH-WILDLIFE AND GENERAL RECREATION ALLOCATIONS (2)		
Annual charges	--	214,400 (43.20)	205,400 (45.15)
Construction cost	--	4,752,500 (39.97)	4,444,700 (42.25)
Annual maintenance and operation cost	--	57,200 (55.53)	58,400 (54.58)

(1) Total yield for Lake Brownwood would increase to about 26 cfs in year 2020 and 29 cfs in year 2070 due to return flows from water supply utilized from Pecan Bayou and Coleman Reservoirs
(2) Allocations - cost and (percentage)

TABLE 6

DISTRIBUTION AND APPORTIONMENT OF COSTS
PROPOSED PLAN OF IMPROVEMENT
PECAN BAYOU WATERSHED
(Costs in thousands of dollars)

Plan Unit	Federal	Non-Federal	Total
DISTRIBUTION OF RESPONSIBILITY FOR ACTUAL CONSTRUCTION COSTS			
Reconstructed Lake Brownwood	3,060.0	--	3,060.0
Brownwood Channel Improvements	11,281.0	2,442.0	13,723.0
Coleman Reservoir	11,890.0	--	11,890.0
Pecan Bayou Reservoir	10,520.0	--	10,520.0
Total Plan	36,751.0	2,442.0	39,193.0
DISTRIBUTION OF RESPONSIBILITY FOR ANNUAL MAINTENANCE AND OPERATION COSTS			
Reconstructed Lake Brownwood	--	45.0	45.0
Brownwood Channel Improvements	--	70.0	70.0
Coleman Reservoir	103.0	--	103.0
Pecan Bayou Reservoir	107.0	--	107.0
Total Plan	210.0	115.0	325.0
APPORTIONMENT OF FIRST COSTS			
Reconstructed Lake Brownwood	3,060.0	4,240.0 (1)	7,300.0
Brownwood Channel Improvements	11,281.0	2,442.0	13,723.0
Coleman Reservoir	9,009.1	2,880.9 (2)	11,890.0
Pecan Bayou Reservoir	8,333.9	2,186.1 (2)	10,520.0
Total Plan	31,684.0	11,749.0	43,433.0
APPORTIONMENT OF ANNUAL MAINTENANCE AND OPERATION COSTS			
Reconstructed Lake Brownwood	23.0 (3)	22.0	45.0
Brownwood Channel Improvement	--	70.0	70.0
Coleman Reservoir	81.7	21.3 (2)	103.0
Pecan Bayou Reservoir	87.5	19.5 (2)	107.0
Total Plan	192.2	132.8	325.0

(1) Value creditable to local interests for existing lands and facilities to be utilized in reconstructed Lake Brownwood.
(2) Project costs allocated to water supply and to be reimbursed by local interests.
(3) Project costs allocated to flood control and to be reimbursed by Federal Government.

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COORDINATION WITH OTHER AGENCIES

117. GENERAL.- During the period 1946 to 1948 prior to completion of this report (originally dated September 3, 1948), other interested agencies were advised of the studies and investigations being made on Pecan Bayou. The U. S. Bureau of Reclamation expressed interest in the proposed improvements especially where reservoirs were being considered. Conferences were held with the Brown County Water Improvement District No. 1 and the Bureau of Reclamation concerning the proposed improvements, and the views of the Public Roads Administration and the Texas State Highway Department were requested on highway modification.

118. During the current preparation of this review report the investigations were coordinated with other interested agencies, including the U. S. Soil Conservation Service, the Bureau of Sport Fisheries and Wildlife, the Bureau of Reclamation, the U. S. Public Health Service, the Texas Water Commission, and responsible local interests on the Pecan Bayou watershed. The response included statements of interest in the investigation and information on available basic and general data.

119. U. S. PUBLIC HEALTH SERVICE.- Estimates of the needs and values of water-supply storages on the Pecan Bayou watershed have been coordinated with the U. S. Public Health Service, Department of Health, Education, and Welfare. On the basis of this coordination, the Public Health Service prepared a report presenting information on the values of water conservation storage in the proposed Coleman and Pecan Bayou Reservoirs; the results of water quality studies; problems and needs relative to water quality control; and the water requirements for years 2020 and 2070. The Public Health Service report is presented in appendix VI.

120. BUREAU OF SPORT FISHERIES AND WILDLIFE.- During the preparation of this report, in accordance with the Fish and Wildlife Coordination Act, as amended, the Bureau was consulted and various conferences were held regarding the fish and wildlife aspects of investigated reservoirs on the Pecan Bayou watershed. A report prepared by the Bureau of Sport Fisheries and Wildlife, containing an evaluation of fishing and hunting potential from water conservation storage on the Pecan Bayou watershed, is presented in appendix VI. However, the benefits credited to the proposed plan of improvement are based on determinations by the Corps of Engineers as presented in paragraph 105 c.

121. The Bureau of Sport Fisheries and Wildlife presents in its report estimates of annual benefits for the investigated reservoir plans on the Pecan Bayou watershed. In its report, the Bureau estimates the annual fishery benefits would be $138,000 for the Pecan Bayou Reservoir and $139,000 for the Coleman Reservoir. Annual hunting benefits are estimated to be $1,000 for each reservoir. The Bureau also states that an additional fish and wildlife benefits amounting to $30,000 would accrue at each reservoir if zoned areas were established for fisherman and hunter use.

122. Recommendations by the Bureau specified the provision of four parking areas of about two acres each at each reservoir including a boat-launch ramp at each area, and the provision of three seining areas at each site 1,000 feet wide and gradually sloping from conservation-pool elevation to a depth of at least 15 feet and cleared to ground level of all obstructions. The Bureau recommended that the location of the seining areas be determined in the design planning stage of the report.

123. The Bureau also indicated that one of the proposed reservoirs may have definite value in carrying out the national migratory bird program if a wildlife refuge was established within the project area. The Bureau states that, because of the preliminary scope of the project at this time, it is not possible to propose a specific plan for a wildlife refuge.

124. NATIONAL PARK SERVICE.- The National Park Service was consulted with respect to recreational aspects and potentialities during the investigations and studies, and a reconnaissance of the area was made by representatives of the National Park Service and the Corps. The Service was requested to furnish a report of its views and recommendations for determination of recreation benefits and development in regard to the investigated Burkett and Camp Colorado Reservoirs. The report of the National Park Service is presented in appendix VI.

125. BUREAU OF RECLAMATION.- During the preparation of this report the investigations and studies were discussed with the Bureau of Reclamation and the Bureau was requested to furnish its views regarding irrigation potentialities and future requirements, and the benefits to be realized from provision of additional irrigation storage. The reply of the Bureau of Reclamation is presented in appendix VII.

126. U. S. SOIL CONSERVATION SERVICE.- During the investigation, the Soil Conservation Service, Department of Agriculture, furnished basic information regarding its program of runoff and waterflow retardation and soil-erosion prevention on the Pecan Bayou watershed. The existing, planned, and potential improvements of the Soil Conservation Service have been previously described in paragraphs 50 through 53.

127. BUREAU OF MINES.- The Bureau of Mines, U. S. Department of the Interior, submitted a letter containing information on mineral resources and developments within investigated reservoir sites in the Colorado River Basin. In regard to the proposed Pecan Bayou Reservoir, the Bureau stated (a) that the dam site is just upstream from Mary Opal gas field in Coleman County, but does not adversely affect any oil wells; and (b) that the upper end of the reservoir adjoins the Odom oil field (which has two or more wells) in Callahan County and that, although no wells are affected now, later drilling may extend the field into the reservoir. In regard to the Coleman Reservoir, the Bureau stated that oil wells in Coleman County within the reservoir site requiring protection (elevating) consist of the only oil well in the Creswell (Strawn) Field, two of five oil wells in the Featherstone Field, and nine oil wells in the Dunman (Gardner Sand) Field. The letter from the Bureau of Mines is presented in appendix VII.

128. LOCAL INTERESTS.- After formulation of the proposed plan of improvement for the Pecan Bayou watershed, meetings were held on April 17, 1962 and June 7, 1962 between representatives of the Brown County Water Improvement District No. 1, the cities of Brownwood and Coleman, the Central Colorado River Authority, the Texas Water Commission, and the Corps of Engineers, at which the units of the proposed plan of improvement and the required items of local cooperation were described and discussed. By joint letter dated June 13, 1962, from the Brown County Water Improvement District No. 1, the city of Brownwood, and the Brown County Commissioners Court, and joint letter dated June 13, 1962, from the city of Coleman, Coleman County Commissioners Court, and the Central Colorado River Authority, the Corps of Engineers was advised of their concurrence in the plan and that action would be initiated for establishing an agency to qualify as the responsible agency to furnish the necessary items of local cooperation. Subsequently, by letters of November 14 and 15, 1963, local interests of Coleman and Brown Counties reiterated their need and desire for the proposed plan of improvement. The letters are presented in appendix VII.

129. REVIEW OF REPORT BY OTHER AGENCIES.- Copies of this report have been forwarded to the interested Federal agencies at field level and to the Texas Water Commission for their preliminary views and comments. Letters are presented in appendix VII of this report. The comments are summarized briefly in the following subparagraphs:

a. National Park Service.- The National Park Service stated that it had reviewed the report and has no comments.

b. Southwestern Power Administration.- The Southwestern Power Administration stated that the proposed improvements would not affect the interests of the Administration.

c. Bureau of Public Roads.- The Bureau of Public Roads stated that basic regulations 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.

d. Federal Power Commission.- The Federal Power Commission stated that because of the low yields and low heads available and the higher priority of water uses for other purposes, the installation of power facilities would not be economically feasible at any of the three reservoir projects.

e. Bureau of Sport Fisheries and Wildlife.- The Bureau of Sport Fisheries and Wildlife stated that it was pleased to note that the Bureau's recommendations has been made a part of the plan except in regard to the proposal for zoned areas on the reservoirs. The Bureau was advised that a zoning plan would be developed during the advance planning stage to insure adequate use of the reservoir lands and waters for the fishing, hunting, and general recreation activities. The Bureau expressed the opinion that since it is the Federal agency for evaluating fish and wildlife resources the benefits estimated for those purposes should be those submitted by the Bureau. The Bureau also questions the treatment of benefits for general recreation given in the report, particularly with respect to fish and wildlife. The Corps estimates of benefits are based on experienced visitor use at comparable operating Corps reservoirs and are considered conservative. In developing the estimates, consideration was given to present population density, predicted population increases during project life, and competition to be satisfied from existing and other proposed reservoirs.

f. Bureau of Reclamation.- The Bureau of Reclamation stated that the projects recommended in the report will not adversely affect any existing or potential project of the Bureau of Reclamation and that it has no comments.

g. Bureau of Mines.- The Bureau of Mines stated that it does not object to the proposed construction provided adequate measures are taken to protect the interests of the mineral industries in the reservoir areas. The letter presents current mining data in regard to Brown and Coleman Counties.

h. U. S. Geological Survey.- The U. S. Geological Survey recommended investigation of the problem of pollution resulting from oil field developments and stated that the Geological Survey would assist in such an investigation. The Geological Survey cited existing geological conditions at the Lake Brownwood spillway, and stated that the proposed erosion control measures should be extended to insure protection of the spillway for a longer period of time. The Geological Survey stated that leakage through channels along joint planes of limestones acting as foundation of the existing dam is an additional reason why steps should be taken as soon as possible to safeguard the dam from failure. The Geological Survey also stated that the construction of the total plan of improvement would require expansion of stream-gaging and chemical-quality networks and that the Geological Survey would cooperate with the Corps in developing an appropriate system. In reply, the Fort Worth District stated that the drawing showing the proposed spillway erosion-control measure did not reflect the plan as intended and that the drawing would be revised to show the proposed erosion-control measures which would be in consonance with the USGS suggestions; and that recognition of the need for expansion of stream-gaging network was previously acknowledged in paragraph 48, appendix III, and that implementation of the network program would be coordinated with the U. S. Geological Survey during preconstruction planning.

i. U. S. Public Health Service.- The U. S. Public Health

Service concurs with the findings of the report and recommends that, in the development of the water-resource projects in the Pecan Bayou watershed, cooperation of the Texas State Department of Health be secured in establishing maximum public health safety.

j. U. S. Soil Conservation Service.- The comments of the State Conservationist, U. S. Soil Conservation Service, Temple, Texas, constitute the field-level-review comments of the Department of Agriculture. By means of a letter containing field level comments, a conference between representatives of the Soil Conservation Service and the Corps of Engineers held on October 24, 1963, and subsequent additional correspondence appended in this report, the Soil Conservation Service expressed the following principal problems: (1) Additional data in a flood-detention plan for Adams Branch and Willis Creek has been completed and proper coordination of activities at this time is essential in the development of a balanced plan for the Brownwood urban area; (2) Approval and authorization of the proposed Pecan Bayou Reservoir would require coordination between the agencies to permit development by the Soil Conservation Service of a flood-detention program on upper Pecan Bayou; (3) Authorization and construction of the proposed Coleman Reservoir project would adversely affect certain existing flood-detention structures on the Jim Ned Creek subwatershed; and (4) That formal presentation of the Corps of Engineers report should not be made pending further coordination of Pecan Bayou watershed activities between the Soil Conservation Service and the Corps of Engineers. In regard to items (1) and (4), the Corps of Engineers, Fort Worth District, proposes immediate formal presentation of the Brownwood Channel Improvements as formulated in this report, subject to the plan being modified during preconstruction planning on the basis of continuing coordination with the Soil Conservation Service to develop a coordinated plan. During the course of formulating the plan for Brownwood Channel Improvements, definite planning of flood-detention systems by the Soil Conservation Service for Adams Branch and Willis Creek had not been completed. Since flood flows on Adams Branch and Willis Creek affect an urban area, the channel improvements on these streams were sized without consideration of the effects of the tentative flood-detention structures. Additional information on the flood-detention plan for Adams Branch and Willis Creek were presented to the Corps of Engineers by letter of November 5, 1963. Delay in the formal presentation of this report on the basis of the need to continue coordination of studies at this time is not considered warranted. In regard to item (2), the Soil Conservation Service agreed during conference on October 24, 1963, to develop a flexible flood-detention program for the upper Pecan Bayou area which could be adjusted in the event the proposed Pecan Bayou Reservoir project is authorized for construction by the United States Congress. In regard to item (3), the Soil Conservation Service was informed that the proposed Coleman Reservoir project would be retained in the proposed plan of improvement for the Pecan Bayou watershed, although it would adversely affect certain existing flood-detention structures. Recognition of the adverse affects and associated economic costs disclosed that the Coleman Reservoir retains a substantially favorable benefit-cost ratio (reducing from 2.3 to 2.2), and that the proposed project should be retained as an essential unit in proposed plan of development for the Pecan Bayou watershed. Local interests, particularly those of Coleman County, have reiterated the urgent need and desire for construction of the proposed Coleman Reservoir project. Additional letters of assurances from Coleman and Brown Counties are presented in appendix VII.

k. State Agency Comments.- Review comments of the Texas State Department of Health, the Texas Highway Department, and the Parks and Wildlife Department were furnished through the Texas Water Commission, along with the comments of the Chief Engineer. The Texas State Department of Health suggested that paragraph c, page 47, be reworded so as to not place any undue blame on the city of Brownwood for organic pollution. The Texas Highway Department stated that the overall costs for all highway relocations appeared to be adequate, but that it wished to emphasize that Highway Department funds could not be expended for work of this nature. The Parks and Wildlife Department had no suggestions for additions or deletions. The comments were summarized by the Texas Water Commission, indicating a general agreement with the report findings and recommendations. Copies of the state-agency letters containing comments on the subject report are presented in appendix VII.

DISCUSSION AND CONCLUSIONS

130. DISCUSSION.- Comprehensive planning considerations for the Pecan Bayou watershed require the improvement of certain features of existing Lake Brownwood to prevent catastrophic flood conditions and to insure continuing benefits from the flood control, water supply, irrigation, fish and wildlife, and recreation functions of the existing project. Corollary improvements which are equally necessary include channel improvement works at the city of Brownwood for local flood protection purposes. To make the plan comprehensive in scope, the addition of the multiple-purpose Coleman and Pecan Bayou Reservoirs are needed for additional flood control, water supply and recreation, and for water quality control.

131. Proper development of the available resources of the Pecan Bayou watershed will act as an accelerant to the economy of the area. The proposed plan is designed to develop the resources to the maximum practical limit which acceptable indicators signify.

132. The additional needs for flood control, water supply, water quality control, and fish-wildlife and general recreation in the Pecan Bayou watershed is apparent. The plan recommended is to satisfy the needs as immediately seen but does not preclude even further expansion should the need become evident.

133. Because of its geographic location, the improvement and development of the resources of the Pecan Bayou watershed is of paramount importance in the Colorado River Basin. The proposed plan of improvement was formulated to provide for a well balanced and orderly development of the resources of Pecan Bayou in consonance with anticipated comprehensive plans for the Colorado River Basin.

134. Coordination between the U. S. Soil Conservation Service and the Corps of Engineers will be a necessary continuing process subsequent to formal submission of this report and during preconstruction planning. The potential program of the Soil Conservation Service, with the exception of the proposed flood-detention structures on the Adams Branch and Willis Creek subwatersheds, has been recognized as an existing development during the formulation of the proposed plan of improvement. The proposed Brownwood Channel Improvements will require modification during preconstruction planning to reflect the effects of a final flood-detention plan on Adams Branch and Willis Creek. Continuation of coordinated studies for the Brownwood area will be essential subsequent to formal submission of this report to afford the development of a balanced plan in the Brownwood area and to facilitate completion of studies and scheduled reports by the Soil Conservation Service. Construction of the proposed multiple-purpose Coleman Reservoir would adversely affect certain existing flood-detention

structures within the Jim Ned Creek area. An economic analysis indicates that the addition of certain adverse economic costs and of certain creditable benefits reduces the overall benefit-cost ratio of the proposed Coleman Reservoir project from 2.3 to 2.2, and thus, has no appreciable effect on the economic merit of the proposed project. The advantages of a likely downstream dam site at river mile 46.4 will be investigated during preconstruction planning. Future studies of the proposed Coleman Reservoir site or alternate sites will be coordinated with the Soil Conservation Service during preconstruction planning. A work plan is currently being developed by the Soil Conservation Service on Pecan Bayou above Lake Brownwood. The Soil Conservation Service has indicated that this work plan would be developed with sufficient flexibility so that the system of proposed flood-detention structures could be adjusted for conformance with the Congressional action taken on the proposed Pecan Bayou Reservoir project.

135. Additional information on the plan of improvement called for by Senate Resolution 148, 85th Congress, adopted January 28, 1958, is contained in supplement A to this report.

136. CONCLUSIONS.- The District Engineer concludes that:

a. The existing features of Lake Brownwood urgently need repair or replacement for continued safe operation of the project.

b. A serious flood problem exists on the Pecan Bayou watershed, and that the problem areas are concentrated in urban Brownwood, in the Lake Brownwood shoreline area, and along the agricultural areas of Jim Ned Creek and Pecan Bayou.

c. Existing surface and ground water supplies will not be sufficient to provide for the requirements of the future.

d. The expenditure of Federal funds is warranted for the purpose of establishing a comprehensive flood-protection and water-supply plan as proposed in this report.

137. RECOMMENDATIONS.- On the basis of studies and conclusions made for this report, the District Engineer recommends:

a. That, in lieu of the authorized plan for enlargement of existing Lake Brownwood, a plan of improvement for the Pecan Bayou watershed be authorized to provide for construction of the following:

(1) Protective measures for Lake Brownwood Dam to provide a reconstructed project for purposes of flood control and water supply;

(2) Brownwood channel improvements for purposes of local flood protection along Pecan Bayou, Adams Branch, Tom Williams Branch, and Willis Creek at Brownwood, Texas;

(3) Coleman Reservoir on Jim Ned Creek and Pecan Bayou Reservoir on Pecan Bayou upstream from existing Lake Brownwood for purposes of flood control, water supply, water quality control, and fish-wildlife and general recreation.

b. That the foregoing be accomplished with such changes and modifications as in the discretion of the Chief of Engineers may be advisable at estimated Federal costs as follows:

(1) Total Federal construction costs of $36,751,000, or a total net Federal construction cost of $31,684,000 after reimbursement by local interests of project costs allocated to water supply.

(2) Total Federal annual maintenance and operation costs of $210,000, or a total net Federal annual cost of $192,200 after reimbursement by Federal and non-Federal interests of project costs allocated to flood control and water supply, respectively.

c. 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 Lake Brownwood Dam protective measures:

(a) Retain ownership, maintain the project, and operate the flood control features in accordance with flood regulations prescribed by the Secretary of the Army, and bear all annual maintenance and operation costs, subject to reimbursement by the Federal Government for annual maintenance and operation costs allocated to flood control;

(b) Hold and save the United States free from damages due to construction and operation of the project, including damages caused by flooding within the reservoir area;

(c) Enter into a contract prior to initiation of the reconstruction work and in accordance with repayment provisions of the Water Supply Act of 1958, as amended, to reimburse the Federal Government for that portion of the construction costs allocated to water supply. Toward this amount, local interest would be given credit for the estimated value of existing lands and easements and usable appurtenances at Lake Brownwood.

(2) With respect to the Brownwood channel improvements:

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

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

(c) Hold and save the United States free from damages due to construction, maintenance, and operation of the project;

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

(e) Provide assurances that encroachments within the channels, and rights-of-way will not be permitted.

(f) Provide without cost to the United States designated fill areas for the disposal of excess materials from the channel excavation work, the areas to be within reasonable haul distance of the project (approximately 5 miles) or cost for excessive haul distance must be borne by local interest.

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

(3) With respect to the Coleman Reservoir and Pecan Bayou Reservoir units:

(a) Reimburse the United States for the project costs allocated to water supply, exclusive of water quality control, 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, and with such modification of the following presently estimated allocated water supply costs as may be necessary to reflect adjustments in the storage capacity for water supply and other purposes, except that the following water supply costs and percentages may be revised in the preconstruction planning stage:

WATER SUPPLY COSTS ALLOCATED TO LOCAL INTERESTS

Item	Coleman Reservoir	Pecan Bayou Reservoir
Construction Costs		
Amount (dollars)	2,880,900	2,186,100
Percent	24.23	20.78
Annual Maintenance and Operative Costs		
Amount (dollars)	21,300	19,500
Percent	20.68	18.22

(b) Obtain without cost to the United States all water rights necessary for operation of the projects in the interests of water supply, including water quality control.

F. P. Koisch

F. P. KOISCH
Colonel, CE
District Engineer

[First endorsement]

SWDGW-4
SUBJECT: Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas

United States Army Engineer Division, Southwestern, Dallas, Texas
January 13, 1964

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

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

C. H. DUNN
Brigadier General, USA
Division Engineer

APPENDIX I

PROJECT FORMULATION, ANALYSES, COSTS, AND COST ALLOCATIONS

REVIEW OF REPORTS ON PECAN BAYOU WATERSHED COLORADO RIVER BASIN, TEXAS

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APPENDIX I

PROJECT FORMULATION, ANALYSES, COSTS, AND COST ALLOCATIONS

WATER PROBLEMS - SUPPORTING DATA

1. GENERAL.- The principal water problems on the Pecan Bayou watershed are caused by the occurrence of periods of excess and deficient rainfall. Flood problems result because of frequent heavy storm rainfall and inadequate channel capacities. Water supply problems result because of drought periods and insufficient sources of surface water supply in certain areas. Also, problems exist at Lake Brownwood relative to the stability and adequacy of the existing dam and spillway.

2. Because the existing dam at Lake Brownwood lacks sufficient height and structural stability, it is probable that the existing embankment would fail during extreme flood conditions. In order to analyze Lake Brownwood in the proper perspective, the flood control and water supply problem on the Pecan Bayou watershed have been analyzed under conditions which assume that Lake Brownwood is nonexistent.

3. FLOOD PROBLEMS.- Major floods originating on the Pecan Bayou watershed cause extensive flood damages to agricultural properties in the valleys of Pecan Bayou and its principal tributaries, and contribute to the amount of flood damages along the main stem of the Colorado River. The principal flood problem on the Pecan Bayou watershed is located about 10 stream miles downstream from Lake Brownwood Dam at the city of Brownwood, Texas, where urban developments within the flood plains of Pecan Bayou and the tributary streams, Adams Branch and Willis Creek, are subject to appreciable damages from frequent floods. The economic studies indicate that substantial increases in the amount of development within the investigated flood plain segments of the Pecan Bayou watershed are to be anticipated during the future. Although the Soil Conservation Service is developing a potential system of flood-detention reservoirs on the Pecan Bayou watershed, analyses indicate that additional flood control measures are needed to reduce flood damages to be anticipated under the projected conditions of flood plain development.

4. The flood plain areas investigated in detail for this report consist of areas subject to overflow from the maximum floods of record which would occur under the conditions as modified by a potential flood-detention reservoir program of the Soil Conservation Service and by the existing Hords Creek Reservoir. Thus, the analyses of the flood problems are based on the conditions

that Lake Brownwood is non-existent and that a potential Soil Conservation Service flood-detention program is existing and is affording flood-flow reductions within the investigated flood plains of Pecan Bayou and Jim Ned Creek. However, as subsequently explained in paragraph 69, the analyses excludes consideration of potential flood-detention structures on the subwatersheds of Adams Branch and Willis Creek. Analyses of the flood problems within the flood plains investigated in detail for this report are summarized in table 1. The magnitude of the problems is indicated by the channel capacities, the peak discharges of maximum floods of record, and by damages from flooding of physical property under existing and projected conditions of flood plain development.

5. WATER SUPPLY PROBLEMS.- The water supply problems on the Pecan Bayou watershed involve consideration of additional surface water storage to meet existing and projected water supply requirements for municipal, industrial, irrigation, and water-quality control uses.

6. The Pecan Bayou watershed has experienced numerous periods of drought and shortages of water supply. The supply of suitable ground water is very limited. Certain local interests have attempted to alleviate these shortages by provision of surface storage. Existing reservoirs include: Lake Scarborough and Hords Creek Reservoir which provide municipal water supply for the city of Coleman; and Lake Brownwood which provides water supply for irrigating lands within the limits of the Brown County Water Improvement District No. 1, for serving the municipal and industrial needs of the city of Brownwood, and for supplementing the municipal needs for the cities of Bangs, Santa Anna, and Early. Other surface-storage reservoirs on the Pecan Bayou watershed have storage capacities of less than 1000 acre-feet. These include Lawn Lake and Merritt Lake, providing water supply for railroad-operation purposes; and Santa Anna Lake, providing water supply for domestic purposes.

7. Studies indicate that the dependable water supply afforded by existing sources will be inadequate to meet the projected water requirements of the Pecan Bayou watershed, particularly for Coleman and smaller cities in the upper portion of the watershed. The total water requirements for the Pecan Bayou watershed are expected to increase from about 21.5 million gallons per day (mgd) in year 1960 to about 23.5 mgd in year 1970, to about 25.5 mgd in year 1980, and about 45.0 mgd in year 2070. Under projected conditions of watershed development, the principal existing sources would provide a total dependable water supply yield of about 23.7 mgd as follows: Lake Brownwood 22.6 mgd; Hords Creek Reservoir, 0.7 mgd; and ground water, 0.4 mgd. Lake Scarborough, which has a capacity of less than 2,000 acre-feet and is served by a drainage area of about 12 square miles, provides a negligible amount of dependable water supply. The existing sources are adequate for the present-day overall requirements of the Pecan Bayou watershed, but are not located to efficiently serve

TABLE 1

SUMMARY OF FLOOD PROBLEMS UNDER CONDITIONS OF
EXISTING AND PROJECTED FLOOD PLAIN DEVELOPMENT AND A
POTENTIAL SOIL CONSERVATION SERVICE FLOOD-DETENTION PROGRAM
(but without SCS Program on Adams Branch & Willis Creek)
PECAN BAYOU WATERSHED

Item	Upstream from Lake Brownwood Dam	Downstream from Lake Brownwood Dam: Total	Downstream from Lake Brownwood Dam: (Urban Brownwood)	Total
1. Flood plain reaches, mile to mile				
a. Pecan Bayou	68.0 - 100.8	0.0 - 57.1	(42.6 - 47.6)	--
b. Jim Ned Creek	10.0 - 52.2	--	--	--
c. Lake Brownwood (elevation range)	1425.0 - 1437.4	--	--	--
d. Adams Branch	--	0.0 - 6.2	(0.0 - 6.2)	--
e. Willis Creek	--	0.0 - 6.1	(0.0 - 6.1)	--
f. Colorado River	--	436.0 - 513.7	--	--
2. Channel capacities, 1000 cfs				
a. Pecan Bayou	13.0 - 10.0	30.0 - 12.0	(12.0)	--
b. Jim Ned Creek	20.0 - 10.0	--	--	--
c. Adams Branch	--	5.0 - 1.8	(5.0 - 1.8)	--
d. Willis Creek	--	6.0 - 2.3	(6.0 - 2.3)	--
3. Max. flood dates, peak discharges (1000 cfs), recurrence interval (yrs)				
a. Pecan Bayou	Sep 1900; 100.0; 85	Jul 1932; 235.0; 84	Jul 1932; 235.0; 84	--
b. Pecan Bayou (With reconstructed Lake Brownwood)*	--	Jul 1932; 60.5; 34	Jul 1932; 60.5; 34	--
c. Jim Ned Creek	Jul 1932; 187.0; 86	--	--	--
d. Lake Brownwood**	Jul 1932; 235.0; --	--	--	--
e. Adams Branch	--	Jul 1945; 12.0; 53	Jul 1945; 12.0; 53	--
f. Willis Creek	--	Jul 1945; 17.8; 45	Jul 1945; 17.8; 45	--
4. Total of flood plain area, acres	18,732	52,805	(4,534)	71,537
5. Value of physical property, dollars				
a. Existing conditions - 1960	12,345,000	57,293,000	(48,314,000)	69,638,000
b. Projected conditions - 1970	17,730,000	84,171,000	(72,805,000)	101,901,000
c. Projected conditions - 2070	69,694,000	328,552,000	(304,621,000)	398,246,000
6. Damages by recurrence of maximum floods, dollars				
a. Existing conditions - 1960	930,800	5,208,200	(3,188,000)	6,139,000
b. Projected conditions - 1970	1,242,900	7,319,100	(4,775,000)	8,562,000
c. Projected conditions - 2070	4,456,100	24,778,900	(18,849,000)	29,235,000
7. Average annual damages, dollars				
a. Existing conditions - 1960	99,300	882,800	(602,500)	982,100
b. Project conditions - 1970 through 2070	240,300	2,088,200	(1,701,300)	2,328,500

* Discharge at Brownwood gage - modified by full reservoir and outlet works inoperative.
** Inflow into empty reservoir.

the needs of all areas on the watershed.

8. The city of Coleman anticipates a future water supply shortage for its municipal and industrial uses, and has investigated additional means of supplementing its present water supply. The city of Coleman has filed application with the Texas Water Commission (formerly Texas Board of Water Engineers) for a permit to utilize 11,200 acre-feet of water annually (15.5 cfs or 10.0 mgd) for municipal and industrial purposes from an investigated reservoir of 40,000 acre-feet storage capacity at the Jim Ned Creek (or Coleman) site on Jim Ned Creek.

9. The existing Lake Brownwood is operated by the Brown County Water Improvement District No. 1 under a water-use permit issued in 1927 by the Texas Board of Water Engineers (Texas Water Commission). The permit limits the municipal and industrial water supply diversion to a maximum of 16,800 acre-feet annually (23.2 cfs or 15.0 mgd) and the irrigation water supply to a maximum of 50,590 acre-feet annually (69.8 cfs or 45.1 mgd).

10. The investigation of the water-supply problems included consideration of the existing and potential water requirements for irrigation. In the vicinity of Brownwood and within the limits of the Brown County Water Improvement District No. 1, there are 5,000 acres of irrigation lands. The limits of the Improvement District are outlined on plates A and B (adjacent to the rear cover of this report). The water requirements for irrigating the 5,000 acres of land are estimated to be a dependable water supply of about 14.8 mgd. The Bureau of Reclamation stated that there are additional lands acceptable for project-type irrigation on the watershed. The lands investigated by the Bureau are 11,000 acres along Pecan Bayou downstream from Lake Brownwood and 5,000 acres along Jim Ned Creek downstream from the Coleman Dam site. The Bureau states, however, that crops which can be irrigated in their investigated Brownwood irrigation project are not of a particularly high value, and that acceptability of new lands for irrigation under present economic conditions would be dependent upon reservoir-storage and distribution costs.

11. The U. S. Public Health Service, in cooperation with the Corps of Engineers, has prepared a report covering the municipal, industrial, and stream-flow-quality requirements for the Pecan Bayou watershed. The report, which is presented in appendix VI, covers a study area comprised of Brown and Coleman Counties and that portion of Callahan County which is in the Pecan Bayou watershed. Brownwood, Coleman, and Cross Plains are the major centers of water use in the study area. The report states or indicates the following:

a. The water quality of the existing and firmly planned sources is either acceptable or can be made acceptable for municipal and industrial uses.

b. The full utilization of all water resources for municipal, industrial, agricultural, and recreation purposes will require control of pollution throughout the area.

c. To maintain water quality within the Pecan Bayou watershed will require releases from storage of about 1.5 mgd and 2.1 mgd in the years 2020 and 2070, respectively. This is based on hydrologic conditions that may be expected to reoccur once in 10 years.

d. The study area's population is expected to reach 68,400 by the year 2020 and 105,700 by the year 2070.

e. Projected municipal and industrial water needs for the study area are 16.3 mgd (million gallons per day) in 2020 and 26.6 mgd in 2070.

f. Projected total water requirements for the study area by year 2020 and year 2070 are 34.3 mgd and 45.0 mgd, respectively, including 14.8 mgd for irrigation needs.

g. The total estimated water resources of the study area in 2020 and 2070 including existing and planned surface reservoirs, existing and future ground water from the relatively unproductive Trinity sand, and reusable municipal and industrial return flows, are 41.6 mgd and 43.3 mgd, respectively.

h. Based on a proposed water supply plan, the potential water resource in the Pecan Bayou watershed, including imports, is sufficient to satisfy all water requirements within the basin until the year 2070.

i. Water supply studies indicate a need for all the water that can be economically developed in the Pecan Bayou watershed.

j. Yield-requirement analysis on an overall watershed basis reflect the need for additional water supply storage on the Pecan Bayou watershed before the year 1980.

12. A supply-demand curve which is based on municipal, industrial, stream-quality maintenance, and irrigation water requirements set forth in the U. S. Public Health Service report is shown on figure 1. The water supply requirements by years 1970, 2020, and 2070 for Brown, Coleman, and Callahan Counties as furnished by the U. S. Public Health Service are as follows:

Water-use item	Brown County	Coleman County	Callahan County	Total
	Water requirements in mgd			
		Year 1970		
Municipal & industrial	4.4	1.6	0.3	6.3
Non-municipal	0.6	0.5	0.2	1.3
Irrigation	14.8	0.0	0.0	14.8
Water quality control	1.1	0.0	0.0	1.1
Total	20.9	2.1	0.5	23.5
		Year 2020		
Municipal & industrial	10.1	5.2	1.0	16.3
Non-municipal	0.8	0.7	0.2	1.7
Irrigation	14.8	0.0	0.0	14.8
Water quality control	1.5	0.0	0.0	1.5
Total	27.2	5.9	1.2	34.3
		Year 2070		
Municipal & industrial	16.4	8.5	1.7	26.6
Non-municipal	0.7	0.6	0.2	1.5
Irrigation	14.8	0.0	0.0	14.8
Water quality control	2.1	0.0	0.0	2.1
Total	34.0	9.1	1.9	45.0

13. The U. S. Study Commission - Texas has recently completed a report, dated March 1962, setting forth a tentative plan of improvement as a guide for solving the water resource problems in the various stream basins of Texas. The report provides a tentative plan for supplying the future water supply needs of the Colorado River Basin, including the Pecan Bayou watershed. In regard to the Pecan Bayou watershed, the report indicates a deficiency in available water supply for municipal, industrial, and irrigation purposes by year 1975 and year 2010. The U. S. Study Commission plan includes the construction of Camp Colorado Reservoir on Jim Ned Creek by 1975 as the means for satisfying the additional water-supply requirements of the Pecan Bayou area. The report also states that the upper Colorado River Basin, particularly such urban centers as Midland, Odessa, Big Spring, and Colorado City, is a potential water-supply-shortage area. The Study Commission plan for supplementing the water supply requirements in the upper Colorado River Basin includes the construction of Colorado River reservoirs at the Robert Lee site, the Stacy site (located southwest from Coleman, Texas), and the Fox Crossing site (located

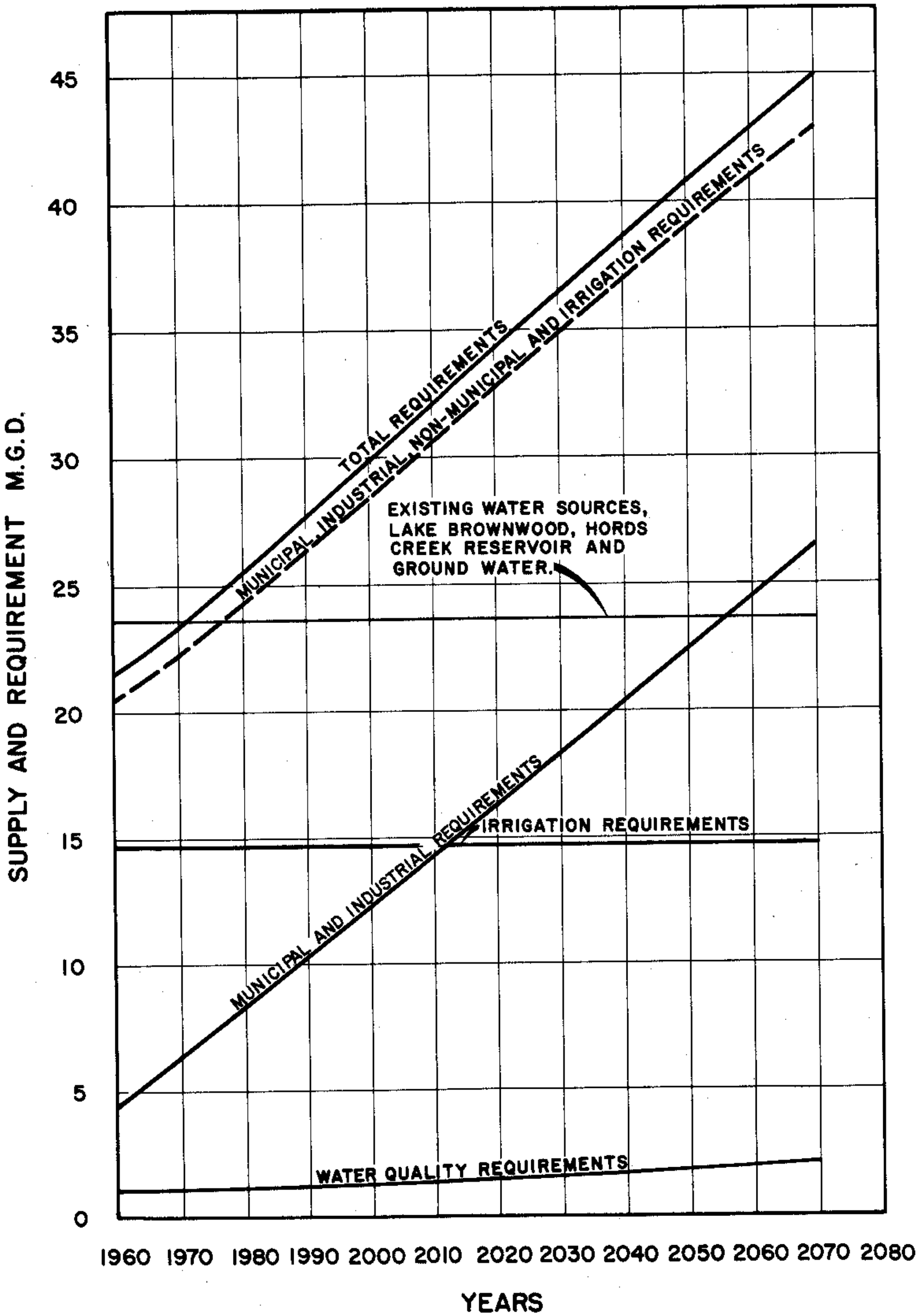
just downstream from the mouth of Pecan Bayou), and the construction of a supply line between Fox Crossing Reservoir and the service area. The Colorado River Basin and the locations of dam sites for the above reservoirs are shown on plate 1 of this appendix.

14. A report by the Texas Water Commission (Texas Board of Water Engineers) dated May 1961 and titled "A Plan for Meeting the 1980 Water Requirements of Texas" indicated that the Pecan Bayou watershed will experience a water-supply deficiency by year 1980. The report presents a plan for the Colorado River Basin which includes a reservoir on Jim Ned Creek as a means of meeting the projected 1980 water supply needs of Coleman and adjacent areas.

15. On the basis of the above studies by Federal and State agencies, a deficiency in water supply during the period 1970 to 1980 for the Pecan Bayou watershed is forecasted. The studies indicated that due to the location of existing sources, additional reservoirs may be required prior to this time, particularly for the city of Coleman and the upper Pecan Bayou watershed. The studies indicate that to meet the water supply requirements predicted for years 2020 and 2070, the maximum economical development of water supply resources is essential at investigated reservoir sites. This procedure would be in consonance with the current policies and desires of the State of Texas.

16. PROBLEMS AT LAKE BROWNWOOD DAM.- Existing Lake Brownwood is valuable as a present source of watér supply and for reducing flood peaks and damages to the downstream Pecan Bayou Valley. However, because of unfavorable conditions at Lake Brownwood Dam, existing Lake Brownwood is considered to be a hazard to the downstream area. Four principal problems exist at Lake Brownwood Dam as follows: (a) That on the basis of Corps of Engineers hydrologic design criteria and investigations, the discharge capacity of the existing spillway is considered inadequate to prevent overtopping of the dam under extreme flood conditons; (b) that the structural condition of the existing earth embankment at Lake Brownwood is questionable; (c) that an erosion problem exists in the Lake Brownwood spillway channel; and (d) that the existing inoperative outlet works are in need of reconstruction or replacement.

17. In order to test the adequacy of the existing earth dam and spillway, actual and hypothetical floods were routed through the reservoir under the assumption that the reservoir level would be at the top of the conservation pool (elevation 1425) at the beginning of the flood routings. The floods routed through the reservoir were (a) the observed flood of July 1932; (b) a flood derived from transposing the storm of June 30-July 2, 1932, over the Pecan Bayou watershed upstream from Lake Brownwood Dam; (c) the standard project flood; (d) and the spillway design flood. The reservoir water surface elevations obtained by flood routings of items a, b, c, and d would be



WATER SUPPLY-DEMAND CURVES

SUMMARY OF PLAN FORMULATION AND ANALYSES

21. PRIMARY OBJECTIVES.- Plans of improvement were formulated with a view to the following objectives: to provide adequate flood protection to the city of Brownwood; to provide substantial reductions in flood damages within all or portions of the investigated agricultural flood plains; to provide additional water conservation storage to meet the projected future water supply requirements for the Pecan Bayou watershed and possibly a portion of the requirements for the upstream Colorado River and adjacent Brazos River areas; and to provide for the development of the fish-wildlife and general recreation potentials which would be afforded by investigated reservoirs.

22. IMPROVEMENTS CONSIDERED.- The principal types of improvements considered for resolution of the combination of flood and water supply problems on the Pecan Bayou watershed involved reservoirs and channel improvements. Reservoirs were investigated at the following dam sites: (a) Lake Brownwood Dam, Pecan Bayou mile 57.1; (b) Burkett Dam site, Pecan Bayou mile 91.9; (c) Pecan Bayou Dam site, Pecan Bayou mile 100.8; (d) Camp Colorado Dam site, Jim Ned Creek mile 26.2; and (e) Coleman Dam site, Jim Ned Creek mile 52.2. Channel improvements were investigated for the following stream reaches: (a) Pecan Bayou, mile 23.0 to 57.1; (b) Adams Branch, mile 0.0 to 6.2; and (c) Willis Creek, mile 0.0 to 6.1. Remedial works or protective measures were investigated for the existing Lake Brownwood Dam.

23. SUMMARY OF PLAN FORMULATION.- General plans were formulated to afford flood control on Pecan Bayou and Jim Ned Creek within the investigated flood plain areas and at the city of Brownwood, and further, to afford maximum economical water resource development on the Pecan Bayou watershed for purposes of water supply, stream quality control, and fish-wildlife and general recreation. The formulated general plans consist of Lake Brownwood protective measures, Brownwood channel improvements at the city of Brownwood, and multiple-purpose reservoirs at the aforementioned dam sites. The Brownwood channel improvements were formulated to protect the city of Brownwood against floods originating on Pecan Bayou, Adams Branch, and Willis Creek. The formulated plans, the existing water-resource developments, and a potential system of flood-detention reservoirs by the Soil Conservation Service, would constitute a comprehensive plan of development for the Pecan Bayou watershed.

24. The plan-formulation studies determined that the control of flood flows originating above the investigated dam sites would not provide sufficient flood protection against flood flows on Pecan Bayou at the city of Brownwood. The Pecan Bayou channel in the vicinity of Brownwood has a minimum capacity of about 12,000 second-feet. The uncontrolled drainage areas between the Brownwood gage and the most upstream two-reservoir system (Pecan Bayou and Coleman Reservoirs), the most-downstream two-reservoir system (Burkett and Camp Colorado Reservoirs), and the

Lake Brownwood enlargement, would be 971, 653, and 78 square miles, respectively. The protection afforded to the city of Brownwood by the existing Pecan Bayou channel capacity and the above reservoir plans would be about once in 3 years, 5 years, and 20 years, respectively. The studies determined, also, that the construction of any upstream two-reservoir system would not eliminate the need for protective measures at Lake Brownwood Dam which are necessary to provide adequate protection to the city of Brownwood. The upstream reservoirs would not eliminate the problems at Lake Brownwood Dam relative to overtopping of the dam by the spillway design flood; the stability of the existing earth structure and potential failure of the dam under extreme flood conditions; and the frequent usage and erosive action within the existing spillway channel. Based on the control which would be afforded by the most upstream and most downstream two-reservoir systems, spillway design flood routings through the existing spillway at Lake Brownwood Dam indicated the need to increase the spillway capacity, or, as an alternate, to increase the height of Lake Brownwood Dam by 19 and 16 feet, respectively, including heights for sufficient freeboard.

25. The studies determined that standard project flood protection for the city of Brownwood by means of reservoirs, channels, and levees is not practical, and is not economically justified on the basis of an overall analysis of benefits and costs. However, the studies determined that channel improvements could provide substantial protection to Brownwood and could eliminate a high percentage of the potential total average annual damages.

26. The investigations and studies established that adequate protection for the city of Brownwood against Pecan Bayou floods could be attained by minimum basic improvements which, in order of importance, consist of protective measures for Lake Brownwood Dam and Brownwood channel improvements. Protective measures at Lake Brownwood would protect the downstream area and the city of Brownwood against catastrophic consequences resulting from failure of the existing embankment. Brownwood channel improvements, consisting of optimum-size improved channels on Pecan Bayou, Adams Branch, and Willis Creek, would provide protection to Brownwood against flood peaks on these streams having frequencies of occurrence of once or more in about 57 years.

27. The plan-formulation studies determined that the addition of reservoirs to the Lake Brownwood protective measures and the Brownwood channel improvements would increase the flood protection at Brownwood to a minimum of 100-year protection against Pecan Bayou flood flows; would afford appreciable reduction in flood flows within the investigated agricultural flood plains; would afford substantial net increases in dependable water supply yields above the basic yield in existing Lake Brownwood; and would provide substantial benefits for fish-wildlife and general recreation.

28. The general plans were formulated and analyzed on the basis that protective measures for Lake Brownwood Dam and Brownwood channel improvements are basic or first-added units operating in combination with Lake Brownwood enlargement or alternate upstream reservoir units as next-added units. The plan for enlargement of Lake Brownwood to provide controlled flood storage capacity and additional water supply storage capacity would automatically incorporate the necessary protective measures for Lake Brownwood Dam.

29. Plan-formulation studies involved the analysis of the performance characteristics of each investigated unit of a plan to determine: (a) Separate benefit-to-cost ratios for each unit; (b) the costs and benefits for each purpose in a unit; (c) the unit or plan which would provide the most practical solution to the problems and the maximum excess benefits over costs; and (d) the merits of each reservoir unit when analyzed as a next-added or last-added unit. Studies for the development of the various plans of improvement included consideration of possible variation in frequency or degree of protection. Project formulation studies involved a detailed analysis of the flood discharges, water conservation yields, storages for these purposes, channel sizes, and a detailed analysis of the benefits which could be derived from each investigated unit or plan. The flood control benefits utilized in the analysis of each plan are based on an economic survey of the investigated flood plains, with consideration being given to the future development anticipated and to a potential system of flood-detention reservoirs by the Soil Conservation Service.

30. SUMMARY OF PLAN STUDIES.- Plan-comparison studies, as summarized in table 2, present economic and cost analyses of the most favorable general plans. The summary presented in table 2 includes general plans 13 and 14, involving enlargement of Lake Brownwood with optimum and maximum economical water supply development, respectively; and the general plans 19 through 22, involving alternate upstream two-reservoir systems of optimum economical size. The above general plans were determined to be the more favorable plans, based on maximum water supply development and analyses of the plan-comparison studies, as presented in table 3. The plan-comparison studies are the basis for selecting the most favorable reservoir unit or system to operate in combination with basic plan 2 of table 3, which includes reconstructed Lake Brownwood and Brownwood channel improvements. The plan-comparison studies are made on the basis that the Brownwood channel improvements are of optimum size. The plan-comparison studies indicate that plan 20, consisting of Lake Brownwood protective measures, Brownwood channel improvements, and the Coleman and Pecan Bayou Reservoirs, is the most economical general plan on the basis of excess benefits over costs.

31. Selected-plan studies, as also summarized in table 2, present additional studies and analyses on the most favorable general plan. Plan 20, the most favorable general plan was selected for application of

certain refinements, and for consideration of increased flood protection at Brownwood--to provide 100-year local flood protection in lieu of about 57-year protection under conditions without the proposed Coleman and Pecan Bayou Reservoirs. The refinement of general plan 20 and the additional considerations are reflected in plans 2B and 20B and plans 2C and 20C of the selected-plan studies. Plans 2B and 20B involve optimum-size channel improvements providing 57-year protection at Brownwood without the proposed upstream reservoirs. Plans 2C and 20C involve channel improvement capacity greater than optimum size to provide 100-year local flood protection without the proposed upstream reservoirs. Plan 20C is selected as the most practical plan and is recommended in this report for authorization.

32. An economic and cost evaluation of the recommended plan of improvement is presented in table 4. Summaries of first cost and annual charges for units in the recommended plan are presented in table 5.

33. The conditions for analyses in the plan-comparison and selected-plan studies with information relative to economic-analysis periods, interest rates, annual benefits, dependable water supply yields, and supporting data, are briefly described in paragraph 39.

34. A discussion of the plan-comparison studies is presented in paragraphs 40 through 47. The discussion compares the merits of the following: selected plan 20, which includes the Pecan Bayou and Coleman Reservoirs; plan 14, which includes the authorized Lake Brownwood enlargement under conditions of maximum economical development; and plan 19, which includes the Burkett and Camp Colorado Reservoirs.

35. A discussion of the selected-plan studies is presented in paragraphs 48 through 55. The discussion summarizes the refinements and alternate considerations involved in the selected-plan studies and covers an evaluation of increased flood protection within the Brownwood urban area.

36. Supporting information on each of the improvement units, including information on design, costs, maximization of benefits over costs, alternate plans or sizes, are presented in paragraphs 56 through 89 in separate sections of this appendix.

37. Cost allocation studies to apportion the project costs of the proposed reconstructed Lake Brownwood and the proposed Pecan Bayou and Coleman Reservoirs are presented in paragraphs 90 through 98 in a separate section of this appendix.

38. Supporting information contained in separate appendixes is as follows: appendix II, foundation conditions, availability of construction materials, and soils design; appendix III, hydrology, hydraulic

TABLE 2

SUMMARY OF ECONOMIC AND COST ANALYSES
INVESTIGATED GENERAL PLANS - PLAN-COMPARISON AND SELECTED-PLAN STUDIES
PECAN BAYOU WATERSHED
(Period of operation 1970-2070)
(July 1963 price level)

Plan No.	Unit	Reservoir storage (acre-feet): Sediment	Reservoir storage: Flood control	Reservoir storage: Water conservation	Reservoir storage: Total	Dependable yield at site (4)(5): cfs	Dependable yield: mgd	Dependable yield: AF/yr(3)	Annual charges (1000 dollars): FC & WC	Annual charges: FC,WC,FW,R	Average annual benefits (1000 dollars): FC	Average annual benefits: WC	Average annual benefits: FW	Average annual benefits: R	Average annual benefits: FC & WC	Average annual benefits: FC,WC,FW,R	Benefit-cost ratio: FC & WC	Benefit-cost ratio: FC,WC,FW,R	Excess benefits (1000 dollars): FC & WC	Excess benefits: FC,WC,FW,R	Maximum design discharges, cfs (Brownwood flood protection): Pecan Bayou	Maximum design discharges: Adams Branch	Maximum design discharges: Willis Creek
	I - PLAN COMPARISON STUDIES																						
	SUMMARY OF MOST FAVORABLE PLANS FROM PLAN-COMPARISON STUDIES OF TABLE 3																						
13	Lake Brownwood Enlargement (2)	49,700	413,900	315,200	778,800	91	58.8	65.9	1,779.0	1,958.6	1,211.2	709.1	353.6	1,000.0	1,920.3	3,273.9	1.08	1.67	141.3	1,315.3	71,000	12,300	17,900
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0			
	Total	49,700	413,900	315,200	778,800	91	58.8	65.9	2,208.3	2,387.9	1,960.5	709.1	353.6	1,000.0	2,669.6	4,023.2	1.21	1.68	461.3	1,635.3	(200-yr)	(57-yr)	(57-yr)
14	Lake Brownwood Enlargement (2)	49,700	419,400	719,800	1,188,900	116	75.0	84.0	2,152.0	2,331.6	1,211.2	945.0	353.6	1,000.0	2,156.2	3,509.8	1.00	1.51	4.2	1,178.2	71,000	12,300	17,900
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0			
	Total	49,700	419,400	719,800	1,188,900	116	75.0	84.0	2,581.3	2,760.9	1,960.5	945.0	353.6	1,000.0	2,905.5	4,259.1	1.13	1.54	324.2	1,498.2	(200-yr)	(57-yr)	(57-yr)
19	Reconstructed Lake Brownwood (1)	20,200	--	104,400	124,600	27	17.4	19.5	314.2	314.2	1,065.4	234.9	--	--	1,300.3	1,300.3	4.14	4.14	986.1	986.1	71,000	12,300	17,900
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0			
	Camp Colorado	21,300	165,600	171,500	358,400	40	25.9	29.0	651.8	757.1	153.6	296.4	176.8	500.0	450.0	1,126.8	0.69	1.49	-201.8	369.7			
	Burkett	12,000	114,200	138,500	264,700	24	15.5	17.4	441.6	554.9	98.8	177.8	176.8	500.0	276.6	953.4	0.63	1.72	-165.0	398.5			
	Total	53,500	279,800	414,400	747,700	91	58.8	65.9	1,836.9	2,055.5	2,067.1	709.1	353.6	1,000.0	2,776.2	4,129.8	1.51	2.01	939.3	2,074.3	(140-yr)	(57-yr)	(57-yr)
20	Reconstructed Lake Brownwood (1)	33,000	--	91,600	124,600	44	28.4	31.9	317.3	317.3	1,065.4	234.9	--	--	1,300.3	1,300.3	4.10	4.10	983.0	983.0	71,000	12,300	17,900
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0			
	Coleman	10,300	92,100	138,500	240,900	24	15.5	17.4	393.4	481.8	98.1	244.4	176.8	500.0	342.5	1,019.3	0.87	2.12	-50.9	537.5			
	Pecan Bayou	10,100	102,700	93,500	206,300	17	11.0	12.3	327.5	442.1	101.8	173.2	176.8	500.0	275.0	951.8	0.84	2.15	-52.5	509.7			
	Total	53,400	194,800	323,600	571,800	85	54.9	61.6	1,467.5	1,670.5	2,014.6	652.5	353.6	1,000.0	2,667.1	4,020.7	1.82	2.41	1,199.6	2,350.2	(100-yr)	(57-yr)	(57-yr)
21	Reconstructed Lake Brownwood (1)	30,900	--	93,700	124,600	40	25.9	29.0	316.8	316.8	1,065.4	234.9	--	--	1,300.3	1,300.3	4.10	4.10			71,000	12,300	17,900
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0			
	Coleman	10,300	92,100	138,500	240,900	24	15.5	17.4	393.4	481.8	95.6	223.3	176.8	500.0	318.9	995.7	0.81	2.07	-74.5	513.9			
	Burkett	12,000	114,200	138,500	264,700	24	15.5	17.4	441.6	554.9	113.8	223.2	176.8	500.0	337.0	1,013.8	0.76	1.83	-104.6	458.9			
	Total	53,200	206,300	370,700	630,200	88	56.9	63.8	1,581.1	1,782.8	2,024.1	681.4	353.6	1,000.0	2,705.5	4,059.1	1.71	2.28	1,124.4	2,276.3	(115-yr)	(57-yr)	(57-yr)
22	Reconstructed Lake Brownwood (1)	22,300	--	102,300	124,600	31	20.0	22.5	314.7	314.7	1,065.4	234.9	--	--	1,300.3	1,300.3	4.13	4.13	985.6	985.6	71,000	12,300	17,900
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.74	1.74	320.0	320.0			
	Camp Colorado	21,300	165,600	171,500	358,400	40	25.9	29.0	651.8	757.1	156.6	313.3	176.8	500.0	469.9	1,146.7	0.72	1.51	-181.9	389.6			
	Pecan Bayou	10,100	102,700	93,500	206,300	17	11.0	12.3	327.5	442.1	88.0	133.2	176.8	500.0	221.2	898.0	0.68	2.03	-106.3	455.9			
	Total	53,700	268,300	367,300	689,300	88	56.9	63.8	1,723.3	1,943.2	2 059.3	681.4	353.6	1,000.0	2,740.7	4,094.3	1.59	2.11	1,017.4	2,151.1	(130-yr)	(57-yr)	(57-yr)
	II - SELECTED-PLAN STUDIES																						
	REFINEMENT OF SELECTED PLAN AND CONSIDERATION OF INCREASED FLOOD PROTECTION AT BROWNWOOD																						
2B	Reconstructed Lake Brownwood (1)	49,700	--	74,900	124,600	35	22.6	25.4	277.6	277.6	1,065.4	234.9	--	--	1,300.3	1,300.3	4.68	4.68	1,022.7	1,022.7	71,000	12,300	17,900
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0			
	Total	49,700	--	74,900	124,600	35	22.6	25.4	706.9	706.9	1,814.7	234.9	--	--	2,049.6	2,049.6	2.90	2.90	1,342.7	1,342.7	(57-yr)	(57-yr)	(57-yr)
20B	Reconstructed Lake Brownwood (1)	33,000	--	91,600	124,600	23	14.9	16.7	277.6	277.6	1,065.4	234.9	--	--	1,300.3	1,300.3	4.68	4.68	1,022.7	1,022.7	71,000	12,300	17,900
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.74	1.74	320.0	320.0			
	Coleman	10,300	92,100	138,500	240,900	20	12.9	14.5	393.4	481.8	98.1	231.8	247.5	700.0	329.9	1,277.4	0.84	2.65	-63.5	795.6			
	Pecan Bayou	10,100	102,700	93,500	206,300	13	8.4	9.4	327.5	442.1	101.8	185.8	106.1	300.0	287.6	693.7	0.88	1.57	-39.9	251.6			
	Total	53,400	194,800	323,600	571,800	56	36.2	40.6	1,427.5	1,630.8	2,014.6	652.5	353.6	1,000.0	2,667.1	4,020.7	1.87	2.47	1,239.6	2,389.9	(100-yr)	(57-yr)	(57-yr)
2C	Reconstructed Lake Brownwood (1)	49,700	--	74,900	124,600	35	22.6	25.4	277.6	277.6	1,065.4	234.9	--	--	1,300.3	1,300.3	4.68	4.68	1,022.7	1,022.7	92,000	13,200	19,000
	Brownwood Channels								507.2	507.2	772.3	--	--	--	772.3	772.3	1.52	1.52	265.1	265.1			
	Total	49,700	--	74,900	124,600	35	22.6	25.4	784.8	784.8	1,837.7	234.9	--	--	2,072.6	2,072.6	2.64	2.64	1,287.8	1,287.8	(100-yr)	(100-yr)	(100-yr)
20C	Reconstructed Lake Brownwood (1)	33,000	--	91,600	124,600	23	14.9	16.7	277.6	277.6	1,065.4	234.9	--	--	1,300.3	1,300.3	4.68	4.68	1,022.7	1,022.7	92,000	13,200	19,000
	Brownwood Channels								507.2	507.2	772.3	--	--	--	772.3	772.3	1.52	1.52	265.1	265.1			
	Coleman	10,300	92,100	138,500	240,900	20	12.9	14.5	393.4	481.8	94.5	231.8	247.5	700.0	326.3	1,273.8	0.83	2.64	-67.1	792.0			
	Pecan Bayou	10,100	102,700	93,500	206,300	13	8.4	9.4	327.5	442.1	95.4	185.8	106.1	300.0	281.2	687.3	0.86	1.55	-46.3	245.2			
	Total	53,400	194,800	323,600	571,800	56	36.2	40.6	1,505.7	1,708.7	2,027.6	652.5	353.6	1,000.0	2,680.1	4,033.7	1.78	2.36	1,174.4	2,325.0	(180-yr)	(100-yr)	(100-yr)

(1) Reconstructed Lake Brownwood includes protective measures and usable existing lands and facilities.
(2) Lake Brownwood enlargement incorporates Lake Brownwood protective measures.
(3) Thousands of acre-feet per year.
(4) Dependable yields for selected-plan studies reflect the effects of a potential Soil Conservation Service program.
(5) Dependable yields for Lake Brownwood, plans 20B and 20C, would increase by about 3 cfs in 2020 and 6 cfs in 2070 due to return flows resulting from water supply utilized from Pecan Bayou and Coleman Reservoirs.

