AQUILLA RESERVOIR, BRAZOS RIVER BASIN, TEXAS

LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY, DATED SEPTEMBER 19, 1966, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON AN INTERIM REPORT ON AQUILLA RESERVOIR, BRAZOS RIVER BASIN, TEXAS, IN PARTIAL RESPONSE TO A RESOLUTION OF THE COMMITTEE ON PUBLIC WORKS, UNITED STATES SENATE, ADOPTED AUGUST 12, 1954

PRESENTED BY: MR. BYRD, OF WEST VIRGINIA
(FOR MR. RANDOLPH)

OCTOBER 16, 1967.—Referred to the Committee on Public Works and ordered to be printed with illustrations

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1967

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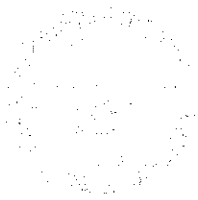

LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY
WASHINGTON, D.C. 20310

October 14, 1967

Honorable Jennings Randolph
Chairman, Committee on Public Works
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

I am transmitting herewith a favorable report dated 19 September 1966, from the Chief of Engineers, Department of the Army, together with accompanying papers and illustrations, on an interim report on Aquilla Reservoir, Brazos River Basin, Texas, in partial response to a resolution of the Committee on Public Works, United States Senate, adopted 12 August 1954.

The views of the Governor of Texas, the Departments of the Interior, Agriculture and Commerce, and the Federal Power Commission are set forth in the inclosed communications.

In accordance with the comment of the Bureau of the Budget, the Chief of Engineers will review the timing of initiation of the project prior to requesting appropriations of funds for construction.

Subject to the foregoing, the Bureau of the Budget has no objection to 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. A copy of the letter from the Bureau of the Budget is inclosed. Use of the currently prescribed interest rate of 3-1/4 percent in computing annual charges and benefits would result in no appreciable change in the benefit-cost ratio.

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

September 28, 1967

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

Dear Mr. Secretary:

Mr. Alfred B. Fitt's letter of October 7, 1966, submitted the favorable report of the Chief of Engineers on Aquilla Reservoir, Brazos River Basin, Texas, in partial response to a resolution of the Committee on Public Works, United States Senate, adopted August 12, 1954.

We have a question concerning the timing of constructing the proposed project. We note that the preponderance of project benefits would not accrue until the last half of the 100-year period of analysis. Therefore, if the project is authorized, the Bureau of the Budget would expect the Chief of Engineers prior to requesting construction appropriations to review the timing of initiation of the project.

I am authorized by the Director of the Bureau of the Budget to advise you that, subject to consideration of these comments, 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.
Director, Natural Resources
Programs Division

COMMENTS OF THE GOVERNOR OF TEXAS

JOHN CONNALLY
GOVERNOR OF TEXAS

August 19, 1966

Lieutenant General William F. Cassidy
Chief of Engineers
Department of the Army
Building T-7, Gravelly Point
Washington, D. C.

Dear General Cassidy:

In accordance with your request of June 10, 1966, I have caused to be studied the proposed report of the Corps of Engineers together with other pertinent papers on Aquilla Reservoir, Brazos Basin, Texas.

Our study shows this project to be feasible and that the public interest would be well served. Accordingly, I recommend adoption of this report and hope that it might be presented to Congress at an early date.

In concurring with the report, we would like to request an opportunity for the Texas Parks and Wildlife Department to review the Corps of Engineers' master plan for recreational development in order that there might be further coordination of federal and state effort in recreational development in the area.

With kindest regards,

Sincerely,

John Connally

John Connally

COMMENTS OF THE DEPARTMENT OF THE INTERIOR

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

19 August 1966

Dear General Cassidy:

This is in reply to your letter of June 10, 1966 requesting our comments on reports on Aquilla Reservoir Basin, Texas.

The recommended construction would not adversely affect any existing or proposed projects of the Bureau of Reclamation.

The Bureau of Outdoor Recreation advises that adequate consideration has been given to the development of outdoor recreation opportunities in connection with the formulation of the project plan. The Bureau notes that the City of Hillsboro, Texas, has provided a letter of intent to assume the non-Federal responsibility for the recreation and fish and wildlife purposes of the project in accordance with the requirements of the Federal Water Project Recreation Act (79 Stat. 213). The State of Texas has stated its approval for Hillsboro to accept this responsibility. The recreation and fish and wildlife developments proposed for the Aquilla Dam and Reservoir project would be consistent with the objectives of the Texas statewide comprehensive outdoor recreation plan.

The Fish and Wildlife Service is pleased that the recommended plan recognizes the importance of fish and wildlife resources and adequately provides for the conservation and development of these resources. The Service notes that wildlife losses have been deducted from fishery benefits in your report and a net fish and wildlife benefit for the project has been derived. The Service does not agree that wildlife losses can be replaced by fishery gains and, therefore, requests that your report recognize that wildlife losses resulting from the project remain uncompensated.

The Service believes that the project economic analysis should show recreation and fish and wildlife separately, particularly since different non-Federal entities would be responsible for payment of the reimbursable portion of project costs allocated to these purposes as provided for in the Federal Water Project Recreation Act. The separation of the recreation enhancement costs would permit a more meaningful evaluation of the reimbursable charges. It is also essential to a meaningful review of project documents by the Bureaus of this Department.

We have no comments in the interest of other Agencies and Bureaus of this Department in addition to those included in the appendix to the District Engineer's report.

Sincerely yours,

Assistant Secretary of the Interior

Lt. General William F. Cassidy
Chief of Engineers
Department of the Army
Washington, D. C. 20315

COMMENTS OF THE DEPARTMENT OF AGRICULTURE

DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

13 July 1966

Honorable Stanley R. Resor
Secretary of the Army

Dear Mr. Secretary:

This is in reply to the Chief of Engineers' letter of June 10, 1966 transmitting for our information and comment his proposed report on Aquilla Reservoir, Brazos River Basin, Texas.

The District and Division Engineers recommend that the authorized plan for the Brazos River Basin be modified to provide for construction of the Aquilla Reservoir on Aquilla Creek. Purposes to be served are flood control, water supply, recreation and fish and wildlife enhancement. The estimated total installation cost is $23,612,000. Average annual costs, including operation and maintenance costs, would be $943,000. The Federal Government share of the installation cost would be $19,493,000.

Average annual benefits are estimated at $1,506,100, of which $725,200 would be flood control benefits, $158,000 water supply benefits, and $622,900 recreation and fish and wildlife enhancement. Although it is stated that 96.8 percent of present flood damages are agricultural flood damages, the extent of agricultural flood damage reduction benefits from the project is not reported. The benefit-cost ratio is 1.6 to 1.0.

The report contains estimates of recreation benefits, along with a discussion of the competing recreational opportunity afforded by another, larger multiple-purpose reservoir nearby. It is concluded that the use of the proposed Aquilla Reservoir for water-based recreation will not be affected by the proximity of the other reservoir because the Aquilla Reservoir is somewhat more conveniently reached from various population centers. If this conclusion is accurate, it would be consistent with the report's method to estimate the extent of the possible decline in use of the nearby reservoir for recreation resulting from the creation of the proposed Aquilla Reservoir.

We note that the construction of the Aquilla Reservoir would reduce the aggregate average annual damages within the flood plain reach on Aquilla Creek by $180,600 or about 66 percent. Also, when considered as the next element to be added to the authorized Brazos River System, the reservoir would reduce the residual average annual damages within the flood plain of the Brazos River downstream of Aquilla Creek by $544,600 or about 7 percent. This level

of protection would be achieved by a capital investment of $14,625,000, the portion of the estimated construction cost of this proposed reservoir allocated to flood control.

The proposed plan would inundate or remove from production approximately 6,000 acres of privately owned woodland. Reduction of flooding in the downstream flood plain would result in a reduction of additional timber through clearings for cropland use. Although timber values are not too significant in this area, nevertheless we recommend that merchantable timber cleared as a result of the project be salvaged for local use.

In November 1965, planning assistance for the proposed Aquilla-Hackberry Watershed Project was authorized under the provisions of PL-83-566, as amended. This watershed has a drainage area of approximately 165,200 acres and includes the drainage area above the proposed Aquilla Reservoir. Works of improvement being planned for this PL-566 project are considered to be comprehensive in nature and complementary to the proposed reservoir.

The proposed Aquilla Reservoir plan would have no adverse effects upon water and related land resource programs of this Department.

Thank you for providing this report for our review.

Sincerely yours,

John A Baker

JOHN A. BAKER
Assistant Secretary

COMMENTS OF THE DEPARTMENT OF COMMERCE

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

September 21, 1966

Lieut. General William F. Cassidy, USA
Chief of Engineers
Department of the Army
Washington, D.C. 20315

Dear General Cassidy:

You invited this Department's comments on your proposed report and accompanying reports concerning Aquilla Reservoir, Aquilla Creek, Texas. You recommend that the authorized plan for Brazos River basin, Texas, be modified to provide for construction of the Aquilla Reservoir on Aquilla Creek for purposes of flood control, water supply, and recreation and fish and wildlife enhancement, at an estimated total first cost of $23,612,000.

We are pleased to note that you also recommend the advance acquisition of the land necessary to preserve the reservoir site and authorization to participate in the cost of reconstructing transportation and utility facilities in advance of project construction as required to preserve the site and avoid increased cost.

The Bureau of Public Roads reports that the proposed construction of the reservoir will require the modification of 7 miles of FM Highway 310 (Federal-aid Secondary Route 462) at an estimated cost of $855,200. It will also require the modification of 0.8 miles of State FM Highway 1947 and 2.9 miles of county roads at an estimated cost of $939,950. The proposed highway changes have been coordinated with the Texas Highway Department and the Bureau of Public Roads. The cost of the work is included in the project cost.

The Coast and Geodetic Survey note that the project area is adequately covered by horizontal and vertical geodetic control. Furthermore, the size and anticipated annual water recreational benefits of the proposed Aquilla Reservoir indicates the need for nautical charting and C & GS recommend that the funds required should be included in the project costs.

The Department concurs in your findings and appreciates the opportunity to review and comment on your report.

Sincerely,

Lowell K. Bridwell
Deputy Under Secretary
for Transportation

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

July 22, 1966

Lieutenant General William F. Cassidy
Chief of Engineers
Department of the Army
Washington, D. C. 20315

Reference: ENGCW-PD

Dear General Cassidy:

This is in response to your letter of June 10, 1966, 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 Aquilla Reservoir, Brazos River Basin, Texas.

The cited reports recommend that the authorized plan for the Brazos River and tributaries be modified to provide for construction of a dam and reservoir on Aquilla Creek for flood control, water supply, recreation, and fish and wildlife enhancement. The proposed Aquilla project would consist of an earthfill dam with gated outlet conduit and uncontrolled saddle spillway, and a reservoir with total storage capacity of 199,300 acre-feet. The estimated construction cost of the recommended project is $23,612,000, of which $4,119,000 would be repaid by local interests for water supply and recreation purposes.

The Commission staff has made studies of the possibility of developing hydroelectric power at the recommended Aquilla project. The studies show that, with the project constructed and operated as planned, the firm yield of the reservoir would be about 15 cubic feet per second during the 1953-1957 critical dry period. Use of the firm yield for power purposes would make possible a continuous output of about 100 kilowatts. Assuming operation at ten percent plant factor during a critical dry period, an installation of about 1,000 kilowatts would be possible. The staff studies show that such a power development would not be economically justified. The staff studies show also that enlargement of the proposed reservoir for power purposes would not be warranted.

Based on its consideration of the reports of your Department and the studies of its own staff, the Commission concludes that the recommended Aquilla reservoir would not provide opportunity for economical hydroelectric power development.

Sincerely,

Lee C. White
Chairman

AQUILLA RESERVOIR, BRAZOS RIVER BASIN, 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 19 September 1966

SUBJECT: Aquilla Reservoir, Brazos River Basin, 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, on Aquilla Reservoir, Aquilla Creek, Texas, in partial response to a resolution by the Committee on Public Works, United States Senate, adopted on 12 August 1954, requesting a review of the report of the Chief of Engineers printed in House Document Numbered 181, Seventy-second Congress, first session, and other reports on the Brazos River and tributaries, Texas, with a view to determining whether any modification of the recommendations contained therein should be made at this time. The report presents the results of an investigation of the problems associated with the water and related land resources of the Aquilla Creek watershed with special emphasis on flood control and water supply problems of the watershed.

2. The District and Division Engineers recommend that the authorized plan for the Brazos River basin, Texas, be modified to provide for construction of the Aquilla Reservoir on Aquilla Creek for purposes of flood control, water supply, and recreation and fish and wildlife enhancement. They estimate the total first cost of the proposed reservoir at $23,612,000 to be borne initially by the Federal Government, or a net Federal cost of $19,493,000 after reimbursement by local interests of $3,386,000 allocated to water supply and $733,000 allocated to recreation and fish and wildlife enhancement. They estimate the total annual operation and maintenance cost of the Aquilla Reservoir at $120,000 or a net Federal annual operation and maintenance cost of $60,000 after reimbursement by local interests of $10,000 allocated to water supply and $50,000 allocated to recreation and fish and wildlife enhancement.

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

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

WILLIAM F. CASSIDY
Lieutenant General, USA
Chief of Engineers

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
BOARD OF ENGINEERS FOR RIVERS AND HARBORS
WASHINGTON, D.C. 20315

IN REPLY REFER TO

ENGBR 4 May 1966

SUBJECT: Aquilla Reservoir, Brazos River Basin, Texas

TO: Chief of Engineers
Department of the Army

1. Authority.--This report is in partial response to the following resolution adopted 12 August 1954:

> Resolved by the Committee on Public Works of the United States Senate, 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 of the Chief of Engineers printed in House Document Numbered 181, Seventy-Second Congress, First Session, and other reports on the Brazos River and tributaries, Texas, with a view to determining whether any modification of the recommendations contained therein should be made at this time.

It considers the advisability of modifying the authorized project for Brazos River and tributaries, Texas, by the addition of Aquilla Reservoir on Aquilla Creek for flood control, water conservation, and related uses. The report includes consideration of the water problems and needs of a study area within the influence of such a development. The flood control study area includes the lower 20.7-mile reach of Aquilla Creek and the Brazos River downstream from the mouth of Aquilla Creek; a water supply problem area consists of Hill, McLennan, and Falls Counties. For recreation and fish and wildlife enhancement, the study area includes all or portions of 17 counties surrounding the project site.

2. Watershed description.--The Aquilla Creek watershed covers an area of about 410 square miles in the middle portion of the Brazos River basin of central Texas. The terrain is generally rolling and hilly,

and the watershed slopes from north to south at about 11 feet per mile. The mean annual precipitation over the watershed is about 34 inches. Aquilla Creek originates near Cleburne and flows about 54 miles to its confluence with the Brazos River. The controlling channel capacity in the 20.7-mile reach below the proposed damsite is about 3,000 cubic feet per second (c.f.s.).

3. Economic development.--The total population of the overall study area in 1960 was 2,125,471, of which 407,854 resided within the flood control study area. Dallas, Fort Worth, Waco, and Houston, four of the State's 21 standard metropolitan statistical areas, are located partially or completely within the study area. In 1960, about 22 percent of the total income in the study area was derived from manufacturing. About 80 percent of the land is in farms. Crops produced include cotton, grains, grain sorghums, vegetables, fruits, peanuts, and sugar. Beef cattle and sheep are also significant in the agricultural economy. Lumber production is important in several counties of the study area. Mineral resources exploited include petroleum, natural gas and gas liquids, sand and gravel, stone, limestone, clays, lignite, lime, magnesium compounds, salt, bromine, and sulphur.

4. Water resource development.--There are no existing Federal flood control structures or non-Federal water resource improvements of significant size on the Aquilla Creek watershed. In studies performed for the report by the United States Study Commission - Texas, the Soil Conservation Service of the United States Department of Agriculture indicated that 42 flood retardation structures were proposed for the Aquilla Creek watershed. In 1965 studies, the Soil Conservation Service indicated that a series of 18 flood detention dams had been recommended for control of the Aquilla-Hackberry watersheds. About 6 structures are contemplated for Aquilla Creek and 12 for the Hackberry Creek watershed. Construction is not expected to begin until 1967.

5. Water resource problems.--Major floods originating on the Aquilla Creek watershed cause appreciable damages along Aquilla Creek and, in addition, augment the flood conditions and damages along the main stem of the Brazos River. During the period of record from 1939 to 1962, nine major floods occurred on Aquilla Creek. The maximum flood of record in May 1944 produced a discharge of 34,200 c.f.s. at the Aquilla gage. Based on historical flood data, the maximum known

flood occurred on 31 August 1887, producing a maximum stage of 34 feet. Also, the flood of 27 September 1936 reached an estimated stage of 33 feet and a peak discharge of 74,200 c.f.s. The channel capacity of Aquilla Creek is insufficient to contain these floods, being about 3,000 c.f.s. downstream of mile 13.2 and 4,000 c.f.s. between miles 13.2 and 20.7. The flood plain contains agricultural property, transportation facilities, and utilities; the area contains no urban development. Along Aquilla Creek from mile 5.0 to 20.7, the estimated value of physical property is about $2,750,000, and average annual damages are estimated at $118,700 under present conditions. The major floods on Aquilla Creek watershed also contribute appreciably to flood problems on the lower Brazos River. During the period from 1898 to 1964, 29 major floods occurred on the Brazos River producing peak discharges ranging from 61,100 to 246,000 c.f.s. at the Waco gage. However, a system of reservoirs authorized for flood control on the Brazos River and the lower reaches of its principal tributaries provides for the protection of urban and highly developed agricultural lands within the flood plain of the lower Brazos River. The controlling channel capacity of the Brazos River is 27,000 c.f.s. from the mouth of Aquilla Creek to the mouth of the Bosque River, and 65,000 c.f.s. through the city of Waco. Because of lesser capacity above the mouth of Bosque River, flood control releases from Whitney Reservoir are limited to 27,000 c.f.s. during the passage of minor floods but may be as high as 60,000 c.f.s. (minimum channel capacity downstream of Richmond) during major floods. Within the investigated Brazos River flood plain below the mouth of Aquilla Creek, the estimated value of physical property is almost $435,000,000 and average annual damages are estimated at $3,023,000 under present conditions of development, assuming the authorized system of Brazos River basin reservoirs in operation.

6. The Federal Water Pollution Control Administration (referred to in the report of the District Engineer as the United States Public Health Service), in cooperation with the Corps of Engineers, has prepared a report covering water supply requirements for the study area. The report indicates a need for Aquilla Reservoir to meet future municipal and industrial water supply demand of the Aquilla Creek watershed.

7. Improvements desired.--Local interests from the cities of Hillsboro and West have requested a multiple-purpose reservoir on Aquilla Creek, indicating an urgent need for present and future water

supply. The Texas Water Commission (now the Texas Water Rights Commission and the Texas Water Development Board) also pointed out the need for consideration of a multiple-purpose reservoir on Aquilla Creek and other tributaries in the middle portion of the Brazos Basin to provide flood control and additional conservation storage.

8. Investigated plans.--The District Engineer investigated multiple-purpose reservoirs of various sizes on Aquilla Creek at miles 20.7 and 23.3. The damsite at mile 23.3 was investigated in prior studies and is the site at which a multiple-purpose project was proposed in the United States Study Commission - Texas report. The investigated plans included recognition of the projected plans of the Soil Conservation Service. These programs are considered comprehensive in character and complementary to the flood control needs of the watershed. Preliminary cost and foundation studies resulted in the elimination of the damsite at mile 23.3 from further consideration.

9. Recommended plan.--The District Engineer finds that the most acceptable plan would provide for the construction of a multiple-purpose reservoir at mile 20.7 on Aquilla Creek for flood control, water supply, and recreation and fish and wildlife enhancement. Reservoir storage and dependable water supply yield for the proposed plan of improvement are as follows:

Item	Amount
Reservoir storage (1,000 acre-feet)	
Flood control	111.5
Water supply	59.7
Sediment	28.1
Total	199.3
Dependable water supply yield	
Cubic feet per second	15.0
Million gallons daily	9.7

10. At January 1965 prices, the District Engineer estimates the total first costs for Aquilla Reservoir as $23,612,000, initially all Federal. The net Federal construction costs are estimated at $19,493,000 after repayment by non-Federal interests of construction costs allocated

to water supply and recreation and fish and wildlife enhancement. The District Engineer estimates the total annual costs of operation, maintenance, and replacement to be $120,000. The net Federal annual operation and maintenance costs are $60,000 after reimbursement by non-Federal interests of annual costs allocated to water supply; non-Federal interests will bear all operation and maintenance costs of $50,000 for recreation. The economic evaluation of the Aquilla Creek Reservoir is as follows:

Item	Quantity
Period of evaluation	1975-2075
First cost	$23,612,000
Annual charges	943,000*
Annual benefits	1,506,100
Benefit-cost ratio	1.6

*Future recreation facilities discounted to present value at year 1975.

11. The District Engineer recommends authorization of Aquilla Reservoir subject to certain requirements of local cooperation for water supply, recreation, and fish and wildlife enhancement. The Division Engineer concurs.

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

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

13. Views.--The Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the reporting officers. It finds that the proposed improvement is economically feasible and that the requirements of local cooperation are appropriate. The Board notes that the recommended plan provides for greater water supply storage than that which presently appears to maximize net benefits. However, it recognizes that authoritative projections of water demand have been rising, available sites for alternative water supply

projects may be pre-empted, and assurances have been given for the full supply to be provided by the project. The Board takes cognizance of the fact that during preconstruction planning, optimum site development will be subject to further study.

14. Recommendations.--Accordingly, the Board recommends that the authorized project for the Brazos River and tributaries be modified to provide for construction of a dam and reservoir on Aquilla Creek for flood control, water supply, recreation, and fish and wildlife enhancement; all generally in accordance with the plan of the District Engineer and with such modifications thereof as in the discretion of the Chief of Engineers may be advisable; at an estimated cost of $23,612,000 for construction and $120,000 annually for maintenance, operation, and replacements: Provided that, prior to initiation of construction, responsible local interests furnish assurances satisfactory to the Secretary of the Army that they will:

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

b. Hold and save the United States free from damages due to water-rights claims resulting from construction and operation of the project;

c. Repay all costs allocated to water supply, as determined by the Chief of Engineers, in accordance with the provisions of the Water Supply Act of 1958, as amended, presently estimated at $3,386,000 for construction and $10,000 annually for operation and maintenance; and

d. In accordance with the Federal Water Project Recreation Act:

(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 cost allocated to recreation and fish and wildlife enhancement, an amount currently estimated at $733,000; and

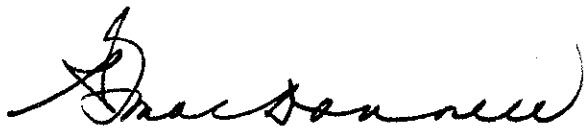
(3) Bear all costs of operation, maintenance, and replacement of recreation and fish and wildlife lands and facilities, the amount involved being currently estimated on an average annual basis as $50,000;

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

15. The Board further recommends that following authorization of the recommended project, detailed site investigations and design be made for the purpose of accurately defining the project lands required; that, subsequently, advance acquisition be made of such title to such lands as may be required to preserve the site against incompatible developments; 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 cost of relocations.

16. The net costs to the United States are estimated at $19,493,000 for construction and $60,000 annually for operation and maintenance, after repayment by local interests of costs allocated to water supply, recreation, and fish and wildlife enhancement, assuming full development of the recreation features.

FOR THE BOARD:



R. G. MacDONNELL
Major General, USA
Chairman

REPORT OF THE DISTRICT ENGINEER

INTERIM REVIEW OF REPORTS
ON
BRAZOS RIVER AND TRIBUTARIES, TEXAS
COVERING
AQUILLA RESERVOIR ON AQUILLA CREEK

SYLLABUS

The District Engineer finds from his investigations that major floods originating on the Aquilla Creek watershed cause a flood problem on Aquilla Creek, and augment appreciably the flood conditions within the lower 417.1-mile reach of the Brazos River; and that an important water supply problem exists for the cities of Hillsboro and West. He concludes that certain of the flood and water supply problems can best be solved by construction of the Aquilla Reservoir. He concludes further that there is an immediate need for the construction of the Aquilla Reservoir to provide for the economical development of the water resources of the Aquilla Creek watershed; and, further, that the construction of the Aquilla Reservoir is fully justified.

The District Engineer recommends that the authorized project for Brazos River and Tributaries, Texas, be modified to provide for construction of the Aquilla Reservoir at an estimated construction cost to the United States of $23,612,000 and an estimated $70,000 for annual operation and maintenance, subject to the conditions that local interests reimburse the United States for the project costs allocated to water supply and to recreation and fish and wildlife enhancement.

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

DECEMBER 28, 1965

SUBJECT: Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek

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

TO: Chief of Engineers
Department of the Army
Washington, D. C. 20315

INTRODUCTION

1. AUTHORITY.- This interim report covering Aquilla Reservoir on Aquilla Creek is submitted in partial response to the following authorization and instructions:

a. Resolution by the Committee on Public Works, United States Senate, adopted August 12, 1954.

> "Resolved by the Committee on Public Works of the United States Senate, 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 of the Chief of Engineers printed in House Document Numbered 181, Seventy-second Congress, first session, and other reports on the Brazos River and tributaries, Texas, with a view to determining whether any modification of the recommendations contained therein should be made at this time."

b. Initiation of comprehensive studies on the Brazos River and Tributaries, Texas, was authorized by Advice of Allotment C-284, dated October 31, 1962.

c. Preparation of an interim report under the above cited authorizations was directed by the Chief of Engineers on April 21,

1964, pursuant to requests by local interests to expedite construction of a multiple-purpose reservoir on Aquilla Creek.

2. SCOPE, PURPOSE, AND EXTENT OF INVESTIGATIONS.- This report presents the results of a study of the water and related land resources of the Aquilla Creek watershed with particular emphasis on determining whether the authorized project for Brazos River and Tributaries, Texas, should be modified at this time by the addition of a multiple-purpose reservoir at the Aquilla site on Aquilla Creek. The report includes consideration of the water problems and needs of a study area within the influence of such a development. The study area includes the flood plains of the lower 20.7-mile reach of Aquilla Creek and of the Brazos River downstream of the mouth of Aquilla Creek; and a water supply problem area consisting of Hill, McLennan, and Falls Counties.

3. The Aquilla Creek watershed with a drainage area of 410 square miles is a principal tributary area of the Brazos River Basin, entering the Brazos River just upstream of Waco, Texas. The watershed is of considerable importance in regard to resolving flood and water supply problems within the study area. The primary water problems of the study area have resulted from the experienced extremes of runoff, resulting in floods or extended periods of drought, without adequate control measures on tributary areas to control and regulate the water for beneficial uses. Local and State officials have included Aquilla Reservoir as an important unit in comprehensive plans for water resource development in the Brazos River Basin, and have requested this investigation be made to determine the engineering and economic feasibility and the practicability of immediate construction of the Aquilla Reservoir as a unit for furthering the water resource development objectives of the authorized plan for Brazos River and Tributaries, Texas.

4. During the preparation of this report, detailed field surveys were made to permit consideration of alternate dam and reservoir sites and determination of the most practicable site location. Field surveys consisted of the following: Reconnaissance by the District Engineer and members of his staff; delineation of the Aquilla Creek flood plain; topographic surveys to obtain dam site profiles; subsurface explorations consisting of 16 borings to determine foundation conditions at alternate dam sites; and economic surveys to determine the character and value of physical property in the flood plain and damages resulting from floods. Office studies consisted of analyses of hydrologic, hydraulic, and economic data; engineering studies to develop alternate and variable sizes of plans of improvement; and determinations of costs and benefits for investigated plans. The subject report studies utilized data available from prior studies on Aquilla Creek, reported in House Document No. 535,

81st Congress, 1st Session. These data included Aquilla Creek channel and valley sections; Aquilla Reservoir mapping; subsurface exploration of the original Aquilla Dam site; and data on highwater marks.

5. ARRANGEMENT OF THE REPORT.- The text of this report is supplemented by various maps and charts and by appendixes which contain the detailed analysis of the basic technical data used in preparation of the report and upon which the conclusions and recommendations of the District Engineer are based. The appendixes consist of the following:

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

Appendix II - Hydrology, Water Resources, and Hydraulic Design

Appendix III - Economics

Appendix IV - Recreation and Fish and Wildlife Enhancement

Appendix VI - Reports of Other Federal Agencies

Appendix VII - Views and Comments of Other Agencies

6. HISTORY OF INVESTIGATIONS.- The congressional authorization for preparation of this report requested a review of reports on the Brazos River and tributaries, including House Document No. 181, 72d Congress, and other reports. House Document No. 181 constitutes a preliminary examination report which was unfavorable in regard to flood control studies of survey scope for the Brazos River Basin. House Document No. 390, 76th Congress, House Document No. 707, 79th Congress, and House Documents Nos. 88 and 535, 81st Congress, recommended four local flood-protection type projects and a system of eight reservoirs in a plan for the comprehensive development of the lower Brazos River Basin for flood control and water conservation purposes. The local flood protection projects and the various units of the eight-reservoir system were authorized by the United States Congress between the years 1941 and 1954. Four of the reservoir units are in operation: Whitney Reservoir on the Brazos River, Belton and Proctor Reservoirs on the Leon River, and Waco Reservoir on the Bosque River. Two others, Stillhouse Hollow Reservoir on the Lampasas River and Somerville Reservoir on Yegua Creek, are now under construction. Laneport Reservoir on the San Gabriel River, now a unit of the San Gabriel River projects, is in the preconstruction planning stage. The eighth reservoir, Ferguson Reservoir on the Navasota River, is currently under restudy. The San Gabriel River projects, consisting of Laneport, South Fork, and North Fork

Reservoirs, were recommended in House Document No. 591, 87th Congress, as a system of reservoirs on the San Gabriel River watershed for purposes of flood control, water supply, and recreation and fish and wildlife enhancement within the lower Brazos River Basin. The North Fork and South Fork Reservoirs were authorized by Congress in year 1962. The relative locations of the reservoir units to the Aquilla Creek watershed are shown on plate 1.

7. House Document No. 535, which reported on a basin-wide study of the Brazos River, included a preliminary investigation of Aquilla Reservoir on Aquilla Creek. However, the study determined that Aquilla Reservoir was not economically justified at that time.

8. 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 Brazos River Basin includes a reservoir for flood control and water supply on Aquilla Creek.

9. The reservoir plan presented in this report has been developed after fully considering all other investigations and reports described above and the information received as a result of the public hearings and meetings with local interest, discussed in the following paragraphs. The plan is generally compatible with the major objectives of plans and investigations developed by local interests and various agencies concerned with water resource problems on the Aquilla Creek watershed and with the comprehensive aspect of the basin-wide Brazos River study now in progress.