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TABLE 3

SUMMARY OF ECONOMIC AND COST ANALYSES
INVESTIGATED GENERAL PLANS - PLAN-COMPARISON STUDIES
PECAN BAYOU WATERSHED
(Period of operation 1970-2070)
(July 1963 price level)

Plan No.	Unit	Reservoir storage (acre-feet) Sediment	Flood control	Water conservation	Total	Dependable yield at site cfs	mgd	AF/yr(3)	Annual charges (1000 dollars) FC & WC	FC,WC,FW,R	Average annual benefits (1000 dollars) FC	WC	FW	R	FC & WC	FC,WC,FW,R	Benefit-cost ratio FC & WC	FC,WC,FW,R	Excess benefits (1000 dollars) FC & WC	FC,WC,FW,R
	BASIC PLAN																			
2	Reconstructed Lake Brownwood (1)	49,700	--	74,900	124,600	59	38.1	42.7	320.3	320.3	1,065.4	234.9	--	--	1,300.3	1,300.3	4.06	4.06	980.0	980.0
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Total	49,700	--	74,900	124,600	59	38.1	42.7	749.6	749.6	1,814.7	234.9	--	--	2,049.6	2,049.6	2.73	2.73	1,300.0	1,300.0
	RESERVOIR UNITS OF INVESTIGATED GENERAL PLANS - OPERATING WITHOUT BROWNWOOD CHANNELS																			
3	Lake Brownwood Enlargement (2)	49,700	393,700	96,000	539,400	62	40.1	44.9	1,517.0	1,517.0	1,584.8	287.3	--	--	1,872.1	1,872.1	1.23	1.23	355.1	355.1
4	Lake Brownwood Enlargement (2)	49,700	422,500	248,400	720,600	85	54.9	61.6	1,726.0	1,905.6	1,584.8	652.5	353.6	1,000.0	2,237.3	3,590.9	1.30	1.88	511.3	1,685.3
5	Lake Brownwood Enlargement (2)	49,700	413,900	315,200	778,800	91	58.8	65.9	1,779.0	1,958.6	1,584.8	709.1	353.6	1,000.0	2,293.9	3,647.5	1.29	1.86	514.9	1,688.9
6	Lake Brownwood Enlargement (2)	49,700	419,400	719,800	1,188,900	116	75.0	84.0	2,152.0	2,331.6	1,584.8	886.0	353.6	1,000.0	2,470.8	3,824.4	1.15	1.64	318.8	1,492.8
7	Reconstructed Lake Brownwood (1)	20,200	--	104,400	124,600	27	17.4	19.5	314.2	314.2	1,065.4	234.9	--	--	1,300.3	1,300.3	4.14	4.14	986.1	986.1
	Camp Colorado	21,300	165,600	171,500	358,400	40	25.9	29.0	651.8	757.1	300.0	296.4	176.8	500.0	596.4	1,273.2	0.92	1.68	-55.4	516.1
	Burkett	12,000	114,200	138,500	264,700	24	15.5	17.4	441.6	554.9	178.5	177.8	176.8	500.0	356.3	1,033.1	0.81	1.86	-85.3	478.2
	Total	53,500	279,800	414,400	747,700	91	58.8	65.9	1,407.6	1,626.2	1,543.9	709.1	353.6	1,000.0	2,253.0	3,606.6	1.60	2.22	845.4	1,980.4
8	Reconstructed Lake Brownwood (1)	33,000	--	91,600	124,600	44	28.4	31.9	317.3	317.3	1,065.4	234.9	--	--	1,300.3	1,300.3	4.10	4.10	983.0	983.0
	Coleman	10,300	92,100	138,500	240,900	24	15.5	17.4	393.4	481.8	160.1	244.4	176.8	500.0	404.5	1,081.3	1.03	2.24	11.1	599.5
	Pecan Bayou	10,100	102,700	93,500	206,300	17	11.0	12.3	327.5	442.1	170.6	173.2	176.8	500.0	343.8	1,020.6	1.05	2.31	16.3	578.5
	Total	53,400	194,800	323,600	571,800	85	54.9	61.6	1,038.2	1,241.2	1,396.1	652.5	353.6	1,000.0	2,048.6	3,402.2	1.97	2.74	1,010.4	2,161.0
9	Reconstructed Lake Brownwood (1)	30,900	--	93,700	124,600	40	25.9	29.0	316.8	316.8	1,065.4	234.9	--	--	1,300.3	1,300.3	4.10	4.10	983.5	983.5
	Coleman	10,300	92,100	138,500	240,900	24	15.5	17.4	393.4	481.8	157.3	223.3	176.8	500.0	380.6	1,057.4	0.97	2.19	-12.8	575.6
	Burkett	12,000	114,200	138,500	264,700	24	15.5	17.4	441.6	554.9	196.4	223.2	176.8	500.0	419.6	1,096.4	0.95	1.98	-22.0	541.5
	Total	53,200	206,300	370,700	630,200	88	56.9	63.8	1,151.8	1,353.5	1,419.1	681.4	353.6	1,000.0	2,100.5	3,454.1	1.82	2.55	948.7	2,100.6
10	Reconstructed Lake Brownwood (1)	22,300	--	102,300	124,600	31	20.0	22.5	314.7	314.7	1,065.4	234.9	--	--	1,300.3	1,300.3	4.13	4.13	985.6	985.6
	Camp Colorado	21,300	165,600	171,500	358,400	40	25.9	29.0	651.8	757.1	301.8	313.3	176.8	500.0	615.1	1,291.9	0.94	1.71	-36.7	534.8
	Pecan Bayou	10,100	102,700	93,500	206,300	17	11.0	12.3	327.5	442.1	152.9	133.2	176.8	500.0	286.1	962.9	0.87	2.18	-41.4	520.8
	Total	53,700	268,300	367,300	689,300	88	56.9	63.8	1,294.0	1,513.9	1,520.1	681.4	353.6	1,000.0	2,201.5	3,555.1	1.70	2.35	907.5	2,041.2
	INVESTIGATED GENERAL PLANS INVOLVING BASIC PLAN & LAKE BROWNWOOD ENLARGEMENT																			
	Incremental - 2 & 11				414,800	3	1.9	2.2	1,196.7	1,196.7	145.8	52.4	--	--	198.2	198.2	0.17	0.17	-998.5	-998.5
11	Lake Brownwood Enlargement (2)	49,700	393,700	96,000	539,400	62	40.1	44.9	1,517.0	1,517.0	1,211.2	287.3	--	--	1,498.5	1,498.5	0.99	0.99	-18.5	-18.5
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Total	49,700	393,700	96,000	539,400	62	40.1	44.9	1,946.3	1,946.3	1,960.5	287.3	--	--	2,247.8	2,247.8	1.15	1.15	301.5	301.5
	Incremental - 2 & 12				596,000	26	16.8	18.8	1,405.7	1,585.3	145.8	417.6	353.6	1,000.0	563.4	1,917.0	0.40	1.21	-842.3	331.7
	Incremental - 11 & 12				181,200	23	14.9	16.7	209.0	388.6	--	365.2	353.6	1,000.0	365.2	1,718.8	1.75	4.42	156.2	1,330.2
12	Lake Brownwood Enlargement (2)	49,700	422,500	248,400	720,600	85	54.9	61.6	1,726.0	1,905.6	1,211.2	652.5	353.6	1,000.0	1,863.7	3,217.3	1.08	1.69	137.7	1,311.7
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Total	49,700	422,500	248,400	720,600	85	54.9	61.6	2,155.3	2,334.9	1,960.5	652.5	353.6	1,000.0	2,613.0	3,966.6	1.21	1.70	457.7	1,631.7
	Incremental - 2 & 13				654,200	32	20.7	23.2	1,458.7	1,638.3	145.8	474.2	353.6	1,000.0	620.0	1,973.6	0.43	1.21	-838.7	335.3
	Incremental - 12 & 13				58,200	6	3.9	4.3	53.0	53.0	--	56.6	--	--	56.6	56.6	1.07	1.07	3.6	3.6
13	Lake Brownwood Enlargement (2)	49,700	413,900	315,200	778,800	91	58.8	65.9	1,779.0	1,958.6	1,211.2	709.1	353.6	1,000.0	1,920.3	3,273.9	1.08	1.67	141.3	1,315.3
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Total	49,700	413,900	315,200	778,800	91	58.8	65.9	2,208.3	2,387.9	1,960.5	709.1	353.6	1,000.0	2,669.6	4,023.2	1.21	1.68	461.3	1,635.3
	Incremental - 2 & 14				1,064,300	57	36.8	41.3	1,831.7	2,011.3	145.8	710.1	353.6	1,000.0	855.9	2,209.5	0.47	1.10	-975.8	198.2
	Incremental - 13 & 14				410,100	25	16.2	18.1	373.0	373.0	--	235.9	--	--	235.9	235.9	0.63	0.63	-137.1	-137.1
14	Lake Brownwood Enlargement (2)	49,700	419,400	719,800	1,188,900	116	75.0	84.0	2,152.0	2,331.6	1,211.2	945.0	353.6	1,000.0	2,156.2	3,509.8	1.00	1.51	4.2	1,178.2
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Total	49,700	419,400	719,800	1,188,900	116	75.0	84.0	2,581.3	2,760.9	1,960.5	945.0	353.6	1,000.0	2,905.5	4,259.1	1.13	1.54	324.2	1,498.2

(1) Reconstructed Lake Brownwood includes protective measures and usable existing lands and facilities.
(2) Lake Brownwood enlargement incorporates Lake Brownwood protective measures.
(3) Thousands of acre-feet per year.

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TABLE 3 (Cont'd)

SUMMARY OF ECONOMIC AND COST ANALYSIS
INVESTIGATED GENERAL PLANS - PLAN-COMPARISON STUDIES
PECAN BAYOU WATERSHED
(Period of operation 1970-2070)
(July 1963 price level)

Plan No.	Unit	Reservoir storage (acre-feet): Sediment	Reservoir storage: Flood control	Reservoir storage: Water conservation	Reservoir storage: Total	Dependable yield at site: cfs	Dependable yield at site: mgd	Dependable yield at site: AF/yr(2)	Annual charges (1000 dollars): FC & WC	Annual charges: FC,WC,FW,R	Average annual benefits (1000 dollars): FC	WC	FW	R	FC & WC	FC,WC,FW,R	Benefit-cost ratio: FC & WC	Benefit-cost ratio: FC,WC,FW,R	Excess benefits (1000 dollars): FC & WC	Excess benefits: FC,WC,FW,R
	INVESTIGATED GENERAL PLANS INVOLVING BASIC PLAN & UPSTREAM RESERVOIRS																			
2	Reconstructed Lake Brownwood (1)	49,700	--	74,900	124,600	59	38.1	42.7	320.3	320.3	1,065.4	234.9	--	--	1,300.3	1,300.3	4.06	4.06	980.0	980.0
	Brownwood Channels		--						429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Total	49,700	--	74,900	124,600	59	38.1	42.7	749.6	749.6	1,814.7	234.9	--	--	2,049.6	2,049.6	2.73	2.73	1,300.0	1,300.0
	Incremental - 2 & 15				358,400	25	16.2	18.1	648.9	780.5	167.8	380.3	247.5	700.0	548.1	1,495.6	0.84	1.92	-100.8	715.1
15	Reconstructed Lake Brownwood (1)	30,800	--	93,800	124,600	44	28.4	31.9	317.4	317.4	1,065.4	234.9	--	--	1,300.3	1,300.3	4.09	4.09	982.9	982.9
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Camp Colorado	21,300	165,600	171,500	358,400	40	25.9	29.0	651.8	783.4	167.8	380.3	247.5	700.0	548.1	1,495.6	0.84	1.91	-103.7	712.2
	Total	52,100	165,600	265,300	483,000	84	54.3	60.9	1,398.5	1,530.1	1,982.5	615.2	247.5	700.0	2,597.7	3,545.2	1.86	2.32	1,199.2	2,015.1
	Incremental - 2 & 16				264,700	16	10.3	11.6	439.7	579.4	108.0	281.3	247.5	700.0	389.0	1,336.8	0.88	2.31	-50.4	757.4
16	Reconstructed Lake Brownwood (1)	38,600	--	86,000	124,600	51	33.0	36.9	318.4	318.4	1,065.4	234.9	--	--	1,300.3	1,300.3	4.08	4.08	981.9	981.9
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Burkett	12,000	114,200	138,500	264,700	24	15.5	17.4	441.6	581.3	108.0	281.3	247.5	700.0	389.3	1,336.8	0.88	2.30	-52.3	755.5
	Total	50,600	114,200	224,500	389,300	75	48.5	54.3	1,189.3	1,329.0	1,922.7	516.2	247.5	700.0	2,438.9	3,386.4	2.05	2.55	1,249.6	2,057.4
	Incremental - 2 & 17				240,900	17	11.0	12.3	392.0	505.9	90.8	291.3	247.5	700.0	382.1	1,329.6	0.97	2.63	-9.9	823.7
17	Reconstructed Lake Brownwood (1)	39,600	--	85,000	124,600	52	33.6	37.7	318.9	318.9	1,065.4	234.9	--	--	1,300.3	1,300.3	4.08	4.08	981.4	981.4
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Coleman	10,300	92,100	138,500	240,900	24	15.5	17.4	393.4	507.3	90.8	291.3	247.5	700.0	382.1	1,329.6	0.97	2.62	-11.3	822.3
	Total	49,900	92,100	223,500	365,500	76	49.1	55.1	1,141.6	1,255.5	1,905.5	526.2	247.5	700.0	2,431.7	3,379.2	2.13	2.69	1,290.1	2,123.7
	Incremental 2 & 18				206,300	11	7.1	8.0	325.9	464.2	94.4	218.4	247.5	700.0	312.8	1,260.3	0.96	2.71	-13.1	796.1
18	Reconstructed Lake Brownwood (1)	40,200	--	84,400	124,600	53	34.3	38.4	318.7	318.7	1,065.4	234.9	--	--	1,300.3	1,300.3	4.08	4.08	981.6	981.6
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Pecan Bayou	10,100	102,700	93,500	206,300	17	11.0	12.3	327.5	465.8	94.4	218.4	247.5	700.0	312.8	1,260.3	0.96	2.71	-14.7	794.5
	Total	50,300	102,700	177,900	330,900	70	45.3	50.7	1,075.5	1,213.8	1,909.1	453.3	247.5	700.0	2,362.4	3,309.9	2.20	2.73	1,286.9	2,096.1
	Incremental - 15 & 19				264,700	7	4.5	5.1	438.4	525.4	84.6	93.9	106.1	300.0	178.5	584.6	0.41	1.11	-259.9	59.2
	Incremental - 16 & 19				358,400	16	10.3	11.6	647.6	726.5	144.4	192.9	106.1	300.0	337.3	743.4	0.52	1.02	-310.3	16.9
19	Reconstructed Lake Brownwood (1)	20,200	--	104,400	124,600	27	17.4	19.5	314.2	314.2	1,065.4	234.9	--	--	1,300.3	1,300.3	4.14	4.14	986.1	986.1
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Camp Colorado	21,300	165,600	171,500	358,400	40	25.9	29.0	651.8	757.1	153.6	296.4	176.8	500.0	450.0	1,126.8	0.69	1.48	-201.8	369.7
	Burkett	12,000	114,200	138,500	264,700	24	15.5	17.4	441.6	554.9	98.8	177.8	176.8	500.0	276.6	953.4	0.63	1.72	-165.0	398.5
	Total	53,500	279,800	414,400	747,700	91	58.8	65.9	1,836.9	2,055.5	2,067.1	709.1	353.6	1,000.0	2,776.2	4,129.8	1.51	2.01	939.3	2,074.3
	Incremental - 17 & 20				206,300	9	5.8	6.5	325.9	414.8	109.1	126.3	106.1	300.0	235.4	641.5	0.72	1.56	-90.5	226.5
	Incremental - 18 & 20				240,900	15	9.7	10.9	392.0	456.7	105.5	199.2	106.1	300.0	304.7	710.8	0.78	1.56	-87.3	254.1
20	Reconstructed Lake Brownwood (1)	33,000	--	91,600	124,600	44	28.4	31.9	317.3	317.3	1,065.4	234.9	--	--	1,300.3	1,300.3	4.10	4.10	983.0	983.0
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Coleman	10,300	92,100	138,500	240,900	24	15.5	17.4	393.4	481.8	98.1	244.4	176.8	500.0	342.5	1,019.3	0.87	2.12	-50.9	537.5
	Pecan Bayou	10,100	102,700	93,500	206,300	17	11.0	12.3	327.5	442.1	101.8	173.2	176.8	500.0	275.0	951.8	0.84	2.15	-52.5	509.7
	Total	53,400	194,800	323,600	571,800	85	54.9	61.6	1,467.5	1,670.5	2,014.6	652.5	353.6	1,000.0	2,667.1	4,020.7	1.82	2.41	1,199.6	2,350.2
	Incremental - 17 & 21				264,700	12	7.8	8.7	439.5	527.3	118.6	155.2	106.1	300.0	273.8	679.9	0.62	1.29	-165.7	152.6
	Incremental - 16 & 21				240,900	13	8.4	9.4	391.8	453.8	101.4	165.2	106.1	300.0	266.6	672.7	0.68	1.48	-125.2	218.9
21	Reconstructed Lake Brownwood (1)	30,900	--	93,700	124,600	40	25.9	29.0	316.8	316.8	1,065.4	234.9	--	--	1,300.3	1,300.3	4.10	4.10	983.5	983.5
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Coleman	10,300	92,100	138,500	240,900	24	15.5	17.4	393.4	481.8	95.6	223.3	176.8	500.0	318.9	995.7	0.81	2.07	-74.5	513.9
	Burkett	12,000	114,200	138,500	264,700	24	15.5	17.4	441.6	554.9	113.8	223.2	176.8	500.0	337.0	1,013.8	0.76	1.83	-104.6	458.9
	Total	53,200	206,300	370,700	630,200	88	56.9	63.8	1,581.1	1,782.8	2,024.1	681.4	353.6	1,000.0	2,705.5	4,059.1	1.71	2.28	1,124.4	2,276.3
	Incremental - 15 & 22				206,300	4	2.6	2.9	324.8	413.1	76.8	66.2	106.1	300.0	143.0	549.1	0.44	1.33	-181.8	136.0
	Incremental - 18 & 22				358,400	18	11.6	13.0	647.8	729.4	150.2	228.1	106.1	300.0	378.3	784.4	0.58	1.08	-269.5	55.0
22	Reconstructed Lake Brownwood (1)	22,300	--	102,300	124,600	31	20.0	22.5	314.7	314.7	1,065.4	234.9	--	--	1,300.3	1,300.3	4.13	4.13	985.6	985.6
	Brownwood Channels								429.3	429.3	749.3	--	--	--	749.3	749.3	1.75	1.75	320.0	320.0
	Camp Colorado	21,300	165,600	171,500	358,400	40	25.9	29.0	651.8	757.1	156.6	313.3	176.8	500.0	469.9	1,146.7	0.72	1.51	-181.9	389.6
	Pecan Bayou	10,100	102,700	93,500	206,300	17	11.0	12.3	327.5	442.1	88.0	133.2	176.8	500.0	221.2	898.0	0.68	2.03	-106.3	455.9
	Total	53,700	268,300	367,300	689,300	88	56.9	63.8	1,723.3	1,943.2	2,059.3	681.4	353.6	1,000.0	2,740.7	4,094.3	1.59	2.11	1,017.4	2,151.1

(1) Reconstructed Lake Brownwood includes protective measures and usable existing lands and facilities.
(2) Thousands of acre-feet per year.

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TABLE 3 (Cont'd)

SUMMARY OF ECONOMIC AND COST ANALYSES
INVESTIGATED GENERAL PLANS - PLAN-COMPARISON STUDIES
PECAN BAYOU WATERSHED
(Period of operation 1970-2070)
(July 1963 price level)

Plan No.	Unit	Reservoir storage (acre-feet): Sediment	Reservoir storage: Flood control	Reservoir storage: Water conservation	Reservoir storage: Total	Dependable yield at site: cfs	Dependable yield at site: mgd	Dependable yield at site: AF/yr(3)	Annual charges (1000 dollars): FC & WC	Annual charges (1000 dollars): FC,WC,FW,R	Average annual benefits (1000 dollars): FC	Average annual benefits: WC	Average annual benefits: FW	Average annual benefits: R	Average annual benefits: FC & WC	Average annual benefits: FC,WC,FW,R	Benefit-cost ratio: FC & WC	Benefit-cost ratio: FC,WC,FW,R	Excess benefits (1000 dollars): FC & WC	Excess benefits (1000 dollars): FC,WC,FW,R
	GENERAL PLANS TO PROVIDE UNIFORM 100-YEAR PROTECTION AT BROWNWOOD																			
12A	Lake Brownwood Enlargement (2)	49,700	422,500	248,400	720,600	85	54.9	61.6	1,726.0	1,905.6	1,364.0	652.5	353.6	1,000.0	2,016.5	3,370.1	1.17	1.77	290.5	1,464.5
	Brownwood Channels (Pecan Bayou design discharge, 28,000 cfs)								294.2	294.2	590.9	--	--	--	590.9	590.9	2.01	2.01	296.7	296.7
	Total	49,700	422,500	248,400	720,600	85	54.9	61.6	2,020.2	2,199.8	1,954.9	652.5	353.6	1,000.0	2,607.4	3,961.0	1.29	1.80	587.2	1,761.2
13A	Lake Brownwood Enlargement (2)	49,700	413,900	315,200	778,800	91	58.8	65.9	1,779.0	1,958.6	1,364.0	709.1	353.6	1,000.0	2,073.1	3,426.7	1.17	1.75	294.1	1,468.1
	Brownwood Channels (Pecan Bayou design discharge, 28,000 cfs)								294.2	294.2	590.9	--	--	--	590.9	590.9	2.01	2.01	296.7	296.7
	Total	49,700	413,900	315,200	778,800	91	58.8	65.9	2,073.2	2,252.8	1,954.9	709.1	353.6	1,000.0	2,664.0	4,017.6	1.28	1.78	590.8	1,764.8
14A	Lake Brownwood Enlargement (2)	49,700	419,400	719,800	1,188,900	116	75.0	84.0	2,152.0	2,331.6	1,364.0	945.0	353.6	1,000.0	2,309.0	3,662.6	1.07	1.57	157.0	1,331.0
	Brownwood Channels (Pecan Bayou design discharge, 28,000 cfs)								294.2	294.2	590.9	--	--	--	590.9	590.9	2.01	2.01	296.7	296.7
	Total	49,700	419,400	719,800	1,188,900	116	75.0	84.0	2,446.2	2,625.8	1,954.9	945.0	353.6	1,000.0	2,899.9	4,253.5	1.19	1.62	453.7	1,627.7
19A	Reconstructed Lake Brownwood (1)	20,200	--	104,400	124,600	27	17.4	19.5	314.2	314.2	1,065.4	234.9	--	--	1,300.3	1,300.3	4.14	4.14	986.1	986.1
	Brownwood Channels (Pecan Bayou design discharge, 60,000 cfs)								419.7	419.7	730.7	--	--	--	730.7	730.7	1.74	1.74	311.0	311.0
	Camp Colorado	21,300	165,600	171,500	358,400	40	25.9	29.0	651.8	757.1	162.9	296.4	176.8	500.0	459.3	1,136.1	0.70	1.50	-192.5	379.0
	Burkett	12,000	114,200	138,500	264,700	24	15.5	17.4	441.6	554.9	104.8	177.8	176.8	500.0	282.6	959.4	0.64	1.73	-159.0	404.5
	Total	53,500	279,800	414,400	747,700	91	58.8	65.9	1,827.3	2,045.9	2,063.8	709.1	353.6	1,000.0	2,772.9	4,126.5	1.52	2.02	954.6	2,080.6
20A (20)	Reconstructed Lake Brownwood (1)	33,000	--	91,600	124,600	44	28.4	31.9	317.3	317.3	1,065.4	234.9	--	--	1,300.3	1,300.3	4.10	4.10	983.0	983.0
	Brownwood Channels (Pecan Bayou design discharge, 71,000 cfs)								439.1	439.1	752.0	--	--	--	752.0	752.0	1.71	1.71	312.9	312.9
	Coleman	10,300	92,100	138,500	240,900	24	15.5	17.4	393.4	481.8	98.1	244.4	176.8	500.0	342.5	1,019.3	0.87	2.12	-50.9	537.5
	Pecan Bayou	10,100	102,700	93,500	206,300	17	11.0	12.3	327.5	442.1	101.8	173.2	176.8	500.0	275.0	951.8	0.84	2.15	-52.5	509.7
	Total	53,400	194,800	323,600	571,800	85	54.9	61.6	1,477.3	1,680.3	2,017.3	652.5	353.6	1,000.0	2,669.8	4,023.4	1.82	2.41	1,192.5	2,343.1
21A	Reconstructed Lake Brownwood (1)	30,900	--	93,700	124,600	40	25.9	29.0	316.8	316.8	1,065.4	234.9	--	--	1,300.3	1,300.3	4.10	4.10	983.5	983.5
	Brownwood Channels (Pecan Bayou design discharge, 70,000 cfs)								436.7	436.7	751.5	--	--	--	751.5	751.5	1.72	1.72	314.8	314.8
	Coleman	10,300	92,100	138,500	240,900	24	15.5	17.4	393.4	481.8	95.3	223.3	176.8	500.0	318.6	995.4	0.81	2.07	-74.8	513.6
	Burkett	12,000	114,200	138,500	264,700	24	15.5	17.4	441.6	554.9	113.4	223.2	176.8	500.0	336.6	1,013.4	0.76	1.83	-105.0	458.5
	Total	53,200	206,300	370,700	630,200	88	56.9	63.8	1,588.5	1,790.2	2,025.6	681.4	353.6	1,000.0	2,707.0	4,060.6	1.70	2.27	1,118.5	2,270.4
22A	Reconstructed Lake Brownwood (1)	22,300	--	102,300	124,600	31	20.0	22.5	314.7	314.7	1,065.4	234.9	--	--	1,300.3	1,300.3	4.13	4.13	985.6	985.6
	Brownwood Channels (Pecan Bayou design discharge, 62,000 cfs)								422.7	422.7	734.2	--	--	--	734.2	734.2	1.74	1.74	311.5	311.5
	Camp Colorado	21,300	165,600	171,500	358,400	40	25.9	29.0	651.8	757.1	160.2	313.3	176.8	500.0	473.5	1,150.3	0.73	1.52	-178.3	393.2
	Pecan Bayou	10,100	102,700	93,500	206,300	17	11.0	12.3	327.5	442.1	90.0	133.2	176.8	500.0	223.2	900.0	0.68	2.04	-104.3	457.9
	Total	53,700	268,300	367,300	689,300	88	56.9	63.8	1,716.7	1,936.6	2,049.8	681.4	353.6	1,000.0	2,731.2	4,084.8	1.59	2.11	1,014.5	2,148.2

(1) Reconstructed Lake Brownwood, includes protective measures and usable existing lands and facilities.
(2) Lake Brownwood enlargement incorporates Lake Brownwood protective measures.
(3) Thousands of acre-feet per year.

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TABLE 4

FIRST COST, ANNUAL CHARGES, ANNUAL BENEFITS AND BENEFIT-COST RATIOS
PROJECTS RECOMMENDED FOR AUTHORIZATION
PECAN BAYOU WATERSHED
(Costs and benefits in thousand dollars)
(July 1963 price level)
(Interest rate, 3% - Amortization period, 100 yrs)

Item	Reconstructed Lake Brownwood	Brownwood Channels	Coleman Reservoir	Pecan Bayou Reservoir	Total Recommended Plan
FIRST COST	7,300.0(1)	13,723.0	11,890.0	10,520.0	43,433.0
ANNUAL CHARGES	286.4	523.9	496.3	454.9	1,761.5
ANNUAL BENEFITS					
Flood control	637.3	947.4	207.2	235.7	2,027.6
Water supply	191.0	--	229.7	195.3	616.0
Water quality control	--	--	29.4	29.4	58.8
Recreation	--	--	676.8	676.8	1,353.6
Total - Benefits	828.3	947.4	1,143.1	1,137.2	4,056.0
BENEFIT-COST RATIO	2.9	1.8	2.3	2.5	2.3

(1) Includes proposed Lake Brownwood protective measures (3,060.0) and value of existing usable facilities (4,240.0)

TABLE 5

SUMMARY OF FIRST COST AND ANNUAL CHARGES
PROPOSED PLAN OF IMPROVEMENT
PECAN BAYOU WATERSHED
(July 1963 price level)
(in 1000 dollars)

Item	Reconstructed Lake Brownwood	Brownwood Channel Improvement	Coleman Reservoir	Pecan Bayou Reservoir	Total
FIRST COSTS					
A. FEDERAL FIRST COSTS					
(01.0) Lands and damages	40.0	--	1,850.0	2,390.0	4,280.0
a. General reservoir	(40.0)	--	(1,710.0)	(2,210.0)	(3,960.0)
b. Fish, wildlife, and recreation	--	--	(140.0)	(180.0)	(320.0)
(02.0) Relocations	--	222.0	230.0	237.0	689.0
a. Reservoir	--	--	(230.0)	(237.0)	(467.0)
b. Channels (railroads)	--	(222.0)	--	--	(222.0)
(03.0) Reservoir (clearing)	--	--	107.0	141.0	248.0
a. General reservoir	--	--	(49.0)	(64.0)	(113.0)
b. Fish, wildlife, and recreation	--	--	(58.0)	(77.0)	(135.0)
(04.0) Dam	2,700.0	--	7,094.0	5,105.0	14,899.0
a. Embankment	(1,267.0)	--	(4,509.0)	(2,446.0)	(8,222.0)
b. Slope protection	(6.0)	--	(24.0)	(14.0)	(44.0)
c. Spillway	(314.0)	--	(914.0)	(1,119.0)	(2,347.0)
d. Outlet works	(973.0)	--	(1,647.0)	(1,526.0)	(4,146.0)
e. Outlet works (irrigation)	(140.0)	--	--	--	(140.0)
(08.0) Access roads	--	--	224.0	440.0	664.0
a. General reservoir	--	--	(114.0)	(69.0)	(183.0)
b. Fish, wildlife, and recreation	--	--	(110.0)	(371.0)	(481.0)
(09.0) Channels	--	10,045.0	--	--	10,045.0
(14.0) Fish, wildlife, and recreation facilities	--	--	1,022.0	1,022.0	2,044.0
(19.0) Buildings, grounds, and utilities	--	--	240.0	219.0	459.0
(20.0) Permanent operating equipment	20.0	--	60.0	60.0	140.0
(30.0) Engineering and design	125.0	406.0	434.0	364.0	1,329.0
(31.0) Supervision and administration	175.0	608.0	629.0	542.0	1,954.0
Total Federal first costs	3,060.0	11,281.0	11,890.0	10,520.0	36,751.0
B. NON-FEDERAL FIRST COSTS					
1. Lands and damages					
a. Reservoirs	3,840.0	--	--	--	3,840.0
b. Channels	--	961.0	--	--	961.0
2. Dam					
a. Spillway	358.0	--	--	--	358.0
3. Relocations and alterations					
a. Channels	--	1,321.0	--	--	1,321.0
4. Engineering and design	17.0	67.0	--	--	84.0
5. Supervision and administration	25.0	93.0	--	--	118.0
Total non-Federal first costs	4,240.0	2,442.0	--	--	6,682.0
C. TOTAL FIRST COST OF PROJECT	7,300.0	13,723.0	11,890.0	10,520.0	43,433.0
Preauthorization cost (not included in first cost)	20.0	25.0	10.0	10.0	65.0
ANNUAL CHARGES					
(Construction period - 3 years)(Amortization period - 100 years) (Interest rate - 3.00%)					
A. FEDERAL INVESTMENT					
a. Federal first cost	3,060.0	11,281.0	11,890.0	10,520.0	36,751.0
b. Interest during construction	138.0	508.0	535.0	473.0	1,654.0
Total Federal investment	3,198.0	11,789.0	12,425.0	10,993.0	38,405.0
B. NON-FEDERAL INVESTMENT					
a. Non-Federal first cost	4,240.0	2,442.0	--	--	6,682.0
b. Investment during construction	191.0	110.0	--	--	301.0
Total non-Federal investment	4,431.0	2,552.0	--	--	6,983.0
C. FEDERAL ANNUAL CHARGES					
a. Interest on investment	95.9	353.7	372.8	329.8	1,152.2
b. Amortization on investment	5.3	19.4	20.5	18.1	63.3
c. Maintenance and operation	--	--	103.0	107.0	210.0
(1) Dam and reservoir	--	--	(68.5)	(65.5)	(207.0)
(2) Replacement of parts (Dam)	--	--	(1.5)	(1.5)	(3.0)
(3) Fish, wildlife, and general recreation	--	--	(33.0)	(40.0)	(73.0)
Total Federal annual charges	101.2	373.1	496.3	454.9	1,425.5
D. NON-FEDERAL ANNUAL CHARGES					
a. Interest on investment	132.9	76.6	--	--	209.5
b. Amortization on investment	7.3	4.2	--	--	11.5
c. Maintenance and operation	45.0	70.0	--	--	115.0
(1) Channels or reservoir	(43.5)	(70.0)	--	--	(113.5)
(2) Replacement of parts	(1.5)	--	--	--	(1.5)
Total non-Federal annual charges	185.2	150.8	--	--	336.0
E. TOTAL ANNUAL CHARGES	286.4	523.9	496.3	454.9	1,761.5

design, and water resources; appendix IV, economic studies; appendix V, recreation and fish and wildlife; appendix VI, reports prepared by Bureau of Sport Fisheries and Wildlife, the National Park Service, and the U. S. Public Health Service.

39. CONDITIONS FOR ANALYSES.- Comparisons of the plans in the plan-comparison and selected-plan studies were based on conditions briefly set forth in the following subparagraphs a through h.

a. Economic and cost analyses.- The economic and cost analyses of improvement units utilized in the plan-comparison and selected-plan studies were based on an interest rate of 2.875 percent and on a useful economic life and amortization period of 100 years between years 1970 and 2070. However, subsequent to selection of the proposed plan from the plan-comparison and selected-plan studies, the annual charges and benefits and allocation of project costs for the proposed plan were redetermined on the basis of the current interest rate of 3.00 percent.

b. Flood control benefits.- The flood control benefits creditable to each improvement unit in the plan-comparison and selected-plan studies were determined on the basis that the existing watershed improvements included a potential flood-detention reservoir system of the Soil Conservation Service which would afford reductions in flood flows on Pecan Bayou and Jim Ned Creek. Because the existing Lake Brownwood project is considered unsafe, the analyses of the plans of improvement were initiated under conditions which included Hords Creek Reservoir and the potential Soil Conservation Service program as the only flood control developments on the watershed affecting flood flows on Pecan Bayou. Also, the analyses excluded flood control benefits within those portions of the Pecan Bayou and Colorado River flood plains which would be inundated by the Fox Crossing Reservoir, a potential reservoir project included in the U. S. Study Commission plan and presently being investigated by the Corps of Engineers under the comprehensive studies of the Colorado River Basin, Texas. The flood control benefits creditable to the Lake Brownwood protective measures, or to a reconstructed Lake Brownwood, are based on the value of Lake Brownwood in reducing flood peaks within the downstream Pecan Bayou Valley. The reconstructed Lake Brownwood is credited with the difference in projected average annual damages which would prevail within the investigated flood plains with and without operation of Lake Brownwood. In the selected-plan studies, the total flood control benefits credited to the proposed plan of improvement were assigned to the individual improvement units in accordance with the plan-formulation sequence.

c. Dependable water supply yields.- The dependable water supply yield is defined as the maximum rate at which water may be withdrawn from a reservoir in order that the total conservation storage provided in the reservoir will be just depleted under maximum drought conditions of record (November 1942 through April 1955). The total dependable water supply yield developed at any investigated reservoir site was determined under conditons of 100-year sediment storages, 1970 storage conditions in the case of Lake Brownwood, and watershed conditions assuming existence of Hords Creek Reservoir and a potential flood detention reservoir system by the Soil Conservation Service, as described in paragraph 27 of appendix III. However, the effects of the potential Soil Conservation Service program on the total dependable yields at the investigated reservoir sites and Lake Brownwood are not reflected in the plan-comparison studies; but are reflected in the selected-plan studies. In the plan-comparison studies, the total dependable yield at reconstructed Lake Brownwood varied from 59.0 cfs without investigated upstream reservoirs to 27.0 cfs with the upstream two-reservoir system composed of Camp Colorado and Burkett Reservoirs. In the selected-plan studies, the total dependable yield at the proposed reconstructed Lake Brownwood project varied from 35.0 cfs without the proposed Coleman and Pecan Bayou Reservoirs to 23.0 cfs with the proposed upstream two-reservoir system composed of the Coleman and Pecan Bayou Reservoirs. However, the total yield at Lake Brownwood would increase to 26.0 cfs in 2020 and 29.0 cfs in 2070 because of return flows into Lake Brownwood resulting from water to be utilized from the proposed Coleman and Pecan Bayou Reservoirs.

d. Water supply benefits.- Based on total supplies and demands for water supply on the Pecan Bayou watershed, additional water conservation storage would not be needed until about 1970. The value of water supply storage for municipal, industrial, irrigation, and water-quality-control purposes was based on the cost of constructing single-purpose water supply reservoirs. However, the value of water supply storage was discounted if the storage would be provided prior to the time of need. In the plan-comparison studies, it was assumed that the reconstructed Lake Brownwood, the Lake Brownwood enlargements, or the alternate upstream reservoir units would be constructed by year 1970. Since the total water supply from the investigated reservoirs would not be needed immediately after completion of construction, discounted water supply benefits were used in the plan-comparison and selected-plan studies and were determined by general method described in appendix IV. In the plan-comparison studies, discounted water supply benefits were used as follows: $234,900 for dependable yield of 59 cfs (or for water supply storage in a reconstructed Lake Brownwood) varying to $652,500 for a dependable yield of 85 cfs, to $709,100 for a dependable yield of 91 cfs, and to $945,000 for a dependable yield of 116 cfs. In the selected-plan studies, the total water supply benefits (including water quality control) of the selected plan amounted to $652,500 and were assigned to each reservoir unit in accordance with the plan-formulation sequence.

e. Fish-wildlife and general recreation.- The fish-wildlife and general recreation benefits assigned to the Lake Brownwood enlargement and alternate upstream two-reservoir systems in the plan-comparison studies and to the proposed Coleman and Pecan Bayou Reservoirs in the selected-plan studies are based on an aggregate average annual visitation of 2,000,000 persons during the period 1970-2070. The total fish-wildlife and general recreation benefits resulting from 2,000,000 visitors to an upstream two-reservoir system were equally divided between the two units of the system. However, in the plan-comparison analyses, the first-added reservoir unit upstream from Lake Brownwood was assigned a visitation of 1,400,000. The above visitations were apportioned to fish-wildlife recreation and to general recreation on a 35-65 percentage basis, respectively. The fish-wildlife portion was established as 1.0 percent hunters and 99.0 percent fishermen. The fish-wildlife portion would provide annual fish and wildlife harvest benefits based on $1.00 per hunter and $0.50 per fisherman; and recreation benefits based on $0.50 per fish-wildlife visitor. The annual benefits from the general-recreation portion was based on a recreation value of $0.50 per visitor-day. The water surface areas at top of conservation pools in the maximum Lake Brownwood enlargement and in the Camp Colorado, Burkett, Coleman, and Pecan Bayou Reservoirs would be about 29,460; 7,300; 5,900; 3,900; and 5,200 acres, respectively. Single-purpose reservoirs for recreation only at the Pecan Bayou Reservoir and Coleman Reservoir sites would require a normal surface area of about 3,000 acres.

f. Credit to reservoir units.- The analyses of the investigated general plans in the plan-comparison studies, involving various combinations of one or two reservoirs, were performed under the following conditions: (1) That the design capacity of the Brownwood channel improvements remain the same, and thus, crediting the upstream reservoir with increased flood control benefits and increased protection at Brownwood; and (2) that the extent and cost of protective measures at Lake Brownwood would vary depending upon the control afforded by the upstream reservoir combinations, and thus, crediting the upstream reservoirs with variations in costs.

g. Reservoir studies.- For purposes of project formulation, economic analyses, and cost allocation studies, the reservoir units involved in the investigated plans were analyzed as single-purpose projects for flood control or water conservation; as dual-purpose projects for flood control and water conservation; and as multiple-purpose projects for flood control and water conservation, with and without fish-wildlife and general recreation. Single-purpose reservoirs for flood control were investigated as dry-pool reservoirs, containing no permanent pool capacity below the flood control storage levels. Also, single-purpose reservoirs for fish-wildlife and general recreation purposes were investigated for cost allocation studies. The economic justification of any investigated reservoir unit in the general plans was tested on the basis that the reservoir would be a last-added unit. The unit was considered worthy of inclusion in the general plan if the incremental annual benefits afforded by the added unit exceeded the incremental annual costs of adding the unit. Further, a reservoir unit was considered to be a worthy Federal undertaking if the addition of the flood control and water conservation functions of a last-added reservoir provided an incremental benefit-to-cost ratio of 0.50 or greater, and thence, if the addition of the recreation function increased the incremental economic ratio to at least 1.0. Also, the addition of a next-added or last-added function in a reservoir unit was not justified unless the benefits provided by the added function equalled or exceeded the incremental costs for adding the function.

h. Water quality control.- In its report, the U. S. Public Health Service states that stream flows of about 1.1 mgd in 1970 to 2.1 mgd in 2070 will be necessary for maintaining water-quality objectives. For purposes of project formulation studies, no attempt was made to define or separate these requirements from the overall water supply requirements.

40. PLAN-COMPARISON STUDIES.- The economic and cost analyses as presented by the plan-comparison studies of the preceding tables 2 and 3 indicate that each of the investigated plans is economically justified, but that plan 20, involving the most upstream two-reservoir system (Pecan Bayou and Coleman Reservoirs) is the most favorable on the basis of economy. Plan 14, which involves enlargement of Lake Brownwood, and plan 19, which involves the most downstream two-reservoir system (Camp Colorado and Burkett Reservoirs) have been selected for discussion and comparison with selected plan 20 in the subsequent paragraphs. Plans 14 and 19 have been selected for comparison and discussion with plan 20 even though the plan-comparison studies indicate that plan 13 is more economically favorable than plan 14; and that plans 21 and 22 are more economically favorable than plan 19. However, plans 14 and 19 have been selected on the basis that plan 14 represents maximum economical water supply development on the Pecan Bayou watershed; and that plan 19 represents maximum flood protection and water supply development which could be afforded by investigated upstream reservoir development. A comparison of plans 14, 19, and 20 reveal that each plan provides certain advantages over the other with respect to economy and to the purposes of flood control and water supply. Plans 14, 19, and 20 are considered about equal relative to evaluations of the fish, wildlife, and general recreation functions.

41. The principal basis for selection of plan 20 for recommendation in this report is that plan 20 is less expensive, provides the maximum amount of annual benefits in excess of the annual costs, and thus, is the most economical plan. A summary of costs and benefits in thousands of dollars involving flood control, water conservation, and fish-wildlife and general recreation is as follows:

Item	Plan 14	Plan 19	Plan 20
First cost	$75,491.0	$53,851.0	$42,268.0
Annual charges	2,760.9	2,055.5	1,670.5
Annual benefits	4,259.1	4,129.8	4,020.7
Benefit-cost ratio	1.5	2.0	2.4
Excess benefits over costs	1,498.2	2,074.3	2,350.2
(FC & WC only)	(324.2)	(939.3)	(1,199.6)

42. The flood control analyses of plans 14, 19, and 20 determined that plan 14 would provide greater flood protection for the flood plain areas downstream from Lake Brownwood Dam, but that plans 19 and 20 would more adequately serve the general flood control needs of larger flood-plain areas on the Pecan Bayou watershed and would provide a greater amount of flood control benefits. Plan 19, although less economical, would provide the greater amount of flood control benefits. Selected plan 20 would serve a larger flood plain area. Each of the plans would afford control of 50-year flood volumes originating upstream from the dam sites. With optimum-size Brownwood channel improvements, plans 14, 19, and 20 would provide about 200-year, 140-year, and 100-year protection, respectively, to the Brownwood urban area against Pecan Bayou floods. In addition to flood control benefits of $1,065,400 creditable to the Lake Brownwood protective measures and a reconstructed Lake Brownwood, and of $749,300 creditable to the Brownwood channel improvements, the Lake Brownwood enlargement under plan 14, the Camp Colorado and Burkett Reservoirs under plan 19, and the Coleman and Pecan Bayou Reservoirs under plan 20 would provide additional annual flood control benefits of $145,800, $252,400, and $199,900, respectively, distributed as follows:

	Plan 14	Plan 19	Plan 20
Upstream from Lake Brownwood	$ -	$142,300	$121,800
Pecan Bayou	-	(23,300)	(29,200)
Jim Ned Creek	-	(26,700)	(29,600)
Lake Brownwood area	-	(92,300)	(63,000)
Downstream from Lake Brownwood	136,600	104,000	73,800
Pecan Bayou (Brownwood)*	(43,700)	(38,900)	(28,300)
Pecan Bayou (other)	(92,700)	(65,100)	(45,500)
Total Pecan Bayou area:	136,600	246,300	195,600
Colorado River area:	9,200	6,100	4,300
Grand total:	$145,800	$252,400	$199,900

* Within improved channel reaches

As previously stated, the analyses exclude flood control benefits within the Fox Crossing Reservoir site. The above study on distribution of benefits indicate that plans 14, 19, and 20 afford only small amounts of annual benefits on the Colorado River. However, an ultimate Fox Crossing Reservoir project would act as a unit in a flood control plan for the Colorado River.

43. The water supply analyses of the plan-comparison studies indicate that plans 20, 19, and 14 would provide dependable water supply yields of 85 cfs, 91 cfs, and 116 cfs, respectively; and total water supply benefits of $652,500, $709,100, and $945,000, respectively. Thus, in regard to water supply, plan 20 provides 6 cfs less yield and $56,600 less benefits than plan 19; and 31 cfs less yield and $292,500 less benefits than plan 14. However, plan 20 is the most economical plan as further indicated in the next paragraph. Of the general plans investigated, plan 14 would provide the maximum amount of water resource development on the Pecan Bayou watershed. Plan 14 would develop an additional dependable water supply yield which is about twice as much as provided by plans 19 and 20. However, plan 19 or plan 20 would more economically and efficiently serve the water supply needs of the upper Pecan Bayou watershed, including the needs of the city of Coleman and other cities.

The enlargement of Lake Brownwood under plan 14 would provide a surplus of water supply which would be a potential source to the water-supply-deficiency areas of the upper Colorado River Basin and to the adjacent Abilene, Albany, and Breckenridge areas of the Brazos River Basin. However, reconstructed Lake Brownwood and the Coleman and Pecan Bayou Reservoirs of plan 20 would provide adequately for the water supply needs of the Pecan Bayou watershed to about year 2050. Plan 19, which would provide about 3.0 to 3.8 mgd more water supply than plan 20, would adequately serve the water supply requirements of the watershed to about year 2070. The possible future construction of the Fox Crossing Reservoir on the Colorado River would afford a method for conserving the undeveloped resources of the Pecan Bayou watershed, and thus, such undeveloped resources would not be lost to the upper Colorado River Basin because of the selection of plan 20. In addition, water used for stream quality control would be available for re-use from the Fox Crossing project.

44. In summary, plan 20 is the most economical plan; plan 19 provides the maximum amount of flood control benefits; and plan 14 provides greater water-supply development and benefits and greater flood protection to the Brownwood urban area. However, when analyzed incrementally to the flood control and water supply functions of plan 20, the additional costs involved in plans 14 and 19 to provide the additional benefits, yields, and Brownwood protection are not economically justified, as shown in the following tabulation:

Item	Plan 20	Incremental to plan 20: Plan 19	Incremental to plan 20: Plan 14
	Costs and benefits in thousands of dollars		
Protection at Brownwood:	100-yr	40-yr	100-yr
Annual benefits:	2,667.1	109.1	238.4
(flood control)	(2,014.6)	(52.5)	(-54.1)
(water supply)	(652.5)	(56.6)	(292.5)
Annual costs:	1,467.5	369.4	1,113.8
Benefit-cost ratio:	1.8	0.3	0.2
Excess benefits over costs:	1,199.6	-260.3	-875.4

45. In addition to the above considerations, current oil-gas field developments and activities influenced to a minor extent the selection of

plan 20 over plans 14 and 19. The location of oil and gas fields on the Pecan Bayou watershed upstream from Lake Brownwood is shown on figure 2. Real estate studies indicated that, at the present time, considerable more mineral cost and disruption of oil-and-gas field activities would result by construction of Lake Brownwood enlargement and the Camp Colorado and Burkett Reservoirs.

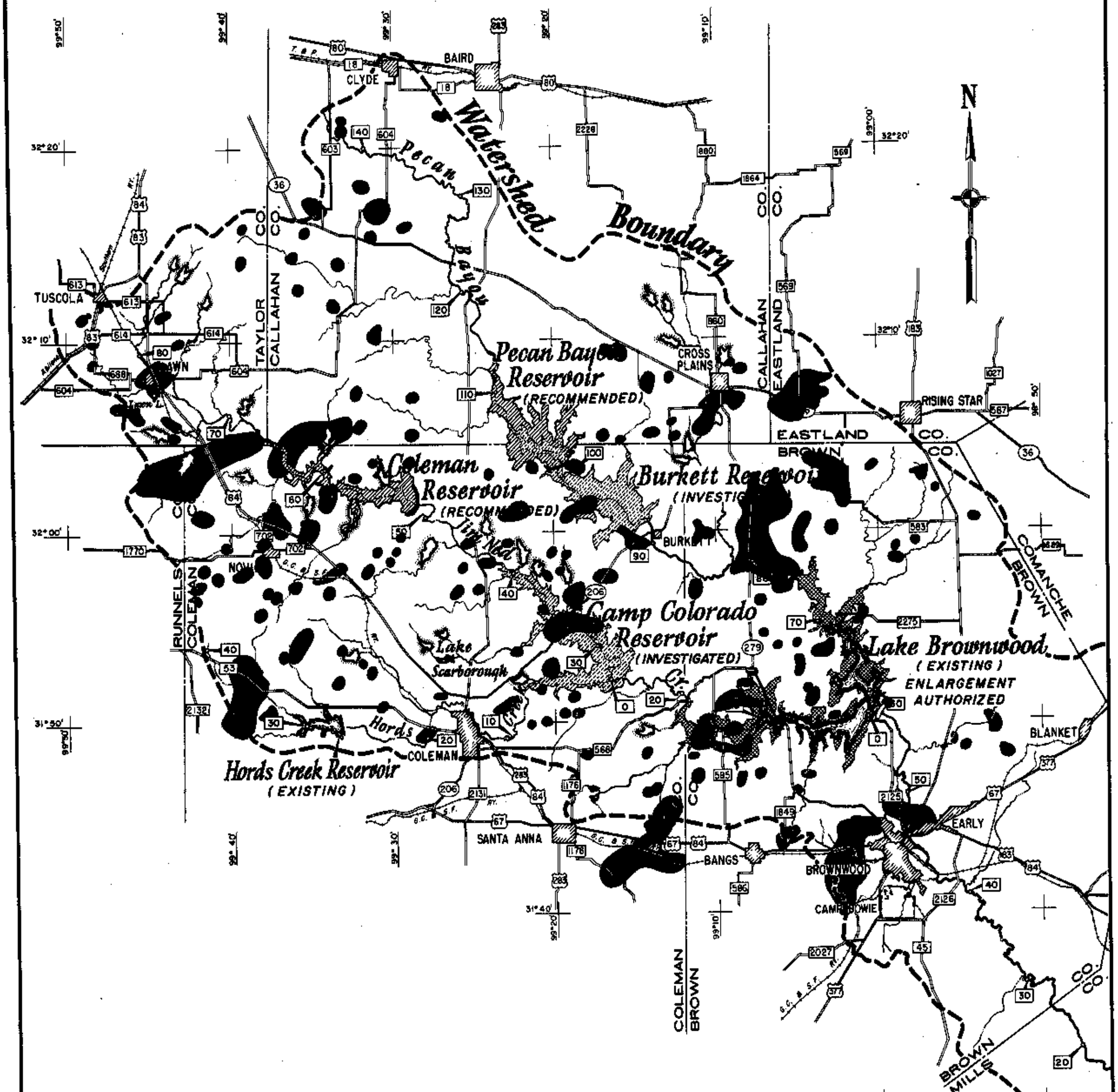
46. A comparison of economic and cost analyses for investigated general plans providing uniform 100-year flood protection at Brownwood is presented by plans 12A through 22A of table 3. The comparison indicates that general plan 20A (plan 20) remains as the most favorable general plan on the basis of excess benefits over costs.

47. Based upon the above considerations, the general plan 20 (or plan 20A) is selected as the most practical and economical plan for purposes of flood control, water supply, fish and wildlife, and general recreation on the Pecan Bayou watershed.

48. SELECTED-PLAN STUDIES.- The conversion of plan 20 of the plan-comparison studies to plans 20B and 20C of the selected-plan studies involved the following refinements and alternate considerations: (a) the revision of dependable water supply yields to reflect the effects of the potential Soil Conservation Service program; (b) the provision of minor spillway protective measures in the reconstruction of Lake Brownwood Dam and the provision of outlet works of 10-foot-diameter size in lieu of the 20-foot-diameter conduit used in the plan-comparison studies; and (c) enlargement of the Brownwood channel-improvement capacities to provide greater flood protection to the Brownwood urban area.

49. The selected-plan studies as shown in the preceding table 2 present a comparison of plans 2B and 20B with plans 2C and 20C for consideration of increased flood protection at Brownwood. Plans 2B and 2C (involving only reconstructed Lake Brownwood and Brownwood channel improvements) would provide 57-year and 100-year protection, respectively, within the improved flood plain reaches at Brownwood. The comparison indicates that plan 2B (with optimum-size channel improvements) is more economically favorable than plan 2C on the basis of providing the maximum amount of flood control benefits in excess of the annual costs. Plan 20B and 20C (involving the addition of the Coleman and Pecan Bayou Reservoirs to plans 2B and 2C, respectively) would increase the degree of flood protection at Brownwood against Pecan Bayou flood flows to about 100-year and 180-year protection, respectively.

50. The decision to select plan 20B, which includes channel-improvement components of optimum-size, or plan 20C, which includes channel improvement components of greater than optimum size, would be dependent upon the magnitude of potential development within the investigated Brownwood urban reaches along Pecan Bayou, Adams Branch, and Willis Creek.



PECAN BAYOU WATERSHED

OIL AND GAS FIELDS

SCALE IN MILES

51. The city of Brownwood has a current population of about 17,000 persons. Based on existing or 1960 conditions of development within the investigated flood plain reaches at Brownwood, the value of physical property is about $48,314,000, and the average annual flood damages are estimated to be about $602,500. An economic base study for the period 1970 through 2070 indicates that by the year 2070 the population of Brownwood will ultimately reach about 40,000. The value of physical property within the flood plain reaches at Brownwood is predicted to be about $72,805,000 by year 1970 and about $304,621,000 by year 2070. The potential average annual flood damages at Brownwood for the 100-year period (1970-2070) are estimated to be about $1,701,300.

52. The economic analysis presented in the preceding paragraph indicates that substantial increases in population, value of physical property, and average annual damages are anticipated in the Brownwood urban area during the period 1970-2070. The analysis substantiates that urban Brownwood is a potentially serious flood problem area worthy of standard project flood protection. Preliminary plan of improvement studies determined that standard project flood protection by means of reservoir, channels, and levees is not practical and is not economically justified on the basis of an overall analysis of benefits and costs. However, these studies determined that channel improvements of optimum size, or greater, could provide substantial protection to Brownwood and could eliminate a high percentage of the potential total average annual damages.

53. Analyses were made of the improved reaches at Brownwood to determine the effects on residual damages, benefits, costs, and excess benefits over costs resulting from the channel improvement units contained in plans 2B and 20B and plans 2C and 20C of the selected-plan studies, table 2. The analyses are presented in table 6. In comparison with plan 2B, plan 2C would provide an additional reduction in annual damages of $23,000 at an additional annual cost of $77,900, and further, would provide an additional 43-year protection at Brownwood against floods originating on Pecan Bayou, Adams Branch, and Willis Creek. In comparison with plan 20B, plan 20C would provide an additional reduction in annual damages of $13,000 at an additional annual cost of $77,900, and further, would provide additional flood protection at Brownwood, amounting to an 80-year increase on Pecan Bayou and to a 43-year increase on Adams Branch and Willis Creek. Thus, the provision of Brownwood channel improvements of greater-than optimum size under plan 20C would result in a reduction of $64,900 in excess benefits over costs; but this loss would be compensated by a substantial increase in flood protection at Brownwood and by an additional 1.6 percent reduction in total annual damages.

54. The adoption of plan 20C as the recommended plan is considered to be warranted in view of the large increase in local flood protection to be afforded the Brownwood urban area, particularly in consideration of reducing loss of life and health hazards, and providing greater security against major flood conditions.

55. The economic justification of the recommended plan (plan 20C) was further tested by analyzing each unit of the plan on a last-added basis. The analyses indicated that each unit was economically justified on a last-added basis. A summary of the analyses made for each unit of the recommended plan, based on crediting benefits for last-added, first-added, sequence-as-formulated, and system-proportion conditions, are presented in table 7. The system-proportion or fair-share benefits were adopted for the proposed individual units and were utilized for the cost allocation studies. The analyses shown in table 7 are based on a current interest rate of 3.0 percent.

55A. ADVERSE EFFECT FROM PROPOSED PLAN.- Construction of the Coleman Reservoir unit of the proposed plan of improvement would adversely affect the existing Soil Conservation Service program on the subwatershed area of Jim Ned Creek. The proposed Coleman unit would physically damage existing flood detention structures numbers 11, 21, and 22 which are shown on plate 6, appendix III. The three structures would cause a total physical damage of about $662,500. Investigations reveal that it would be impossible to construct a multiple-purpose reservoir on Jim Ned Creek without adversely affecting the operation of a number of existing flood-detention structures. Multiple-purpose reservoir sites investigated on Jim Ned Creek include the Camp Colorado site with dam at stream mile 26.2; the proposed Coleman site with dam at mile 52.2; and the lower Coleman site with dam at mile 46.4. The Camp Colorado site is involved in the framework plan of the U. S. Study Commission - Texas. The proposed Coleman site is essentially the same as involved in the Texas Water Commission plan for meeting the 1980 water requirements of Texas. The lower Coleman site was briefly investigated subsequent to field level review as a likely alternate site having minimum adverse effects on the existing flood-detention program. Topographic mapping in the vicinity of the lower Coleman site was recently made available by the U. S. Geological Survey. Based on information furnished by the Soil Conservation Service, monetary evaluations of the adverse effects on the flood-detention program as would be caused by construction of the three multiple-purpose reservoirs are summarized as follows:

	Proposed Coleman	Lower Coleman	Camp Colorado
Annual damage to structures physically damaged.	$25,752(-)	$12,546(-)	$ 2,286(-)
Annual benefits within major reservoir lost to other structures not physically damaged.	14,457(-)	10,646(-)	41,668(-)
Annual benefits creditable to major reservoir acting as reliable substitute for structures physically damaged.	20,465(+)	23,264(+)	8,797(+)
Net annual loss or gain	$19,744(-)	$ 72(+)	$35,157(-)

Based on the above summary, it is apparent that the lower Coleman site would have the least adverse effect on the existing flood-detention program. The advantages and comparable economic merit of the lower Coleman site will be investigated during preconstruction planning. The benefit-cost ratio for the proposed Coleman Reservoir unit is 2.30, as shown in table 4 of this appendix. Integration of the adverse annual economic costs and the creditable annual benefits into the economic analysis for the proposed Coleman Reservoir unit would only reduce the benefit-cost ratio to 2.17. The Coleman Reservoir unit is retained in the proposed plan of improvement on the basis of the following: (a) The Coleman unit would act as a reliable substitute for flood-retarding structures physically damaged; (b) a reevaluation of the proposed Coleman unit to include recognition of such adverse effects in monetary terms indicates that the overall benefit-cost ratio is not appreciably affected; (c) the Coleman and Pecan Bayou Reservoir units are the most practical and economical means of developing a substantial portion of available water resources of the Pecan Bayou watershed for current and future water supply needs; (d) local interests of Coleman and Brown County are in perfect agreement for joint participation in maximum economical water supply development to be afforded by the proposed Coleman and Pecan Bayou Reservoirs; (e) Coleman County interests have recently reiterated their urgent need and desire for construction of the proposed multiple-purpose Coleman Reservoir on Jim Ned Creek; and (f) deletion of the proposed Coleman Reservoir would not be in accordance with the desires of local interests and would not be in keeping with good planning concepts for development of water resources.

55B. FLOOD CONTROL TEST.- The following tabulation shows the year in which the average annual flood control benefits apportioned on a system basis to each separate unit of the proposed plan of improvement would equal the allocated annual charges for the unit:

Proposed Flood-Control Unit	Year in which average annual benefits would exceed annual charges: With Fox Crossing Reservoir	Year in which average annual benefits would exceed annual charges: Without Fox Crossing Reservoir
Reconstructed Lake Brownwood	1963	1963
Brownwood Channel Improvement	1972	1972
Coleman Reservoir	1978	1975
Pecan Bayou Reservoir	1973	1970

TABLE 6

COMPARISON OF 57-YEAR AND 100-YEAR FLOOD PROTECTION WITHIN IMPROVED REACHES AT BROWNWOOD AS PROVIDED BY BROWNWOOD CHANNEL IMPROVEMENTS
(Analyzed incrementally to reconstructed Lake Brownwood)

Item	Incremental to reconstructed Lake Brownwood					
	Plan 2B	Incremental	Plan 2C	Plan 20B	Incremental	Plan 20C
	Without Pecan Bayou and Coleman Reservoirs			With Pecan Bayou and Coleman Reservoirs		
Protection against floods:						
a. Pecan Bayou (mile 37.8-47.6)	57-yr.	43-yr.	100-yr.	100-yr.	80-yr.	180-yr.
b. Adams Branch (mile 0.0-6.1)	57-yr.	43-yr.	100-yr.	57-yr.	43-yr.	100-yr.
c. Willis Creek (mile 0.0-3.9)	57-yr.	43-yr.	100-yr.	57-yr.	43-yr.	100-yr.
Annual charges (channels), $1000:	429.3	77.9	507.2	429.3	77.9	507.2
Annual flood damages, $1000:						
a. Total damages	811.5	0.0	811.5	811.5	0.0	811.5
b. Total damages prevented	749.3	23.0	772.3	777.6	13.0	790.6
(1) By channels	(749.3)	(23.0)	(772.3)	(749.3)	23.0	(772.3)
(2) By reservoirs*	-	-	-	(28.3)	-10.0	(18.3)
c. Residual damages	62.2	23.0	39.2	33.9	13.0	20.9
d. Percent reduction in total damages	92.3	2.9	95.2	95.8	1.6	97.4
Benefit-cost ratio:	1.7	0.3	1.5	1.8	0.2	1.6
Excess benefits over costs, $1000:	320.0	54.9	265.1	348.3	64.9	283.4

* By Pecan Bayou and Coleman Reservoirs as last-added units.

TABLE 7
SUMMARY OF ECONOMIC AND COST ANALYSES
RECOMMENDED PROJECTS
PECAN BAYOU WATERSHED
(July 1963 price level)
(Interest rate, 3% - Amortization period, 100 yrs)

Item	Basis for benefit-cost analyses: System proportion	Sequence as formulated	First-added	Last-added
RECONSTRUCTED LAKE BROWNWOOD				
1. Total annual benefits:	$ 828,300	$1,308,300	$1,308,300	$405,000
a. Flood control	(637,300)	(1,065,400)	(1,065,400)	(329,400)
b. Water supply	(191,000)	(242,900)	(242,900)	(75,600)
2. Total annual charges:	286,400	286,400	286,400	286,400
3. Benefit-cost ratio:	2.9	4.6	4.6	1.4
BROWNWOOD CHANNEL IMPROVEMENT				
1. Total annual benefits:	947,400	772,300	1,425,400	631,500
a. Flood control	(947,400)	(772,300)	(1,425,400)	(631,500)
2. Total annual charges:	523,900	523,900	523,900	523,900
3. Benefit-cost ratio:	1.8	1.5	2.7	1.2
COLEMAN RESERVOIR				
1. Total annual benefits:	1,143,100	1,280,800	1,574,300	690,800
a. Flood control	(207,200)	(94,500)	(305,400)	(92,700)
b. Water supply	(229,700)	(209,400)	(292,000)	(162,600)
c. Water quality control	(29,400)	(29,400)	(29,400)	(29,400)
d. Recreation (Including fish and wildlife recreation)	(676,800)	(947,500)	(947,500)	(406,100)
2. Total annual charges:	496,300	496,300	496,300	496,300
3. Benefit-cost ratio:	2.3	2.6	3.2	1.4
PECAN BAYOU RESERVOIR				
1. Total annual benefits:	1,137,200	694,600	1,578,700	694,600
a. Flood control	(235,700)	(95,400)	(353,200)	(95,400)
b. Water supply	(195,300)	(163,700)	(248,600)	(163,700)
c. Water quality control	(29,400)	(29,400)	(29,400)	(29,400)
d. Recreation (Including fish and wildlife recreation)	(676,800)	(406,100)	(947,500)	(406,100)
2. Total annual charges:	454,900	454,900	454,900	454,900
3. Benefit-cost ratio:	2.5	1.5	3.5	1.5
TOTAL RECOMMENDED PLAN				
1. Total annual benefits:	4,056,000	4,056,000		
a. Flood control	(2,027,600)	(2,027,600)		
b. Water supply	(616,000)	(616,000)		
c. Water quality control	(58,800)	(58,800)		
d. Recreation (Including fish and wildlife recreation)	(1,353,600)	(1,353,600)		
2. Total annual charges:	1,761,500	1,761,500		
3. Benefit-cost ratio:	2.3	2.3		

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LAKE BROWNWOOD PROTECTIVE MEASURES
(RECONSTRUCTED LAKE BROWNWOOD)

56. GENERAL.- Based on investigations, studies, and analyses, the existing Lake Brownwood Dam is regarded as unsafe and, therefore, is an existing flood hazard to the downstream Pecan Bayou Valley, including urban Brownwood. The existing dam and spillway are inadequate to safely withstand extreme flood conditions. The existing spillway has insufficient capacity to pass the standard project flood without utilizing all available freeboard of the existing dam. The safety factor of the existing earth embankment is below the minimum value considered adequate for an earthen structure. There is no assurance the dam would not fail on recurrence of the maximum flood of record. Strengthening measures, such as grouting and additional compacted fill, are needed to insure the stability of the existing embankment. Erosion control measures are needed to prevent or reduce deterioration of the spillway channel. In addition, the existing outlet works are virtually inoperative and are in need of replacement.

57. The seriousness of the Lake Brownwood problems establishes the provision of Lake Brownwood protective measures as an urgently needed measure and as a prerequisite to any additional flood control developments within the downstream Pecan Bayou flood plain area. Protective measures to provide a reconstructed Lake Brownwood project would prevent the possibility of catastrophic flood conditions within the downstream area, would extend the useful life of Lake Brownwood, and would insure its continued operation as an effective means of reducing flood peaks and damages within the downstream Pecan Bayou area and as the principal existing source of water supply on the Pecan Bayou watershed.

58. Failure of the Lake Brownwood Dam would result in loss of lives and an enormous amount of damages. The damages by one such failure are estimated to be about $40,000,000.

59. The flood control benefits creditable to a reconstructed Lake Brownwood project for reducing the magnitude of flood peaks to the downstream area is estimated to be about $1,065,400 annually. These benefits are based on the difference in estimated average annual damages without and with a reconstructed Lake Brownwood.

60. The water supply benefits used in the selected-plan studies and credited to a reconstructed Lake Brownwood project for preventing loss of existing water supply is estimated to be about $234,900 annually. These benefits are slightly discounted and are derived from annual charges of $236,300 for constructing and operating a water

supply project at the Lake Brownwood site. The annual charges were based on a construction cost of $6,635,000, including costs of dam, spillway, lands, and small capacity outlet works.

61. A plan for protective measures to provide a reconstructed Lake Brownwood would not involve provision of additional storage, acquisition of additional reservoir lands, nor relocation or alteration of roads, utilities, or other improvements. The plan would not include provisions to increase the recreation facilities at Lake Brownwood since existing facilities adequately serve present private and public visitations. The existing Lake Brownwood shoreline area has experienced considerable private and commercial recreation development and the recreational advantages are supplemented by the existing Texas State park facilities.

62. PLANS FOR PROTECTIVE MEASURES.- Two general alternate plans of protective measures were investigated for Lake Brownwood Dam. The two plans were compared under the two extremes of upstream conditions: (1) that no flood control reservoirs would be in operation on Jim Ned Creek and Pecan Bayou upstream from Lake Brownwood; and (2) that the most downstream two-reservoir system (Camp Colorado and Burkett Reservoirs on Jim Ned Creek and Pecan Bayou respectively) would be in operation. The first plan, represented by plans LB-1 and LB-2, consists of strengthening the existing embankment, retaining approximately the same height as the existing dam; the construction of a concrete ogee spillway, controlled by tainter gates; and the provision of sluices in the spillway system. The second plan, represented by plans LB-3 and LB-4, consists of the construction of a new embankment to the height necessary to prevent overtopping by the spillway design flood; the utilization of the existing natural spillway; and the provision of new outlet works of 20-foot-diameter size in the new embankment. The cost studies indicate that both methods are economically justified, but that the second plan would be the most economical means of providing the necessary protective measures. Consideration was also given to a plan which involved paving the existing embankment. However, this plan was not considered as economical and practical as the second plan, due to the height of the existing dam, the need to strengthen the existing structure, and the need for replacement of existing outlet works. The first costs and annual charges for the first and second plans are presented in table 8, page I-51. The cost of the protective measures and the value of existing lands and usable facilities would constitute the total cost of a reconstructed Lake Brownwood.

63. The second plan was adopted for use in the plan-comparison studies. Flood routing studies indicated the need to increase the height of Lake Brownwood Dam by 22 to 16 feet, depending upon the control afforded under conditions (1) and (2) stated above. The 20-foot-size outlet works used in the plan-comparison studies would

provide substantial reductions in spillway flows, and thus, reduce the amount of erosion in the spillway channel. Plan LB-5 represents the Lake Brownwood protective measure when in combination with the Pecan Bayou and Coleman Reservoirs under plan 20 of the plan-comparison studies.

64. The adopted plan was modified for use in the selected-plan studies. The plan was revised as follows: The provision of new outlet works of 10-foot-diameter size in lieu of 20-foot-diameter size; and the provision of erosion-control measures in the existing channel spillway. Based on additional study and consideration of a 100-year project life, it was concluded that a certain amount of erosion-control measures should be included in the selected plan, and thus, with these measures the size of the outlet works could be reduced. The first costs and annual charges of the revised plan, represented as plan LB-6, is summarized in table 8, page 120.

65. SPILLWAY EROSION CONTROL.- The existing spillway channel, located northeast of the embankment, was constructed by excavating through natural rock. Local interests added a concrete sill to serve as a control in the spillway channel. The spillway approach channel extends about 700 feet upstream of the sill. Downstream of the concrete sill the spillway channel has eroded considerably. At the nearest point, the distance from the concrete sill to the start of a series of cave-offs is about 340 feet. The cave-offs consist of limestone ledges separated by layers of shale and clay. As water spills over the ledges, it erodes the shale and clay layers, leaving the rock overhanging. The rock layers in turn break off. Due to the massiveness of the spillway section, when considered parallel to the direction of flow, there appears to be no danger of abrupt total failure either by slippage or by the erosive action during a single flood. However, if the erosive action is not stopped, several large floods could result in the need for expensive remedial measures.

66. The spillway erosion-control plan used in the selected-plan studies would provide principally for construction of concrete curtain walls to protect the exposed alternate layers of shale and limestone at the drop-off areas; the disposal of loose boulders and rubble within the spillway channel just downstream from the drop-off areas; and utilization of such material as protection stone along the abutments of the concrete weir sill and for filling deep gouges within the spillway channel. A permanent-type plan providing for a concrete spillway channel section, was considered as an alternative; however, the above-described plan was determined to be most practical and economical as an erosion-check plan operating in combination with the outlet works.

67. SUPPORTING DATA.- In regard to the plan of Lake Brownwood protective measures utilized in the selected-plan studies, pertinent data for reconstructed Lake Brownwood is presented in table 9; detailed estimate of first costs are presented in table 10; and design details of dam and of spillway erosion-control measures are presented on plates 2 and 3.

TABLE 8

INVESTIGATED PLANS
PROTECTIVE MEASURES - RECONSTRUCTED LAKE BROWNWOOD
PECAN BAYOU WATERSHED
(July 1963 price level)
(in 1,000 dollars)

Plan	Description
LB-1	Modify existing spillway by construction of a concrete ogee section with sluices and tainter gates; raise two feet and strengthen existing embankment; and block existing outlet-works conduit. Lake Brownwood without upstream reservoirs.
LB-2	Modify existing spillway by construction of a concrete ogee section with sluices and tainter gates; strengthen existing dam; and block existing outlet-works conduit. This dam is a unit in a plan composed of three reservoirs - Lake Brownwood and Camp Colorado and Burkett Reservoirs.
LB-3	Construct new dam just downstream from the existing dam to top elevation of 1472.0; construct new outlet works (20-foot conduit) through the new dam; provide new low-flow facilities; and breach and partially remove old dam. No revisions proposed for the existing spillway. Lake Brownwood without upstream reservoirs.
LB-4	Construct new dam just downstream from existing dam to top elevation of 1466.0; construct new outlet works (20-foot conduit) through new dam; provide new low-flow facilities; and breach and partially remove old dam. No revisions proposed for existing spillway. This dam is a unit in a plan composed of three reservoirs - Lake Brownwood and Camp Colorado and Burkett Reservoirs.
LB-5	Construct new dam just downstream from existing dam to top elevation of 1469.0; construct new outlet works (20-foot conduit) through new dam; provide new low-flow facilities; and breach and partially remove old dam. No revisions proposed for existing spillway. This dam is a unit in a plan composed of three reservoirs - Lake Brownwood and Coleman and Pecan Bayou Reservoirs.
LB-6	Construct new dam just downstream from existing dam to top elevation of 1469.0; construct new outlet works (10-foot conduit) through new dam; provide new low-flow facilities; add erosion-control measures to the existing spillway; breach and partially remove old dam. This dam is a unit in a plan composed of three reservoirs - Lake Brownwood and Coleman and Pecan Bayou Reservoirs.

Item	Alternate plan studies: Plan LB-1	Alternate plan studies: Plan LB-2	Comparison plan studies: Plan LB-3	Comparison plan studies: Plan LB-4	Comparison plan studies: Plan LB-5	Selected plan studies: Plan LB-6
PERTINENT DATA						
Top of dam, elevation	1452.0	1450.0	1472.0	1466.0	1469.0	1469.0
Top of gates, elevation	1435.0	1440.0	--	--	--	--
Spillway crest, elevation	1405.0	1409.0	1425.0	--	--	1425.0
Top of conservation pool, elevation	1425.0	1425.0	1425.0	1425.0	1425.0	1425.0
FIRST COST						
1. FEDERAL FIRST COST (PROTECTIVE MEASURES)						
Lands and damages	--	--	40.0	40.0	40.0	40.0
Dam	10,242.0	8,269.0	3,901.0	3,728.0	3,810.0	2,700.0
a. Embankment	(256.0)	(225.0)	(1,330.0)	(1,230.0)	(1,267.0)	(1,267.0)
b. Slope protection	(6.0)	(6.0)	(6.0)	(6.0)	(6.0)	(6.0)
c. Spillway	(9,980.0)	(8,269.0)	--	--	--	(314.0)
d. Outlet works	--	--	(2,415.0)	(2,360.0)	(2,397.0)	(973.0)
e. Irrigation outlet	--	--	(150.0)	(132.0)	(140.0)	(140.0)
Operating equipment	20.0	20.0	20.0	20.0	20.0	20.0
Engineering and design	464.0	380.0	178.0	169.0	177.0	125.0
Supervision and administration	678.0	570.0	261.0	253.0	260.0	175.0
Total Federal first cost -	11,404.0	9,240.0	4,400.0	4,210.0	4,307.0	3,060.0
2. NON-FEDERAL FIRST COST (EXISTING LANDS AND FACILITIES						
Lands and damages	3,840.0	3,840.0	3,840.0	3,840.0	3,840.0	3,840.0
Dam	358.0	358.0	358.0	358.0	358.0	358.0
a. Spillway	(358.0)	(358.0)	(358.0)	(358.0)	(358.0)	(358.0)
Engineering and design	17.0	17.0	17.0	17.0	17.0	17.0
Supervision and administration	25.0	25.0	25.0	25.0	25.0	25.0
Total non-Federal first cost	4,240.0	4,240.0	4,240.0	4,240.0	4,240.0	4,240.0
3. TOTAL FIRST COST OF RECONSTRUCTED PROJECT	15,644.0	13,480.0	8,640.0	8,450.0	8,547.0	7,300.0
ANNUAL CHARGES						
(Interest rate - 2.875%)(Amortization period - 100 years)						
Construction period, years	3	3	3	3	3	3
1. FEDERAL INVESTMENT						
a. Federal first cost	11,404.0	9,240.0	4,400.0	4,210.0	4,307.0	3,060.0
b. Interest during construction	492.0	398.0	190.0	182.0	186.0	132.0
Total Federal investment	11,896.0	9,638.0	4,590.0	4,392.0	4,493.0	3,192.0
2. NON-FEDERAL INVESTMENT						
a. Non-Federal first cost	4,240.0	4,240.0	4,240.0	4,240.0	4,240.0	4,240.0
b. Interest during construction	183.0	183.0	183.0	183.0	183.0	183.0
Total non-Federal investment	4,423.0	4,423.0	4,423.0	4,423.0	4,423.0	4,423.0
3. FEDERAL ANNUAL CHARGES						
a. Interest on investment	341.9	277.1	132.0	126.3	129.2	91.8
b. Amortization of investment	21.3	17.3	8.2	7.9	8.0	5.7
c. Maintenance & operation	--	--	--	--	--	--
Total Federal annual charges	363.2	294.4	140.2	134.2	137.2	97.5
4. NON-FEDERAL ANNUAL CHARGES						
a. Interest on investment	127.2	127.2	127.2	127.2	127.2	127.2
b. Amortization of investment	7.9	7.9	7.9	7.9	7.9	7.9
c. Maintenance and operation (including replacement of parts)	60.0	60.0	45.0	45.0	45.0	45.0
Total Non-Federal annual charges	195.1	195.1	180.1	180.1	180.1	180.1
5. TOTAL ANNUAL CHARGES OF PROJECT	558.3	489.5	320.3	314.3	317.3	277.6

TABLE 9

PERTINENT DATA
PROPOSED RECONSTRUCTED LAKE BROWNWOOD
(IN OPERATION WITH COLEMAN AND PECAN BAYOU RESERVOIRS)
PECAN BAYOU WATERSHED

Item	Existing Lake Brownwood				Reconstructed Lake Brownwood			
DRAINAGE AREA								
Square miles	1,544				1,544			
SPILLWAY DESIGN FLOOD								
Peak inflow, cfs	708,300				676,200			
Volume, acre-feet	1,605,800				1,613,600			
Volume, inches	19.50				19.60			
Peak outflow, cfs	(1)				352,800 (2)			
RESERVOIR	Elev.(3) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Elev.(3) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
Top of dam	1450.0	--	--	--	1469.0	--	--	--
Maximum design water surface	(1)	--	--	--	1464.1	30,600	812,100	9.86
Top conservation pool	1425.0	7,570	124,600	1.51	1425.0	7,570	124,600	1.51
Sediment storage	1425.0	--	49,700	0.60	1425.0	--	33,000	0.40
DAM								
Type	Earth fill				Earth fill			
Total length, feet	2,060				2,330 (4)			
Embankment section:								
Type	Compacted earth fill				Compacted earth fill			
Total length, feet	1,580				1,850			
Height above streambed, feet	110				129			
Freeboard, feet	(1)				4.9			
Crown width, feet	20				20			
Side slopes:								
Upstream	1 on 2 & 1 on 3				1 on 2-1/2 & 1 on 3-1/2			
Downstream	1 on 2				1 on 2-1/2 & 1 on 3			
Spillway section:								
Type	Broadcrested				Broadcrested			
Gross length, feet	480				480			
Net length, feet	480				480			
Spillway discharge, cfs:								
Maximum design water surface	(1)				349,300			
OUTLET WORKS								
Type	Gate-controlled conduit				Gate-controlled conduit			
Number of conduits	2				1			
Dimensions	9' horseshoe shaped				10' diameter			
Invert elevation, feet	1330.0				1342.0			
Control	2 - 24" outlets, usable				2 - 5' x 10' tractor-type gates			
OUTLET WORKS (for irrigation)								
Type	Conduit				Conduit			
Dimensions	5' diameter				5' diameter			
Invert elevation, feet	1406.0				1406.0			
Control	Gate				Gate			
LANDS								
Dam and reservoir								
Land acquisition:								
Fee simple, acres	7,570				7,720			
(Top control elevation)	(1425.0)				(1425.0)			
Flood easements, acres	4,250 (1425.0 - 1435.0)				4,250 (1425.0 - 1435.0)			

(1) Embankment will be overtopped
(2) Includes discharge through outlet works as follows: 3,500 cfs
(3) All elevations refer to mean sea level
(4) Includes 480-foot spillway

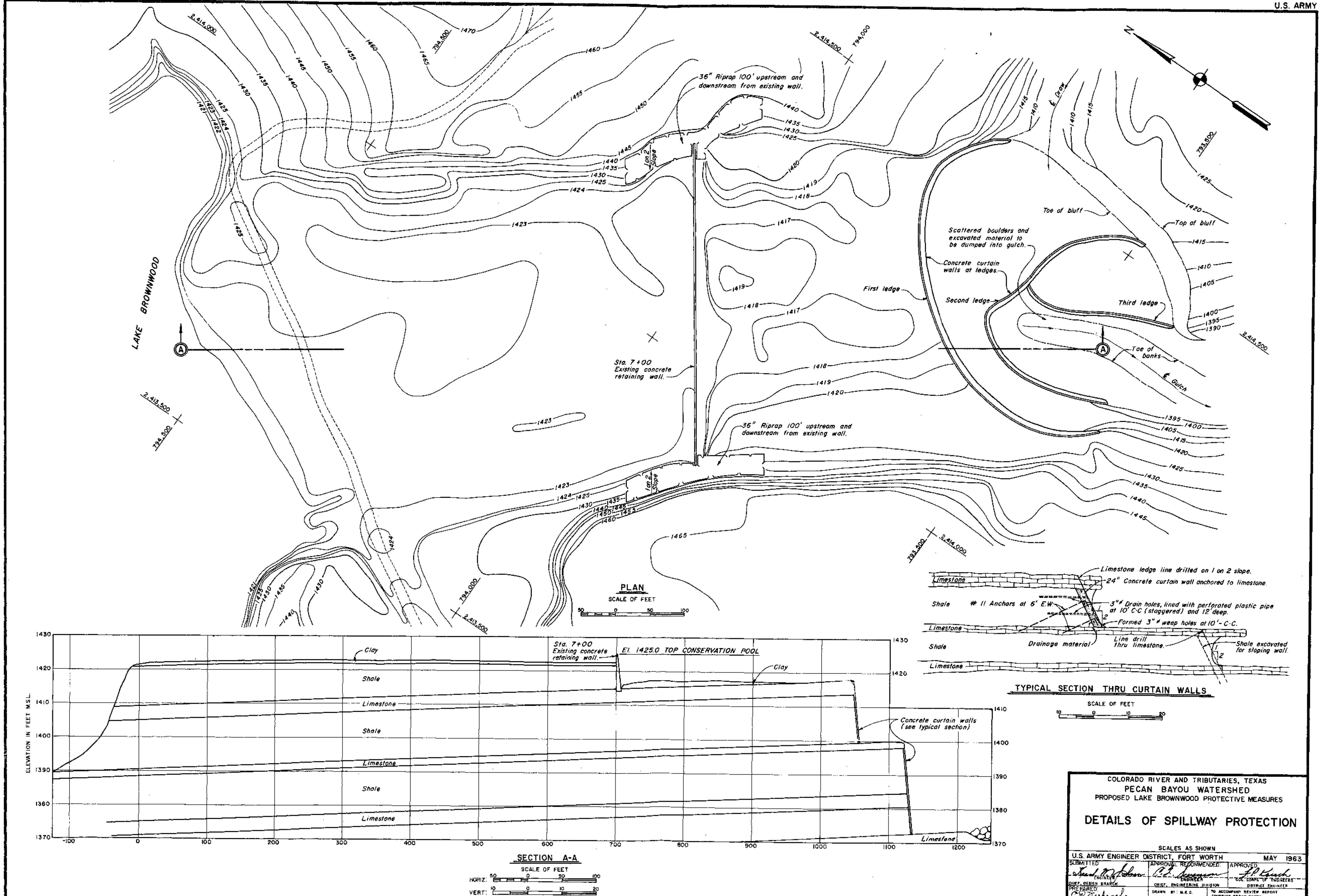
TABLE 10

DETAILED ESTIMATE OF FIRST COST
PROPOSED PROTECTIVE MEASURES AT LAKE BROWNWOOD DAM
PECAN BAYOU WATERSHED
(July 1963 price level)

Item	Unit Quantity	Unit Cost	Quantity	Cost
PERTINENT INFORMATION				
Top of dam elevation		1469.0		
Spillway crest, elevation		1425.0		
A. FEDERAL FIRST COST (PROTECTIVE MEASURES)				
(01.0) Lands & damages	L.S.			$ 40,000
(04.0) Dams				
a. Earth embankment				
(1) Diversion and care of water	L.S.	--	--	11,000
(2) Clearing and grubbing	Acre	$150.00	22	3,300
(3) Excavation, stripping	C.Y.	0.25	32,800	8,200
(4) Excavation, common	C.Y.	0.25	55,200	13,800
(5) Excavation, borrow	C.Y.	0.26	1,513,500	393,500
(6) Compacted fill	C.Y.	0.08	1,402,500	112,200
(7) Drainage blanket	C.Y.	3.50	68,800	240,800
(8) Riprap	C.Y.	6.00	15,000	90,000
(9) Bedding	C.Y.	3.50	6,860	24,000
(10) Flexible base	C.Y.	4.50	760	3,400
(11) Aggregate	C.Y.	6.00	70	400
(12) Asphalt treatment	Gal.	0.20	2,500	500
(13) Timber guide posts	Ea.	5.00	200	1,000
(14) Grouting	L.S.	--	--	100,000
(15) Breaching & partial removal of existing embankment	L.S.	--	--	50,000
Subtotal - earth embankment				1,052,100
b. Slope protection	Acre	500.00	10	5,000
c. Spillway				
(1) Care of water	Sum	--	--	7,000
(2) Excavation. Unclassified	C.Y.	2.00	7,100	14,200
(3) Drill and grout anchor holes	L.F.	2.25	16,900	38,025
(4) Line drilling	S.F.	1.75	5,600	9,800
(5) Concrete, curtain wall	C.Y.	50.00	1,800	90,000
(6) Cement	Bbl.	5.00	2,250	11,250
(7) Reinforcing steel	Lb.	0.15	253,000	37,950
(8) Drill 3" ϕ drain holes lined with perforated plastic pipe	L.F.	4.00	2,100	8,400
(9) Riprap	C.Y.	7.00	2,330	16,310
(10) Cleanup	L.S.	--	--	29,000
Subtotal - spillway				261,935
d. Outlet works				
(1) Care of water during construction	L.S.	--	--	25,000
(2) Clearing	Acre	150.00	5	750
(3) Excavation, common	C.Y.	0.35	23,000	8,050
(4) Excavation, rock (shale)	C.Y.	1.00	22,000	22,000
(5) Backfill, structural	C.Y.	1.50	8,000	12,000
(6) Operating house	L.S.	--	--	26,000
(7) Concrete, control tower	C.Y.	50.00	1,260	63,000
(8) Concrete, tower base and transition	C.Y.	40.00	950	38,000
(9) Concrete, conduit	C.Y.	35.00	1,540	53,900
(10) Concrete, slab	C.Y.	22.00	570	12,540
(11) Concrete, walls	C.Y.	30.00	2,910	87,300
(12) Concrete, bridge	C.Y.	50.00	170	8,500
(13) Cement	Bbl.	4.50	9,360	42,100
(14) Steel, reinforcement	Lb.	0.13	898,000	116,740
(15) Steel, structural	Lb.	0.30	42,400	12,720
(16) Pipe railing	Lb.	0.50	1,600	800
(17) Metal, miscellaneous	Lb.	0.50	1,400	700
(18) Ladders, grating, and grills	Lb.	0.50	1,400	700
(19) Conduit liner	Lb.	0.30	128,000	38,400
(20) Rubber water stop	L.F.	3.00	700	2,100
(21) Water gages, tile	L.F.	12.00	50	600
(22) Gates and operating equipment	L.S.	--	--	170,000
(23) Bulkhead	L.S.	--	--	16,000
(24) Overhead crane	L.S.	--	--	27,000
(25) Electrical facilities	L.S.	--	--	11,000
(26) Riprap	C.Y.	7.00	1,700	11,900
(27) Bedding	C.Y.	5.00	640	3,200
Subtotal - outlet works				811,000
e. Irrigation outlet works				
(1) Excavation, common	C.Y.	0.35	571	200
(2) Excavation, rock	C.Y.	1.20	1,400	1,680
(3) Backfill	C.Y.	1.00	230	230
(4) Close line drilling	S.F.	1.50	5,000	7,500
(5) Foundation clean-up	Square	3.00	40	120
(6) Concrete, intake structure	C.Y.	32.00	240	7,680
(7) Concrete, conduit	C.Y.	30.00	750	22,500
(8) Concrete, headwalls	C.Y.	35.00	16	560
(9) Concrete, service bridge	C.Y.	60.00	275	16,500
(10) Drilling 3" anchor holes	L.F.	2.25	520	1,170
(11) Foundation grouting	L.S.	--	--	5,250
(12) Concrete, canal lining	S.Y.	2.50	1,140	2,850
(13) Water stops, rubber	L.F.	3.00	525	1,575
(14) Reinforcing steel	Lb.	0.13	133,000	17,290
(15) 5' diameter gate with guides	Lb.	0.50	7,200	3,600
(16) 3-1/2" diameter stem, gate	Lb.	0.50	1,900	950
(17) Gate hoist	L.S.	--	--	2,600
(18) Structural steel	Lb.	0.30	57,800	17,340
(19) Cast iron pipe, 12"	L.F.	10.00	58	580
(20) Miscellaneous metals		0.50	5,250	2,625
(21) Handrail		0.50	8,000	4,000
Subtotal - irrigation outlet works				116,800
Subtotal - dams				2,246,835
Contingencies, 20%±				453,165
Total - Dams				2,700,000
(20.0) Operating equipment				
(1) Stream gages	L.S.	--	--	12,000
(2) Evaporation and rain gages	L.S.	--	--	2,000
(3) Sediment and degradation ranges	L.S.	--	--	2,700
Subtotal - operating equipment				16,700
Contingencies, 20%±				3,300
Total - Operating equipment				20,000
(30.0) Engineering and design				125,000
(31.0) Supervision and administration				175,000
TOTAL ESTIMATED FEDERAL FIRST COST				$3,060,000
B. NON-FEDERAL FIRST COST (EXISTING LANDS AND FACILITIES)				
1. Lands and damages				
a. Land costs				
(1) Fee simple lands, improvements and severances	Acre	--	7,770	1,710,000
(2) Flood easement lands and improvements	Acre	--	4,250	494,000
(3) Subordination of minerals	L.S.	--	--	868,000
(4) Resettlement reimbursement	L.S.	--	--	18,000
Subtotal - land costs				3,090,000
Contingencies, 20%±				620,000
Total - Land costs				3,710,000
b. Land acquisition expense				130,000
Total - Lands and damages				3,840,000
2. Dams				
a. Spillway				
(1) Excavation, common	C.Y.	0.25	402,000	100,500
(2) Excavation, rock	C.Y.	1.20	165,000	198,000
Subtotal - spillway excavation				298,500
Contingencies, 20%±				59,500
Total - Existing spillway excavation				358,000
3. Engineering and design				17,000
4. Supervision and administration				25,000
TOTAL ESTIMATED NON-FEDERAL FIRST COSTS				4,240,000
C. TOTAL ESTIMATED FIRST COST OF PROJECT				$7,300,000

CORPS OF ENGINEERS

U.S. ARMY



COLORADO RIVER AND TRIBUTARIES, TEXAS
PECAN BAYOU WATERSHED
PROPOSED LAKE BROWNWOOD PROTECTIVE MEASURES

DETAILS OF SPILLWAY PROTECTION

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — MAY 1963

SUBMITTED: CHIEF, DESIGN BRANCH — APPROVAL RECOMMENDED: CHIEF, ENGINEERING DIVISION — APPROVED: COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

PREPARED: HEAD, CIVIL DESIGN SECTION — DRAWN BY: M.E.C. — CHECKED BY: W.R.B. — TO ACCOMPANY REVIEW REPORT COVERING PECAN BAYOU

FILE: COLO. 601-97

I-59 "R" 12-4-63 PLATE 3

96-452 O-68 (Face blank p. 122) No. 2

68. GENERAL.- Brownwood channel improvements were investigated to provide local flood protection to the Brownwood urban area against flood flows on Pecan Bayou, Adams Branch, and Willis Creek. Because of the physical pattern of these streams and the fact that separate and coincident floods on these streams affect a large common area at urban Brownwood, the streams were considered for improvement and analysis as a unit. The Brownwood channel improvements were formulated and designed considering a reconstructed Lake Brownwood operational in conjunction with Hords Creek Reservoir and a potential flood-detention system of the Soil Conservation Service.

69. As previously stated, formulation of plans for control of floods on Pecan Bayou and Jim Ned Creek recognize the effects of a potential system of flood-detention reservoirs by the Soil Conservation Service. The potential flood-detention system includes three reservoir units on the Adams Branch subwatershed and two units on the Willis Creek subwatershed to control drainage areas of about 7.1 and 14.2 square miles, respectively. The total floodwater capacity would be about 2,827 acre-feet and 5,335 acre-feet for the subwatersheds of Adams Branch and Willis Creek, respectively. Definite planning of flood-detention systems for these subwatersheds have not been completed by the Soil Conservation Service. Thus, since flows on Adams Branch and Willis Creek affect an urban area, the channel improvements on Adams Branch and Willis Creek were sized without consideration of the effects of the proposed flood-detention reservoirs. However, it is recognized that during advance planning studies and after confirmation of location and design of the flood-detention structures by the Soil Conservation Service, the design of the Adams Branch and Willis Creek segments of the Brownwood channel improvements would require reanalysis and necessary coordination with the Soil Conservation Service. Based on data now available, preliminary studies indicate that construction of the flood-detention reservoirs would probably reduce the design discharges for the Adams Branch and Willis Creek channel improvement segments by about 30 percent. However, the studies indicate that the improved channel segments would remain as needed and economically-justified components of the proposed Brownwood channel-improvement plan.

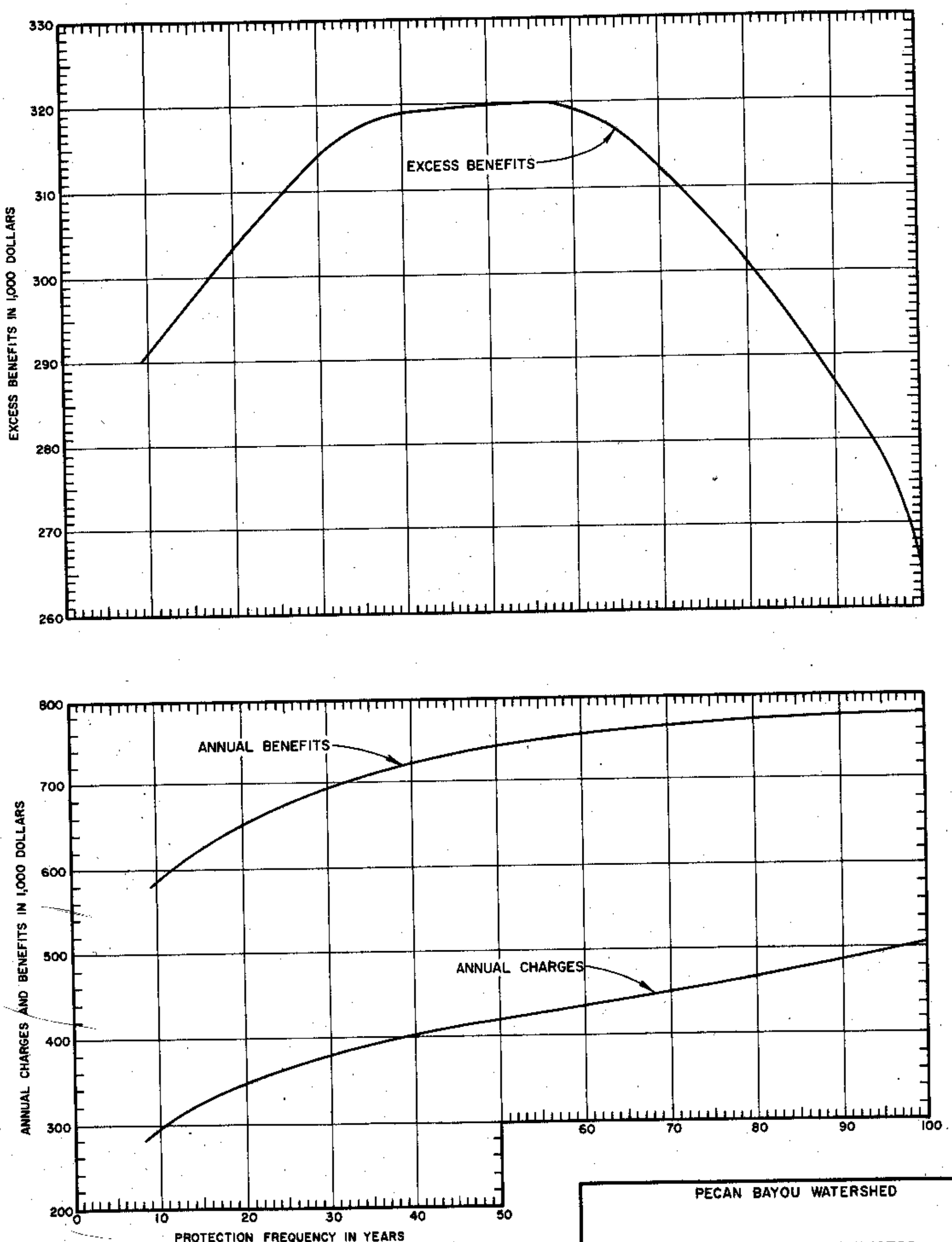
70. PLANS FOR URBAN BROWNWOOD.- The Brownwood channel improvements utilized in the plan-comparison and selected-plan studies involved channel improvement components on Pecan Bayou, Adams Branch, and Willis Creek. A plan view of the selected channel improvements is shown on plate B (adjacent to rear cover of this report). A layout plan on aerial photographic map is shown on plate 4, page I-79. The extent of the Brownwood channel improvements on Pecan Bayou, Adams Branch, and Willis Creek are described as follows:

a. Pecan Bayou.- The Pecan Bayou channel-improvement component to protect urban Brownwood against Pecan Bayou floods would involve straightening and enlarging the existing Pecan Bayou channel from mile 37.8 to mile 47.6. The channel improvement would extend northwestward at the upstream end to intercept West Slough flood flows at a point about 1.5 miles above the confluence of West Slough and Adams Branch. The interception of flows on West Slough, including overflows from Pecan Bayou to West Slough, would reduce the magnitude of flood flows to the channel improvements along Adams Branch within the Brownwood commercial area. The channel improvements along Pecan Bayou were sized so that the Pecan Bayou design flows would be contained within banks from mile 41.7 (just downstream from the confluence with Willis Creek at mile 42.7) to the head of the Pecan Bayou channel improvements at mile 47.6. The channel improvement segment between mile 37.8 and 41.7 was determined to be necessary for the purpose of attaining the above flood protection. However, the lower 3.9 mile segment would provide variable and partial protection for which flood control benefits would be credited.

b. Adams Branch.- The Adams Branch channel-improvement component to protect urban Brownwood against floods originating on the Adams Branch subwatershed would involve straightening and enlarging the existing Adams Branch channel from mile 3.0 to a point (mile 6.1) about 300 feet upstream of the Gulf, Colorado, and Santa Fe Railway; and the excavation of a cutoff channel to be located just upstream from and generally parallel to Broadway Street and extending from Pecan Bayou mile 46.9 to Adams Branch mile 3.0. The Adams Branch channel-improvement component also includes enlargement and realignment of the lower 0.3-mile portion of the Tom Williams channel. The Tom Williams channel improvement segment, or cutoff channel, is aligned to join Adams Branch upstream of the railroad crossing (Adams Branch mile 4.0), thus eliminating modification of one railroad bridge opening.

c. Willis Creek.- The Willis Creek channel-improvement component to protect urban Brownwood against floods originating on the Willis Creek watershed would involve straightening and enlarging the existing Willis Creek channel from its confluence with Pecan Bayou at mile 42.7 to the confluence (mile 2.7) of Willis and South Willis Creeks; thence, extending along Willis Creek to a point (mile 3.9) about 3,000 feet upstream of the Fourth Street crossing.

71. The flood control analyses and maximization of benefits for the Brownwood channel improvements were based on channel capacities which would contain flood peaks having average frequencies of occurrence of once in 10 years, 50 years, and 100 years. Pertinent data for the investigated channel sizes and the economic analyses are presented under plans BCI-1, 2, 2A, and 3 in table 11, page 129. The flood control analyses and maximization of excess benefits over costs are illustrated in figure 3. The analyses of plans BCI-1 through 3



PECAN BAYOU WATERSHED

MAXIMIZATION OF EXCESS
FLOOD CONTROL BENEFITS OVER COST

BROWNWOOD CHANNEL IMPROVEMENTS

FLOOD PROTECTION FREQUENCY
VS
EXCESS BENEFITS

FIGURE 3

determined that Brownwood channel improvements for protection of the Brownwood urban area is economically justified and that plan BCI-2A, which provides 57-year protection to the Brownwood urban area under conditions without Lake Brownwood enlargement or upstream reservoirs, is the optimum and most favorable plan on the basis of providing the maximum amount of excess benefits over costs. Plan BCI-2A was included for further consideration in the plan-comparison and selected-plan studies. Plan BCI-3, which provides 100-year protection to the Brownwood area, was included for further consideration in the selected-plan studies, and was selected for recommendation in this report.

72. The Brownwood channel improvements would involve the following alterations and rights-of-way widths:

a. Pecan Bayou.- The alteration or replacement of three highway bridges, one railroad bridge, urban utilities and pipe lines, and an existing channel dam at mile 47.1 used for recreation-park purposes; and the acquisition of rights-of-way to a maximum width of about 550 feet.

b. Adams Branch.- The alteration of eight highway or road crossings, three railroad crossings, and urban utilities and pipe lines; and the acquisition of rights-of-way to a maximum width of about 300 feet.

c. Willis Creek.- The alteration of two street crossings, and urban utilities and pipe lines; and the acquisition of rights-of-way to a maximum width of about 250 feet.

The Willis Creek channel-improvement component provides for riprapping the channel slopes within the reach between stream miles 1.0 and 3.9. The Willis Creek riprap requirements would be as follows: Use 18-inch riprap in all cases; at the confluence of South Willis Creek with Willis Creek, riprap both sides of channel 100 feet above and below the confluence; from station 60+00 to station 70+00 riprap both sides of channel; from station 45+00 to station 60+00 and from station 70+00 to station 160+00 riprap only the outside bank of all bends (bends consist of an arc greater than 5 degrees); and all riprap would extend to design water surface plus 1.0 foot.

73. ADDITIONAL BROWNWOOD PLANS.- Additional considerations for flood protection in the Brownwood area involved the following: (a) Improvement of the lower reach of Adams Branch from its mouth (at Pecan Bayou mile 44.4) to Adams Branch mile 3.0 in lieu of the adopted cut-off channel of plans BCI-1 through 3; (b) A second channel-improvement increment along Willis Creek extending from mile 3.9 to the U. S. Highway 377 crossing at mile 6.1; (c) A flood protection dike extending generally parallel to Pecan Bayou from about mile 43.3 (near the mouth of Adams Branch) to about opposite mile 48.3. The results of the studies are as follows:

a. Adams Branch (Item a).- Comparison and economical analyses of plan BCI-3 and BCI-4 in table 11, page 129, indicate that under 100-year flood-protection conditions the cut-off route for Adams Branch under plan BCI-3 is more economically favorable than the longer route along lower Adams Branch under plan BCI-4. Thus, the cut-off route was adopted for the plan-comparison and selected-plan studies.

b. Willis Creek (Item b).- Economic and cost analyses of the Willis Creek channel-improvement increment between miles 3.9 and 6.1 determined that its addition to the adopted Brownwood channel improvements is not economically justified. A summary of annual benefits and cost is as follows:

Item	Degree of flood protection		
	10-year	50-year	100-year
Annual charges:	14,700	17,400	20,200
Annual benefits:	4,100	4,100	4,100
Benefit-cost ratio:	0.3	0.2	0.2

c. Flood-protection dike (Item c).- The addition of the dike was investigated under optimum (57-year) flood protection conditions. The additional protection afforded by the dike, however, would be limited to the water surface elevations and backwater effects at the downstream end of the dike, located downstream from the mouth of Adams Branch. The addition of the flood-protection dike was analyzed under plan BCI-5 in table 11, page 129, and compared with plan BCI-2A. The addition of the dike was not found to be incrementally justified.

74. PECAN BAYOU CHANNEL IMPROVEMENT EXTENSIONS.- Investigations of Brownwood channel improvements were expanded to include the downstream reach of Pecan Bayou between the Fox Crossing Reservoir site and the urban Brownwood plan (or between miles 23.0 and 37.8), and to include the upstream reach between the urban Brownwood plan and Lake Brownwood Dam (between miles 47.6 and 57.1). The downstream and upstream channel-improvement reaches were analyzed as next-added units to the recommended plan BCI-3. Also, these reaches were analyzed with capacities to contain Pecan Bayou flood flows of 10-year, 50-year, and 100-year frequency. Economic and cost analyses for plans PB-1, 2, and 3 which involve the downstream reach, and for plans PB-4, 5, and 6 which involve the upstream segment, are summarized in table 12, page 130. The analyses indicate that the addition of the downstream or upstream channel-improvement segment to recommended plan BCI-3 cause a reduction of excess benefits over costs. Thus, the analyses indicate that the addition of the downstream segment or the upstream segment on Pecan Bayou is not economically justified on an incremental basis.

75. SUPPORTING DATA.- In regard to the recommended plan for Brownwood channel improvements, pertinent data is shown on table 13; bridge modifications are described on table 14; detailed estimate of first costs are presented in table 15; a plan view on aerial photographic map is shown on plate 4; and improved channel profiles are shown on plates 5 through 8. Profiles of the existing channels are shown in appendix III.

TABLE 11

SUMMARY OF FIRST COSTS, ANNUAL CHARGES, AND ANNUAL BENEFITS
INVESTIGATED BROWNWOOD CHANNEL IMPROVEMENTS
LOCAL FLOOD PROTECTION - BROWNWOOD, TEXAS
(Pecan Bayou, Adams Branch, and Willis Creek)
(July 1963 price level)

Item	Description and Pertinent Data					
	Improvement of Existing Channels			Cutoff Channels		
	Pecan Bayou	Adams Branch	Willis Creek	West Slough to Pecan Bayou	Adams Branch to Pecan Bayou	Tom Williams Branch to Adams Branch
Plans BCI-1, BCI-2, BCI-3, and BCI-2A						
Reach, mile to mile	PB 37.8 - PB 47.6	AB 3.0 - AB 6.1	WC 0.0 - WC 3.9	WS 1.5 - PB 47.5	AB 3.0 - PB 46.9	TWB 0.3 - AB 4.0
Improved distance, feet	38,800	11,600	16,000	2,000	3,600	1,100
Side slopes	1 on 2.5	1 on 2.5	1 on 2.5	1 on 2.5	1 on 2.5	1 on 2.5
Plan BCI-1 (10-year protection)						
Design capacities, cfs	31,000	8,600 - 5,200	13,300 - 7,000	-	8,600	5,800
Bottom widths, feet	115	55 - 40, 35	40, 55 - 30, 15	25	55	25
Plan BCI-2 (50-year protection)						
Design capacities, cfs	67,000	12,000 - 7,000	17,500 - 11,000	-	12,000	5,800
Bottom widths, feet	215	80 - 40	40, 80 - 50, 30	25	80	25
Plan BCI-2A (Optimum size - 57-year protection)						
Design capacities, cfs	71,000	12,300 - 7,100	17,900 - 11,400	-	12,300	5,800
Bottom widths, feet	225	82 - 41	42, 80 - 53, 32	25	82	25
Plan BCI-3 (100-year protection)						
Design capacities, cfs	92,000	13,200 - 7,400	19,000 - 12,700	-	13,200	5,800
Bottom widths, feet	300	90 - 50	70, 80 - 60, 40	25	90	25

Plan BCI-4 (100-year protection)

(Same as plan BCI-3, except that existing Adams Branch channel is improved between mile 0.0 - 3.0 in lieu of providing Adams Branch - to - Pecan Bayou cutoff channel.)

Plan BCI-5 (Brownwood Dike)(57-year-plus protection)

(Essentially same as plan BCI-2A with Brownwood Dike added to provide added protection against Pecan Bayou floods. Adams Branch channel improved between mile 0.0 - 3.0 in lieu of Adams Branch cutoff channel to Pecan Bayou.)

Item	SUMMARY - ECONOMIC AND COST ANALYSES					
	Plan BCI-1 10-year	Plan BCI-2 50-year	Plan BCI-2A 57-year	Plan BCI-3 100-year	Plan BCI-4 100-year	Plan BCI-5 (Dike) 57-year-plus
1. FIRST COST						
Federal	6,013,000	9,126,000	9,325,000	11,281,000	11,746,000	10,153,000
Non-Federal	1,421,000	1,925,000	1,986,000	2,442,000	2,589,000	2,334,000
Total	7,434,000	11,051,000	11,311,000	13,723,000	14,335,000	12,487,000
2. ANNUAL CHARGES						
Federal	191,600	290,700	297,000	359,400	374,100	323,400
Non-Federal	105,300	129,300	132,300	147,800	165,600	182,300
Total	296,900	420,000	429,300	507,200	539,700	505,700
3. ANNUAL BENEFITS	588,000	739,800	749,300	772,300	772,300	810,000
4. BENEFIT-COST RATIO	1.98	1.76	1.75	1.52	1.43	1.60
5. EXCESS BENEFITS OVER COSTS	291,100	319,800	320,000	265,100	232,600	304,300

TABLE 12

SUMMARY OF FIRST COSTS, ANNUAL CHARGES, AND ANNUAL BENEFITS
INVESTIGATED PECAN BAYOU CHANNEL IMPROVEMENT EXTENSIONS
DOWNSTREAM AND UPSTREAM OF BROWNWOOD CHANNEL IMPROVEMENT PLAN
(July 1963 price level)

Plan	Description
BCI-3	Selected Brownwood channel improvement plan BCI-3 included as base plan in analyses of downstream and upstream increments on Pecan Bayou. (100-year protection)(Brownwood increment, Pecan Bayou mile 37.8 - 47.6) Improved length 38,800 ft., bottom width 300 ft., design capacity 92,000 cfs. Includes Adams Branch and Willis Creek segments.
PB-1	(10-year protection)(Downstream increment, mile 23.0 - 37.8) Improved length 89,000 ft., BW 40 ft., design capacity 34,000 cfs. (100-year protection)(Brownwood increment, mile 37.8 - 47.6) Improved length 38,800 ft., BW 250 ft., design capacity 92,000 cfs.
PB-2	(50-year protection)(Downstream increment, mile 23.0 - 37.8) Improved length 89,000 ft., BW 150 ft., design capacity 74,000 cfs. (100-year protection)(Brownwood increment, mile 37.8 - 47.6) Improved length 38,800 ft., BW 250 ft., design capacity 92,000 cfs.
PB-3	(100-year protection)(Downstream increment, mile 23.0 - 37.8) Improved length 89,000 ft., BW 225 ft., design capacity 100,000 cfs. (100-year protection)(Brownwood increment, mile 37.8 - 47.6) Improved length 38,800 ft., BW 225 ft., design capacity 92,000 cfs.
PB-4	(10-year protection)(Upstream increment, mile 47.6 - 57.0) Improved length 48,000 ft., BW 70 ft., design capacity 31,000 cfs. (100-year protection)(Brownwood increment, mile 37.8 - 47.6) Improved length 38,800 ft., BW 300 ft., design capacity 92,000 cfs.
PB-5	(50-year protection)(Upstream increment, mile 47.6 - 57.0) Improved length 48,000 ft., BW 200 ft., design capacity 67,000 cfs. (100-year protection)(Brownwood increment, mile 37.8 - 47.6) Improved length 38,800 ft., BW 300 ft., design capacity 92,000 cfs.
PB-6	(100-year protection)(Upstream increment, mile 47.6 - 57.0) Improved length 48,000 ft., BW 250 ft., design capacity 92,000 cfs. (100-year protection)(Brownwood increment, mile 37.8 - 47.6) Improved length 38,800 ft., BW 300 ft., design capacity 92,000 cfs.

Item	Brownwood Plan BCI-3 100-year	Downstream increment (with Brownwood 100-year) Plan PB-1 10-year	Plan PB-2 50-year	Plan PB-3 100-year	Upstream increment (with Brownwood 100-year) Plan PB-4 10-year	Plan PB-5 50-year	Plan PB-6 100-year
1. FIRST COST							
Federal	$11,281,000	$12,281,000	$19,632,000	$22,017,000	$11,830,000	$13,428,000	$14,643,000
Non-Federal	2,442,000	2,499,000	2,601,000	2,592,000	2,826,000	2,964,000	3,137,000
Total	13,723,000	14,780,000	22,233,000	24,609,000	14,656,000	16,392,000	17,780,000
2. ANNUAL CHARGES							
Federal	359,400	391,200	625,300	701,400	376,800	427,800	466,400
Non-Federal	147,800	229,700	233,500	233,400	195,000	206,300	214,900
Total	507,200	620,900	858,800	934,800	571,800	634,100	681,300
3. ANNUAL BENEFITS	772,300	852,800	878,600	884,000	809,500	822,100	824,800
4. BENEFIT-COST RATIO	1.52	1.37	1.02	0.95	1.42	1.30	1.21
5. EXCESS BENEFITS OVER COSTS	265,100	231,900	19,800	-50,800	237,700	188,000	143,500

TABLE 13

PERTINENT DATA
BROWNWOOD CHANNEL IMPROVEMENTS - BROWNWOOD, TEXAS
PECAN BAYOU WATERSHED

	Pecan Bayou		Adams Branch		Willis Creek	
LOCATION						
Stream	Pecan Bayou		Adams Branch		Willis Creek	
River mile limits	37.8 to 47.6		0.0 to 6.1		0.0 to 3.9	
DRAINAGE AREA						
Above mouth, square miles	2,202.0		26.0		27.0	
Above head of proposed improvement, square miles	1,621.0		8.6		11.2	
CHANNEL IMPROVEMENTS						
Length of existing channel before improvement, miles	9.8		6.1		3.9	
Length of channel after improvement, miles	7.3		2.9		3.0	
Channel enlargement and realignment:						
Channel excavation, cubic yards	11,482,000		725,000		651,900	
Side slopes of excavated channel	1 on 2-1/2		1 on 2-1/2		1 on 2-1/2	
Average depth of excavated channel, feet	32		18		18	
Bottom widths of excavated channel, feet	Station limits	Bottom width	Station limits	Bottom width	Station limits	Bottom width
	0+00-388+00	300	0+00-83+00	90	0+00-70+00	70
	0+00-20+00 (1)	25	83+00-152+00	50	70+00-118+21	80
			0+00-11+00 (2)	25	118+21-121+00	60
					121+00-160+00	40
Clearing, improved channel	Station limits	Width	Station limits	Width	Station limits	Width
	0+00-388+00	550	0+00-83+00	300	0+00-121+00	250
	0+00-20+00 (1)	220	83+00-152+00	230	121+00-160+00	230
			0+00-11+00 (2)	220		
Number of acres	413		40		69	
Location of bridges over excavated channel, stations						
FM 2126	150+00					
G. C. & SF Railway	190+50					
Old US Highway 67 (S. Broadway)	360+00					
US Highways 67 & 377	369+00					
Low water dam	371+50					
G. C. & SF Ry (abandoned)	388+00					
North Fisk Street			36+50			
US Highway 377			39+50			
Belle Plain Avenue			53+50			
Baker Street			60+00			
Cordell Street			69+50			
G. C. & SF Ry Spur			81+00			
Beaver Street			89+80			
G. C. & SF Ry Spur			108+10			
Petty Street			108+80			
Coleman Avenue			135+00			
G. C. & SF Ry			149+00			
Austin Avenue					104+76	
4th Street					131+00	
RIGHTS-OF-WAY						
Fee simple acquisition:						
Improved channel station limits	0+00-388+00		0+00-152+00		0+00-160+00	
Land area, acres	500		112		100	

(1) West Slough to Adams Branch
(2) Tom Williams Branch to Adams Branch

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TABLE 14

BRIDGE ALTERATIONS OR MODIFICATIONS
PROPOSED BROWNWOOD CHANNEL IMPROVEMENTS

Location	Channel Station	Design WS Elevation (ft.msl)	Low Steel Elevation Existing (ft.msl)	Low Steel Elevation Required (ft.msl)	Proposed Alternate or Modification
			PECAN BAYOU		
FM 2126	150+00	1312.7	1318.0	1315.7	Replace existing 250-foot bridge with 520-foot slab and girder span bridge
GC and SF Rwy	190+50	1314.0	1328.0	1317.0	Remove and salvage 220-feet of pile trestle and 2 concrete abutments. Place new 2 - 110-foot steel girders and 4 piers.
South Broadway Street	360+00	1325.1	1332.5	1328.1	Replace existing 190-foot bridge with 450-foot slab and girder span bridge.
US Highway 377	369+00	1325.8	1332.0	1328.8	Replace existing 260-foot bridge with 450-foot slab and girder span bridge
Channel dam	371+50	-	-	-	Replace low water dam
			ADAMS BRANCH		
North Fisk Street	36+50	1324.3	1328.3	1327.3	Replace existing 50-foot bridge with 250-foot slab and girder span bridge
US Highway 377	39+50	1325.5	1330.2	1328.5	Replace existing 100-foot bridge with 200-foot slab and girder span bridge
Belle Plain Avenue	53+50	1328.2	1329.5	1331.2(1)	Replace existing 60-foot bridge with 160-foot slab and girder span bridge
Baker Street	60+00	1329.0	-	1332.0	Replace existing 50-foot bridge with 160-foot slab and girder span bridge
Cordell Street	69+50	1330.3	-	1333.3	Replace 20" C M pipe low water bridge with 160-foot slab and girder span bridge
GC & SF Rwy Spur	81+00	1332.0	1337.0	1335.0	Redrive 8 pile bents. Construct 70 feet of new trestle
Beaver Street	89+80	1333.3	1333.2	1336.3(1)	Replace existing 50-foot bridge with 130-foot slab and girder span bridge
GC & SF Rwy Spur	108+10	1341.0	1345.2	1344.0	Redrive 4 pile bents
Petty Street	108+80	1342.2	-	1345.2	Replace low water crossing with 130-foot slab and girder span bridge
Coleman Avenue	135+00	1349.8	1349.0	1352.8(1)	Replace 48-foot bridge with 120-foot slab and girder span bridge
GC & SF Rwy	149+00	1356.9	1360.4	1359.9	Redrive 7 pile bents, add 30 feet of new trestle, build up ballast on trestle ends
			WILLIS CREEK		
Austin Avenue	104+76	1331.1	1329.2	1334.1(1)	Replace existing 85-foot bridge with 160-foot slab and girder span bridge
Fourth Street	131+00	1338.5	1336.7	1341.5(1)	Replace existing 50-foot bridge with 120-foot slab and girder span bridge

(1) Bridge to be raised for conformance with required low-steel elevation

TABLE 15

DETAILED ESTIMATE OF FIRST COST
PROPOSED CHANNEL IMPROVEMENTS
LOCAL FLOOD PROTECTION - BROWNWOOD, TEXAS
(July 1963 price level)

Item	Unit Quantity	Unit Cost	Quantity	Cost
A. FEDERAL FIRST COST				
(02.0) Railroad alterations				
1. Pecan Bayou				
a. GC & SF bridge	LS	-	-	140,000
Subtotal				140,000
2. Adams Branch				
a. GC & SF spur bridge	LS	-	-	23,000
b. GC & SF spur bridge	LS	-	-	5,000
c. GC & SF bridge	LS	-	-	17,000
Subtotal				45,000
Subtotal - items 1 & 2				185,000
Contingencies 20% ±				37,000
Total - railroad contingencies				222,000
(09.0) Channels				
1. Pecan Bayou				
a. Care of water	LS	-	-	290,000
b. Clearing	Acre	$150.00	413	61,950
c. Excavation, common	CY	0.60	11,482,000	6,889,200
d. Slope protection	Acre	500.00	151	75,500
Subtotal				7,316,650
2. Adams Branch				
a. Care of water	LS	-	-	19,000
b. Clearing	Acre	150.00	40	6,000
c. Excavation, common	CY	0.60	725,000	435,000
d. Slope protection	Acre	500.00	16	8,000
Subtotal				468,000
3. Willis Creek				
a. Care of water	LS	-	-	25,200
b. Clearing	Acre	150.00	69	10,350
c. Excavation, common	CY	0.60	651,900	391,140
d. Slope protection	Acre	500.00	6	3,000
e. Riprap	CY	6.00	18,890	113,340
f. Bedding	CY	4.50	9,500	42,750
Subtotal				585,780
Subtotal - items 1, 2, & 3				8,370,430
Contingencies 20% ±				1,674,570
Total - channels				10,045,000
(30.0) Engineering and design				406,000
(31.0) Supervision and administration				608,000
TOTAL ESTIMATED FEDERAL FIRST COST				11,281,000
B. NON-FEDERAL FIRST COST				
1. Lands and damages				
a. Pecan Bayou				
(1) Fee simple, lands and improvements	Acre	-	500	483,000
(2) Administrative cost	LS	-		12,000
Subtotal				495,000
b. Adams Branch				
(1) Fee simple, lands and improvements	Acre	-	112	208,000
(2) Administrative cost	LS	-	-	5,000
Subtotal				213,000
c. Willis Creek				
(1) Fee simple, lands and improvements	Acre	-	100	91,000
(2) Administrative cost	LS	-	-	2,000
Subtotal				93,000
Subtotal - items a, b, & c				801,000
Contingencies 20% ±				160,000
Total - lands and damages				961,000
2. Relocations and alterations				
a. Bridges and roads				
(1) Pecan Bayou				
(a) FM 2126 bridges	LS	-	-	100,000
(b) South Broadway bridge	LS	-	-	85,000
(c) U.S. Highway 67 bridge	LS	-	-	179,000
Subtotal				364,000
(2) Adams Branch				
(a) North Fisk Street bridge	LS	-	-	26,000
(b) U.S. Highway 377 bridge	LS	-	-	22,000
(c) Belle Plain Street bridge	LS	-	-	25,000
(d) Baker Street bridge	LS	-	-	24,000
(e) Cordell Street bridge	LS	-	-	24,000
(f) Beaver Street bridge	LS	-	-	24,000
(g) Petty Street bridge	LS	-	-	18,000
(h) Coleman Ave. bridge	LS	-	-	16,000
Subtotal				179,000
(3) Willis Creek				
(a) Austin Ave. bridge	LS	-	-	29,000
(b) 4th Street bridge	LS	-	-	29,000
Subtotal				58,000
Subtotal, items (1), (2), & (3)				601,000
Contingencies 20% ±				120,000
Total - bridges & roads				721,000
b. Utilities				
(1) Pecan Bayou	LS	-	-	45,000
(2) Adams Branch	LS	-	-	69,000
(3) Willis Creek	LS	-	-	15,000
Subtotal				129,000
Contingencies 20% ±				26,000
Total				155,000
c. Channel dam				
(1) Pecan Bayou	LS	-	-	371,000
Contingencies 20% ±				74,000
Subtotal				445,000
d. Engineering and design				
(1) Pecan Bayou	-	-	-	47,000
(2) Adams Branch	-	-	-	15,000
(3) Willis Creek	-	-	-	5,000
Subtotal				67,000
e. Supervision and administration				
(1) Pecan Bayou	-	-	-	66,000
(2) Adams Branch	-	-	-	21,000
(3) Willis Creek	-	-	-	6,000
Subtotal				93,000
TOTAL NON-FEDERAL FIRST COST				2,442,000
C. TOTAL ESTIMATED FIRST COST OF PROJECT				13,723,000

LAKE BROWNWOOD ENLARGEMENT AND ALTERNATE UPSTREAM RESERVOIRS

76. GENERAL.- The Lake Brownwood enlargement and four alternate upstream reservoirs on Pecan Bayou and Jim Ned Creek were investigated for purposes of flood control, water supply (including stream-quality control), and fish-wildlife and general recreation. The reservoir units were investigated as last-added units under general plans of the plan-comparison studies, summarized in tables 2 and 3, pasters accompanying Appendix I.

77. Economic and cost analyses of the various reservoir units determined in general that the provision of 50-year flood control storage and maximum development of the water supply resources upstream from each dam site would constitute optimum economical conditions for reservoir storage development. Assuming the existence of Hords Creek Reservoir, a reconstructed Lake Brownwood and a potential system of flood-detention reservoirs by the Soil Conservation Service, the studies determined that the optimum-size reservoirs would afford general reduction in flood flows and damages within the investigated flood plains of Pecan Bayou and Jim Ned Creek, including the Lake Brownwood shoreline area; would increase the degree of local flood protection at Brownwood as afforded by Brownwood channel improvements; would provide substantial increases in dependable water supply; and would afford substantial benefits for fish-wildlife and general recreation.

78. Comparisons of the optimum-size reservoir units in the plan-comparison studies and the amounts of excess benefits over costs determined that a two-reservoir system of Coleman and Pecan Bayou Reservoirs was the most favorable reservoir development; that the combination of Coleman and Burkett Reservoirs was the second most favorable reservoir plan; and that Lake Brownwood enlargement was the least favorable, as well as the most costly reservoir plan. The Coleman and Pecan Bayou Reservoirs were included for further consideration in the selected-plan studies, and were selected for recommendation in this report. The locations of investigated reservoir units are shown on plate A (adjacent to the rear cover of this report).

79. PLANS FOR LAKE BROWNWOOD ENLARGEMENT.- The plans for Lake Brownwood enlargement as utilized in the plan-comparison studies were based on the construction of the following principal appurtenant structures: New outlet works near the Pecan Bayou channel; a new embankment just downstream from the existing dam (Pecan Bayou mile 57.1); and a concrete ogee spillway to be controlled by tainter gates and to be located in the existing spillway channel. The design and cost studies determined that it was more economical and practical to construct a new embankment and new outlet works rather than to reconstruct the existing outlet works and to enlarge and strengthen the

existing embankment. The enlargement of Lake Brownwood, under actual planning and construction procedures, would incorporate the protection measures necessary for a reconstructed Lake Brownwood.

80. Incremental analyses of plans involving enlargement of Lake Brownwood to various sizes are reflected in the plan-comparison studies of table 3, by plan 2 and plans 11 through 14. Plan 2 represents the basic plan consisting of a reconstructed Lake Brownwood and Brownwood channel improvements. Plan 11, which is essentially the authorized plan, involves only the addition of flood control storage. Plans 12 and 13 involve the addition of flood control storage as well as water conservation storage to provide intermediate water resource developments comparable to the most-upstream and most-downstream two-reservoir systems in plans 20 and 19, respectively. Plan 14 provides for the maximum development of the water supply resources of the Pecan Bayou watershed upstream from Lake Brownwood Dam. Plan 13 represents the most favorable amount of water conservation storage at Lake Brownwood on the basis of excess benefits over costs, as shown in table 3. The incremental analyses between plans 2 and 11 of table 3 determined that enlargement of Lake Brownwood to provide only flood control storage (essentially the authorized plan) is not economically justified. However, similar incremental analyses for general plans 12, 13, and 14 determined that the addition of the flood control, water supply, and fish-wildlife harvest functions provide economic ratios of 0.5 or greater, and that the further addition of the recreation function provides total incremental ratios greater than unity. Thus, in accordance with formulation requirements set forth in paragraph 39g, the enlargements of Lake Brownwood in accordance with plans 12, 13, and 14 are considered to be worthy Federal undertakings.

81. The maximization of water supply benefits for the Lake Brownwood enlargement are reflected by plans 11 through 14 of table 3. The analyses indicate that optimum economical water supply development would be provided by plan 13 (dependable yield of 91 cfs), based on the maximum amount of excess benefits over costs.

82. Separate economic and cost analyses of investigated Lake Brownwood enlargement plans, operating without Brownwood channel improvements but incorporating the necessary protective measures for Lake Brownwood Dam, are summarized under plans 3 through 6, table 3.

83. SUPPORTING DATA.- In regard to Lake Brownwood enlargement in the plan-comparison studies, pertinent data for maximum economical enlargement is presented in table 16, paster. Summaries of first cost and annual charges for all sizes considered are presented in table 17, paster, and a map of the Lake Brownwood reservoir area is shown on plate 9.

84. LANDS FOR LAKE BROWNWOOD ENLARGEMENT.- A principal cost item involved in plans for Lake Brownwood enlargement is the cost of reservoir lands. The real estate studies substantiate that the shoreline area has experienced rapid subdivision and development and that any plan for enlargement would be an expensive undertaking. The Brown County Water Improvement District No. 1, at the time land was acquired for the operation of the existing lake, acquired an easement on the land between elevation 1425.0 and 1435.0. Real estate investigations indicate that the value of existing property surrounding Lake Brownwood, exclusive of contingencies, minerals, and land acquisition expenses, is approximately as follows: Within the easement area $8,700,000, including $250,000 for improvements, between elevations 1425.0 and 1445.0, $13,500,000 including $800,000 for improvements; and between elevations 1425.0 and 1462.0, $25,600,000, including $2,850,000 for improvements. In regard to investigated plans for Lake Brownwood enlargement, lands would be required below elevation 1459.0 for plan 11, and below elevation 1480.0 for plan 14.

85. PLANS FOR ALTERNATE UPSTREAM RESERVOIRS.- The plans for alternate upstream reservoirs involve the Burkett and Pecan Bayou sites on Pecan Bayou and the Camp Colorado and Coleman sites on Jim Ned Creek. The plans for the upstream reservoirs were based on the construction of the following principal structures: earth-fill embankments, excavated uncontrolled saddle spillways, and separate outlet works through the embankment.

86. Incremental analyses of plans involving alternate upstream reservoirs of optimum size are reflected in the plan-comparison studies of table 3, by plan 2 and plans 15 through 22. The analyses of upstream two-reservoir systems were limited to combinations consisting of one reservoir unit on Jim Ned Creek and one reservoir unit on Pecan Bayou. The incremental analyses of plans 15 through 22 determined that the addition of any single reservoir to plan 2 (the basic improvements), and thence, the addition of a second reservoir, was economically justified. However, the last-added Burkett and Pecan Bayou Reservoirs of plans 19 and 22, respectively, do not meet the requirement of an incremental 0.5 benefit-cost ratio for flood control and water supply.

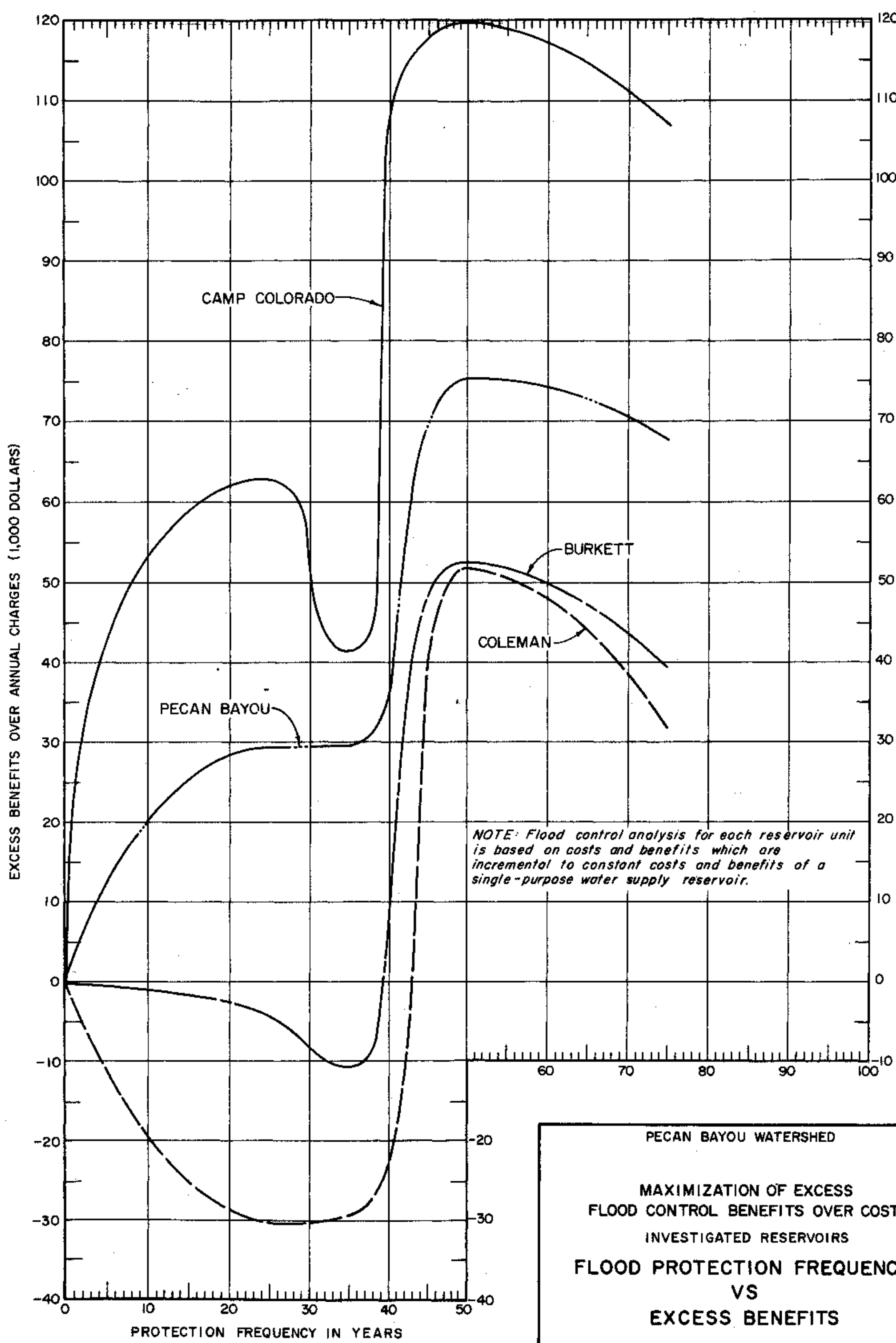
87. Economic and cost analyses were made of the upstream reservoirs to determine optimum storage conditions for flood control and water supply purposes. The flood control analyses were made on the basis of flood storage capacities which would control volumes having average frequencies of occurrence of once in 25 years, 35 years, 50 years, and 75 years. The flood storage capacities were analyzed on the basis of the following: (a) Dual-purpose reservoirs for flood control and water conservation acting as next-added units to the Lake Brownwood protective measures; and (b) each reservoir containing water conservation storage to develop approximately the maximum water supply resources at the site. The flood control analysis for each reservoir unit is based on costs and benefits which are incremental to constant

costs and benefits of a single-purpose water supply reservoir. These studies determined, as illustrated in figure 4, that 50-year flood control storages would provide the maximum excess of benefits over costs. The maximization curves indicate that the amount of excess benefits over costs for 25-year and 35-year storages were considerably less than the amounts for 50-year storages. The geological formations at the upstream dam sites are similar to those at the existing Lake Brownwood where frequent discharges cause deterioration of the spillway channel. Since utilization of the upstream spillway sites would be considerably more frequent under 25-year and 35-year storage conditions, erosion-control measures and, thus, additional costs, were essentially involved in these cases. The water conservation storages were analyzed on the basis of the following: (a) Dual-purpose reservoirs for flood control and water conservation acting as next-added units to Lake Brownwood protective measures; and (b) each reservoir unit containing 50-year flood storage capacity. The water supply analysis for each reservoir unit is based on costs and benefits which are incremental to constant costs and benefits of a single-purpose flood control reservoir. The studies reveal, as illustrated in figure 5, that storages to develop the maximum amount of water resources at each site would provide the maximum amount of excess benefits over costs. Thus, the adopted reservoir storages for each upstream reservoir unit under the investigated general plans would be of sufficient volume to control floods having average flood-control storage requirement frequency of occurrence of once in 50 years at the respective dam sites; and to develop the maximum water resources of the Pecan Bayou watershed upstream from the respective dam sites, assuming existing conditions of watershed development. The flood control and water supply analyses are summarized in tables 18 and 19. The average unit cost of water supply as a last-added function in each dual-purpose reservoir is shown in table 19.