10. PUBLIC HEARING AND IMPROVEMENTS DESIRED.- A public hearing was held at Waco, Texas, on March 13, 1963, to obtain the views of local interests concerning the improvements for flood control and allied purposes in the Brazos River Basin, Texas and New Mexico. Statements of interests submitted during or subsequent to the public hearing in connection with the report studies include those of Congressman Olin E. Teague, U. S. House of Representatives, sponsor of the investigation.

11. Local interests from the cities of Hillsboro and West have specifically requested a multiple-purpose reservoir on Aquilla Creek, indicating that they urgently need such improvements for present and future water requirements. Various meetings were held at Fort Worth and Hillsboro, Texas, between representatives of the cities of Hillsboro and West, the Brazos River Authority, and the Corps of Engineers.

12. At the public hearing the Texas Water Commission (now the Texas Water Rights Commission and the Texas Water Development Board) pointed out the need for consideration of a multiple-purpose reservoir on Aquilla Creek and other tributaries in the middle portion of the Brazos Basin to provide flood control and additional conservation storage.

WATERSHED DESCRIPTION

13. LOCATION AND SIZE.- The Aquilla Creek watershed is located in Central Texas, and in the middle portion of the Brazos River Basin. The watershed is almost due north of the city of Waco and just east of Whitney Reservoir. The Aquilla Creek watershed is bounded on the west and south by Whitney Reservoir and the main stem of the Brazos River; on the southeast by the Tehuacana watershed of the Brazos River Basin; or the northwest by Nolan Creek watershed of the Brazos River Basin; and on the north and east by the Richland-Chambers Creeks watershed of the Trinity River Basin. The Aquilla Creek watershed has a maximum length of about 41 miles, and a maximum width of about 16 miles. The major urban areas on the watershed include the cities of West, Hillsboro, and Itasca. Other smaller communities include Abbott, Peoria, and Aquilla. The watershed is shown on plate A (adjacent to the rear cover of this report). The relative location of the Aquilla Creek watershed within the Brazos River Basin is shown on plate 1. The component drainage areas on the Aquilla Creek watershed are shown on plate 2.

14. PHYSICAL CHARACTERISTICS OF THE WATERSHED.- Most of the Aquilla Creek watershed is located in the Eastern Cross Timbers physiographic province, a subdivision of the West Gulf Coastal Plain province; however, the extreme eastern and western portions include areas designated as the Blacklands and Grand Prairies, respectively. The watershed slopes from north to south at about 11 feet per mile. The terrain varies, but is generally described as rolling and hilly, with narrow valleys and streams which are moderately entrenched. The watershed soils are related to their physiographic origins; those of the Eastern Cross Timbers being subsoils of sandy subsoils of clay to sandy clay loams; those of the Blacklands being black waxy soils. Elevations on the watershed vary from about 850 feet above mean sea level along the headwater divide, about 8 miles southeast of Cleburne, to about 380 feet at the confluence of Aquilla Creek with the Brazos River at mile 417.1, about 7 miles northwest of Waco, Texas.

15. GEOLOGY.- Geologic formations of the watershed area include those of the Lower Cretaceous or Commanche series and the Upper Cretaceous or Gulf series. The Lower Cretaceous is represented by the Georgetown, Del Rio, and Buda formations; the Upper Cretaceous is represented by formations of the Woodbine and Eagle Ford groups. Although the Balcones fault zone parallels the investigated Aquilla dam site region, about 10 miles east, no geologic structural features have been observed in the watershed area. A detailed discussion of the geology of the area is presented in appendix V.

16. STREAMS.- Aquilla Creek originates near Cleburne and flows a distance of about 54 miles in a south to southeasterly

direction to its confluence with the Brazos River. The stream valley is relatively narrow. The major tributaries, beginning at the headwaters region and proceeding toward the mouth of the Aquilla Creek, include Cottonwood Creek, Little Aquilla, Hackberry, Cobb, and Alligator Creeks. Pertinent data, drainage areas, lengths, and channel capacities for Aquilla Creek and its principal tributaries are shown in table 1. The relative locations of the streams on the Aquilla Creek watershed are shown on plate 2. The stream profiles of Aquilla Creek are shown on plate 3.

17. CLIMATOLOGICAL DATA.- The Aquilla Creek watershed has a generally mild climate with 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.

18. The mean annual temperatures for the watershed is about 66 degrees Fahrenheit. Temperatures have ranged from a maximum of 113 degrees to a minimum of minus 1 degree. January, the coldest month, has an average minimum daily temperature of about 34 degrees. August, the warmest month, has an average maximum daily temperature of about 98 degrees. The average length of growing season between killing frosts is about 250 days.

19. The mean annual precipitation over the Aquilla Creek watershed is about 34 inches and varies from 36.91 inches at Hillsboro in the headwater region to 32.08 inches at the Waco Airport near the confluence of Aquilla Creek and the Brazos River. Snowfall is an insignificant portion of the total precipitation. Annual precipitation recorded at Hillsboro has varied from a maximum of 54.87 inches in 1935 to a minimum of 18.4 inches in 1963.

20. RUNOFF.- The stream gage records for the stream gaging station near Aquilla, Texas, during the period of record 1939 to 1962, indicates an average runoff of about 5.15 inches, and ranges between a maximum of 13.76 and a minimum of 0.49 inches.

21. FLOODS AND DROUGHTS.- The amounts of average annual precipitation and runoff indicate that the Aquilla Creek watershed receives a substantial amount of fresh water through rainfall and runoff. However, the variability in rainfall and runoff 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 reservoir extended from May 1953 through March 1957.

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TABLE 1

PHYSICAL CHARACTERISTICS
AQUILLA CREEK AND TRIBUTARIES

Stream	Confluence with parent stream (miles above mouth)	Length (river miles)	Approximate total fall (feet)	Drainage area (sq. mi.)
Aquilla Creek				
At mouth	417.1	54	470	410
Elm Creek	4.1	6	180	8
Dry Creek	5.3	7	120	8
Patten Branch	7.9	7	140	11
Snake Creek	11.1	5	180	11
Alligator Creek	16.5	10	210	31
Dead Horse Creek	18.5	7	160	8
Cobb Creek	19.5	18	340	40
Hackberry Creek	23.5	24	320	129
Little Aquilla	31.6	10	270	25
Cottonwood Creek	39.8	10	170	22

Section of stream	Average streambed slope (feet per mile)	Minimum channel capacity (cfs)
Aquilla Creek		
0.0 to 13.2	3.4	3,000
13.2 to 20.6	4.7	4,000

22. The topography of the Aquilla Creek watershed, the character of the soil, and the nature of the rainfall in the area are conducive to rapid runoff and sharp-crested flood hydrographs. Such floods occur frequently and at almost any time of the year. Based on historical and recorded flood data, the maximum known flood in the vicinity of the gaging station on Aquilla Creek near Aquilla, Texas, occurred in August 1887, based on information from a local resident. The stage for the August 1887 flood was 34 feet (discharge not determined). The flood of September 27, 1936, was the highest since 1887 and reached a stage of 33 feet (determined from flood marks). The peak discharge of this flood as determined by the U. S. Geological Survey was 74,200 second-feet. The maximum flood during the period of record at the Aquilla gage was that of May 1944, with a peak discharge of 34,200 second-feet and a maximum stage of 30.84 feet. The following tabulation gives the peak discharge in second feet, and volume in acre-feet for the larger floods occurring during the period of record at the Aquilla gage (1939-1962).

Flood Date	Peak Discharge (cfs)	Volume (ac-ft)
April 22-28, 1942	16,000	47,550
April 29-May 10, 1944	34,200	69,120
April 20-May 17, 1957*	10,800	100,100
April 29-May 8, 1958	18,500	66,900
January 6-11, 1961	16,700	39,440

*The flood of April-May 1957 (which consisted of a series of floods) has been included in the above tabulation because of its large volume.

ECONOMIC DEVELOPMENT

23. INTRODUCTION.- This study is concerned primarily with water problems and demands associated with the water resources of the Aquilla Creek that can be solved by the construction of water resource improvements having as project purposes flood control, water supply, and recreation and fish and wildlife enhancement. Figure 1 shows the composite study area for all purposes, including the flood control area. The economy of the flood control area was used as a guide in planning for flood plain improvements. The water supply area, consisting of Falls, Hill, and McLennan Counties, is also within the study area. The area selected for the economic base study comprises 23 counties and contains about 18,980 square miles, 7.22 percent of the total land area of the State of Texas. The economic base study presented in appendix III contains a detailed analysis of current and historical economic conditions and projections of industrial development, population, employment, and income for the study area.

24. POPULATION.- The population of the study area in 1960 was 2,125,471, of which 407,854 resided within the flood control area. The comparative rates of growth for the periods 1890 to 1960 and 1960 to 2020 for the United States, Texas, study area, and flood control area are shown below.

	Average annual percent of change in population	
	1890-1960	1960-2020
United States	1.50	1.73
Texas	2.10	1.89
Study area	2.06	2.03
Flood control area	.86	1.74
Residual area	2.69	2.10

25. Dallas, Fort Worth, Waco, Houston, four of the State's 21 standard metropolitan statistical areas, are located partially or completely within the study area. Collin, Denton, and Rockwall Counties, which are part of the Dallas standard metropolitan statistical area, are outside the study area. Brazoria and Fort Bend Counties, which are in the 5-county Houston standard metropolitan area, are within the study area. For the period from 1890 to 1960, the residual area (study area less flood control area) experienced quite a rapid growth, principally because of the development in the Dallas-Fort Worth area. The larger urban centers are influencing the

nearby counties of the flood control area to a greater extent than they have in the past. This is particularly noticeable in the flood control counties which are adjacent to Harris County. The Houston standard metropolitan statistical area was recently enlarged by the addition of Montgomery, Liberty, Brazoria, and Fort Bend Counties. The future population growth rate of the flood control area is expected to outpace that of the residual area until about 1980 as the urban centers expand into areas of lower population density. Growth of business and industry in these recently added counties of the Houston metropolitan statistical area will create additional employment and increase population.

26. Urban population is expected to increase at a more rapid rate than total population in the period from 1960 to 2020. Figure 2 graphically demonstrates the increasing proportion that urban population represents of total population. Since 1930, the rate of increase of urban population has been more rapid than that of total population.

27. REAL PERSONAL INCOME.- Real personal income is the most comprehensive available measure of economic activity and bears a close and generally constant relationship with the gross national product over the long run. At the national level, it has been found that personal income exhibits the same rate of increase that characterizes the gross national product. Personal income, when reduced by taxes, becomes disposable personal income, that portion of the income most representative of the economic condition of an area. In 1960, the disposable personal income of the 2,125,471 persons in the study area and the 451,220 persons in the flood control area was $4,194,600,000 and $654,200,000, respectively. On the basis of a 1960 per capita total, this amounted to $1,973 for the study area and $1,450 for the flood control area. This higher per capita income in the study area is attributed to the industrialization and greater business activity in the Fort Worth-Dallas area. The 1960 per capita disposable income for the nation was $1,937. Figure 3 graphically illustrates the distribution of family income in the study area for 1959. The exhibit shows the percentage of total families in each of the income categories. The basic data were taken from the Department of Commerce, Bureau of the Census, United States Census of Population for 1960. Over half of the families in the study area had incomes in the $5,000 - $14,999 range for the year of 1959.

28. MANUFACTURING.- Prior to 1940, manufacturing in Texas was greatly dependent on agriculture and forestry for raw materials and furnished the farmer with the tools of his livelihood. There was the beginning of a mineral-oriented industrial expansion but nothing like the upsurge that followed the advent of World War II.

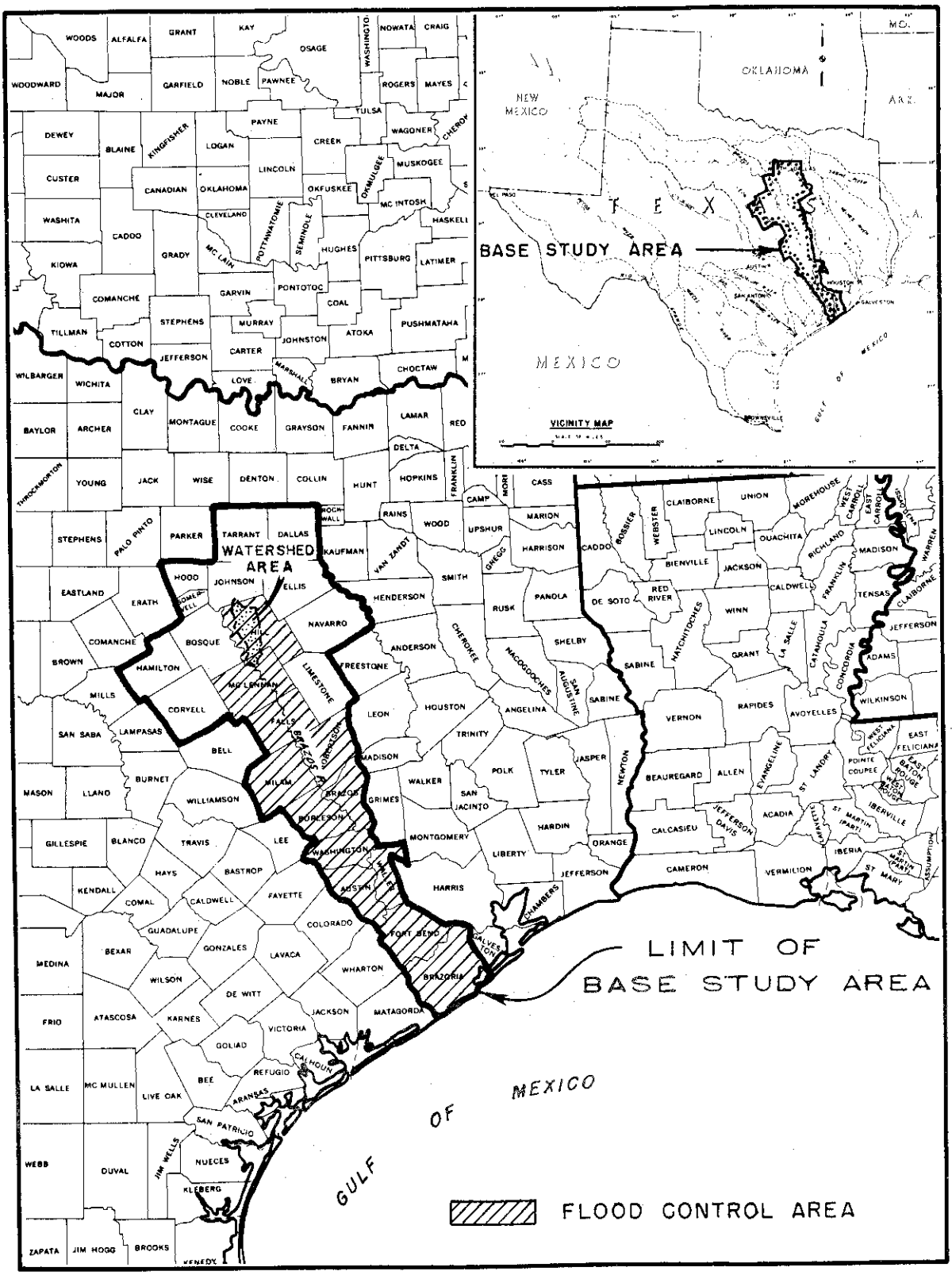
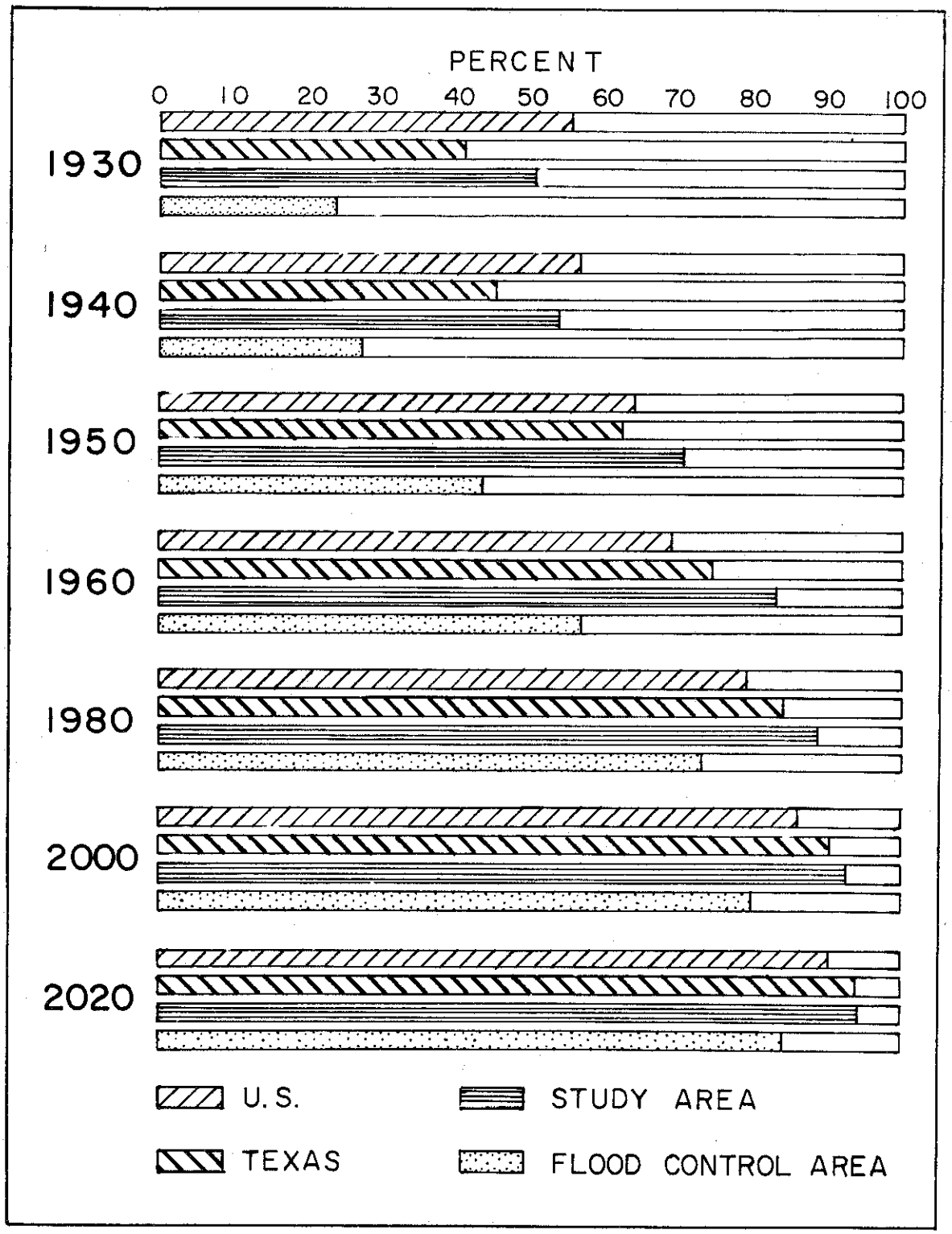


FIGURE I. AQUILLA BASE STUDY AREA



URBAN POPULATION AS PERCENT
OF TOTAL POPULATION

FIGURE 2

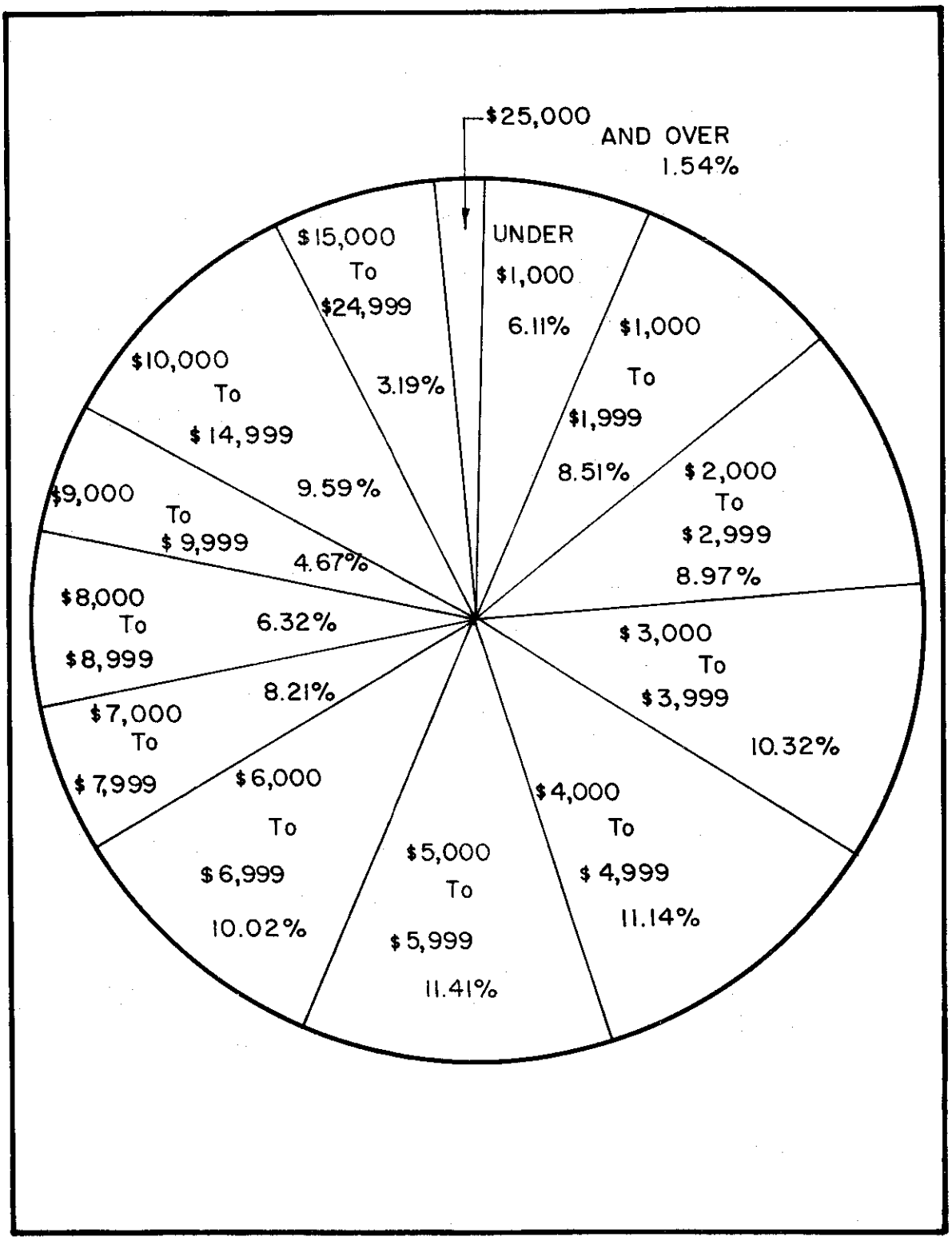


FIGURE 3: DISTRIBUTION OF FAMILY INCOME IN THE STUDY AREA – 1959.

29. During the war years, the national policy of industrial dispersion and development and the availability of large quantities of mineral resources combined to give impetus to the growth of the refining industry, established the aircraft industry, and gave the state a tremendous boost in the chemical field. The state's income originating in the chemical industry is about 16 percent of the total, nearly double the 9 percent which was derived from manufacturing in 1940.

30. For the study area, manufacturing is quite important. In 1960, about 22 percent of the total participation income was derived from manufacturing. The study area rate of expansion exceeded that of the state for the period 1939 to 1958. Measured in terms of the value added by manufacture, the study area gained from about 25.6 percent in 1929 to about 33.1 percent of the state's total value added in 1958.

31. The electronics, machinery, aerospace, and aircraft industries are important in the study area. A number of these firms are located in the Dallas-Fort Worth area. A significant number of manufacturing employees are engaged in the food and kindred products category. The Aluminum Corporation of America operates an alumina reduction plant in Milam County. Manufacturing in the counties of the study area is oriented to transportation equipment except motor vehicle equipment. Employment in this category represented over 20 percent of the 1960 manufacturing employment. The next two largest manufacturing employment categories were food and kindred products (13.41 percent) and electrical machinery (8.60 percent). Figure 4 shows the values of the various manufacturing categories for Dallas and Fort Worth in 1958. The value added by manufacture from these two cities represents a significant part of the total value added by manufacture in the study area. Comparable data by category was not available for each of the remaining counties of the study area; therefore, a similar graph could not be prepared for the total study area.

32. The relative importance of manufacturing expressed as manufacturing employment is illustrated in table 2 which shows employment in the various manufacturing categories as a percent of the total manufacturing employment for the United States, Texas, study area, and flood control area.

33. AGRICULTURE.- Varieties of crops being produced include: cotton, corn, grains, grain sorghums, vegetables, fruits, oats, melons, peanuts, rice, sugar processing, and other various field crops. Lumber production is important in several counties of the study area. Beef cattle, sheep and wool production, angora goats, dairy products and poultry production are significant in the agricultural economy of the study area. Livestock and livestock

products sold represent about 58 percent of the estimated 1960 value of farm products sold in the study area. Crops and livestock provide livelihood for operators of about 35,457 farms and ranches in the study area and 20,317 farms and ranches in the flood control area. The 1960 income in agriculture was about 2.8 percent of the total for the study area. Between the 1954 and 1959 agricultural census, the number of farms was reduced by 24 percent in the study area. The total land in farms represented slightly over 82 percent of the total land area in the study area.

34. In 1959, the total value of all farm products sold was $195.4 million for the study area and $114.3 million for the flood control area.

35. MINERAL PRODUCTION.- About 6.5 percent of the state's value of mineral production came from the study area in 1960. The minerals produced in the study area include petroleum, natural gas, natural gas liquids, sand and gravel, stone, limestone, clays, lignite, lime, magnesium compounds, salt, bromine and sulfur. About 86 percent of the study area's value of mineral production came from the flood control area in 1960.

36. Petroleum production is important in the study area. There are several oil fields producing more than one million barrels. These include Hastings, East and West Fields, West Columbia - old and new fields. There are several large salt domes in the study area that are used for storage of natural gas liquids.

37. Portland and masonry cements were produced at the cement plants in the study area. In Milam County, lignite was mined from open pits by Industrial Generating Company and used for fuel to generate electric power. The Aluminum Company of America operated its Rockdale aluminum reduction works near full capacity during 1964. Alumina from its Point Comfort alumina refinery supplied feed for the reduction plant. Lignite will become more important as a fuel and will occupy a greater proportion of the value of mineral production in the future.

38. GOVERNMENT.- The economy of the study area is influenced by the effect of government employment. About 9.7 percent of the total employment in the study area was from government in 1960. It is expected that government will continue to occupy an important role in the economy of the study area. Carswell Air Force Base, 7 miles WNW of Fort Worth, (part of the Strategic Air Command's network of defense installations), Dallas Naval Air Station (Hensley Field), 11 miles SSW of Dallas, and James Connally Air Force Base, 7 miles NNE of Waco, contribute to the economy of the study area. The U. S. Public Health Service Hospital at Fort Worth and

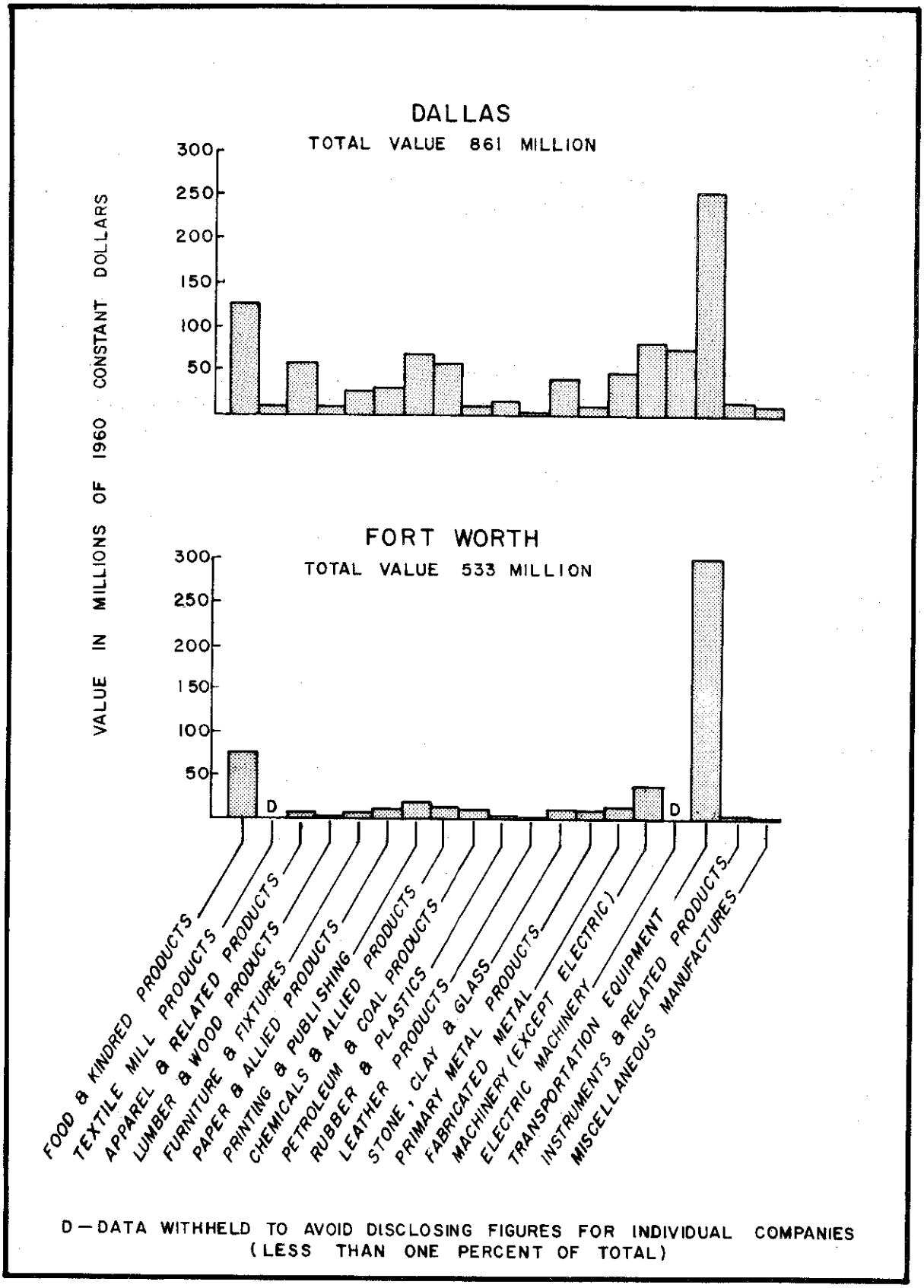


FIGURE 4: MANUFACTURING IN 1958 - DALLAS, FORT WORTH

TABLE 2

EMPLOYMENT IN MANUFACTURE - 1960

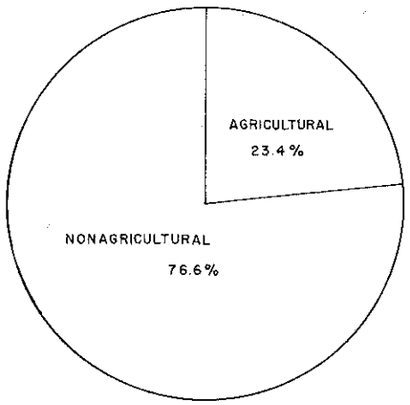
Item	United States	Texas	Study area	Flood control area
	Percent of manufacturing employment			
Furniture, lumber and wood products	6.09	6.11	4.07	8.38
Primary metal industries	6.99	4.99	2.05	4.19
Fabricated metal industries	7.38	5.79	4.48	2.80
Machinery except electrical	8.95	8.68	7.43	3.58
Electrical machinery	8.49	4.08	8.63	0.79
Motor vehicles and motor vehicle equipment	4.81	1.25	2.77	0.32
Transportation equipment except motor vehicle equipment	5.58	9.09	20.48	2.69
Other durable goods	7.83	6.34	5.61	7.59
Total durable goods	56.12	46.33	55.52	30.34
Food and kindred products	10.41	14.77	13.45	14.82
Textile mill products	5.48	1.44	1.14	3.34
Apparel and other fabricated textiles	6.62	6.16	7.61	4.73
Printing, publishing and allied products	6.52	7.46	8.03	6.17
Chemical and allied products	4.92	8.70	6.15	25.82
Other nondurable products	9.93	15.14	8.10	14.78
Total nondurable products	43.88	53.67	44.48	69.66
Total	100.00	100.00	100.00	100.00

Source of basic data: U. S. Bureau of Census, U. S. Census of Population: 1960.