88. SUPPORTING DATA.- In regard to the alternate upstream reservoirs in the plan-comparison studies, pertinent data for optimum-size projects are presented in table 16; summaries of first cost and annual charges are presented in table 17; and reservoir maps and details of dams for the investigated Burkett and Camp Colorado Reservoirs are presented on plates 10 through 13. In regard to the Pecan Bayou and Coleman Reservoirs used in the selected-plan studies and recommended for construction in this report, pertinent data are presented in table 20; detailed estimates of first cost are presented in tables 21 and 22; and reservoir maps and details of dams are presented on plates 14 through 17.

89. DESCRIPTION OF RESERVOIR LANDS.- Description of reservoir lands within the proposed Pecan Bayou and Coleman Reservoirs is presented in the following subparagraphs:

a. Pecan Bayou Reservoir.- The Pecan Bayou Reservoir would have a surface area of 5,150 acres at the top of the conservation



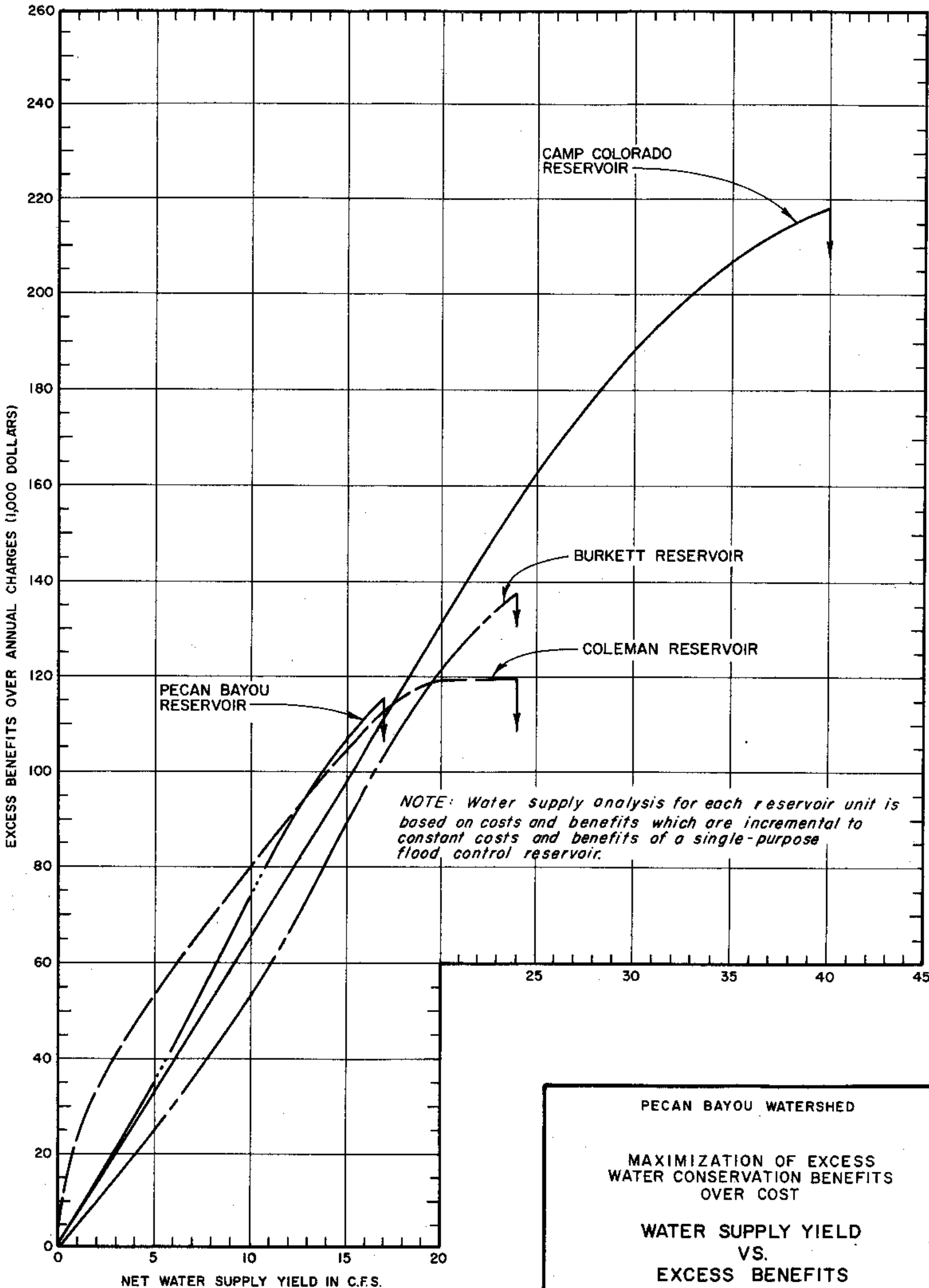
PECAN BAYOU WATERSHED

MAXIMIZATION OF EXCESS FLOOD CONTROL BENEFITS OVER COST

INVESTIGATED RESERVOIRS

FLOOD PROTECTION FREQUENCY VS EXCESS BENEFITS

FIGURE 4



PECAN BAYOU WATERSHED

MAXIMIZATION OF EXCESS
WATER CONSERVATION BENEFITS
OVER COST

WATER SUPPLY YIELD
VS.
EXCESS BENEFITS

FIGURE 5

pool, elevation 1637.0, and an area of 8,030 acres at the top of the flood control pool, or spillway crest, elevation 1653.0. Lands required for reservoir operation, construction of the proposed dam, and for fish-wildlife and general recreation purposes amount to about 10,550 acres in fee simple and 1,100 acres in flood easements. Of this total land requirement, 2 percent is classified as homesites or pecan land, 5 percent as bottom cropland, 8 percent as upland cropland, and 85 percent as rangeland.

b. Coleman Reservoir.- The Coleman Reservoir would have a surface area of 3,930 acres at the top of the conservation pool, elevation 1764.0, and an area of 5,430 acres at the top of the flood control, or spillway crest, elevation 1784.0. Lands required for reservoir operation, construction of the proposed dam, and for fish-wildlife and general recreation purposes amount to 7,100 acres in fee simple and 700 acres in flood easements. Of this total land requirement, 59 percent is classified as cropland, which includes supplemental pasture, idle or conservation reserve cropland; and 41 percent is classified as rangeland.

TABLE 16

PERTINENT DATA
INVESTIGATED OPTIMUM SIZE RESERVOIRS FOR PLAN-COMPARISON STUDIES
PECAN BAYOU WATERSHED

Item	Lake Brownwood Enlargement	Camp Colorado Reservoir	Burkett Reservoir	Coleman Reservoir	Pecan Bayou Reservoir
MISCELLANEOUS					
Dam location, river mile	57.12	26.2	91.94	52.15	100.82
Drainage area, square miles	1,544	593	376	287	316
Conservation storage, acre-feet	719,700	171,500	138,500	138,500	93,500
Yield, cfs	116	40	24	24	17
SPILLWAY DESIGN FLOOD					
Peak inflow, cfs	708,300	414,100	333,100	307,100	317,500
Volume, acre-feet	1,605,800	703,500	469,900	371,100	406,100
Volume, inches	19.50	22.24	23.43	24.24	24.10
Peak outflow, cfs	410,000(1)	246,500(1)	179,000(1)	202,800(1)	184,200(1)
TYPE OF DAM	Earth fill	Earth fill	Earth fill	Earth fill	Earth fill
SPILLWAY					
Type	Concrete ogee	Broadcrested	Broadcrested	Broadcrested	Broadcrested
Length in feet at crest (net)	400	900	800	600	800
Control	10 - 40' x 30' tainter gates	None	None	None	None
Spillway discharge, cfs					
Maximum design water surface	392,100	234,700	166,100	192,500	173,200
OUTLET WORKS					
Type	Gate controlled conduit	Gate controlled conduit	Gate controlled conduit	Gate controlled conduit	Gate controlled conduit
Number of sluices, conduits	1	1	1	1	1
Dimensions (width x height)	20' diameter	15' diameter	16' diameter	14' diameter	16' diameter
Invert elevations, feet	1342.0	1480.0	1525.0	1672.0	1588.0
Sluice or conduit control	3 - 6' x 20' slide gates	2 - 7.5' x 15' gates	3 - 5' x 16' gates	3 - 4'2" x 14' gates	3 - 5' x 16' gates

RESERVOIR	Lake Brownwood Enlargement Elev. (2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Camp Colorado Reservoir Elev. (2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Burkett Reservoir Elev. (2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Coleman Reservoir Elev. (2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Pecan Bayou Reservoir Elev. (2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
Sediment storage	--	--	49,700	0.60	--	--	21,300	0.67	--	--	12,000	0.60	--	--	10,300	0.67	--	--	10,100	0.60
Top of conservation storage	1462.5	29,460	764,100	9.28	1566.0	7,300	190,200	6.01	1594.5	5,940	149,100	7.44	1764.0	3,930	147,600	9.64	1637.0	5,150	102,000	6.05
Five-year pool	1467.0	32,660	903,800	10.98	1572.0	8,560	237,700	7.52	1600.0	6,930	184,400	9.20	1771.0	4,440	176,900	11.56	1642.0	5,950	129,700	7.70
Top of flood control storage	1475.0	38,810	1,188,900	14.44	1584.0	11,680	358,400	11.33	1610.0	9,250	264,700	13.20	1784.0	5,430	240,900	15.74	1653.0	8,030	206,300	12.24
Spillway crest or top of gates	1475.0	38,810	1,188,900	14.44	1584.0	11,680	358,400	11.33	1610.0	9,250	264,700	13.20	1784.0	5,430	240,900	15.74	1653.0	8,030	206,300	12.24
Guide taking line	1480.0	42,680	1,392,600	16.91	1589.0	13,290	420,700	13.30	1615.0	10,850	314,700	15.69	1789.0	5,820	269,100	17.58	1658.0	9,100	249,100	14.78
Maximum design water surface	1486.0	47,330	1,662,600	20.19	1604.3	19,130	668,000	21.12	1627.0	16,670	479,700	23.92	1806.3	7,360	382,000	24.96	1670.4	12,010	379,700	22.53
Top of dam	1491.0	51,200	1,908,900	23.18	1610.0	21,640	783,900	24.79	1632.0	18,480	567,800	28.31	1812.0	8,090	426,000	27.83	1676.0	13,400	450,800	26.75

(1) Includes discharge through outlet works, as follows: 17,900 cfs (Lake Brownwood Enlargement); 11,800 cfs (Camp Colorado Reservoir); 12,900 cfs (Burkett Reservoir); 10,300 cfs (Coleman Reservoir); 11,000 cfs (Pecan Bayou Reservoir)

(2) All elevations refer to mean sea level.

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TABLE 17

SUMMARY OF FIRST COST AND ANNUAL CHARGES
INVESTIGATED RESERVOIRS FOR PLAN-COMPARISON STUDIES
PECAN BAYOU WATERSHED
(July 1963 price level)
(in 1000 dollars)

Item	Lake Brownwood Enlargement (1)	Lake Brownwood Enlargement (1)	Lake Brownwood Enlargement (1)	Lake Brownwood Enlargement (1)	Camp Colorado (1)	Burkett (1)
FIRST COST						
A. DAM AND RESERVOIR						
Lands and damages	29,000.0	33,356.0	34,440.0	43,000.0	5,225.0	4,375.0
Relocations	2,900.0	3,336.0	3,444.0	4,000.0	2,810.0	712.0
Clearing		100.0	200.0	400.0	293.0	69.0
Dam	9,790.0	10,300.0	10,420.0	10,910.0	7,908.0	5,977.0
Embankment	(1,300.0)	(1,722.0)	(1,782.0)	(2,100.0)	(3,927.7)	(2,313.4)
Spillway	(6.0)	(8.0)	(8.0)	(8.0)	(22.8)	(12.0)
Slope protection	(6,070.0)	(6,100.0)	(6,150.0)	(6,302.0)	(2,117.0)	(1,617.7)
Outlet works	(2,414.0)	(2,470.0)	(2,480.0)	(2,500.0)	(1,840.5)	(2,033.9)
Access road	100.0	90.0	90.0	90.0	274.0	35.0
Buildings and grounds	290.0	290.0	290.0	300.0	288.0	204.0
Operating equipment	65.0	65.0	65.0	70.0	65.0	60.0
Engineering and design	650.0	710.0	730.0	790.0	616.0	400.0
Supervision and administration	955.0	1,063.0	1,091.0	1,180.0	876.0	663.0
Subtotal	43,750.0	49,310.0	50,770.0	60,740.0	18,355.0	12,495.0
B. FISH-WILDLIFE AND GENERAL RECREATION						
Lands and damages		320.0	320.0	320.0	225.0	220.0
Clearing		135.0	135.0	135.0	144.0	120.0
Access roads		481.0	481.0	481.0	112.0	151.0
Facilities		2,044.0	2,044.0	2,044.0	1,394.0	1,394.0
Engineering and design		180.0	180.0	180.0	110.0	113.0
Supervision and administration		280.0	280.0	280.0	170.0	177.0
Subtotal		3,440.0	3,440.0	3,440.0	2,155.0	2,175.0
C. TOTAL FIRST COST	43,750.0	52,750.0	54,210.0	64,180.0	20,510.0	14,670.0
ANNUAL CHARGES						
(Interest rates - Federal, 2.875%)(Amortization period - 100 years)						
Construction period - years	5	6	6	7	3	3
A. DAM AND RESERVOIR						
Investment						
First cost	43,750.0	49,310.0	50,770.0	60,740.0	18,355.0	12,495.0
Interest during construction	3,145.0	4,253.0	4,379.0	6,112.0	792.0	539.0
Subtotal	46,895.0	53,563.0	55,149.0	66,852.0	19,147.0	13,034.0
Annual charges						
Interest on investment	1,348.0	1,540.0	1,585.0	1,922.0	550.5	374.7
Amortization on investment	84.0	96.0	99.0	120.0	34.3	23.3
Maintenance and operation	85.0	90.0	95.0	110.0	88.0	72.0
Subtotal	1,517.0	1,726.0	1,779.0	2,152.0	672.8	470.0
B. FISH-WILDLIFE AND GENERAL RECREATION						
Investment						
First cost		3,440.0	3,440.0	3,440.0	2,155.0	2,175.0
Interest during construction		148.0	148.0	148.0	93.0	94.0
Subtotal		3,588.0	3,588.0	3,588.0	2,248.0	2,269.0
Annual charges						
Interest on investment		103.2	103.2	103.2	64.6	65.2
Amortization		6.4	6.4	6.4	4.0	4.1
Maintenance and operation		70.0	70.0	70.0	42.0	42.0
Subtotal		179.6	179.6	179.6	110.6	111.3
C. TOTAL FEDERAL ANNUAL CHARGES	1,517.0	1,905.6	1,958.6	2,331.6	783.4	581.3

Item	Coleman (1)	Pecan Bayou (1)	Camp Colorado (2)	Burkett (2)	Coleman (2)	Pecan Bayou (2)
FIRST COST						
A. DAM AND RESERVOIR						
Lands and damages	1,710.0	2,210.0	5,225.0	4,375.0	1,710.0	2,210.0
Relocations	230.0	237.0	2,810.0	712.0	230.0	237.0
Clearing	49.0	64.0	293.0	69.0	49.0	64.0
Dam	7,094.0	5,105.0	7,908.0	5,977.0	7,094.0	5,105.0
Embankment	(4,509.0)	(2,446.0)	(3,927.7)	(2,313.4)	(4,509.0)	(2,446.0)
Spillway	(24.0)	(14.0)	(22.8)	(12.0)	(24.0)	(14.0)
Slope protection	(914.0)	(1,119.0)	(2,117.0)	(1,617.7)	(914.0)	(1,119.0)
Outlet works	(1,647.0)	(1,526.0)	(1,840.5)	(2,033.9)	(1,647.0)	(1,526.0)
Access road	114.0	69.0	274.0	35.0	114.0	69.0
Buildings and grounds	240.0	219.0	288.0	204.0	240.0	219.0
Operating equipment	60.0	60.0	65.0	60.0	60.0	60.0
Engineering and design	352.0	264.0	616.0	400.0	352.0	264.0
Supervision and administration	511.0	392.0	876.0	663.0	511.0	392.0
Subtotal	10,360.0	8,620.0	18,355.0	12,495.0	10,360.0	8,620.0
B. FISH-WILDLIFE AND GENERAL RECREATION						
Lands and damages	190.0	210.0	165.0	160.0	140.0	180.0
Clearing	80.0	100.0	106.0	86.0	58.0	77.0
Access roads	116.0	376.0	112.0	147.0	110.0	371.0
Facilities	1,394.0	1,394.0	1,022.0	1,022.0	1,022.0	1,022.0
Engineering and design	107.0	125.0	85.0	87.0	82.0	100.0
Supervision and administration	163.0	185.0	120.0	128.0	118.0	150.0
Subtotal	2,050.0	2,390.0	1,610.0	1,630.0	1,530.0	1,900.0
C. TOTAL FIRST COST	12,410.0	11,010.0	19,965.0	14,125.0	11,890.0	10,520.0
ANNUAL CHARGES						
(Interest rates - Federal, 2.875%)(Amortization period - 100 years)						
Construction period - years	3	3	3	3	3	3
A. DAM AND RESERVOIR						
Investment						
First cost	10,360.0	8,620.0	18,355.0	12,495.0	10,360.0	8,620.0
Interest during construction	447.0	372.0	792.0	539.0	447.0	372.0
Subtotal	10,807.0	8,992.0	19,147.0	13,034.0	10,807.0	8,992.0
Annual charges						
Interest on investment	310.7	258.5	550.5	374.7	310.7	258.5
Amortization on investment	19.3	16.1	34.3	23.3	19.3	16.1
Maintenance and operation	70.0	67.0	88.0	72.0	70.0	67.0
Subtotal	400.0	341.6	672.8	470.0	400.0	341.6
B. FISH-WILDLIFE AND GENERAL RECREATION						
Investment						
First cost	2,050.0	2,390.0	1,610.0	1,630.0	1,530.0	1,910.0
Interest during construction	88.0	103.0	69.0	70.0	66.0	82.0
Subtotal	2,138.0	2,493.0	1,679.0	1,700.0	1,596.0	1,982.0
Annual charges						
Interest on investment	61.5	71.7	48.3	48.9	45.9	57.0
Amortization	3.8	4.5	3.0	3.0	2.9	3.5
Maintenance and operation	42.0	48.0	33.0	33.0	33.0	40.0
Subtotal	107.3	124.2	84.3	84.9	81.8	100.5
C. TOTAL FEDERAL ANNUAL CHARGES	507.3	465.8	757.1	554.9	481.8	442.1

(1) Reservoirs alone.
(2) Reservoirs in combination.

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TABLE 18

MAXIMIZATION OF FLOOD CONTROL BENEFITS
INVESTIGATED RESERVOIR PLANS FOR FLOOD CONTROL AND WATER CONSERVATION
PECAN BAYOU WATERSHED

Plan	Frequency of flood protection (years)	Gross yield at site (cfs)	Total usable storage (acre-feet)	Flood control (incremental to water supply): Total annual benefits ($1000)	Total annual charges ($1000)	Benefit cost ratio	Excess benefits over costs ($1000)
CAMP COLORADO							
Water conservation only	-	40	172,600	-	-	-	-
Dual purpose	25	40	303,400	287.5	224.6	1.28	62.9
Dual purpose	35	40	325,500	295.5	254.2	1.16	41.3
Dual purpose	50	40	337,100	298.6	178.7	1.67	119.9
Dual purpose	75	40	361,100	300.6	193.5	1.55	107.1
BURKETT							
Water conservation only	-	24	140,100	-	-	-	-
Dual purpose	25	24	234,700	171.3	175.5	0.98	-4.2
Dual purpose	35	24	243,500	175.3	186.1	0.94	-10.8
Dual purpose	50	24	252,700	177.9	125.6	1.42	52.3
Dual purpose	75	24	271,700	178.6	139.3	1.28	39.3
COLEMAN							
Water conservation only	-	24	137,300	-	-	-	-
Dual purpose	25	24	209,600	136.8	167.0	0.82	- 30.2
Dual purpose	35	24	219,900	140.0	169.3	0.83	- 29.3
Dual purpose	50	24	230,600	142.5	91.0	1.57	51.5
Dual purpose	75	24	241,700	143.6	112.0	1.28	31.6
PECAN BAYOU							
Water conservation only	-	17	97,200	-	-	-	-
Dual purpose	25	17	180,500	146.3	116.9	1.25	29.4
Dual purpose	35	17	188,200	149.2	119.7	1.25	29.5
Dual purpose	50	17	196,200	151.3	76.2	1.99	75.1
Dual purpose	75	17	212,600	152.0	84.2	1.81	67.8

TABLE 19

MAXIMIZATION OF WATER CONSERVATION BENEFITS
INVESTIGATED RESERVOIR PLANS FOR FLOOD CONTROL AND WATER CONSERVATION
PECAN BAYOU WATERSHED

Plan	Total yield at site (cfs)	Total Usable storage (acre-feet)	Water conservation (incremental to flood control)				
			Total annual benefits ($1000)	Total annual charges ($1000)	Benefit cost ratio	Excess benefits over costs ($1000)	Water cost per 1000 gallons ($1000)
CAMP COLORADO							
Flood control only	-	161,700	-	-	-	-	
Dual purpose	20	183,900	201.8	70.3	2.87	131.5	0.014900
Dual purpose	30	243,100	302.6	114.5	2.64	188.1	0.016179
Dual purpose	35	282,200	353.1	146.2	2.42	206.9	0.017707
Dual purpose	40	337,100	403.5	185.2	2.18	218.3	0.019626
BURKETT							
Flood control only	-	122,700	-	-	-	-	
Dual purpose	12	146,200	121.1	54.5	2.22	66.6	0.019252
Dual purpose	18	186,600	181.6	71.3	2.55	110.3	0.016791
Dual purpose	24	252,700	242.1	104.0	2.33	138.1	0.018369
COLEMAN							
Flood control only	-	88,500	-	-	-	-	
Dual purpose	9	94,800	90.8	15.9	5.71	74.9	0.007489
Dual purpose	14	122,100	141.2	41.5	3.40	99.7	0.012566
Dual purpose	20	171,000	201.8	82.2	2.45	119.6	0.017422
Dual purpose	24	230,600	242.1	122.4	1.98	119.7	0.021619
PECAN BAYOU							
Flood control only	-	97,200	-	-	-	-	
Dual purpose	8	119,600	80.7	23.1	3.49	57.6	0.012240
Dual purpose	12	144,800	121.1	32.6	3.71	88.5	0.011516
Dual purpose	17	196,200	171.5	56.5	3.04	115.0	0.014088

TABLE 20

PERTINENT DATA
PROPOSED PECAN BAYOU AND COLEMAN RESERVOIRS
PECAN BAYOU WATERSHED

Item	Pecan Bayou Reservoir				Coleman Reservoir			
DRAINAGE AREA								
Square miles	316				287			
SPILLWAY DESIGN FLOOD								
Peak inflow, cfs	317,500				307,100			
Volume, acre-feet	406,100				371,100			
Volume, inches	24.10				24.24			
Peak outflow, cfs	184,200 (1)				202,800 (1)			
RESERVOIR	Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
Top of dam	1676.0	-	-	-	1812.0	-	-	-
Maximum design water surface	1670.4	12,010	379,700	22.53	1806.3	7,360	382,000	24.96
Top flood control pool and spillway crest	1653.0	8,030	206,300	12.24	1784.0	5,430	240,900	15.74
Top conservation pool	1637.0	5,150	102,000	6.05	1764.0	3,930	147,600	9.64
Sediment storage	1653.0	-	10,100	0.60	1784.0	-	10,300	0.67
Sediment storage	1637.0	-	8,500	0.50	1764.0	-	9,100	0.59
DAM								
Type	Earth fill				Earth fill			
Total length, feet	15,090 (3)				16,660			
Embankment section:								
Type	Compacted earth fill				Compacted earth fill			
Total length, feet	14,290				16,060			
Height above streambed, feet	107				156			
Freeboard, feet	5.6				5.7			
Crown width, feet	20				20			
Side slopes:								
Upstream	1 on 2-1/2 & 1 on 3-1/2				1 on 2-1/2 & 1 on 3-1/2			
Downstream	1 on 2-1/2 & 1 on 3				1 on 2-1/2 & 1 on 3			
Spillway section:								
Type	Broadcrested				Broadcrested			
Gross length, feet	800				600			
Net length, feet	800				600			
Spillway discharge, cfs:								
Maximum design water surface	173,200				192,500			
OUTLET WORKS								
Type	Gate-controlled conduit				Gate-controlled conduit			
Number of conduits	1				1			
Dimensions	16' diameter				14' diameter			
Invert elevation, feet	1588.0				1672.0			
Control	3 - 5' x 16' slide gates				3 - 4'2" x 14' slide gates			
RELOCATIONS								
County roads, miles	5.6				5.2			
Power lines, miles	13.3				7.3			
Telephone lines, miles	25.0				8.3			
Pipe lines, miles	None				1			
Cemeteries	1				1			
LANDS								
Dam and reservoir								
Clearing, acres	1,335				1,019			
Land acquisition:								
Fee simple, acres	10,000				6,550			
(Top control elevation)	(1658.0)				(1789.0)			
Flood easements, acres	1,100				700			
Recreation								
Clearing, acres	1,600				1,200			
Land acquisition:								
Fee simple above general taking limits, acres	550				550			

(1) Includes discharge through outlet works as follows: 11,000 cfs (Pecan Bayou Reservoir); 10,300 cfs (Coleman Reservoir)
(2) All elevations refer to mean sea level
(3) Includes 4,850' dike on right bank

TABLE 21

DETAILED ESTIMATE OF FIRST COST
PROPOSED PECAN BAYOU RESERVOIR
PECAN BAYOU WATERSHED
(July 1963 price level)

Item	Unit quantity	Unit cost	Single-purpose flood control: Quantity	Single-purpose flood control: Cost	Single-purpose water conservation (1): Quantity	Single-purpose water conservation (1): Cost	Multiple-purpose FC,WC,FW,& R: Quantity	Multiple-purpose FC,WC,FW,& R: Cost
PERTINENT DATA								
Top of dam, elevation			1663.0		1663.0		1676.0	
Spillway crest, elevation			1638.0		1637.0		1653.0	
Lands, fee simple, acres					6,900		10,550	
(Top control elevation)					(1643.0)		(1658.0)	
Lands, flood easements, acres			6,300				1,100	
(Top control elevation)			(1644.0)					
A. FEDERAL FIRST COST								
(01.0) Lands and damages								
a. Land costs								
(1) Fee simple lands, improvements, and severance damages	Acre		500	$ 185,135	6,900	$ 865,000	10,000	$1,220,000
(2) Flood easement lands and improvements	Acre		6,300	350,760		--	1,100	99,000
(3) Subordination of minerals	L.S.			328,000		276,000		470,000
(4) Resettlement reimbursement	L.S.			5,000		5,000		5,000
Subtotal - land costs				868,895		1,146,000		1,794,000
Contingencies, 20%±				130,105		229,000		356,000
Total - Land costs				999,000		1,375,000		2,150,000
b. Land acquisition expense	L.S.			51,000		55,000		60,000
Total - Lands and damages				1,050,000		1,430,000		2,210,000
(02.0) Relocations								
a. Roads (County)				134,000		133,000		152,000
b. Cemeteries and utilities								
(1) Electric lines				12,000		12,000		20,000
(2) Telephone lines				8,000		8,000		15,000
(3) Cemeteries				1,000		1,000		3,000
Subtotal - cemeteries and utilities				21,000		21,000		38,000
Subtotal - relocations				155,000		154,000		190,000
Contingencies, 25%±				39,000		37,000		47,000
Total - Relocations				194,000		191,000		237,000
(03.0) Reservoirs								
a. Reservoir clearing	Acre	40.00		--	1,335	53,400	1,335	53,400
Contingencies, 20%±				--		10,600		10,600
Total - Reservoirs				--		64,000		64,000
(04.0) Dams								
a. Earth embankment								
(1) Diversion and care of water	L.S.			30,000		30,000		25,000
(2) Clearing and grubbing	Acre	250.00	41	10,250	39	9,750	60	15,000
(3) Excavation, stripping	C.Y.	0.25	60,100	15,025	57,700	14,425	86,000	21,500
(4) Excavation, common	C.Y.	0.25	60,100	15,025	57,700	14,425	86,000	21,500
(5) Excavation, borrow	C.Y.	0.26	1,421,270	369,530	1,364,420	354,749	2,704,000	703,040
(6) Compacted fill	C.Y.	0.08	1,877,600	150,208	1,802,500	144,200	2,749,000	219,920
(7) Drainage blanket	C.Y.	3.50	84,300	295,050	80,900	283,150	141,000	493,500
(8) Riprap	C.Y.	6.00	41,500	249,000	39,500	237,000	50,200	301,200
(9) Bedding	C.Y.	3.50	17,900	62,650	17,200	60,200	20,400	71,400
(10) Flexible base	C.Y.	4.50	2,750	12,375	2,640	11,880	4,900	22,050
(11) Aggregate	C.Y.	6.00	145	870	139	834	260	1,560
(12) Asphalt treatment	Gal.	0.20	8,550	1,710	8,200	1,640	15,900	3,180
(13) Timber guide posts	Ea.	5.00	596	2,980	570	2,850	1,018	5,090
(14) Grouting	L.S.		--	58,000	--	150,000	--	135,000
Subtotal - earth embankment				1,272,673		1,315,103		2,038,940
b. Slope protection	Acre	500.00	18	9,000	17.4	8,700	24	12,000
c. Spillway								
(1) Care of water during construction	L.S.			20,000		20,000		20,000
(2) Clearing	Acre	100.00	41	4,100	41	4,100	25	2,500
(3) Excavation, common	C.Y.	0.25	715,600	178,900	715,600	178,900	312,000	78,000
(4) Excavation, rock	C.Y.	1.20	433,600	520,320	476,900	572,280	5,700	6,840
(5) Backfill	C.Y.	1.00	6,500	6,500	6,500	6,500	5,700	5,700
(6) Line drilling	S.F.	1.50	14,000	21,000	14,000	21,000	13,400	20,100
(7) Concrete, wall	C.Y.	35.00	2,740	95,900	2,740	95,900	2,510	87,850
(8) Concrete, slab	C.Y.	20.00	14,790	295,800	14,790	295,800	14,510	290,200
(9) Cement	Bbl.	5.00	21,910	109,550	21,910	109,550	21,400	107,000
(10) Steel, reinforcing	Lb.	0.13	1,849,000	240,370	1,849,000	240,370	1,801,000	234,130
(11) Riprap	C.Y.	6.00	11,260	67,560	11,260	67,560	11,060	66,360
(12) Bedding	C.Y.	3.50	4,020	14,070	4,020	14,070	3,910	13,685
Subtotal - spillway				1,574,070		1,626,030		932,365
d. Outlet works								
(1) Care of water during construction	L.S.			20,000		20,000		20,000
(2) Clearing	Acre	150.00	6	900	1	150	6	900
(3) Excavation, common	C.Y.	0.35	56,000	19,600	1,370	480	56,000	19,600
(4) Excavation, rock (shale)	C.Y.	1.20	144,600	173,520		--	144,600	173,520
(5) Backfill, structural	C.Y.	1.00	32,200	32,200	1,050	1,050	32,200	32,200
(6) Drilling and grouting anchor holes	L.F.	2.25	650	1,463		--	650	1,463
(7) Drilling drain holes	L.F.	2.00	650	1,300		--	650	1,300
(8) Line drilling	S.F.	1.50	5,000	7,500		--	5,000	7,500
(9) Operating house	L.S.			41,000		--		41,000
(10) Concrete, control tower	C.Y.	45.00	1,506	67,770	250	11,250	1,647	74,115
(11) Concrete, tower base and transition	C.Y.	32.00	2,400	76,800		--	2,400	76,800
(12) Concrete, conduit	C.Y.	30.00	2,340	70,200	840	25,200	3,260	97,800
(13) Concrete, slab	C.Y.	25.00	1,270	31,750	65	1,625	1,270	31,750
(14) Concrete, walls	C.Y.	35.00	2,760	96,600	65	2,275	2,760	96,600
(15) Concrete, bridge	C.Y.	60.00	21	1,260		--	21	1,260
(16) Cement	Bbl.	5.00	12,860	64,300	1,520	7,600	13,310	66,550
(17) Steel, reinforcement	Lb.	0.13	1,243,000	161,590	143,100	18,603	1,397,700	181,701
(18) Steel, structural	Lb.	0.30	33,300	9,990		--	56,700	17,010
(19) Pipe railing	Lb.	0.50	9,100	4,550		--	14,800	7,400
(20) Metal, miscellaneous	Lb.	0.40	1,110	444	500	200	1,290	516
(21) Ladders, gratings, and grills	Lb.	0.50	2,590	1,295	1,000	500	3,000	1,500
(22) Conduit liner	Lb.	0.30	224,000	67,200	27,200	8,160	224,000	67,200
(23) Rubber water stop	L.F.	3.00	680	2,040	510	1,530	908	2,724
(24) Water gages, tile	L.F.	14.00	65	910		--	77	1,078
(25) Gates and operating equipment	L.S.			200,000		7,500		200,000
(26) Bulkhead	L.S.			8,000		--		8,000
(27) Overhead crane	L.S.			20,000		--		20,000
(28) Electrical facilities	L.S.			7,000		--		7,000
(29) Riprap	C.Y.	6.00	2,010	12,060	100	600	2,010	12,060
(30) Bedding	C.Y.	4.50	690	3,105	31	140	690	3,105
Subtotal - outlet works				1,204,347		106,863		1,271,652
Subtotal - dams				4,060,090		3,056,696		4,254,957
Contingencies, 20%±				812,910		613,304		850,043
Total - Dams				4,873,000		3,670,000		5,105,000
(08.0) Access road	Mile	30,000.00	2.2	67,000	2.4	71,000	1.9	57,000
Contingencies, 20%±				14,000		14,000		12,000
Total - Access road				81,000		85,000		69,000
(19.0) Buildings and grounds								
(1) Maintenance buildings	L.S.			92,000		92,000		92,000
(2) Power line to site	Mile	10,000.00	2.3	23,000	2.3	23,000	2.0	20,000
(3) Water well and accessories	L.S.			30,000		30,000		30,000
(4) General clean-up, landscaping	L.S.			20,000		20,000		20,000
(5) Visitor overlook facilities	L.S.			20,000		20,000		20,000
Subtotal - buildings and grounds				185,000		185,000		182,000
Contingencies, 20%±				37,000		37,000		37,000
Total - Buildings and grounds				222,000		222,000		219,000
(20.0) Operating equipment								
(1) Stream gages	L.S.			10,000		14,000		15,000
(2) Radio facilities	L.S.			4,000		5,600		4,000
(3) Government work boat	L.S.			--		--		8,000
(4) Evaporation and rain gages	L.S.			1,500		2,100		1,500
(5) Farm-type tractor and miscellaneous small tools	L.S.			2,000		2,800		6,500
(6) Sediment and degradation ranges	L.S.			--		--		12,000
(7) Office furniture and equipment	L.S.			3,000		4,200		3,000
Subtotal - operating equipment				20,500		28,700		50,000
Contingencies, 20%±				4,500		6,300		10,000
Total - Operating equipment				25,000		35,000		60,000
(30.0) Engineering and design				216,000		199,000		264,000
(31.0) Supervision and administration				339,000		297,000		392,000
Subtotal - estimated Federal first cost - dam and reservoir				7,000,000		6,193,000		8,620,000
TOTAL ESTIMATED FIRST COST OF FLOOD CONTROL AND/OR WATER CONSERVATION				7,000,000		6,193,000		8,620,000
B. DETAILED ESTIMATE OF FIRST COST - FISH-WILDLIFE AND GENERAL RECREATION								
(01.0) Lands and damages								
a. Land costs above general taking limits								
(1) Fee simple lands, improvements and severances	Acre			--		--	550	123,700
(2) Subordination of minerals	L.S.			--		--		22,000
(3) Resettlement reimbursement				--		--		1,000
Subtotal - land costs				--		--		146,700
Contingencies, 20%±				--		--		28,300
Total - Land costs				--		--		175,000
b. Acquisition expense	L.S.			--		--		5,000
Total - Lands and damages				--		--		180,000
(03.0) Reservoir clearing	Acre	40.00		--		--	1,600	64,000
Contingencies, 20%±				--		--		13,000
Total - Reservoir clearing				--		--		77,000
(08.0) Access roads	Mile	31,000.00		--		--	10.00	310,000
Contingencies, 20%±				--		--		61,000
Total - Access roads				--		--		371,000
(14.0) Facilities								
(1) Initial for first 3 years	L.S.			--		--		412,500
(2) Future development after 3 years				--		--		440,000
Subtotal - Facilities				--		--		852,500
Contingencies, 20%				--		--		169,500
Total - Facilities				--		--		1,022,000
(30.0) Engineering and design				--		--		100,000
(31.0) Supervision and administration				--		--		150,000
Subtotal - estimated Federal first cost - fish-wildlife and general recreation				--		--		1,900,000
C. TOTAL ESTIMATED PROJECT FIRST COST				$7,000,000		$6,193,000		$10,520,000

(1) Includes water quality control

TABLE 22

DETAILED ESTIMATE OF FIRST COST
PROPOSED COLEMAN RESERVOIR
PECAN BAYOU WATERSHED
(July 1963 price level)

Item	Unit quantity	Unit cost	Single-purpose flood control		Single-purpose water conservation (1)		Multiple-purpose FC,WC,FW,& R	
			Quantity	Cost	Quantity	Cost	Quantity	Cost
PERTINENT INFORMATION								
Top of dam, elevation			1781.0		1795.0		1812.0	
Spillway crest, elevation			1750.0		1765.0		1784.0	
Lands, fee simple, acres			--		5,120		7,100	
(Top control elevation)			--		(1769.0)		(1789.0)	
Lands, flood easements, acres			3,170		--		700	
(Top control elevation)			(1755.0)		--		--	
A. FEDERAL FIRST COST								
(01.0) Lands and damages								
a. Land costs								
(1) Fee simple lands, improvements, and severances	Acre		500	$ 55,000	5,120	$ 850,000	6,550	$1,068,000
(2) Flood easement lands and improvements	Acre		3,170	460,000			700	51,000
(3) Subordination of minerals	L.S.			130,000		180,000		253,000
(4) Resettlement reimbursement	L.S.			5,000		5,000		5,000
Subtotal - land costs				650,000		1,035,000		1,377,000
Contingencies, 20%±				130,000		210,000		273,000
Total - Land costs				780,000		1,245,000		1,650,000
b. Land acquisition expense	L.S.			50,000		55,000		60,000
Total - Lands and damages				830,000		1,300,000		1,710,000
(02.0) Relocations								
a. Roads (County)				--		41,000		138,000
b. Cemeteries and utilities								
(1) Electric lines				7,000		8,500		10,000
(2) Telephone lines				3,000		3,500		4,000
(3) Pipelines				10,000		20,000		29,000
(4) Cemeteries				1,000		2,000		3,000
Subtotal - cemeteries and utilities				21,000		34,000		46,000
Subtotal - relocations				21,000		75,000		184,000
Contingencies, 25%±				5,000		19,000		46,000
				26,000		94,000		230,000
(03.0) Reservoirs								
a. Reservoir clearing	Acre	$ 40.00		--	1,019	40,760	1,019	40,760
Contingencies, 20%±				--		8,240		8,240
Total - Reservoirs				--		49,000		49,000
(04.0) Dams								
a. Earth embankment								
(1) Diversion and care of water	L.S.			30,000		30,000		25,000
(2) Clearing and grubbing	Acre	250.00	47	11,750	76	19,000	90	22,500
(3) Excavation, stripping	C.Y.	0.25	71,500	17,875	115,700	28,925	140,400	35,100
(4) Excavation, common	C.Y.	0.25	71,500	17,875	115,700	28,925	82,500	20,625
(5) Excavation, borrow	C.Y.	0.26	2,917,000	758,420	4,719,700	1,227,122	6,460,000	1,679,600
(6) Compacted fill	C.Y.	0.08	2,854,000	228,320	4,617,800	369,424	6,165,000	493,200
(7) Drainage blanket	C.Y.	3.50	105,500	369,250	170,700	597,450	235,100	822,850
(8) Riprap	C.Y.	6.00	46,900	281,400	79,000	474,000	71,000	426,000
(9) Bedding	C.Y.	3.50	21,000	73,500	34,000	119,000	29,600	103,600
(10) Flexible base	C.Y.	4.50	1,910	8,595	3,090	13,905	5,800	26,100
(11) Aggregate	C.Y.	6.00	100	600	160	960	310	1,860
(12) Asphalt treatment	Gal.	0.20	5,560	1,112	9,000	1,800	28,070	5,614
(13) Timber guide posts	Ea.	5.00	414	2,070	670	3,350	1,122	5,610
(14) Cofferdam	L.S.			5,000		8,000		--
(15) Grouting	L.S.			50,000		100,000		90,000
Subtotal - earth embankment				1,855,767		3,021,861		3,757,659
b. Slope protection	Acre	500.00	23	11,500	31	15,500	40	20,000
c. Spillway								
(1) Care of water during construction	L.S.			20,000		20,000		20,000
(2) Clearing	Acre	100.00	26	2,600	30	3,000	11	1,100
(3) Excavation, common	C.Y.	0.25	148,000	37,000	171,600	42,900	73,500	18,375
(4) Excavation, rock	C.Y.	1.20	195,400	234,480	226,600	271,920	86,660	103,992
(5) Drilling and grouting anchor holes	L.F.	2.25		--		--	14,500	32,625
(6) Backfill	C.Y.	1.00	6,500	6,500	7,500	7,500	--	--
(7) Line drilling	S.F.	1.50	13,700	20,550	15,900	23,850	5,600	8,400
(8) Concrete, wall	C.Y.	35.00	2,950	103,250	3,420	119,700	2,490	87,150
(9) Concrete, slab	C.Y.	20.00	14,410	288,200	16,700	334,000	10,700	214,000
(10) Cement	Bbl.	5.00	21,700	108,500	25,900	129,500	16,340	81,700
(11) Steel, reinforcing	Lb.	0.13	1,839,000	239,070	2,132,000	277,160	1,465,000	190,450
(12) Riprap	C.Y.	6.00	11,000	66,000	12,700	76,200	--	--
(13) Structural backfill	C.Y.	1.00		--		--	3,900	3,900
(14) Bedding	C.Y.	3.50	3,930	13,755	4,560	15,960		--
Subtotal - spillway				1,139,905		1,321,690		761,692
d. Outlet works								
(1) Care of water during construction	L.S.			20,000		20,000		20,000
(2) Clearing	Acre	150.00	11	1,650	1	150	10	1,500
(3) Excavation, common	C.Y.	0.35	132,500	46,375	2,229	780	129,500	45,325
(4) Excavation, rock (shale)	C.Y.	1.20	137,400	164,880		--	133,400	160,080
(5) Backfill, structural	C.Y.	1.00	26,800	26,800	1,050	1,050	28,600	28,600
(6) Drilling and grouting anchor holes	L.F.	2.25	670	1,508		--	670	1,508
(7) Drilling drain holes	L.F.	2.00	670	1,340		--	670	1,340
(8) Line drilling	S.F.	1.50	11,070	16,605		--	14,080	21,120
(9) Operating house	L.S.			41,000		--		35,000
(10) Concrete, control tower	C.Y.	45.00	1,760	79,200	405	18,225	2,248	101,160
(11) Concrete, tower base and transition	C.Y.	32.00	2,375	76,000		--	2,300	73,600
(12) Concrete, conduit	C.Y.	30.00	3,000	90,000	1,090	32,700	3,320	99,600
(13) Concrete, slab	C.Y.	25.00	600	15,000	65	1,625	640	16,000
(14) Concrete, walls	C.Y.	35.00	3,350	117,250	65	2,275	3,240	113,400
(15) Concrete, bridge	C.Y.	60.00	110	6,600			230	13,800
(16) Cement	Bbl.	5.00	13,100	65,500	2,030	10,150	15,000	75,000
(17) Steel, reinforcement	Lb.	0.13	1,414,000	183,820	191,046	24,836	1,580,000	205,400
(18) Steel, structural	Lb.	0.30	51,500	15,450		--	220,000	66,000
(19) Pipe railing	Lb.	0.50	1,130	565		--	2,720	1,360
(20) Metal, miscellaneous	Lb.	0.40	40,000	16,000	500	200	30,000	12,000
(21) Ladders, gratings, and grills	Lb.	0.50	1,500	750	1,000	500	1,500	750
(22) Conduit liner	Lb.	0.30	54,500	16,350	47,367	14,210	54,500	16,350
(23) Rubber water stop	L.F.	3.00	550	1,650	880	2,640	750	2,250
(24) Water gages, tile	L.F.	14.00	130	1,820		--	161	2,254
(25) Gates and operating equipment	L.S.			200,000		7,500		200,000
(26) Bulkhead	L.S.			8,000		--		8,000
(27) Overhead crane	L.S.			20,000		--		20,000
(28) Electrical facilities	L.S.			7,000		--		7,000
(29) Riprap	C.Y.	6.00	3,100	18,600	100	600	3,100	18,600
(30) Bedding	C.Y.	4.50	1,100	4,950	31	140	1,100	4,950
Subtotal - outlet works				1,264,663		137,581		1,371,947
Subtotal - dams				4,271,835		4,496,632		5,911,298
Contingencies, 20%±				855,165		899,368		1,182,702
Total - Dams				5,127,000		5,396,000		7,094,000
(08.0) Access road	Mile	30,000.00	4.7	140,000	3.9	118,000	3.2	95,000
Contingencies, 20%±				29,000		24,000		19,000
Total - Access road				169,000		142,000		114,000
(19.0) Buildings and grounds								
(1) Maintenance buildings	L.S.			91,000		83,000		90,000
(2) Powerline to site	Mile	10,000.00	4.9	49,000	4.9	49,000	4.0	40,000
(3) Water well and accessories	L.S.			30,000		30,000		30,000
(4) General cleanup, landscaping	L.S.			20,000		20,000		20,000
(5) Visitor overlook facilities	L.S.			20,000		20,000		20,000
Subtotal - buildings and grounds				210,000		202,000		200,000
Contingencies, 20%±				42,000		40,000		40,000
Total - Buildings and grounds				252,000		242,000		240,000
(20.0) Operating equipment								
(1) Stream gages	L.S.			10,000		14,000		15,000
(2) Radio facilities	L.S.			4,000		5,600		4,000
(3) Government work boat	L.S.			--		--		8,000
(4) Evaporation and rain gages	L.S.			1,500		2,100		1,500
(5) Farm-type tractor and miscellaneous small tools	L.S.			2,000		2,800		6,500
(6) Sediment and degradation ranges	L.S.			--		--		12,000
(7) Office furniture and equipment	L.S.			3,000		4,200		3,000
Subtotal - operating equipment				20,500		28,700		50,000
Contingencies, 20%±				4,500		6,300		10,000
Total - Operating equipment				25,000		35,000		60,000
(30.0) Engineering and design				230,000		275,000		352,000
(31.0) Supervision and administration				341,000		405,000		511,000
Subtotal - estimated Federal first cost - dam and reservoir				7,000,000		7,938,000		10,360,000
TOTAL ESTIMATED FIRST COST OF FLOOD CONTROL AND/OR WATER CONSERVATION				7,000,000		7,938,000		10,360,000
B. DETAILED ESTIMATE OF FIRST COST - FISH-WILDLIFE AND GENERAL RECREATION								
(01.0) Lands and damages								
a. Land costs above general taking limits								
(1) Fee simple lands, improvements, and severances	Acre			--		--	550	93,000
(2) Subordination of minerals	L.S.			--		--		20,000
(3) Resettlement reimbursement	L.S.			--		--		1,000
Subtotal - land costs				--		--		114,000
Contingencies, 20%±				--		--		22,000
Total - land costs				--		--		136,000
b. Acquisition expense	L.S.			--		--		4,000
Total - Lands and damages				--		--		140,000
(03.0) Reservoir clearing	Acre	40.00		--		--	1,200	48,000
Contingencies, 20%±				--		--		10,000
Total - Reservoir clearing				--		--		58,000
(08.0) Access roads	Mile	31,000.00		--		--	3.00	93,000
Contingencies, 20%±				--		--		17,000
Total - Access roads				--		--		110,000
(14.0) Facilities								
(1) Initial for first 3 years	L.S.			--		--		412,500
(2) Future development after 3 years				--		--		440,000
Subtotal - facilities				--		--		852,500
Contingencies, 20%±				--		--		169,500
Total - Facilities				--		--		1,022,000
(30.0) Engineering and design				--		--		82,000
(31.0) Supervision and administration				--		--		118,000
Subtotal - estimated Federal first cost - fish-wildlife and general recreation				--		--		1,530,000
C. TOTAL ESTIMATED PROJECT FIRST COST				$7,000,000		$7,938,000		$11,890,000

(1) Includes water quality control

COST ALLOCATION STUDIES

90. GENERAL.- Cost allocation studies were made to determine the division of reservoir project costs to the various purposes as follows: (a) The proposed reconstructed Lake Brownwood (Lake Brownwood protective measures) to purposes of flood control and water supply; and (b) the proposed Pecan Bayou and Coleman Reservoirs to purposes of flood control, water supply (excluding water quality control), water quality control, and recreation (including general recreation and fish-wildlife recreation and harvest). The cost allocation studies were made on the basis of the Separable Cost-Remaining Benefits method. The method involves studies of single-purpose and multiple-purpose reservoirs as instruments in the cost allocation procedures. Cost allocation studies for the reconstructed Lake Brownwood and the Pecan Bayou and Coleman Reservoirs were of normal procedure. However, in the case of reconstructed Lake Brownwood, construction costs allocated to water supply and to be borne by local interests involved credit to local interests for value of existing useful lands and facilities at existing Lake Brownwood. The proposed Brownwood channel improvements are primarily for flood control purposes and, therefore, cost allocation studies are not involved.

91. Because of the nature of water quality control objectives, water quality control is interpreted as being a Federal responsibility and therefore is allocated as a separate water supply purpose in the Coleman and Pecan Bayou Reservoirs.

92. Cost allocation studies for the proposed reconstructed Lake Brownwood project and for the proposed Pecan Bayou and Coleman Reservoirs are presented in table 23, **paster. A unit cost study** relative to water supply costs allocated to local interests is presented in table 24, **paster. Separable costs for use as instruments** in cost allocation studies for reconstructed Lake Brownwood and the Coleman and Pecan Bayou Reservoirs were based on multiple-purpose-project costs shown in table 25. Estimates of first cost and annual charges and pertinent data for single-purpose reservoirs used for cost allocation studies are presented in tables 26 through 28.

93. The allocation of construction, investment, and annual maintenance and operation costs to various purposes of the proposed reconstructed Lake Brownwood and the proposed Pecan Bayou and Coleman Reservoirs are shown by costs and percentages in the cost allocation studies of table 23. The allocated costs and percentages are summarized in table 5 of the text. A summary of apportionment of total project costs between Federal and non-Federal interests is presented in table 6 of the text.

94. The amount of local participation for the water supply function in the proposed reconstructed Lake Brownwood project and the proposed Pecan Bayou and Coleman Reservoirs is tentatively established on the basis of the July 1963 price level, and is subject to modification at the time of initiation of construction to reflect the prevalent price levels; and further, at time of completion of construction to reflect the actual project costs.

95. LAKE BROWNWOOD COST ALLOCATION.- In regard to the Lake Brownwood protective measures, cost-sharing studies were based on the overall construction-cost value and annual maintenance and operation costs for a reconstructed Lake Brownwood project. The proposed Lake Brownwood protective measures and the useful existing facilities would constitute a proposed reconstructed Lake Brownwood project. The proposed reconstructed Lake Brownwood project, designed for operation with the proposed Pecan Bayou and Coleman Reservoirs, would have a present-day total construction-cost value of about $7,300,000, and the estimated annual maintenance and operation costs would be about $45,000. The costs of the proposed project, as well as single-purpose reservoirs used in the cost allocation studies, are summarized in table 26.

96. The cost allocation studies in table 23 indicate that the construction-cost portion allocated to water supply to be borne by local interests is 49.34 percent or $3,601,800. Since local interests own existing Lake Brownwood, they would be given credit of $4,240,000 as the estimated value of certain useful facilities in the reconstructed project, including lands and easements, spillway excavation, engineering and design, and supervision and administration. Since the total value of these items exceeds the construction cost allocated to water supply, local interests would not be required to contribute any of the construction costs of the proposed Lake Brownwood protective measures. Thus, the total construction cost of the proposed protective measures, estimated to be $3,060,000 would be borne by the Federal Government. However, based on the cost allocation studies, local interests would be required to bear 48.89 percent (or $22,000) of a total annual maintenance and operation cost of $45,000.

97. ALLOCATED WATER SUPPLY COSTS.- Local interests in Brown and Coleman Counties have indicated a desire to defer payment for water supply storage needed for future water supply. Local interests in Coleman County have indicated a desire for immediate use of a portion of the water supply storage in Coleman Reservoir after completion of construction. In regard to the Coleman and Pecan Bayou Reservoirs, the project costs allocated to water supply are less than 30 percent of the total project costs, and thus, cost payments for the total water supply storage in the proposed projects can be deferred in accordance with repayment provisions of the Water Supply Act of 1958, as amended

98. Water supply storage for municipal, industrial, and non-municipal purposes have been investigated and included in the Coleman and Pecan Bayou Reservoirs in accordance with the desires of local interests and the State of Texas. The storage provides for maximum economical development of water supply resources upstream from the dam sites. This report presents estimates of dependable yields to be realized from the water supply storages. However, the issuance of water permits and the manner of utilizing the water supply storage are matters to be resolved by local interests and the State of Texas. The unit costs of water supply, based on total dependable yields at the sites and on the increases in dependable yield above that provided by reconstructed Lake Brownwood operating alone -- without and with recognition of average return flows into reconstructed Lake Brownwood resulting from water supply utilized from the Coleman and Pecan Bayou Reservoirs -- are reflected in the unit water-supply cost study presented in table 24, paster. Based on studies presented in the U. S. Public Health Service report, the above-mentioned return flows into reconstructed Lake Brownwood would amount to about 3.2 cfs in year 2020 and about 6.0 cfs in year 2070, or an average of about 3.2 cfs during the 100-year period from 1970 to 2070.

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TABLE 23

ALLOCATION OF COST
RESERVOIR UNITS OF PROPOSED PLAN OF IMPROVEMENT
PECAN BAYOU WATERSHED
(SEPARABLE COST-REMAINING BENEFITS METHOD)
(Interest rate, 3% - Amortization period, 100 yrs)

Item	Reconstructed Lake Brownwood: Single-purpose: Flood control	Reconstructed Lake Brownwood: Single-purpose: Water supply	Reconstructed Lake Brownwood: Dual-purpose	Coleman Reservoir: Single-purpose: Flood control	Coleman Reservoir: Single-purpose: Water supply	Coleman Reservoir: Single-purpose: Water quality control	Coleman Reservoir: Single-purpose: Fish-wildlife and general recreation	Coleman Reservoir: Multiple-purpose	Pecan Bayou: Single-purpose: Flood control	Pecan Bayou: Single-purpose: Water supply	Pecan Bayou: Single-purpose: Water quality control	Pecan Bayou: Single-purpose: Fish-wildlife and general recreation	Pecan Bayou: Multiple-purpose
PERTINENT INFORMATION													
First cost, dollars	5,810,000	6,635,000	7,300,000	7,000,000	7,190,000	--	8,660,000	11,890,000	7,000,000	5,970,000	--	7,995,000	10,520,000
Annual charges, dollars	217,100	244,400	286,400	279,500	291,800	(1)	364,400	496,300	279,500	247,500	(1)	345,500	454,900
Annual maintenance & operation, dollars	25,000	25,000	45,000	48,000	54,000	--	78,000	103,000	48,000	50,000	--	81,000	107,000
Dependable stream flow, second-feet	--	23.0	23.0	--	18.4	1.6	--	20.0	--	11.4	1.6	--	13.0
Dependable stream flow, mgd	--	14.87	14.87	--	11.89	1.03	--	12.92	--	7.37	1.03	--	8.40
Total annual benefits, dollars	637,300	191,000	828,300	207,200	229,700	29,400	676,800	1,143,100	235,700	195,300	29,400	676,800	1,137,200
Flood control storage, acre-feet	36,900	--	--	88,500	--	--	--	92,100	97,200	--	--	--	102,700
Water conservation storage, acre-feet	--	91,600	91,600	--	111,000	--	115,000	138,500	--	70,000	--	44,400	93,500
Sediment storage, acre-feet	33,000	33,000	33,000	10,300	10,300	--	10,300	10,300	10,100	10,100	--	10,100	10,100

Item	Flood control	Water supply	Dual-purpose	Flood control	Water supply	Water quality control	Fish-wildlife and general recreation	Multiple-purpose	Flood control	Water supply	Water quality control	Fish-wildlife and general recreation	Multiple-purpose
COST ALLOCATIONS													
Allocation of annual charges													
1. Benefits	637,300	191,000	828,300	207,200	229,700	29,400	676,800	1,143,100	235,700	195,300	29,400	676,800	1,137,200
2. Alternate cost	217,100	244,400	--	279,500	291,800	(1)	364,400	--	279,500	247,500	(1)	345,500	--
3. Benefits limited by alternate cost	217,100	191,000	--	207,200	229,700	29,400	364,400	--	235,700	195,300	29,400	345,500	--
4. Separable costs	42,000	69,300	111,300	83,200	23,200	23,200	90,600	220,200	78,600	27,000	11,800	117,500	234,900
5. Remaining benefits	175,100	121,700	296,800	124,000	206,500	6,200	273,800	610,500	157,100	168,300	17,600	228,000	571,600
6. % distribution of item 5	59.00	41.00	100.00	20.31	33.82	1.02	44.85	100.00	27.52	29.47	3.08	39.93	100.00
7. Allocated joint cost	103,300	71,800	175,100	56,100	93,400	2,800	123,800	276,100	60,500	64,800	6,800	87,900	220,000
8. Total allocation	145,300	141,100	286,400	139,300	116,600	26,000	214,400	496,300	139,100	91,800	18,600	205,400	454,900
9. % distribution of line 8	50.73	49.27	100.00	28.07	23.49	5.24	43.20	100.00	30.58	20.18	4.09	45.15	100.00
Allocation of operation and maintenance costs													
10. Separable costs	20,000	20,000	40,000	10,000	3,000	3,000	33,000	49,000	13,000	6,000	2,000	40,000	61,000
11. % joint costs, item 6	59.00	41.00	100.00	20.31	33.82	1.02	44.85	100.00	27.52	29.47	3.08	39.93	100.00
12. Allocated joint costs	3,000	2,000	5,000	11,000	18,300	500	24,200	54,000	12,700	13,500	1,400	18,400	46,000
13. Total allocation	23,000	22,000	45,000	21,000	21,300	3,500	57,200	103,000	25,700	19,500	3,400	58,400	107,000
14. % distribution of item 13	51.11	48.89	100.00	20.39	20.68	3.40	55.53	100.00	24.02	18.22	3.18	54.58	100.00
Allocation of initial investment													
15. Allocated annual charges	145,300	141,100	286,400	139,300	116,600	26,000	214,400	496,300	139,100	91,800	18,600	205,400	454,900
16. Allocated O&M costs	23,000	22,000	45,000	21,000	21,300	3,500	57,200	103,000	25,700	19,500	3,400	58,400	107,000
17. Remainder	122,300	119,100	241,400	118,300	95,300	22,500	157,200	393,300	113,400	72,300	15,200	147,000	347,900
18. Allocation in percent	50.66	49.34	100.00	30.08	24.23	5.72	39.97	100.00	32.60	20.78	4.37	42.25	100.00
19. Allocated investment	3,864,900	3,764,100	7,629,000	3,737,400	3,010,600	710,700	4,966,300	12,425,000	3,583,700	2,284,400	480,400	4,644,500	10,993,000
20. Allocated construction costs	3,698,200	3,601,800	7,300,000	3,576,500	2,880,900	680,100	4,752,500	11,890,000	3,429,500	2,186,100	459,700	4,444,700	10,520,000
Ratio of annual benefits to allocated annual charges	4.4	1.4	2.9	1.5	2.0	1.1	3.2	2.3	1.7	2.1	1.6	3.3	2.5
Allocated unit construction cost (cost/acre-ft exclusive of O&M)(dollars)													
Flood control storage			--					38.83					33.39
Water conservation storage (water supply only)			39.32					25.95					31.23
Water conservation storage (WS, WQC, R)			--					60.03					75.83
Allocated water supply cost per 1000 gallons (Water quality control excluded)(dollars)			0.0260					0.0269					0.0341

(1) Alternate cost exceeds annual benefits

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TABLE 24

UNIT WATER-SUPPLY COST STUDY
WATER SUPPLY COSTS TO BE BORNE BY LOCAL INTERESTS
PROPOSED RESERVOIRS
PECAN BAYOU WATERSHED
(Interest rate, 3% - Amortization period, 100 yrs)

Item	Reconstructed Lake Brownwood (RLB)	Coleman Reservoir (CR)	Pecan Bayou Reservoir (PBR)
1. ALLOCATED WATER SUPPLY COSTS (100-YEAR BASIS):			
a. First costs	$3,601,800	$2,880,900	$2,186,100
b. Investment	3,764,100	3,010,600	2,284,400
c. Annual charges	141,100	116,600	91,800
d. Annual maintenance and operation	22,000	21,300	19,500
e. Present value of annual charges (including 100 M&O payments)	4,458,600	3,684,400	2,900,800
2. ALLOCATED WATER SUPPLY COSTS (50-YEAR BASIS)(3):			
a. First costs	3,601,800	2,880,900	2,186,100
b. Investment	3,764,100	3,010,600	2,284,400
c. Annual charges	168,300	138,300	108,300
d. Annual maintenance and operation	22,000	21,300	19,500
e. Present value of annual charges (including 50 M&O payments)	4,330,300	3,558,400	2,786,500
3. WATER SUPPLY STORAGE, ACRE-FEET:	91,600	111,000	70,000

Item	Reconstructed Lake Brownwood			Coleman Reservoir			Pecan Bayou Reservoir		
	cfs	mgd	1000 AF per year	cfs	mgd	1000 AF per year	cfs	mgd	1000 AF per year
4. DEPENDABLE YIELDS - WITHOUT AVERAGE RETURN FLOWS INTO LAKE BROWNWOOD (PERIOD 1970 - 2070):									
a. Total at site (Sequence-as-formulated)									
Condition 1 - RLB operating alone	35.0	22.6	25.4	-	-	-	-	-	-
Condition 2 - RLB & CR	30.0	19.4	21.7	18.4	11.9	13.3	-	-	-
Condition 3 - RLB & CR & PBR	23.0	14.9	16.7	18.4	11.9	13.3	11.4	7.4	8.3
b. Additional above RLB operating alone									
Condition 4 - RLB & CR & PBC (Sequence-as-formulated)	-	-	-	13.4	8.7	9.7	4.4	2.8	3.2
Condition 5 - RLB & CR & PBC (System-proportion basis)	-	-	-	11.4	7.4	8.3	6.4	4.1	4.6
5. DEPENDABLE YIELDS - WITH AVERAGE RETURN FLOWS INTO LAKE BROWNWOOD (PERIOD 1970 - 2070)(2):									
a. Total at site (Sequence as formulated)									
Condition 6 - RLB operating alone	35.0	22.6	25.4	-	-	-	-	-	-
Condition 7 - RLB & CR	32.4	20.9	23.5	18.4	11.9	13.3	-	-	-
Condition 8 - RLB & CR & PBR	26.2	16.9	19.0	18.4	11.9	13.3	11.4	7.4	8.3
b. Additional above RLB operating alone									
Condition 9 - RLB & CR & PBR (Sequence-as-formulated)	-	-	-	15.8	10.2	11.4	5.2	3.4	3.8
Condition 10 - RLB & CR & PBR (System-proportion basis)	-	-	-	13.8	8.9	10.0	7.2	4.7	5.2

6. UNIT COST (DOLLARS) OF WATER SUPPLY ALLOCATED TO LOCAL INTERESTS (as tabulated below):

Conditions (see items 4 and 5 above)	Reconstructed Lake Brownwood: Storage (1)			Coleman Reservoir: Storage (1)			Pecan Bayou Reservoir: Storage (1)		
	Acre-foot	Dependable yield: 1000 gals/yr	Ac-ft/yr	Acre-foot	Dependable yield: 1000 gals/yr	Ac-ft/yr	Acre-foot	Dependable yield: 1000 gals/yr	Ac-ft/yr
DEPENDABLE YIELD - WITHOUT AVERAGE RETURN FLOWS INTO LAKE BROWNWOOD									
100-YEAR ANNUAL COST BASIS									
Condition 3 (total at site)	48.67	0.0260	8.45	33.19	0.0269	8.77	41.44	0.0341	11.06
Condition 4 (additional above RLB)	48.67	--	--	33.19	0.0369	12.02	41.44	0.0884	28.69
Condition 5 (additional above RLB)	48.67	--	--	33.19	0.0434	14.05	41.44	0.0608	19.96
50-YEAR ANNUAL COST BASIS (3)									
Condition 3 (total at site)	47.27	0.0310	10.08	32.06	0.0319	10.40	39.81	0.0403	13.05
Condition 4 (additional above RLB)	47.27	--	--	32.06	0.0438	14.26	39.81	0.1043	33.84
Condition 5 (additional above RLB)	47.27	--	--	32.06	0.0514	16.66	39.81	0.0717	23.54
DEPENDABLE YIELD - WITH AVERAGE RETURN FLOWS INTO LAKE BROWNWOOD (2)									
100-YEAR ANNUAL COST BASIS									
Condition 8 (total at site)	48.67	0.0228	7.43	33.19	0.0269	8.77	41.44	0.0341	11.06
Condition 9 (additional above RLB)	48.67	--	--	33.19	0.0313	10.23	41.44	0.0748	24.16
Condition 10 (additional above RLB)	48.67	--	--	33.19	0.0358	11.66	41.44	0.0540	17.65
50-YEAR ANNUAL COST BASIS (3)									
Condition 8 (total at site)	47.27	0.0272	8.86	32.06	0.0319	10.40	39.81	0.0403	13.05
Condition 9 (additional above RLB)	47.27	--	--	32.06	0.0371	12.13	39.81	0.0883	28.50
Condition 10 (additional above RLB)	47.27	--	--	32.06	0.0425	13.83	39.81	0.0638	20.83

(1) Unit cost of storage on one-time-payment basis (items 1e and 2e)
(2) Includes average return flows (3.2 cfs during period 1970 - 2070) into reconstructed Lake Brownwood resulting from water supply utilized from Coleman and Pecan Bayou Reservoirs
(3) Local interest repayment period.

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TABLE 25

COST ALLOCATION STUDIES - MULTIPLE-PURPOSE PROJECTS
INVOLVING PROPOSED RESERVOIRS
FLOOD CONTROL, WATER SUPPLY, WATER QUALITY CONTROL,
AND RECREATION (INCLUDING FISH AND WILDLIFE RECREATION AND HARVEST)
PECAN BAYOU WATERSHED

Item	Cost in thousand dollars		
	First cost	Annual charges	Annual M&O
RECONSTRUCTED LAKE BROWNWOOD			
1. FC:WS	7,300.0	286.4	45.0
2. --:WS	6,635.0	244.4	25.0
3. FC:--	5,810.0	217.1	25.0
COLEMAN RESERVOIR			
1. FC:WS:WQC:R	11,890.0	496.3	103.0
2. --:WS:WQC:R	9,678.0	413.1	93.0
3. FC:--:WQC:R	11,280.0	473.1	100.0
4. FC:WS:---:R	11,280.0	473.1	100.0
5. FC:WS:WQC:-	10,150.0	405.7	70.0
PECAN BAYOU RESERVOIR			
1. FC:WS:WQC:R	10,520.0	454.9	107.0
2. --:WS:WQC:R	8,538.0	376.3	94.0
3. FC:--:WQC:R	9,885.0	427.9	101.0
4. FC:WS:---:R	10,225.0	443.1	105.0
5. FC:WS:WQC:R	10,110.0	434.4	100.0
6. FC:WS:WQC:-	8,175.0	337.4	67.0

TABLE 26

SUPPORTING COST DATA FOR COST ALLOCATION
PROPOSED LAKE BROWNWOOD PROTECTIVE MEASURES - RECONSTRUCTED LAKE BROWNWOOD
PECAN BAYOU WATERSHED
(in 1000 dollars)

Item	Single-purpose reservoir		Dual-purpose reservoir		
	Flood control	Water conservation	Value of existing Features	Protective measures	Reconstructed Lake Brownwood FC & WC
Top of dam, elevation	1464.0	1470.0	1450.0	1469.0	1469.0
Spillway crest, elevation	1416.0	1425.0	1425.0	1425.0	1425.0
FIRST COSTS					
1. FIRST COST (PROTECTIVE MEASURES)					
Lands and damages	2,360.0	3,785.0		40.0	40.0
Relocations	-				
Reservoir	-				
Dam	3,060.0	2,514.0		2,700.0	2,700.0
a. Embankment	(1,200.0)	(1,283.0)		(1,267.0)	(1,267.0)
b. Slope protection	(6.0)	(6.0)		(6.0)	(6.0)
c. Spillway	(933.0)	(672.0)		(314.0)	(314.0)
d. Outlet works	(921.0)	(410.0)		(973.0)	(973.0)
e. Irrigation outlet		(143.0)		(140.0)	(140.0)
Access road	-	-			
Buildings and grounds	-	-			
Operating equipment	20.0	20.0		20.0	20.0
Engineering and design	150.0	127.0		125.0	125.0
Supervision and administration	220.0	189.0		175.0	175.0
Subtotal - first cost protective measures	5,810.0	6,635.0		3,060.0	3,060.0
2. FIRST COST (EXISTING LANDS AND FACILITIES)					
Lands and damages	-	-	3,840.0		3,840.0
Dam	-	-	358.0		358.0
a. Spillway	-	-	(358.0)		(358.0)
Engineering and design	-	-	17.0		17.0
Supervision and administration	-	-	25.0		25.0
Subtotal - first cost existing lands & facilities	-	-	4,240.0		4,240.0
3. TOTAL FIRST COST OF PROJECT	5,810.0	6,635.0	4,240.0	3,060.0	7,300.0
ANNUAL CHARGES					
(Interest rate - 3.00%)(Amortization period - 100 years) (Construction period - 3 years)					
1. INVESTMENT					
a. First cost	5,810.0	6,635.0	4,240.0	3,060.0	7,300.0
b. Interest during construction	261.0	299.0	191.0	138.0	329.0
Total - investment	6,071.0	6,934.0	4,431.0	3,198.0	7,629.0
2. ANNUAL CHARGES					
a. Interest on investment	182.1	208.0	132.9	95.9	228.8
b. Amortization of investment	10.0	11.4	7.3	5.3	12.6
c. Maintenance and operation	25.0	25.0	25.0	20.0	45.0
Total annual charges	217.1	244.4	165.2	121.2	286.4

TABLE 27

SUMMARY OF FIRST COST AND ANNUAL CHARGES
PROPOSED RESERVOIRS
PECAN BAYOU WATERSHED
(July 1963 price level)

Item	Coleman Reservoir: Flood Control Only	Coleman Reservoir: Water Supply Only	Coleman Reservoir: Recreation Only (1)	Coleman Reservoir: Multiple-Purpose	Pecan Bayou Reservoir: Flood Control Only	Pecan Bayou Reservoir: Water Supply Only	Pecan Bayou Reservoir: Recreation Only (1)	Pecan Bayou Reservoir: Multiple-Purpose
FIRST COST								
FEDERAL FIRST COST								
Lands and damages	$ 830,000	$1,238,000	$1,540,000	$1,850,000	$1,050,000	$1,303,000	$1,720,000	$ 2,390,000
Relocations	26,000	70,000	68,000	230,000	194,000	183,000	170,000	237,000
Clearing	--	45,000	100,000	107,000	--	63,000	132,000	141,000
Dam	5,127,000	4,726,000	4,583,000	7,094,000	4,873,000	3,547,000	3,530,000	5,105,000
Embankment	(2,227,000)	(2,700,000)	(2,618,000)	(4,509,000)	(1,528,000)	(1,340,000)	(1,110,000)	(2,446,000)
Slope protection	(13,800)	(20,000)	(20,000)	(24,000)	(10,800)	(12,000)	(10,000)	(14,000)
Spillway	(1,368,200)	(1,636,000)	(1,586,000)	(914,000)	(1,889,000)	(2,070,000)	(2,290,000)	(1,119,000)
Outlet works	(1,518,000)	(370,000)	(359,000)	(1,647,100)	(1,445,200)	(125,000)	(120,000)	(1,526,000)
Access road	169,000	170,000	272,000	224,000	81,000	87,000	462,000	440,000
Recreation facilities	--	--	991,000	1,022,000	--	--	1,022,000	1,022,000
Buildings and grounds	252,000	240,000	233,000	240,000	222,000	219,000	219,000	219,000
Operating equipment	25,000	35,000	34,000	60,000	25,000	35,000	35,000	60,000
Engineering and design	230,000	266,000	337,000	434,000	216,000	208,000	285,000	364,000
Supervision and administration	341,000	400,000	502,000	629,000	339,000	325,000	420,000	542,000
Total - first cost	$7,000,000	$7,190,000	$8,660,000	$11,890,000	$7,000,000	$5,970,000	$7,995,000	$10,520,000
ANNUAL CHARGES								
(Construction period - 3 years)(Amortization period - 100 years) (Interest rates - Federal, 3.00%)								
FEDERAL INVESTMENT								
First cost	$7,000,000	$7,190,000	$8,660,000	$11,890,000	$7,000,000	$5,970,000	$7,995,000	$10,520,000
Interest during construction	315,000	324,000	390,000	535,000	315,000	269,000	360,000	473,000
Total - investment	$7,315,000	$7,514,000	$9,050,000	$12,425,000	$7,315,000	$6,239,000	$8,355,000	$10,993,000
ANNUAL CHARGES								
Interest on investment	$ 219,500	$ 225,400	$ 271,500	$ 372,800	$ 219,500	$ 187,200	$ 250,700	$ 329,800
Amortization	12,000	12,400	14,900	20,500	12,000	10,300	13,800	18,100
Maintenance and operation	48,000	54,000	78,000	103,000	48,000	50,000	81,000	107,000
Dam and reservoir	(46,500)	(52,500)	(76,500)	(101,500)	(46,500)	(48,500)	(79,500)	(105,500)
Replacement of parts	(1,500)	(1,500)	(1,500)	(1,500)	(1,500)	(1,500)	(1,500)	(1,500)
Total - annual charges	$ 279,500	$ 291,800	$ 364,400	$ 496,300	$ 279,500	$ 247,500	$ 345,500	$ 454,900

(1) Including fish-wildlife recreation and harvest.

TABLE 28

PERTINENT DATA
SINGLE-PURPOSE RESERVOIRS FOR COST ALLOCATION STUDIES
LAKE BROWNWOOD, PECAN BAYOU AND COLEMAN RESERVOIRS
PECAN BAYOU WATERSHED

	LAKE BROWNWOOD - R.M. 57.1		COLEMAN RESERVOIR - R.M. 52.15		PECAN BAYOU RESERVOIR - R.M. 100.82	
	Flood Control Only	Water Supply Only	Flood Control Only	Water Supply Only	Flood Control Only	Water Supply Only
DRAINAGE AREA						
Square miles	1,544	1,544	287	287	316	316
SPILLWAY DESIGN FLOOD						
Peak inflow, cfs	676,200	676,200	307,100	307,100	317,500	317,500
Volume, acre-feet	1,613,300	1,613,300	371,100	371,100	406,100	406,100
Volume, inches	19.60	19.60	24.24	24.24	24.10	24.10
Peak outflow, cfs	396,800 (1)	354,000 (1)	240,000 (1)	242,400 (1)	220,000 (1)	245,000 (1)

RESERVOIR — LAKE BROWNWOOD - R.M. 57.1

RESERVOIR	Flood Control Only: Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Water Supply Only: Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
Top of dam	1464.0	--	--	--	1470.0	--	--	--
Maximum design water surface	1458.2	26,400	644,000	7.82	1464.4	30,810	821,300	9.97
Top flood control pool and spillway crest	1416.0	4,930	69,900	0.85	1425.0	7,570	124,600	1.51
Top conservation pool	--	--	--	--	1425.0	7,570	124,600	1.51
Sediment storage	--	--	33,000	0.40	1425.0	--	33,000	0.40

RESERVOIR — COLEMAN RESERVOIR - R.M. 52.15

RESERVOIR	Flood Control Only: Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Water Supply Only: Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
Top of dam	1781.0	--	--	--	1789.0	--	--	--
Maximum design water surface	1775.2	4,760	196,200	12.82	1784.0	5,430	240,900	15.74
Top flood control pool and spillway crest	1750.0	3,090	98,800	6.45	--	--	--	--
Top conservation pool	--	--	--	--	1757.0	3,480	121,800	7.96
Sediment storage	--	--	10,300	0.67	--	--	10,300	0.67

RESERVOIR — PECAN BAYOU RESERVOIR - R.M. 100.82

RESERVOIR	Flood Control Only: Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Water Supply Only: Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
Top of dam	1663.0	--	--	--	1658.0	--	--	--
Maximum design water surface	1657.7	9,030	246,400	14.62	1653.1	8,050	207,100	12.29
Top flood control pool and spillway crest	1638.0	5,300	107,300	6.37	--	--	--	--
Top conservation pool	--	--	--	--	1632.5	4,450	80,100	4.75
Sediment storage	--	--	10,100	0.60	--	--	10,100	0.60

	LAKE BROWNWOOD - R.M. 57.1		COLEMAN RESERVOIR - R.M. 52.15		PECAN BAYOU RESERVOIR - R.M. 100.82	
	Flood Control Only	Water Supply Only	Flood Control Only	Water Supply Only	Flood Control Only	Water Supply Only
DAM						
Type	Earth fill	Earth fill	Earth fill	Earth fill	Earth fill	Earth fill
Total length, feet	2,310	2,360	7,000	8,600	8,000	6,800
Embankment section:						
Type	Compacted earth fill	Compacted earth fill	Compacted earth fill	Compacted earth fill	Compacted earth fill	Compacted earth fill
Total length, feet	1,830	1,880	6,400	8,000 (3)	7,200 (4)	6,000
Height above streambed, feet	124	130	125	133	94	92
Freeboard, feet	5.8	5.6	5.8	5.0	5.3	5.3
Crown width, feet	20	20	20	20	20	20
Side slopes:						
Upstream	1 on 2-1/2 and 1 on 3-1/2	1 on 2-1/2 and 1 on 3-1/2	1 on 2-1/2 and 1 on 3-1/2	1 on 2-1/2 and 1 on 3-1/2	1 on 2-1/2 and 1 on 3-1/2	1 on 2-1/2 and 1 on 3-1/2
Downstream	1 on 2-1/2 and 1 on 3	1 on 2-1/2 and 1 on 3	1 on 2-1/2 and 1 on 3	1 on 2-1/2 and 1 on 3	1 on 2-1/2 and 1 on 3	1 on 2-1/2 and 1 on 3
Spillway section:						
Type	Broadcrested weir	Broadcrested weir	Broadcrested weir	Broadcrested weir	Broadcrested weir	Broadcrested weir
Gross length, feet	480	480	600	600	800	800
Net length, feet	480	480	600	600	800	800
Gates			None	None	None	None
Spillway discharge, cfs:						
Maximum design water surface	393,500	354,000	231,000	242,400	209,900	245,000
OUTLET WORKS						
Type	Gate-controlled conduit	Gate-controlled conduit	Gate-controlled conduit	Gate-controlled conduit	Gate-controlled conduit	Gate-controlled conduit
Number of conduits	1	1	1	1	1	1
Dimensions	10' diameter	36" diameter	14' diameter	36" diameter	16' diameter	36" diameter
Invert elevation, feet (2)	1342.0	1360.0	1672.0	1672.0	1588.0	1588.0
Conduit control	2 - 5'x10' tractor-type gates	1 - 36" gate valve	3 - 4'2"x14' gates	1 - 36" gate valve	3 - 5'x16' slide gates	1 - 36" gate valve
RELOCATIONS						
County roads, miles	--	--	3.1	4.2	4.5	4.5
Power lines, miles	--	--	4.4	5.8	11.5	11.5
Telephone lines, miles	--	--	5.0	6.6	22.0	22.0
Cemeteries, number	--	--	1	1	1	1
LANDS						
Clearing, acres	--	--	--	950	--	1,250
Land acquisition:						
Fee simple, acres	--	7,720	--	3,860	--	5,060
(top control elevation)	--	(1425.0)	--	(1763.0)	--	(1636.5)
Flood easement, acres	6,090	3,330	3,370	--	6,120	--
(top control elevation)(2)	(1421.0)	(1433.0)	(1755.0)	--	(1643.0)	--
(1) Includes discharge through outlet works:	3,300 cfs	--	9,000 cfs	--	10,100 cfs	--

(2) All elevations refer to mean sea level
(3) Includes 800 foot dike
(4) Includes 400 foot dike

APPENDIX V

RECREATION AND FISH AND WILDLIFE

REVIEW OF REPORTS ON PECAN BAYOU WATERSHED

COLORADO RIVER BASIN, TEXAS

APPENDIX V

RECREATION AND FISH AND WILDLIFE

REVIEW OF REPORTS ON PECAN BAYOU WATERSHED
COLORADO RIVER BASIN, TEXAS

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APPENDIX V

RECREATION AND FISH AND WILDLIFE

REVIEW OF REPORTS ON PECAN BAYOU WATERSHED, TEXAS

INTRODUCTION

1. SCOPE.- Described here are the methods and techniques employed in this report to meet the requirements placed upon recreation and fish and wildlife as equal physical and economic purposes served by the proposed plan of improvement for water resources in the Pecan Bayou watershed, a sub-basin in the Colorado River Basin. These studies have been concluded through use and projections of data compiled at existing Corps of Engineers projects, together with data obtained from reports prepared by others, especially the Outdoor Recreation Resources Review Commission (ORRRC) and through special studies made specifically to determine the effects, needs, and economics of the recreation and fish and wildlife aspects of this proposed plan of improvement. The studies were coordinated with the U. S. Fish and Wildlife Service and the National Park Service, and reports prepared by these agencies are presented in appendix VI.

2. The conclusions reached in this appendix have been used to support the analysis of the general and fish-wildlife recreation purposes that entered into all steps of the planning included in the formulation of the recommended plan of improvement.

EXISTING AND PROPOSED IMPROVEMENT

3. GENERAL.- Improvements in the interest of water conservation and flood control have been accomplished in the Pecan Bayou watershed by the Federal Government, local governmental agencies, and individuals. These improvements include channel rectification and reservoir projects. Locations of existing, authorized, and proposed improvements are shown on plates 1, 2, and 17 of the main report. The reservoir projects in the Pecan Bayou watershed and zone of influence which will have an effect on the recreation and fish and wildlife resources are as follows:

a. Corps of Engineers.

(1) Existing - Hords Creek.

(2) Proposed - Coleman and Pecan Bayou.

(3) Under Study - Fox Crossing, Stacy and Robert Lee.

b. Others.

(1) Existing - Twin Buttes, Brownwood and some small reservoirs constructed by local governmental agencies for municipal water supply.

4. EXISTING AND PROPOSED RECREATION AREAS.- Recreation areas and facilities are developed or proposed at all Corps' multiple-purpose projects cited above and will be open to free public use. Some of the reservoirs constructed by local governmental agencies for municipal water supply are open to public use. However, the recreational facilities are limited, also, in many cases nominal fees are levied against those desiring to fish or participate in other recreational activities. As of 1 July 1962 there were about 32 completed and an additional 23 planned flood detention reservoirs in the Jim Ned Creek and Turkey Creek watersheds, tributaries of Pecan Bayou. These projects were planned and constructed by the Soil Conservation Service. At the top of the conservation pools levels, they range in size from about eight to about 50 surface acres. These reservoirs are not generally open to free public use since they are located on privately-owned land. However, the projects do afford some water-related recreation potentialities as some owners invite or permit relatives, friends, and associates to participate in the recreational activities available. In addition to the existing and proposed water development projects in the watershed, the Texas State Parks Board owns and operates the Lake Brownwood State Park. While these developments meet some of the recreation needs of the area, the principal public outdoor recreation opportunities are, or will be, afforded by the existing and proposed Corps projects.

5. Two existing reservoirs in Colorado River Basin and one existing reservoir in the Brazos River Basin are less than 75 and 50 miles, respectively, from the existing and proposed reservoirs in the Pecan Bayou watershed. The Colorado Basin reservoirs are San Angelo, under the jurisdiction of the Corps of Engineers, which has been in operation since 1952, and Twin Buttes, under the jurisdiction of the Bureau of Reclamation, which is under construction. Also, this district is now conducting studies and preparing a comprehensive survey report on the Colorado River Basin. In this study, consideration will be given to the Fox Crossing, Stacy and Robert Lee Reservoirs, included in the report of the U. S. Study Commission - Texas. Two of these reservoirs are within 50 miles and one is within 75 miles of the projects recommended in the Pecan Bayou watershed. The Brazos Basin reservoir is Proctor Reservoir on the Leon River under the jurisdiction of the Corps of Engineers, which is under construction. These existing reservoirs as well as the three under study, if constructed, will attract some of the individuals residing within the Pecan Bayou watershed desiring to participate in water oriented recreational activities.

RECREATION RESOURCE DEVELOPED BY PROJECT

6. The Pecan Bayou watershed, located in the north central part of the Colorado River Basin, is situated near the geographical center of Texas. The watershed slopes generally downward toward the southeast and the

relief is low to moderate. The area is generally devoid of timber other than along valleys and draws but will support tree growth. Soils are clay, clay loam, and sandy.

7. Proposed improvements would result in the addition of two reservoirs in the upper reaches of the watershed (Coleman and Pecan Bayou sites), protective measures for the existing Lake Brownwood dam, and channel improvements at Brownwood along Pecan Bayou, Adams Branch, and Willis Creek. The proposed improvements included in this report would result in an increase in impounded water surface at top of conservation pool levels by approximately 9,000 acres. Reservoir waters would be relatively clear and of good quality.

8. Experience at completed multi-purpose projects in the Fort Worth District indicates that the principal recreational use of projects in the proposed plan of improvement would fall in the day-use category, i.e., the principal use would be individuals residing within a distance that would permit driving to the project, participating in recreational activities, and returning the same day. However, the projects would attract visitors from longer distances as well, and would even attract some visitation from outside the state.

9. POPULATION OF MARKET AREA.- On the basis of the above analysis, it is considered that the principal area of influence would be the eight counties which are entirely or partially within the watershed and four other counties outside of and within a 50-mile radius of the approximate geographic center of the watershed. The actual and projected populations for these counties are as follows:

Year	1960	1970	1980	2030	2080
Population	143,050	161,240	178,030	228,600	257,900

10. DEMAND FOR OUTDOOR RECREATION.- Conclusions reached by the Outdoor Recreation Resources Review Commission and others interested in the field of recreation indicate that past actions taken to provide for outdoor recreation has not been adequate for present needs and will not be adequate for the future. The population is increasing rapidly, and individually the people are seeking the outdoors at a growing rate which is expected to increase over the coming decades. The major factors which underlie this large and sustained increase in outdoor recreation demand are as follows:

a. Rapid and steady growth in population with a marked trend toward a more urbanized population;

b. Larger than average increase in numbers of older people, retired or otherwise, with time for outdoor recreation;

c. Larger than average increase in young people not yet in the labor force;

d. Steady growth in per capita real incomes;

e. Improved travel facilities which bring more distant recreation areas within usable range;

f. Increase in leisure time due to paid vacations and shortened work needs.

Outdoor Recreation Resources Review Commission studies further indicate that the greatest need for recreational activities is generated by the concentrated population in the metropolitan areas and to a slightly lesser degree by the adjacent urban areas. In addition there is an apparent trend for a higher percentage of participation in outdoor recreation activities as compared to the past.

11. DEMAND FOR WATER-BASED RECREATION.- The demand for water-based recreation is evidenced by the increase in visitation to existing reservoirs under the jurisdiction of the Corps of Engineers, as well as by the increase in the number of hunting and fishing licenses being issued; and increases in sales of boats, motors, and equipment used for camping, fishing, and hunting, and other recreation activities. Visitation to reservoir projects under the jurisdiction of the Southwestern Division is shown in figure 1. Visitation to projects under the jurisdiction of the Fort Worth District is shown in figure 2. It will be noted that visitation to projects in the Southwestern Division almost quadrupled during the past 10-year period and the visitation to Fort Worth District projects has increased at approximately the same rate. While a substantial part of this increase has resulted from filling or completion of additional reservoirs, with a resultant increase in opportunities, it is indicative of a surging demand for water-based recreation and the fact that this demand is far from being satisfied. Experience indicates that attendance at an individual project tends to level off a few years after completion and then increase at a slower rate. However, the addition of a new reservoir in the area of influence seldom actually depresses attendance at the existing reservoir. Attendance may become nearly static for a few years but eventually begins to increase, along with that of a new reservoir. This would indicate that there is a latent demand in every area for water-based recreation and all that is needed to translate this demand into actual attendance is to develop and provide the recreation opportunities associated with water resource projects.

12. RECREATION PROJECTIONS FOR AREA OF INFLUENCE.- In projecting the demand for water-based recreation in the Pecan Bayou watershed, several factors were considered, including those cited in paragraph 9 and 10. Cognizance was taken of the report published by Resources for the Future entitled "The Crisis in Outdoor Recreation" and the report entitled "Water Recreation Needs in the United States, 1960-2000," contained in Committee Print No. 17, 86th Congress, 2nd Session, both of which indicate increases in outdoor recreation visitation of tenfold or more by the year 2000, of which 75% is estimated to be water-oriented. It became apparent that the recreation demand for this immediate area would be satisfied, provided the

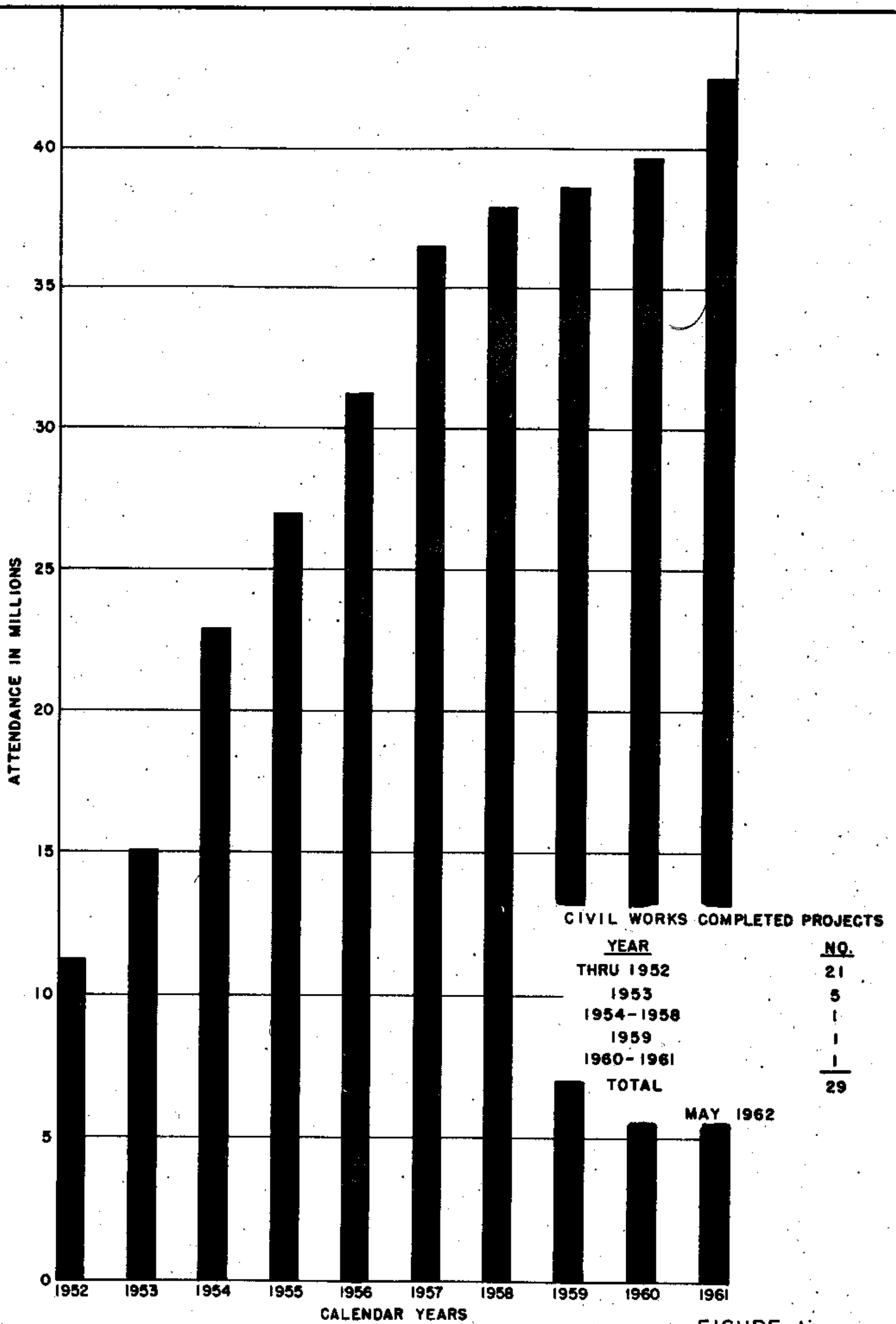
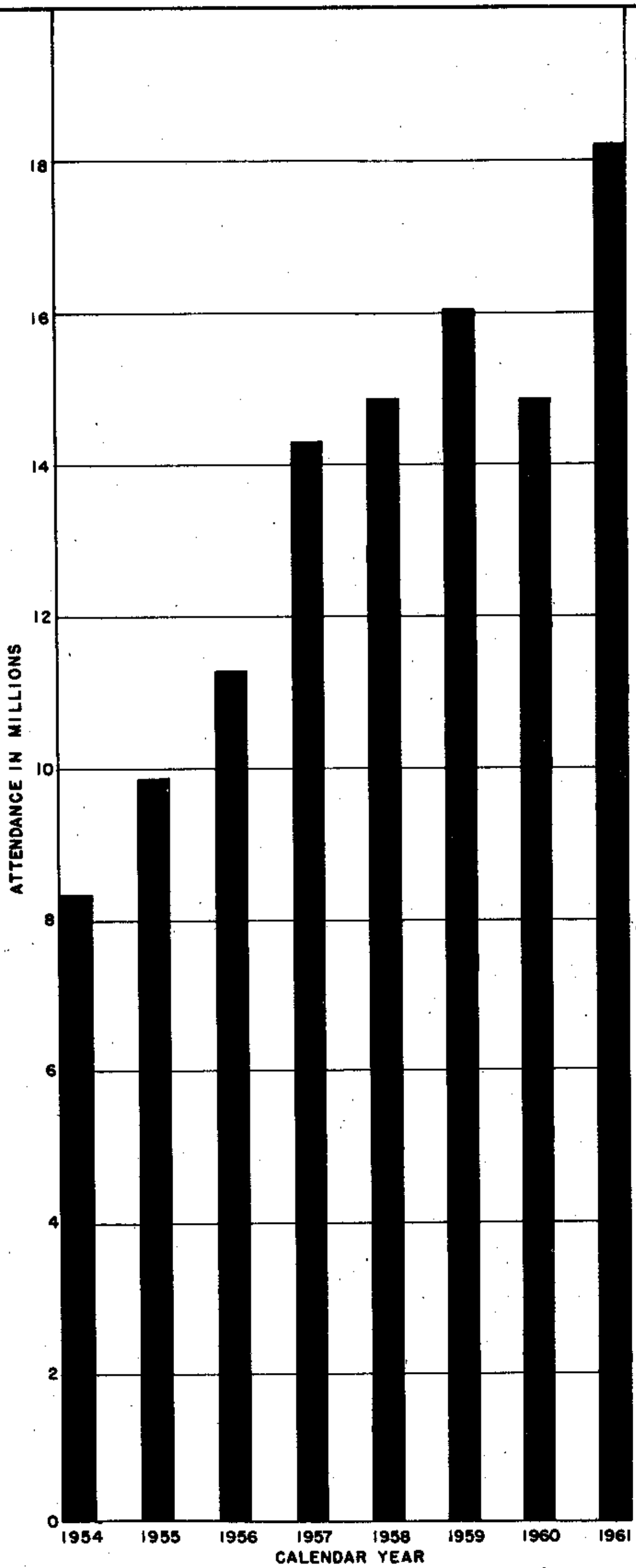


FIGURE I
PUBLIC RECREATIONAL USE
RESERVOIR ATTENDANCE
SWD COMPLETED PROJECTS



CIVIL WORKS COMPLETED PROJECTS

YEAR	NO.
THRU 1954	9
1955-1961	0
TOTAL	9

MAY 1962

FIGURE 2

PUBLIC RECREATIONAL USE
RESERVOIR ATTENDANCE
FWD COMPLETED PROJECTS

projects recommended and under study are authorized and developed. This conclusion is based on experience records on visitation for recreational activities at existing water developed projects; existing and projected populations; the number and locations of existing and recommended projects; as well as those under study and investigations; and the anticipated date of placing the projects in operation. Results of these studies and the projected demands are outlined below.

13. Hords Creek Reservoir attracted 254,200 visitors during the year 1960. The 1960 population within the 50-mile radius zone of influence was 188,700 persons, which indicates an average ratio of 1.34 visits per person. Based on the ORRRC estimate that recreation demand would triple by the year 2000, the potential attendance at Hords Creek at the time would be approximately 760,000 visitors. However, it is quite evident that Hords Creek Reservoir, with its small water surface area (510 surface acres at top of conservation storage level), is not capable of supporting so high a visitation. In fact, the present use of the project is nearing its optimum capacity.

14. San Angelo Reservoir attracted 1,594,900 visitors in 1960. However, 17 percent, or 271,100, of these visitors came from beyond the 50-mile zone. The 1960 population within the 50-mile radius zone of influence was 103,976 persons, which indicates an average ratio of 12.7 visits per person. Using the ORRRC estimate, the potential attendance at San Angelo Reservoir for the year 2000 would be approximately 4,800,000 persons. It appears quite evident from past project attendance and future projected population increase in this area that the San Angelo project is not capable of supporting so high a visitation. Based on the type of development and usage, in the foreseeable future, it is believed that the optimum capacity of the project will not support a future potential attendance of over 3,000,000 visitors.

15. Visitation figures are not available for Lake Brownwood Reservoir. Figures are available for the 538-acre Lake Brownwood State Park, but they pertain only to the state park and cannot be considered indicative of the total visitation to the reservoir. Because of the size of the reservoir (7510 surface acres at conservation level) visitation at Lake Brownwood should be considered to be at least equal to that at Hords Creek Reservoir, approximately 250,000 persons in 1960. However, because of the extensive private shoreline development at Lake Brownwood, the full recreational development of the reservoir for free public use cannot be utilized. The Corps does not propose the development or management of recreational areas at Lake Brownwood. The Corps participation in the project will consist only of the construction of the protective measures for Lake Brownwood.

16. The Comprehensive Survey Report on the Colorado River Basin is not sufficiently advanced to indicate the location or size of projects outside the Pecan Bayou watershed that can be justified and recommended.

17. PROJECT VISITATION.- In estimating the number of annual recreation visits that would be made to the project, it has been assumed that the project would be physically complete in 1980. On this basis, taking into account experienced visitation at existing reservoirs and other considerations involved it is conservatively estimated that visitation to the project sites included in the plan of improvement would be as follows:

Project Site	Initial 1980	Average Annual	Ultimate Annual Visitation
Coleman	500,000	1,000,000	1,300,000
Pecan Bayou	500,000	1,000,000	1,300,000
Totals	1,000,000	2,000,000	2,600,000

18. The two recommended projects are not equivalent in surface acres. However, it is estimated that the visitation for recreational activities would be equivalent due to their close proximity and as neither would exceed its optimum capacity.

19. GENERAL RECREATION VS. FISH AND WILDLIFE.- Visitor attendance statistics compiled in nine completed reservoirs in the Fort Worth District with a total water surface area of 88,550 acres and varying in size from 510 acres to 23,470 acres at the top of the conservation or power storage levels were as follows:

	Total recreation	General recreation		Fish and Wildlife recreation	
	Visitors (millions)	Visitors (millions)	Per cent	Visitors (millions)	Per cent
1957	14.4	9.8	68	4.6	32
1958	15.0	9.0	60	6.0	40
1959	16.0	9.5	60	6.5	40
1960	15.0	8.5	57	6.5	43
Average			62		38

20. Data and information presented above for nine reservoir projects under the jurisdiction of the Fort Worth District indicate that 62 percent of the visitors participated in general recreation activities such as picnicking, camping, etc. and that 38 percent participated in fish and wildlife recreation activities such as sport fishing, hunting, etc. The Texas Game and Fish Commission issued a news item during 1960 which revealed that the percentage of Texans who fish and hunt is about 10 percent higher than the national average. It showed that 33.2 percent of the population which are 12 years old and over fish and hunt; whereas, the

national average is 23.0 percent. For the purpose of this report, it is assumed that 65 percent of the estimated visitors would participate in general recreation activities such as picnicking, camping, etc., and 35 percent would participate in fish and wildlife recreation activities such as sport fishing, hunting, etc.

PLAN OF IMPROVEMENT

21. STUDIES.- Preliminary studies indicate that the recreation resources are sufficient to justify recreation and fish and wildlife as primary purposes for the multiple-purpose reservoir projects. Pertinent information relative to size, land requirements, costs, and benefits of the recreational purposes in the proposed projects are shown in table 1 and described in the following paragraphs.

TABLE 1
PERTINENT DATA - RECREATION AND FISH AND WILDLIFE

		Land required (acres)			
		Recreation, including sport fishing & hunting			
	Water surface area, acres	Project purposes	Public use & access	Total	Benefits
Coleman	3,930	550	550	1100	$ 676,800
Pecan Bayou	5,150	550	550	1100	676,800
Grand Total	9,080	1100	1100	2200	$1,353,600

22. The location, size, and number of areas to be developed at each authorized project will be presented in a preliminary master plan. Details of the proposed development to provide for public recreation and the conservation and management of fish and wildlife will be presented in a master plan for each project. Basic recreational facilities to be provided would include access roads, parking areas, public camping and picnicking areas, water supply, sanitary facilities, boat launching ramps, signs, essential safety devices, etc. Group picnic shelters, beach improvements for public swimming, including simple change houses, and boat anchorage areas would also be provided where such facilities are warranted. Additional facilities and services necessary or desirable for full development of the recreation potential will normally be arranged for by concessions and permits to private organizations and individuals or by leases or licenses to other Federal agencies or to state and local governmental agencies.

23. COLEMAN PROJECT.- The Coleman Dam is located on Jim Ned Creek about 15 miles north of Coleman, Texas. The impounded water would cover 3,930 acres at the top of conservation pool. Based on the existing and projected population for this area and the number of visitors that the existing projects have attracted, it is conservatively estimated that the proposed Coleman Reservoir project would attract an initial annual visitation

of about 500,000 visitors after sufficient water is impounded and would eventually attract a total of 2,000,000 visitors, or an average of about 1,000,000 visitors annually over the period 1970-2070. The total lands required for public use and access are estimated to be 1100 acres. Of this amount, 550 acres would be acquired under the 1962 joint land acquisition policy for project purposes. The remainder consists of 550 acres for public use and access. The estimated costs for lands, clearing, and facilities in the interest of public use are shown on table 2.

24. PECAN BAYOU PROJECT.- Pecan Bayou Dam is located on Pecan Bayou about 20 miles northeast of Coleman, Texas. The impounded water would cover 5,150 acres at the top of the conservation storage level. Based on the existing and projected population for this area and the number of visitors existing projects have attracted, it is conservatively estimated that the Pecan Bayou project would attract an initial annual visitation of about 500,000 visitors after sufficient water is impounded and would eventually attract a total of 2,000,000 visitors, or an average of about 1,000,000 visitors annually over the period 1970-2070. The total lands required for public use and access are estimated to be 1100 acres. Of this amount, 550 acres would be acquired under the 1962 joint land acquisition policy for project purposes. The remainder consists of 550 acres for public use and access. The estimated cost for lands, clearing, and facilities in the interest of public use is shown in table 2.

TABLE 2

ESTIMATED COST OF LANDS, CLEARING, AND FACILITIES FOR PUBLIC USE AND ACCESS

Project	Lands (1) Public use and access Acres	Lands (1) Public use and access Cost	Clearing (1) Acres	Clearing (1) Cost	Facilities (2) Initial Dev Cost	Facilities (2) Future Dev Cost	Facilities (2) Optimum Dev Cost	Grand Total
Coleman	550	$140,000	1200	$ 58,000	$ 605,000(3)	$ 527,000	$1,132,000	$1,330,000
Pecan Bayou	550	180,000	1600	77,000	866,000(4)	527,000	1,393,000	1,650,000
Grand Total	1100	$320,000	2800	$135,000	$1,471,000	$1,054,000	$2,525,000	$2,980,000

(1) Separable cost over and above project requirements.
(2) Does not include engineering and design or supervision and administrative costs.
(3) Includes three miles of access roads.
(4) Includes ten miles of access roads.

ECONOMIC BENEFITS OF RECREATION

25. RECREATION BENEFITS.- Economic benefits resulting from the development of the recreation resources associated with water resource projects can be evaluated and expressed in several different ways, including actual assignment of a monetary value for each project visit. The latter method has been used in benefits vs. cost considerations of this report, using a conservation unit value of 50 cents per visit for general recreation and $1.00 for sport fishing and hunting, the latter being in accordance with the schedule of value adopted by the Inter-Agency Committee on Water Resources at its 18 October 1960 meeting.

26. While values used indicate substantial benefits from recreational aspects of the project, they are considered most conservative and in many ways do not indicate fully the economic impact of recreation and related activities associated with large water resource projects. The fact is that recreation invariably improves the local economy, the degree depending primarily on the recreation demand of the area and the quality of recreation afforded.

27. Experience and actual studies at existing projects in the Southwestern Division show that counties in which large reservoirs are wholly or partially located have a notably better economic performance than non-reservoir counties in terms of broad indicators such as population, per capita income, wages, retail trade, and bank deposits. There are many reasons for this. Of basic importance is the fact that each large reservoir provides new opportunities for capital to be profitably used in the development of businesses associated with recreation, thereby putting capital to work in an economically productive manner.

28. Recreation associated with major water resource projects attracts outside dollars and investment in the area affected 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 finance or develop overnight accommodations, marinas, and many other recreation-related sales and service facilities. The Corps of Engineers encourages needed service facilities on Federal lands and waters by concession agreements and special use permits.

c. Recreational aspects of projects attract many newcomers to the reservoir area who construct homes and cabins for themselves as near the shorelines as possible.

d. Industry is attracted to the general area because of the recreation climate afforded its employees, even though the industry itself may not be a heavy water user.

COORDINATION WITH OTHER FEDERAL AGENCIES

29. U. S. FISH AND WILDLIFE SERVICE.- The U. S. Fish and Wildlife Service was furnished data and information applicable to the proposed plan of improvement on the Pecan Bayou and tributaries. The Service was requested to prepare a report on the fish and wildlife aspects relative to the developments proposed by the Corps of Engineers. The Service's report dated January 14, 1963 is presented in appendix VI. The report contains several recommendations with regard to the development of the fish and wildlife resources of the Pecan Bayou and tributaries project.

30. NATIONAL PARK SERVICE.- The National Park Service was consulted with respect to recreational aspects of the Pecan Bayou watershed. A reconnaissance of the area was made by a representative of the Region 3 Office, National Park Service, and a report of the findings was submitted, which is presented in appendix VI. The report contained an appraisal of the recreation potential of Burkett and Camp Colorado Reservoirs. However, these two sites were not included in the plan of improvement. The National Park Service was not requested to supplement its original report to include the added facilities, since they are situated in an area where the needs and potential are already known. Also, the estimated visitation and recreation benefits utilized in this appendix in the analyses of the investigated reservoirs were based on studies made by Corps of Engineers as described herein.

31. TYPICAL LAYOUTS.- The preliminary studies were based on providing necessary facilities required for access and internal roads, picnicking, camping, sanitary facilities, potable water supplies, parking areas, boat launching ramps, play areas, etc. The recreation facilities would be generally as shown on the typical layout for reservoir projects, plate 1.

CONCLUSIONS

32. CONCLUSIONS.- The existing and projected effective population and resulting recreation needs within the Pecan Bayou Basin and the surrounding area of influence have been determined, and consideration has been given to these requirements in the development of the plan of improvement. Analysis of the proposed multiple-purpose projects, which include recreational facilities to meet requirements for the optimum annual visitation, indicate that they are fully justified from an economic standpoint.

33. Satisfaction of the ultimate outdoor recreation requirements in the subject basin would come from supplementary development of needed facilities by the state and local governmental agencies, by private enterprise, and possibly by construction of additional water resource projects.

CORPS OF ENGINEERS U. S. ARMY

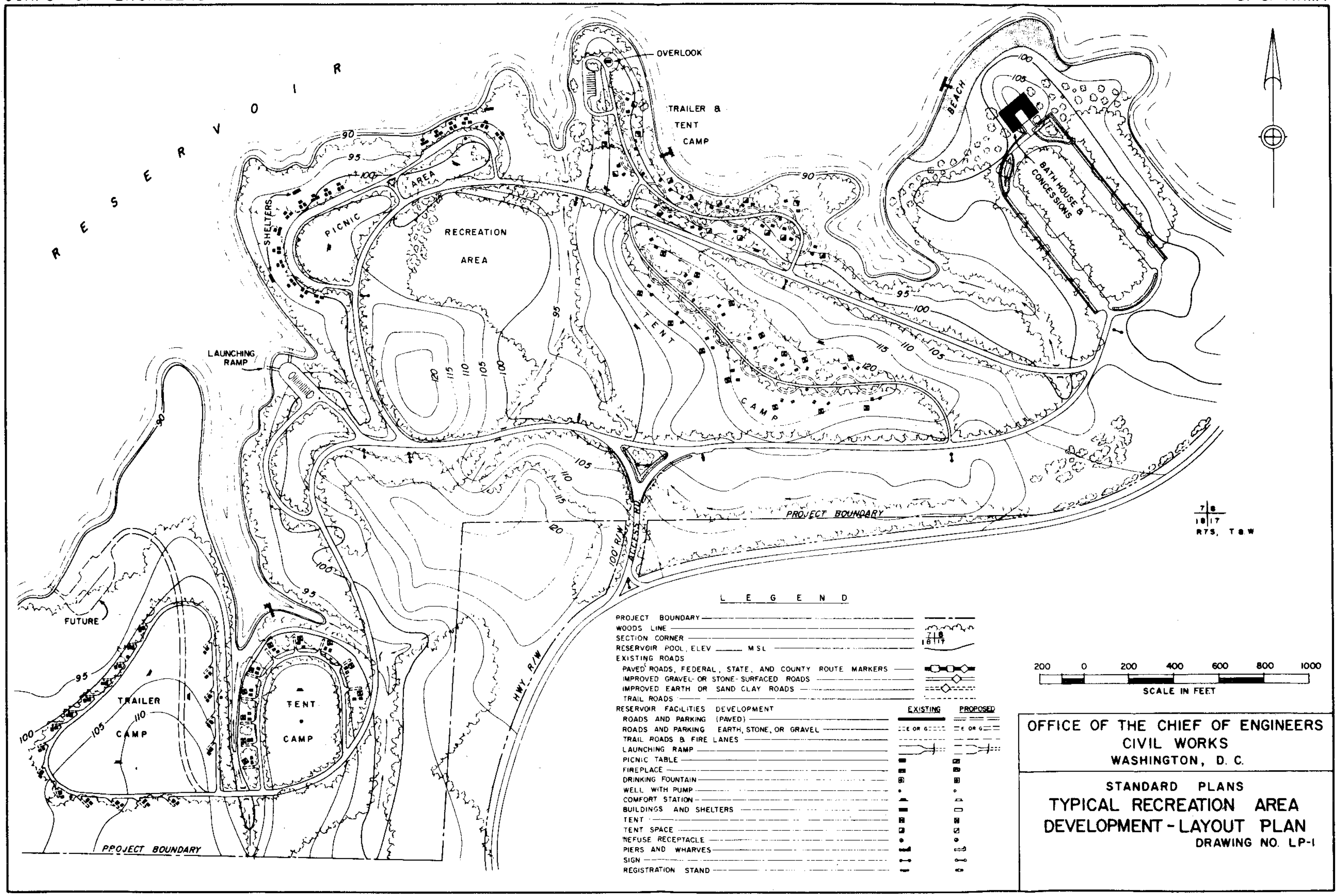


PLATE 1

96-452 O-68 (Face p. 168)

APPENDIX VI

REPORTS OF OTHER FEDERAL

AGENCIES

REVIEW OF REPORTS ON PECAN BAYOU WATERSHED

COLORADO RIVER BASIN, TEXAS

APPENDIX VI

REPORTS BY OTHER FEDERAL AGENCIES

REVIEW OF REPORTS ON PECAN BAYOU WATERSHED
COLORADO RIVER BASIN, TEXAS

CONTENTS

BUREAU OF SPORT FISHERIES AND WILDLIFE, DEPARTMENT OF THE INTERIOR:
Report on Fish and Wildlife Resources Affected by Investigated Camp Colorado, Coleman, Burkett, and Pecan Bayou Reservoir Projects on the Pecan Bayou Watershed, Texas

NATIONAL PARK SERVICE, REGION THREE, DEPARTMENT OF THE INTERIOR:
Reconnaissance Report - Recreational Use and Development - Pecan Bayou Watershed - Colorado River Basin, Texas

PUBLIC HEALTH SERVICE, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE:
Report on Study of Potential Needs and Value of Water for Municipal, Industrial, and Quality Control Purposes - Pecan Bayou Watershed - Colorado River Basin, Texas

REPORT ON
FISH AND WILDLIFE RESOURCES
PECAN BAYOU WATERSHED

PREPARED BY

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

FOR

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

January 14, 1963

GAME AND FISH COMMISSION

AUSTIN, TEXAS

October 23, 1962

Regional Director
Bureau of Sport Fisheries and Wildlife
P. O. Box 1306
Albuquerque, New Mexico

Dear Mr. Gatlin:

This is to concur with your draft of a supplement to your report dated June 14, 1961, on the Corps of Engineers' Pecan Bayou and Tributaries, Texas, which was forwarded to Mr. Howard D. Dodgen on October 12, 1962, by Mr. Carey H. Bennett.

Sincerely yours,

Eugene A. Walker
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Eugéne A. Walker, Director
Program Planning

em

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE

P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO

January 14, 1963

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

Dear Sir:

The Corps of Engineers has requested that we reevaluate the fish and wildlife resources in relation to Pecan Bayou and Tributaries, Coleman and Callahan Counties, Texas, as analyzed in the Bureau of Sport Fisheries and Wildlife report of June 14, 1961, to reflect modifications in the project plans and the 1962 Department of the Interior-Department of the Army land-acquisition policy.

The Bureau of Sport Fisheries and Wildlife, in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), has reanalyzed the effects of the project on fish and wildlife resources. This report, prepared to accompany the survey report of the Corps of Engineers, Fort Worth District, has been coordinated with the Bureau of Commercial Fisheries. The Texas Game and Fish Commission has indicated its concurrence as indicated in the enclosed copy of the letter dated October 23, 1962, signed by Mr. Eugene A. Walker, Director of Program Planning. This report reflects a 100-year period of analysis (1980-2080). The location of the project is shown on Plate I.

We understand that your agency is investigating four sites on Pecan Bayou and Jim Ned Creek to provide storage for flood control purposes and water conservation storage for municipal, industrial, irrigation, and water quality control purposes. It is planned, however, that only two reservoirs will be constructed, one on Pecan Bayou and the other on Jim Ned Creek.

Burkett and Pecan Bayou sites are on Pecan Bayou about 15 to 20 miles northeast of Coleman, Texas; Camp Colorado and Coleman sites are on Jim Ned Creek, about 12 to 15 miles east and north, respectively, of Coleman.

The project sites lie in the Rolling Plains physiographic region. Soils of the region are sandy clay loam and support a shortgrass vegetal type consisting of buffalograss, curly mesquite, and grama. Principal woody vegetation is shin oak and mesquite. The watershed is predominantly rangeland with some cultivation. Principal agricultural crops are oats, grain sorghum, wheat, corn, hay, and peanuts.

The project area has a temperate climate characterized by hot summers and cool winters. Mean annual temperature at the Brownwood Gage is about 65° F. January's normal is 46.3° F.; July's, 83.9°F. Mean annual precipitation is 27.44 inches.

The Pecan Bayou and Tributaries Project is located in a moderately populated rural area. Agriculture, manufacturing, and petroleum production are the principal sources of income.

The construction of a new embankment and outlet structures and minor spillway improvements are being considered for Brownwood Reservoir. Channel improvements are proposed on streams through the City of Brownwood, Texas.

Burkett and Pecan Bayou Reservoirs will have earthen dams at mile 91.9 and 100.8, respectively, and uncontrolled broad-crested spillways with net crest lengths of 800 feet. The outlet works will consist of a 16-foot-diameter conduit through the dam with upstream inverts at elevation 1525 at the Burkett site and 1588 at the Pecan Bayou site. Three slide gates, 5 feet by 16 feet, will control the outlet works at these sites.

Camp Colorado and Coleman Reservoirs also will have earthen dams at mile 26.2 and 52.2, respectively, and uncontrolled broad-crested spillways. The outlet works for Camp Colorado Reservoir will consist of a 15-foot-diameter conduit through the dam with upstream invert at elevation 1480. The outlet works for Coleman Reservoir will consist of a 14-foot-diameter conduit through the dam with upstream invert at elevation 1672. Two slide gates, 7 feet by 15 feet, will control the Camp Colorado Reservoir outlet works; three slide gates, 4.2 feet by 14 feet, will control the outlet works at Coleman Reservoir.

The proposed dam for the Brownwood Reservoir will be an earthen structure about 900 feet downstream from the existing dam. The outlet works will consist of a 10-foot-diameter conduit through the dam, with upstream invert at elevation 1342. Two tractor gates, 5 feet by 10 feet, will control the outlet works.

Channel improvements are proposed on Pecan Bayou from river mile 37.8 to river mile 47.5, and on Willis Creek and Adams Branch from their mouths to river mile 3.9 and 5.0, respectively. The channel improvements include diversion channels extending from mile 3.2 on Adams Branch and mile 1.5 on West Slough to the improved Pecan Bayou channel, and from mile 0.3 on Tom Williams Branch to the improved Adams Branch channel.

Table 1 presents pertinent data for each reservoir site under investigation. Specific reservoir operations are not available at this time. There will be constant releases of about 1.5 second-feet from the reservoirs for water-quality control. These releases will pass through Brownwood Reservoir and down Pecan Bayou.

Table 1. Pertinent Data, Pecan Bayou and Tributaries Project, Texas

Reservoir	Pool Elevation		Pool Area (acres)		Pool Capacity (ac.ft.)		Proposed Land Acquisition in Fee (acres)
	Conservation	Flood	Conservation	Flood	Conservation	Flood	
Burkett 1/	1594.5	1610	5,940	9,250	149,100	264,700	11,350
Pecan Bayou 2/	1637.0	1653	5,150	8,030	102,000	206,300	10,550
Camp Colorado 3/	1566.0	1584	7,300	11,680	190,200	358,400	13,290
Coleman 4/	1764.0	1784	3,930	5,430	147,600	240,900	7,100
Brownwood	Same as existing conditions						

1/ 39,200 acre-feet reserved for 100 years sedimentation.

2/ 10,100 acre-feet reserved for 100 years sedimentation.

3/ 39,000 acre-feet reserved for 100 years sedimentation.

4/ 10,300 acre-feet reserved for 100 years sedimentation.

FISH

There are about 143,000 people living within 50 miles of the project sites. By the year 2080, the population in this area is expected to increase to about 258,000 and is expected to require facilities for about 900,000 man-days of fishing annually. Reservoir and stream fishing is to be found in Brownwood, Hords Creek, Cisco, Leon, Olden, Eastland, Comanche, Scarborough, Eames, Kirby, Lytle, Abilene, and Ballinger Reservoirs; Pecan Bayou; and the San Saba and Colorado Rivers. Proctor Reservoir is under construction a short distance from the project area.

There is no fish habitat in Willis Creek, Adams Branch, Tom Williams Branch, or West Slough. Stream fishing is of minor importance in Jim Ned Creek and in Pecan Bayou above Brownwood Reservoir and the 7-mile reach immediately downstream from Brownwood Dam. Outcrop seepages, occasional releases from Brownwood Reservoir, irrigation returns to the stream, and two low-water dams at river miles 47.0 and 49.0 provide good fish habitat in the lower 50 miles of Pecan Bayou. The stream is usually clear, very fertile, and partially shaded by a dense canopy of pecans, elms, oaks, and willows.

Approximately 10,000 man-days of sport fishing annually occur on the lower 50-mile reach of Pecan Bayou. Access to the stream is possible but may require walking along the banks from several public road crossings. Bank fishing predominates; pole and line and trotline fishing are the principal methods used. Largemouth bass, bluegill, channel catfish, flathead catfish, blue catfish, freshwater drum, carp, and buffalofishes are the principal fishes taken. The quality and value of the fishery and access to Pecan Bayou are not expected to change materially during the period of analysis without the project.

Brownwood Reservoir receives moderate fishing. The principal fishes taken are largemouth bass, white bass, white crappie, channel catfish, and flathead catfish. Excellent camping, overnight lodging, and parking facilities at the reservoir attract vacationers from central and west Texas, as well as from eastern New Mexico.

The reservoir water usually is clear, becoming muddy following periods of heavy rains. There is little aquatic vegetation; however, fish production in the reservoir has been high. Boat fishing predominates and the principal method of fishing is by rod and reel.

Approximately 80,000 man-days of fishing would occur annually in Brownwood Reservoir without construction and operation of the proposed Pecan Bayou Project.

Only a moderate amount of commercial fishing has taken place in Brownwood Reservoir, and it is doubtful that it will expand in the future. About 500,000 minnows valued at $5,000 are taken annually from Pecan Bayou downstream from Brownwood Reservoir. This value could be expected to be maintained without the project.

Construction of any of the proposed reservoirs will eliminate a stream fishery of minor importance. The reservoirs will have much in common, in that each will inundate fertile bottom lands and will produce clear, productive waters. All the reservoirs will have much deep water with relatively few shallow areas. Largemouth bass, white bass, white crappie, bluegill, redear sunfish, green sunfish, and channel catfish will be the principal game fishes in the reservoirs.

The construction of a new dam for Brownwood Reservoir and elimination of the existing dam will not affect the conservation pool capacity or the reservoir fishery. Hence, no project effects are anticipated on the sport-fishing values in Brownwood Reservoir.

A constant release of 1.5 second-feet from the reservoirs to be constructed on Pecan Bayou and Jim Ned Creek and the passing of this release through the Brownwood Reservoir into Pecan Bayou for water quality control will create a stream fish habitat and improve the existing stream fish habitat downstream from these reservoirs.

A summary of fishing anticipated under without and with project conditions of the various combinations of reservoir sites is given in Table 2. The man-days of fishing are based on the assumption that only one reservoir will be constructed on each stream.

Table 2. Summary of Fish Habitat and Sport Fishing
Pecan Bayou and Tributaries, Texas

Area	Amount of Habitat	Without the Project (Man-days per year)	With the Project (Man-days per year)
Brownwood Reservoir	7,570 acres	80,000	80,000
Lower Pecan Bayou	55 miles	10,000	15,000
Pecan Bayou Reservoir	5,150 acres	--	120,000
Pecan Bayou	32 miles	350	13,000
Burkett Reservoir	5,940 acres	--	120,000
Pecan Bayou	23 miles	350	12,000
Coleman Reservoir	3,930 acres	--	120,000
Jim Ned Creek	41 miles	300	14,000
Camp Colorado Reservoir	7,300 acres	--	145,000
Jim Ned Creek	15 miles	300	11,500

The development of new reservoirs on Jim Ned Creek and Pecan Bayou and constant release of 1.5 second-feet from these reservoirs will result in project benefits. The magnitude of these benefits will be dependent largely upon the locations of the reservoir sites and the plans of operation.

Commercial fishing will not be significant in Brownwood Reservoir or in any of the reservoirs proposed for construction. The demands created by the construction of reservoirs on Pecan Bayou and Jim Ned Creek will result in the taking of about 1 million minnows annually from Pecan Bayou downstream from Brownwood Dam. Value of the bait-minnow catch will be $10,000 annually.

Game species of importance in the project area are white-tailed deer, wild turkey, mourning dove, bobwhite, fox squirrel, gray fox, raccoon, and waterfowl. No change in land-use trends is anticipated without the project except that more efficient brush eradication will convert some mesquite areas to improved pastures.

Wildlife habitat and populations in general are good except for white-tailed deer in the Burkett area and wild turkeys which occur as small colonies of 20 to 30 birds at several points on Pecan Bayou upstream from Brownwood Reservoir and on Jim Ned Creek. Turkey populations are not expected to increase significantly. On the Pecan Bayou flood plain downstream from Brownwood Reservoir, stocking of turkeys on the Camp Bowie Game Restoration Area by the Texas Game and Fish Commission has provided a huntable population. Waterfowl use of project streams is negligible and is not highly important on Brownwood Reservoir.

Throughout the project area, landowners generally restrict hunting to friends. There is some leasing of land for deer hunting. This practice is confined to the Brownwood area and the downstream flood plain of Pecan Bayou and is not extensive. These conditions are expected to prevail in future years without the project.

Without the project, it is estimated that the Burkett Reservoir site would support about 600 man-days of upland-game hunting annually. Deer and waterfowl hunting would be negligible. The Pecan Bayou Reservoir site would sustain about 150 man-days of deer hunting and 250 man-days of upland-game hunting annually. Waterfowl hunting would be insignificant.

Without the project, the Coleman Reservoir site would provide about 150 man-days of deer hunting and 200 man-days of upland-game hunting annually. The Camp Colorado Reservoir site would support about 180 man-days of deer hunting and 650 man-days of upland-game hunting annually. Waterfowl hunting on these reservoir sites would be negligible.

About 500 man-days of waterfowl hunting are carried out annually on Brownwood Reservoir by local residents and a few non-local people. It is expected that this would not change materially in the future.

Construction of Burkett or Pecan Bayou Reservoir on Pecan Bayou and Camp Colorado or Coleman Reservoir on Jim Ned Creek will result in loss of wildlife habitat and populations but will provide resting habitat for waterfowl. The nature of the topography in the reservoir basins precludes the establishment of many aquatic waterfowl food plants.

No change in wildlife habitat, populations, or hunting is anticipated on Brownwood Reservoir and the downstream flood plain. Hunting in the reservoir areas with the project, except for waterfowl, will be insignificant. Waterfowl hunting will amount to 350 man-days annually at either of the proposed reservoirs on Jim Ned Creek and Pecan Bayou.

Table 3 presents a summary of hunting without and with the project.

Table 3. Summary of Wildlife Habitat and Hunting
Pecan Bayou and Tributaries, Texas

Reservoir and Type of Game	Habitat (acres)	Without the Project (Man-days per year)	With the Project (Man-days per year)
Pecan Bayou			
Big game	10,550	150	0
Upland game	"	265	350
Waterfowl	"	0	350
Burkett			
Big game	11,350	0	0
Upland game	"	600	400
Waterfowl	"	0	350
Coleman			
Big game	7,100	150	0
Upland game	"	200	100
Waterfowl	"	0	350
Camp Colorado			
Big Game	13,290	180	0
Upland game	"	650	600
Waterfowl	"	0	350

DISCUSSION

Fish and wildlife benefits are based upon the assumption that adequate all-weather access roads to reservoirs, parking areas, and boat-launching ramps will be provided. To accommodate the hunting and fishing anticipated at these reservoirs, four parking areas of about 2 acres each will be required at each reservoir. Further study of these proposals will be undertaken when project sites are selected from among the alternates now under consideration by your office.

The quality of fishing in the proposed reservoirs will depend in part upon fishery management. To conduct properly the fishery investigations in these reservoirs, the Texas Game and Fish Commission has requested 3 seining areas in each reservoir. These areas should be 1,000-foot-wide strips sloping gradually from the conservation-pool elevation to a depth of at least 15 feet and should be cleared to ground level of all man-made obstructions, stumps, and vegetation to permit uninterrupted seining and netting. Definite location of these areas will be made when the most feasible project plans are made known to us or when studies are made by the Bureau of Sport Fisheries and Wildlife during the design planning stage of the project.

Heavy recreational use is anticipated on the reservoirs. Uncontrolled use will prevent optimum fishing and hunting on the reservoirs. To capitalize fully on the hunting and fishing potential of the reservoirs, to protect life and property, and to prevent unnecessary conflict in reservoir use between speed boaters and water skiers and fishermen and hunters, zoned areas should be established. Benefits in the amount of $30,000 annually would be realized on each reservoir from adequate provision of such zoned areas. The Texas Game and Fish Commission and the Bureau of Sport Fisheries and Wildlife will be prepared to indicate approximate areas to be zoned for hunting and fishing during the design planning stage of the project.

At least one of the proposed reservoirs may have definite value in carrying out the national migratory bird program. A national wildlife refuge established within the project area could provide much-needed resting and feeding habitat for waterfowl and would provide an opportunity to insure future hunting through a waterfowl management program. The preliminary scope of project information is such that at this time it is not possible to propose a specific plan or to delineate lands required for a national wildlife refuge. However, refuge potentialities will be investigated further after the Corps of Engineers has recommended a specific project plan.