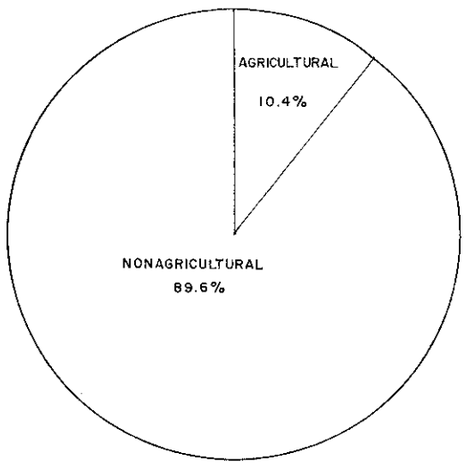
the U. S. Veterans' Hospitals at Marlin and Waco are also within the study area.

39. EMPLOYMENT.- Since 1940, employment in the study area has become more heavily oriented toward nonagricultural endeavors. Manufacturing has shown the greatest proportionate increase of any of the nonagricultural categories. Figure 5 shows that from 1940 to 1960, there were relative losses in the employment categories of: services (-5.2 percent), wholesale and retail trade (-2.7 percent), government (-2.5 percent), transportation (-0.8 percent), and mining (-0.1 percent). Figure 6 shows the proportion in each of the employment categories as they are projected for the years 1980, 2000, and 2020.

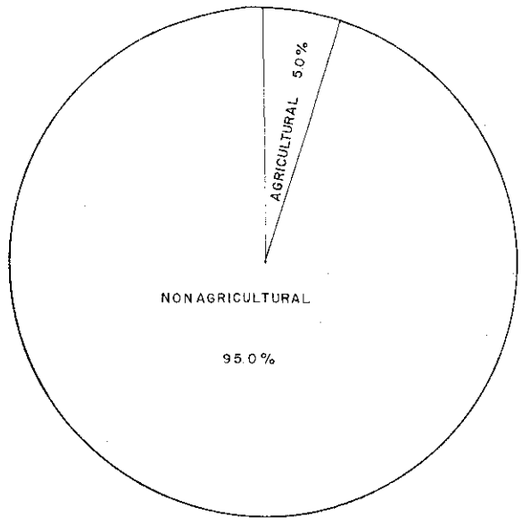
TOTAL EMPLOYMENT



1940 (459,881)

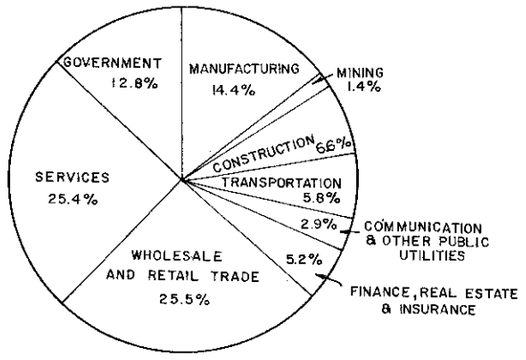


1950 (659,989)

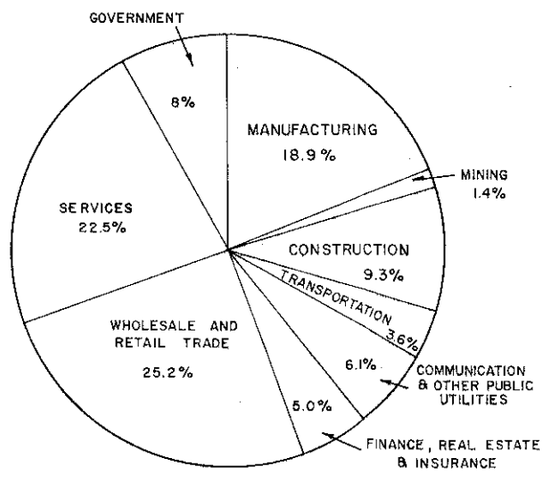


1960 (825,613)

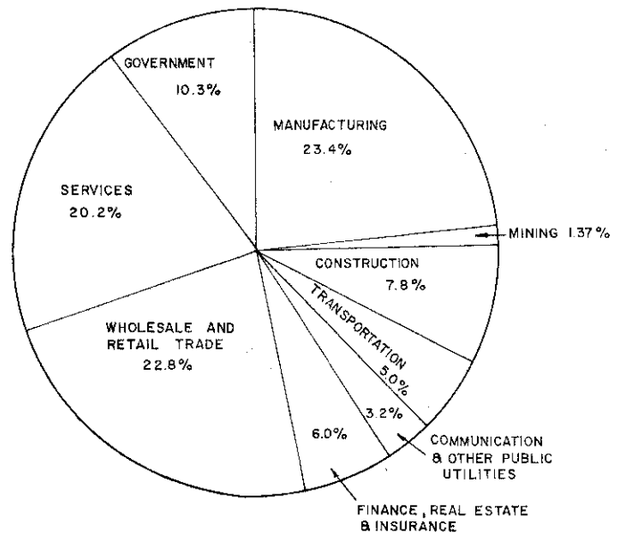
NONAGRICULTURAL EMPLOYMENT



1940 (352,149)



1950 (591,868)



1960 (784,526)

FIGURE 5 STUDY AREA EMPLOYMENT

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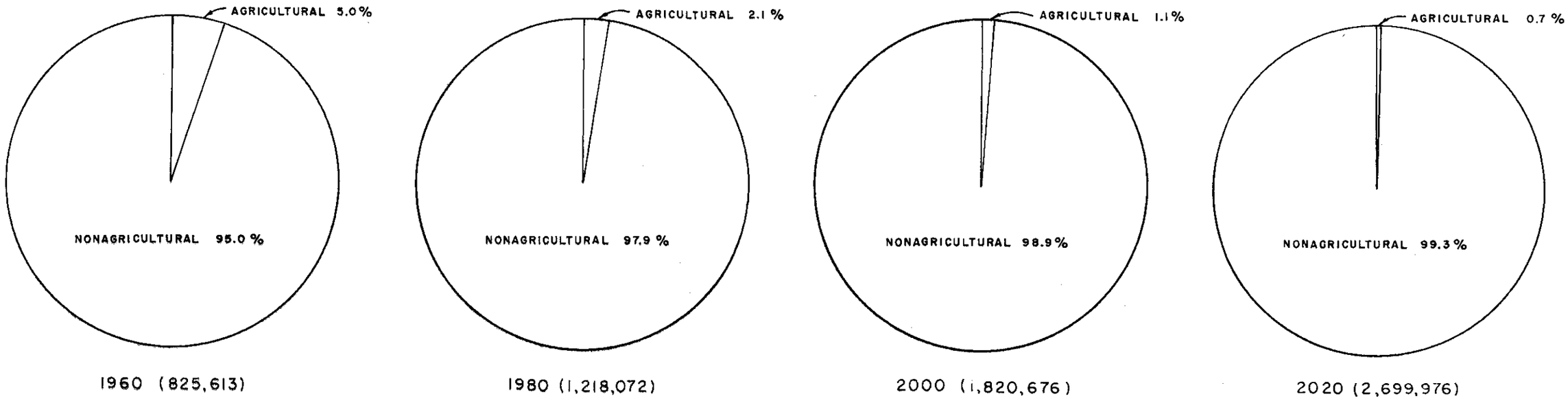
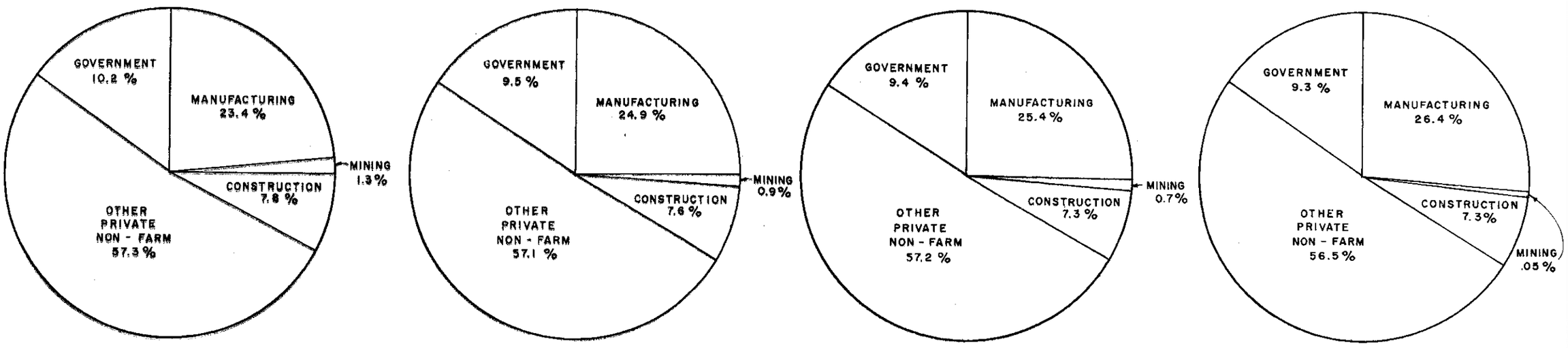


TOTAL EMPLOYMENT



NONAGRICULTURAL EMPLOYMENT

FIGURE: 6 STUDY AREA EMPLOYMENT PROJECTIONS

85-251 O-67 (Face blank p. 30) No. 2

40. FEDERAL IMPROVEMENT.- There are no existing Federal flood control structures on the Aquilla Creek watershed.

41. NON-FEDERAL IMPROVEMENTS.- There are no existing non-Federal water resource improvements of significant size on the Aquilla Creek watershed.

42. SOIL CONSERVATION SERVICE PLANS.- In studies performed in connection with the preparation of the U. S. Study Commission report, the U. S. Soil Conservation Service indicated that 42 flood retardation structures were proposed for the Aquilla Creek watershed. Thirty of these would be located above the Aquilla Dam site at mile 20.7, 14 of which would be on Hackberry Creek. The 30 structures would have a total detention storage of 51,973 acre-feet, a combined release of 1,496 second-feet, and would retard runoff from 149.6 square miles. The remaining 12 structures proposed for the watershed area downstream from the Aquilla gage would have a total detention storage of 20,947 acre-feet, a combined release of 628 second-feet, and would retard runoff from 62.7 square miles. None of the structures have been constructed.

43. The Soil Conservation Service is conducting preliminary work plan studies on the Aquilla Creek watershed. Based on the current studies, a series of 18 flood retention dams have been recommended for control of the Aquilla-Hackberry watersheds. About 6 structures are contemplated for Aquilla Creek and 12 on the Hackberry Creek watershed. The estimated cost of the program is $1,507,000 and the annual benefits would be $81,000. The Soil Conservation Service has stated that the State Soil Conservation Board has recommended a planning priority for the Aquilla-Hackberry watershed and that detailed planning would begin in October 1965. Construction of the structures is not expected to begin until 1967. Notification was received from the Soil Conservation Service by letter dated 10 December 1965 that the Aquilla-Hackberry Creeks watershed in Hill and Johnson Counties, Texas, was approved for planning under Public Law 566, as amended, Watershed Protection and Flood Prevention Act. The letter of notification is presented in appendix VII.

44. LOWER BRAZOS BASIN.- Other principal water resource developments in the lower Brazos River Basin between Whitney Reservoir and the mouth of the Brazos River are shown in the following tabulation:

Project	Location	Controlled storage (ac-ft)	Status
Whitney Reservoir	Brazos River	1,999,500	In operation
Belton Reservoir	Leon River	1,097,500	In operation
Proctor Reservoir	Leon River	374,200	In operation
Waco Reservoir	Bosque River	726,400	In operation
Stillhouse Hollow Reservoir	Lampasas River	630,400	Under construction
Somerville Reservoir	Yegua Creek	507,500	Under construction
San Gabriel River projects (Laneport, North Fork, South Fork Reservoirs)	San Gabriel River	692,000	Advance planning
Ferguson Reservoir*	Navasota River	619,200	Under restudy
Allens Creek Reservoir	Allens Creek	575,000	U. S. Study Comm.
Wayland Crossing Reservoir	Navasota River	44,200	U. S. Study Comm.

*System of Millican and Navasota No. 2 Reservoir (with total controlled storage of 3,493,000 acre-feet) recommended in lieu of authorized Ferguson Reservoir project.

WATER PROBLEMS

45. 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 resources developments have value only to the extent that they are needed. The magnitude of the demands for water resources development and control in the study area 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. In the evaluation of the demands for water resources, including resolution of various water problems, consideration was given to all available information on present and projected needs as developed by the State of Texas and by Federal agencies, the desires of local interests as expressed at public hearings, and the directives from Congress for this investigation.

46. The principal water problems within the influence of multiple-purpose water resource developments on Aquilla Creek involve the frequent occurrence of floods and those of insufficient water supply. Major floods originating on the Aquilla Creek watershed cause appreciable damages along Aquilla Creek and, in addition, augment the flood conditions and damages along the main stem of the Brazos River. The cities of Hillsboro and West, presently served by ground water sources, have requested immediate construction of a multiple-purpose reservoir project on Aquilla Creek to meet existing and anticipated future municipal and industrial water supply needs.

47. The study area considered in evaluating the various water problems that would be affected by water resource developments on Aquilla Creek includes the influenced areas of the several project purposes. The study area for the flood-control problems consists of the flood plain of Aquilla Creek downstream of stream mile 20.7 and the flood plain of the Brazos River downstream of the mouth of Aquilla Creek. The study area for water supply comprises Hill, McLennan, and Falls Counties, including the cities of Hillsboro in Hill County, West, Waco, and McGregor in McLennan County, and Marlin in Falls County. The study area for recreation and fish and wildlife enhancement consists of an area that would be served by developments on Aquilla Creek. Other water problems and needs were studied in a similar manner.

48. FLOOD PROBLEMS ON AQUILLA CREEK.- The flood problems on Aquilla Creek are the result of frequent floods caused by heavy and frequent storm rainfall and inadequate channel capacities. During the period of record 1939 to 1962, nine major floods occurred producing peak discharges at the Aquilla gage (mile 18.2) varying from 10,800 to 34,200 second-feet. The maximum flood of record, producing a discharge of 34,200 second-feet, occurred in May 1944. Prior to

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the period of record, the maximum known flood occurred on August 31, 1887, producing a maximum stage of 34 feet at the Aquilla Creek gaging station. Also, the flood of September 27, 1936, reached a stage of 33 feet and a peak discharge of 74,200 second-feet. The channel capacity of Aquilla Creek is insufficient to contain these floods, being about 3,000 second-feet downstream of mile 13.2 and being as low as 4,000 second-feet between miles 13.2 and 20.6. The flood problem area on Aquilla Creek investigated for this report is the flood plain of Aquilla Creek from its mouth to an investigated dam site at about river mile 20.7. The problem area is an agricultural area. It contains agricultural property, transportation facilities, and utilities. The problem area contains no urban development. Within the investigated problem area, between Aquilla Creek miles 5.0 and 20.7, the estimated value of physical property is about $2,750,400, and the estimated average annual damages are about $118,700, under present conditions of development.

49. FLOOD PROBLEMS ON THE BRAZOS RIVER.- In addition to the flood problem on Aquilla Creek, the need for reduction of floodflows on the main stem of the Brazos River is an important flood problem to be considered in conjunction with the investigation of flood control improvements on the Aquilla Creek watershed. The major floods that originate on the Aquilla Creek watershed contribute appreciably to the flood problems on the lower Brazos River. Based on records during the period 1898-1964, 29 major floods have occurred on the Brazos River producing peak discharges ranging from 61,100 second-feet to 246,000 second-feet at the Waco gage. However, as the result of prior investigations covering the flood problems of the lower Brazos River Basin, between Whitney Dam and the mouth of the Brazos River, a system of reservoirs were authorized to facilitate the control of floods on the Brazos River and the lower reaches of its principal tributaries and, thus, provide for the protection of urban development and highly developed agricultural lands within the flood plain of the lower Brazos River. Aquilla Reservoir on Aquilla Creek would afford additional flood protection to the Brazos River flood plain downstream of the mouth of Aquilla Creek. The minimum channel capacity of the Brazos River from the mouth of Aquilla Creek to the mouth of the Bosque River is 27,000 second-feet, and 65,000 second-feet through the city of Waco. Because of the smaller channel capacity above the mouth of the Bosque River, flood-control releases from Whitney Reservoir are limited to 27,000 second-feet during the passage of minor floods but may be as high as 60,000 second-feet (minimum channel capacity downstream of Richmond) during the passage of major floods. The Brazos River problem area contains urban and highly developed agricultural areas as well as numerous transportation facilities, utilities, and rural non-agricultural properties. Within the investigated Brazos River problem area below

the mouth of Aquilla Creek, the estimated value of physical property is about $434,603,800 and the estimated average annual damages are about $3,022,800 under present conditions of development, assuming the authorized system of Brazos River Basin reservoirs is in operation.

50. WATER SUPPLY PROBLEMS.- At various conferences and at the public hearing held by the Corps of Engineers at Waco, Texas, on March 13, 1963, local interests stated the need for conservation of water for municipal, industrial, and other related purposes within the study area and on the Aquilla Creek watershed. The cities of Hillsboro and West, located on the Aquilla Creek watershed requested immediate construction of Aquilla Reservoir as a source of dependable municipal and industrial water supply for meeting existing and future needs. Representatives of the cities of Hillsboro and West indicated that ground water development is expensive (in excess of $0.30 per 1,000 gallons), is considered inadequate for the municipal and industrial needs, and is not an attractive source for industrial expansion. The Texas Water Commission (now the Texas Rights Commission and Texas Water Development Board) requested consideration be given to a multiple-purpose reservoir on Aquilla Creek, and other tributaries of the Brazos River Basin to provide for the future municipal and industrial water requirements of the central portion of the Brazos River Basin, particularly the city of Waco. The Commission has requested that the optimum water supply storage be investigated in multiple-purpose reservoirs proposed by the Corps of Engineers. The U. S. Study Commission - Texas published a report which indicates an increasing demand for water supply in the lower Brazos River Basin, and includes a multiple-purpose reservoir on Aquilla Creek, containing about 80,000 acre-feet of water supply storage for municipal and industrial purposes.

51. In connection with the water supply problem, the U. S. Public Health Service, in cooperation with the Corps of Engineers, has prepared a report covering the water requirements for the study area, including the Aquilla Creek watershed. The report is presented in appendix VI. The estimated total water requirements and sources of supply for the Aquilla Creek portion of the study area, as estimated by the U. S. Public Health Service, is presented in figure 7. The municipal, industrial, water quality, and irrigation needs, based on information contained in the Public Health Service report, are discussed in the following subparagraphs.

a. Municipal, industrial, and rural.- The estimated municipal, industrial, and rural water requirements for a study area, composed of Hill, McLennan, and Falls Counties, (including such municipalities as Hillsboro, Itasca, West, Waco, McGregor, and Marlin), and for the included Aquilla Creek watershed (including Hillsboro and

Itasca, but excluding West) are shown in the following tabulation:

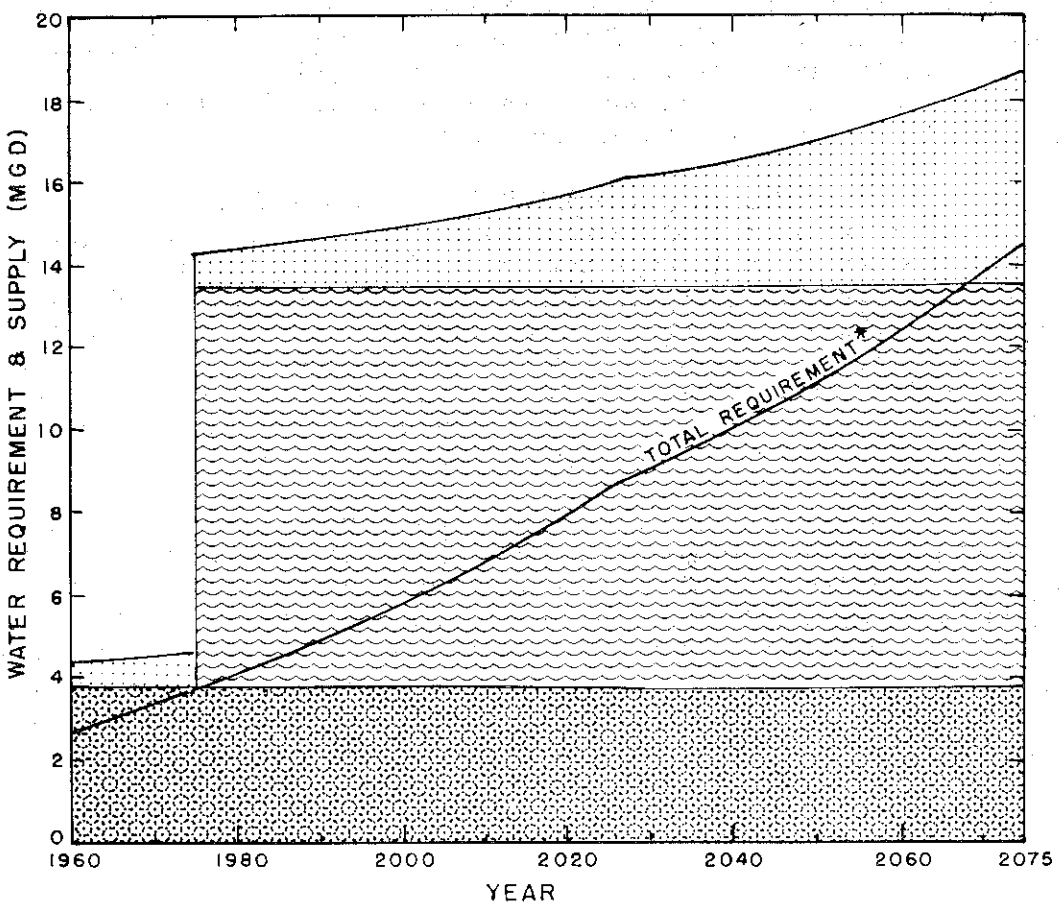
	Year and need (mgd)		
	1975	2025	2075
Study Area	37.0	105.7	201.6
Aquilla Creek Area	2.7	4.5	9.1
Hillsboro	1.6	3.4	7.2
West	0.5	1.3	2.7

The needs are mainly sttributable to expected increases in population and industrial growth. The population of the areas is expected to increase from 195,000 in 1960 to 513,000 in 2025, and 771,000 in 2075. The study area is in a period of rapid economic expansion, as evidenced by the highly diversified manufacturing complex of Waco. The major water-using industry of the study areas is food and kindred products processing. The principal water-supply sources in the study area are Whitney and Waco Reservoirs and ground-water pumpage. The principal source of water supply on the Aquilla Creek watershed is ground water. The supply and demand data in the Public Health Service report indicate a need for Aquilla Reservoir by year 1975 to meet the increasing municipal and industrial needs of the Aquilla Creek watershed during the period 1975-2075.

b. Water quality control.- The future organic and mineral qualities of Aquilla Creek watershed waters are expected to remain satisfactory for municipal, industrial, recreational, fish and wildlife, and agricultural uses. Storage for water quality control purposes is not required from Aquilla Reservoir.

c. Irrigation.- The investigation of the water supply problems included consideration of the existing and potential water requirements for irrigation. Water for irrigation will be obtained from surface water sources, such as pumping directly from streams, and from wells located within the flood plains. The report of the Public Health Service indicates that the water requirement for irrigation will be satisfied, and that the municipal, industrial, rural and irrigation water requirements for the Aquilla Creek watershed would be met by a plan utilizing ground-water sources, return flows, and storage in Aquilla Reservoir.

52. HYDROELECTRIC POWER AND NAVIGATION.- Investigations indicate that the development of hydroelectric power on the Aquilla Creek watershed is not economically attractive. Preliminary



* INCLUDES ALL REQUIREMENTS IN THE AQUILLA CREEK WATERSHED AND INDUSTRIAL AND MUNICIPAL REQUIREMENTS FOR THE CITY OF WEST.

LEGEND

REUSEABLE RETURN FLOW

AQUILLA CREEK RESERVOIR

GROUNDWATER DEVELOPMENT

NOTE:
Adopted from U.S. Public Health Service Report, APPENDIX VI

BRAZOS RIVER BASIN, TEXAS
AQUILLA RESERVOIR
AQUILLA CREEK, TEXAS

WATER REQUIREMENT AND SUPPLY

FIGURE 7

estimates, including data prepared for the U. S. Study Commission - Texas, show that the benefit-cost ratio would be less than unity. The navigation needs for the Brazos River Basin, from the mouth of the Brazos River to the vicinity of Waco, Texas, are being investigated in connection with the comprehensive study currently being made of the entire basin. The study of navigation has not progressed far enough to permit definite conclusions at this time; however, proper development of the water resources of the Aquilla Creek watershed will not adversely affect navigation.

53. RECREATION AND FISH AND WILDLIFE ENHANCEMENT.- There are no existing facilities of recreational significance on the Aquilla Creek watershed. It is adjacent to the Whitney and Waco Reservoir areas and this has an appreciable effect upon its potential development since there are competing facilities. The effects of these competing reservoir areas are partially nullified by the fact that access to the Aquilla site would be easier due to Interstate Highway 35. The location of a reservoir at the Aquilla Creek site would aid in meeting the recreational needs of Hillsboro and West.

54. The Bureau of Sport Fisheries and Wildlife, cooperating with the Corps of Engineers, has prepared a report, included as a part of appendix VI, which discussed the need and potential for development of the fish and wildlife resources of the Aquilla Creek area. The Bureau report indicates that fishing under present conditions is insignificant. The important upland game and fur animals in the area include squirrels, bobwhites, mourning doves, cottontails, swamp rabbits, skunks, ring-tailed cats, raccoons, opossums, red foxes, and gray foxes.

INVESTIGATED PLANS

55. OBJECTIVES.- The objectives used for the investigations described in this interim report included the analysis of plans to provide: (a) effective flood control for the Aquilla Creek watershed area and to diminish the flooding along the Brazos River; (b) water conservation storage for the present and future needs of the Aquilla Creek watershed vicinity, especially the needs of the cities of Hillsboro and West; and (c) development of the recreation and fish and wildlife enhancement potentials which would be afforded by reservoir construction.

56. IMPROVEMENTS CONSIDERED.- Multiple-purpose reservoirs were investigated which involved dam sites on Aquilla Creek at miles 20.7 and 23.3. The dam site at mile 23.3 was investigated in prior studies by the Corps of Engineers, and is the site at which a multiple-purpose project was proposed in the U. S. Study Commission - Texas report. Project purposes for the reservoir investigation included flood control, water supply, and recreation and fish and wildlife enhancement. Plate A (adjacent to the rear cover of this report) shows the location of the investigated dam sites. No favorable dam sites exist downstream of river mile 20.7.

57. Preliminary cost and foundation studies of the two dam sites mentioned in paragraph 56 resulted in the elimination of the dam site at mile 23.3. In addition to costs and foundation conditions, the lower site at mile 20.7 was found to be superior in terms of effective flood control and water supply development. The lower site at mile 20.7 would afford control of runoff from floods originating on Cobb Creek, a drainage area of about 39 square miles. The control of this additional drainage area would also increase the potential water supply yield.

58. Detailed investigation of the lower reservoir site and maximization studies for flood control established that the reservoir plans should contain sufficient storage to control 50-year frequency floods originating upstream of the dam site. The studies determined that such flood-control storage would be sufficient to control the maximum flood of record with respect to flood volume. The maximum flood of record with respect to flood volume occurred in April-May 1957. The April-May 1957 flood approximates a 50-year frequency flood, based on a regional analysis for flood-control storage requirements.

59. The water supply requirements for the study area, the Aquilla Creek watershed, and the lower Brazos River Basin have been evaluated by the United States Public Health Service. Data furnished indicate that for the planning period 1975-2075 the Brazos River Basin is a water-deficient basin, particularly in the Gulf

Coastal areas; the lower Brazos River Basin upstream of the Navasota River to Whitney Reservoir, including the study area for this report, will be adequately served by existing, and planned resources which include Aquilla Reservoir; but that Aquilla Reservoir will be needed for meeting the municipal and industrial water requirements of the Aquilla Creek watershed, including the cities of Hillsboro and West.

60. The water supply storages considered in investigated reservoir plans would adequately serve the potential water-based recreational needs of the area, and thus, specific storage for recreation and fish and wildlife enhancement purposes are not required.

61. Reservoir plans were investigated to provide optimum-economical to maximum water resource development by construction of a dam on Aquilla Creek at stream mile 20.7. Maximization studies determined that the most economical development for water supply would be based on a water supply storage of about 40,000 acre-feet (as contained in plan 2), yielding a dependable water supply of about 10 cubic feet per second (cfs), or 6.5 million gallons daily (mgd), under projected conditions of watershed development. A summary of economic evaluations of multiple-purpose Aquilla Reservoir plans 2 through 5, containing 50-year-frequency flood storage and different amounts of water supply storage, is presented in table 3.

62. The results of reservoir plan studies, including cost allocation studies, were presented to representatives of the Brazos River Authority and the cities of Hillsboro and West for consideration of the amount of water supply desired. Plan 3 was selected by the local interests representatives as adequate for meeting the existing and future water requirements of the Aquilla Creek watershed, including the cities of Hillsboro and West. Detailed refinements in the selected plan consisted of additional studies in regard to spillway design, quantities, and cost. Plan 7 of table 3 is essentially plan 3 except for the type of spillway. The proposed plan (plan 7) is described in paragraphs 63 through 69.

TABLE 3

SUMMARY OF PRELIMINARY ECONOMIC AND COST ANALYSES
INVESTIGATED RESERVOIR PLANS
AQUILLA CREEK WATERSHED

Item	Gated Ogee Channel Spillway				Uncontrolled Spillway
	Plan 2 FC50 WS10 R	Plan 3 FC50 WS15 R	Plan 4 FC50 WS22 R	Plan 5 FC50 WS38 R	Plan 7 FC50 WS 15 R
1. PERTINENT DATA					
Purpose: Flood control - FC, Water supply - WS, recreation and fish and wildlife enhancement - R	FC WS R	FC WS R	FC WS R	FC WS R	FC WS R
Construction period - years	4	5	5	6	5
Total controlled storage, acre-feet	173,200	199,300	218,400	463,100	199,300
Flood control storage, acre-feet	(104,900)	(111,500)	(103,700)	(117,200)	(111,500)
Water supply storage, acre-feet	(40,200)	(59,700)	(86,600)	(317,800)	(59,700)
Sediment storage, acre-feet	(28,100)	(28,100)	(28,100)	(28,100)	(28,100)
Dependable flow, water supply					
Second-feet, cfs	10	15	22	38	15
Million gallons daily, mgd	6.5	9.7	14.2	24.6	9.7
2. TOTAL FIRST COST OF PROJECT (in $1,000)	22,054.0	23,714.0	24,964.0	37,324.0	23,300.0
3. TOTAL ANNUAL CHARGES (in $1,000)	887.6	957.6	1,001.8	1,467.3	943.0
4. TOTAL ANNUAL BENEFITS (in $1,000)	1,487.6	1,506.1	1,532.0	1,591.2	1,506.1
5. RATIO OF BENEFITS TO COSTS	1.7	1.6	1.5	1.1	1.6
6. EXCESS BENEFITS OVER COSTS (in $1,000)	600.0	548.5	530.2	123.9	563.1

63. PROPOSED PLAN OF IMPROVEMENT.- The proposed plan of improvement for the Aquilla Creek watershed provides for the construction of the multiple-purpose Aquilla Reservoir. The proposed Aquilla Reservoir project would be constructed for flood control, water supply, and recreation and fish and wildlife enhancement. Aquilla Reservoir would be located on Aquilla Creek with the dam at mile 20.7, about 10.2 miles southwest of Hillsboro, Texas, and about 22.0 miles north of Waco, Texas. The location of Aquilla Reservoir is shown on plate A (adjacent to the rear cover of this report). Pertinent data on the earth embankment, spillway, outlet works, reservoir storages, surface areas, land requirements, and relocations are presented in table 4. The reservoir area, and details of the dam, spillway and outlet works are shown on plates 7 and 8. Hydrologic and hydraulic design data for the proposed project are contained in appendix II.

64. DAM.- The Aquilla Reservoir would be formed by a main earth dam having a length of about 10,600 feet and a maximum height above streambed of about 97 feet. In addition, an earth-fill dike, 700 feet long, would be constructed on the right abutment. The dike section would be similar to that for the embankment. The spillway structure would be located on the left abutment and would consist of an uncontrolled broadcrested weir. The spillway crest length would be about 1,200 feet long. The outlet works would consist of a 10-foot diameter conduit, controlled by two 5-foot by 10-foot sluice gates.

65. RESERVOIR.- The Aquilla Reservoir would have a surface area of 4,560 acres at elevation 533.5, top of conservation pool, and an area of 9,180 acres at elevation 551.0, top of flood control pool. The total controlled storage at elevation 551.0 would be 199,300 acre-feet. Lands required for reservoir operation, construction of the proposed dam, and recreation and fish and wildlife enhancement purposes amount to 15,040 acres in fee simple. Of this total land requirement, 59 percent is classified as homesites and cropland, 41 percent as pastureland and woodland. Construction of the Aquilla Reservoir would necessitate the relocation of about 10.7 miles of highways (Farm-Market highways and County roads), 14.0 miles of power lines, 5.6 miles of pipelines, and 6.0 miles of telephone lines. The protection and/or acquisition of the mineral value (including oil and gas) is included in the construction cost estimate.

66. The proposed reservoir would contain sufficient flood control storage to control the 50-year frequency flood originating above the dam site. Water conservation storage of 59,700 acre-feet in the reservoir would develop a total dependable water supply yield at the site of about 15 cubic feet per second or 9.7 million gallons

daily, based on maximum drought conditions (May 1953 through March 1957), and on projected conditions of watershed development. Sediment storage of 28,100 acre-feet would allow for deposition of sediment for a 100-year period.

67. FOUNDATION CONDITIONS.- Surface and subsurface investigations in connection with the proposed Aquilla Dam at mile 20.7, included visual inspection and mapping of available outcrops, drilling two fishtail borings to develop the regional geologic structure; four core borings to determine foundation conditions along the proposed dam axis; four core borings at potential spillway locations on the right and left abutments to determine foundation rock conditions; and two core borings contiguous to the dam axis to determine the lateral characteristics of the flood plain and foundation materials. Based on the analysis of the subsurface explorations, the left abutment was selected as the most favorable for a spillway location. Summarization of the foundation investigations at the Aquilla Dam site indicates that no condition exists which would adversely affect the construction or stability of the project. A detailed presentation of the results of the foundation investigations is presented in appendix V.

68. AVAILABILITY OF MATERIALS.- Preliminary investigations indicate that an adequate quantity of embankment fill material is available from the valley alluvium. Sources for other construction materials do not appear to be available in the immediate vicinity; however, there are numerous commercial sources within an economical haul distance. Sources for concrete aggregates, riprap, filter, and bedding materials can be found at Belton, Palestine, Weatherford, Hearne, Burnet, Waco, and Granbury, Texas.

69. RECREATION AND FISH AND WILDLIFE ENHANCEMENT FACILITIES.- In conformance with reports and recommendations prepared by the Bureau of Sport Fisheries and Wildlife and in consonance with the latest policies for such purposes, essential facilities would be included in the Aquilla Reservoir project for development of the potential aspects for fishing and hunting activities and for general recreation purposes. Basic facilities to be provided in development of the proposed project include necessary access roads, parking area, trails, and public use areas, as well as appropriate picnic areas, campgrounds, and swimming beaches. Other facilities will consist of site preparation as required, utility installations, boat docks and launching ramps for boating, fishing, and water skiing. Adequate water supply, sanitary, and basic safety facilities will also be provided to serve the visitors at the reservoir. Appropriate signs would be provided along the access roads and trails and in other areas for identification of the facilities designated for public use.

TABLE 4

PERTINENT DATA
PROPOSED AQUILLA RESERVOIR
AQUILLA CREEK WATERSHED

Item	Proposed Reservoir			
DRAINAGE AREA				
Square miles	294			
SPILLWAY DESIGN FLOOD				
Peak inflow, cfs	283,800			
Volume, acre-feet	450,600			
Volume, inches	28.74			
Peak outflow, cfs	172,000(1)			
RESERVOIR	Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inches)
Top of dam	570.0	-	-	-
Maximum design water surface	565.2	14,950	369,000	23.24
Top of flood control pool and spillway crest	551.0	9,180	199,300	12.71
Top of conservation pool	533.5	4,560	82,200	5.24
Sediment storage	-	-	28,100	1.73
STORAGE SUMMARY				
Flood control, acre-feet	111,500			
Water conservation, acre-feet	59,700			
Sediment, acre-feet	28,100			
Total	199,300			
DAM				
Type	Concrete and earth fill			
Total length, feet	12,500(3)			
Embankment section:				
Type	Compacted earth fill			
Total length, feet	10,600			
Height above streambed, feet	97			
Freeboard, feet	4.8			
Crown width, feet	34			
Side slopes:				
Upstream	1 on 2-1/2 and 1 on 13 and 1 on 3			
Downstream	1 on 2-1/2 and 1 on 13 and 1 on 3			
Spillway section:				
Type	Broadcrested weir			
Gross length, feet	1,200			
Net length, feet	1,200			
Spillway discharge, cfs:				
Maximum design water surface	169,100			
OUTLET WORKS				
Type	Gate-controlled conduit			
Number of conduits	1			
Dimensions	10' diameter			
Invert elevation, feet	485.0			
Control	2 - 5' x 10' sluice gates			
RELOCATIONS				
County roads, miles	2.7			
FM roads, miles	5.3			
Power lines, miles	14			
Telephone lines, miles	6			
Pipelines, miles	5.6			
Cemeteries	-			
LANDS				
Dam and reservoir				
Clearing acres	3,740			
Land acquisition:				
Fee simple, acres	14,500			
(Top of control elevation)	(556.0)(4)			
Recreation				
Land acquisition:				
Fee simple above general taking limits, acres	540			

(1) Includes discharge through outlet works as follows: 2,900 cfs
(2) All elevations refer to mean sea level
(3) Includes 1,200-foot spillway in left abutment and 700-foot dike in right abutment.
(4) In local vicinity of urban Hillsboro the taking like is elevation 558.0.

Appendix IV presents supporting data on an analysis of the recreation requirements of the project. Recommendations were made by the Bureau of Sport Fisheries and Wildlife in regard to the provision of two seining areas in the upper portion of the reservoirs; release of at least 10 second feet into Aquilla Creek to enhance downstream channel fishing; the establishment of zoning plans to insure safety and availability of areas for fishing and hunting without conflicting use by other recreationist; and the retention of timber in the reservoir as may be possible to provide waterfowl habitat, to serve as breakwaters to diminish turbidity, and to provide havens for fishermen during periods of high wind. The recommendations of the Bureau will be given additional study during preconstruction planning of the project and during the development of the recreational program after the proposed project becomes operational. The adoption of the recommendations would depend upon such factors as the established pattern of public use, clearing requirements for the reservoir operation, and proposed use of the water supply storage by non-Federal interests.

PHYSICAL EFFECTS OF THE PLAN

70. GENERAL.- The proposed Aquilla Reservoir is designed to meet the existing and immediately foreseeable needs of the project area. The project is designed to function as a unit in long-range plans for the Aquilla Creek watershed and the Brazos River Basin. The construction of the reservoir will not preclude the further development of water resource improvements by others for the watershed.

71. FLOOD CONTROL.- The proposed Aquilla Reservoir, providing 111,500 acre-feet of flood control storage, would afford a high degree of protection to physical properties on the watershed, and would add to the protection possible for the physical property in the lower Brazos River Basin. The construction of the Aquilla Reservoir would eliminate about 66 percent of the aggregate average annual damages within the investigated 20.7-mile flood plain reach on Aquilla Creek; and about 7 percent of the residual average annual damages within the flood plain of the Brazos River downstream of Aquilla Creek, when considered as the next-constructed reservoir to the authorized Brazos River system. Flood releases from Aquilla Creek will be adequately served by the existing channel capacity of Aquilla Creek, allowing the emptying of flood storage within a period of about 19 days.

72. WATER SUPPLY.- The proposed Aquilla Reservoir will meet the overall water supply needs of the Aquilla Creek watershed during the period 1975 through 2075. Based on projections of population and other developments, the municipal and industrial water supply needs on the Aquilla Creek watershed will increase from about 2.7 mgd in year 1975 to 9.1 mgd in year 2075. Construction of the Aquilla Reservoir will solve the critical water supply shortages faced by the cities of Hillsboro and West. Studies of the anticipated needs of these two cities, and the inadequate quality and quantity of groundwater sources, indicate that the Aquilla Reservoir would be required by year 1975.

73. OTHER PHYSICAL EFFECTS.- The Aquilla Creek watershed is located in a fast-growing area of urban as well as rural developments. The proposed reservoir would have a beneficial effect in providing facilities for outdoor recreation and fish and wildlife enhancement. The studies of these project features indicate ample justification for water resource improvements to help meet these needs. The Aquilla Reservoir project would have a surface area of about 4,600 acres at top of water conservation pool level. This surface area would have an upstream reach of about 12 miles and a shoreline distance of about 54 miles. The reservoir, with adequate facilities would afford excellent opportunities for sight-seeing,

camping, picnicking, boating, skiing, hunting, and fishing and is expected to attract an average annual visitation of 1,000,000 persons during the period 1975 to 2075.

ECONOMIC EVALUATION OF PROPOSED PLAN

74. GENERAL.- Economic evaluations of the recommended Aquilla Reservoir included an appraisal to assure that (a) project benefits exceed costs; and (b) there is no more economical means evaluated on a comparable basis of accomplishing the same purpose. The project costs and benefits were estimated on the basis of the January 1965 price level. The proposed Aquilla Reservoir is a multiple-purpose reservoir for flood control, water supply, and recreation and fish and wildlife enhancement purposes.

75. COSTS.- The first cost comprise all initial expenditures for the physical construction of the project, including lands and damages, relocations, engineering and design, and supervision and administration. An economic summary of the proposed Aquilla Reservoir is shown in table 5. Detailed estimates of the first costs and annual charges are presented in tables 3, 4, and 5 of appendix I. The annual charges for the proposed project include interest and amortization of the Federal investment at an interest rate of 3.125 percent for a 100-year period, and operation and maintenance costs.

76. BENEFITS.- The proposed Aquilla Reservoir would be added to and become an integral part of the existing and authorized system of Brazos River Basin reservoirs, with all benefits being considered to be added to the existing and authorized system. In this study, it has been assumed that the proposed Millican Reservoir would replace the authorized Ferguson Reservoir on the Navasota River, as recommended in the report on the Navasota River submitted recently. Removal of the control on this river to a point further upstream would have the effect of increasing the flood control benefits for Aquilla Reservoir. The benefits which would be expected to accrue from construction of Aquilla Reservoir have been estimated for the 100-year period 1975 through 2075. The benefits which are expected to accrue over the 100-year period have been reduced to an average annual equivalent value by compound interest methods. The estimates of average annual benefits for Aquilla Reservoir are described and shown in table 5 by purposes.

a. Reduction in flood damages.- The average annual benefits for reduction of flood damages, as shown in detail in appendix III, were determined by use of discharge-damage and discharge-frequency relationships. The residual average annual damages of $3,141,500 under present conditions of economic development in the flood plain below Aquilla Reservoir would be reduced to $2,855,500 for benefits of $286,000. An allowance to reflect the economic trends and development anticipated in the agricultural and urban areas of the flood plain during the period 1975 to 2075 would

increase the average annual flood control benefits to a total of $725,200.

b. Water supply.- The benefits for water supply were estimated by the U. S. Public Health Service on the basis of the cost of obtaining the same quantity and quality of water by the cheapest alternative means that would most likely be developed by the potential users in the absence of the Federal project. The estimated cost of the alternative means was based on non-Federal financing and interest rates for existing private- and publicly-owned projects. The proposed Aquilla Reservoir has been credited with water supply benefits of $158,000 annually for the period 1975-2075. A detailed computation of the water supply benefits is shown in the U. S. Public Health Service report in appendix VI.

c. Recreation and fish and wildlife enhancement.- Studies of the Aquilla Reservoir by the Corps of Engineers indicate that the estimated average annual project visitation for recreation and fish and wildlife enhancement would amount to about 1,000,000; and that the annual benefits for such recreational activities as picknicking, swimming, boating, sightseeing, camping, and other outdoor pursuits would be about $350,000, as shown in appendix V. The annual benefits for sport fishing and hunting activities were estimated by the Bureau of Sport Fisheries and Wildlife. The report of the Bureau of Sport Fisheries and Wildlife presented in appendix VI shows a benefit of $275,000 annually to sport fishing and a net loss of 700 man-days of upland-game and fur-animal hunting. It is estimated that the monetary loss to hunting would be $2,100 annually, thus resulting in a net benefit of $272,900 annually for fish and wildlife enhancement. Thus, the total annual benefits for recreation and fish and wildlife enhancement for the proposed Aquilla Reservoir is estimated at $622,900.

77. ECONOMIC JUSTIFICATION.- The comparison of the annual benefits with annual charges presented in table 5 indicate that Aquilla Reservoir is economically justified. This justification is based entirely upon tangible benefits, although it is recognized that the project would also provide important intangible benefits to the area and to the state. The flood control effects of the reservoir would reduce the threat to lives and further stabilize the economy of the area subject to flooding downstream from the project. The recreation and fish and wildlife enhancement aspects of the project would improve the social well-being of a large segment of the population within the study area. The water supply features would stimulate the general economy of the area. Even though these intangible benefits cannot be evaluated in monetary terms, it is evident that they are of major significance and would add materially to the justification of the proposed project. Estimates of annual charges, benefits, and the benefit-to-cost ratio for the recommended

Aquilla Reservoir plan are shown in table 5.

TABLE 5

ECONOMIC SUMMARY
AQUILLA RESERVOIR
BRAZOS RIVER BASIN, TEXAS

Item	Amount
FIRST COST	$23,300,000*
ANNUAL CHARGES	943,000
AVERAGE ANNUAL BENEFITS	
Prevention of flood damages	725,200
Water supply	158,000
Recreation and fish and wildlife enhancement	622,900(1)
Total	1,506,100
BENEFIT-COST RATIO	1.6
EXCESS BENEFITS OVER COSTS	563,100

*With future recreation facilities ($575,000) discounted to present worth ($263,000) at year 1975.

(1) Includes $350,000 as annual benefits for general recreation and $272,900 as annual benefits for sport fishing and hunting.

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LOCAL COOPERATION

78. PROPOSED LOCAL COOPERATION.- Construction of the proposed Aquilla Reservoir would require local cooperation with respect to the water supply and the recreation and fish and wildlife enhancement functions of the proposed project. Prior to initiation of construction of the proposed reservoir, responsible local interests would be required to give assurances satisfactory to the Secretary of the Army that they will:

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

b. Hold and save the United States free from water rights claims resulting from construction and operation of the project.

c. Reimburse the United States for the project costs allocated to water supply 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 presently estimated allocated water supply costs as may be necessary to reflect adjustments in the storage capacity for water supply and other purposes.

d. In accordance with the Federal Water Project Recreation Act of 1965:

(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 cost of the project allocated to recreation and fish and wildlife enhancement; and

(3) Bear all costs of operation, maintenance, and replacement of recreation and fish and wildlife lands and facilities.

Provided further, that the sizing and responsibility for development, operation and maintenance, and replacement of the recreation and fish and wildlife enhancement features of the reservoirs, involving items (1), (2), and (3) cited above, 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.

79. The water supply provisions include water that is needed to meet anticipated future needs. Payment is not required with respect to storage for future water supply until such supply is first used except that payments must begin so as to permit paying out the costs allocated to water supply within the life of the project, but in no event to exceed 50 years after first use. Not more than 30 percent of the total estimated construction cost of the project can be allocated to anticipate future demands. No interest will be charged to the investment costs (construction costs plus interest during construction) allocated to future water supply until use is initiated, but the interest-free period shall not exceed 10 years.

80. The Brazos River Authority is the agency designated by the Texas Water Commission (now the Texas Water Rights Commission and the Texas Water Development Board) to negotiate with the Corps of Engineers in matters pertaining to water supply storage in Corps projects in the Brazos River Basin. The Brazos River Authority, in a letter dated April 9, 1965, notified the Corps of Engineers of its approval of the proposed plan and expressed their willingness to assume the requirements of local cooperation for the water-supply portion of the project. A copy of the resolution of the Texas Water Commission and of the letter from the Brazos River Authority is shown in appendix VII.

81. The Texas Parks and Wildlife Department is the agency designated by the Governor of Texas to negotiate with the Corps of Engineers in matters pertaining to recreation and fish and wildlife enhancement in Federal projects in Texas. The matter of non-Federal participation in recreation and fish and wildlife enhancement in the Aquilla Reservoir is still under consideration by the State of Texas.

COST ALLOCATION AND APPORTIONMENT

82. COST ALLOCATION TO PROJECT PURPOSES.- Cost allocation studies were made for 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 costs of the proposed Aquilla Reservoir was allocated to purposes of flood control, water supply, and recreation and fish and wildlife enhancement. A summary of cost allocation for the project is presented in table 6.

83. APPORTIONMENT OF COSTS AMONG INTERESTS.- The construction cost and the annual operation and maintenance cost for the Aquilla Reservoir 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 7.

84. The costs allocated to flood control are apportioned to the Federal Government in accordance with the general policy established in the Flood Control Act of 1936 Public Law 738, 74th Congress as amended. The costs allocated to the flood control function are assigned to the Federal Government because of the widespread and general nature of the benefits associated with the flood control effects.

85. The costs allocated to water supply are apportioned to non-Federal interests in accordance with the provisions of the water Supply Act of 1958, Public Law 580, 85th Congress, as amended.

86. The costs allocated to recreation and fish and wildlife enhancement are apportioned to Federal and non-Federal interests in accordance with Public Law 89-72, cited as the Federal Water Project Recreation Act.

TABLE 6

SUMMARY OF COST ALLOCATION
PROPOSED AQUILLA RESERVOIR
AQUILLA CREEK WATERSHED
(ALLOCATED COSTS AND PERCENTAGES)

Item	:Aquilla Reservoir
PERTINENT DATA	
Total project first cost (dollars)	23,612,000
Total project first cost (dollars)(discounted)(1)	23,300,000
Total project annual charges (dollars)	954,000
Total project annual charges (dollars)(discounted)(1)	943,000
Average annual operation and maintenance (dollars)	50,000
Total controlled storage, acre-feet	199,300
Flood control storage, acre-feet	(111,500)
Water supply storage, acre-feet	(59,700)
Sediment storage, acre-feet	(28,100)
Dependable water supply yield at site, cfs(mgd)	15(9.7)
FLOOD CONTROL (2)	
Annual charges	$ 554,600(58.81)
Construction costs	14,625,000(62.77)
Annual operation and maintenance cost	38,000(31.67)
Construction cost per acre-foot	131.17 -
WATER SUPPLY (2)	
Annual charges	$ 129,600(13.74)
Construction costs	3,386,000(14.53)
Annual operation and maintenance cost	10,000(8.33)
Construction cost per acre-foot	56.72 -
Cost per 1,000 gallons (100-yr basis)	0.03662 -
" " " " (50-yr basis)	0.04386 -
RECREATION AND FISH AND WILDLIFE ENHANCEMENT (2)	
Annual charges	$ 258,800(27.45)
Construction costs	5,601,000
Construction costs discounted	5,289,000(22.70)
Annual operation and maintenance cost	72,000(60.00)

(1) Cost allocations based on total project first cost and annual charges, with future recreation facilities discounted to present worth at year 1975.
(2) Allocations by cost and (percentages).

TABLE 7

APPORTIONMENT OF COST
PROPOSED AQUILLA RESERVOIR

Item	Federal	Non-Federal	Total
FIRST COST			
1. Flood control	$14,625,000	-	$14,625,000
2. Water supply	-	$3,386,000	3,386,000
3. Optimum recreation	4,868,000	733,000	5,601,000
a. Joint cost	(4,135,000)	-	(4,135,000)
b. Specific cost			
(1) Present value portion	(577,000)	(577,000)	(1,154,000)
(2) Discounted increment*	(156,000)	(156,000)	(312,000)
4. Total	$19,493,000	$4,119,000	$23,612,000
AVERAGE ANNUAL OPERATION AND MAINTENANCE			
1. Flood control	$38,000	-	$38,000
2. Water supply	-	$10,000	10,000
3. Optimum recreation	22,000	50,000	72,000
a. Joint cost	(22,000)	(-)	(22,000)
b. Specific cost	(-)	(50,000)	(50,000)
4. Total	$60,000	$60,000	$120,000

* Difference between total cost of recreation facilities and total cost with future facilities discounted to present worth at year 1975.

COORDINATION WITH OTHER AGENCIES

87. GENERAL.- During the preparation of this report the investigations were coordinated with interested Federal and State agencies and responsible local interests on the Aquilla Creek watershed. The response included statements of interest in the investigation and information on available basic and general data.

88. U. S. PUBLIC HEALTH SERVICE.- Estimates of the needs and values of water-supply storages on the Aquilla Creek 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 problems and needs and the water requirements to the year 2075 on the Aquilla Creek watershed. The Public Health Service report is presented in appendix IV. The U. S. Public Health Service has also presented recommendations for vector controls and public health safeguards for the proposed Aquilla Reservoir area. The recommendations are presented in appendix VII.

89. 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 investigations on the Aquilla Creek watershed. A report prepared by the Bureau of Sport Fisheries and Wildlife, is presented in appendix VI.

90. BUREAU OF MINES.- In answer to an inquiry regarding the mineral resources of the Aquilla Reservoir area, the U. S. Bureau of Mines, Area IV office, stated that a review of the available information indicated no productive oil and gas wells, or other mineral developments in the limits of the reservoir site. The Bureau stated it has no objection to the proposed construction. The Bureau recommended that a detailed field examination of the area be made during preconstruction planning phases of the project, if it is authorized for construction. A letter containing the comments of the Bureau of Mines is presented in appendix VII.

91. 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 Aquilla Creek watershed. In a letter dated August 4, 1965, as presented in appendix VII, the Service indicated that local sponsors, due to the probability of the installation of the Aquilla Reservoir, had amended their original applications for assistance by combining the drainage areas of Hackberry and Aquilla Creeks, forming the Aquilla-Hackberry Creek watershed. Field studies indicate a system of 18 flood-water retarding structures will provide the desired protection to agricultural and non-agricultural properties. The Service states that the total estimated cost for the upstream project is about $1,500,000,

that a favorable benefit-cost ratio is indicated and that detailed planning will begin in October 1965.

92. U. S. GEOLOGICAL SURVEY.- Coordination work with the U. S. Geological Survey consisted of the acquisition of basic data from that agency. These data included drainage area information, stream gaging data, discharge and runoff data, historical floods, water-quality data, topographic maps, and other pertinent information.

93. BUREAU OF PUBLIC ROADS AND TEXAS HIGHWAY DEPARTMENT.- The Bureau of Public Roads and the Texas Highway Department were consulted regarding the desirability of a roadway across the Aquilla Dam. The Texas Highway Department stated in its reply of May 26, 1965, that the need of an additional road would be questionable. The Department indicated that such a road would have scenic value, but its benefits would be negligible. In addition, the horizontal alignment of the dam, the restricted width at its crest, and the requirement for a structure across the spillway area precludes further consideration of a farm-to-market road across the dam. The Bureau of Public Roads indicated that since the Texas Highway Department did not indicate an interest in providing a roadway, the Bureau could not recommend a roadway across the Aquilla Dam. In a letter dated June 23, 1965, the Highway Department indicated that, after being advised of the tentative plans and estimated costs for the relocation and alteration of farm-to-market roads in the Aquilla Reservoir area, it might become necessary to give further consideration to this matter. The Department suggested further analysis of the routes to be followed by FM 310 and FM 1947. A review of the costs by the Corps of Engineers indicated that the difference in cost, for providing a farm-to-market road along the routes contemplated, as compared to a route across the dam, would be insignificant.

94. LOCAL INTERESTS.- As previously stated, local interests from Hillsboro and West have indicated a definite interest in water supply development of the Aquilla Creek watershed. As a result of their interests, the Brazos River Authority requested the Texas Water Commission (now the Texas Water Rights Commission and the Texas Water Development Board) to designate the Authority as the responsible agency to negotiate with the Corps of Engineers for acquisition of storage space in the Aquilla Reservoir. Local interests from Hillsboro and West can be expected to contract for water supplies from the Brazos River Authority.

95. The Texas Water Commission, by a resolution adopted March 30, 1965, designated the Brazos River Authority as the responsible agency. As a result, the Brazos River Authority, by a letter dated April 9, 1965, informed the Corps of Engineers of the action of the Texas Water Commission and indicated that the Authority is

willing to assume the obligations and requirements of local cooperation for the water-supply portion of the Aquilla Reservoir project. Copies of the resolution of the Texas Water Commission and the letter of intent from the Brazos River Authority are presented in appendix VII.