RECOMMENDATIONS

It is recommended:

1. That the report of the District Engineer , Fort Worth District, Corps of Engineers, incluue fish and wildlife conservation among the purposes for which the project is authorized.

2. That 4 parking areas of about 2 acres each be provided at each reservoir and that boat-launching ramps be provided at each parking area.

3. That 3 seining areas, 1,000 feet wide and gradually sloping from conservation-pool elevation to a depth of at least 15 feet and cleared to ground level of all man-made obstructions, stumps, and vegetation, be made part of the project's plans of development for each reservoir site. Location of these seining areas will be made during the design planning stage of the project.

4. That zoned areas be established on the reservoirs to protect life and property and to permit optimum fishing and hunting.

CONCLUSION

The Pecan Bayou and Tributaries Project will provide a fresh-water fishery that will receive heavy use. Conflicting uses of the reservoirs by water recreationists will prevent optimum use by fishermen and hunters. Releases from the proposed reservoirs for water-quality control will provide fish habitat in the streams below the reservoirs. The releases also will improve the quality of existing fish habitat in the streams below the proposed reservoirs and in Pecan Bayou downstream from Brownwood Reservoir.

Reservoir inundation and human disturbance will greatly reduce the deer populations on the Pecan Bayou, Camp Colorado, and Coleman Reservoir sites. Generally upland-game habitat and populations will be reduced. The reservoirs will provide resting areas for waterfowl. Waterfowl use and hunting will increase with the reservoirs.

It is estimated that annual fishery benefits will amount to $137,000 for the Burkett Reservoir; $138,000 for the Pecan Bayou Reservoir; $161,000 for the Camp Colorado Reservoir; and $139,000 for the Coleman Reservoir. Annual hunting benefits will amount to $1,000 for each reservoir. These benefits are based upon the assumption that only one reservoir would be constructed on each stream, Jim Ned Creek and Pecan Bayou; also, that all project lands and water would remain open to free use for hunting and fishing except for sections reserved for safety, efficient operation, protection of public property, or fish and wildlife management.

Additional fish and wildlife benefits amounting to $30,000 annually at each reservoir would accrue if zoned areas were established on the reservoirs for fishermen and hunter use as advocated in Recommendation No. 4 .

Our investigations are based upon data received prior to August 31, 1962. Any modification of the project plans should be brought to the attention of the Bureau of Sport Fisheries and Wildlife and the Texas Game and Fish Commission.

The cooperation of the Fort Worth District Corps of Engineers in furnishing engineering data and planning information is appreciated.

Sincerely yours,

John C. Gatlin

John C. Gatlin
Regional Director

Enclosure

Copies 10

Distribution:

(5) Executive Secretary, Texas Game and Fish Commission, Austin, Texas

(2) Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Fort Worth, Texas

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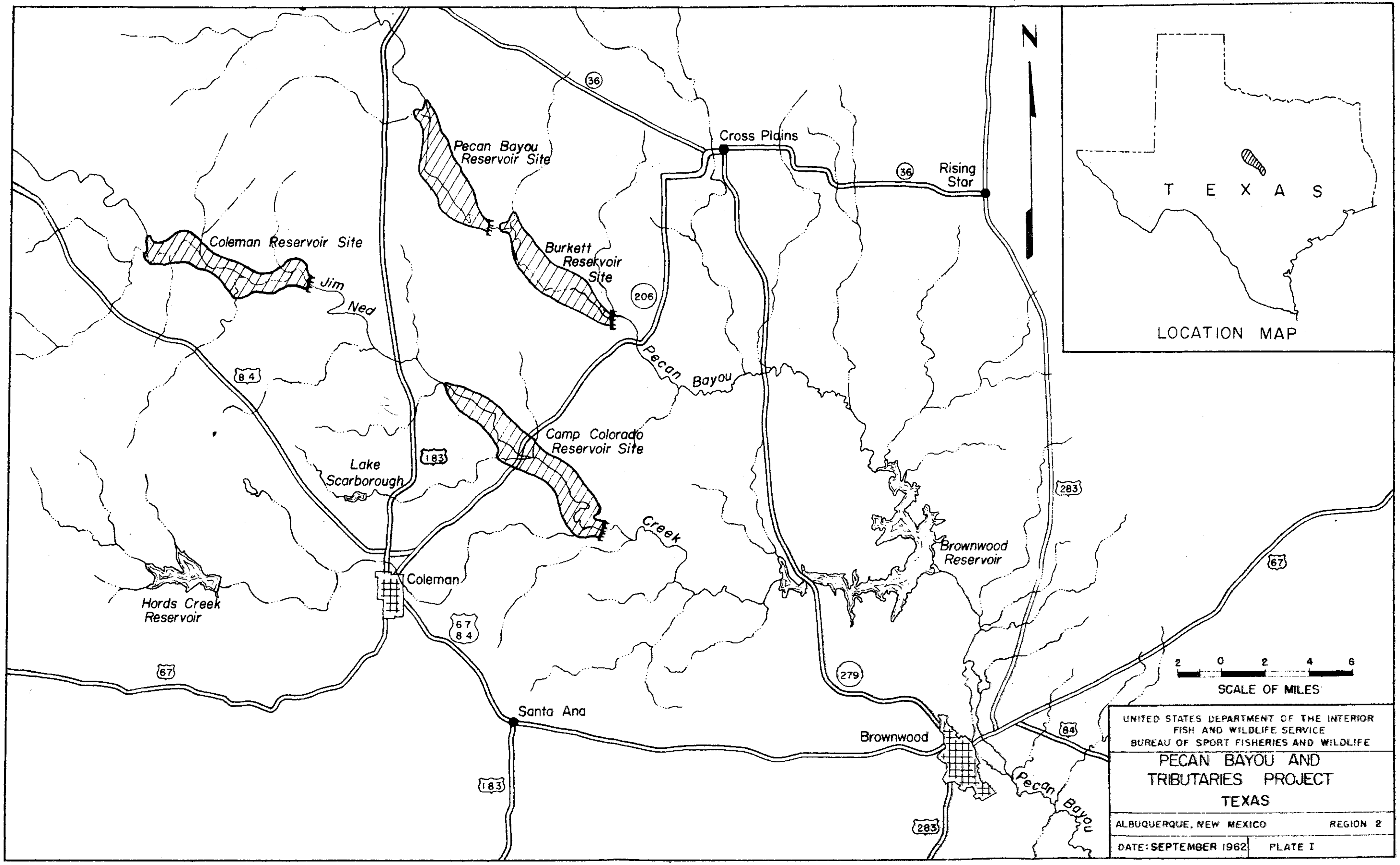

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
PECAN BAYOU AND TRIBUTARIES PROJECT
TEXAS
ALBUQUERQUE, NEW MEXICO
REGION 2
DATE: SEPTEMBER 1962
PLATE I
LOCATION MAP
T E X A S
N
SCALE OF MILES
2 0 2 4 6
Pecan Bayou Reservoir Site
Coleman Reservoir Site
Burkett Reservoir Site
Camp Colorado Reservoir Site
Jim Ned
Pecan Bayou
Creek
Cross Plains
Rising Star
Lake Scarborough
Hords Creek Reservoir
Coleman
Santa Ana
Brownwood
Brownwood Reservoir
36
206
84
183
283
67
279
67 84

RECONNAISANCE REPORT

RECREATION USE AND DEVELOPMENT

PECAN BAYOU WATERSHED

COLORADO RIVER BASIN

TEXAS

Prepared by

Region Three Office, National Park Service
Department of the Interior

for

Fort Worth District
U. S. Corps of Engineers
Department of the Army

November 1960

William L. Bowen, Regional Chief
Division of Recreation Resource Planning

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Branch of State Cooperation and Reservoir
Recreation Planning

Field Study and Report by:
Urban E. Rogers
Park Landscape Architect

River Basin Code No. XXXVI/97

INTRODUCTION

Authority

This reconnaisance report has been prepared pursuant to the Park, Parkway, and Recreational Area Study Act of June 1936 and the Corps of Engineers', Fort Worth District Office, letter request of February 17, 1960.

A field investigation of the reservoir sites was made on February 29 and March 1 by Messrs. F. K. Mixon and F. E. Clary of the Corps of Engineers Fort Worth District Office and Park Landscape Architect Urban E. Rogers of the Region Three Office, National Park Service.

Purpose

This report presents an appraisal of the recreational potentials of the proposed reservoir projects on the Pecan Bayou Watershed. The report also indicates the type of recreation development believed justified and includes an estimated monetary evaluation of recreation benefits.

SUMMARY

1. The reservoir sites are generally quite attractive and the impoundments will create good recreation development sites.

2. Both sites are desirable for public recreation use; however, Burkett, the larger site, has more recreation potentialities than the Camp Colorado site.

3. The proposed reservoirs, with adequate recreation facilities, will enhance nearby existing water recreation areas particularly Lake Brownwood State Park.

4. Public use, concession and administration facilities are recommended for development.

5. A historical and archaeological survey should be made of the reservoir areas and at the dam construction sites.

6. Annual use, in addition to estimated use of the area without the project reservoirs, is conservatively estimated at 400,000 visitor-days.

7. The estimated monetary recreational benefits of this project would equal $640,000 annually.

8. More land than is required for project purposes is needed for recreation access roads and development sites.

9. Local day-use is anticipated and administration should be a local responsibility.

GENERAL DESCRIPTION

Location

The Pecan Bayou Watershed, Colorado River Basin, currently under study is situated in the northeast quarter of Coleman County. Two upstream reservoir sites are being investigated. Burkett site is on Pecan Bayou and located immediately northwest of the small community of Burkett. The other site, Camp Colorado, is on Jim Ned Creek and approximately ten miles northeast of Coleman.

Federal and State highways in the vicinity link with farm roads to provide access to and through the reservoir basins.

Purpose

The two proposed reservoir projects are being investigated for flood control and conservation storage purposes. They will be operated in combination with Lake Brownwood. Lake Brownwood is an existing multiple-purpose project located on Pecan Bayou approximately 15 miles downstream. Both reservoirs will be recommended for authorization.

The following preliminary data were supplied by the Corps of Engineers:

(see following page)

	RESERVOIR SITES	
	BURKETT	CAMP COLORADO
Drainage Area (sq. miles)	376	593
Type of Dam	earth fill	earth fill
Flood Control Pool		
Elevation (ft.M.S.L.)	1602.0	1568.0
Surface Area (acres)	7,340	7,690
Capacity (acre feet)	198,600	205,200
Conservation Pool		
Elevation (ft.M.S.L.)	1580.0	1531.5
Surface Area (acres)	3,920	2,230
Capacity (acre feet)	78,400	33,700
Five-Year Pool		
Elevation (ft.M.S.L.)	1587.0	1547.0
Surface Area (acres)	4820	4200
Sediment Storage (acre feet)	19,600	19,500

Camp Colorado will inundate approximately 10 land miles of Jim Ned Creek and the Burkett site will inundate about the same number of miles of Pecan Bayou. The impoundments will extend in a northwesterly direction and have very irregular shorelines with many bays and inlets. The recreation potential is enhanced by the fact that the conservation pools will have a relatively stable water surface.

Physical Characteristics

The Pecan Bayou watershed is characterized by rolling to level terrain heavily covered with mesquite. Pecan, sycamore, cottonwood, and several species of oak are found along the streams and side drainages. The area is generally quite attractive and with the impoundments will have good recreation potentiality. Some of the land is under cultivation and more is being cleared of mesquite for seeding and grazing. The soils range from alluvial in the valleys to clays, chocolate loams, and sands on the hills. The drainage area has an agricultural, industrial, and commercial economy.

Climate

The very favorable Central West Texas climate is conducive to recreation. The summers are hot and the winters are mild. Approximately eight months of each year are normally frost free. Coleman County, site of the proposed reservoirs, has a mean annual temperature of 65° F. Temperatures average 47° F. in January and 83° F. in July. Annual precipitation, 28.30 inches, usually occurs as rainfall in Coleman County. The spring months of April, May, and June account for the heaviest amounts of moisture. Southerly breezes prevail throughout most of the year.

Historical and Archaeological Investigations

Upon authorization of the reservoirs and prior to their construction, a historical and archaeological survey should be made of the reservoir areas and at the dam construction sites.

Present Recreation Use

Present use of the reservoir basins for recreation purposes, even though readily accessible by road, is limited to hunting and incidental fishing.

FACTORS INFLUENCING RECREATION DEVELOPMENT

The reservoir sites are generally quite attractive and the impoundments will create good recreation development sites. Of importance to the development of potential recreation sites is the proximity of existing roads, rolling mesquite covered terrain, size of the impoundments, the very irregular shorelines, favorable climate, and the fact that the conservation pools should not fluctuate more than a few feet.

The project area had a balanced rural-urban population in 1950 with an agricultural, industrial, and commercial economy. The 1960 preliminary census count indicates Coleman County, site of the project, has a population of 12,307. This represents a 20.6 percent decrease from the 1950 census count. The population of Coleman, the county seat, declined from 6,530 in 1950 to 6,298 in 1960. Taylor is the only county within 50 miles of the project that showed an increase in population during the past decade.

The total population 1/ within a 50 mile radius of the Burkett and Camp Colorado sites is 155,876 and 157,675 respectively. In each instance, close to one-half of the people reside in Taylor County. Approximately 90 percent of the Taylor County residents live in Abilene, 45 miles northwest.

1/ Based on the 1960 preliminary census count.

The most significant existing recreation area within one hour's drive is Lake Brownwood, 15 miles south. Lake Brownwood State Park, 36th Division State Park, is located on the west shore of this 8,900 acre lake. Visitor-use at this attractive State Park was close to 100,000 in 1959. Picnicking, fishing, camping, boating, water skiing, swimming, and cabin and group camp facilities are available at the park.

In addition to the State Park development, overnight accomodations, homesites, and other miscellaneous facilities have been developed around the lake for public and private use.

Abilene State Park on Lake Abilene is situated about 20 miles south of Abilene. Recreation development includes picnic, camping, swimming, and concession facilities. Total visitation in 1959 was 147,282.

Several smaller lakes and reservoirs have been developed in the project area with recreation as a secondary purpose. These include Lakes Ft. Phantom Hill and Kirby near Abilene; Lake Cisco north of Cisco; Lake Leon southeast of Eastland; and Hords Creek Reservoir west of Coleman. These impoundments offer limited recreation opportunities for local residents.

The geographical center of the State of Texas is located 45 miles south of the Camp Colorado site.

One proposed Corps of Engineers reservoir project, Proctor, is located nearby. This project, authorized but not under construction, is on the Leon River near Comanche. Recreation sites for the future 4,610 acre conservation pool are being selected by the Corps of Engineers.

ESTIMATE OF RECREATION NEED AND USE

Camp Colorado and the Burkett reservoir sites will provide additional recreation outlets for the local people. It is believed the reservoirs will appeal to the nearby urban communities, especially Abilene, more than to the local rural residents. Visitor-use attributed to tourists would not be significant.

The greatest need will be for day-use recreation facilities with some camping desirable. Week-end and holiday use during the summer months will comprise an appreciable portion of the total visitation.

RECREATION ANALYSIS

Both sites are desirable for public recreation use; however, Burkett, the larger site, has more recreation potentialities than the Camp Colorado site. The sites are generally quite attractive and the rolling mesquite covered terrain provides interesting reservoir settings. The impoundments will create good recreation development sites that will be readily accessible from existing roads. The shoreline topography lends itself to water recreation developments and the plan of operation is favorable. The climate and close proximity of over 150,000 people are also significant.

Nearby existing water recreation areas provide excellent recreation opportunities. These areas receive intensive use and it seems logical to conclude that the proposed reservoirs, with adequate recreation facilities, will relieve to some extent the pressure on existing crowded areas. Potential sites should be selected and developed to complement the existing recreation areas.

Since local day-use is anticipated, administration should be a local responsibility.

RECOMMENDED RECREATION DEVELOPMENT

The extent of recreation development at each reservoir is subject to further study; however, it is believed the larger site, Burkett, offers more recreation potentialities and, therefore, should have more extensive development.

Public use facilities primarily for day-use are recommended for development. These facilities are necessary for access, sanitation, and safety of the public and for protection of the areas. Access and circulatory roads and parking areas including barriers and signs, fencing, water and sanitary facilities, site preparation, boat docks and launching ramps for boating, fishing and water skiing, picnic areas including tables, fireplaces, trash receptacles and shelters if immediate shade is not available, swimming beaches with changing booths, and the installation of basic safety features are all considered public use facilities. Some camping facilities are also recommended.

Concession facilities are very desirable to complete the recreation developments. These facilities are generally revenue producing and furnished by the administering agency or its authorized concessioner. Such facilities could include marina and fishing supply centers, dining facilities, snack bars, and additional boat docks and mooring facilities. It is very doubtful if overnight accomodations will ever be justified.

Administration facilities are essential to assure the safe and full public use of all facilities. One headquarters area could very economically serve both reservoirs. It is suggested that the headquarters area be located at the Burkett site with only nominal administration facilities at Camp Colorado.

ESTIMATED MONETARY EVALUATION OF RECREATION BENEFITS

Many economic benefits are generated from the availability of adequate recreation facilities at water control projects. However, a long study of the subject has convinced economists of the National Park Service that such benefits cannot be measured scientifically in monetary terms. The Service, however, believes that its experience warrants a "judgement value" approach to assigning certain monetary values to potential recreation benefits of such projects.

An estimate in monetary terms of the recreation values of reservoirs with developments proposed is based on the estimated number of visitor-days of use expected, multiplied by a visitor-day factor. The annual use, in addition to estimated use of the area without the project reservoirs, is conservatively estimated at 400,000 visitor-days. Research by statisticians of the National Park Service has produced a factor or derived monetary value of $1.60 per visitor-day for all types of recreation.[1/]

Using this value, the estimated monetary recreational benefit of the project reservoirs would equal $640,000 annually.

No known existing recreation values of significance will be destroyed by construction of the project reservoirs.

LAND NEEDS

It is apparent that more land than is required for project purposes is needed for recreation access roads and development sites. Sufficient land should be purchased to protect each development site and provide for foreseeable future expansion.

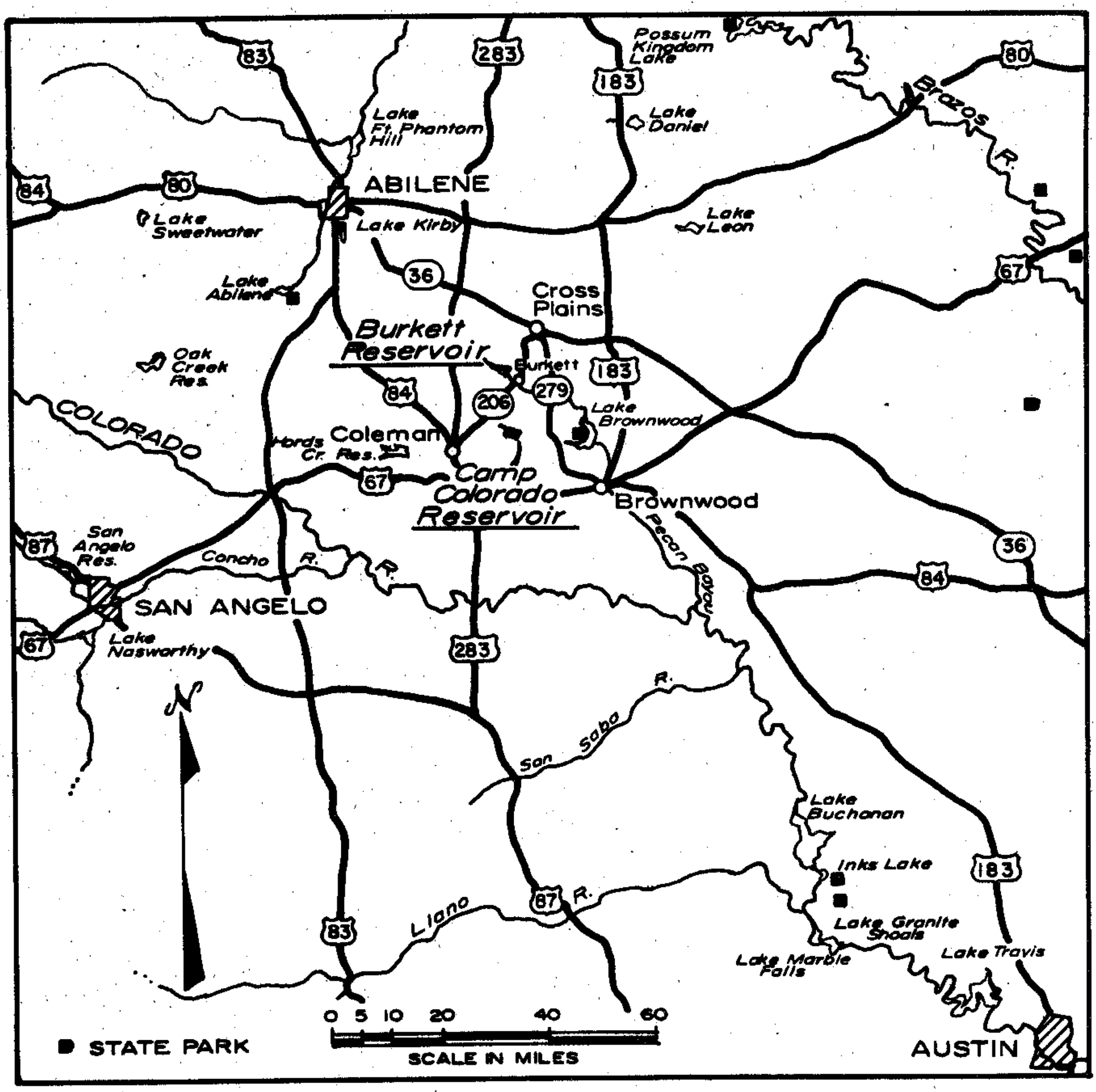
ADMINISTRATION, OPERATION, MAINTENANCE

Since the project reservoirs are considered of local significance, nearby communities should be approached regarding the administration of the recreational resources of the project if authorized.

FURTHER STUDY AND PLANNING

Upon authorization of the project, it will be necessary to make more detailed studies and surveys of the recreation potentialities of the reservoirs. Such studies and surveys will entail the selection of recreation sites and determining the extent of development and amount of land required to realize the recreational resources inherent in the project.

1/ A Method of Evaluating Recreation Benefits of Water Control Projects. National Park Service, August 1957.



VICINITY MAP

PECAN BAYOU WATERSHED

COLORADO RIVER BASIN
TEXAS

NOVEMBER 1960 CODE No. XXXVI/97

WATER RESOURCES STUDY

PECAN BAYOU WATERSHED

COLORADO RIVER BASIN

TEXAS

Study of Potential Needs and Value of
Water for Municipal, Industrial, and
Quality Control Purposes

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

In Cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer District - Fort Worth, Texas

OCTOBER 1962

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I. INTRODUCTION

General

In a letter dated June 8, 1959, the Corps of Engineers, Fort Worth District, requested "Views and recommendations of HEW on present and prospective needs for municipal and industrial water supply for Brownwood and desirability of meeting these needs from the Pecan Bayou project." In compliance with this request, a report entitled "Municipal and Industrial Water Requirements, Pecan Bayou, Colorado River Basin, Texas" was prepared and submitted in July 1961. Since the preparation of this report, there have been several changes in: (1) the laws governing water resource planning; (2) the planning policies of Federal agencies; and (3) the plans for the reservoir projects included in the original request.

Authority

The Corps of Engineers, Fort Worth District, in a letter dated July 13, 1962, provided revised data and requested a supplement to the July 1961 report.

This study has been made in accordance with: (1) the Water Supply Act of 1958 (Public Law 85-500, Title III) and a Memorandum of Agreement between the Department of the Army and the Department of Health, Education, and Welfare, dated November 4, 1958; and (2) the Federal Water Pollution Control Act (Public Law 84-660) as amended by Public Law 87-88.

Purpose and Scope

This report indicates the requirements for municipal, industrial, and water quality control purposes to the year 2070 in the Pecan Bayou watershed. Estimates are made of the benefits attributable to the storage of water for these purposes in proposed Federal reservoirs.

Acknowledgments

The cooperation of many persons and agencies is gratefully acknowledged. Special appreciation is expressed to the following:

Bureau of Reclamation, Austin, Texas
Lower Colorado River Authority, Austin, Texas
Central Colorado River Authority, Austin, Texas
Texas Water Commission, Austin, Texas
Texas State Department of Health, Austin, Texas
Brown County Water Improvement District No. 1,
  Brownwood, Texas
Coleman Board of Community Development, Coleman, Texas
Brownwood Chamber of Commerce, Brownwood, Texas
Officials of cities in the study area

II. SUMMARY AND CONCLUSIONS

Summary

1. The study area comprises Brown and Coleman Counties and that portion of Callahan County within the Pecan Bayou watershed as shown in Figure 1. It is situated in west-central Texas and contains an area of about 2,600 square miles.

2. The major water users in the study area are the cities of: Brownwood, Coleman, and Cross Plains.

3. The total estimated water resources of the study area in 2020 and 2070 including surface reservoirs, ground water from the relatively unproductive Trinity sand, reusable municipal and industrial return flows, and imports are 41.6 mgd and 45.2 mgd, respectively.

4. The water quality of the existing and firmly planned sources is either acceptable or can be made acceptable for municipal and industrial uses.

Conclusions

1. Efficient development of all of the water resources of the Pecan Bayou watershed is essential to the continued growth of the area. To attain full utilization of these resources for municipal, industrial, agricultural, and recreation purposes will require control of pollution throughout the area. Therefore, provision of water to maintain minimum acceptable quality conditions in the waters of the watershed must be made a part of the water supply plan until such time as future advances in waste treatment technology can economically provide for removal of residual pollutants before they reach the receiving streams.

2. The study area's population is expected to reach 68,400 by the year 2020 and 105,700 by the year 2070.

3. Projected municipal and industrial water needs for the study area are 16.3 mgd (million gallons per day) in 2020 and 26.6 mgd in 2070.

4. With the water supply plan as herein presented, the potential water resource in the Pecan Bayou watershed including imports is sufficient to satisfy all water requirements within the basin until the year 2070.

5. To maintain water quality within the Pecan Bayou watershed will require releases from storage in Coleman and Pecan Bayou Reservoirs of about 1.5 mgd and 2.1 mgd in the years 2020 and 2070, respectively. This is based on hydrologic conditions that may be expected to reoccur once in 10 years.

6. The estimated benefits of storage by purpose in Pecan Bayou and Coleman Reservoirs are shown in Table IX-1, page 231.

III. DESCRIPTION OF PROJECT

Location

Pecan Bayou is a tributary of the Colorado River. It rises in Callahan County in central Texas and flows generally southeast 130 miles to its confluence with the Colorado River near the city of Goldthwaite in Mills County. Other major streams in the watershed are Hords Creek and Jim Ned Creek. Hords Creek is a tributary of Jim Ned Creek which in turn flows into Pecan Bayou a short distance above Brownwood Dam.

The watershed is a fan-shaped area approximately 85 miles long and 30 miles wide at its widest point. Portions of the following eight counties are within the watershed's boundaries: Taylor, Eastland, Runnells, Comanche, Mills, Brown, Callahan, and Coleman. The latter three contain the bulk of the drainage area and comprise the study area for purposes of this report.

The Pecan Bayou project as used in this study consists of the reconstruction of the Brownwood Dam, construction of Pecan Bayou Reservoir at mile 100.8 on Pecan Bayou, and construction of Coleman Reservoir at mile 52.2 on Jim Ned Creek. The location of the project is shown in Figure 1.

Streamflow

Most of the flow of Pecan Bayou is surface runoff, with little contribution from ground water seepage. The U. S. Geological Survey maintains a gaging station on Pecan Bayou located one mile north of the city of Brownwood and 10 miles downstream from Brownwood Reservoir. The Corps of Engineers supplied estimated natural annual discharges at the Brownwood Dam site for a 43-year period ending in 1958. A discharge frequency curve was constructed from these data and is shown in Figure 2.

Ground Water

Ground water in the study area is practically nonexistent. Small amounts may be found in thin beds of sand in stream alluvium and in the relatively unproductive Trinity sands which underlie the northeastern portion of the area. The U. S. Study Commission-Texas estimated that there were less than 500 acre-feet per year of ground water available in the study area. The Texas Water Commission concurred in a Public Health Service estimate of 2.0 mgd which was made as a part of the water resources study of the Colorado River basin, Texas.

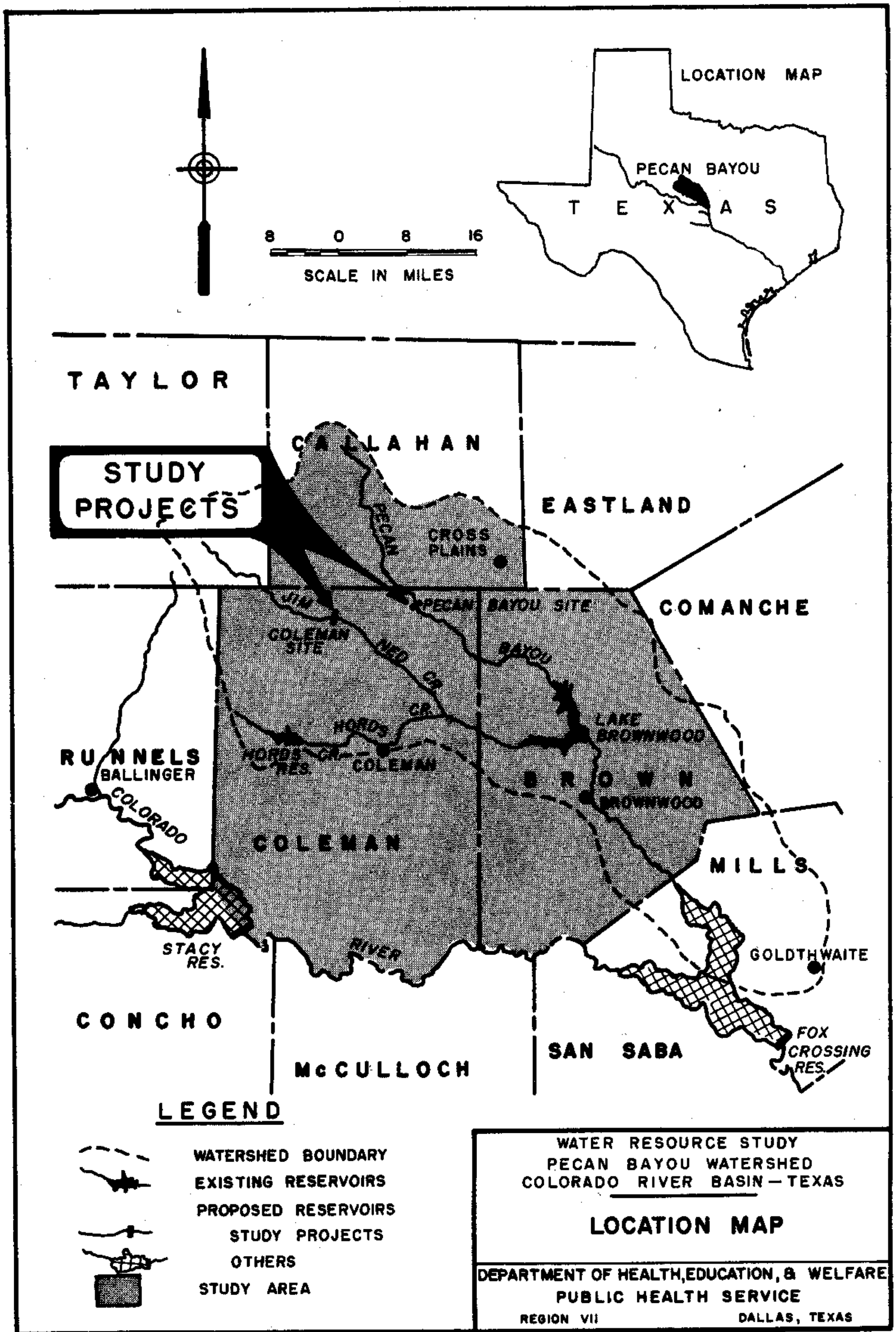
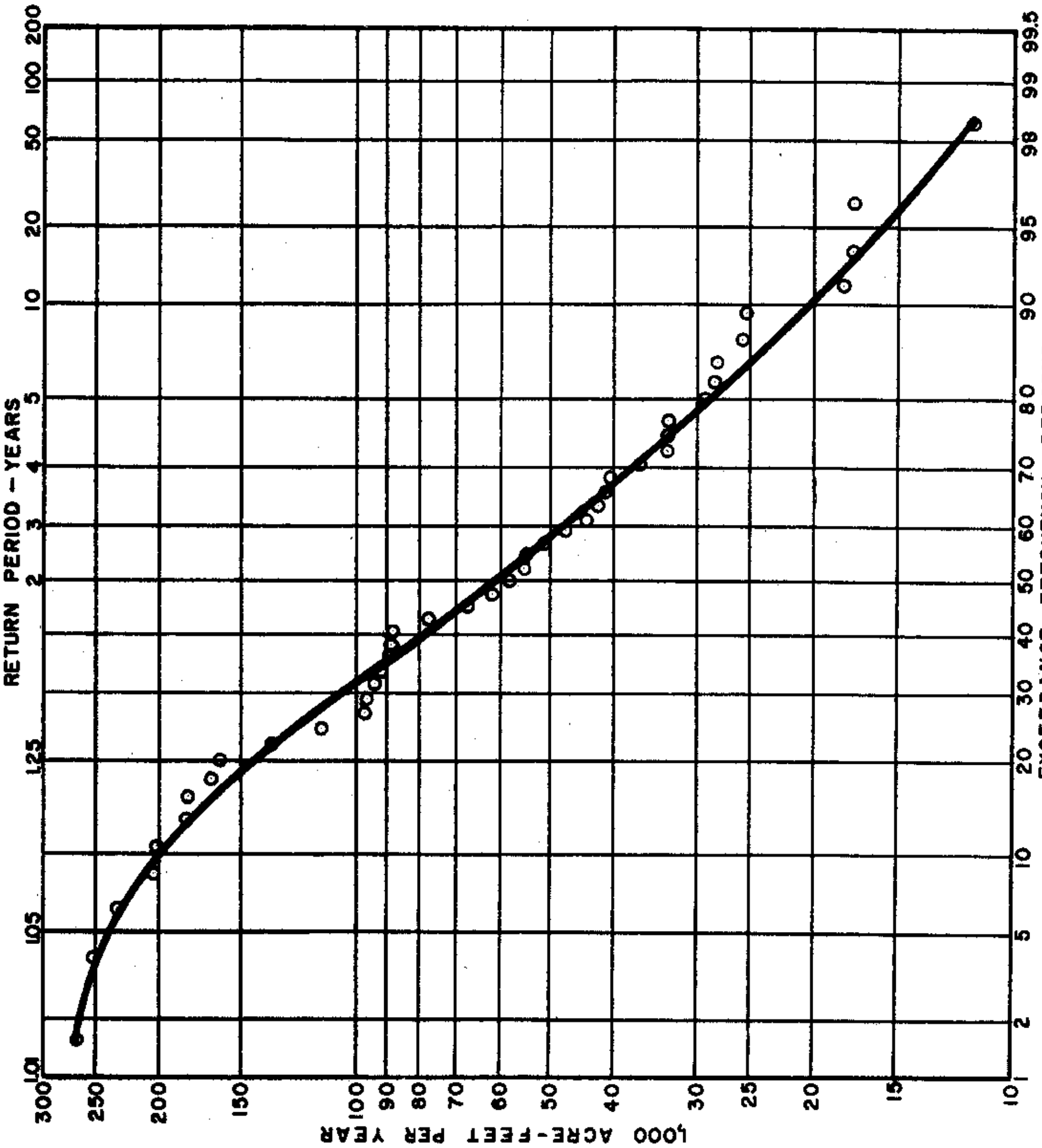

LOCATION MAP
PECAN BAYOU
T E X A S
8 0 8 16
SCALE IN MILES
TAYLOR
CALLAHAN
STUDY PROJECTS
EASTLAND
CROSS PLAINS
PECAN
COMANCHE
PECAN BAYOU SITE
JIM
COLEMAN SITE
NED CR.
BAYOU
CR.
HORDS
LAKE BROWNWOOD
RUNNELS
BALLINGER
HORDS RES.
CR.
COLEMAN
BROWN
BROWNWOOD
COLORADO
COLEMAN
MILLS
STACY RES.
RIVER
GOLDTHWAITE
CONCHO
SAN SABA
FOX CROSSING RES.
McCULLOCH
LEGEND
WATERSHED BOUNDARY
EXISTING RESERVOIRS
PROPOSED RESERVOIRS
STUDY PROJECTS
OTHERS
STUDY AREA
WATER RESOURCE STUDY
PECAN BAYOU WATERSHED
COLORADO RIVER BASIN—TEXAS
LOCATION MAP
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII
DALLAS, TEXAS

FIGURE I



WATER RESOURCE STUDY
PECAN BAYOU WATERSHED
COLORADO RIVER BASIN — TEXAS

NATURAL ANNUAL
DISCHARGE FREQUENCY

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 2

Water Quality

The concentrations of the chemical constituents in Pecan Bayou water are currently within the limits suggested by the Public Health Service Drinking Water Standards--1961. A summary of analyses of biweekly water samples taken from Pecan Bayou at the bridge on U. S. Highway 377 by the Texas State Department of Health are shown in Table III-1.

Table III-1

Water Quality--Pecan Bayou
(Period of Record - 11/12/57 to 3/2/59)

	Concentrations in mg/l.*		
	Total Solids	Chlorides	Sulfates
Arith. Average	318	54	36
Maximum	630	140	105
Minimum	171	20	11

* Milligrams per liter

The city of Cross Plains is the only municipality in the study area presently using ground water. Quality data are sparse but a random sample collected by the Texas State Department of Health in May 1955 showed the following concentrations: total solids, 372 mg/l.; chlorides, 32 mg/l.; and sulfates, 17 mg/l.

The waters of the Pecan Bayou watershed are of satisfactory quality for general municipal and industrial use after conventional treatment.

Pertinent Data

Pertinent data on Pecan Bayou, Coleman, and Brownwood Reservoirs, as determined by the Corps of Engineers, are shown in Table III-2.

Table III-2

Pertinent Data

Storage (Acre-feet)	Reservoir Brownwood	Coleman	Pecan Bayou
Conservation	85,900	138,500	93,520
Sediment	33,000	10,300	10,100
Flood Control	-0-	92,100	102,680
Total	118,900	240,900	206,300
Yield (cfs)*	23	20	13

* The yields shown are based on the worst drouth period of record. The yield of Brownwood Reservoir before the addition of Coleman and Pecan Bayou Reservoirs is 35 cfs (cubic feet per second), and after the addition of the two upstream reservoirs is reduced to 23 cfs. Thus, the addition of Coleman and Pecan Bayou Reservoirs provides a net increase in dependable yield of about 21 cfs of which (on a system-basis proportion) 13 cfs and 8 cfs would be creditable to the Coleman and Pecan Bayou Reservoirs, respectively.

IV. DESCRIPTION OF THE STUDY AREA

Location and Boundaries

The boundaries of the study area are shown in Figure 1. The area is generally coincident with the watershed boundaries of Pecan Bayou to the Mills County line, and it is wholly within the Colorado River basin. The major municipalities in the study area are Brownwood in Brown County; Cross Plains in Callahan County; and Coleman in Coleman County.

Geography

The terrain of the study area is characterized by rather rough, broken relief. The major soil region within the area is the North Central Prairie. This region is characterized by loams and clays which are suitable for the growth of grains, cotton, and truck crops.

The area has a temperate climate with hot summers and cool winters. The mean annual temperature is about 65 degrees, and the mean annual precipitation over the area is approximately 25 inches. The average length of the growing season is on the order of 235 days.

V. ECONOMICS AND POPULATION

Extractive Industries

Mining

The mineral deposits of the study area are many and varied. The following paragraphs describe the mineral extraction activities of each county.

Brown County has produced principally quarried stone and some petroleum. The limited petroleum production has been from shallow, small fields, and recent exploration has not indicated any new fields which could be expected to alter the situation. There were 472,000 barrels produced in 1958. 1/

In Callahan County mineral production consists of oil and natural gas. There were 2,616,000 barrels of oil produced in 1958. 1/

Petroleum production in the Glen Cove and Goldsboro fields of Coleman County accounts for the major portion of the value of mineral production there. The production in 1958 was 2,935,000 barrels. 1/ In addition, glass sand and other rock minerals are found in this county.

The value of mineral production for each of the counties for the period 1952 to 1958 is shown in Table V-1. 2/

Table V-1

Value of Mineral Production
(1,000's of 1958 Dollars)

Year	County: Brown	Callahan	Coleman	Total
1952	2,115	2,009	8,077	12,201
1953	2,393	5,563	11,875	19,831
1954	2,792	6,689	11,526	21,007
1955	2,417	9,878	11,194	23,489
1956	2,438	11,715	10,476	24,629
1957	2,409	10,427	12,098	24,934
1958	1,996	8,323	11,188	21,507

The total value of all minerals produced in the three counties in 1958 showed an increase of approximately 76 percent over the total of 1952. This increase is significantly greater than the 7 percent increase for the entire State for the same period.

Agriculture

The acres of cropland harvested and the value of all crops sold in the study area have shown an overall downward trend for the period of record as shown in Table V-2. [3/] Conversely, the value of livestock and livestock products sold rose sharply in 1959. This activity has become a more important segment of the agricultural economy of the area.

Table V-2

Agricultural Activity in Brown, Callahan, and Coleman Counties

Year	Cropland Harvested (Acres)	Value of All Crops Sold (1,000's of 1958 $'s)	Value of Livestock and Livestock Products Sold (1,000's of 1958 $'s)
1959	161,342	3,645	15,246
1954	273,992	3,258	9,689
1949	409,246	9,073	9,455
1944	394,789	6,322	9,628

Manufacturing

Manufacturing employment in the study area increased 154 percent or 1,000 workers in the two decades from 1940 to 1960. The statewide increase was also 154 percent. This accelerated growth of manufacturing in recent years is characteristic of many parts of the Southwestern States, which before World War II engaged principally in the extraction and primary processing of raw materials. Data on manufacturing activities for the three counties are shown in Table V-3. [4/]

Table V-3

Manufacturing Activities

County	Employees			Payroll ($1,000's)			Value Added (1,000's of 1958 $'s)		
	1947	1954	1958	1947	1954	1958	1947	1954	1958
Brown	442	604	1,125	851	1,451	3,664	2,236	2,683	6,598
Callahan	47	61	--	--	--	--	--	--	--
Coleman	220	224	254	362	558	689	933	943	1,209
Total	709	889	1,379	1,213	2,009	4,353	3,169	3,626	7,807

Generally, an increase in employment, coupled with increased value added per employee as shown in the table above, reflects favorably on the prospect for continued growth in the manufacturing industries.

Population

The population of the study area was 40,540 in 1960. This is a decrease of 26 percent since 1910, compared to the same period increase of 146 percent for the State of Texas. Closer examination of the records will show, however, that the municipal component of the total population showed an increase of 179 percent during the same five decades, while the nonmunicipal population declined 226 percent. The decrease in agricultural employment and the accompanying increase in manufacturing employment and associated service industries between 1940 and 1960, along with outmigration to larger population centers, are the primary reasons for these population trends. The historical populations are summarized in Table V-4. 5/

Table V-4

Historical Population

Year	Population Total	Population Municipal	Population Nonmunicipal
1910	51,041	10,013	41,028
1920	45,497	11,091	34,406
1930	55,459	18,867	36,592
1940	51,388	23,425	27,963
1950	47,954	30,917	17,037
1960	40,540	27,939	12,601

Future Growth

Economic Projections

The projections represent the level of economic activities that can be expected under assumptions of relatively high employment, a trend toward peace, continued population and economic growth, and a stable general price level. In general, the projections reflect the long-term levels that might reasonably be reached with production and requirements in balance under competitive conditions. The study area is endowed with many factors which can be expected to promote economic growth. Raw materials, fuel, power, and climate are some of the more important.

The study area contains over 30,000 acres of potentially irrigable land and some of the best natural rangeland in the entire State. Production, as reflected by the constant dollar values, has leveled off in crops and shown a marked increase in livestock and livestock products sold. Agricultural production in the study area is expected to increase 140 percent by the year 2020. Seventeen percent of the labor force, or 2,660 workers, were engaged in agriculture in 1960. By 2020, about 9 percent of the labor force, or 2,200 workers, will be sufficient to achieve the expected production.

The minerals industry, which is presently very active, has good promise for expansion. The petroleum and natural gas reserves will probably continue to be utilized at a rate at least equal to the present rate of production. There are deposits of brick clay and silica sand present which can be expected to come into use in the manufacture of brick, pottery, and glass. In 1960 almost 5 percent of the labor force in the area was employed in mining, compared to a statewide average of slightly less than 3 percent. Employment in mining is expected to increase from 724 workers in 1960 to about 900 workers in 2020. This will represent about 3.7 percent of the labor force in 2020.

Growth and diversification of the manufacturing industries will continue in the study area. Resource-oriented manufacturing is expected to grow, especially that associated with food processing; stone, clay, and glass products; petroleum and natural gas; and possibly chemicals. Also, as the population grows, the market-oriented industries such as fabricated metals, machinery, and transportation equipment can be expected to increase. In 1960, 10.5 percent of the labor force, or 1,648 workers, were employed in manufacturing. By 2020, over 18 percent, or 4,500, will be so employed.

The service industries, which include sales, insurance, finance, personal services, and transportation, employed about 63 percent of the labor force, or 9,903 workers, in 1960. Based on past trends modified by relative growth and income in the area, comparable employment in 2020 will be about 16,000 workers or 65 percent of the labor force.

A summary of the present and projected future employment in the study area is shown in Table V-5.

Table V-5

Study Area Employment--Present and Projected

Industry	1960 Labor Force		2020 Labor Force	
	Number	Percent	Number	Percent
Agriculture	2,660	17.0	2,200	8.9
Forestry and Forest Products	4	--	15	0.1
Mining	724	4.6	900	3.7
Manufacturing	1,648	10.5	4,500	18.3
Service Industries	9,903	63.5	16,000	65.0
Unemployed	671	--	--	--
Labor Force	15,610	--	24,600	--

Population Projections

The population of the study area has been decreasing at an annual rate of approximately 0.5 percent. This compares with a same period increase of about 0.875 percent per year in the Colorado River basin area of Texas (of which the study area is a part) and a national average increase of about 1.5 percent per year.

Based on its economic potential, it is reasonable to expect a reversal in the past population trend of the study area to a growth rate at least equal to that experienced in the Colorado River basin, Texas, as a whole. The projected population in the study area is 68,400 by 2020 and 105,700 by 2070.

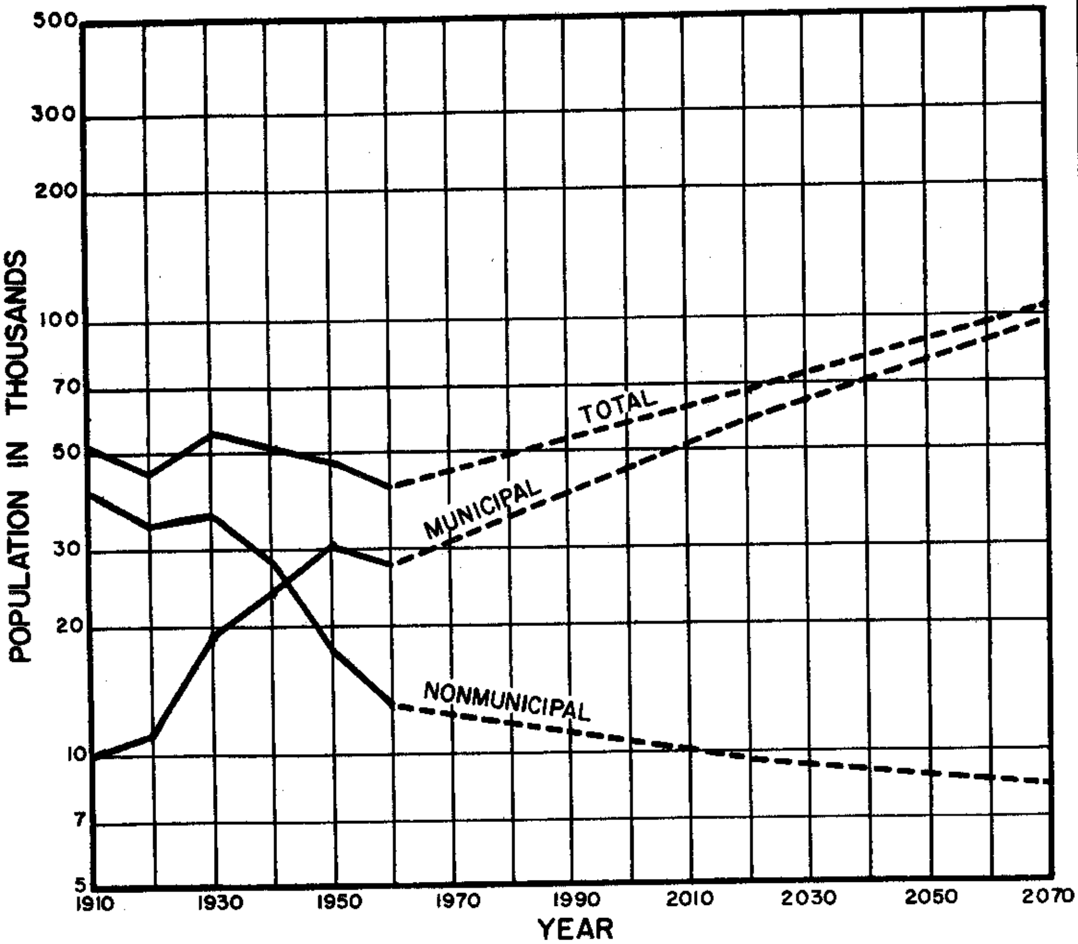
A summary of the population projections is presented in Table V-6* and Figure 3.*

Table V-6

Population Base and Projections

Year	Population Total	Population Municipal	Population Nonmunicipal
1960	40,540	27,939	12,601
2020	68,400	58,800	9,600
2070	105,700	97,500	8,200

* Municipal is defined here as including the population of all places of 1,000 or more persons, and nonmunicipal is the classification used for the remainder of the population.



WATER RESOURCE STUDY
PECAN BAYOU WATERSHED
COLORADO RIVER BASIN — TEXAS

POPULATION PROJECTIONS

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 3

VI. WATER REQUIREMENTS

General

Under the provisions of Title III, Public Law 85-500, the inclusion of storage to meet present and anticipated future demand or need for municipal and industrial water is authorized in any reservoir project surveyed, planned, or constructed by the Corps of Engineers, U. S. Army. A Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare states that the Public Health Service will submit to the Corps of Engineers a report of its views and recommendations on present and prospective needs for municipal and industrial water supply and the desirability of meeting those needs from the project or projects under consideration.

The probable future water requirements of the study area in the year 2020 were based on detailed economic and population projections, coupled with analyses of unit water requirements. The overall unit water use determined for the projected population in 2020 is assumed to remain constant for the period from 2020 to 2070. Therefore, determination of the 2070 water requirements involves population as the only variable.

Municipal Water Use

Municipal water is defined here as municipally supplied water for all purposes excluding that supplied to industrial establishments. Included in the resulting per capita quantities are losses in the distribution system, treatment plants, and terminal reservoirs.

Future municipal water needs are calculated by multiplying the estimated 2020 per capita use by the projected municipal population for the area. The unit municipal water use for the year 2020 is expected to be 200 gallons per capita day. On this basis, the municipal water requirement for the study area is estimated to be 11.8 million gallons per day (mgd) in the year 2020 and 19.5 mgd in 2070.

Industrial Water Use

The definition of industrial water use here refers to all water regardless of source used by the manufacturing industries (Standard Industrial Classification categories 13, 14, and 20 through 39). The total industrial requirements are determined by combining the projected number of employees with the projected unit employee water use for each of the several industrial categories. Industrial water use for the years 2020 and 2070 is estimated to be 1.2 mgd and 2.0 mgd, respectively. The base data were obtained from an industrial survey of the study area, and adjustments have been made for anticipated recirculation and reuse practices.

Power Generation Water Use

Consumptive use of water for thermal power generation is a part of the industrial requirement but is determined separately, since water for this purpose is a function of population rather than employment. Information on future water use was gathered from power companies in the area and combined with data developed by the Federal Power Commission and the Edison Electric Institute for the Senate Select Committee on National Water Resources. The general locations of future power generation installations were determined and the projected needs apportioned throughout the study area according to the service areas for the several generating plants. The water requirements for this purpose are estimated to be 3.3 mgd in the year 2020 and 5.1 mgd in 2070.

Nonmunicipal Water Use

A small segment of the total water need that is sometimes overlooked is that of nonmunicipal water supply for purposes other than irrigation. In an area where the terminal year requirement for all of the water available is anticipated, however, an estimate of this use becomes necessary so as not to understate the total water requirements.

For purposes of this study, the nonmunicipal water requirements are assumed to consist of domestic water for the nonmunicipal population and water for the maintenance of livestock. The 2020 and 2070 requirements for nonmunicipal water are estimated to be 1.7 mgd and 1.5 mgd, respectively, based on a nonmunicipal per capita use of 180 gallons per day.

Other Water Uses

The projected diversion of water for irrigation was furnished by the Corps of Engineers. The quantity for this purpose is 14.8 mgd for both the years 2020 and 2070.

General

Under the provisions of the Federal Water Pollution Control Act, Public Law 84-660 as amended, consideration must be given to the inclusion, in any reservoir being planned by a Federal agency, of storage for regulation of streamflow to control water quality. Storage and release of this water are not to be provided as a substitute for adequate treatment or control of wastes at their sources.

To attain full utilization of the water resources of Pecan Bayou for municipal, industrial, agricultural, and recreation purposes will require abatement of present and future pollution. Treatment alone, at the present stage of its development, is not sufficient to achieve desirable stream conditions in the Pecan Bayou watershed.

Provision of storage for the control of water quality will have many benefits. Maintenance of low concentrations of total dissolved solids will improve the competitive position of the area in attracting industry. Preservation of an adequate level of dissolved oxygen will enhance the recreational attractiveness of the stream by providing a balanced ecology. Low flows will be less severe and pest breeding, stagnant pools will be eliminated.

When treatment methods improve, the need for the addition of water to maintain quality will diminish and may someday entirely disappear. Until such time, however, it is essential that recognition be given to the need for flows which must prevail in receiving streams if their water quality is to be maintained at acceptable levels. Therefore, estimates of the water required to maintain quality in the Pecan Bayou watershed have been made since these requirements are an inseparable part of the water supply plan of the study area.

Quality Parameters

The determination of water quality takes into consideration the wastes which will result from the economic development of an area and the effects of these wastes on stream regimen. At any point in a stream, the water quality will be the result of mixing various qualities and quantities of water which make up the total flow modified by forces such as reaeration and evaporation which tend to change its character.

A comprehensive study of water quality requires the analysis of a large number of individual contaminants which occur in most streams. Estimates of pollution are based on water use as a logical outgrowth of present conditions and technology, and quality analysis is based on broad parameters which are currently available for evaluation of future stream conditions. Total dissolved solids projections are 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).

Stream Loading

The expected amounts of return flow and characteristics of the wastes were estimated and the following assumptions regarding quality control requirements were made.

1. Sufficient treatment will be provided to remove 90 percent of the biochemical oxygen demand and 15 percent of the total dissolved solids.

2. Evaporation and seepage from streams are reflected in streamflow records and require no adjustments. Adjustments for evaporation in reservoirs were necessary, however.

3. Uniform mixing of wastes and receiving waters will occur.

4. Water for quality control is required when the dissolved oxygen content of the mixed water in the stream is below 4.0 milligrams per liter (mg/l.) or the total dissolved solids exceed 500 mg/l.

Allowances for Streamflow

In determining the amount of water from storage required to preserve the quality of the stream, it is necessary to make allowances for natural flows that can be expected to occur in the stream. A discharge frequency analysis of the stream based on monthly flows was made from 43 years of data furnished by the Corps of Engineers. Calculations were then performed to determine the amount of regulation water from storage required to maintain quality in the stream for hydrologic conditions that could be expected to reoccur in the watercourse every 5, 10, 20, and 50 years, respectively.

Need for Water for Quality Control Purposes

An analysis of the watershed was made on a Bendix G-15 computer. The computations based on the above assumptions indicated the following:

1. The waters of the basin will not be degraded below acceptable limits by the stable pollutants (total dissolved solids).

2. Organic pollution in the reach of Pecan Bayou below the city of Brownwood exceeds the assimilative capacity of the stream and will require release of water from storage to maintain an acceptable oxygen balance in the stream.

A summary of the water required for quality control purposes in Pecan Bayou below the city of Brownwood is shown in Table VII-1. The maximum monthly requirements are independent of recurrence because the base flow during the maximum month is zero at the five-year recurrence interval.

Table VII-1

Water Requirements for Quality Control Purposes (mgd)

Year and Condition	Recurrence Interval in Years			
	5 Year	10 Year	20 Year	50 Year
1960				
Maximum Month	3.5	3.5	3.5	3.5
Minimum Month	0	0	0	0
Average Annual	1.0	1.1	1.3	1.4
2020				
Maximum Month	4.8	4.8	4.8	4.8
Minimum Month	0	0	0	0
Average Annual	1.3	1.5	1.7	1.9
2070				
Maximum Month	6.5	6.5	6.5	6.5
Minimum Month	0	0	0	0
Average Annual	1.8	2.1	2.3	2.5

The 10-year recurrence interval was chosen for the purpose of evaluating benefits for quality control after consideration of the following items.

1. Length of affected stream--approximately 15 miles. Pecan Bayou drains into the proposed Fox Crossing Reservoir on the Colorado River about 15 miles below the last point of pollution. The additional dilution available in this reservoir is sufficient to assimilate the wastes even for the 50-year recurrence interval without adverse effects on the stored water.

2. Prospective downstream uses--for normal recreation and agricultural pursuits.

3. Historical flows--records indicate that Pecan Bayou is an intermittent stream.

4. Quantity of quality control water available--limited. The amount of water available for quality control within the watershed is necessarily limited if the water resources of the basin are to be developed to provide for the several anticipated uses. The use of the 10-year frequency will keep importation into the watershed at a minimum.

Operations Plan to Maintain Water Quality

Operation of the watershed according to the plan outlined in the following section on supplying future requirements will restrict the need for quality control water to the reach of Pecan Bayou below Brownwood Reservoir. On this assumption, it is reasonable to distribute the quality control requirement between Coleman and Pecan Bayou Reservoirs. The plan calls for releases of stored water from these upstream reservoirs to Brownwood Reservoir, which will act as a terminal reservoir for the release of the quality control requirements.

It is recommended that storage sufficient to provide for average annual releases of 1,232 acre-feet and 1,120 acre-feet be provided in Coleman and Pecan Bayou Reservoirs, respectively. Reregulation of these amounts to meet the varying monthly needs for quality control would then be accomplished in Brownwood Reservoir.

VIII. PLANS FOR SUPPLYING FUTURE WATER REQUIREMENTS

General

The estimated 2020 municipal and industrial water need in the study area is 16.3 mgd. Of this total, it is expected that 0.3 mgd will be supplied from ground water and the remaining 16 mgd from surface sources. In addition, the projected nonmunicipal requirements of 1.7 mgd are expected to be satisfied wholly from ground water; and, of the projected irrigation needs of 14.8 mgd, expectations are that 12.3 mgd will be supplied from the watershed reservoirs and 2.5 mgd from municipal and industrial return flows. A summary of supply sources for the year 2070 is shown in Table VIII-1.

Table VIII-1

Summary of Study Area Supply Sources--2070

Source	Amount (mgd)
Ground water for municipal and industrial use	0.3
Ground water for nonmunicipal use	1.5
Surface water for municipal and industrial use	26.3
From: Pecan Bayou watershed	24.4
Imports from Colorado River basin	1.9
Stacy Reservoir	1.1
Fox Crossing Reservoir	0.8
Surface water for irrigation	14.8
From: Pecan Bayou watershed	10.6
Reuse of municipal and industrial return flows	4.2
Surface water for quality control	2.1
From: Pecan Bayou watershed	2.1

The plans for supplying water to the study area by counties for the years 2020 and 2070 are shown in Tables VIII-2 and VIII-3. A water balance for the watershed for the years 2020 and 2070 is shown in Table VIII-4.

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Table VIII-2

2020 Water Supply Plan
(All quantities in mgd)

Area and Use	Total Need	Estimated Ground Water Use	Surface Supply Need	Surface Supply: Source	Surface Supply: Amount	Estimated Return Flow	Disposition of Return Flow: Disposal Stream	Disposition of Return Flow: Gaining Reservoir	Disposition of Return Flow: Amount Returned
Callahan Co.									
M & I	1.0	0.3	0.7	Pecan Bayou Res.	0.7	0.5	Pecan Bayou	Brownwood	0.5
Nonmun.	0.2	0.2	0						
Irrig.	0	0	0						
TOTAL	1.2	0.5	0.7						
Coleman Co.									
M & I	5.2	0	5.2	Hords Cr. Res.	0.9	2.0	Hords Cr.	Brownwood	2.0
Nonmun.	0.7	0.7	0	Coleman Res.	4.3				
Irrig.	0	0	0						
TOTAL	5.9	0.7	5.2						
Brown Co.									
M & I	10.1	0	10.1	Brownwood Res.	14.9	8.5*	Pecan Bayou	Fox Crossing	8.5*
Nonmun.	0.8	0.8	0	Pecan Bayou Res.	6.7				
Irrig.	14.8	0	14.8	Coleman Res.	2.3				
TOTAL	25.7	0.8	24.9	Return Flows	1.0				

* Composed of 4.1 mgd of municipal and industrial return flows and 4.4 mgd of irrigation return flows.

Table VIII-3

2070 Water Supply Plan
(All quantities in mgd)

Area and Use	Total Need	Estimated Ground Water Use	Surface Supply Need	Surface Supply: Source	Surface Supply: Amount	Estimated Return Flow	Disposition of Return Flow: Disposal Stream	Disposition of Return Flow: Gaining Reservoir	Disposition of Return Flow: Amount Returned
Callahan Co.									
M & I	1.7	0.3	1.4	Pecan Bayou Res.	1.4	0.9	Pecan Bayou	Brownwood	0.9
Nonmun.	0.2	0.2	0						
Irrig.	0	0	0						
TOTAL	1.9	0.5	1.4						
Coleman Co.									
M & I	8.5	0	8.5	Hords Cr. Res.	0.9	3.3	Hords Cr.	Brownwood	3.3
Nonmun.	0.6	0.6	0	Coleman Res.	6.5				
Irrig.	0	0	0	Stacy Res.*	1.1				
TOTAL	9.1	0.6	8.5						
Brown Co.									
M & I	16.4	0	16.4	Brownwood Res.	14.9	11.1**	Pecan Bayou	Fox Crossing	11.1**
Nonmun.	0.7	0.7	0	Pecan Bayou Res.	6.0				
Irrig.	14.8	0	14.8	Coleman Res.	5.3				
TOTAL	31.9	0.7	31.2	Fox Crossing Res.*	0.8				
				Return Flows	4.2				

* Stacy and Fox Crossing Reservoirs are located on the Colorado River outside the Pecan Bayou watershed.

** Composed of 6.7 mgd of municipal and industrial return flows and 4.4 mgd of irrigation return flows.

Table VIII-4

2020 and 2070 Water Balance
(All quantities in mgd)

Resources					Requirements				
Reservoir Yields	Imports	Ground Water	Reused Water	Total	Munic. and Indus.	Non-municipal	Water Quality Control	Irrigation	Total
For the Year 2020									
37.1	0	2.0	2.5	41.6	16.3	1.7	1.5	14.8	34.3
Surplus: 7.3 mgd									
For the Year 2070									
37.1	1.9*	2.0	4.2	45.2	26.6	1.5	2.1	14.8	45.0
Surplus: 0.2 mgd									

* From Stacy and Fox Crossing Reservoirs on the Colorado River.

IX. BENEFITS OF STORAGE

Evaluation Method

The report of the Sub-Committee on Evaluation Standards of the Federal Inter-Agency Committee on Water Resources makes the following comment on evaluation of municipal and industrial water supply:

> "From an over-all public viewpoint, a municipal and industrial water supply development will be economically justified if it provides water to meet expected needs at a cost not greater than the cost of the alternative source that would likely be utilized in the absence of the project."

The alternative cost method has been used for evaluation of all storage proposed in this report.

Costs

For purposes of comparison of alternatives, the Corps of Engineers converted capital costs of the alternatives to equivalent annual costs, and added estimated annual operation, maintenance, and replacement costs. The "present" (1970) value of the costs so determined for the date of first use of the project is shown in this report.

Alternative Plans

Benefits are calculated for Coleman and Pecan Bayou Reservoirs. The alternatives used for Coleman and Pecan Bayou Reservoirs are single-purpose reservoirs at the project sites since the watershed contains no appreciable ground water and the project sites are the most economical available.

Some of the benefits resulting from storage of water for quality control at these sites are: (1) improvements in the areal industrial "climate" and recreational facilities; and (2) elimination of nuisances caused by low flows.

A yield-requirement analysis determined a need for water supply and/or water quality storage in both Coleman and Pecan Bayou Reservoirs by the year 1980. The benefits attributable to these projects are shown in Table IX-1. The benefits are prorated by purpose according to the yield reserved for that purpose.

Table IX-1

Benefits of Storage in Pecan Bayou and Coleman Reservoirs

Project	Creditable Yield (cfs)	Annual Benefits ($)
Pecan Bayou		
Total	8.0	253,700
Water Supply	6.5	206,100
Quality Control	1.5	47,600
Coleman		
Total	13.0	314,200
Water Supply	11.3	273,100
Quality Control	1.7	41,100

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APPENDIX VII

VIEWS AND COMMENTS OF OTHER AGENCIES

REVIEW OF REPORTS ON PECAN BAYOU WATERSHED
COLORADO RIVER BASIN, TEXAS

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31 March 1961

Mr. Harry P. Burleigh
Area Engineer
Bureau of Reclamation
U. S. Department of the Interior
P. O. Box 817
Austin, Texas

Dear Mr. Burleigh:

In connection with an investigation of Pecan Bayou, Texas pursuant to a revision of our report titled, "Review of Reports on Pecan Bayou, Texas, Flood Protection, Brownwood, Texas," dated 3 September 1948, this office is reviewing various plans for flood control, water conservation, and allied purposes on the Pecan Bayou watershed.