96. REVIEW OF REPORT BY OTHER AGENCIES.- Copies of this report have been forwarded to interested Federal agencies at field level and to the Texas Water Rights Commission and the Texas Water Development Board for their preliminary views and comments. The reply 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 indicated that the Aquilla Reservoir project would not appear to affect any State park or other significant existing recreation area. The Park Service requested that they be contacted during early preconstruction planning regarding the customary archeological surveys and site salvage operations.

b. Bureau of Mines.- The Bureau of Mines indicated that it does not object to the proposed construction, providing a detailed field examination is made by a qualified engineer during preconstruction planning for the purpose of recommending adequate protective measures for petroleum and mineral resources in the Aquilla Reservoir area.

c. Forest Service.- The Forest Service, United States Department of Agriculture, stated that the construction of Aquilla Reservoir will not have any significant effects on timber resources.

d. Bureau of Public Roads.- The Bureau of Public Roads stated that all cost relating to highway relocation and reconstruction within the reservoir area is interpreted to be a responsibility of the water resource project.

e. Bureau of Outdoor Recreation.- The Bureau of Outdoor Recreation commented on the relationship of the report recommendations with regard to the Federal Water Project Recreation Act (Public Law 89-72). The Bureau indicates that the Aquilla Reservoir lies in Planning Region II as defined by the Texas Statewide Comprehensive Outdoor Recreation Plan. The Bureau's analysis of Planning Region II shows that the area exhibits a surplus of water and related land resources for swimming and boating, a condition which is estimated to continue into the 1970's. The analysis reveals a deficit of facilities for picnicking and camping, and that facility expansion is expected to be on existing lands. The Bureau pointed out that if local cooperation is not secured at this time, the

recommendations should include provisions to set aside those lands considered necessary for the preservation of the recreational potential of the project. In reply, the Corps of Engineers stated that the State of Texas has no legislative authority to participate in the Federal Water Project Recreation Act (P.L. 89-72), and has not indicated its intent regarding participation in the recreational development of Aquilla Reservoir; and that, in any event, minimum facilities (including lands) would be provided to preserve the recreational enhancement potential of the project for ten years.

f. Southwestern Power Administration.- The Southwestern Power Administration indicated that the proposed Aquilla Reservoir would not affect the interests of the Administration in the Brazos River Basin.

g. Federal Power Commission.- The Federal Power Commission reviewed the subject report and asserted that because of the low yield of the reservoir, the development of power at this project would be impractical.

h. Bureau of Reclamation.- The Bureau of Reclamation suggested that the report could be improved by including sufficient data to check the irrigation requirements with the U. S. Study Commission - Texas report. In reply, the Corps of Engineers stated that the data in the report is based on a correlation and an interpretation of irrigation data contained in the Bulletin No. 6018 "Irrigation in Texas, 1958," by the Texas Board of Water Engineers and the planning report "Irrigation Diversion Requirements and Return Flow, 2010 Conditions," dated August 1960 by the U. S. Study Commission - Texas.

i. Texas Water Development Board.- The Texas Water Development Board commented that the project recommended by the report does not conflict with the State Water Plan now being prepared by that agency. The Board stated that construction of the project as recommended is desirable.

j. Texas Highway Department.- The Texas Highway Department in a letter to the Texas Water Development Board indicated that it had no further comments in regard to the report.

k. U. S. Soil Conservation Service.- The comments of the Soil Conservation Service with regard to the reduction of residual damages was due to a typographical error in the report. Paragraph 76 of page 55 has been corrected. Pursuant to comments of the Service with regard to annual depletions, the Corps of Engineers indicated that data in the report was based on information from the Service, the Bureau of Reclamation, and analysis by the Corps. The report

assumes that the year 2010 and year 2075 conditions, with reference to the resources and depletions, would be approximately the same.

l. Bureau of Sport Fisheries and Wildlife.- In its review of the report, the Bureau of Sport Fisheries and Wildlife stated that the discussion of fish and wildlife accurately reflects the Bureau's analysis of the project's effects on these resources. The Bureau stated that its recommendations regarding provisions for seining areas and a zoning plan were discussed in the report but that the matter of streamflow releases and retention of standing timber in the reservoir area were not discussed as to acceptability. Also, the Bureau suggested that the report show the division of non-Federal costs between fish-and-wildlife activities and general-recreation activities so that those responsible for repayment would be aware of the charges to be imposed. In reply, the Corps of Engineers explained existing regulations and restrictions in regard to the incorporation of the recommendations of the Bureau at this time, but stated that additional consideration would be given to the recommendations during the advance planning stage. Paragraph 69 of the report text was revised to acknowledge consideration of the recommendations of the Bureau.

m. Texas Water Rights Commission.- The Texas Water Rights Commission reaffirmed its resolution of 30 March 1965, naming the Brazos River Authority as the local sponsor of the proposed project and as the agency responsible for acquisition of the water rights when the project is developed. The Brazos River Authority, whose comments were forwarded with those of the Water Rights Commission, stated that the project would fit into the Brazos River system.

n. Federal Water Pollution Control Administration.- In its comments on the report, the Federal Water Pollution Control Administration, previously referred to in this report as the U. S. Public Health Service, pointed out that the U. S. Public Health Service Drinking Water Standards recommends total dissolved solids concentration not to exceed 500 mg/l. The Administration states that this is not attainable in the watershed, and a practical goal of 1,000 mg/l was selected. Paragraph 51b of the report was revised to agree with the above comments.

o. U. S. Geological Survey.- The Geological Survey requested that the report be revised to include a recommendation for hydrologic instrumentation for water quality and water discharge. Paragraph 41 of appendix II of the report has been modified to comply with this request.

DISCUSSION AND CONCLUSIONS

97. DISCUSSION.- This interim report considers the desirability of modifying the authorized Brazos River Basin system to include improvements for flood control, water conservation and related water uses on the Aquilla Creek watershed.

98. Local interests from the cities of Hillsboro and West requested the investigation of the Aquilla Reservoir on Aquilla Creek for water resource development. They have indicated a desire and need for flood protection and water supply. The present water supply for this area is viewed as critical due to the very limited volume and quality of ground water which is the only source of supply.

99. Long range planning aspects of the Brazos River Basin in the interest of flood control, water supply, and recreation and fish and wildlife enhancement indicates a need for development of the water resource potentials of the Aquilla Creek watershed. The Aquilla Reservoir was recommended as a unit in the U. S. Study Commission - Texas water plan. The construction of the Aquilla Reservoir would function efficiently as a unit in the Brazos River Basin plans.

100. 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.

101. CONCLUSIONS.- The District Engineer concludes:

a. That a serious flood problem exists on the Aquilla Creek watershed.

b. That the floodflows discharging from Aquilla Creek contribute materially to the damages to properties along the Brazos River downstream of the mouth of Aquilla Creek.

c. That an urgent water supply need exists on the Aquilla Creek watershed, necessitating an economical and practical development of the water-supply resources of the Aquilla Creek watershed.

d. That the selected plan for a multiple-purpose reservoir on the Aquilla Creek watershed is economically justified.

e. That there is an immediate need for the proposed Aquilla Reservoir, which would be an important element in the system of authorized reservoir projects for flood control, water supply, and allied purposes in the Brazos River Basin.

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

a. That the Aquilla Reservoir be authorized for construction and for the beneficial public use of the water resources of the Aquilla Creek watershed.

b. That the authorized project for Brazos River and Tributaries, Texas, be modified to provide for authorization of the Aquilla Reservoir for purposes of flood control, water supply, and recreation and fish and wildlife enhancement.

c. That the foregoing be accomplished, including such changes and modifications as in the discretion of the Chief of Engineers may be advisable, at an estimated cost, based on the January 1965 price level, to the United States of $23,612,000 for construction and $70,000 for annual operation and maintenance provided that, prior to the initiation of construction of the reservoir, responsible local interests give assurances satisfactory to the Secretary of the Army that they will:

(1) Obtain without cost to the United States all water rights necessary for operation of the project in the interest of water supply;

(2) Hold and save the United States free from water rights claims resulting from construction and operation of the project;

(3) Reimburse the United States for the project costs allocated to water supply 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. The water supply costs allocated to local interests for the Aquilla Reservoir include $3,386,000 in construction first costs and an average annual operation and maintenance cost of $10,000.

(4) In accordance with the Federal Water Project Recreation Act of 1965:

(a) Administer project land and water areas for recreation and fish and wildlife enhancement;

(b) Pay, contribute in kind, or repay, which may be through user fees, with interest, one-half of the separable cost of the projects allocated to recreation and fish and wildlife enhancement, the amount involved currently estimated at $733,000 for Aquilla Reservoir;

(c) Bear all costs of operation, maintenance, and replacement of recreation and fish and wildlife lands and facilities, the amount involved currently estimated on an average annual basis at $50,000 for the Aquilla Reservoir.

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, involving items (a), (b), and (c) cited above, 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.

103. On the foregoing basis, the net cost to the United States for construction, after repayment by local interests for construction costs allocated to water supply and recreation and fish and wildlife enhancement is $19,493,000 for the Aquilla Reservoir. The net cost to the United States for operation, maintenance, and replacements on an average annual basis is $60,000 for the Aquilla Reservoir.

104. The non-Federal costs and responsibilities set forth above with respect to recreation and fish and wildlife enhancement are based on the desirable level of development for these purposes which would be afforded by the plan on which my recommendations are based. However, under the flexibility afforded by the Federal Water Project Recreation Act less extensive development for these purposes would be possible, with attendant reduction in non-Federal costs and responsibilities. As a minimum, it may be possible under the provisions of the Act to limit development to basic provisions for public health and safety and preservation of recreation and fish and wildlife enhancement potentials, without non-Federal participation. The extent to which the scale of development for recreation and fish and wildlife enhancement may be reduced within these limits, without adverse effect on economic justification,

remains to be established. I am confident, however, that mutually acceptable arrangements between Federal and non-Federal interests can be worked out in connection with detailed preconstruction planning.

JACK W. FICKESSEN
Colonel, CE
District Engineer

[First endorsement]

SWDGA-5
SUBJECT: Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek

Division Engineer, Southwestern Division, Corps of Engineers, 1114 Commerce Street, Dallas, Texas 75202, 24 March 1966

TO: Chief of Engineers, Department of the Army, Washington, D. C. 20315

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

R. H. FREE
Brigadier General, USA
Division Engineer

APPENDIX I

PROJECT FORMULATION, ANALYSES, COSTS AND COST ALLOCATION

INTERIM REVIEW OF REPORTS ON BRAZOS RIVER AND TRIBUTARIES, TEXAS COVERING AQUILLA RESERVOIR ON AQUILLA CREEK

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APPENDIX I

PROJECT FORMULATION, ANALYSES, COSTS, AND COST ALLOCATION

1. INTRODUCTION.- The subject report is an interim study under authority for the current basinwide review of Brazos River and tributaries, Texas and New Mexico. The subject report considers the desirability of modifying the existing project for Brazos River and Tributaries, Texas, by the addition of the Aquilla Reservoir on Aquilla Creek, Texas.

2. An important object of this report is the formulation of an Aquilla Reservoir plan which will contribute most beneficially in the resolution of existing and projected water problems within a determined regional study area. Based on studies of the water resource needs of the study area, project formulation studies, and the desires expressed by responsible local interests, the subject report includes recommendations for authorization and construction of a multiple-purpose Aquilla Reservoir on Aquilla Creek for purposes of flood control, water supply, and recreation and fish and wildlife enhancement. The recommended Aquilla Reservoir project, with dam on Aquilla Creek at mile 20.7, contains a total controlled storage of 199,300 acre-feet, of which 111,500 is for flood control, 59,700 is for water supply, and 28,100 acre-feet is for sedimentation. The reservoir storages provide: Control of 50-year-frequency floods originating upstream of the dam site; a dependable water supply yield of about 15 cubic feet per second, or about 9.7 million gallons daily; provision for 100-year sedimentation; and sufficient surface area, shoreline, and reservoir depth to serve an average annual visitation of 1,000,000 persons expected to participate in recreation and fish and wildlife activities. The proposed project was analyzed and evaluated on the basis of a 100-year economic life during the period 1975-2075.

3. SUMMARY OF WATER PROBLEMS.- The formulation of the proposed Aquilla Reservoir project involved a study of all possible water problems within the zone of influence of the reservoir project. The water problem studies determined that the purposes of flood control, water supply for municipal and industrial uses, and recreation and fish and wildlife enhancement should be included in the formulation and analysis of plans for Aquilla Reservoir on Aquilla Creek. The purposes of water quality control, irrigation, hydroelectric power development, and navigation were considered but were excluded on the basis that these purposes in Aquilla Reservoir were not practical or needed, as indicated in paragraphs 50 through 52 of the text. The study area for flood control includes the flood plains of Aquilla Creek downstream of mile 20.7 and of the Brazos River downstream of Aquilla Creek. The flood studies indicate that floods originating on the Aquilla Creek watershed cause appreciable damages along Aquilla Creek, and contributed substantially to flood conditions and damages along the main stem of the Brazos River. The study area for water

supply was limited to Hill, McLennan, and Falls Counties, which includes the cities of Hillsboro, McGregor, Marlin, Waco, and West. The water supply provided by Aquilla Reservoir will assist in meeting the municipal and industrial needs of the study area, with the principal service area consisting of the Aquilla Creek watershed, including the cities of Hillsboro and West. The study area for recreation and fish and wildlife enhancement involves all or portions of 17 counties surrounding the project area and includes such competing reservoir projects as Bardwell, Belton, Benbrook, Navarro Mills, Stillhouse Hollow, Waco, and Whitney Reservoirs. Studies determined that the Aquilla Reservoir is needed to assist in meeting the recreation and fish and wildlife needs of the study area for the period 1975 to 2075.

4. The U. S. Public Health Service and the Bureau of Sport Fisheries and Wildlife, at the request of the Corps of Engineers, furnished reports pertaining to the water supply, water quality control, fishing, hunting, wildlife, and recreation aspects of the investigated Aquilla Reservoir plans. The reports of the two Federal agencies are presented in appendix VI. Pertinent data and reservoir plan costs as needed for various analyses were furnished the two agencies. The annual benefits for fish and wildlife by the Bureau of Sport Fisheries and Wildlife and annual benefits for water supply by the Public Health Service were utilized for evaluation of the proposed Aquilla Reservoir project.

5. BASIC PROJECT-FORMULATION CONSIDERATIONS.- The more important physical, legal, and design objectives and constraints utilized in the formulation of Aquilla Reservoir plans on Aquilla Creek are presented below.

a. Flood control.-

(1) To provide flood protection to the agricultural and urban developments within the investigated flood plains of Aquilla Creek and the Brazos River against a recurrence of at least a 50-year flood, or possibly greater floods to the extent practicable within reasonable economic efficiency as determined by the maximization of excess benefits over cost.

(2) To provide channel improvements and/or flood easements as necessary to allow efficient operation of investigated reservoir projects by evacuation of flood control storages within a reasonable period of time.

(3) To give full cognizance to the long-range waterflow retardation and land conservation programs of the Soil Conservation Service to the extent such programs relate to hydrologic and economic aspects of the affected project or plan selected in this report.

(4) To determine the economic justification of flood control storage in the investigated Aquilla Reservoir on a next-added basis to the authorized Brazos River reservoir system, which includes Millican Reservoir (in lieu of the authorized Ferguson project) as a last-added unit; and as a last-added increment in any investigated multiple-purpose Aquilla Reservoir plan on Aquilla Creek.

b. Water supply.-

(1) To make maximization studies of excess benefits over costs and to determine optimum economical water supply storage conditions in investigated Aquilla Reservoir plans on Aquilla Creek.

(2) To meet the demands for water supply in the study area to the extent possible with "in basin" supplies, including ground water and return flows.

(3) To fully coordinate water supply developments on the Aquilla Creek watershed with plans of affected municipalities, the Brazos River Authority, and the Texas Water Commission (now the Texas Water Development Board and the Texas Water Rights Commission).

(4) To determine dependable water supply yield on a net basis, recognizing existing watershed developments, and a potential system of flood detention reservoirs by the Soil Conservation Service as reported in the U. S. Study Commission - Texas plan.

c. Recreation and fish and wildlife enhancement.-

(1) To provide facilities for recreation and fish and wildlife enhancement purposes to the maximum practicable extent for satisfying expected visitor demands.

(2) To determine the economic justification of the recreation purpose on the basis of : utilizing a reasonable average annual visitation for the basis of benefits and facility needs; establishing a reasonable schedule for installation of facilities in accordance with expected increases in visitor demands; and utilizing present value of first cost and average annual equivalent charges for recreation facilities, based on the schedule of installation.

6. INVESTIGATED RESERVOIR SITES.- Dam sites for the Aquilla Reservoir were considered on Aquilla Creek at miles 23.3 and 20.7. The dam site at mile 23.3 was investigated in prior studies by the Corps of Engineers, as reported in House Document 535, 81st Congress; and was adopted for use in the Brazos River Basin framework plan proposed in the report of the U. S. Study Commission - Texas. Based on preliminary cost and project formulation studies, the site at

mile 20.7 was found to be more economically favorable for flood control and water supply purposes. Also, the lower site would control runoff from a larger drainage area, including the Cobb Creek tributary area, and would provide a greater potential in dependable water supply yield.

7. DETAILED STUDIES.- Detailed studies for Aquilla Reservoir involved hydrologic, hydraulic, and structural design studies; economic field and office studies; and cost studies. Detailed investigations included subsurface explorations to determine foundation conditions at the dam site, and topographic surveys to obtain dam site profiles and establish location and elevations for the boring plan. Drainage area delineations and values were established and finalized in cooperation with the U. S. Geological Survey. The reservoir areas and capacities were established on the basis of available mapping by the U. S. Geological Survey. Channel and valley sections for Aquilla Creek available from prior investigations were utilized for hydraulic, economic, and plan of improvement studies.

8. Aquilla Reservoir (with dam at mile 20.7) was investigated in a wide range of plans for purposes of flood control, water supply, and recreation and fish and wildlife enhancement. Detailed studies and investigations included economic and cost analyses to determine the most favorable amounts of controlled storage for flood control and water supply. The costs and benefits for the analyses were based on the January 1965 price level, an interest rate of 3-1/8 percent, and a 100-year economic life and evaluation period (1975-2075).

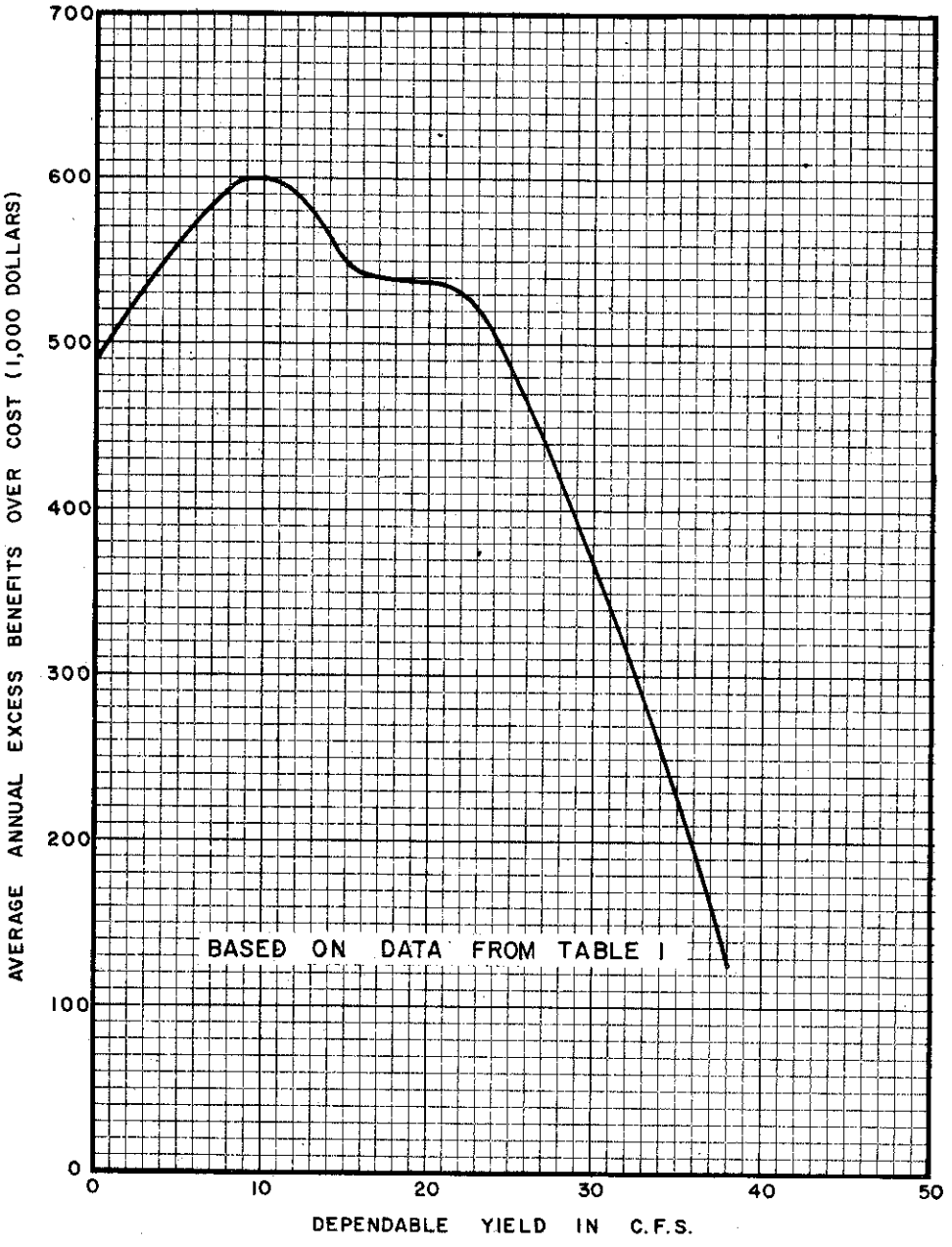
9. RESERVOIR STORAGE STUDIES.- Reservoir storage studies for the investigated plans are summarized as follows:

a. Water supply storage.- Analyses were made of Aquilla Reservoir to determine the water supply storage conditions which would provide the maximum amount of excess water supply benefits over costs. Multiple-purpose Aquilla Reservoir plans for flood control, water supply, and recreation and fish and wildlife enhancement purposes were investigated with a range of water supply storages to cover optimum-economical to maximum development of the water supply resources available upstream of the Aquilla Dam site. The plans included water supply storages to provide dependable water supply yields of 10, 15, 22, and 38 cubic feet per second (cfs). The studies were based on 50-year flood control storage conditions and constant benefits for flood control and for recreation and fish and wildlife enhancement. The maximization studies for determining optimum economical water supply storage conditions for Aquilla Reservoir are based on economic and cost analyses for plans 2 through 5 as presented in table 1, and are illustrated by figure 1. The

TABLE 1

PRELIMINARY ECONOMIC AND COST ANALYSES
INVESTIGATED RESERVOIR PLANS
AQUILLA CREEK WATERSHED

Item	Gated Ogee Channel Spillway					Broadcrested Uncontrolled Spillway		
	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6	Plan 7	Plan 8
	FC50	FC50 WS10 R	FC50 WS15 R	FC50 WS22 R	FC50 WS38 R	FC25 WS15 R	FC50 WS15 R	FC100 WS15 R
1. PERTINENT DATA								
Purpose: Flood control - FC, Water supply - WS, recreation and fish and wildlife enhancement - R	FC	FC WS R	FC WS R	FC WS R	FC WS R	FC WS R	FC WS R	FC WS R
Construction period - years	4	4	5	5	6	4	5	5
Elevations, feet - msl								
Top of dam	559.0	562.0	564.0	566.0	581.0	566.0	570.0	571.0
Top of flood control pool	543.0	548.0	551.0	553.0	571.0	547.0	551.0	553.0
Top of water supply pool	-	528.5	533.5	539.0	563.5	533.5	533.5	533.0
Surface area, acres								
Top of flood control pool	6,800	8,240	9,180	9,900	17,520	7,950	9,180	9,900
Top of water supply pool	-	3,720	4,560	5,800	14,200	4,560	4,560	4,460
Total controlled storage, acre-feet	139,700	173,200	199,300	218,400	463,100	165,200	199,300	218,400
Flood control storage, acre-feet	(111,600)	(104,900)	(111,500)	(103,700)	(117,200)	(78,800)	(111,500)	(132,300)
Water supply storage, acre-feet	(-)	(40,200)	(59,700)	(86,600)	(317,800)	(58,300)	(59,700)	(58,000)
Sediment storage, acre-feet	(28,100)	(28,100)	(28,100)	(28,100)	(28,100)	(28,100)	(28,100)	(28,100)
Dependable flow, water supply								
Second-feet, cfs	-	10	15	22	38	15	15	15
Million gallons daily, mgd	-	6.5	9.7	14.2	24.6	9.7	9.7	9.7
2. TOTAL FIRST COST OF PROJECT (in $1,000)	17,170.0	22,054.0	23,714.0	24,964.0	37,324.0	22,494.0	23,300.0	23,964.0
Reservoir	(17,170.0)	(20,900.0)	(22,560.0)	(23,810.0)	(36,170.0)	(21,340.0)	(22,146.0)	(22,810.0)
Recreation and fish and wildlife enhancement	(-)	(1,154.0)	(1,154.0)	(1,154.0)	(1,154.0)	(1,154.0)	(1,154.0)	(1,154.0)
3. TOTAL ANNUAL CHARGES (in $1,000)	656.6	887.6	957.6	1,001.8	1,467.3	893.0	943.0	971.4
Annual investment	597.6	767.6	837.6	881.8	1,337.3	783.0	823.0	846.4
Reservoir	(597.6)	(767.4)	(796.8)	(841.0)	(1,296.0)	(742.8)	(782.2)	(805.6)
Recreation and fish and wildlife enhancement	(-)	(40.2)	(40.8)	(40.8)	(41.3)	(40.2)	(40.8)	(40.8)
Annual operation, maintenance and replacement	59.0	120.0	120.0	120.0	130.0	110.0	120.0	125.0
Reservoir	(59.0)	(70.0)	(70.0)	(70.0)	(80.0)	(60.0)	(70.0)	(75.0)
Recreation and fish and wildlife enhancement	(-)	(50.0)	(50.0)	(50.0)	(50.0)	(50.0)	(50.0)	(50.0)
4. TOTAL ANNUAL BENEFITS (in $1,000)	725.2	1,487.6	1,506.1	1,532.0	1,591.2	1,304.4	1,506.1	1,525.2
Prevention of damages	(725.2)	(725.2)	(725.2)	(725.2)	(725.2)	(523.5)	(725.2)	(744.3)
Water supply	(-)	(139.5)	(158.0)	(183.9)	(243.1)	(158.0)	(158.0)	(158.0)
Recreation and fish and wildlife enhancement	(-)	(622.9)	(622.9)	(622.9)	(622.9)	(622.9)	(622.9)	(622.9)
5. RATIO OF BENEFITS TO COSTS	1.1	1.7	1.6	1.5	1.1	1.5	1.6	1.6
6. EXCESS BENEFITS OVER COSTS (in $1,000)	68.6	600.0	548.5	530.2	123.9	411.4	563.1	553.8



* *Maximization for water supply under 50-year flood control storage conditions and with constant benefits for flood control and for recreation and fish and wildlife enhancement.*

AQUILLA CREEK WATERSHED

MAXIMIZATION OF EXCESS BENEFITS OVER COST *

DEPENDABLE YIELD

VS

EXCESS BENEFITS

FIGURE 1

maximization studies determined that the most economical development for water supply would be realized by a plan providing a dependable water supply of about 10 cfs. The results of the water supply studies, including preliminary cost allocation studies, were presented to responsible local interests for selection of the desired water supply development. Plan 3, which provides a dependable water supply of about 15 cfs, was selected as adequate for meeting the existing and future municipal and industrial water requirements of the Aquilla Creek watershed, including the cities of Hillsboro and West. Studies by the U. S. Public Health Service substantiated that the selected plan of development would assist adequately in meeting the total water supply needs of the study area during the period 1975 to 2075. Analyses determined that water supply was economically justified as a last-added function in the investigated reservoir plans. The costs of plans 2 through 5 were based on gate-controlled ogee-type channel spillways.

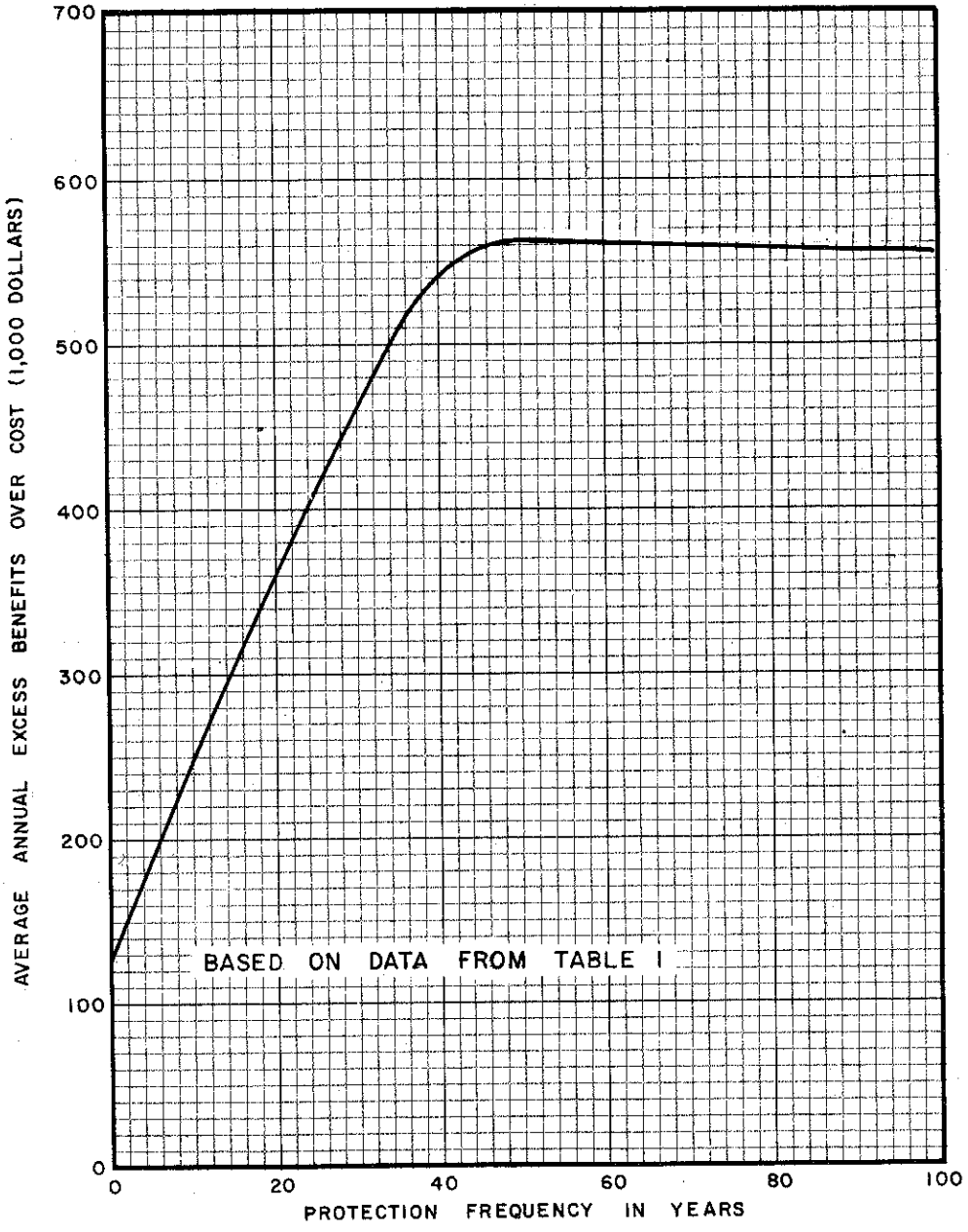
b. Flood control storage.- Analyses for Aquilla Reservoir were made to determine the flood control storage conditions which would provide the maximum amount of excess flood control benefits over costs. The flood control analyses were made on the basis of flood control storage requirements for the frequency range of once in 25 years to once in 100 years. The flood control analyses were made on the basis of multiple-purpose plans under conditions of constant water supply storage (as selected by local interests) and constant annual benefits for water supply and for recreation and fish and wildlife enhancement. The maximization studies for flood control are based on plans 6 through 8 as presented in table 1, and are illustrated by figure 2. The curve shown in figure 2 indicates that flood control storage capacity which would control flood volumes having a frequency of occurrence of once in 50 years would provide the maximum amount of excess benefits over costs. Thus, the flood control storage capacity adopted for Aquilla Reservoir approximates that required for 50-year flood control as based on a regional analysis of flood control storage requirements, and is sufficient to control the maximum flood of record (April-May 1975) with respect to flood volume. The economic analysis for plan 1 of table 1 indicates that a single-purpose flood control reservoir at the Aquilla site is economically justified. As indicated in the previous subparagraphs, the reservoir plans were based on utilizing gated-controlled ogee-type channel spillways. After selection of the desired size of water supply development (plan 3) by the local interests, it was determined by additional foundation and spillway design studies that an uncontrolled broadcrested spillway beyond the left abutment would be more practical and desirable for an Aquilla Reservoir project of the controlled-volume size as set forth under plan 3. Thus, the flood storage analyses involving plans 6 through 8 are based on the uncontrolled spillway design, and plan 3 and plan 7 are essentially the same plan in regard to total controlled storage.

c. Flood-release channel.- Flood control studies determined that improvement of the Aquilla Creek channel downstream of the Aquilla Dam site would not be required for flood storage release purposes and for proper operation of the reservoir project. The existing channel capacity of 3,000 second-feet will be sufficient to allow evacuation of the 50-year flood control pool in a period of about 19 days under ideal conditions.

d. Recreation storage.- The inclusion of conservation storage for recreation and fish and wildlife enhancement purposes was considered in the early planning stages. However, after determining the water supply requirements and the range of project sizes that would be used to satisfy these requirements, it was concluded that additional conservation storage would not enhance the water-based recreational aspects of projects significantly. Therefore, specific reservoir storage for the recreation purposes was not included in the reservoir plans studied.

9. PROPOSED PLAN OF IMPROVEMENT.- The plan selected as most feasible for water resource development at the Aquilla Reservoir site and for satisfying the needs of the study area is plan 7 of table 1. Pertinent data on the design characteristics of the proposed Aquilla Reservoir project are presented in table 2. Detailed estimate of first costs and annual charges are presented in tables 3 through 5. A reservoir map and details of the earth embankment, spillway, and outlet works are shown on plates 7 and 8.

10. The project formulation studies showed that a single-purpose flood control reservoir at the Aquilla Dam site would be economically justified, and that each purpose produces benefits in excess of the costs of adding that purpose to the multiple-purpose plan. The proposed Aquilla Reservoir plan accomplishes a reasonable balance in the several purposes in a manner which provides the maximum amount of excess flood control benefits over cost; development of water supply resources to the hydrologic optimum and to the extent desired by responsible local interests; and optimum development for recreation and fish and wildlife enhancement. The proposed Aquilla Reservoir would provide for the control of 50-year frequency floods originating upstream from the dam site; the development of comparatively economical and dependable water supply yield of about 15 cfs, or 9.7 mgd. The reservoir would eliminate about 66 percent of the average annual damages along Aquilla Creek downstream of the dam site, and about 7 percent of the residual flood damages along the Brazos River. The dependable water supply would assist in providing the water supply needs of the study area for the period 1975-2075, with principal usage slated for the Aquilla Creek watershed, including the cities of Hillsboro and West. The proposed project would increase the water-oriented recreation and fish and wildlife opportunities in the study area. The project would serve an estimated average annual visitation of approximately 1,000,000 visitors, and would provide a substantial increase in annual benefits over those currently provided by existing



* *Maximization for flood control under constant water supply storage condition (15 cfs yield size) and with constant benefits for water supply and for recreation and fish and wildlife enhancement.*

AQUILLA CREEK WATERSHED

MAXIMIZATION OF EXCESS BENEFITS OVER COST *

FLOOD PROTECTION FREQUENCY VS EXCESS BENEFITS

FIGURE 2

TABLE 2

PERTINENT DATA
PROPOSED AQUILLA RESERVOIR
AQUILLA CREEK WATERSHED

Item	Proposed Reservoir			
DRAINAGE AREA				
Square miles	294			
SPILLWAY DESIGN FLOOD				
Peak inflow, cfs	283,800			
Volume, acre-feet	450,600			
Volume, inches	28.74			
Peak outflow, cfs	172,000(1)			
RESERVOIR	Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inches)
Top of dam	570.0	-	-	-
Maximum design water surface	565.2	14,950	369,000	23.24
Top of flood control pool and spillway crest	551.0	9,180	199,300	12.71
Top of conservation pool	533.5	4,560	82,200	5.24
Sediment storage	-	-	28,100	1.73
STORAGE SUMMARY				
Flood control, acre-feet	111,500			
Water conservation, acre-feet	59,700			
Sediment, acre-feet	28,100			
Total	199,300			
DAM				
Type	Concrete and earth fill			
Total length, feet	12,500(3)			
Embankment section:				
Type	Compacted earth fill			
Total length, feet	10,600			
Height above streambed, feet	97			
Freeboard, feet	4.8			
Crown width, feet	34			
Side slopes:				
Upstream	1 on 2-1/2 and 1 on 13 and 1 on 3			
Downstream	1 on 2-1/2 and 1 on 13 and 1 on 3			
Spillway section:				
Type	Broadcrested weir			
Gross length, feet	1,200			
Net length, feet	1,200			
Spillway discharge, cfs:				
Maximum design water surface	169,100			
OUTLET WORKS				
Type	Gate-controlled conduit			
Number of conduits	1			
Dimensions	10' diameter			
Invert elevation, feet	485.0			
Control	2 - 5' x 10' sluice gates			
RELOCATIONS				
County roads, miles	2.7			
FM roads, miles	5.3			
Power lines, miles	14			
Telephone lines, miles	6			
Pipelines, miles	5.6			
Cemeteries	-			
LANDS				
Dam and reservoir				
Clearing acres	3,740			
Land acquisition:				
Fee simple, acres	14,500			
(Top of control elevation)	(556.0)(4)			
Recreation				
Land acquisition:				
Fee simple above general taking limits, acres	540			

(1) Includes discharge through outlet works as follows: 2,900 cfs
(2) All elevations refer to mean sea level
(3) Includes 1,200-foot spillway in left abutment and 700-foot dike in right abutment.
(4) In local vicinity of urban Hillsboro the taking like is elevation 558.0.

TABLE 3

SUMMARY OF FIRST COST AND ANNUAL CHARGES
PROPOSED AQUILLA RESERVOIR
AQUILLA CREEK WATERSHED

Item	Costs
FIRST COSTS	
1. FEDERAL FIRST COST	
a. Lands and Damages	$ 5,187,000
b. Relocations	3,063,000
c. Reservoir	336,000
d. Dam	11,190,000
(1) Embankment	(2,934,000)
(2) Slope Protection	(41,000)
(3) Spillway	(7,303,000)
(4) Outlet Works	(912,000)
e. Buildings and Grounds	134,000
f. Operating Equipment	60,000
g. Engineering and Design	1,180,000
h. Supervision and Administration	996,000
Subtotal - estimated first cost - dam and reservoir	22,146,000
i. Recreation and Fish and Wildlife Enhancement	1,154,000(1)
Subtotal - estimated Federal first cost	23,300,000
2. NON-FEDERAL FIRST COST	None
3. TOTAL ESTIMATED FIRST COST OF PROJECT	23,300,000
ANNUAL CHARGES	
(Construction period - 5 years)(Amortization period - 100 years)(Interest rate - 3.125 percent)	
1. FEDERAL INVESTMENT	
a. Dam and Reservoir	
(1) First Cost	22,146,000
(2) Interest During Construction	1,730,000
(3) Total Investment	23,876,000
b. Recreation and Fish and Wildlife Enhancement	
(1) First Cost	1,154,000
(2) Interest During Construction	90,000
(3) Total Investment	1,244,000
2. NON-FEDERAL INVESTMENT	None
3. FEDERAL ANNUAL CHARGES	
a. Dam and Reservoir	
(1) Interest on Investment	746,100
(2) Amortization of Investment	36,100
(3) Operation and Maintenance (including replacement of parts)	70,000
Subtotal	852,200
b. Recreation and Fish and Wildlife Enhancement	
(1) Interest on Investment	38,900
(2) Amortization of Investment	1,900
(3) Operation and Maintenance (including replacement of parts)	50,000
Subtotal	90,800
4. NON-FEDERAL ANNUAL CHARGES	None
5. TOTAL ESTIMATED ANNUAL CHARGES	943,000

(1) Future facilities of $575,000 (present value 1975 - $263,000).

TABLE 4

DETAILED ESTIMATE OF FIRST COST
PROPOSED AQUILLA RESERVOIR
AQUILLA CREEK WATERSHED

Item	Unit quantity	Unit cost	Multiple-purpose FC,WC,FW,& R Quantity	Multiple-purpose FC,WC,FW,& R Cost
PERTINENT INFORMATION				
Top of dam, elevation			570.0	
Spillway crest, elevation			551.0	
Lands, fee simple, acres			15,040	
(Top control elevation)			(556.0)	
A. FEDERAL FIRST COST				
(01.0) Lands and damages				
a. Land costs				
(1) Fee simple lands, improvements, and severances	Acre		$ 14,500	$ 3,750,000
(2) Resettlement reimbursement	L.S.			40,000
Subtotal - land costs				3,790,000
b. Land acquisition expense				360,000
Subtotal - land and acquisition expense				4,150,000
Contingencies, 25% ±				1,037,000
Total - Lands and damages				5,187,000
(02.0) Relocations				
a. Roads				
(1) FM highways				1,630,700
(2) County roads				164,450
Subtotal - roads				1,795,150
b. Pipelines and utilities				
(1) Pipelines				426,000
(2) Electric lines				222,000
(3) Telephone lines				7,200
Subtotal - pipelines and utilities				655,200
Subtotal - relocations				2,450,350
Contingencies, 25% ±				612,650
Total - Relocations				3,063,000
(03.0) Reservoirs				
a. Reservoir clearing	Acre	$ 75.00	3,740	280,500
Contingencies, 20% ±				55,500
Total - Reservoirs				336,000
(04.0) Dams				
a. Earth embankment				
(1) Diversion and care of water	L.S.			45,000
(2) Clearing and grubbing	Acre	250.00	183	45,750
(3) Excavation, stripping	C.Y.	0.40	287,000	114,800
(4) Excavation, common	C.Y.	0.40	164,000	65,600
(5) Excavation, borrow	C.Y.	0.35	677,000	236,950
(6) Compacted fill	C.Y.	0.10	7,241,000	724,100
(7) Riprap	C.Y.	9.00	93,700	843,300
(8) Bedding	C.Y.	7.00	35,200	246,400
(9) Base course	C.Y.	5.00	9,260	46,300
(10) Aggregate	C.Y.	10.00	710	7,100
(11) Asphalt	Gal.	0.18	36,500	6,570
(12) Metal guard fence	L.F.	3.00	21,000	63,000
Subtotal - earth embankment				2,444,870
b. Slope protection	Acre	400.00	85	34,000
c. Spillway				
(1) Clearing	Acre	150.00	234	35,100
(2) Excavation, unclassified	C.Y.	0.40	7,671,000	3,068,400
(3) Structural backfill	C.Y.	1.00	50,000	50,000
(4) Drilling and grouting anchor holes	L.F.	2.25	52,200	117,450
(5) Drainage system	L.S.			522,000
(6) Concrete, slab (includes baffles)	C.Y.	25.00	42,700	1,067,500
(7) Concrete, wall	C.Y.	35.00	5,230	183,050
(8) Cement	Bbl.	5.00	59,900	299,500
(9) Steel, reinforcing	Lb.	0.13	4,254,000	553,020
(10) 6' chain link fence	L.F.	5.00	1,200	6,000
(11) Waterstop, rubber	L.F.	3.00	7,600	22,800
(12) Tile gages	L.F.	20.00	82	1,640
(13) Riprap	C.Y.	9.00	13,170	118,530
(14) Bedding	C.Y.	7.00	4,620	32,340
(15) Erosion control	Acre	400.00	22	8,800
Subtotal - spillway				6,086,130
d. Outlet works				
(1) Care of water during construction	L.S.			25,000
(2) Clearing	Acre	150.00	9	1,350
(3) Excavation, unclassified	C.Y.	0.40	201,000	80,400
(4) Compacted backfill	C.Y.	1.00	30,800	30,800
(5) Foundation excavation protection	S.Y.	6.00	1,800	10,800
(6) Drilling and grouting 4" anchor holes	L.F.	2.25	380	855
(7) Drilling 3" drain holes	L.F.	2.00	330	660
(8) Foundation drainage system	L.S.			2,500
(9) Concrete, approach apron and wall footings	C.Y.	25.00	155	3,875
(10) Concrete, approach walls	C.Y.	40.00	110	4,400
(11) Concrete, intake structure and transition base below elevation 536	C.Y.	40.00	830	33,200
(12) Concrete, vertical shaft of intake structure above elevation 536	C.Y.	70.00	100	7,000
(13) Concrete, conduit and collars	C.Y.	35.00	2,290	80,150
(14) Concrete, stilling basin slab	C.Y.	25.00	520	13,000
(15) Concrete, stilling basin walls	C.Y.	35.00	1,810	63,350
(16) Concrete, bridge piers, footings, and abutement	C.Y.	55.00	205	11,275
(17) Concrete, bridge deck	C.Y.	80.00	93	7,440
(18) Cement	Bbl.	5.00	7,640	38,200
(19) Steel, reinforcement	Lb.	0.15	761,000	114,150
(20) Steel, structural, bridge	Lb.	0.22	95,000	20,900
(21) Water stops	L.F.	3.00	1,350	4,050
(22) Concrete trash bars	L.S.			2,000
(23) Flood control gates and operating equipment	L.S.			65,000
(24) Gage well facilities	L.S.			5,200
(25) Handrailing, guard posts and guard chains	L.S.			1,800
(26) Bridge railing, aluminum	L.F.	12.00	570	6,840
(27) Tile staff gages	L.F.	20.00	102	2,040
(28) Aluminum gratings and frames	L.S.			2,000
(29) Metal, miscellaneous	Lb.	0.60	1,500	900
(30) Gate-vent stacks	L.S.			9,000
(31) Project letters and insignia	L.S.			2,000
(32) Ladders	L.F.	2.00	900	1,800
(33) Electrical facilities	L.S.			4,000
(34) Fencing 6' chain link	L.F.	5.00	380	1,900
(35) Emergency bulkhead gate and frames	L.S.			4,000
(36) Riprap	C.Y.	9.00	8,500	76,500
(37) Bedding	C.Y.	7.00	3,120	21,840
Subtotal - outlet works				760,175
Subtotal - dams				9,825,175
Contingencies, 20% ±				1,864,825
Total - Dams				11,190,000
(19.0) Buildings and grounds				
(1) Maintenance buildings	L.S.			54,000
(2) Powerline to site	Mile	8,000.00	6	48,000
(3) Water well and accessories	L.S.			10,000
Subtotal - buildings and grounds				112,000
Contingencies, 20% ±				22,000
Total - Buildings and grounds				134,000
(20.0) Operating equipment				
(1) Stream gages	L.S.			15,000
(2) Radio facilities	L.S.			4,000
(3) Government work boat	L.S.			8,000
(4) Evaporation and rain gages	L.S.			1,500
(5) Farm-type tractor and miscellaneous small tools	L.S.			6,500
(6) Sediment and degradation ranges	L.S.			12,000
(7) Office furniture and equipment	L.S.			3,000
Subtotal - operating equipment				50,000
Contingencies, 20% ±				10,000
Total - Operating equipment				60,000
(30.0) Engineering and design				1,180,000
(31.0) Supervision and administration				996,000
Subtotal - estimated Federal first cost - dam and reservoir				22,146,000
TOTAL ESTIMATED FIRST COST OF FLOOD CONTROL AND WATER CONSERVATION				22,146,000
B. DETAILED ESTIMATE OF FIRST COST - RECREATION AND FISH AND WILDLIFE				
(01.0) Lands and damages				
a. Land costs above general taking limits				
(1) Fee simple lands, improvements, and severances	Acre		540	139,860
b. Acquisition expense	L.S.			13,000
Subtotal - land costs				152,860
Contingencies, 20% ±				30,540
Total - Lands and damages				183,400
(08.0) Access roads				
Contingencies, 20%				87,500
Total - Access roads				17,500
				105,000
(14.0) Facilities				
(1) Initial for first 3 years	L.S.			372,500
(2) Future development after 3 years				479,200
Subtotal - facilities				851,700
Contingencies, 20% ±				170,300
Total - Facilities				1,022,000(1)
(30.0) Engineering and design				85,000
(31.0) Supervision and administration				70,600
Subtotal - estimated Federal first cost - recreation and fish and wildlife				1,466,000
Subtotal - estimated Federal first cost - recreation and fish and wildlife (with future facilities discounted)				1,154,000
C. TOTAL ESTIMATED PROJECT FIRST COST				23,612,000
D. TOTAL ESTIMATED PROJECT FIRST COST (with future facilities discounted)				$23,300,000

(1) Future facilities of $575,000 (present value 1975 - $263,000).

TABLE 5

DETAILED ESTIMATE OF RELOCATION COSTS
PROPOSED AQUILLA RESERVOIR
AQUILLA CREEK

Item	Unit Quantity	Unit Cost	Quantity	Cost
A. Roads				
(1) FM Highway 310				
Embankment, Complete	C.Y.	0.55	264,000	145,200
Unclassified Excavation	C.Y.	0.60	300,000	180,000
Base and Surfacing	Mi.	20,000.00	7.0	140,000
Riprap	C.Y.	7.00	17,000	119,000
Bedding	C.Y.	5.00	6,400	32,000
Bridge, Complete	L.F.	200.00	880	176,000
Guard Rail	L.F.	2.50	4,000	10,000
Rights-of-Way	Acre	200.00	65	13,000
Minor Drainage	L.S.			40,000
				$855,200
(2) FM Highway 1947				
Embankment, Complete	C.Y.	0.55	296,000	162,800
Unclassified Excavation	C.Y.	0.60	12,000	7,200
Base and Surfacing	Mi.	20,000.00	0.8	16,000
Riprap	C.Y.	7.00	20,000	140,000
Bedding	C.Y.	5.00	7,500	37,500
Bridge	L.F.	250.00	1,600	400,000
Guard Rail	L.F.	2.50	4,400	11,000
Minor Drainage	L.S.			1,000
				$775,500
(3) County Roads				
Embankment, Complete	C.Y.	0.55	17,000	9,350
Unclassified Excavation	C.Y.	0.60	100,000	60,000
Riprap	C.Y.	7.00	800	5,600
Bedding	C.Y.	5.00	300	1,500
Base and Surfacing	Mi.	20,000.00	2.9	58,000
Rights-of-Way	Acre	200.00	2.5	5,000
Minor Drainage	L.S.			25,000
				$164,450
Subtotal - Roads				1,795,150
Contingencies 25% ±				448,850
Total - Roads				$2,244,000
B. Pipelines and Utilities				
(1) Pipelines				
Lone Star Gas Company 3" Line	Mi.	30,000.00	0.3	9,000
Lone Star Gas Company 12" Line	Mi.	90,000.00	2.3	207,000
Sinclair 10" Line	Mi.	70,000.00	3.0	210,000
				$426,000
(2) Electric and Telephone Lines				
TP&L 138 Kv. Line (Steel Towers)	Mi.	35,000.00	6.0	210,000
REA Distribution	Mi.	1,500.00	8.0	12,000
Telephone Lines	Mi.	1,200.00	6.0	7,200
				$229,200
Subtotal - Pipelines and Utilities				655,200
Contingeucnies 25% ±				163,800
Total - Pipelines and Utilities				$819,000
C. Total Relocations Cost				$3,063,000

natural resources, even though numerous competing reservoir facilities (existing and planned) are within the study area. Development on the Aquilla Creek watershed will be substantially stimulated, particularly in view of the close proximity of the city of Hillsboro and of Interstate Highway No. 35 between Waco and the Dallas-Fort Worth area.

11. Although the proposed project has been justified entirely by monetary benefits, the project would also provide important intangible benefits to the area and to the State. The flood control effects of the reservoirs would reduce the threat to lives and further stabilize the economy of the area subject to flooding downstream from the project. The recreation and fish and wildlife enhancement aspects of the project would improve the social well being of a large segment of the population within the study area. The water supply features would stimulate the general economy of the area. The intangible benfits of the selected plan are considered significantly and would add materially to the justification of the plan.

12. COST ALLOCATION AND APPORTIONMENT.- Cost allocation studies were made to determine the equitable distribution of the costs to the various purposes of the proposed Aquilla Reservoir project (plan 7). The cost allocation studies were made on the basis of the Separable Costs-Remaining Benefits method. This method involves studies of single-purpose and multiple-purpose reservoirs as instruments in the allocation procedures. The detailed cost allocation of construction, investment, and annual operation and maintenance costs of the selected plan of improvement to the purpose of flood control, water supply, and recreation and fish and wildlife enhancement are presented in table 6.

13. Alternatives were considered for furnishing the dependable water supply yield included in the proposed plan of improvement. After evaluating these alternatives in view of the quantity and location of the water requirements, the most efficient method among the feasible alternatives was determined to be a stage-development plan of water supply reservoirs on the Aquilla Creek. The cost of the cheapest plan to develop the yield was used as the alternative cost for water supply. A single-purpose flood control reservoir at the project site was used as the flood control alternative for the Aquilla Reservoir. The cheapest alternative for recreation and fish and wildlife enhancement purposes was considered to be two small non-Federal type reservoirs on the Aquilla Creek watershed, providing a total surface area of about 3,100 acres.

14. The construction cost and the annual operation and maintenance cost of the proposed plan of improvement was apportioned to Federal and non-Federal interests in accordance with existing laws, policies, and procedures. A cost-allocation and apportionment summary is presented in tables 6 and 7 of the text.

15. The costs allocated to flood control are apportioned to the Federal Government in accordance with the general policy established in the Flood Control Act of 1936, Public Law 738, 74th Congress, as amended. The apportionments are made to the Federal Government because of the widespread and general nature of the benefits associated with the flood control effects of the reservoir project.

16. The costs allocated to water supply are apportioned to non-Federal interests in accordance with the provisions of the Water Supply Act of 1958, Public Law 580, 85th Congress, as amended.

17. The costs allocated to recreation and fish and wildlife enhancement are apportioned to Federal and non-Federal interests in accordance with the Federal Water Project Recreation Act (Public Law 89-72), approved July 9, 1965.

85-251 O-67—7

TABLE 6

ALLOCATION OF COSTS
(SEPARABLE COSTS-REMAINING BENEFITS METHOD)
PROPOSED AQUILLA RESERVOIR
AQUILLA CREEK WATERSHED

Item	Single-purpose			Multiple-purpose	Dual-purpose		
	FC	WS	R		FC & WS	FC & R	WS & R
PERTINENT INFORMATION							
First costs, dollars	17,170,000	6,200,000	7,666,000	23,300,000	22,146,000	20,980,000	15,574,000
Investment costs, dollars	18,243,000	6,393,800(1)	7,906,000	25,120,000	23,876,000	22,619,000	16,630,000
Annual charges, dollars	656,600	145,600	322,000(3)	943,000	852,200	856,000	659,800
Annual operation and maintenance, dollars	59,000	30,000	63,000	120,000	70,000	115,000	117,000
Dependable yield, second-feet	-	15.0	-	15.0	15.0	-	15.0
Dependable yield, million gallons daily	-	9.7	-	9.7	9.7	-	9.7
Dependable yield, thousand gallons annually	-	3,538,586	-	3,538,586	3,538,586	-	3,538,586
Total annual benefits, dollars	725,200	158,000(2)	622,900	1,506,100	883,200	1,348,100	780,900
Flood control storage, acre-feet	111,600	-	-	111,500	111,500	111,600	-
Water supply storage, acre-feet	-	60,600	23,400	59,700	59,700	23,400	58,800
Sediment storage, acre-feet	28,100	28,100	28,100	28,100	28,100	28,100	28,100
Total storage, acre-feet	139,700	88,700	51,500	199,300	199,300	163,000	86,900
COST ALLOCATIONS							
Allocation of annual charges, dollars							
1. Benefits	725,200	158,000	622,900	1,306,100			
2. Alternate cost	656,600	145,600	322,000	-			
3. Benefits limited by alternate cost	656,600	145,600	322,000	-			
4. Separable costs	283,200	87,000	90,800	461,000			
5. Remaining benefits	373,400	58,600	231,200	663,200			
6. Percent distribution of item 5	56.30	8.84	34.86	100.00			
7. Allocated joint cost	271,400	42,600	168,000	482,000			
8. Total allocation	554,600	129,600	258,800	943,000			
9. Percent distribution of item 8	58.81	13.74	27.45	100.00			
Allocation of operation and maintenance costs, dollars							
10. Separable costs	3,000	5,000	50,000	58,000			
11. Percent joint costs, item 6	56.30	8.84	34.86	100.00			
12. Allocated joint costs	35,000	5,000	22,000	62,000			
13. Total allocation	38,000	10,000	72,000	120,000			
14. Percent distribution of item 13	31.67	8.33	60.00	100.00			
Allocation of initial investment, dollars							
15. Allocated annual charges	554,600	129,600	258,800	943,000			
16. Allocated O&M costs	38,000	10,000	72,000	120,000			
17. Remainder	516,600	119,600	186,800	823,000			
18. Percent distribution of item 17	62.77	14.53	22.70	100.00			
19. Allocated investment	15,768,000	3,650,000	5,702,000	25,120,000			
20. Allocated first costs	14,625,000	3,386,000	5,289,000	23,300,000			
21. Discount first cost increment of future recreational facilities	-	-	312,000	312,000			
22. Total allocated first cost	14,625,000	3,386,000	5,601,000	23,612,000			
Ratio of annual benefits to allocated annual charges	1.3	1.2	2.4	1.6			
Allocated unit construction cost (cost/acre-feet exclusive of O&M), dollars							
Flood control storage				131.17			
Water supply storage				56.72			
Allocated water supply cost per 1,000 gallons, dollars				0.03662			
Excess benefits over annual charges, dollars				563,100			

SPECIFIC COSTS

Purpose	Amount (dollars)
Recreation	
First costs	1,466,000
First cost (present value)	1,154,000
Annual charges	90,800
Annual operation and maintenance	50,000

NOTES:

(1) Alternative is construction of two reservoirs equivalent to the Cleburne Reservoir - first unit in 1975, second unit in 2025, cost of second unit discounted.

(2) Benefits derived on basis of construction of two reservoirs equivalent to Cleburne Reservoir. Benefits for second unit discounted.

(3) Alternative is construction of two reservoirs equivalent to Cleburne Reservoir with optimum recreation facilities.

APPENDIX VI

REPORTS BY OTHER FEDERAL AGENCIES

INTERIM REVIEW OF REPORTS
ON
BRAZOS RIVER AND TRIBUTARIES, TEXAS
COVERING
AQUILLA RESERVOIR ON AQUILLA CREEK

CONTENTS

PARKS AND WILDLIFE DEPARTMENT

J. WELDON WATSON
EXECUTIVE DIRECTOR

JOHN H. REAGAN BUILDING
AUSTIN, TEXAS 78701

March 11, 1965

Mr. Carey H. Bennett
Chief, Division of Technical Services
Bureau of Sport Fisheries and Wildlife
P. O. Box 1306
Albuquerque, N. M.

Dear Mr. Bennett:

This is in response to your letter of March 1, 1965 and the attached revised draft of your report regarding the Corps of Engineers' Aquilla Reservoir Project, Aquilla Creek, Texas.

We have reviewed this draft and concur with the report as presented.

Sincerely yours,

J. Weldon Watson

JWW:AJS:lf
cc: 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
POST OFFICE BOX 1306
ALBUQUERQUE, NEW MEXICO 87103

March 31, 1965

District Engineer
Corps of Engineers, U. S. Army
Post Office Box 1600
Fort Worth, Texas

Dear Sir:

This letter constitutes the Bureau of Sport Fisheries and Wildlife report on fish and wildlife resources in relation to the Aquilla Reservoir Project, Aquilla Creek, a tributary of the Brazos River in Hill County, Texas.

Our report is designed to accompany the Corps of Engineers' Interim Report on Review of Reports, Brazos River and Tributaries, Texas and New Mexico, covering Aquilla Creek Watershed. Prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), the report has been coordinated with the Bureau of Commercial Fisheries and has received concurrence from the Texas Parks and Wildlife Department by letter dated March 11, 1965, signed by Mr. J. Weldon Watson, Executive Director. A copy of that letter is enclosed.

Evaluations of fish and wildlife are based on the Evaluation Standards for Primary Outdoor Recreation Benefits, Supplement No. 1, approved by the Ad Hoc Water Resources Council, Washington, D. C., on June 4, 1964. This report reflects a 100-year period of analysis.

This report considers plans under investigation by the Corps of Engineers to provide flood control and conservation storage for municipal and industrial uses. Conservation storage plans under study would provide either 10, 15, 22, or 38 second-feet of dependable yield.

Aquilla Creek is an intermittent stream that heads about 7 miles north of Covington, Texas, and flows in a southeasterly direction for about 48 miles to its confluence with the Brazos River approximately 3 miles northwest of Waco, Texas. Its principal tributaries are Hackberry,

Little Aquilla, Cottonwood, and Cobbs Creeks. These streams are entrenched moderately well and have beds of mud or silt. Usually, in late summer, Aquilla Creek is reduced to long, narrow pools, downstream from the damsite, while upstream from the damsite, the stream and its tributaries are dry throughout most of their courses.

The topography of the project area is gently rolling east of Aquilla Creek and rolling to moderately hilly west of the stream. The area lies in the Blackland Prairie Game Region. Much of this fertile prairie is cultivated intensively. Most of the timber is found adjacent to stream courses. In the reservoir area, a narrow band of timber, consisting primarily of oak, pecan, mesquite, hackberry, elm, and cottonwood, occurs along Aquilla Creek. The timber is wider but less dense along Hackberry Creek. Downstream from the damsite, timber along the streams tends to be larger and more dense.

Cotton, corn, grain sorghums, oats, peanuts, and vetch are the principal crops on the intensively cultivated lands in the project area of influence. Most of the land that is not cultivated is used for pasture and has been overgrazed. Flooding inhibits intensive farming on some floodplain acres. Without flood protection, future land-use changes are expected to consist principally of conversion of small amounts of bottomland timber to cropland, better management of pastures, more intensive management of native pecans for nut crops, and planting of additional domestic pecan orchards.

The average population within a 60-mile radius of the reservoir is expected to be about 2,100,000 people during the period of analysis. The cities of Waco, Fort Worth, and Dallas are within this distance. Excellent highways serve the project area.

Aquilla Dam will be located at stream mile 20.66 on Aquilla Creek, about 10 miles southwest of Hillsboro and 1 mile northeast of Aquilla in Hill County, Texas. The dam will be of earthen construction.

A gated spillway or an uncontrolled spillway is being considered for a reservoir which would provide a dependable yield of either 10, 15, or 22 second-feet. A gated spillway is being considered for a reservoir which would provide a dependable yield of 38 second-feet. Pertinent data for each of the reservoir plans under investigation to provide a conservation storage with a dependable yield of either 10, 15, 22, or 38 second-feet are shown in Table 1.