The above referenced report included consideration of investigated Bureau of Reclamation irrigation projects for lands above and below Lake Brownwood.

In the course of our restudy we are considering potential reservoir sites in the area above Lake Brownwood with a view to determining the feasibility of the development of upstream projects as alternates for the authorized project for enlargement of existing Lake Brownwood. As discussed with you by Mr. Jentz of this office in telephone conversation 29 March, this office is interested in obtaining current information which would indicate the desirability and justification for irrigation as a project purpose in any of the alternate projects under consideration. We would appreciate receiving at an early date your views in regard to the irrigation potentialities, future requirements, and benefits which may be realized from the availability of additional irrigation water in Pecan Bayou watershed.

Sincerely yours,

/s/ C. F. SWENSON

C. F. SWENSON
Chief, Engineering Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Region 3
AUSTIN DEVELOPMENT OFFICE
P. O. Box 517
Austin 64, Texas

April 5, 1961

Mr. C. F. Swenson
Chief
Engineering Division
Corps of Engineers
Fort Worth District Office
100 West Vickery Blvd.
Fort Worth 4, Texas

Dear Mr. Swenson:

Following is in reply to your letter of March 31 regarding irrigation potential in Pecan Bayou.

In 1958 the Brownwood Irrigation District irrigated 4,000 acres and had an additional 1,000 acres under ditch. In examinations made by us of the area under Lake Brownwood some years ago, we concluded that an additional 11,000 acres were acceptable (topographically, production wise, etc.) for project type of irrigation.

In other studies in the general Pecan Bayou area we have noted in the past that there were approximately 5,000 acres of land acceptable for irrigation below the Jim Ned site. However, it should be pointed out that these lands are above the Camp Colorado site. We know of no consequent acreage that is irrigable above the headwaters of Lake Brownwood and below either the Burkett site or Camp Colorado site.

In our earlier examinations of the additional acreage under Lake Brownwood (the 11,000 acres) we found that the irrigation could be developed under Reclamation law and on the basis of economic conditions then current. Crops that can be irrigated in the area are not of a particularly high value. Acceptability of new lands for irrigation under present economic circumstances would require a re-examination of new storage cost, present-day distribution costs and other matters. These data are not currently available to us.

I regret that we cannot be of further assistance in this matter.

Very truly yours,

/s/ Harry P. Burleigh

Harry P. Burleigh
Area Engineer

BROWN COUNTY WATER IMPROVEMENT DISTRICT, NO. 1
113 East Baker * Phone 3469
P. O. Box 118
BROWNWOOD, TEXAS

May 21, 1962

Col. R. P. West, C.E.
District Engineer
U. S. Army, Corps of Engineers
100 West Vickery Boulevard
Fort Worth 4, Texas

Dear Col. West:

We hand to you herewith six copies of a statement from this District for the hearing, May 22, 1962, at Ballinger, Texas, on the portion of the Colorado River Basin above Austin.

It is probably unnecessary for this agency to make any statement at this time since it has under consideration, along with other agencies on the immediate watershed, a tentative plan proposed by the Corps of Engineers. However, an independent expression by this agency at this time is probably not out of place.

An expression of intent, in cooperation with other agencies involved, will be made at a later date, after all agencies have studied the tentative plan.

Very truly yours,

/s/ N. E. Trostle

N. E. Trostle, Manager
BROWN COUNTY WATER IMPROVEMENT
DISTRICT, NO. ONE

NET:11

Evidence Prepared

for

U. S. ARMY, CORPS OF ENGINEERS

Hearing

at

Ballinger, Texas

May 22, 1962

Submitted

by

BROWN COUNTY WATER IMPROVEMENT DISTRICT NUMBER ONE

Brownwood, Texas

Col. R. P. West, CE, District Engineer
U. S. Army, Corps of Engineers
100 West Vickery Boulevard
Fort Worth 4, Texas

This is a report to the Ballinger, Texas, hearing May 22, 1962, on the upper part of the Colorado River drainage basin.

The Brown County Water Improvement District No. One consists of the City of Brownwood and immediate surrounding area, a little over 14,000 acres total area and is represented by:

J. P. Keith, Board President	Wm. H. Pruitt, Director
Levie Old, Vice President	Stuart Coleman, Director
Charlie Trigg, Secretary	N. E. Trostle, Engineer-Mgr.

T. C. Wilkinson, Attorney for the District

The District is the owner and operator of Lake Brownwood. It also serves the City of Brownwood, City of Bangs, City of Santa Anna, and City of Early with water for municipal supplies. It holds a permit from the Texas Water Commission, No. 1036, dated Dec. 3, 1929, application No. 1085, dated Sept. 1, 1927, for the impounding of 125,000 acre-feet of water and withdrawing each year 16,800 acre-feet for municipal, industrial and domestic use and 50,590 acre-feet for irrigation.

The officials of the District are in general agreement with the general objectives as have been indicated by past correspondence and discussion dealing with conservation storage and flood control on the upper Colorado Drainage Basin. They would welcome as many impounding reservoirs, on the main stem of the Colorado as well as on the Pecan Bayou water shed, as can be economically justified, both for flood control and conservation storage.

Considering the latest proposal of the Corps of Engineers for development on the Pecan Bayou watershed above the juncture of that stream with the main stem of the Colorado, they are in general agreement. The three reservoir system, Lake Brownwood and the two proposed reservoirs above, give certain advantages. The flood control features particularly present certain advantages as well as some disadvantages. The Conservation storage is increased which is an advantage, though the optimum for that particular drainage basin may not be reached since no figures on the optimum conservation storage have been presented.

The flood control features, as understood by these officials, would be full control at each site, one on the Jim Ned branch and the other on the Pecan Bayou branch, above Lake Brownwood. On Lake Brownwood itself, only flood gates through the dam would be controlled and the present spillway would remain uncontrolled and unimproved. This would lead them to assume that the present spillway would be unused by any water flow. The present condition of the spillway is such that any anticipated use of it in the future would require that it be improved.

It then follows, if the present spillway remains unused the freeboard on the present dam will be unused and a new dam will be unnecessary as far as the height of the dam is concerned. There would then be a possibility, if not a probability, that with two other structures on the watershed above Lake Brownwood and flood control outlet below the present spillway level, a new dam at Lake Brownwood would not be necessary.

The conservation storage as understood by these officials, would be provided in upstream reservoirs but not change the conservation storage space in Lake Brownwood, except that which would accrue through the protection from siltation by the reservoirs and Soil Conservation Service programs on the watershed above. It would, however, change the yield from Lake Brownwood. The yield as estimated by different agencies is shown in Table 1.

Taking into consideration, (1) this District's previous request for optimum storage in Lake Brownwood, (2) the Texas Water Commission permit quantities, and (3) yield quantities from Lake Brownwood as estimated, this District would request that conservation storage be made available to this District. It would request that this District be provided in the upper reservoirs sufficient storage, without cost to the District, to provide the same yield as the present reservoir and be given the opportunity to purchase additional conservation storage up to the optimum of the present reservoir.

TABLE I

LAKE BROWNWOOD RESERVOIR

AUTHOR AND DATE	CAPACITY in Ac. Ft.			YIELD	
	Total	Sediment	Conservation	cfs	mgd
U. S. Army Corps of Engrs. Sept. 1948			90,400 Stages 1406 to 1423	64	41.3
Forrest & Cotton August 1955			96,300 Considering SCS Programs	59	38.0
Freese & Nichols Oct. 1958	137,000	41,000	96,300	57.4	37.0
" "	(Same except loss of 292 sq. mi., 18.1%, of drainage area to Coleman reservoir.)			47.0	30.3
Marvin Nichols Nov. 1958	125,000	(at stage 1423.3)		54.7	35.3
U. S. Army Corps of Engrs. April 1962	124,600	36,300	88,300	59.1	38.1
" "	124,600 (Conservation loss of about 610 sq. mi., about 41% of drainage area.)	21,200	103,400	44.0	28.4

BROWN COUNTY WATER IMPROVEMENT DISTRICT, NO. 1
113 East Baker * Phone 3469
P. O. Box 118
BROWNWOOD, TEXAS

June 13, 1962

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

Dear Colonel West:

At a meeting held on April 17, 1962, in your office at Fort Worth and at a subsequent meeting held on June 7, 1962, in Brownwood, Texas, you and members of your staff discussed with representatives of the cities of Brownwood and Coleman, the Brown County Water Improvement District No. 1, and the Central Colorado River Authority, the results of your studies and investigations of the water problems of the Pecan Bayou Watershed, Colorado River Basin, Texas.

The investigation and study, we understand, was made pursuant to a resolution adopted October 8, 1945, by the Committee on Flood Control of the House of Representatives, United States, which authorized a review of reports on Pecan Bayou, Texas, published as House Document No. 370, 76th Congress, First Session, with a view to determining whether any modifications of the recommendations contained therein with respect to flood protection for the city of Brownwood, Texas, are advisable at this time.

At the April 17, 1962, and the June 7, 1962, meetings, the proposed units of a tentative plan of improvement and the required items of local cooperation were described and discussed. The plan consisted of reconstruction of Lake Brownwood, which is principally a water supply project but which has a flood control value by reducing flood peaks; channel improvements on Pecan Bayou, Adams Branch, and Willis Creek in the vicinity of Brownwood, Texas; and Pecan Bayou Reservoir on Pecan Bayou and Coleman Reservoir on Jim Ned Creek for purposes of flood control, water supply, fish and wildlife, and general recreation.

The Corps of Engineers is hereby advised that the Board of Directors of Brown County Water Improvement District No. 1, The City of Brownwood and Brown County Commissioners Court concur with the general plan of flood control as outlined above and have authorized their designated officials to sign a letter of intent indicating their desire to cooperate in these programs.

In connection with the proposed reconstruction of Lake Brownwood and the proposed channel improvements; and Pecan Bayou Reservoir on Pecan Bayou and Coleman Reservoir on Jim Ned Creek, the interested parties in Brown County have resolved to initiate action in the interest of designating or establishing under the laws of the State of Texas a responsible agency to qualify as the responsible agency to which the Federal Government can look for necessary items of local cooperation.

Sincerely yours,

BROWN COUNTY WATER IMPROVEMENT DISTRICT
NO. ONE

By /s/ J. P. Keith
President

CITY OF BROWNWOOD

By /s/ W. L. Lamkin
Mayor

BROWN COUNTY COMMISSIONERS COURT

By /s/ F. A. Loudermilk
County Judge

Coleman, Texas
June 13, 1962

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

Dear Colonel West:

At a meeting held on April 17, 1962 in your office at Fort Worth, you and members of your staff discussed with representatives of the cities of Coleman and Brownwood, the Brown County Water Improvement District No. One, and the Central Colorado River Authority, the results of your studies and investigations of the water problems of the Pecan Bayou Watershed, Colorado River Basin, Texas.

The investigation and study, we understand, was made pursuant to a resolution adopted October 8, 1945, by the Committee on Flood Control of the House of Representatives, United States, which authorized a review of reports on Pecan Bayou, Texas, published as House Document No. 370, 76th Congress, First Session, with a view to determining whether any modifications of the recommendations contained therein with respect to flood protection for the city of Brownwood, Texas, are advisable at this time.

At the April 17, 1962 meeting, the proposed units of a tentative plan of improvement and the required items of local cooperation were described and discussed. The plan consisted of reconstruction of Lake Brownwood, which is principally a water supply project but which has a flood control value by reducing flood peaks; channel improvements on Pecan Bayou, Adams Branch, and Willis Creek in the vicinity of Brownwood, Texas; and Pecan Bayou Reservoir on Pecan Bayou and Coleman Reservoir on Jim Ned Creek for purposes of flood control, water supply, fish and wildlife, and general recreation.

The Corps of Engineers is hereby advised that the City of Coleman, the County of Coleman and the Central Colorado River Authority, in cooperation with Brown County Water Improvement District No. One, the City of Brownwood, and the County of Brown, concur with the general plan of flood control as outlined above and have authorized their designated officials to sign a letter of intent indicating their desire to cooperate in those programs.

In connection with the proposed reconstruction of Lake Brownwood and the proposed channel improvements; and Pecan Bayou Reservoir on Pecan Bayou and Coleman Reservoir on Jim Ned Creek, the interested parties in Coleman County have resolved to initiate action in the interest of designating or establishing under the laws of the State of Texas, a responsible agency to qualify as the responsible agency to which the Federal Government can look for necessary items of local cooperation.

Sincerely yours,

CITY OF COLEMAN

By /s/ Foster Miller
Foster Miller, Mayor

COUNTY OF COLEMAN COMMISSIONERS COURT

By /s/ Frank Lewis
Frank Lewis, County Judge

CENTRAL COLORADO RIVER AUTHORITY

By /s/ R. G. Hollingsworth
R. G. Hollingsworth, Chairman

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
REGION IV

Office of
Regional Director

Room 206 Federal Building
Bartlesville, Oklahoma

June 13, 1963

Mr. Kermit Speeg
U. S. Army Corps of Engineers
Fort Worth District
100 West Vickery
Fort Worth, Texas

Dear Mr. Speeg:

Following our conversation regarding the Corps of Engineers plans for developing seven river basins in Texas, I sent Warren Mankin, Petroleum and Natural Gas Engineer on my staff, to collect more detailed information and continue the discussion.

We now have completed an office review of the proposed Colorado River Basin projects in Texas. This study indicates that petroleum, natural gas, and other minerals will be affected by the following Corps of Engineers proposed projects: Mitchell County, Robert Lee, Stacy, Pecan Bayou, and Coleman Reservoirs and Lake Brownwood Enlargement; also, by the Navigation Channel on the Colorado River. Because of the economic importance of the petroleum industry in the Colorado River basin, it is important the Corps of Engineers and Bureau of Mines evaluate this industry before completing the Corps comprehensive report on the Colorado River. I recommend, as a very minimum, the following steps: A field reconnaissance by a qualified petroleum and natural gas engineer followed by a preliminary report on each of the proposed projects mentioned above. The Bureau of Mines have qualified petroleum and natural gas engineers and will be glad to undertake the study at the Corps of Engineers request. The estimated cost would be between $5,000 and $6,000. This estimate does not include the Bureau of Reclamations Columbus Bend project. Letters covering the other six river basins are being prepared.

A brief resume of the Colorado River Basin proposed projects, using oil-field maps and other data on file in our office, is as follows:

cc:
L. W. Dupuy, WO
W. W. Mankin
D. Underwood

1. Mitchell County Reservoir (upstream from Robert Lee Reservoir)

a. Located on Colorado River and Beals Creek in Mitchell County.

b. Top of conservation pool at elevation 2,020 feet.

c. Hurlburt Oilfield with three oil wells will be affected on Beals Creek Arm.

d. Water will extend from dam at NW edge of Jamison Oilfield (not affected), upstream on Colorado River to Lake Colorado City at Colorado City.

e. It may be possible to protect this one oilfield by an elevated barrier and dike - oilfield may be depleted before completion of reservoir. Also, two pipelines will need protection.

2. Robert Lee Reservoir (Lower) Site

a. Located on Colorado River in Coke County.

b. Top of conservation pool at elevation 1,900 feet.

c. The dam site has been moved downstream about 4 miles, based on Bureau of Mines recommendation to U. S. Study Commission Report--Texas - old reservoir was at the 1,920 foot contour and passed through the middle of Jamison oilfield; dam now just west of Robert Lee townsite.

d. Oil and gasfields.

(1) Upper end of reservoir will affect 13 wells in eastern end of Jamison oilfield as shown on December 1957 aerial photographs. Wells will need elevation and protection.

(2) Four oil wells in southern end of Lygay oilfield (three other wells outside conservation pool) will need considerable elevation and protection.

(3) A lone oil well in South Lygay oilfield will need elevation and protection.

(4) All three oil wells in the South Bloodworth oilfield will need elevation and protection.

e. Wells in the above four oilfields will need elevation and protection. Less mineral resources will be affected by moving the dam site downstream about 4 miles. This reservoir was scheduled for construction by State or local interests, but the Corps is studying it for justification.

3. Stacy Reservoir

a. This reservoir site is on the Concho River and Colorado Rivers in Coleman, Concho, and Runnels Counties.

b. Top of conservation pool at elevation 1,600-ft.

c. One well will be submerged in one small oilfield (Giesecke) in Runnels County, but is not producing at present although bought in 1949. Probably no adverse effects will result on this or other oil or gasfields. Sand and gravel deposits were reported in U. S. Study Commission--Texas report, Part III, page 155.

4. Burkett Reservoir - Coleman and Callahan Counties

a. After the Corps of Engineers investigated this reservoir Pecan Bayou, they recommended the alternate Pecan Bayou Reservoir upstream.

5. Pecan Bayou Reservoir - Coleman and Callahan Counties

a. This reservoir is on Pecan Bayou.

b. The dam site is just upstream from Mary Opal gasfield in Coleman County, but does not affect adversely any oil wells.

c. The upper end of reservoir adjoins the Odom oilfield in Callahan County which has two or more wells. No wells are affected now, but later drilling may extend the field into reservoir.

d. Corps of Engineers is now submitting a report prior to our field level comments (with Pecan Bayou Watershed).

6. Camp Colorado Reservoir - Coleman County

a. Corps of Engineers investigated this reservoir and did not recommend its construction on Jim Ned Creek. Instead, they recommended a reservoir upstream first named Jim Ned Reservoir and now named Coleman Reservoir. The U. S. Study Commission--Texas report, Part III, page 154-155, reported oil and gas resources, lignite, and limestone in the area of the former Camp Colorado Reservoir.

7. Coleman Reservoir

a. This reservoir, formerly Jim Ned Reservoir, is to replace the Camp Colorado Reservoir (downstream) and is located on Jim Ned Creek in Coleman, Callahan, and Taylor Counties.

b. This reservoir would adversely affect three Soil Conservation Service existing dams.

c. The only oil well in Creswell (Strawn) Field of Coleman County will need elevating for protection.

d. Will affect two of five oil wells in the Featherstone Field, Coleman County. These wells will need elevation and protection.

e. Will affect all nine oil wells of the Dunman (Gardner Sand) Field, Coleman County. These wells will need elevation and protection.

f. The Corps is now submitting a report on this reservoir and others in the Pecan Bayou Watershed (such as Pecan Bayou Reservoir). The Corps did not request a Bureau of Mines field review but had included $40 per acre in the estimates for mineral subordination.

8. Lake Brownwood Reservoir Enlargement

a. This reservoir, on Colorado River and Jim Ned Creek in Brown and Coleman Counties, is controlled by the City of Brownwood, but the enlargement has been authorized for Corps work.

b. The Enlargement will affect Brownwood oilfield, Clear Creek Oilfield, Childress Oilfield, and other small oilfields - all in Brown County. It will also affect the Bangs Gasfield, Young Gasfield, and other small gasfields - all in Brown County.

c. The Corps is now submitting a report on this reservoir and others in the Pecan Bayou Watershed. They forgot to request Bureau of Mines field review, but have included $40 per acre in the estimates for mineral subordination.

9. San Saba Reservoir

a. This reservoir, on San Saba River and Brady Creek in San Saba and McCulloch Counties, is a Bureau of Reclamation Project, but Corps of Engineers is making a study for justification of flood control.

b. No oil or gas resources are known in the reservoir area.

10. Menard Reservoir

a. This reservoir is on San Saba River in Menard and Schleicher Counties.

b. No oil or gas resources are known here.

11. Llano Reservoir

a. This reservoir is on Llano River in Llano County.

b. No oil or gas resources are known in the reservoir area.

12. Pedernales Reservoir

a. This reservoir is on Pedernales River in Blanco and Gillespie Counties.

b. No oil or gas resources are known in the reservoir area.

13. Fox Crossing Reservoir

a. This reservoir is on Colorado River and Pecan Bayou in Mills and San Saba Counties.

b. No oil or gas resources are known in the reservoir area.

14. LaGrange Reservoir

a. This reservoir is on Colorado River in Fayette and Bastrop Counties.

b. No oil or gas resources are known in the reservoir area.

15. Columbus Bend Reservoir

a. This reservoir is on Colorado River in Colorado and Fayette Counties.

b. U. S. Study Commission--Texas report, Part III, page 155, showed at least two gasfields affected by the reservoir, but the dam site has now been moved upstream and clears both gasfields.

c. This is a Bureau of Reclamation project but has not yet been authorized.

d. No oil or gas resources are involved now, but the U. S. Study Commission--Texas report shows bentonite, fuller's earth, grinding pebbles, sand and gravel, and lignite in the area.

16. Navigation on Colorado River - Austin to mouth

a. This project is on Colorado River in Travis, Bastrop, Fayette, Colorado, Wharton, and Matagorda Counties.

b. It will cross many oil and gasfields such as in Colorado County (North Columbus and Cecil Noble Gasfields, and Altair Oilfield); Wharton County (North Prasifka Oilfield); and Matagorda County (Lucky Oilfield); and possibly others that will need protection.

Sincerely yours,

/s/ Robert S. Sanford

Robert S. Sanford
Acting Regional Director
Region IV

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

Southwest Region
Santa Fe, New Mexico

IN REPLY REFER TO:

L7423

SEP 4 1963

Dallas L. Knoll, Jr.
Lt. Col., CE, Executive Officer
Corps of Engineers
P. O. Box 1600
Fort Worth, Texas

Dear Col. Knoll:

The opportunity to review the draft of your "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas", enclosed in your letter of 27 August is appreciated. Our review discloses that we have no comments.

The draft copy is being returned, as requested.

/s/ Daniel B. Beard

Daniel B. Beard
Regional Director

Enclosure (Serial No. 07)

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

September 6, 1963

Your reference:
SWFGB

District Engineer
Fort Worth District
Corps of Engineers
P. O. Box 1600
Fort Worth, Texas 76101

Dear Sir:

Thank you for your letter of August 27, 1963, enclosing a draft copy (serial number 20) in final form of your "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas" dated July 1963.

The proposed improvements will not affect the interests of this Administration. The draft copy is returned as requested.

Sincerely yours,

/s/ Carl E. Roberts

Carl E. Roberts
Chief, Division of
Planning and Resources

Enclosure

REGION SIX

ARKANSAS
LOUISIANA
OKLAHOMA,
TEXAS

06-41

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
404 VFW Building
Austin, Texas 78701

September 20, 1963

Lt. Colonel Dallas L. Knoll, Jr.
Executive Officer
Corps of Engineers
100 West Vickery Boulevard
Ft Worth, Texas

Dear Colonel Knoll:

The draft copy (serial number 10) of your "Review of Reports on Pecan Bayou Watersheds, Colorado River Basin, Texas," forwarded with your letter dated August 27, 1963 has been reviewed and is returned herewith.

With respect to the Brownwood channel improvements it is noted that prior to initiation of construction, responsible local interests are to give assurance satisfactory to the Secretary of the Army that they will "provide without cost to the United States all relocations of buildings, utilities, bridges and roads (except railroads) sewers, pipelines, channel dams, and offer alterations of existing improvements which may be required for the construction of the project."

The construction of flood protective works at Brownwood requires the construction or modification of several bridges on highways that are on the Federal-aid Highway System. The basic regulations of the Bureau of Public Roads will not permit Federal-aid highway funds to be used to relieve local interest of obligations they agree to assume as a condition to approval of any project.

We appreciate the opportunity to review the draft report on this project.

Sincerely yours,

L. S. Coy
Division Engineers

By
/s/ J. F. Cary

J. F. Cary
Asst. Division Engineer

Enclosure

U. S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
P. O. BOX 12037
FORT WORTH 16, TEXAS
September 24, 1963

Lt. Colonel Dallas L. Knoll, Jr.
Executive Officer
Corps of Engineers
100 West Vickery Boulevard
Fort Worth, Texas

Dear Colonel Knoll:

Enclosed is Division Engineer Coy's September 20 reply to your August 27, 1963 letter furnishing a draft copy of your "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas," dated July 1963.

We have also reviewed this report and have no comments to offer in addition to those furnished by Mr. Coy.

We appreciate the opportunity you have afforded the Division and Regional offices to review and comment on the draft copy of your review of reports. The draft copies numbers 10 and 11, are returned as requested. We would appreciate being furnished a copy of the final report.

Sincerely yours,

/s/ Bill L. Andrews

Bill L. Andrews
Assistant Regional Engineer

Attachments

FEDERAL POWER COMMISSION
REGIONAL OFFICE
100 North University Drive
Fort Worth, Texas 76107
September 20, 1963

The District Engineer
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth, Texas 76101

Dear Sir:

Receipt is acknowledged of your letter dated August 27 forwarding for our review and comments a draft copy of your "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas".

Our primary interest in water resources development is with regard to the potential for including an economically feasible hydroelectric power development at each reservoir site and to the effect of development on existing or potential hydroelectric facilities. Accordingly, we have reviewed the basic data in your report with particular attention to the development of hydroelectric power at the three proposed reservoir developments.

Using the favorable assumption that the total yield of each reservoir could be used for power production it was determined the Brownwood and Coleman projects would support an installation of 2,400 and 2,500 kilowatts, respectively, operating at a 5 percent load factor. A similar installation at the Pecan Bayou site would have a capacity of approximately 1,100 kilowatts. Because of the low yields and low heads available and the higher priority of water uses for other purposes the installation of power facilities would not be economically feasible at any of the three projects. This is consistent with the conclusion of the Commission in regard to power installation at the Brownwood Reservoir in its letter of March 27, 1950 from the Commission Chairman to the Chief of Engineers.

No attempt was made to determine the effect, if any, that the proposed plan would have on Lower Colorado River Authority hydro plants which are approximately 156 river miles downstream from Brownwood Reservoir. All diverted flows and losses from evaporation in any of the projects would be withheld from the LCRA's Buchanan Lake. It is conceivable, however, that flood flows stored at the Coleman and Pecan Bayou projects could be utilized for power production at the downstream plants rather than be spilled through their flood release outlets.

We appreciate the opportunity to review this report which is returned herewith in accordance with your request. Please note that our comments are submitted at field level and as such are not to be construed as official comments of the Federal Power Commission.

Sincerely yours,

/s/ Lenard B. Young

Lenard B. Young
Regional Engineer

Enclosure No. 4110:
as stated above

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO
September 23, 1963

District Engineer
Corps of Engineers, U. S. Army
Post Office Box 1600
Fort Worth, Texas

Dear Sir:

By letter dated August 27, 1963, your reference SWFGB, Colonel Dallas L. Knoll, Jr., Executive Officer, requested our comments on the draft of your "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas," dated July 1963.

The Bureau of Sport Fisheries and Wildlife is pleased to note that its report of January 14, 1963, is included as part of Appendix VI of your report. Except for acceptance of the proposal that zoned areas be established on the reservoirs, it appears that our Bureau's recommendations have been made a part of the plan for project development.

We trust you will agree that safe, orderly use of the reservoirs for fishing and hunting and such general recreational activities as speedboating and waterskiing will require the development of a reservoir zoning plan. We believe this need should be recognized in your report. Development of an adequate zoning plan reserving certain portions of the reservoir for fishing (and hunting during certain periods) would result in additional benefits which could be attributed to the project.

It is noted on page 53, under d. Fish and Wildlife, that the Corps of Engineers had independently evaluated the benefits for fishing and hunting in the project analysis. Since this Bureau is the Federal agency responsible for evaluating fish and wildlife resources, it is suggested that the benefits for fishing and hunting presented in our report be accepted.

The treatment of benefits for general recreation, as given on page 54 under c. Recreation, is disturbing. We question whether fishing and hunting should be included among the activities used in an analysis of benefits for general recreation since benefits for fishing and hunting are given in the next paragraph under d. Fish and Wildlife.

The presentation concerning fish and wildlife and recreation is confusing also in other portions of the report. Table 5 on page 66 lists benefits for fish and wildlife harvest and also benefits for fish-wildlife and general recreation. In Table 5, Page 100, Appendix I, it is not possible to distinguish cost estimates of features for fish and wildlife from those for recreation.

We appreciate the opportunity extended to us to comment on the Review of Reports and are returning copy No. 18 to you under separate cover. By copy of this letter we are requesting that Mr. John G. Degani, Field Supervisor of our Branch of River Basin Studies office in Fort Worth, Texas, return copy No. 19 to your office.

Sincerely yours,

/s/ John C. Gatlin

John C. Gatlin
Regional Director

Separate Cover
Copy No. 18 of report

cc:
Executive Director, Texas Parks and Wildlife Department, Austin, Texas
Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Fort Worth, Texas

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE

Branch of River Basin Studies
1104 T. & P. Building
Fort Worth, Texas 76102

September 26, 1963

District Engineer
Corps of Engineers, U. S. Army
P. O. Box 1600
Fort Worth, Texas 76101

Dear Sir:

Enclosed is copy No. 19 of your draft Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas.

Thank you for permitting us to review this draft.

Sincerely yours,

/s/ Louis E. Alderson

Louis E. Alderson
Acting Field Supervisor

Enclosure

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

SWFGB

4 October 1963

Mr. John C. Gatlin
Regional Director
U. S. Department of the Interior
Bureau of Sport Fisheries and Wildlife
P. O. Box 1306
Albuquerque, New Mexico

Dear Mr. Gatlin:

This is in reply to your letter dated 23 September 1963, furnishing your comments on the draft of our report, "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas," dated July 1963.

This office agrees that safe, orderly use of the reservoirs for fishing, hunting, and general recreation activities will require the development of a reservoir zoning plan. Our report will be revised to acknowledge this need. Thus, paragraph 89 of the text is being revised to state that a zoning plan will be developed during preconstruction planning to insure adequate use of the reservoir for these activities.

The treatment of fish-wildlife and general recreation in the report is consistent with present policies of the Corps of Engineers. Based on attendance records of fishing and hunting activities at Corps of Engineers' reservoir projects in Texas, it is believed that our estimated benefits are conservative.

A copy of your letter of comments and this reply will accompany the report to the Congress.

Sincerely yours,

/s/ F. P. Koisch

F. P. KOISCH
Colonel, CE
District Engineer

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

Sep 26 1963

Lt. Col. Dallas L. Knoll, Jr.
Executive Officer
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Knoll:

The draft of your "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas," transmitted with your letter of August 27, 1963, has been reviewed by this office and by our Austin Development Office.

We have no comments to make on the draft of your report. The projects recommended therein will not adversely affect any existing or potential project of the Bureau of Reclamation.

Thank you for the opportunity to review the draft of your report. In accordance with your request, the copy of the report, Serial No. 08, is being returned under separate cover. Please furnish one copy of the final report to this office and one copy to our Area Engineer, Austin, Texas.

Sincerely yours,

/s/ John Thompson

Acting Regional Director

Separate cover: (35948)
Draft of "Review of Reports on Pecan Bayou Watershed"

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
Area IV
Mineral Resource Office

Room 206 Federal Building
Bartlesville, Oklahoma

September 26, 1963
Refer to: SWFGB

Lt Colonel Dallas L. Knoll, Jr.
Executive Officer
U. S. Army Engineer District, Fort Worth
100 West Vickery Boulevard
Fort Worth 4, Texas

Dear Colonel Knoll:

We thank you for the opportunity to make a field level review of your "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas" dated July 1963. The report has been reviewed by petroleum engineers on my staff and our comments are as follows:

The report recommends that protective measures to provide a reconstructed Lake Brownwood for flood control and water supply be authorized in lieu of the authorized Lake Brownwood enlargement. The proposed plan also provides for the following construction:

a. Pecan Bayou Dam and Reservoir in Coleman and Callahan Counties, Texas.

b. Coleman Dam and Reservoir in Coleman County, Texas.

c. Brownwood channel improvements in Brown County, Texas.

Coleman Dam and Reservoir. The proposed Coleman reservoir will be a multi-purpose project and provide for flood control, water supply, water quality control, recreation, and fish and wildlife benefits. The reservoir will include 92,100 acre-feet for flood control, 138,500 acre-feet for conservation, and 10,300 acre-feet for sediment reserve. The elevation on top of the dam will be 1,812 feet, and the top of the flood control pool will be 1,784 feet above sea level.

Importance of mineral production in the proposed Coleman reservoir area is mentioned on page 69, page 214 appendix VI, and page 254 appendix VII of the report under consideration. The proposed dam site is approximately fourteen miles north of the city of Coleman on Jim Ned Creek.

From a study of office maps and the Proration Schedule of the Texas Railroad Commission, an estimated 25 oil wells may be affected. Twelve of these wells have a daily oil allowable of 35 barrels. These wells are located in the Cresswell, Featherstone, and Dunman oilfields, and will require protection (elevating) as mentioned in the report under study.

Aside from petroleum and natural gas, there are no other known mineral deposits in the Coleman Reservoir area.

In 1962, petroleum, natural gas, natural gas liquids, sand and gravel, and clay valued at over $10-million were produced in Coleman County.

Pecan Bayou Dam and Reservoir. The proposed Pecan Bayou Reservoir will be a multipurpose project and provide for flood control, water supply, water quality control, recreation, and fish and wildlife benefits. The reservoir will include 102,700 acre-feet for flood control, 93,500 acre-feet for conservation, and 10,100 acre-feet for sediment reserve. Elevation of the top of the dam will be 1,676 feet, and the top of the flood control pool will be 1,653 feet above sea level.

Importance of mineral production in the proposed Pecan Bayou Reservoir area is mentioned on page 69, **page 214 appendix VI, and page 253** appendix VII of the report under consideration. The proposed dam site is approximately 17 miles north of the city of Coleman on Pecan Bayou, just upstream from the Mary Opal gasfield. From a study of office maps, it appears as if the dam site and reservoir will not adversely affect any oil or gas wells as mentioned in the report under study. There are no other known mineral deposits in the Pecan Bayou Reservoir area.

In 1962, petroleum and natural gas valued at over $7-million were produced in Callahan County, Texas.

Lake Brownwood Proposed Reconstruction. The proposed reconstructed Lake Brownwood will be a multipurpose project and provide for flood control, water supply, water quality control, irrigation, recreation, and fish and wildlife benefits. The reconstructed lake will include 91,600 acre-feet conservation and 33,000 acre-feet for sediment reserve. The elevation of the top of the dam will be 1,469 feet and top of the conservation pool will be 1,425 feet above sea level.

Importance of mineral production in the reconstructed Lake Brownwood area is mentioned in paragraph 45, page 39 appendix 1; paragraph 61, **page 117 appendix 1; and Table 10, paster** appendix 1 of the report under consideration. The proposed dam site will be located approximately 800 feet downstream from the existing dam. From a study of office maps, it appears as if the new dam site and reconstructed lake will not adversely affect any oil or gas wells. The land, flood easements and mineral interests have been acquired by non-federal agencies as their share of the first cost on the reconstructed Lake Brownwood project.

In 1962, petroleum, natural gas, stone and clay valued at over $2-million were produced in Brown County, Texas.

Channel Improvement. The proposed Brownwood channel improvements have no mineral problems as far as the Federal Government is concerned. Local interests are to provide without cost to the United States all land easements, and rights-of-way necessary for the construction, maintenance, and operation of the project. Reference paragraph 137, page 72 of the report under consideration.

In our opinion, the report could be improved by bringing the Appendix V. ECONOMICS AND POPULATION, Extractive Industries, Mining up-to-date with the following information. The first paragraph is OK. Delete the second, third, and fourth paragraphs and substitute:

Brown County. Increased output of natural gas, clay, and sand and gravel offset declines in crude oil and stone production to account for a 19 percent increase in total mineral value. Over 300,000 tons of limestone was crushed and prepared as concrete aggregate and roadstone for the Texas Highway Department. A large brick company recovered shale from open pits adjoining its plant at Brownwood for use in manufacturing brick and tile.

Coleman County. The 13 percent decline in mineral value was due to combined losses in crude oil and natural gas which offset increased output of natural gas liquids, clay, and sand and gravel. Coleman County Regular field produced 1.1 million barrels of crude. A new oilfield - Glen Cove/Morris - was proven on the west flank of the Bend Arch. Four small gasoline plants recovered natural gas liquids. A brick company mined shale from open pits for use in manufacturing brick, tile, and heavy clay products. Glass and industrial sand were mined and sold.

Table V-1 should be brought up-to-date by adding the following:

	County			
Year	Brown	Callahan	Coleman	Total
1959	1,913	7,282	11,455	20,650
1960	2,023	6,484	11,995	20,502
1961	1,790	6,678	12,015	20,483
1962	2,129	7,145	10,472	19,746

NOTE: The production statistics for 1959-1962 are in current dollars from the Bureau of Mines Minerals Yearbook. Your Table V-1 was in

(1,000's of 1958 Dollars)". Hence, you may or may not wish to adjust them all to the same base.

The last paragraph on page V-1 must be revised if you add our more recent production data for the years 1959-1962.

It is evident that continued mineral production is of vital importance to the economy of the Pecan Bayou Watershed, Colorado River Basin, Texas. In order to achieve this objective, it is recommended that a field examination and report prepared by a qualified petroleum engineer and/or mining engineer be completed during the early planning stages of these projects. The purpose of the report would be to recommend methods of protecting mineral producing facilities.

The Federal Bureau of Mines Area IV Office will not object to the proposed construction provided adequate measures are taken to protect the interests of the mineral industries in the reservoir areas.

/s/ Robert S. Sanford

Robert S. Sanford

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

SWFGB

4 October 1963

Mr. Robert S. Sanford
Area Director, Area IV
Mineral Resource Office
U. S. Department of the Interior
Bureau of Mines
Room 206 Federal Building
Bartlesville, Oklahoma

Dear Mr. Sanford:

This will acknowledge receipt of your letter dated 26 September 1963, concerning our "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas."

Your letter contains current mining data on Brown and Coleman Counties and the suggestion that this data be used as replacement of mining information contained in appendix V of our report. The substitution of data would involve revision of the final report prepared and submitted by the U. S. Public Health Service. However, revision of the Public Health Service report is not considered necessary since your letter containing the current mining data will be available in appendix VII of our report, and will be acknowledged in paragraph 129 of the text.

It is noted that the Federal Bureau of Mines does not object to the Federal authorizations of the projects recommended in the subject report, provided that protection for continued operation and development is given the mineral resources and mineral producing and handling facilities.

I wish to advise that investigations will be conducted during the preconstruction planning of the various projects to insure that any changes in the mineral situation will be adequately considered and evaluated.

Sincerely yours,

/s/ F. P. Koisch

F. P. KOISCH
Colonel, CE
District Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
SOUTHWEST FIELD COMMITTEE, REGION SIX
807 Brazos Street
Austin, Texas 78701

October 2, 1963

Lieutenant Colonel Dallas L. Knoll, Jr.
Executive Officer
U. S. Army Engineer District, Fort Worth
Corps of Engineers
100 West Vickery Boulevard
Fort Worth, Texas 76101

Dear Colonel Knoll:

The draft copy (serial number 23) of the Corps of Engineers' report "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas," has been reviewed by the Geological Survey at field level. The relatively short time allowed for this review did not permit a detailed analysis of data that are of interest to the Geological Survey. It is evident, however, that your agency has fully utilized all of the available data on surface runoff collected by the Geological Survey, that consideration has been given to possible ground-water resources, and that available data on geology as it relates to reservoir construction was utilized.

Mr. D. Hoye Eargle, geologist, has made various geologic investigations in the Pecan Bayou watershed. In his studies, he has examined in considerable detail rock outcrops at the dam which forms Lake Brownwood. He concurs in the Corps' decision that remedial measures should be taken to maintain the stability of the dam and spillway. His comments to me on Sept. 18, 1963 follow:

> In response to your request of September 13 I reviewed briefly the U. S. Engineers' report, "Pecan Bayou Watershed, Colorado River Basin, Texas." I believe the Bureau of Mines reviewed in detail the relation of the engineering works planned to the oil and gas fields, and pointed out specific areas and wells that should be protected in the region. I am of the opinion, however, that one advantage that might accrue from the development of reservoirs in the area would be to make available more water for water-flooding the many marginal oil fields of the region. On the other hand, protection of the reservoirs from pollution by oil-field brines would be a problem that should be considered.

I want to make specific comments on the geology of the Lake Brownwood site, which I know well. The photograph in USGS Prof. Paper 315-D, pl. 29, illustrates on a full-page spread the beds that will be involved in the treatment of the Lake Brownwood spillway. A comparison of these photographs, taken in 1952, with those in fig. 4, p. 45, of the Engineers' report shows considerable erosion during the interval between the two groups. The channel of the spillway has been deepened as shown by the three limestone beds that are exposed in the head of the overfall in the Engineers' photograph, whereas only two are exposed in the USGS paper. This illustrates the fact that even though the spillway is seldom occupied by water overflowing from Lake Brownwood, such water causes considerable erosion when it overflows, and that emphasizes the need for adequate spillway protection.

In regard to the protection of the spillway from headward erosion of the overfalls, I interpret from the details of pl. 3, I-59, Details of Spillway protection, only two shale beds that underlie strong limestone beds are protected from erosion by concrete curtain walls. The geologic section shown on pl. 9, II-27, however, shows a thicker bed of shale and a higher overfall, plus some thinner beds of shale and lower overfall, just downstream from those that are shown on the diagram to be protected. The limestone above this high overfall--downstream from the one to be protected--is impure and thin, and the shales beneath are highly erodible.

Adequate protection of the spillway for the future demands some protection of these overfalls too. It seems also that protection of the spillway would require some confinement of the water on the eastern end of each of the limestone ledges that will be protected. This eastern wall of the spillway consists only of shale and soil--as shown in the photograph on pl. 29, USGS Prof. Paper 315-D-- and is a concave-inward wall that narrows the channel to about a third of its width above the overfalls, as shown on pl. 3, Engineers' Report, p. I-59.

Consequently, I don't consider the present plan adequate for protection of the spillway for a long period of time.

In addition to the matter of Spillway protection, the dam has as part of its foundation limestones that may contain some channels, particularly along joint planes on the weathered steep slopes as shown in pl. 2, p. I-57. This is especially true of the uppermost thicker bed of limestone shown on pl. 9, p. II-27. I am of the opinion--based only on memory--that this limestone may be responsible for some of the leakage from the present dam. I do not recall that leakage from the present dam was mentioned as a reason why some steps should be taken as soon as possible to safeguard the dam from failure.

I am not familiar with the details of the geological conditions of the other dam sites in the report, but the following publications, in addition to the USGS Prof. Paper 315-D, already quoted, detail some of the general geology of the area.

1. U.S. Geol. Survey Bull. 1096-B, Geology of the Cross Plains quadrangle, Brown, Callahan, Coleman, and Eastland Counties, by P. T. Stafford, 1960.
2. U.S. Geol. Survey Bull. 1096-A, Geology of the Grosvenor quadrangle, Brown and Coleman Counties, Texas, by R. T. Terriere, 1960.
3. U.S.G.S. Oil and Gas Investigations Preliminary Map 80, Rocks of Permian (?) age in the Colorado River valley, north-central Texas, by R. C. Moore, 1949.
4. Texas Univ. Bur. Econ. Geol. Map, Geologic map of Brown County, Texas, by M. G. Cheney and D. H. Eargle, 1951.
5. Abilene Geological Society Guidebook, 1961, A study of the Pennsylvanian and Permian sedimentation in the Colorado River valley of west central Texas, Sept. 15-16, 1961.
6. USGS Bull. 1081-G, Stratigraphy of the Wichita Group in part of the Brazos River valley, north Texas, by P. T. Stafford, 1960.

The Geological Survey has only meager basic data as to the chemical quality of water in Pecan Bayou basin. What is available, however, supports the general statement submitted to you by the U. S. Public Health Service. The extensive oil field developments and associated salt brines resulting from these developments in Pecan Bayou basin probably will introduce further pollution abatement problems that are not anticipated in the report. The Geological Survey's investigations of salt pollution in the Hubbard Creek basin, contiguous to Pecan Bayou, show that the chloride content of the water in that watershed is increasing at an alarming rate. This increased pollution is due to the manner in which some of the oil wells in that basin were operated in the past and also because of the ineffective manner in which old wells were plugged in earlier years. It is recommended, therefore, that the Corps of Engineers explore this probable source of increased chloride pollution. The Geological Survey will assist your agency in such an investigation if it is determined to be desirable.

The Geological Survey, in cooperation with the Corps of Engineers, Texas Water Commission, and other agencies, is now maintaining in the Pecan Bayou basin 3 stream-gaging stations, 2 reservoir-stage and content-stations, and 1 station on the diversion canal from Lake Brownwood. If the reservoirs proposed in this report are constructed, together with certain channel rectification measures and the extensive flood-flow retarding network proposed by the U. S. Soil Conservation Service, it will be necessary to expand the stream-gaging station network to conform with these extensive man-made changes.

The proposed construction of a new dam at Lake Brownwood and the rectification of the Pecan Bayou channel will destroy the existing stream-gaging stations in that area. The hydrologic network (stream-gaging, reservoir-content, and canal stations) is considered to be primarily a reconnaissance study of surface water conditions. The comprehensive development proposed in the Corps of Engineers' report will require that this network be expanded and that the accuracy of data collected be improved. Stream-gaging stations have not been operated on Adams Branch and Willis Creek which contribute to flood damages in the City of Brownwood. It is recommended, therefore, that maximum-stage and flood-discharge stations be established in the rectified floodway channels of these streams for the purpose of supplying basic data on floodflows and for use in modifying floodways if this becomes necessary in future years. The anticipated changes in the chemical-quality of water in Pecan Bayou basin will require an appropriate network of chemical quality of water stations for monitoring this phase of water-use operations. The Geological Survey will cooperate with the Corps of Engineers in developing an appropriate hydrologic stream-gaging and chemical-quality network that will be needed by those operating water-control and water-use facilities as proposed in the Corps of Engineers' plan for Pecan Bayou basin.

The numbered report is enclosed.

Very truly yours,

/s/ Trigg Twichell

Trigg Twichell
Contact Official of
the Geological Survey

cc: Douglas R. Woodward, Washington, D. C.
S. K. Jackson, Denver, Colo.
D. Hoye Eargle, Austin, Tex.
C. H. Hembree, QW, Austin, Tex.

1 November 1963

Mr. Trigg Twichell
U. S. Department of the Interior
U. S. Geological Survey
Southwest Field Committee, Region Six
807 Brazos Street
Austin, Texas 78701

Dear Mr. Twichell:

This is in reply to your letter dated 2 October 1963, furnishing the comments of the Geological Survey on the draft of our report, "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas," dated July 1963.

The following comments are relative to the questions posed by Mr. D. Hoye Eargle, whose remarks were contained in your letter:

a. Pollution.- Oil field pollution control measures are currently under investigation by the State of Texas. It is assumed that effective regulations will be established and enforced in an attempt to eliminate, control, or minimize this source of pollution. The Corps estimates include sufficient costs for the protection of the oil and gas wells in the reservoir areas of the recommended projects.

b. Spillway.- Historical data indicates that headward erosion of the spillway discharge channel is taking place. Records in this office show that the first overfall moved only 45 feet toward the spillway concrete retaining wall during the period 1931-1958 or at a rate of about 1.74 feet per year. In 1958 the distance from the concrete wall to the first overfall was about 335 feet. Closer examination of the photographs in USGS Professional Paper 315 and Corps of Engineers' report reveals that the same four limestone beds are in evidence in the spillway discharge channel. Plate 3 of Section 1 does indicate that the third band of shale mentioned in the geologist's comments is not protected. However the intention was that the second-ledge curtain wall be extended downward to protect the third band of shale. The cost estimate includes the cost for this protection. Plate 3 has been revised to reflect the design intended. The protection suggested to the eastward (downstream) is not considered necessary since erosion in that direction would only open up the discharge channel. It is felt that this condition, even if eroded, would offer no threat to the spillway proper.

c. Embankment.- Leakage through foundation rock in the abutment would have little or no effect on the stability of the dam. It was pointed out in paragraphs 5, 9, and 21 of appendix II that grouting and/or foundation treatment would be required to control seepage through the foundation rocks, particularly the jointed and fractured limestones.

With respect to stream gaging statements in your agencies comments, reference is made to paragraph 48, page III-69, appendix III, "Hydrology, Hydraulic Design, and Water Resources," which generally outlines a future requirement for expansion of the existing network and states, "Detailed requirements for the complete hydrologic network will be presented in connection with preconstruction planning studies." This proposed program for expansion of the hydrologic network will be implemented as the need arises and will be coordinated with the U. S. Geological Survey at that time.

Your cooperation in reviewing and commenting on our Pecan Bayou report is appreciated.

Sincerely yours,

/s/ F. P. Koisch

F. P. KOISCH
Colonel, CE
District Engineer

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE

PUBLIC HEALTH SERVICE

Tenth Floor - 1114 Commerce Street
Dallas 2, Texas

October 8, 1963

Your reference:
SWFGB

Colonel R. P. West, District Engineer
U. S. Army Engineer District, Ft. Worth
Corps of Engineers
Post Office Box 1600
Fort Worth, Texas 76101

Dear Colonel West:

Reference is made to your letter of August 27, 1963, requesting comments on the "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas."

In the development of water resource projects and improvements in this watershed, it is recommended that cooperation of the Texas State Department of Health be secured in establishing maximum public health safety.

Our report entitled "Water Resources Study, Pecan Bayou Watershed, Colorado River Basin, Texas," dated October 1962, is attached as part of Appendix VI of the report. Several minor inconsistencies of data and reporting were revealed during preparation of your report; however, all of these have been resolved in meetings with your staff. We concur with the findings of the report and have no further comments in this regard.

The draft copy of the report (Serial No. 12) is being returned as requested. The opportunity of reviewing this report is appreciated.

Sincerely yours,

/s/ I. Bernstein

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

Enclosure

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
AWR Basins Office
Agricultural Office Building, 15th and Quebec
Tulsa, Oklahoma 74112
October 8, 1963

District Engineer
U. S. Army Engineers,
Fort Worth District
Post Office Box 1600
Fort Worth, Texas

Dear Sir:

Under date of October 3, 1963, Mr. H. N. Smith, Texas State Conservationist, submitted to your office a letter of comments covering the field level review of the Soil Conservation Service on the draft report, "Review of Reports on Pecan Bayou, Colorado River Basin, Texas." This is to advise that the letter of comments from Mr. Smith constitutes the field level review comments of the Department of Agriculture.

In accordance with your request, we are returning under this cover one copy of the draft report. With your permission, we would like to retain two copies of the draft report for reference.

Thank you for the opportunity of reviewing this report.

Yours very truly,

/s/ John A. Short

John A. Short
River Basin Representative

Enclosure

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P. O. Box 648
Temple, Texas 76502

October 3, 1963

Colonel F. P. Koisch
District Engineer
Corps of Engineers, U. S. Army
100 West Vickery Blvd.
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Koisch:

Thank you for an opportunity to review a draft copy of the "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas". The report was found to be well organized, clear, and concise, by the reviewing technicians of the Soil Conservation Service. We are returning copies Nos. 13 and 14 in compliance with the request in your letter of transmittal.

The report proposes the solution of existing flood and water supply problems by certain protective measures to the existing Lake Brownwood; by channel improvement work along Pecan Bayou, Adams Branch, and Willis Creek in the urban Brownwood area; and by construction of the Pecan Bayou and Coleman Reservoirs upstream from existing Lake Brownwood. The estimated Federal construction cost for the reconstructed Lake Brownwood for flood control and water supply is $3,060,000, and the annual cost for flood control maintenance and operation is $22,900. The estimated Federal construction cost for the Brownwood channel improvements for local flood protection is $11,281,000, subject to certain conditions of local cooperations. The estimated Federal construction cost for the multiple-purpose Pecan Bayou and Coleman Reservoirs is $22,410,000, and the annual maintenance and operation cost is $210,000.

Work plans have been developed and upstream projects approved for construction on Jim Ned Creek Watershed and on Turkey Creek Watershed, a part of Pecan Bayou above Lake Brownwood. Field planning in connection with a work plan for the remainder of the Upper Pecan Bayou and for the Brownwood Laterals of Pecan Bayou below Lake Brownwood currently is underway.

During detailed planning by the Soil Conservation Service in connection with the development of a work plan for the Jim Ned Creek Watershed, some coordination , including the exchange of pertinent field survey data, was accomplished between the Corps of Engineers and the Soil Conservation Service. At that time, a reservoir which would provide municipal water storage capacity for the City of Coleman was discussed. Data on 8 planned floodwater retarding structures which would be affected by the reservoir were withheld from the work plan awaiting a final decision by the City.

The City of Coleman notified local sponsors of the Jim Ned project by letter that it was not interested in developing a reservoir for municipal water supply. Consequently, the Jim Ned sponsors asked that their work plan be developed, disregarding the proposed Coleman site.

The Jim Ned upstream flood prevention project, authorized in October, 1960, consisted of 43 floodwater retarding structures supplementing land treatment on the agricultural lands of the watershed. To date, 28 of these planned structures have been installed, at a Federal cost of $2,526,000. The estimated total installation cost for planned structural measures in the Jim Ned project is slightly in excess of $4,260,000. The Coleman Reservoir recommended at the site shown in your report for the Pecan Bayou Watershed would affect adversely this approved project which is now under construction. Federal funds expended to date in installation of 4 floodwater retarding structures which would be directly involved in construction of the proposed Coleman Reservoir amount to $923,683.

Evaluation of the system of floodwater retarding structures planned for the Jim Ned Creek Watershed showed a reduction in average annual damages of 83 percent in Reach 4 and 79 percent in Reach 5. These reaches, in general, cover Jim Ned Creek from the recommended Coleman Reservoir to Lake Brownwood. If damage reduction benefits from this area have been used in justification of the Coleman Reservoir, it is possible that there has been a duplication of benefits. Even if duplicating benefits had not been claimed, there is a duplication of physical facilities.

The following comments are presented for your information and consideration:

Page I-33 (Paragraph 39b) - It is stated "---benefits to reconstructed Lake Brownwood are based on the value of Lake Brownwood in reducing flood peaks within the downstream Pecan Bayou Valley. The reconstructed Lake Brownwood is credited with the difference in projected average annual damage which would prevail with and without Lake Brownwood". Based on this approach, any justified structure may be justifiably reconstructed if a project flood is selected which might cause the structure to fail, even though flood control storage is justified in two reservoirs located upstream. Therefore, $6,000,000, of a $7,000,000 cost is written off.

Page I-40 (Paragraph 48a) - The selected plan studies are said to contain refinements to reflect the "revision of dependable water supply yields to reflect the effects of the potential Soil Conservation Service program". If consideration has been given to possible increases in downstream floodwater and sediment damages as a result of water moving to this area more rapidly in evaluating the effects of recommended channel improvements, a statement relative to this would strengthen the report.

Page I-61 (Paragraph 69) - It is noted that evaluation of channel improvement on Willis Creek and Adams Branch was made without consideration of floodwater regarding structures under investigation by the Soil Conservation Service. The report proposes that in the final design stage coordination with the plans being developed by the Soil Conservation Service will be achieved and that such structures probably would reduce the design discharge by about 30 percent.

Page I-101 (Table 17) - Estimated costs for land acquisition for the Pecan Bayou and Coleman Reservoirs do not differ greatly when regarded on a per-acre basis. However, the Pecan Bayou site has only 5 percent bottom cropland while cropland in the Coleman site constitutes 59 percent. If not already done, consideration might be given to the possibility that the capitalized value of agricultural production losses in the Coleman site might exceed the site acquisition value shown.

Page III-18 and III-19 - It is noted that an estimated trap efficiency of 50 percent was used on Soil Conservation Service floodwater retarding structures. Available data obtained from studies over the past several years for installed structures show an average trap efficiency of 90 percent for the design life of the structures. Sediment pools of floodwater retarding structures already in place are designed for a 50-year life; however, it is estimated that their trap efficiency over a 100-year period will approximate 70 percent. Those structures to be installed with 100-year sediment capacity will provide 90 percent average trap efficiency.

Page III-25, (Paragraph 27) - Natural runoff was diminished by applying factors which varied from 59 percent in 1947, to 87 percent in 1955. These are comparable to the U. S. Study Commission - Texas figures for 1975 conditions and were used to determine reservoir yields 100 year hence. Runoff tabulations by the U. S. Study Commission - Texas for 2010 conditions show variations from 70 to 87 percent. It is expected that the sediment pools of floodwater retarding structures will be filled in 100 years and any runoff reductions will be further reduced.

It is stated that uncontrolled outflow of 1,510 second-feet released from the 142 square miles controlled by floodwater retarding structures below Lake Brownwood will reduce the maximum allowable release rates from Lake Brownwood and the Pecan Bayou, Coleman and Hords Creek Reservoirs. The prevailing channel capacity, as shown on page 7, varies from 12,000 cfs at Lake Brownwood to 30,000 cfs at the mouth of Pecan Bayou. Thus, release at Brownwood would be restricted to 12,000 cfs. The control afforded by floodwater retarding structures does not begin at the dam. At the Brownwood stream gage, the release would be 240 cfs. At mile 44, as shown on page 7, the capacity is 13,000 cfs. Therefore, the maximum effect of releases from floodwater retarding structures is 240 cfs, or 2 percent of the channel capacity. It would be anticipated that reconstructed Lake Brownwood also would prolong releases since it cannot pass the flood peak instantaneously.

A similar statement concerning releases from Upstream structures appear on III-20. It is felt that a study of the combined SCS and Corps programs for the Pecan Bayou Watershed would show the upstream improvement to complement, rather than impair the recommended Corps projects.

While some limited coordination between our agencies has occurred in planning in the Middle Colorado River Basin, it appears that considerably more coordination is needed. Based on the report data of our respective agencies covering the Jim Ned Creek Watershed, it is apparent that close and continuing coordination is needed to obtain maximum efficiency in resources development and in the use of Federal and local funds for these purposes. It is suggested that further coordination in Pecan Bayou planning activities be accomplished prior to submission of your Pecan Bayou report.

The cooperation and assistance in watershed planning which have been extended this Service by personnel of the Fort Worth District are appreciated. I shall be happy to assign members of this staff to work in any way possible to achieve the high level of planning efficiency, which is our mutual goal.

Sincerely yours,

/s/ H. N. Smith

H. N. Smith
State Conservationist

Enclosures

9 December 1963

Mr. H. N. Smith
State Conservationist
U. S. Soil Conservation Service
P. O. Box 648
Temple, Texas 76502

Dear Mr. Smith:

This is in reply to your letter of 3 October 1963 furnishing your comments on our "Review of Reports on Pecan Bayou Watershed, Texas."

Subsequent to receipt of your letter, representatives of our agencies arranged a conference in the Fort Worth area office of the Soil Conservation Service on 24 October 1963 to discuss the comments contained in your letter, the matter of coordination between our agencies, and the formulation of a coordinated plan of improvement for the Pecan Bayou watershed.

Paragraphs 4 and 5 of your letter indicates that the Soil Conservation Service proceeded with construction of flood detention structures within the Coleman Reservoir area on the basis that the city of Coleman notified local sponsors of the Jim Ned Creek flood-detention project that it was not interested in development of a reservoir on Jim Ned Creek for municipal water supply. At our recent conference, your representatives were advised that the Corps of Engineers had received no such notification from local interests and were uninformed from any source of such action until receipt of your letter of 3 October 1963; that local interests of Coleman County were presented with our proposed plan at a meeting on 17 April 1962; that the proposed plan was publicly presented at a meeting in Brownwood on 7 June 1962; and that local interests of Brown and Coleman Counties presented letters dated 13 June 1962, containing their approval of the plan proposed by the Corps of Engineers and the assurances for local cooperation.

It was recognized both in the USSC-T studies and in the 1980 plan of the Texas Water Commission for meeting water requirements of Texas that a major water supply project must be built on Jim Ned Creek to satisfy the projected water supply requirements of that area. Furthermore, the city of Coleman applied to the Texas Water Commission in August 1958 for a permit to develop a reservoir project on Jim Ned Creek in the interest of satisfying the urgently needed and projected water supply requirements for the Coleman area. The Texas Water Commission granted this permit in May 1959 and the city of Coleman has continuously pursued the development of the water resources either singularly or jointly with other local interests and the Federal government.

With the existing system of Soil Conservation Service reservoirs on Jim Ned Creek, it would be almost impossible to develop the water resources of this stream by construction of a major reservoir without adversely effecting the operation of a number of existing detention structures. During fiscal year 1963, the Soil Conservation Service constructed four flood-detention structures -- three of which are located in the conservation and/or flood control pools of the Coleman Reservoir. Three of the four would be affected by the operation of Coleman Reservoir. Your letter states that the four structures involved a Federal construction cost of $923,683 and that construction of the proposed Coleman Reservoir would result in a duplication of physical facilities.

As indicated in our Pecan Bayou report, the proposed Coleman and Pecan Bayou Reservoirs were formulated on the basis of last-added units on the watershed and on the assumed basis that the potential system of flood-detention structures by the Soil Conservation Service is an existing program. The economic justification of the proposed multiple-purpose reservoirs was established on the basis of average annual flood damages which are residual to the Soil Conservation program and, thus, does not involve duplication of flood control benefits initially creditable to the potential Soil Conservation Service program.

At the conference held on 24 October 1963, your agency agreed to determine which multiple-purpose reservoir site on Jim Ned Creek would have the least adverse effect on the Soil Conservation program established for the Jim Ned Creek subwatershed. Your representatives indicated that inundation of the flood plain by a multiple-purpose project would have an effect on the economic justification of certain flood-detention structures not physically effected. Multiple-purpose sites considered for this study were located according to the following dam sites; the proposed Coleman Dam site; an alternate Coleman Dam site at river mile 46.4, about 5.8 river miles downstream from the proposed Coleman Dam site; and the investigated Camp Colorado Dam site. Based on information furnished by your agency, it was concluded that the lower Coleman Reservoir site would be less detrimental in terms of monetary benefits to your program even though it would, also, physically affect certain existing flood-detention structures.

Information on the adverse effects from the multiple-purpose sites were furnished by letters of 14 November and 3 December 1963. The above-referenced letters, which will be included in appendix VII of our report, presented the following types of data relative to the three multiple-purpose reservoir sites: (a) Construction cost (and annual damage value)of existing floodwater retarding structures physically affected; (b) estimated annual benefits in areas inundated by major reservoirs that will accrue to floodwater retarding structures; (c) estimated annual benefits in major reservoir sites allocated to retarding structures physically affected; and (d) flood reduction benefits allocated to floodwater retarding structures physically affected by major reservoirs. Since any multiple-purpose reservoir project would act as a reliable substitute for the retarding structures physically damaged, it should be credited with a major portion of the benefits set forth in the above item (d). A summary of the adverse economic effects of each multiple-purpose reservoir on the Soil Conservation Service program is summarized in monetary terms as follows:

	Proposed Coleman	Lower Coleman	Camp Colorado
Annual physical damage (a)	$25,752	$12,546	$ 2,286
Annual benefit losses (b)	19,557	19,637	45,705
Less allocated benefits (c)	5,100	8,991	4,037
Subtotal - adverse economic cost	$40,209	$23,192	$43,954
Less creditable benefits (d)	20,465	23,264	8,797
Net annual loss or gain	$19,744(-)	$ 72(+)	$35,157(-)

Based upon the above summary, it is apparent that the lower Coleman Reservoir site would have the least adverse affect on the Soil Conservation Service's retarding-structure program. A cursory review of the lower Coleman site indicates the probability that it would have a total construction cost approximately equal to that of the proposed upstream site. It is proposed to investigate in detail the advantage of the lower Coleman site during the preconstruction stage. Integration of the adverse economic costs and the creditable benefits in the economic analyses for the proposed Coleman Reservoir would cause an insignificant reduction of the overall benefit-cost ratio (from 2.30 to 2.17).

Your letter of 14 November 1963 contains the suggestion that the Coleman Reservoir project be deleted from our proposed plan of improvement, and that the city of Coleman obtain any additional water supply needs from the proposed Pecan Bayou Reservoir. You state that construction of the Pecan Bayou Reservoir would also serve the cities of Clyde and Cross Plains, which are presently considering the provision of water conservation storage in your flood-retarding structures as a means of satisfying current additional water supply needs. Preliminary study of pipeline installation and transmission costs and consideration of the cost of raw water at the proposed Coleman and Pecan Bayou Reservoir projects indicate that the overall cost of water delivered to the city of Coleman from the Pecan Bayou site in lieu of the Coleman site would be substantially increased, approximately 2.0 cents per 1000 gallons, or an average of about $30,000 annually over the life of the project. Deletion of the proposed Coleman Reservoir from our proposed plan of improvement would not be in accordance with the expressed desires of local interests, and would not be in keeping with good planning concepts for development of water resources. There has been agreement and mutual understanding between Coleman County and Brown County interests with respect to the outstanding permit to the city of Coleman for development of 40,000 acre-feet of water supply storage on Jim Ned Creek. Further, there is perfect agreement between these local interests for joint participation in maximum economical water supply development as would be afforded by the proposed Coleman and Pecan Bayou Reservoirs.

Paragraph 5 of your letter of 3 October 1963 contains the statement: "The City of Coleman notified local sponsors of the Jim Ned project by letter that it was not interested in developing a reservoir for municipal water supply. Consequently, the Jim Ned sponsors asked that their work plan be developed, disregarding the proposed Coleman site." Since the information appeared to be in direct conflict with letter (17 June 1962) from responsible representatives of Coleman County, conferences were held with local interests at Coleman and Brownwood on 14 November 1963 to ascertain their current views and desires with respect to the proposed Coleman project and the proposed plan of improvement. By letters dated 14 November and 15 November 1963, local interests of Coleman County and Brown County restated their desire for construction of the proposed plan of improvement. Coleman County interests indicated that their letter of 19 February 1962 to the Central Colorado Soil Conservation District No. 517 had apparently been misinterpreted and that their desire for a water supply project on Jim Ned Creek has been consistent. Further, Coleman County interests emphasized that there is an immediate and acute need for such a project as a source of additional water supply for their general use. The letters of local interests are being reproduced and will be included in appendix VII of our report. Copies of the local interest letters are inclosed for your information.