Table 1. Reservoir Plans, Aquilla Reservoir

Dependable Reservoir Yield	Top of Conservation Pool	Top of Flood Control Pool	Guide Taking Line for Reservoir	
			Gated Spillway	Uncontrolled Spillway
10 second-feet				
Elevation (feet)	528.5	548.0	551.0	553.0
Capacity (acre-ft) 1/	61,600	173,200	--	--
Area (acres)	3,720	8,240	9,180	9,900
15 second-feet				
Elevation (feet)	533.5	551.0	554.0	556.0
Capacity (acre-ft) 1/	82,200	199,300	--	--
Area (acres)	4,570	9,180	10,264	11,030
22 second-feet				
Elevation (feet)	539.0	553.0	556.0	558.0
Capacity (acre-ft) 1/	110,600	218,400	--	--
Area (acres)	5,800	9,900	11,030	11,840
38 second-feet				
Elevation (feet)	563.5	571.0	574.0	--
Capacity (acre-ft) 1/	344,200	463,100	--	--
Area (acres)	14,200	17,520	19,200	--

1/ Includes allowance for 100-year sedimentation of 28,100 acre-feet

Access will be provided to the reservoir, and parking and associated recreational facilities will be developed by the Corps of Engineers around the perimeter of the reservoir for public use.

Operation plans for the reservoir have not yet been developed. Water levels in the reservoir will be maintained as near as possible at conservation pool elevation consistent with providing a water supply for municipal and industrial uses. Water above that elevation will be released as rapidly as the capacity of the stream below the dam will permit. There will be no constant minimum release from the reservoir.

It is believed that the principal water users will be in the Hillsboro area. It is not known if there will be any water users downstream from the reservoir.

Without the Project

The area of project influence on fish includes the Aquilla Reservoir site and the 20.7 miles of Aquilla Creek downstream from the damsite.

The Aquilla Reservoir Project would affect about 20.7 miles of poor quality fish habitat in Aquilla Creek downstream from the damsite. Streams within the reservoir area are dry much of the time and provide no fish habitat. A few farm ponds in the reservoir area provide poor to fair fish habitat.

The principal species of fish in the stream are the flathead catfish, channel catfish, buffalofishes, and carp. Largemouth bass and bluegill are the principal species of fish in the farm ponds.

A few people fish in Aquilla Creek when it is filled by occasional backwater from the Brazos River. Private landowners limit access to the farm ponds. There is no commercial fishing in the project area.

Projected over the period of analysis without the project, sport fishing in the 20.7 miles of stream below the damsite and farm ponds in the reservoir area would be insignificant and there would be no commercial fishing.

With the Project

Aquilla Reservoir will inundate exceptionally fertile soils. It will have large acreages of shallow water in relation to the total surface area of the reservoir. The reservoir water will be clear and productive.

During the early years of impoundment, largemouth bass, bluegills, and redear sunfish will provide good fishing. As the reservoir ages, good fishing can be expected to occur for white crappies and later, for white bass. Eventually, nongame fishes will predominate and lower the quality of fishing. Channel catfish will do well and will be the most sought-after game fish in the reservoir throughout the life of the project.

Aquilla Reservoir will be near the Brazos and Bosque Rivers, and in an area with many small municipal water-supply reservoirs. Waco, Benbrook, Whitney, and Navarro Mills Reservoirs are near the project area. When

construction is completed, DeCordova Bend and Bardwell Reservoirs will supplement those fishing waters. The reservoir will lie also within a short distance of such large populous areas as the cities of Waco, Dallas, and Fort Worth.

Projected over the period of analysis with the project, it is estimated that sport fishing in the reservoir will amount to about 275,000 man-days annually, for any of the reservoir plans of development.

Occasional flood releases from the reservoir and backwaters from the Brazos River will not be sufficient to improve fish habitat in Aquilla Creek downstream from the reservoir. Project analysis with the project indicates that sport fishing will be insignificant in the stream below the dam.

Waters in this region of the State now produce commercial fish far in excess of market demands. There is little likelihood, therefore, that a significant commercial fishery will develop in Aquilla Reservoir.

WILDLIFE

Without the Project

Wildlife habitat, ranging from 9,180 acres to 19,200 acres, would be affected by the project within the reservoir area depending upon which plan of development is selected. Any of the plans would affect about 6,200 acres of downstream floodplain.

White-tailed deer are scarce in the project area of influence. The reservoir area and the floodplain for a few miles immediately downstream from the dam could support limited numbers of deer. However, most landowners do not permit deer to become established because they fear crop depredations. Moderate populations of white-tailed deer would become established on a small acreage on the portion of the floodplain farthest downstream. Deer hunting would be insignificant in the project area.

Fox squirrels, bobwhites, mourning doves, cottontails, swamp rabbits, skunks, ring-tailed cats, raccoons, opossums, red foxes, and gray foxes are the important upland game and fur animals in the area.

Oak and pecan timber is in excellent condition and provides high quality habitat for fox squirrels. Consequently, populations of these animals usually are high and they are hunted heavily. The waste grains and weed seeds associated with the great amount of farming in the area attract large flocks of mourning doves in the fall, and doves provide excellent hunting. Raccoons are hunted heavily for sport and meat. Foxes are highly esteemed for sport hunting.

Intensive farming and the scarcity of adequate cover preclude the establishment of huntable numbers of wild turkeys in the area.

Leasing of hunting rights does not occur in the area now, but it is believed that there would be some leasing for bobwhite and mourning-dove hunting in the future.

Projected over the period of analysis without the project, upland-game and fur-animal hunting would amount to 2,300 man-days annually on reservoirs with a dependable yield of 10, 15, or 22 second-feet and 3,400 man-days annually on a reservoir with a dependable yield of 38 second-feet.

Waterfowl hunting and fur trapping would be insignificant.

With the Project

The project will eliminate terrestrial wildlife habitat within the conservation pool of Aquilla Reservoir. The remaining habitat on project lands above the conservation pool will be reduced in quality because of reservoir fluctuations and human disturbances. Reduction of flooding in the downstream floodplain will allow the clearing of some timber and will impair the quality of other woodland habitat for arboreal species of wildlife. More intensive farming will improve the habitat for a few species.

Huntable populations of bobwhites, mourning doves, and cottontails will persist on fee-title lands above the conservation pool with any of the plans. In the reservoir area, habitat changes will have little effect on raccoon populations, but most other fur-animal populations will decline.

On the downstream floodplain, changes will have adverse effects on fox-squirrel and swamp-rabbit populations. More intensive farming will improve habitat for bobwhites and mourning doves. The loss of timber and more intensive farming will affect adversely all fur-animal populations.

The reservoir will provide resting areas for waterfowl, primarily for blue-winged teals, scaups, gadwalls, pintails, American widgeons, mallards, and coots. Reservoir operation studies are not available, but considerable acreages of shallow water will occur when water levels are at or near conservation pool elevation. The reservoir will be attractive to waterfowl.

In any plan, there will be about 1,400 man-days of upland-game and fur-animal hunting and about 200 man-days of waterfowl hunting annually. Fur-animal trapping will be insignificant. Therefore, upland-game and fur-animal hunting will be reduced by 900 man-days annually on a project with a dependable yield of either 10, 15, or 22 second-feet. The loss will be 2,000 man-days annually on a project with a dependable yield of 38 second-feet.

DISCUSSION

As an aid to fishery management and to facilitate the removal of non-game fishes, two seining areas should be provided in the upper portion of the reservoir. These areas should be about 1,000 feet wide and should extend from the streambank to the top of the conservation pool elevation. They should be cleared to ground level of all obstructions. Much of the reservoir area is cleared rangeland, pasture, and cropland which would involve no clearing except for the removal of fences and fenceposts. Cost to develop seining areas would be insignificant. Specific location of these areas will be made by the Texas Parks and Wildlife Department during the planning stage of reservoir development.

A need for municipal and industrial water may develop in areas downstream from Aquilla Reservoir. If a demand for water by downstream users should necessitate a release from the dam, fish habitat in Aquilla Creek downstream from the dam could be improved. Integrating the downstream water needs to provide a minimum instantaneous release of at least 10 second-feet would result in a high quality fish habitat

in this reach of stream. Approximately 25,000 man-days of sport fishing would occur in the lower 20.7-mile reach of the stream as a result of this release.

Aquilla Reservoir will lie near large population centers and will be served by excellent highways. The reservoir will receive heavy use by recreationists, primarily by fishermen, speedboaters, and waterskiers. Unless the reservoir is zoned, conflicting and unsafe conditions will result and optimum fishing will not be possible.

Establishment of adequately zoned areas on the reservoir would promote safety and increase the amount of fishing. Until details of a zoning plan are developed and accepted, however, it will not be possible to estimate specific monetary benefits. The location of these areas would be determined by the Texas Parks and Wildlife Department, in cooperation with the Corps of Engineers, prior to the construction of the reservoir.

The reservoir area is not timbered heavily. However, as much timber should be left standing as is consistent with the safe and efficient operation of the project. The retention of timber would provide waterfowl habitat, form wind barriers to reduce erosion on shoreline areas and retard turbidity, and supply a safety feature for fishermen by providing protected areas for anchoring during periods of high winds.

RECOMMENDATIONS

It is recommended:

1. That conservation, improvement, and development of fish and wildlife resources be included among the purposes for which the project is to be authorized.

2. That project plans provide for two seining areas in the upper portion of the reservoir, each to be about 1,000 feet wide, extending from the streambank to the top of conservation pool and cleared to ground level of all obstructions to seining.

3. That, if a demand for water should necessitate a release of water into Aquilla Creek, a minimum instantaneous release of at least 10 second-feet be integrated into the plan of reservoir operation to enhance the stream fishing.

4. That a zoning plan be developed cooperatively by the Corps of Engineers and the Texas Parks and Wildlife Department in connection with the overall planning of the reservoir to promote safety and to insure that certain areas will be available for fishing and hunting without conflicting use by other recreationists.

5. That as much timber be left standing in the reservoir area as is consistent with the safe and efficient operation of the project to provide waterfowl habitat, to serve as breakwaters to diminish water turbidity, and to provide havens for fishermen during periods of high wind.

CONCLUSIONS

Aquilla Reservoir will provide sport fishing benefits in the amount of $275,000 annually from any of the investigated reservoir plans of development.

The project will cause a loss of 900 man-days of upland-game and fur-animal hunting annually for a plan to provide a dependable yield of either 10, 15, or 22 second-feet. Losses will be 2,000 man-days of upland-game and fur-animal hunting annually for a plan to provide a 38-second-foot dependable yield. Any of the plans selected will provide a gain of 200 man-days of waterfowl hunting annually.

Project provision of seining areas as proposed in Recommendation No. 2 would facilitate management of the reservoir for fishing. Provision of a minimum instantaneous release of 10 second-feet as requested in Recommendation No. 3 would result in a gain of 25,000 man-days of sport fishing providing benefits of $25,000 annually.

Important additional sport fishing benefits would be made possible by reservoir zoning as proposed in Recommendation No. 4. Retention of timber as proposed in Recommendation No. 5 would provide waterfowl habitat, reduce erosion, retard turbidity, and supply a safety feature for fishermen.

This report is based upon information supplied to us by the Corps of Engineers, Fort Worth District, prior to December 22, 1964. Any modification of plans should be brought to the attention of the Texas Parks and Wildlife Department and the Bureau of Sport Fisheries and Wildlife. The opportunity extended to us to report on the proposed development is appreciated.

Sincerely yours,

John C. Gatlin

John C. Gatlin
Regional Director

Enclosure

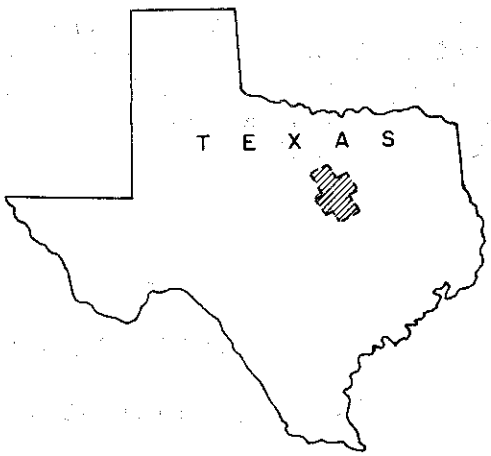
Copies (10)

Distribution:

(4) Executive Director, Texas Parks and Wildlife Department, Austin, Texas
(2) Regional Director, Bureau of Commercial Fisheries, Region 2, St. Petersburg Beach, Florida
(2) Laboratory Director, Biological Laboratory, Bureau of Commercial Fisheries, Galveston, Texas
(1) Regional Coordinator, Southwest Field Committee, U. S. Department of the Interior, Muskogee, Oklahoma
(1) Area Director, Bureau of Mines, Area 4, Bartlesville, Oklahoma
(1) Administrator, Southwestern Power Administration, Tulsa, Oklahoma
(1) Regional Engineer, Public Health Service, Region 7, Dallas, Texas
(1) Regional Director, National Park Service, Southwest Region, Santa Fe, New Mexico
(2) Field Supervisor, Branch of River Basins Studies, Bureau of Sport Fisheries and Wildlife, Fort Worth, Texas

WATER SUPPLY AND WATER QUALITY CONTROL STUDY AQUILLA CREEK WATERSHED LOWER BRAZOS RIVER SYSTEM TEXAS

Study of Needs and Value of Storage for Municipal and Industrial Water Supply and Water Quality Control



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas
OCTOBER 1965

WATER SUPPLY

AND

WATER QUALITY CONTROL STUDY

AQUILLA CREEK WATERSHED

LOWER BRAZOS RIVER SYSTEM

TEXAS

Abstract

An investigation has been carried out which discloses the need for and value of storage for municipal and industrial water supply purposes in the proposed Aquilla Creek Reservoir on Aquilla Creek. A portion of the future needs for water in the study area can be satisfied from storage in this project. The investigation further found that there is no need for storage for water quality control in the proposed reservoir. Economic and demographic studies revealed a potential for increased industrial development and population growth, and serve as the foundation for the projected needs.

Prepared for

DEPARTMENT OF THE ARMY

U.S. Army Engineer District

Fort Worth, Texas

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

OCTOBER 1965

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I. INTRODUCTION

Request and Authority

The U.S. Army Engineer District, Fort Worth, in a letter dated December 9, 1964, requested studies of the Aquilla Creek watershed ". . . to determine the municipal and industrial water requirements, the quality of water, the extent of existing and potential pollution, as well as the need for and the benefits from conservation storage for purposes of municipal and industrial water supply and water quality control. . . ."

This study has been made in accordance with (1) 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, as amended (33 USC 466 et seq.).

Purpose and Scope

The purpose of this study is to estimate the water requirements for municipal and industrial water supply, and water quality control purposes to the years 2025 and 2075 in the Aquilla Creek watershed. Estimates are made of the value of benefits attributable to the storage of water for these purposes in the Federally proposed Aquilla Creek Reservoir project. This area is also covered in a companion report,"Water Supply and Water Quality Control Study, Navasota River Watershed, Lower Brazos River System, Texas," issued by this office in June 1965. 1/

Acknowledgments

The cooperation of many persons and agencies is gratefully acknowledged. Special appreciation is expressed to the following:

U.S. Army Engineer District, Fort Worth, Texas
U.S. Geological Survey, Austin, Texas
Texas State Department of Health, Austin, Texas
Texas Water Commission, Austin, Texas
Brazos River Authority, Waco, Texas
Officials of cities in the study area

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The U.S. Army Engineer District, Fort Worth, is considering the development of the Aquilla Creek watershed, Texas, through the construction of the multiple-purpose Aquilla Creek Reservoir at mile 20.66 on Aquilla Creek.

2. The study area comprises Falls, Hill, and McLennan Counties in central Texas.

3. These 3 counties had a total population of about 195,000 in 1960. Of this total, 135,000 were classified as urban, and 60,000 as rural.

4. Except for the Standard Metropolitan Statistical Area (SMSA) of Waco (McLennan County), the area is generally rural in character.

5. The study area is in a period of rapid economic expansion, as evidenced by the highly diversified manufacturing complex of Waco.

6. Present municipal and industrial water use in the study area is about 23 million gallons per day (mgd).

7. The major water-using industry in the study area is food and kindred products processing. Other major uses are irrigation and recreation.

8. There is one existing reservoir (Whitney) and one reservoir (Waco) under construction with conservation capacities greater than 5,000 acre-feet in the study area. The aggregate conservation and power storage of these reservoirs is 566,000 acre-feet. Reported ground water pumpage in 1958 amounted to almost 18,000 acre-feet.

9. Current inventories show that there are 20 municipal and industrial waste treatment plants in operation in the study area. In general, these plants provide secondary treatment and are operating efficiently within their design capabilities.

10. The organic quality of the water of the Aquilla Creek watershed can be described as good.

Conclusions

1. The study area's population is expected to reach 513,000 by the year 2025, and 771,000 by the year 2075. The urban segment of these totals is 480,000 and 751,000 in 2025 and 2075, respectively. Similarly, the rural portion of the population is expected to be 33,000 in 2025, and 20,000 in 2075.

2. Estimated future municipal, industrial, and rural water supply needs for the Aquilla Creek watershed area are 4.5 mgd in the year 2025 and 9,1 mgd in the year 2075.

3. With the water supply plan as presented herein, the potential water resources of the Aquilla Creek watershed are sufficient to satisfy municipal, industrial, and rural water requirements of the watershed throughout the time horizon of the study (2075). Projected irrigation needs to this time will also be satisfied.

4. The future organic quality of Aquilla Creek watershed waters is expected to remain satisfactory for municipal, industrial, recreational, fish and wildlife, and agricultural uses.

5. Concentrations of total dissolved solids in Aquilla Creek Reservoir can be expected to exceed 500 milligrams per liter (mg/l) for short periods, approximately once in 9 years.

6. No storage for water quality control purposes is required in Aquilla Creek Reservoir.

7. Minimum annual value of benefits of storage for water supply in Aquilla Creek Reservoir based on the most reasonable alternative cost is $158,000. The year of first need is 1975, which is considered "present" for purposes of benefit calculations; therefore, no discounting has been used.

III. PROJECT DESCRIPTION

Pertinent Project Data

The development plan for Aquilla Creek under consideration by the Corps of Engineers provides for the construction of a multiple-purpose reservoir at mile 20.66.

The location of the reservoir site is shown in figure III-1, located at the back of this report, and more specific pertinent data for the plan being considered are shown in table III-1.

Table III-1

Pertinent Data
Aquilla Creek Reservoir

Dam Location	Mile 20.66
Contributing Drainage Area	294 Square Miles
Conservation Storage	59,700 acre-feet
Sediment Storage	28,100 acre-feet
Dependable Yield	9.7 mgd
Approximate depth to top of conservation pool at dam	60 feet

Source: Corps of Engineers 2/

IV. STUDY AREA DESCRIPTION

Location and Boundaries

The study area comprises Falls, Hill, and McLennan Counties in central Texas, (see figure III-1).

The study area chosen is the same as Subarea 1 in the "Water Supply and Water Quality Control Study, Navasota River Watershed, Lower Brazos River System, Texas," 1/ which covers the entire lower Brazos River basin utilizing a single integrated plan of development for both surface and ground water resources. This study is primarily concerned with water resource development in the Aquilla Creek watershed.

Geography and Topography

The study area lies in two physiographic provinces. The eastern portion of the area is in the Gulf Coastal Plain section of the Coastal Plains Province, while the western portion is in the central Texas section of the Great Plains Province.

In the central Texas section part, Cretaceous rocks dip eastward toward the Gulf of Mexico, plateau remnants with undulating to rolling surfaces form interstream divides, and the deeply entrenched streams are bordered by rough hillsides and valleys.

The terrain of that portion of the area in the West Gulf Coastal Plain can be described as level to gentle rolling.

Climate

The study area is characterized by a mild and fairly uniform climate. The mean annual temperature is about 66 degrees, and the normal annual rainfall is about 36 inches. 3/ The average length of the growing season is 241 days. 3/

Principal Communities and Industries

The principal communities of the study area are Waco, West, and McGregor in McLennan County; Hillsboro in Hill County; and Marlin in Falls County. Major manufacturing industries include rubber tires, building materials, glass containers, apparel, and rocket fuel. In addition, agriculture is very important to the areas' economy.

V. WATER RESOURCES OF THE STUDY AREA

Ground Water

The study area includes parts of two physiographic sections - primarily, the West Gulf Coastal Plain section of the Coastal Plain Province and, to a lesser extent, the central Texas section of the Great Plains Province.

Principal aquifers in the study area are the Trinity group, and the Quaternary alluvium.

Quantity of Water Available

Present ground water withdrawal in the study area is 16.0 mgd. [4 5/] The ground water that is potentially available for municipal and industrial, thermal power generation, irrigation, and rural use throughout the study area was evaluated as 25.1 mgd. [4/] A similar figure for the Aquilla Creek watershed is 3.8 mgd. [4/]

Quality of Water Available

The chemical quality of ground water differs throughout each aquifer as well as in different aquifers. Analysis of the water from selected wells in the principal aquifers in the basin is given in table V-1. The extremes and the mean were evaluated from only a portion of the total number of analyses on record, but they were considered as representative of the quality of the water in the aquifer. In general, the chemical quality of ground water in the principal aquifers is such that with proper treatment, the water is acceptable for most municipal and industrial water supply purposes.

The public water supplies of many communities are obtained from the Trinity sands, although the concentrations of dissolved solids, and sulfates in some of the wells exceed the maximum limits of the U.S. Public Health Service Standards. The water is suitable for most types of industries, but high concentrations of sodium bicarbonate may be undesirable in boiler and laundry operations. Generally, the Trinity sands yield water that is suitable for irrigation. [5/]

The quality of the water from wells in the alluvium along the Brazos River varies greatly, as shown by the following range of concentrations; dissolved solids, 483 to 1,101 mg/l, hardness, 312 to 1,360 mg/l, chloride, 16 to 880 mg/l, specific conductance, 825 to 4,020 micromhos per centimeter. No public water supplies are obtained from the alluvium in the study area.

Table V-1

Characteristic Analysis of Ground Water from the Principal Aquifers in the Aquilla Creek Study Area

Characteristic	Trinity Sands Concentration (mg/l) Max.	Min.	Mean	Alluvium Concentration (mg/l) Max.	Min.	Mean
Silica (SiO_2)	*	*	*	19	16	18
Iron (Fe)	0.08	0.01	0.04	*	*	*
Calcium (Ca)	270	3	92	320	56	158
Magnesium (Mg)	42	1	15	136	7	55
Sodium & Potassium (Na & K)	1420	213	715	384	50	159
Bicarbonate (HCO_3)	444	209	339	574	318	464
Sulfate (SO_4)	3320	75	1159	473	43	178
Chloride (Cl)	214	50	105	880	16	267
Fluoride (F)	0.9	0.8	0.8	0.5	0.1	0.3
Nitrate (NO_3)	1.1	0.0	0.4	76	>1	35
Dissolved Solids	5370	594	2192	2500	483	1101
Hardness (as $CaCO_3$)	846	10	289	1360	312	621
Specific Conductance (micromhos @ 25°C)	990	988	989	4020	825	1781
pH (pH units)	8.1	8.0	8.0	7.7	7.0	7.3

*Data not available.

Source: Texas Water Commission 5/

Table V-2 shows the range and mean values of chemical constituents of the ground water from municipal wells in the Aquilla Creek watershed. Some of these concentrations exceed the maximum limits of the U.S. Public Health Service Drinking Water Standards. The high fluoride concentrations found in some wells is tempered by blending the waters from several wells.

Table V-2

Characteristic Analysis of Water from Municipal Wells in the Aquilla Creek Watershed

Item	Concentration (mg/l) Maximum	Minimum	Average
Iron (Fe)	2.5	0.1	1.1
Calcium (Ca)	37	2	10
Magnesium (Mg)	19	1	5
Sodium (Na)	464	232	321
Sulfate (SO_4)	67.0	65	288
Chloride (Cl)	75	28	50
Fluoride (F)	5.0	0.4	1.5
Nitrate (NO_3)	5.1	0.4	1.1
Total Hardness (as $CaCO_3$)	171	9	44
Total Dissolved Solids (Residue at 105°C)	1,424	660	948
pH (in pH units)	8.5	8.0	8.2

Source: Texas State Department of Health 6/

Surface Water

Quantity of Water Available

There are no existing reservoirs in the Aquilla Creek watershed. The proposed Aquilla Creek project will have a total dependable yield of 9.7 mgd. 2/

Other reservoirs in the study area include Whitney and Waco which are existing and under construction, respectively. The aggregate, dependable yield of these two reservoirs is 358.9 mgd. 2/

Quality of Water Available

The expected dissolved solids concentrations of the principal reservoirs in the study area are shown in table V-3. The concentrations were estimated applying the relationship of the quantity of runoff and total dissolved solids concentration for the drainage area of the study reservoir. Using reservoir operation data furnished by the Corps of Engineers, periodic concentrations in the reservoir were

determined. In this manner, a total dissolved solids concentration of each reservoir was evaluated. For the Aquilla Creek Reservoir, it is estimated that total dissolved solids concentrations can be expected to exceed 500 mg/1 for short periods, approximately once in 9 years. This is based on data obtained from two months of intensive sampling of Aquilla Creek for this study by the U. S. Geological Survey at the request of the Texas Water Commission.

Table V-3

Estimated Total Dissolved Solids Concentration
in Principal Reservoirs in the Study Area
(50%, 80%, and 98% Low Flow Basis)

Reservoir	Total Dissolved Solids Concentration (mg/1)		
	50%	80%	98%
Waco	255	263	350
Whitney	870	870	870
Aquilla Creek	350	440	760

Mean values of total dissolved solids, chlorides, and sulfates of four streamflow sampling stations located in the study area are shown in table V-4.

Table V-4

Characteristic Analysis of Streamflow
in the Study Area

Location of Sampling Station	Characteristic (mg/1)			
	No. of Samples	Total Dissolved Solids	Sulfates	Chlorides
Brazos River at Whitney Dam near Whitney	a/	851	175	260
Aquilla Creek near Aquilla	b/	393	134	28
Brazos River at Waco	1	1,240	325	450
Brazos River near Marlin	33	808c/	204	296

a/ Continuous sampling from September 9, 1947 through May 16, 1948, and from October 1948 through September 1961.
b/ Continuous sampling from May 1, 1965 through June 25, 1965.
c/ 31 samples.

Source: Texas State Department of Health 7/, Texas Water Commission 8/, and Geological Survey 9/

VI. THE ECONOMY

An economic study and projections were made of the study area and the Aquilla Creek watershed. These projections serve as a basis for estimating future municipal and industrial water use requirements and anticipated waste discharges.

Present

Main cities in the study area are Waco and its suburbs, West, Hillsboro, Marlin, and McGregor. Hillsboro is the largest city in the watershed. Study area population increased from 162,450 in 1920 to 195,004 in 1960, [10] with most of the growth occurring in the Waco SMSA.

Manufacturing is an important segment of the study area economy with manufacturing accounting for 16 percent of the 1960 labor force. [11] The principal items of manufacture in the study area are rubber tires and innertubes, doors, windows, glass containers, and apparel in Waco, asbestos cement products in Hillsboro, and the production of rocket fuel in McGregor. [12]

Agriculture is relatively important in the study area, accounting for 10 percent of the 1960 labor force. [11] The 1959 value of farm products sold was $41 million, [13] about equally distributed between crops and livestock. Cotton is the major crop grown. Corn, oats, grain sorghums, and vegetables are also produced. Livestock production is diversified with cattle, dairy, poultry, and hogs contributing to the agricultural income. Very little irrigation is done in the study area, with only 8,650 acres irrigated in 1959. [13]

Future

Future growth of the study area is expected to be centered around continued growth and physical expansion of the Waco SMSA. Industry growth is expected to occur in those industries already located in the study area. Projected labor force for 2025 and 2075 is shown in table VI-1.

Table VI-1

Study Area Labor Force, Present and Projected

	1960*		2025		2075	
	Number	Percent	Number	Percent	Number	Percent
Agriculture (Forestry & Fisheries)	7,541	10.6	2,800	1.4	2,800	.9
Mining, Total (SIC 13, 14)	76	.1	150	.1	250	.1
Manufacturing	11,243	15.8	32,450	16.7	52,350	17.5
Resource Oriented	6,983	9.8	19,200	9.9	29,700	9.9
Furn., Lbr., Wood (SIC 24, 25)	1,278	1.9	2,900	1.5	5,200	1.7
Primary Metals (SIC 33)	12	--	250	0.1	550	.2
Food and Kindred (SIC 20)	1,835	2.6	5,900	3.0	8,500	2.8
Chemical & Allied (SIC 28)	309	.4	700	0.4	1,400	.5
Stone, Clay, Glass (SIC 32)	1,442	2.0	3,500	1.8	6,150	2.1
Other Nondurables (SIC 26, 29, 30, 31)	2,107	2.9	5,950	3.1	7,900	2.6
Nonresource Oriented	4,260	6.0	13,250	6.8	22,650	7.6
Fabricated Metal (SIC 34, 35, 36, 37, 38)	1,329	1.9	5,700	2.9	9,400	3.1
Textiles (SIC 22, 23)	2,037	2.9	6,400	3.3	11,700	3.9
Print., Publ., NEC (SIC 27, 39)	894	1.2	1,150	0.6	1,550	.6
Service and Other	48,745	68.6	151,360	77.8	232,600	77.5
Unemployed	3,474	4.9	7,740	4.0	12,000	4.0
Total Labor Force	71,079	100.0	194,500	100.0	300,000	100.0

*Source: Bureau of the Census 11/

Based on a resource and employment analysis, the study area population was determined. A portion of this population was then allocated to the Aquilla Creek watershed. The watershed area, located adjacent to both the Fort Worth and Waco SMSA, is expected to grow mainly as a result of expansion of these metropolitan areas. Projections of populations for the study area and the watershed appear in table VI-2.