The status of the proposed Coleman and Pecan Bayou Reservoirs are summarized as follows: (a) Construction of the proposed Coleman Reservoir project would have an adverse effect on certain existing flood-retarding structures constructed by the Soil Conservation Service and would result in a partial duplication of flood control facilities; (b) The Coleman project would act as a reliable substitute for flood-retarding structures physically damaged; (c) A reevaluation of the proposed Coleman Reservoir project to include recognition of such adverse effects in monetary terms indicates that the overall benefit-cost ratio is not appreciably affected; (d) The Coleman and Pecan Bayou Reservoirs are the most practical and economical means of developing a substantial portion of available water resources of the Pecan Bayou watershed for current and future water supply needs; (e) Local interest of Coleman and Brown Counties are in perfect agreement for joint participation in maximum economical water supply development to be afforded by the proposed Coleman and Pecan Bayou Reservoirs; and (f) Coleman County interests have reiterated their urgent need and desire for construction of the proposed multiple-purpose project on Jim Ned Creek. In recognition of the above, it is proposed to retain the Coleman Reservoir in the proposed plan of improvement for the Pecan Bayou watershed. In the event the proposed Coleman project is authorized by the United States Congress, the advantages of the alternate lower Coleman site will be investigated during preconstruction planning and all studies will be coordinated with the Soil Conservation Service.

At our conference held on 24 October 1963, it was indicated that the Pecan Bayou Reservoir would adversely affect the Soil Conservation Service's authorized planning of flood-detention structures within the upper Pecan Bayou area. Your representatives indicated that alternate plans for location of flood-detention structures would be developed and that the Pecan Bayou Reservoir would be honored in the event this proposed project was authorized by the United States Congress.

Under subparagraph headings in your letter, additional comments are presented for our information and consideration. Replies to your agency's comments are as follows:

a. Page I-33 (paragraph 39b).- The intent of the comment contained in your letter under this subparagraph heading is not totally understood. Your comments implies that the Corps of Engineers adopted a project flood of such magnitude so as to purposefully promote and justify reconstruction of the Lake Brownwood by the Federal government. Evidently, your statement was made disregarding results of conscientious investigations, studies, and analyses which indicate that the existing dam and spillway are inadequate to withstand extreme flood conditions; that the existing spillway is of insufficient capacity to pass the standard project flood without encroachment within the freeboard area of the existing dam; that the safety factor of the existing earth embankment is below the minimum value considered adequate for an earthen structure; that due to the questionable stability of the embankment, there is no assurance that the dam would not fail on recurrence of the maximum flood of record; and that failure of the dam would result in catastrophic flood conditions to the downstream area and the city of Brownwood, causing enormous flood damages and loss of lives. Flood routings through Lake Brownwood were made of the following floods under conditions of Lake Brownwood operating in combination with the proposed Coleman and Pecan Bayou Reservoirs; (a) The observed flood of July 1932; (b) a flood derived from transposing the storm of 30 June-2 July 1932 over the Pecan Bayou watershed upstream from Lake Brownwood Dam; (c) the standard project floods; and (d) the spillway design flood. The elevations obtained by flood routings of items a, b, c, and d would be 1431.6, 1449.7, 1445.8, and 1464.1, respectively, and are compared to top of existing dam at elevation 1450.0. The studies indicate that the dam must not only be strengthened to withstand likely extreme flood conditions such as those under items a, b, and c, but that the dam must be raised extensively to contain the spillway design flood, a normal hydrologic design criteria adopted for dam construction undertaken by the Federal government.

b. <u>Page I-40 (paragraph 48a)</u>.- The effects of the Brownwood channel improvements have been evaluated from the vicinity of Brownwood to the head of the Fox Crossing Reservoir site. No adverse effects are apparent to the flood plain area downstream from the beginning of the channel improvement.

c. <u>Page I-61 (paragraph 69)</u>.- The comments under this subparagraph heading constitute restatement of information contained in our report. However, at the conference held on 24 October 1963, your representatives stated that your agency had just completed a revised flood-detention program for Adams Branch and Willis Creek and desire that, prior to submission of our report, our studies be coordinated with a view to development of a joint plan. Your agency desires to reflect the results of such coordinated studies in your pending planning report. It is the opinion of the Fort Worth District that delay of our report to await the results of coordinated studies by our agencies is not warranted. Thus, it is proposed to submit the plan of Brownwood Channel Improvements as was presented in our report during field-level review. Also, it is proposed that coordination of studies on Adams Branch and Willis Creek by our agencies be continued after formal submission of our report in order that results of such coordination may be available for presentation in your planning report. Further, it may be possible to include the results of the coordinated studies in the reports of the Board of Engineers for Rivers and Harbors and of the Chief of Engineers, depending on the time required to complete such studies.

d. <u>Page I-101 (Table 17)</u>.- The estimated costs for land acquisition for the Pecan Bayou and Coleman Reservoirs are based on gross land appraisals by our Real Estate Division. Exclusive of costs and expenses for minerals, improvements and severances, flood easements, land acquisition procedures, and contingencies, the basic average unit costs of lands to be acquired in fee simple for the Pecan Bayou and Coleman Reservoirs are $98.00 and $145.00, respectively.

e. Page III-18 and III-19.- Assuming an average trap efficiency of 70 percent for the proposed Soil Conservation Service structures above Coleman and Pecan Bayou Reservoirs and Lake Brownwood over a hundred year period would produce a slight increase in the conservation storage, however, this would have no significant effect on the estimated yields of these reservoirs.

f. Page III-25 (paragraph 27).- The yield determinations presented in this report and as stated in paragraph 25, page III-19 and on plate 5, page III-21, are based on the most critical conditions of runoff as determined for the U. S. Study Commission-Texas. The minimum firm yields are from the net storage specifically allocated for conservation purposes and excludes that additional storage in the conservation pools which has been provided for deposition of sediment. These severe coincidental conditions were assumed to obtain the minimum firm yields from the reservoirs. The statement (paragraph 27) that the uncontrolled outflows from Soil Conservation Service structures downstream from Lake Brownwood would amount to 1,510 second-feet refers to the total outflow from Soil Conservation Service structures below Brownwood Dam. It was not intended to imply that this total amount would affect the maximum allowable release rates from Lake Brownwood. This statement will be revised to indicate that outflow from the Soil Conservation Service structures will have only minor effects on releases from Lake Brownwood.

Your cooperation in reviewing and commenting on our Pecan Bayou report is appreciated.

Sincerely yours,

/s/ F. P. Koisch

F. P. KOISCH
Colonel, CE
District Engineer

2 Incl
1. Ltr from Brown County interests
2. Ltr from Coleman County interests

96-452 O-68—21

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

P. O. Box 648
Temple, Texas
Nov. 5, 1963

Mr. Kermit Speeg
U. S. Army Corps of Engineers
Fort Worth District
100 West Vickery
Fort Worth, Texas

Dear Mr. Speeg:

At our meeting to discuss Pecan Bayou planning activities on October 24, 1963, it was agreed that we would furnish you the following items:

1. Results of hydrologic data developed by the Soil Conservation Service on Adams Branch and Willis Creek.

2. The cost of existing SCS structures physically affected by the proposed Coleman reservoir site in its present location and moved downstream to a point immediately upstream from floodwater retarding structure 23.

3. The cost of existing SCS structures physically affected by the Camp Colorado site.

4. Estimated benefits accrued to the SCS structural program in the areas inundated by the proposed major reservoirs.

5. Flood reduction benefits allocated to floodwater retarding structures physically affected by the proposed major reservoirs.

6. The extent that SCS structures will be physically affected by the proposed major reservoirs.

The first item of this data is enclosed. Hydrologic data on Adams Branch and Willis Creek include the following:

(1) Table showing selected valley section stationing, drainage area, and peak discharge under existing conditions and with planned floodwater retarding structures installed when a 100-year frequency 6-hour duration storm runoff is routed.

(2) Photographic map showing stream channel alignment and location of selected valley sections.

(3) Table showing physical data for floodwater retarding structures.

(4) Map showing location of planned floodwater retarding structures.

Details concerning the development of hydrologic data are located at the Watershed Planning Party office in Brownwood, Texas. Valley section rating curves were developed at surveyed sections using water surface profiles computed by the Doubt Method. Flood hydrographs for the 100-year frequency 6-hour duration storm were developed for incremental drainage areas. Storage indication routings using variable travel time determined peak discharges for the two conditions of watershed development studied.

Other items that are to be furnished are being prepared and should reach you soon.

Sincerely yours

/s/ C. W. Graham
by AMM

Clyde Graham

Enclosures

STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
Brownwood Laterals Watershed
Structures Effecting Channel Improvement through Brownwood

ITEM	UNIT	SITE NUMBERS 1	1-A	2	2-A	3	4
Drainage	Sq.Mi.	2.72	3.25	3.87	2.03	8.84	5.29
Storage Capacity							
Sediment Pool	Ac.Ft.	132	139	198	78	400	219
Sed.in Det. Pool	Ac.Ft.	16	10	26	14	28	17
Floodwater Det.	Ac.Ft.	1,067	772	1,545	785	3,446	2,025
Total	Ac.Ft.	1,215	921	1,769	877	3,874	2,261
Elevation Top of Dam	Foot	1,446.3	1,413.4	1,479.7	1,554.7	1,472.4	1,425.1
Elevation Emergency Spillway	Foot	1,439.0	1,408.0	1,474.0	1,549.1	1,464.0	1,418.1
Percent Chance of Use	-	1.0	2.8	1.0	1.0	.09	1.0
Principal Spillway Capacity	C.F.S.	27	32	39	20	120	64
Capacity Equivalents							
Sediment Volume	Inch	1.02	.86	1.27	.85	.91	.84
Detention Volume	Inch	7.34	4.45	7.12	7.25	7.30	7.18
Spillway Storage	Inch	7.86	3.38	4.68	9.94	6.00	6.63
Class of Structure	-	C	A	C	C	C	C

Discharge Caused by 100-Year Frequency, 6-Hour Duration
Storm on Willis Creek and Adams Branch, Brownwood, Texas

Section Number	Station	Drainage Area Sq. Mi.	DISCHARGE C.F.S. Present Condition	DISCHARGE C.F.S. With Planned Structure
		Willis Creek		
W-1	301/92	25.42	14,270	6,280
W-3	266/42	23.67	13,600	5,485
W-7	232/34	22.88	13,360	5,130
W-11	197/85	10.94	8.590	1,710
W-14	124/17	9.62	7,920	720
W-19	94/83	9.17	7,715	345
W-21	76/35	9.00	7,630	230
W-22	25/00	8.84	7,550	90
		South Willis Creek		
W-11A	196/03	10.66	8,440	4,210
W-24	197/33	9.32	7,820	3,340
W-28	169/17	9.22	7,735	3,260
W-36	92/34	5.29	5.560	50
		Adams Branch		
A-1	340/13	15.28	10,820	4,560
A-11	306/30	14.91	10,650	4,370
A-13	291/04	10.04	8,400	3,360
A-20	248/44	8.58	7,650	2,340
A-24	226/00	8.46	7,570	2,240
		Williams Branch		
W-1	292/86	4.52	5,240	2,020
W-7	263/89	4.34	5,080	1,830
W-10	236/40	3.74	4,660	1,240
W-14	163/40	2.72	3.830	30

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P. O. Box 648
Temple, Texas 76502

November 14, 1963

Colonel F. P. Koisch, District Engineer
U. S. Army Corps of Engineers
Post office Box 1600
Fort Worth, Texas 76101

Dear Colonel Koisch: Attention: Mr. Kermit Speeg

Items which it was agreed would be furnished you at our meeting on Pecan Bayou planning activities October 24, 1963, are enclosed.

The construction cost of existing floodwater retarding structures which will be physically affected by the proposed Coleman Reservoir, the proposed Coleman Reservoir moved downstream, and the Camp Colorado site, is shown on Table 1.

This table shows the estimated extent that floodwater retarding structures are affected and an estimate of total damage to the structures if the major reservoir were built.

Table 2 shows the estimated annual benefits, in areas inundated by the proposed major reservoirs, that will accrue to floodwater retarding structures. These have been tabulated by evaluation reaches. The percent of area covered was based on the estimated area below the ten-year flood frequency level.

Table 3 tabulates, by evaluation reaches, the estimated annual benefits in the area inundated by the major reservoir sites that were allocated to floodwater retarding structures physically affected by the major reservoirs. These are benefits allocated to the site multiplied by the percent the site is physically affected.

For comparative purposes the construction cost of existing floodwater retarding structures physically affected by the major reservoirs has been amortized for 50 years at three percent. Comparative monetary effects of the major reservoir sites are shown on Table 4. This comparative analysis indicates that the Coleman site moved downstream would have the least effect on the existing SCS Work Plan on Jim Ned Creek Watershed. Effects on this site are based on an assumed conservation pool elevation of 1724 feet and an emergency spillway crest elevation of 1744 feet. Also, it may be possible to further reduce the detrimental effects of the Coleman Reservoir by considering a reduction of flood storage requirements to the extent upstream floodwater retarding structures are effective. This would reduce the damage to existing structures in the Jim Ned Creek Watershed.

A similar reduction in the Pecan Bayou site may result in a more acceptable site to local organizations.

The towns of Clyde and Cross Plains are presently considering the addition of conservation storage to floodwater retarding structure sites being planned in the Upper Pecan Bayou Watershed. If these materialize, local need for planned storage in Pecan Bayou site will be decreased. If the damage to existing structures in the Jim Ned Creek Watershed are excessive, you may want to consider using the Pecan Bayou site to supply the town of Coleman's future water needs and drop the sites on Jim Ned Creek from consideration.

The non-federal cost of channel improvement on Pecan Bayou mainstem is approximately 1.5 million dollars. Protection from a lesser flood may be more acceptable to the local people. A further reduction in improved channel cost would result from the consideration of effects that the floodwater retarding structures located between Lake Brownwood and the proposed major reservoirs will have on discharges through the spillway of Lake Brownwood.

In the interest of coordination between the Corps of Engineers and the Soil Conservation Service, we feel that these suggestions should be incorporated fully in the Pecan Bayou Report. Also, we feel that every effort should be made to supply future needs of the cities of Coleman and Brownwood from the Pecan Bayou Reservoir. This would eliminate duplication of Federal investments on Jim Ned Creek.

Sincerely yours,

/s/ H. N. Smith

H. N. Smith
State Conservationist

Enclosures (4)

TABLE 1

CONSTRUCTION COST OF EXISTING FLOODWATER RETARDING STRUCTURES
PHYSICALLY AFFECTED BY THE PROPOSED COLEMAN RESERVOIR

Floodwater Retarding Structure No.	Contract (dollars)	Eng. Services and Other (dollars)	Total (dollars)	Extent Affected (percent)
11	182,164	35,000	217,164	100
21	339,673	48,483	388,156	90
22	80,942	15,070	96,012	100
12	171,994	43,049	215,043	0

Total damage with Coleman Reservoir as planned $662,516
Total damage with spillway changed to opporite end of dam $566,504

CONSTRUCTION COST OF EXISTING FLOODWATER RETARDING STRUCTURES
PHYSICALLY AFFECTED BY THE PROPOSED COLEMAN RESERVOIR MOVED DOWNSTREAM
Elevation, Conservation Pool 1724; Emergency Spillway Crest 1744

Floodwater Retarding Structure No.	Contract (dollars)	Eng. Services and Other (dollars)	Total (dollars)	Extent Affected (percent)
9	44,691	10,013	54,704	100
10	38,481	7,896	46,377	100
11	182,164	35,000	217,164	40
21	339,673	48,483	388,156	10
22	80,942	15,070	96,012	100

Total damage to sites $322,775

CONSTRUCTION COST OF EXISTING FLOODWATER RETARDING STRUCTURES
PHYSICALLY AFFECTED BY THE CAMP COLORADO RESERVOIR SITE

Floodwater Retarding Structure No.	Contracts (dollars)	Eng. Services and Other (dollars)	Total (dollars)	Extent Affected (percent)
25	96,726	20,900	117,626	50

Total damage to site $58,813

TABLE 2

ESTIMATED ANNUAL BENEFITS IN AREAS INUNDATED BY PROPOSED MAJOR RESERVOIRS THAT WILL ACCRUE TO FLOODWATER RETARDING STRUCTURES

Evaulation Reach	Damage Reduction Benefits (dollars)	Area Covered (percent)	Total Lost (dollars)
	COLEMAN SITE		
R-3	12,044	100	12,044
R-2	15,027	50	7,513
		Total	19,557
	COLEMAN SITE MOVED DOWNSTREAM		
R-3	12,044	100	12,044
R-4	37,967	20	7,593
		Total	19,637
	CAMP COLORADO SITE		
R-4	37,967	25	9,492
R-5	68,314	50	34,157
R-7	3,694	10	369
R-8	6,740	25	1,685
		Total	45,705

TABLE 3

ESTIMATED ANNUAL BENEFITS IN MAJOR RESERVOIR SITES ALLOCATED TO FLOODWATER RETARDING STRUCTURES PHYSICALLY AFFECTED BY PROPOSED MAJOR RESERVOIRS

COLEMAN SITE

Evaluation Reach No.	Site 11	Site 21	Site 22	Total
3	1223	3877	0	5100

COLEMAN SITE MOVED DOWNSTREAM

Evaluation Reach No.	Site 9	Site 10	Site 11	Site 21	Site 22	Total
3	381	287	1223	3877	0	
4	210	150	682	1683	498	
Total	591	437	1905	5560	498	8991

CAMP COLORADO SITE

Reach No.	Site 25
5	4037

TABLE 4

COLEMAN SITE AS PLANNED

Annual damage to sites	$25,752
Annual damage to benefited area	19,557
Total	45,309
Less allocated benefit	5,100
	$40,209

COLEMAN SITE WITH SPILLWAY CHANGED

Annual damage to sites	$22,020
Annual damage to benefited area	19,557
Total	41,577
Less allocated benefit	5,100
	$36,477

COLEMAN SITE MOVED DOWNSTREAM

Annual damage to sites	$12,546
Annual damage to benefited area	19,637
Total	32,183
Less allocated benefit	8,991
	$23,192

CAMP COLORADO SITE

Annual damage to site	$ 2,286
Annual damage to benefited area	45,705
Total	47,991
Less allocated benefit	4,037
	$43,954

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

SWFGB

18 November 1963

Mr. H. N. Smith
State Conservationist
U. S. Soil Conservation Service
P. O. Box 648
Temple, Texas 76502

Dear Mr. Smith:

This is to acknowledge receipt of your letters of 5 November and 14 November 1963, concerning data to be furnished this office in regard to the effects of multiple reservoirs on Jim Ned Creek on your existing flood-detention program.

It is noted that all data to be furnished this office, as listed in your letter of 5 November 1963, is contained in your letter of 14 November 1963, except for item 5, described as "Flood reduction benefits allocated to floodwater retarding structures physically affected by the proposed major reservoirs." The data listed under item 5 of your letter of 5 November 1963 is essential for completing analyses of multiple-purpose reservoirs on Jim Ned Creek. During telephone conversation between your Mr. Jim Cunningham and our Mr. Kermit Speeg on 15 November 1963, it was agreed that this data would be furnished as soon as possible.

Your cooperation in furnishing the information contained in your letters of 5 November and 14 November 1963 is appreciated.

Sincerely yours,

/s/ Dallas L. Knoll, Jr.

DALLAS L. KNOLL, JR.
Lt Col, CE
Executive Officer

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P. O. BOX 648
Temple, Texas 76502

December 3, 1963

Colonel F. P. Koisch, District Engineer
U. S. Army Corps of Engineers
100 West Vickery Blvd.
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Koisch:

This is in reply to your letter of November 18, 1963, concerning flood reduction benefits previously allocated to floodwater retarding structures affected by the proposed major reservoirs.

Table 3 attached to my letter of November 14, 1963, presented damage reduction benefits allocated to affected floodwater retarding structures from within the pool areas of the proposed major reservoirs. Additional damage reduction benefits attributable to the affected structures accrue on the flood plan downstream from the proposed major reservoirs. These benefits are shown below and should be added to the reservoir area benefits appearing in Table 3.

COLEMAN RESERVOIR SITE

Site 11	Site 21	Site 22	Total
$5,615	$14,850	$3,957	$24,422

COLEMAN SITE DOWNSTREAM

Site 9	Site 10	Site 11	Site 21	Site 22	Total
$591	$1,114	$4,933	$13,167	$3,459	$23,264

CAMP COLORADO SITE

Site 25
$8,797

If we can furnish additional information, please let me know.

Sincerely yours,

/s/ H. N. Smith

H. N. Smith
State Conservationist

Brownwood, Texas
November 15, 1963

Colonel F. P. Koisch, District Engineer
U. S. Army Engineer District, Fort Worth
Fort Worth, Texas

Dear Colonel Koisch:

On November 14, 1963, Mr. Kermit Speig and Mr. John Dixon from your office, met with representatives of the Brown County Water Improvement District No. One, the City of Brownwood and Brown County for the purpose of discussing the interest we have in a project resulting from your studies and investigations of the water problems of Pecan Bayou Watershed, Colorado River Basin, Texas.

This is to advise the Corps of Engineers that the officials of the three agencies, Brown County Water Improvement District No. One, City of Brownwood and County of Brown, are still interested and desire that the work continue on the project.

Sincerely yours,

BROWN COUNTY WATER IMPROVEMENT DIST. #1

By /s/ J. P. Keith
J. P. Keith, President

CITY OF BROWNWOOD

By /s/ W. L. Lampkin
W. L. Lampkin, Mayor

BROWN COUNTY COMMISSIONERS COURT

By /s/ William O. Breedlove
Wm. Breedlove, County Judge

CITY OF COLEMAN
COLEMAN, TEXAS

OFFICE OF
CITY MANAGER

November 14, 1963

Colonel F. P. Koisch, District Engineer
U. S. Army Engineers District, Fort Worth
P. O. Box 1600
Fort Worth, Texas

Dear Colonel Koisch:

At a meeting held, today, in the Council Room of the City Hall in the City of Coleman, Texas between members of your staff Messrs. John K. Dixon and K. V. Speeg and Coleman Mayor Foster Miller, Councilman George Robey, Joe Stevens, Dr. A. O. Brink, Lewis Barker, City Manager Walter L. Garland, City Secretary Noris Sneed, Public Relations Representative Jim Ferguson, Water Committeemen R. G. Hollingsworth, Y. B. Johnson, F. W. Taylor, Jr., and County Judge Frank Lewis, said meeting being called for discussion of the proposed Jim Ned Creek Reservoir in Coleman County, Texas.

During the discussion reference was made to a communication dated February 19, 1962 to the Central Colorado Soil Conservation District No. 517, % J. B. McCord, Chairman, Coleman, Texas, as follows:

> "Dear Sir:
>
> At a regular meeting of the Coleman City Council Saturday, February 17, 1962 with A. L. Hubbard, Councilman, and presiding as Mayor-pro-tem; Press Gallaway, Councilman; and George Robey, councilman, present, the writer was instructed to inform you that the City of Coleman has no active plans for the construction of the proposed Jim Ned Creek Reservoir.
>
> Yours very truly,
>
> Albert J. Pope
> City Manager"

This letter has apparently been misinterpreted as the City of Coleman is still in the position it was on June 13th, 1962, very interested, indeed, in the development of water resources on the Jim Ned Creek as a Municipal Water supply for home consumption and industrial use, for the City and County of Coleman, as we were at a meeting held on April 17th, 1962 in the offices of the U. S. Corp of Engineers in Fort Worth, Texas.

The conditions have really become acute at this time due to prolonged drouth conditions and our need for water for future development and existence.

Any effort made by you in our behalf will be greatly appreciated.

Sincerely yours,

City of Coleman

By /s/ Foster Miller

Foster Miller, Mayor

County of Coleman Commission Court

By /s/ Frank Lewis

Frank Lewis, County Judge

Central Colorado River Authority

By /s/ R. G. Hollingsworth

R. G. Hollingsworth, Chairman

TEXAS WATER COMMISSION
P. O. Box 2311
Capitol Station
Austin 11, Texas

November 15, 1963

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

Dear Colonel Koisch:

By letter of 27 August, 1963, you transmitted four copies of your "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas" for review.

Copies of the report were transmitted by our agency to the Texas State Department of Health, the Texas Highway Department, and the Parks and Wildlife Department. A copy of the comments received from each of these agencies is enclosed.

The report includes recommendations for authorization of the following, in lieu of the previous authorized Enlargement of Lake Brownwood:

1. Replacement of Lake Brownwood Dam with a new embankment and outlet facilities a short distance below the existing dam; and remedial work to the present spillway.

2. A multiple-purpose reservoir at the Coleman site on Jim Ned Creek and a multiple-purpose reservoir at the Pecan Bayou site on Pecan Bayou.

3. Channel improvements for purposes of local flood protection along Pecan Bayou, Adams Branch, and Willis Creek at Brownwood.

The two proposed reservoirs each have an amount of conservation storage allocated for water quality maintenance. It is our understanding that the report proposes releases from either or both of these reservoirs, if constructed, which would flow into Brownwood Reservoir and this portion of the inflow to Brownwood Reservoir would be released to meet water quality maintenance needs estimated for the reach of Pecan Bayou downstream from Brownwood Dam.

While the report does not contain a recommended sequence of construction of the four units, it would appear that the condition of the existing outlet facilities of Brownwood Dam suggests the replacement of Brownwood Dam, and downstream channel improvements would be most appropriate as the initial unit.

With respect to proposed water quality objectives, your attention is invited to the comments of the State Department of Health concerning the effectiveness of existing treatment facilities of the City of Brownwood.

Future water requirements for the area were made on a regional basis and indicate existing facilities are capable of supplying regional requirements to some period after 1970. It is noted that the Public Health Service projection of population (Fig. 3, Appendix V) contains an abrupt change in the population trend line at the year 1960 for both municipal and total populations of their study area. While such a reversal is possible, it appears that a more gradual transition would occur. With a more gradual transition, regional water requirements would not increase as rapidly as projected. Under such circumstances, the existing regional facilities would have the capability of meeting the adjusted regional needs until after 1980.

It is recognized that consideration of regional water requirements often do not adequately reflect individual problem areas. Existing facilities for Coleman will not be adequate to serve their municipal and industrial needs.

The Texas Water Commission included a proposed reservoir on Jim Ned Creek in its report "A Plan for Meeting the 1980 Water Requirements of Texas." This proposed reservoir site is upstream from the Coleman Reservoir site contained in your report. The City of Coleman has a water permit (Number 1924) from this Agency for the construction of the project contained in our 1980 Planning Report. The City of Coleman may desire to reconsider its proposed project (40,000 acre-feet of storage) and participate in the Coleman Reservoir project proposed by the Corps of Engineers (138,500 acre-feet of conservation storage). It would appear that the Brown County Water Improvement District No. 1 may also desire to participate in the proposed Coleman Reservoir.

The opportunity for this review is appreciated.

Sincerely yours,

/s/ John J. Vandertulip

John J. Vandertulip
Chief Engineer

Enclosures (3)

TEXAS STATE DEPARTMENT OF HEALTH
Austin, Texas

September 25, 1963

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

ATTN: Mr. John J. Vandertulip
Chief Engineer

Dear Mr. Carter:

This is to acknowledge receipt of your letter of September 3, 1963, requesting preliminary review and comments on the report "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas", by the Fort Worth District Office, Corps of Engineers.

We have reviewed the report and, at this time, have only one exception to call to your attention. Paragraph "C" on Page 47, "Water Quality Control" contains the statement, "Studies indicate that organic pollution in the reach of Pecan Bayou downstream from the City of Brownwood exceeds the assimilative capacity of the stream and will require release of water from storage to maintain an acceptable oxygen balance in the stream." We note in the data section of the report that these remarks appear to be credited to a Bendix G-15 computer. The computations were apparently based on a desired total solids value of less than 500 parts per million and a dissolved oxygen value of more than 4.0 parts per million.

We realize the value of water releases in order to maintain adequate water quality, but do not think this should be predicated primarily on "organic pollution -- from the City of Brownwood." Neither our central office files nor the regional office files contain reports of chronic pollution below Brownwood. A recent investigation by our regional office including samples from various points of the sewage treatment works, Willis Creek, and Pecan Bayou, indicate no pollution and presence of desirable fish life above and below the point of outfall. It is for this reason, that we suggest that the paragraph in question be re-worded so as to not place any undue blame on the City of Brownwood, which actually has very effective secondary treatment of sewage.

We trust that the above comments may be of some assistance to you in the preparation of your comments to the Corps of Engineers.

Very truly yours,

/s/ N. E. Davis

N. E. Davis, Chief Engineer
Field Investigations
Division of Water Pollution Control

NED:go

cc: Region VI

THROUGH:

/s/ G. R. Herzik, Jr.

G. R. Herzik, Jr., C.E., Chief
Environmental Sanitation Services

TEXAS HIGHWAY DEPARTMENT
Austin 14, Texas

September 25, 1963

In reply refer
to File No. D-5

Brown County
Pecan Bayou Watershed Development Projects

Mr. John J. Vandertulip
Chief Engineer
Texas Water Commission
P. O. Box 2311
Capitol Station
Austin 11, Texas

Dear Mr. Vandertulip:

Reference is made to your letter dated September 3, 1963 requesting our comments on the draft copy, "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas," dated July, 1963 as prepared by the Fort Worth District Office, Corps of Engineers. The Department is pleased to have the opportunity to express its views prior to final editing of the report.

Apparently, the construction of the proposed Coleman Reservoir and Pecan Bayou Reservoir will not affect our highway system. Nor does it appear that relocation or adjustment of any highways will be required for the Reconstructed Lake Brownwood project.

The Brownwood Channel Improvement feature, however, will affect several highways as is indicated by the report. From the information shown on pages I-75 and I-77 of the report, it would appear that all the affected highways involved have been covered with the exception of a necessary relocation of FM 2525 at its intersection with US 67. Our estimate of the cost for such relocation is $10,000.

The existing US 377 bridge over Adams Creek consists of four 25 ft. Slab Spans on a 30° skew with a 78 ft. width from face of rail to face of rail. The existing structure is suitable for lengthening. However, the lengthened portion probably should be 230 ft. instead of the additional 200 ft. indicated by the report in order to accommodate the skew.

The existing FM 2126 bridge over Pecan Bayou consists of two 40 ft. Concrete Girder Spans and one 164 ft. Continuous Concrete Girder Unit with a width of 31 ft. from face of rail to face of rail. While the structure is suitable for lengthening, it will be necessary to remove the two 40 ft. end spans due to shallow pile tips.

The existing US 67 bridge over Pecan Bayou consists of two 32.5 ft. Concrete Girder end spans and one 205 ft. Continuous Concrete Girder Unit which have been previously widened to 66 ft. between faces of rail with Concrete Girders and later by I-Beams. This structure is also suitable for lengthening.

The total estimated cost shown in the report for all the highways affected appears to be adequate. However, it is certain to be necessary to redistribute the costs according to the individual crossings involved at the time that final plans are made since at the present state of preliminary planning, sufficient detail is lacking to accurately predict the method of alteration or modification of each structure.

We wish to emphasize that Highway Department funds may not be expended for work of this nature thus underscoring the responsibility for costs of relocations by local interests as the report clearly indicates.

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

Yours truly,

D. C. Greer
State Highway Engineer

By: /s/ Clyde F. Silvus

Clyde F. Silvus
Bridge Engineer

MLY:sw

PARKS AND WILDLIFE DEPARTMENT
John H. Reagan Building
Austin, Texas 78701

September 26, 1963

Mr. John J. Vandertulip
Chief Engineer
Texas Water Commission
Austin, Texas

Dear Mr. Vandertulip:

Reference is made to your letter of September 3, 1963, in which you requested the comments of the Parks and Wildlife Department concerning the "Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas," dated July 1963, which was prepared by the Fort Worth District Office, U. S. Army Corps of Engineers. You indicated that these comments were needed for a preliminary review.

Your attention is directed to Appendix VII of the above referenced review report and the Report on Fish and Wildlife Resources, Pecan Bayou Watershed as prepared by the Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, for the U. S. Army Engineer District, Fort Worth, Corps of Engineers, Fort Worth, Texas. This report was dated January 14, 1963.

A review of material presented in Appendix VII reveals that information included was concurred in by this agency by letter of May 4, 1961 by Mr. H. D. Dodgen, Executive Secretary, Texas Game and Fish Commission, and by letter of October 23, 1962, signed by Eugene A. Walker, Director, Program Planning.

We have no suggestions for additions or deletions in the review report as included in Appendix VII.

Sincerely yours,

/s/ Eugene A. Walker

Eugene W. Walker, Director
Program Planning

EAW:em

REVIEW OF REPORTS
ON
PECAN BAYOU WATERSHED
COLORADO RIVER BASIN, TEXAS

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

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

2. WATER PROBLEMS.- The principal water problems on Pecan Bayou and tributaries result from frequent occurrence of floods, possible failure of existing Lake Brownwood, and prolonged drought periods. Questionable stability of the embankment, a safety factor well below present day standards, and spillway erosion threaten to cut short existing Lake Brownwood's useful life. Failure of this reservoir would bring about an extremely critical water shortage for the area of Brownwood. Periods of prolonged drought, upward trends in population, and expansion of industrial and municipal developments have made evident the increasing need for the conservation of surface runoff for all beneficial purposes in the Pecan Bayou watershed and adjacent areas.

3. FLOOD PROBLEM.- A flood problem exists on Pecan Bayou within the investigated reach from the proposed reservoir sites to its mouth and immediate reaches below its mouth on the Colorado River, where an agricultural area devoted principally to farming and ranching is subjected to damage by flood flows originating on the Pecan Bayou watershed. The most serious flood problem occurs in the city of Brownwood where urban developments within the flood plains of Pecan Bayou, Adams Branch, and Willis Creek, are subject to appreciable damages from frequent overflows. The drainage area between Lake Brownwood and the city of Brownwood is great enough to create floods without any spill from the reservoir. The discharge capacity of the spillway is considered inadequate to prevent overtopping of the dam under extreme flood conditions, and the stability of the dam is below the safety factor of present day embankment construction. Either condition can cause complete failure of the existing reservoir which in turn can result in considerable loss of life, particularly if failure occurred in the night.

4. WATER SUPPLY PROBLEM.- A public hearing was held at Brownwood, Texas, September 11, 1946, during which local interest stated their desires for the preservation of the existing water supply for municipal, industrial and agricultural purposes. A public hearing was held at Ballinger, Texas, on May 22, 1962, during which the Brown County Water Improvement District No. 1 indicated its approval of as many reservoirs as could be economically justified on Pecan Bayou for flood control and

water conservation. Water supply studies by the U. S. Public Health Service indicate there will be water supply deficiencies in the Pecan Bayou watershed as follows: 1980, 1.8 mgd, 2.8 cfs; 2020, 10.6 mgd, 16.4 cfs; and 2070, 21.3 mgd, 33.0 cfs. In view of the above deficiencies, storage for water supply purposes, in the maximum amounts which can be economically provided, should be included in all multiple-purpose reservoir projects planned by the Corps of Engineers on Pecan Bayou and its tributary system.

5. RECOMMENDED PLAN OF IMPROVEMENT.- The District Engineer recommends in lieu of the authorized plan for enlargement of existing Lake Brownwood, that a plan of improvement for the Pecan Bayou watershed be authorized to provide for the construction of protective measures for establishment of a reconstructed Lake Brownwood, Brownwood Channel Improvements, and multiple-purpose Coleman and Pecan Bayou Reservoirs for flood control, water supply, water quality control, and fish-wildlife and general recreation. The foregoing to be accomplished with such changes and modifications as in the discretion of the Chief of Engineers may be advisable at an estimated total Federal construction cost of $36,751,000 and annual charges (including annual maintenance and operation costs of $210,000) of $1,425,500, subject to reimbursement by Federal and non-Federal interests of project costs allocated to flood control and water supply, respectively. Pertinent data for the proposed plan is shown in table 1.

6. PROJECT COST AND ECONOMIC ANALYSIS.- The recommended Pecan Bayou projects would have a total estimated first cost of $43,433,000 on the basis of July 1963 price levels. Individual first costs per project are as follows: reconstructed Lake Brownwood, $7,300,000; Coleman Reservoir, $11,890,000; Pecan Bayou Reservoir, $10,520,000; Brownwood Channel Improvements, $13,723,000. The estimated annual charges shown in the report are $1,761,500, consisting of $1,436,500 for interest and amortization, and $325,000 for maintenance and operation. The Federal Government is to be refunded project costs allocated to water conservation in the Pecan Bayou and Coleman Reservoirs. Non-Federal interests would be refunded annual maintenance and operation costs allocated to flood control in the reconstructed Lake Brownwood. The interest and amortization were computed on 3.00 percent, 100-year life, and a construction period of three years.

7. BENEFITS AND BENEFIT-COST RATIO.- The annual charges, annual benefits, and benefit-cost ratio for 50-year and 100-year economic life are summarized in table 2.

8. PHYSICAL FEASIBILITY AND PROVISIONS FOR FUTURE NEEDS.- The proposed plan is designed to satisfy various water and related land resource needs of the Pecan Bayou watershed. The plan involves a correlation of the existing and proposed improvements to efficiently serve present and future needs. The plan was determined to be physically and economically feasible and to be the most economical of all plans

TABLE 1

PERTINENT DATA FOR PROPOSED PLAN
PECAN BAYOU WATERSHED

Item	Reservoirs: Reconstructed Lake Brownwood	Reservoirs: Pecan Bayou Reservoir	Reservoirs: Coleman Reservoir
DAM			
Location, river mile	57.1	100.8	52.2
River	Pecan Bayou	Pecan Bayou	Jim Ned Creek
Drainage area, sq. mi.	1,544	316	287
Type	Compacted earth fill	Compacted earth fill	Compacted earth fill
Length (feet)	1,850	14,700	16,060
Height (feet)	129	107	156
Freeboard (feet)	4.9	5.6	5.7
Crown width (feet)	20	20	20
SPILLWAY			
Type	Broadcrested	Broadcrested	Broadcrested
Control	Uncontrolled	Uncontrolled	Uncontrolled
Length	480	800	600

RESERVOIR	Reconstructed Lake Brownwood: Elevation (ft. msl)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Pecan Bayou Reservoir: Elevation (ft. msl)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Coleman Reservoir: Elevation (ft. msl)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
Top of dam	1469.0	--	--	--	1676.0	--	--		1812.0	--	--	--
Maximum design water surface	1464.1	30,600	812,100	9.86	1670.4	12,010	379,700	22.53	1806.3	7,360	382,000	24.96
Top of flood control pool and spillway crest	--	--	--	--	1653.0	8,030	206,300	12.24	1784.0	5,430	240,900	15.74
Top conservation pool	1425.0	7,570	124,600	1.51	1637.0	5,150	102,000	6.05	1764.0	3,930	147,600	9.64
Sediment storage	1425.0	--	33,000	0.40	1653.0	--	10,100	0.60	1784.0	--	10,300	0.67

Item	Pecan Bayou	Brownwood Channels: Adams Branch	Brownwood Channels: Willis Creek
IMPROVEMENTS			
River mile limits, main stem	PB 37.8 - PB 47.6	AB 3.0 - AB 6.1	WC 0.0 - WC 3.9
River mile limits, cutoff	WS 1.5 - PB 47.5	AB 3.0 - PB 46.9	
River mile limits, cutoff		TWB 0.3 - AB 4.0	
DRAINAGE AREA			
Head of improvement, sq. mi.	1,621.0	8.6	11.2
CHANNEL IMPROVEMENTS			
Existing length (main channel), mi.	9.8	6.1	3.9
Improved length (main channel), mi.	7.3	2.9	3.0
Average depth, feet	32	18	18
Bottom width, feet	300, 25 (WS)	90, 50, 25(TWB)	70, 80, 60, 40
Clearing			
Width, feet	290 - 460	75 - 200	120 - 160
Area, acres	413	40	69
RIGHTS-OF-WAY			
Land area, acres	500	112	100

Legend
- AB - Adams Branch
- PB - Pecan Bayou
- SWC - South Willis Creek
- TWB - Tom Williams Branch
- WC - Willis Creek
- WS - West Slough

TABLE 2

ANNUAL CHARGES, ANNUAL BENEFITS AND BENEFIT-COST RATIO
50-YEAR AND 100-YEAR ECONOMIC LIFE
PECAN BAYOU WATERSHED
(Interest rate, 3% - Amortization period, 100 yrs)

Item	Reservoirs: Reconstructed: Lake Brownwood	Reservoirs: Coleman	Reservoirs: Pecan Bayou	Brownwood Channels
BASED ON ECONOMIC LIFE OF 50-YEARS				
AVERAGE ANNUAL COSTS				
Investment costs	$289,000	$482,900	$416,500	$557,400
Maintenance, operation & replacement	45,000	103,000	107,000	70,000
Total	341,600	585,900	534,300	627,400
AVERAGE ANNUAL BENEFITS				
Flood prevention	557,700	181,800	206,500	827,000
Water supply	179,800	216,300	183,900	--
Water quality control	--	27,600	27,600	--
Recreation	--	524,500	524,500	--
Total	737,500	950,200	942,500	827,000
RATIO OF BENEFITS TO COST	2.2	1.6	1.8	1.3
BASED ON ECONOMIC LIFE OF 100-YEARS				
AVERAGE ANNUAL COSTS				
Investment costs	241,400	393,300	347,900	453,900
Maintenance, operation & replacement	45,000	103,000	107,000	70,000
Total	286,400	496,300	454,900	523,900
AVERAGE ANNUAL BENEFITS				
Flood prevention	637,300	207,200	235,700	947,400
Water supply	191,000	229,700	195,300	--
Water quality control	--	29,400	29,400	--
Recreation	--	676,800	676,800	--
Total	828,300	1,143,100	1,137,200	947,400
RATIO OF BENEFITS TO COST	2.9	2.3	2.5	1.8

Reconstructed Lake Brownwood includes protective measures and usable existing lands and facilities considered. The provisions for present and future needs are summarized briefly in the following subparagraphs:

a. The proposed Lake Brownwood protective measures are urgently needed to prevent possible failure of the existing dam under extreme flood conditions, and thus, to prevent catastrophic flood conditions and loss of lives within the downstream area. Protective measures would extend the useful life of Lake Brownwood and insure its continued operation as an effective means in reducing flood peaks and damages within the downstream area, even though controlled flood storage space is not specifically dedicated.

b. The proposed Brownwood Channel Improvement project, operating with reconstructed Lake Brownwood but without the proposed Coleman and Pecan Bayou Reservoirs, would provide about 100-year-frequency flood protection to a substantial portion of the existing and future Brownwood urban area.

c. The proposed Coleman and Pecan Bayou Reservoirs would provide for the control of 50-year-frequency floods originating upstream from the respective dam sites, and thus, would afford general reduction in flood flows and damages along Pecan Bayou and Jim Ned Creek, including the Lake Brownwood shoreline area and Pecan Bayou at Brownwood.

d. Based on projected conditions of flood plain development with Hords Creek Reservoir and the potential system of Soil Conservation Service reservoirs as the only existing improvements, the addition of the proposed plan of improvement, including a reconstructed Lake Brownwood, would eliminate about 85 percent of the aggregate average annual damages within the total flood plains investigated for this report.

e. Based on projected conditions of flood plain development during the period 1970-2070 with Hords Creek Reservoir, the potential system of Soil Conservation Service reservoirs, and a reconstructed Lake Brownwood in operation, the addition of the Brownwood Channel Improvements and the Pecan Bayou and Coleman Reservoirs would eliminate about 97 percent of the average annual damages within the improved channel reaches of Pecan Bayou, Adams Branch, and Willis Creek at Brownwood.

f. The proposed plan of improvement will assist substantially in meeting the overall water supply needs of the Pecan Bayou watershed during the period 1970 through 2070. Water supply of 14.8 mgd (or 16,500 acre-feet per annum) is needed to irrigate 5,000 acres of existing arable lands within the boundaries of the Brown County Water Improvement District No. 1. Based on projections of population and urban developments, the municipal and industrial water supply needs on the Pecan Bayou watershed will increase from about 6.3 mgd in year 1970 to about 26.6 mgd in year 2070. Completion of a reconstructed

Lake Brownwood would insure continued use of the principal source of water supply on the Pecan Bayou watershed for municipal, industrial, non-municipal, and irrigation purposes. The existing available water supplies in the Pecan Bayou watershed, consisting of Hords Creek Reservoir, developed ground-water sources, and a reconstructed Lake Brownwood, would provide an aggregate dependable supply of about 23.7 mgd. The existing supply is adequate to meet the water requirements of the watershed as a whole to about year 1970, but the supply sources are not located to efficiently serve the increasing needs of areas upstream from Lake Brownwood, such as the city of Coleman. The proposed plan of improvement tentatively provides for completion and operation of the Coleman and Pecan Bayou Reservoirs by year 1970, or at such time that additional water supply is needed. The proposed Coleman and Pecan Bayou Reservoirs would provide for the maximum economical development of the water supply resources of the Pecan Bayou watershed upstream from the respective dam sites. The proposed Coleman and Pecan Bayou Reservoirs together with return flows into Lake Brownwood resulting from water supply utilized from the Coleman and Pecan Bayou Reservoirs would provide additional total dependable water supply yields of about 15.8 mgd in year 2020 and 17.7 mgd in year 2070. The aforementioned total existing and proposed water supply sources would provide sufficient dependable supply to meet projected total needs of 40.8 mgd in year 2050, or to meet about 92 percent of the projected total watershed requirements to year 2070. The construction of the Coleman and Pecan Bayou Reservoirs would not completely solve, but would lessen, the problems of distribution within the upper Pecan Bayou watershed. Because of the distribution problem and the increasing water needs of the city of Coleman and other upstream areas, construction of the Coleman Reservoir will be required in the near future.

g. Water quality control is an important purpose in the proposed plan. Based on recommendations of the U. S. Public Health Service, the plan of improvements provides an average water supply of about 2.1 mgd for water quality control. Such provision will afford continuous or occasional releases from reservoir storage to effectively reduce concentration of pollutants on Pecan Bayou downstream from the city of Brownwood. The proposed plan predicates releases from the Coleman and Pecan Bayou Reservoirs, with regulation from reconstructed Lake Brownwood.

h. A complete water plan for the Pecan Bayou watershed to year 2070 would require use of return flows entering Lake Brownwood, additional ground-water development, and imports from reservoirs being investigated on the main stem of the Colorado River. Water-use plans for Brown, Coleman, and Callahan Counties for years 2020 and 2070 are suggested in the U. S. Public Health Service report.

i. The Pecan Bayou area is fortunately endowed with recreational areas and facilities at Lake Brownwood and Hords Creek

Reservoir. A reconstructed Lake Brownwood would insure continued use of existing private, commercial, and state-park recreational facilities within the Lake Brownwood shoreline area. Hords Creek Reservoir and reconstructed Lake Brownwood would continue to serve a current visitation estimated to be at least 1,000,000 persons annually. The recreational and fish-wildlife facilities proposed for development in Coleman and Pecan Bayou Reservoirs would accommodate projected public recreational needs. The upstream reservoirs would provide recreational cpportunities for an expected average annual visitation of 2,000,000 persons during the period 1970-2070. Of this total, about 1,300,000 visitors are expected to participate in general recreation activities and about 700,000 visitors in fishing and hunting.

j. The proposed plan, including channel improvements and regular maintenance in urban Brownwood, will have notable value in the esthetic effect it provides by improved appearance. The Coleman and Pecan Bayou Reservoirs will give definite impetus toward further development of the immediate areas for public use.

9. EXTENT OF INTEREST IN THE PROJECT.- By letters dated 13 June and 19 June 1962, the cities of Brownwood and Coleman, Brown County and Coleman County Commissioners' Courts, Brown County Water Improvement District No. 1, and the Central Colorado River Authority indicated tentative approval of the proposed plan of improvement and proposed action to establish, under the laws of the State of Texas, an agency to qualify as the responsible agency with which the Federal Government can negotiate in regard to the necessary items of local cooperation.

10. ALLOCATION OF COST.- The results of cost allocations for reconstructed Lake Brownwood and the Coleman and Pecan Bayou Reservoirs by the Separable Cost-Remaining Benefits method and by alternative methods listed in Senate Resolution 148, based on simultaneous conditions and on assumed economic lives of 50 and 100 years, are presented on tables 3, 4, and 5. Costs allocated to water supply (exclusive of water quality control) are the responsibility of local interest. A summary of allocated water supply costs to be borne by local interests is shown in the following tabulation:

Reservoir	First Costs	Percent	Annual M&O Charges	Percent
Lake Brownwood	$3,601,800	49.34	$22,000	48.89
Coleman	2,880,900	24.23	21,300	20.68
Pecan Bayou	2,186,100	20.78	19,500	18.22
Total	$8,668,800		$62,800	

The full local cooperation requirements for water supply 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 project and the annual cost of operation, maintenance, and replacements allocated to water conservation. Local cooperation requirements further provide that local interests be permitted to contribute their share of the construction cost (a) in lump sum prior to initiation of construction, (b) in annual amounts during the period of construction, proportioned 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 water supply, except that (1) no payment need be made with respect to storage for future water supply until such supply is first used, and (2) no interest shall be charged on such cost until such supply is first used, but in no case shall the interest-free period exceed 10 years. The 50-year limitation for payout may be considered applicable to the entire future demand storage, or to each of the progressive increments thereof as placed in service for water supply. Also, that local interest 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.

11. REPAYMENT ARRANGEMENTS.- Possible repayment arrangements for the water supply provisions in the recommended Pecan Bayou watershed projects are described in the preceding paragraph 10 above.

12. ALTERNATE PROJECT CONSIDERATIONS.- The most favorable general plans of improvement formulated and investigated for the Pecan Bayou watershed for purposes of flood control, water supply, stream-quality control, fish-wildlife and general recreation involved unit improvements, in sequence of importance, as follows: (a) protective measures for Lake Brownwood Dam; (b) channel improvements on Pecan Bayou, Adams Branch, and Willis Creek at the city of Brownwood; (c) enlargement of Lake Brownwood, or as alternates, upstream two-reservoir systems, consisting of one reservoir on Pecan Bayou at either the Burkett (mile 91.9) or Pecan Bayou (mile 100.8) sites and one reservoir on Jim Ned Creek at either the Camp Colorado (mile 26.2) or Coleman (mile 52.2) sites. Plans involving enlargement of Lake Brownwood would incorporate necessary protective measures for Lake Brownwood Dam. The plan of improvement determined to be most comprehensive and favorable for the Pecan Bayou watershed involves the construction of Lake Brownwood protective measures; Brownwood Channel Improvements; and the Coleman

TABLE 3

ALLOCATION OF COSTS
PROPOSED RECONSTRCUTED LAKE BROWNWOOD
PECAN BAYOU WATERSHED
(Costs in thousand dollars)

Item	Separable Cost-Remaining Benefits	Use of Facilities	Priority of Use	Incremental Cost
ECONOMIC LIFE OF 50 YEARS				
Allocations to flood control				
First cost	4,179.0 (57.25%)	2,097.0 (28.72%)	4,322.0 (59.21%)	3,238.0 (44.36%)
Annual cost of maintenance, operation, & replacement	23.4 (52.00%)	12.9 (28.72%)	26.6 (59.21%)	22.5 (50.00%)
Allocations to water supply				
First cost	3,121.0 (42.75%)	5,203.0 (71.28%)	2,978.0 (40.79%)	4,062.0 (55.64%)
Annual cost of maintenance, operation, & replacement	21.6 (48.00%)	32.1 (71.28%)	18.4 (40.79%)	22.5 (50.00%)
Allocations to water quality control				
First cost	-- --	-- --	-- --	-- --
Annual cost of maintenance, operation, & replacement	-- --	-- --	-- --	-- --
Allocations to recreation (fish & wildlife harvest included)				
First cost	-- --	-- --	-- --	-- --
Annual cost of maintenance, operation, & replacement	--	--	--	--
ECONOMIC LIFE OF 100 YEARS				
Allocations to flood control				
First cost	3,698.2 (50.66%)	2,095.0 (28.70%)	3,884.0 (53.20%)	3,238.0 (44.36%)
Annual cost of maintenance, operation & replacement	23.0 (51.11%)	12.9 (28.72%)	23.9 (53.20%)	22.5 (50.00%)
Allocations to water supply				
First cost	3,601.8 (49.34%)	5,205.0 (71.30%)	3,416.0 (46.80%)	4,062.0 (55.64%)
Annual cost of maintenance, operation & replacement	22.0 (48.89%)	32.1 (71.28%)	21.1 (46.80%)	22.5 (50.00%)
Allocations to water quality control				
First cost	-- --	-- --	-- --	-- --
Annual cost of maintenance, operation & replacement	-- --	-- --	-- --	-- --
Allocations to recreation (fish & wildlife harvest included)				
First cost	-- --	-- --	-- --	-- --
Annual cost of maintenance, operation & replacement	-- --	-- --	-- --	-- --

TABLE 4

ALLOCATION OF COSTS
PROPOSED COLEMAN RESERVOIR
PECAN BAYOU WATERSHED
(Costs in thousand dollars)

Item	Separable Cost-Remaining Benefits	Use of Facilities	Priority of use	Incremental Cost
ECONOMIC LIFE OF 50 YEARS				
Allocations to flood control				
First cost	3,136.6 (26.38%)	4,292.0 (36.10%)	2,701.0 (22.72%)	4,606.0 (38.74%)
Annual cost of maintenance, operation, & replacement	17.4 (16.89%)	28.0 (27.18%)	23.0 (22.72%)	30.0 (29.13%)
Allocations to water supply				
First cost	2,733.5 (22.99%)	3,868.0 (32.53%)	2,710.0 (22.79%)	5,021.0 (42.23%)
Annual cost of maintenance, operation, & replacement	20.1 (19.52%)	33.7 (32.72%)	24.0 (22.79%)	38.0 (36.89%)
Allocations to water quality control				
First cost	605.2 (5.09%)	958.0 (8.06%)	351.0 (2.95%)	523.0 (4.40%)
Annual cost of maintenance, operation, & replacement	3.0 (2.91%)	8.3 (8.06%)	3.0 (2.95%)	2.0 (1.94%)
Allocations to recreation (fish & wildlife harvest included)				
First cost	5,414.7 (45.54%)	2,772.0 (23.31%)	6,128.0 (51.54%)	1,740.0 (14.63%)
Annual cost of maintenance, operation, & replacement	62.5 (60.68%)	33.0 (32.04%)	53.0 (51.54%)	33.0 (32.04%)
ECONOMIC LIFE OF 100 YEARS				
Allocations to flood control				
First cost	3,576.5 (30.08%)	4,192.0 (35.26%)	3,097.0 (26.05%)	4,606.0 (38.74%)
Annual cost of maintenance, operation & replacement	21.0 (20.39%)	28.0 (27.18%)	26.8 (26.05%)	30.0 (29.13%)
Allocations to water supply				
First cost	2,880.9 (24.23%)	3,798.0 (31.94%)	2,877.0 (24.20%)	5,021.0 (42.23%)
Annual cost of maintenance, operation & replacement	21.3 (20.68%)	33.7 (32.72%)	24.9 (24.20%)	38.0 (36.89%)
Allocations to water quality control				
First cost	680.1 (5.72%)	939.0 (7.90%)	375.0 (3.15%)	523.0 (4.40%)
Annual cost of maintenance, operation & replacement	3.5 (3.40%)	8.3 (8.06%)	3.3 (3.15%)	2.0 (1.94%)
Allocations to recreation (fish & wildlife harvest included)				
First cost	4,752.5 (39.97%)	2,961.0 (24.90%)	5,541.0 (46.60%)	1,740.0 (14.63%)
Annual cost of maintenance, operation & replacement	57.2 (55.53%)	33.0 (32.04%)	48.0 (46.60%)	33.0 (32.04%)

TABLE 5

ALLOCATION OF COSTS
PROPOSED PECAN BAYOU RESERVOIR
PECAN BAYOU WATERSHED
(Costs in thousand dollars)

Item	Separable Cost-Remaining Benefits	Use of Facilities	Priority of use	Incremental cost
ECONOMIC LIFE OF 50 YEARS				
Allocations to flood control				
First cost	3,066.0 (29.14%)	4,158.0 (39.53%)	2,688.0 (25.55%)	4,491.0 (42.69%)
Annual cost of maintenance, operation, & replacement	22.5 (21.03%)	35.1 (32.80%)	27.4 (25.55%)	30.0 (28.04%)
Allocations to water supply				
First cost	2,092.0 (19.89%)	2,180.0 (20.72%)	1,988.0 (18.90%)	3,551.0 (33.75%)
Annual cost of maintenance, operation, & replacement	18.7 (17.47%)	23.9 (22.34%)	20.2 (18.90%)	34.0 (31.78%)
Allocations to water quality control				
First cost	426.0 (4.05%)	732.0 (6.96%)	305.0 (2.90%)	133.0 (1.27%)
Annual cost of maintenance, operation, & replacement	3.1 (2.90%)	8.0 (7.48%)	3.1 (2.90%)	3.0 (2.80%)
Allocations to recreation (fish & wildlife harvest included)				
First cost	4,936.0 (46.92%)	3,450.0 (32.79%)	5,539.0 (52.65%)	2,345.0 (22.29%)
Annual cost of maintenance, operation, & replacement	62.7 (58.60%)	40.0 (37.38%)	56.3 (52.65%)	40.0 (37.38%)
ECONOMIC LIFE OF 100 YEARS				
Allocations to flood control				
First cost	3,429.5 (32.60%)	4,038.0 (38.38%)	3,022.0 (28.73%)	4,491.0 (42.69%)
Annual cost of maintenance, operation, & replacement	25.7 (24.02%)	35.1 (32.80%)	30.7 (28.73%)	30.0 (28.04%)
Allocations to water supply				
First cost	2,186.1 (20.78%)	2,125.0 (20.20%)	2,077.0 (19.74%)	3,551.0 (33.75%)
Annual cost of maintenance, operation, & replacement	19.5 (18.22%)	23.9 (22.34%)	21.1 (19.74%)	34.0 (31.78%)
Allocations water quality control				
First cost	459.7 (4.37%)	715.0 (6.80%)	322.0 (3.06%)	133.0 (1.27%)
Annual cost of maintenance, operation, & replacement	3.4 (3.18%)	8.0 (7.48%)	3.3 (3.06%)	3.0 (2.80%)
Allocations to recreation (fish & wildlife harvest included)				
First cost	4,444.7 (42.25%)	3,642.0 (34.62%)	5,099.0 (48.47%)	2,345.0 (22.29%)
Annual cost of maintenance, operation, & replacement	58.4 (54.58%)	40.0 (37.38%)	51.9 (48.47%)	40.0 (37.38%)

and Pecan Bayou Reservoirs. Economic and cost comparisons of the alternate general plans are presented in table 6. The proposed plan was selected on the basis that it is the most favorable on the basis of economy; that it would be less costly and would provide the maximum amount of excess benefits over costs; and that, in comparison to the alternate plans, it would be substantially and comprehensively beneficial to the Pecan Bayou watershed with respect to purposes of flood control, water conservation, and fish-wildlife and general recreation.

Other alternate considerations involved the size of the Brownwood Channel Improvements for the selected plan. Studies determine that optimum size channels would provide about 57-year protection at Brownwood under conditions without the Pecan Bayou and Coleman Reservoirs. However, even though the larger-size channels resulted in less excess benefits over costs, channel sizes to provide 100-year flood protection (under conditions without Pecan Bayou and Coleman Reservoirs) were selected in view of the magnitude of potential Brownwood urban developments, the large increase in degree of local flood protection, and particularly in consideration of reducing loss of life and health hazards and of providing greater security against major flood conditions. In combination with the proposed Pecan Bayou and Coleman Reservoirs, the selected-size channel improvements would provide about 180-year protection at Brownwood against Pecan Bayou flood flows.

TABLE 6

SUMMARY OF ECONOMIC AND COST STUDIES
RECOMMENDED AND ALTERNATIVE PROJECTS

Plan	Storage: FC (acre-feet)	Storage: WC (acre-feet)	Dependable yield: CFS	Dependable yield: MGD	First cost	Annual charges	Annual Benefits	Benefit cost ratio	Excess benefits over cost
PLAN-COMPARISON STUDIES*									
(Reconstructed Lake Brownwood and Brownwood Channels in combination with Lake Brownwood Enlargement or alternate upstream reservoirs)									
13 (with Lake Brownwood Enlargement**)	413,900	315,200	91	58.8	$65,521,000	$2,387,900	$4,023,200	1.68	$1,635,300
14 (with Lake Brownwood Enlargement**)	419,400	719,800	116	75.0	75,491,000	2,760,900	4,259,100	1.54	1,498,200
19 (with Camp Colorado and Burkett Reservoirs)	274,800	414,400	91	58.8	53,851,000	2,055,500	4,129,800	2.01	2,074,300
20 (with Coleman and Pecan Bayou Reservoirs) (selected)	194,800	323,600	85	54.9	42,268,000	1,670,500	4,020,700	2.41	2,350,200
21 (with Coleman and Burkett Reservoirs)	206,300	370,700	88	56.9	45,856,000	1,782,800	4,059,100	2.28	2,276,300
22 (with Camp Colorado and Pecan Bayou Reservoirs)	268,300	367,300	88	56.9	50,246,000	1,943,200	4,094,300	2.11	2,151,100
SELECTED PLAN***									
(Reconstructed Lake Brownwood and Brownwood Channels in combination with Coleman and Pecan Bayou Reservoirs)									
20B (Brownwood Channels, 57-year protection)	194,800	323,600	56	36.2	41,021,000	1,681,700	4,043,000	2.40	2,361,000
20C (Brownwood Channels, 100-year protection)	194,800	323,600	56	36.2	43,433,000	1,761,500	4,056,000	2.30	2,294,500

*Plan-comparison studies were made using 2.875 percent interest, optimum-size channels (57-year protection), 20' dia. conduit in reconstructed Lake Brownwood.
**Lake Brownwood Enlargement includes Lake Brownwood protective measures.
***In selected plan a 10-foot diameter conduit in lieu of the 20-foot diameter conduit in reconstructed Lake Brownwood was used. Interest rate increased to 3 percent.

Legend
FC - Flood Control
WC - Water Conservation
CFS - Cubic Feet Per Second
MGD - Million Gallons Daily

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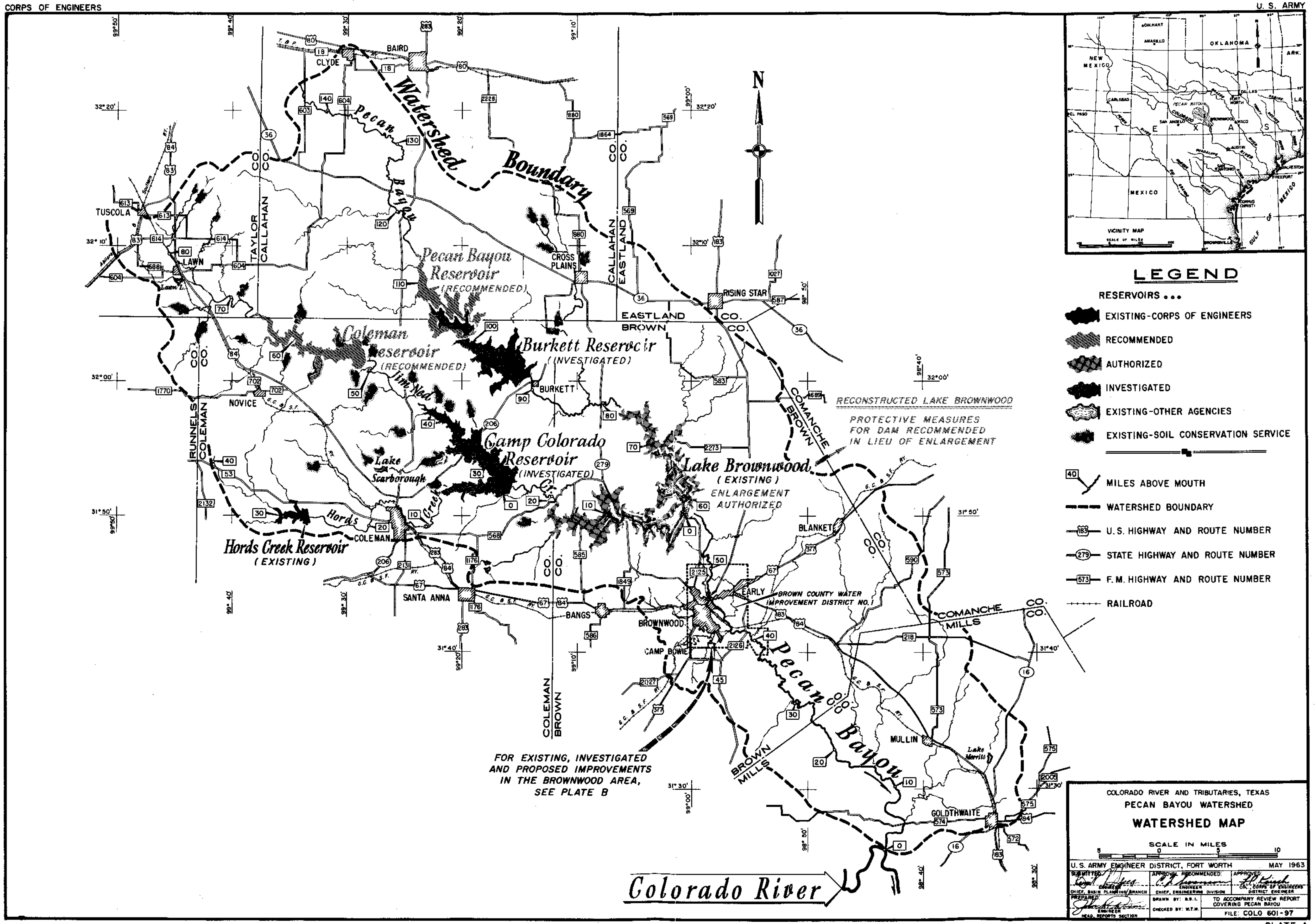

PLATE A

96-452 O-68 (Face p. 326) No. 1

96-452 O-68 (Face p. 326) No. 2