Table VI-2

Population Projections for the Study Area and Watershed
1960, 2025, 2075
(1,000's)

Study Area

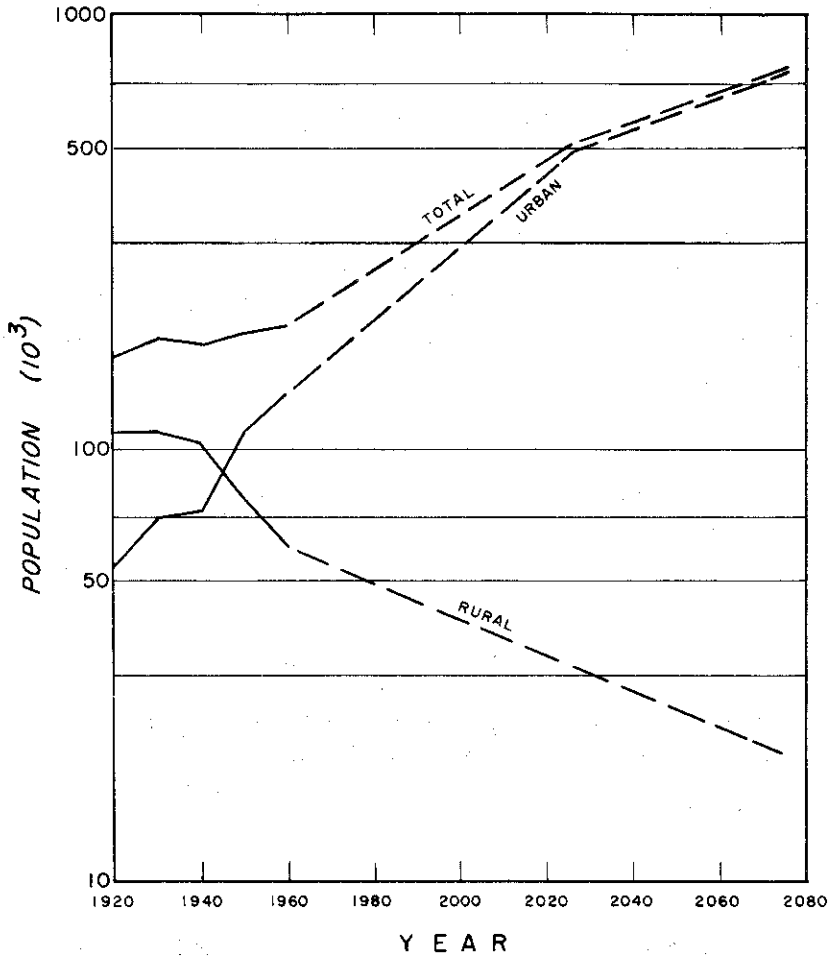
Year	Urban	Rural	Total
1960	135.0	60.0	195.0
2025	480.0	33.0	513.0
2075	751.0	20.0	771.0

Aquilla Creek Watershed

1960*	7.5	8.0	15.5
2025	21.5	2.5	24.0
2075	37.5	2.5	40.0

*Estimated.

A graphical presentation of the study area population projections is shown in figure VI-1.



WATER SUPPLY & WATER QUALITY CONTROL STUDY
AQUILLA CREEK WATERSHED
BRAZOS RIVER BASIN, TEXAS

STUDY AREA POPULATION TRENDS AND PROJECTIONS

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service
REGION VII DALLAS, TEXAS

FIGURE VI-1

85-251 O-67—9

VII. WATER REQUIREMENTS

General

The term water requirements encompasses several uses which are dependent upon a large number of variables. Although primarily concerned with water requirements for municipal, industrial, and water quality control purposes, this study examines all of the consumptive uses of water as they affect the supply and demand for water within the basin.

Types of Water Use

Municipal

Municipal water as defined here includes residential, commercial, public, and those industrial uses which can reasonably be reflected in a per capita use figure. Also included in the per capita quantities are losses in distribution systems and treatment plant attentuation.

Industrial

The definition of industrial water use in this study refers to all water except that supplied from municipal systems which is used by the manufacturing industries (Standard Industrial Classification Categories 13, 14, and 20 through 39). 14/

Power Generation

Use of water for thermal power generation is a part of the industrial requirement that has been determined separately. Although withdrawal for this purpose is very large, only the water used consumptively is considered.

Rural

An estimate of the rural water use was made so as not to understate the total study area water requirements. As referred to in this investigation, rural water requirements are assumed to consist of domestic water for that portion of the population not served by municipal water systems and water for the maintenance of livestock.

Irrigation

Another important water use in the study area is irrigation. These requirements are included, since (1) return flows from this use affect the quality of the study area's water and (2) a fully integrated water supply plan must include irrigation, especially

in an area where it represents a considerable portion of the demand on the potential water resource. Historic as well as projected quantities of water for this use were determined by the Corps of Engineers, based on U. S. Study Commission, Texas values. 2/

Base Year Water Use

The year 1958 was selected as the base for the water use study because it was the most recent year for which reliable data from several sources were available. The 1958 study area water use by type is shown in table VII-1.

Table VII-1

Study Area Base Year Water Use

Type of Use	1958 (mgd)
Municipal	19.4
Industrial*	3.8
Rural	6.0
Irrigation	6.0
Total	35.2

*Includes consumptive use for thermal power generation.

Source: Public Health Service 15/, Texas Board of Water Engineers 16-18/, University of Texas 19/, and Bureau of the Census 20/

Similar estimates for the Aquilla Creek watershed are shown in table VII-2.

Table VII-2

Aquilla Creek Watershed Base Year Water Use

Type of Use	1958 (mgd)
Municipal	1.6
Industrial*	Negligible
Rural	0.7
Irrigation	0.1
Total	2.4

*Includes consumptive use for thermal power generation.

Future Water Requirements

Estimates of water requirements for the years 2025 and 2075 for the several types of water use (excluding irrigation) in the study area were made using the technique of combining projected unit uses with economic and population projections. Rural per capita use was assumed to remain constant from 2025 to 2075. Irrigation requirements were furnished by the Corps of Engineers, based on U. S. Study Commission, Texas values. 2/

Municipal

The several items considered in making projections of per capita municipal water use for this study are as follows:

1. Past Trends - analysis of records from municipalities and industries.

2. Characteristics of the subarea - factors peculiar to an area such as per capita income and precipitation.

3. Analysis of projections by others - projections made by other governmental agencies, consulting engineers, and the municipalities themselves.

4. Judgment - after considering and weighing the above factors, discrepancies which existed were resolved by judgment.

Present and projected values of per capita municipal use are shown in table VII-3.

Table VII-3

Municipal Per Capita Water Use
(in gal/day)

1958	2025	2075
121	170	185

Industrial

Base year data on industrial water use were combined with employment data and resulted in a unit water use per employee for each of the industrial categories (SIC 13, 14, and 20-39). Considerations involved in economic projections of the labor force required consolidation of some of the industrial categories into groups, as shown in table VII-4.

In order to project unit industrial water use, the following assumptions were made:

1. In presently undeveloped counties where large future developments are projected, the base year unit employee water uses were adjusted to those of surrounding counties where present conditions approach those forecasted for the undeveloped counties.

2. An average net productivity factor (i.e., the multiplier to obtain unit employee use for the years 2025 and 2075 from 1958 data) was determined as follows: Unit employee industrial water use projections of Resources for the Future, Inc., and the Business and Defense Services Administration prepared for the Senate Select Committee on National Water Resources 21/ were extrapolated and an average curve constructed. The ratio of the 2025 and 2075 values to the 1958 value on the average curve gave the productivity factors of 2.1 and 2.6 for 2025 and 2075, respectively.

Unit industrial water use for all industries in the years 2025 and 2075 is shown in table VII-4.

Power Generation

Consumptive use of water for thermal power generation is considered to be a part of the industrial requirement but is determined separately. 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. Consideration was given to the general locations of future power generation installations and the projected needs apportioned throughout the study area using hypothetical service areas for the several generating plants.

Rural

For purposes of this study, the rural water requirements are assumed to consist of domestic water for that portion of the population not served by municipal water systems and water for the maintenance of livestock. The 2025 and 2075 requirements for rural water are based on a rural per capita use of 180 gallons per day, of which 80 gpcd is for the maintenance of livestock.

Table VII-4

Future Unit Industrial Water Use
(gal. per employee day)

Item	2025	2075
Mining (SIC 13, 14)	50	70
Manufacturing		
Furniture, Lumber & Wood (SIC 24, 25)	190	230
Primary Metals (SIC 33)	1,650	2,040
Food & Kindred (SIC 20)	450	560
Chemicals & Allied Products (SIC 28)	1,050	1,300
Stone, Clay, and Glass Products (SIC 32)	880	1,090
Petroleum (SIC 29)	530	660
Pulp and Paper (SIC 26)	210	280
Other Nondurables (SIC 30, 31)	510	630
Fabricated Metals (SIC 34, 35, 36, 37, 38)	170	210
Textile & Apparel (SIC 22, 23)	160	190
Printing & Publishing and Not Elsewhere Classified (SIC 27, 39)	40	50

The estimated future study area water requirements are shown in table VII-5.

Table VII-5

Future Study Area Water Requirements
(mgd)

Type of Use	Year 2025	Year 2075
Municipal	81.7	139.0
Industrial*	18.1	59.0
Rural	5.9	3.6
Irrigation	122.5	122.5
Total	228.2	324.1

*Includes consumptive use for thermal power generation.

Similar estimates of future water use for the watershed are shown in table VII-6.

Table VII-6

Future Aquilla Creek Watershed Water Requirements
(mgd)

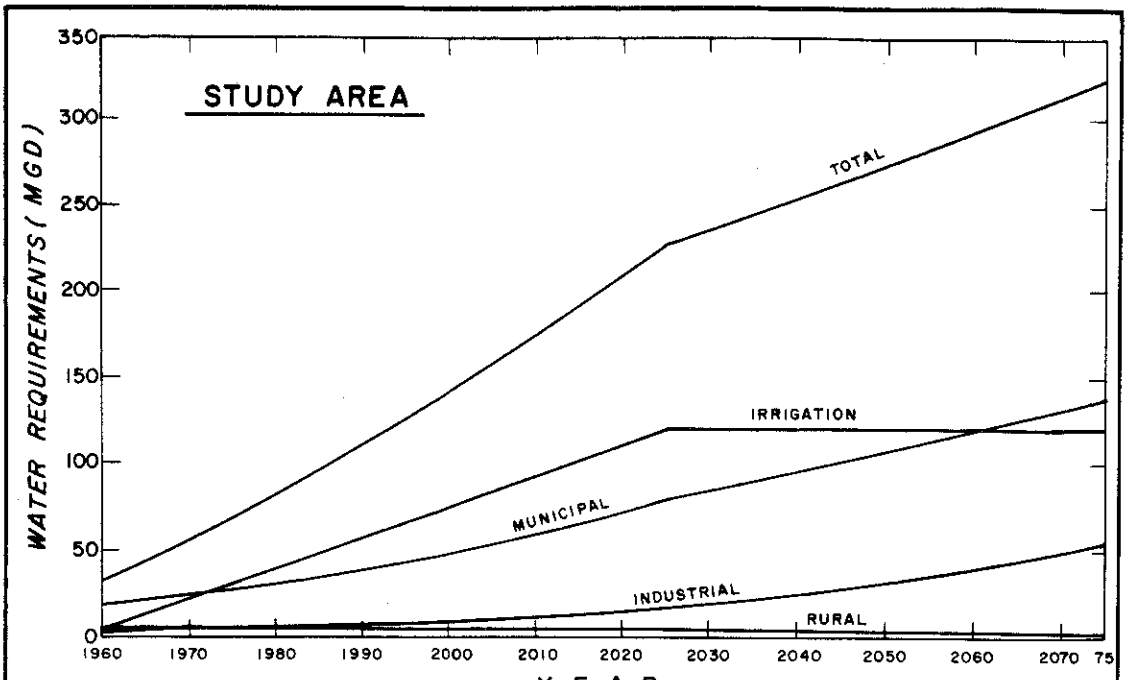
Type of Use	Year 2025	Year 2075
Municipal	3.4	7.0
Industrial*	0.6	1.6
Rural	0.5	0.5
Irrigation	2.9	2.9
Total	7.4	12.0

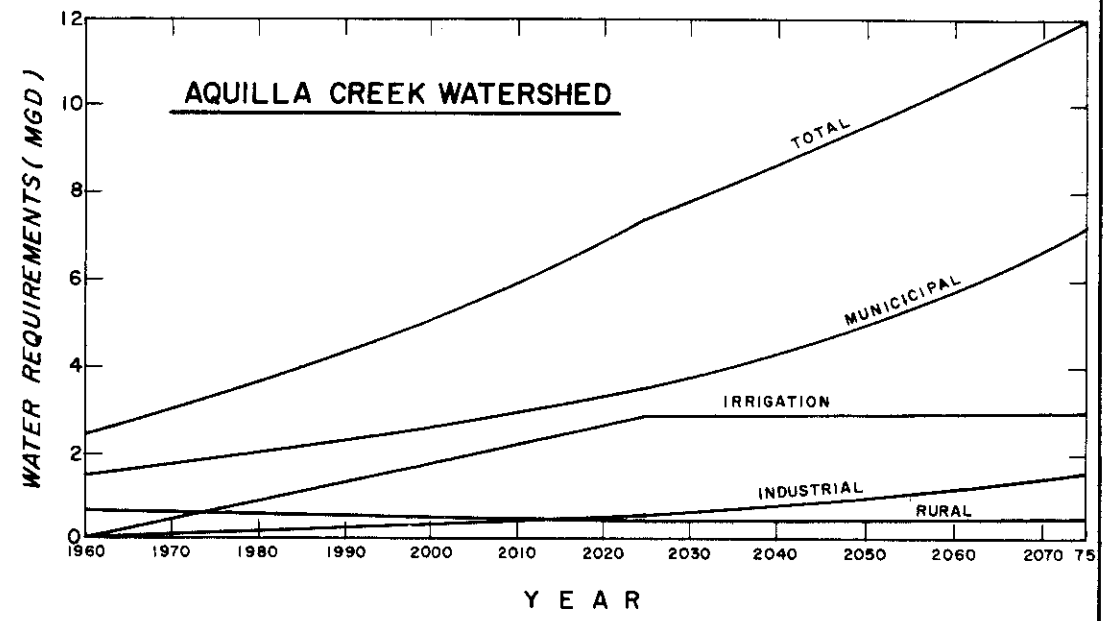
*Includes consumptive use for thermal power generation.

Graphic illustrations of the water requirements for the study area and watershed are shown in figure VII-1.

The city of West, which is outside the Aquilla Creek watershed, is expected to contract for part of the storage in the proposed project. Estimated future municipal and industrial needs for this city are 1.3 mgd in 2025 and 2.7 mgd in 2075.

An examination of historical records indicated that there are no significant seasonal variations in municipal and industrial water use in the study area. It is concluded, therefore that water needs are relatively constant throughout the year and no release schedule of water stored for municipal and industrial use is required.





WATER SUPPLY & WATER QUALITY CONTROL STUDY
AQUILLA CREEK WATERSHED
BRAZOS RIVER BASIN, TEXAS

WATER REQUIREMENTS

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service
REGION VII DALLAS, TEXAS

FIGURE VII-1

VIII. WATER QUALITY CONTROL

General

Water quality control is defined as any measure employed to enhance the utility, value, and attractiveness of waters used for purposes which are affected by changes in water quality. Waters in nature are never PURE in the strict chemical sense of the word. More often than not, however, natural waters are fit for use by man in his pursuit of normal endeavors. This use and subsequent return of waste almost always causes some degradation of water quality downstream, even after provision of secondary waste treatment. As population and the associated demand for water increase, this degradation of the water resource increases. Presently, water quality is controlled by providing the best practical waste treatment. When further water quality improvement is needed, this treatment is supplemented by the provision of additional water to dilute the treated wastes. This, then, is the method of water quality control with which this report is concerned.

Municipal, Industrial, and Agricultural Pollution

Stream Loading

The determination of the quantity and quality of return flows expected to reach a stream is the first step necessary in analyzing water needs for quality control.

The quantity of municipal and industrial return flows is estimated as a percentage of water use. The municipal return flow percentage used is 62.0 percent, 22/ while industrial return flow percentages vary from 23 percent to 90 percent. 23/

The quality of municipal return flow is based on assumed per capita contributions of 0.23 pounds per day of total dissolved solids and 0.25 pounds per day of ultimate first-stage BOD.

The contribution of total dissolved solids resulting from industrial use varies from 1.2 tons per million gallons to 12.2 tons per million gallons of return flow. 23/ For the BOD contribution from industry, it was assumed that final industrial effluents would contain the same concentration of BOD as a municipal sewage that has been treated to remove 85 percent of the BOD. This concentration is 56 mg/l ultimate first-stage BOD assuming a typical municipal sewage has an untreated concentration of 370 mg/l ultimate first-stage BOD.

It was assumed that there would be no return flow resulting from rural water use.

Irrigation return flows were assumed to be one-third of the water applied for that purpose, and it was further assumed that all of the dissolved solids in the irrigation source water would be returned to the stream. 24/

Present and projected study area municipal and industrial return flows, population equivalents, BOD, and total dissolved solids loads are shown in table VIII-1.

Water Quality Criteria

Of the indicators presently available as a measure of water quality, dissolved oxygen and total dissolved solids were chosen for use in this study. The principal causes of pollution in this watershed are (1) domestic sewage and a large variety of industrial wastes, both of which contribute BOD and total dissolved solids; and (2) irrigation return flows which would contribute total dissolved solids. Water quality control requirements are based on the assumption that sufficient waste treatment will be provided for the manmade portion of the pollution to remove 85 percent of the BOD and none of the total dissolved solids.*

Water to regulate quality is assumed to be needed when the dissolved oxygen content of a stream drops below 4 mg/l and/or when the total dissolved solids reach 1,000 mg/l. The lower limit of 4 mg/l of dissolved oxygen was used since (1) it provides an acceptable environment for most aquatic life native to this area; and (2) it provides a buffer zone in the event unforseen spills of waste occur. U. S. Public Health Service Drinking Water Standards 26/ recommend total dissolved solids concentration not exceed 500 mg/l. Although a goal of maintaining total dissolved solids below this figure is desirable, it is not attainable in the watershed; therefore the practical goal of 1,000 mg/l was selected.

Flow Regulation

Allowance for Streamflow

In determining the draft-on-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. Discharge frequency analyses of the streams in the basin were made from Corps of Engineers' streamflow data, which included adjustments to reflect conditions in the basin in 2025. Calculations were then performed

* With conventional treatment methods currently used, removal of some of the total dissolved solids probably occurs; however, this removal can be considered as incidental rather than planned and no reliable estimates of the quantity so removed are available.

Table VIII-1

Present and Projected Study Area
Municipal and Industrial Return Flows and Waste Loads

County	1962*			2025			2075		
	Return Flow (mgd)	P.E. (BOD) Discharged	Total Dissolved Solids Discharged (tons/day)	Return Flow (mgd)	P.E. (BOD) Discharged	Total Dissolved Solids Discharged (tons/day)	Return Flow (mgd)	P.E. (BOD) Discharged	Total Dissolved Solids Discharged (tons/day)
Falls	0.58	3,510	0.99	3.27	4,368	5.56	7.50	9,804	12.53
Hill	0.79	1,370	1.10	3.35	4,620	4.65	7.14	9,144	10.39
McLennan	11.54	16,150	15.44	52.43	70,248	71.05	87.04	112,968	111.98
Total	12.91	21,030	17.53	59.05	79,236	81.26	101.68	131,916	134.90

*Source: Public Health Service 25/

to determine the amount of regulation water from storage needed to maintain stream quality for hydrologic conditions that can be expected to recur in the basin streams every 50 years. This hydrologic condition was used since the downstream use of the water is for municipal and industrial purposes.

Quality Control Requirements

The analyses of the basin waters, one of organic pollution (BOD), and one of chemical pollution (total dissolved solids), were made utilizing electronic computational methods where applicable. These studies were made for the watershed by constructing a mathematical model of the system containing Aquilla Creek Reservoir and points of withdrawal and inflow.

Computations of both organic and inorganic pollution indicated that the surface waters of the watershed will not be degraded below the stated acceptable limits within the time horizon of the study (2075). The city of Hillsboro discharges adequately treated sewage effluent into the proposed Aquilla Creek Reservoir via Hackberry Creek. The quality of the water stored in Aquilla Creek is not expected to be adversely affected by this waste discharge.

Consideration was given to providing storage for water quality control in Aquilla Creek Reservoir to improve the quality of the Brazos River downstream from the confluence of Aquilla Creek. The storage available however, is so small compared to the flows of the Brazos River at this point that no appreciable improvement in quality would result.

IX. WATER SUPPLY AND WATER QUALITY CONTROL PLAN

General

In order to supply the water needs shown in Section VII, a plan is presented utilizing all available water resources in the Aquilla Creek watershed. This plan was incorporated into a single integrated plan for the entire lower Brazos River basin in a companion report. 1/

Water Availability

With the proposed Aquilla Creek Reservoir in operation, the water resources of the Aquilla Creek watershed in the years 2025 and 2075 will be as shown in table IX-1.

Table IX-1

Future Water Resources
of the Aquilla Creek Watershed

Surface:	Dependable Yield (mgd)
Aquilla Creek Reservoir	9.7*
Reusable municipal, industrial, and irrigation return flows - varying quantity 1960 - 2025	0.6 - 2.5
Ground Water	3.8
Total resources in 2025	16.0
Additional resources available after 2025	
Additional reusable municipal, industrial and irrigation return flows - varying quantity 2025 - 2075	
(gross 2.5 - 5.3)	net 0 - 2.8
Total resources in 2075	18.8

*Source: Corps of Engineers 2/

The cities of Hillsboro and West are expected to contract for the conservation storage in Aquilla Creek Reservoir. 2/ The water resources of the watershed therefore will be used to satisfy the total requirements within the confines of the drainage area as shown in figure VII-1, plus the municipal and industrial requirements of the city of West.

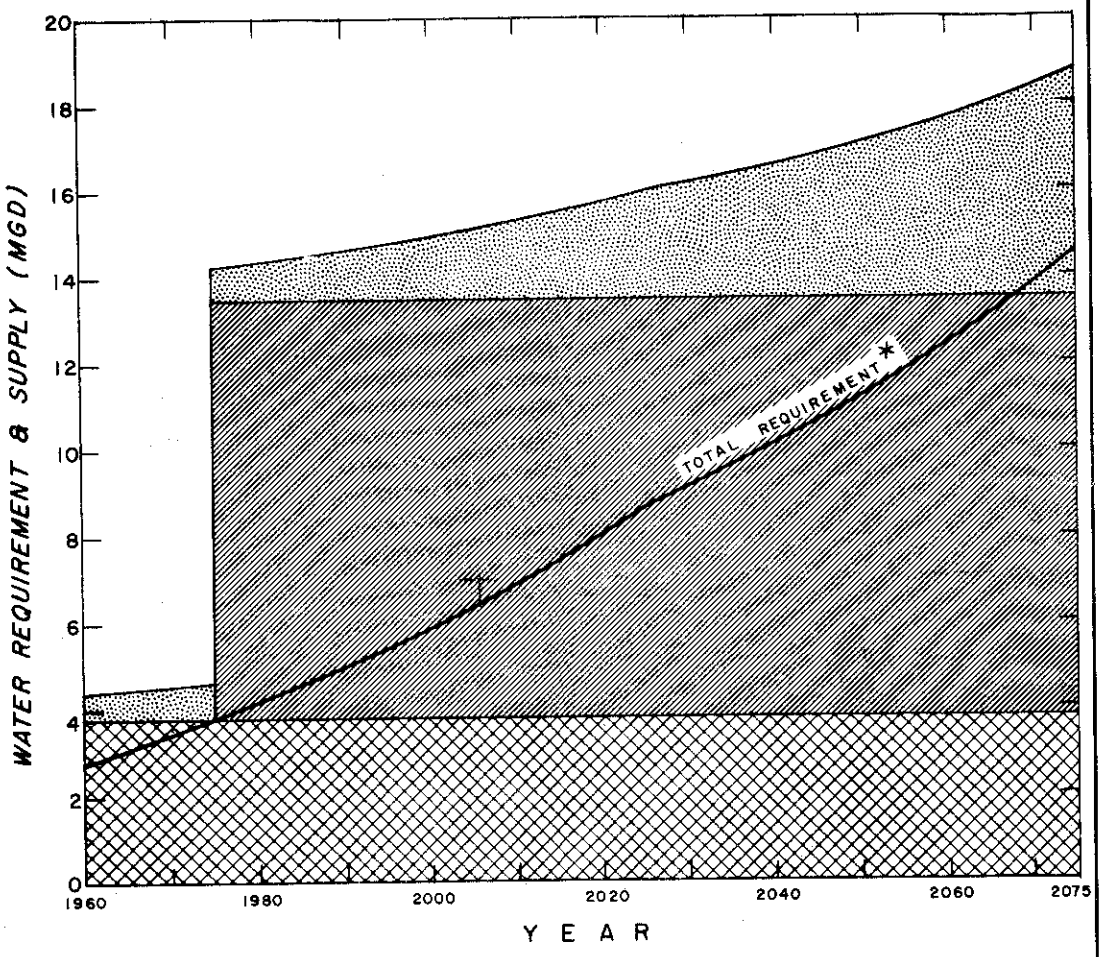
An overplot of the water resources of the watershed on the requirement described above shows that they are adequate to meet requirements through the terminal year of the study (2075). See figure IX-1.

Time of Need

The time of need for the proposed Aquilla Creek Reservoir was determined from the watershed requirement and supply study shown in figure IX-1. This curve shows that there is a need in the Aquilla Creek watershed for the Aquilla Creek Reservoir in the year 1975. Therefore, the benefits for Aquilla Creek Reservoir need not be discounted, since the year 1975 is used as "present" for purposes of benefit calculations.

Alternatives

After consideration of several reservoir sites as well as ground water development, it is concluded that the most likely alternative to the multiple-purpose development in the Aquilla Creek watershed is a single-purpose, two stage development near the same location.



LEGEND

GROUNDWATER DEVELOPMENT

AQUILLA CREEK RESERVOIR

REUSEABLE RETURN FLOW

*INCLUDES ALL REQUIREMENTS IN THE AQUILLA CREEK WATERSHED AND INDUSTRIAL AND MUNICIPAL REQUIREMENTS FOR THE CITY OF WEST.

WATER SUPPLY & WATER QUALITY CONTROL STUDY
AQUILLA CREEK WATERSHED
BRAZOS RIVER BASIN, TEXAS

WATER REQUIREMENT AND SUPPLY

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service
REGION VII DALLAS, TEXAS

FIGURE IX-1

X. BENEFITS

Method of Evaluation

Senate Document No. 97 (87th Congress 2nd session) makes the following statement concerning evaluation of benefits of municipal and industrial water supply storage in Federal reservoirs:

> "The amount water users should be willing to pay for such improvements in lieu of foregoing them affords an appropriate measure of this value. In practice, however, the measure of the benefit will be approximated by the cost of achieving the same results by the most likely alternative means that would be utilized in the absence of the project."

This alternative cost method was used to evaluate storage requirements for municipal and industrial use in the multiple-purpose reservoir project proposed to be developed in the Aquilla Creek watershed. The values determined in this way are considered to be minimum annual benefits.

Costs

For purposes of comparison of alternatives, capital costs were converted to equivalent annual costs and added to the estimated annual operation and maintenance costs. The costs were determined for the date of first use of the project and, when necessary, discounted to "present" 1975 values.

Water Supply Benefits

The annual project water supply benefit is $158,000. The methods of calculation used for the benefit evaluation are appended. The above value represents present worth in 1975.

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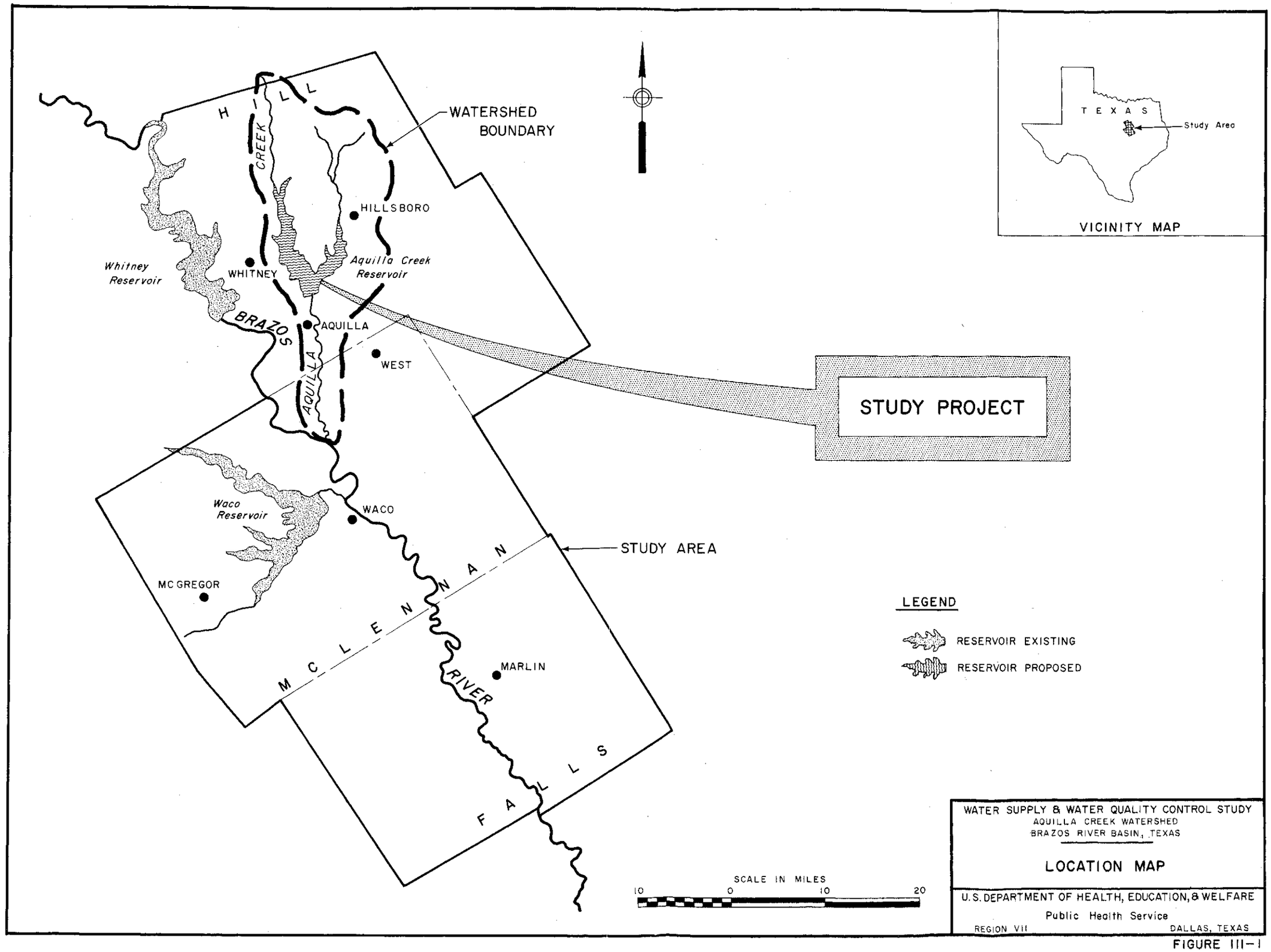


FIGURE III-1

85-251 O-61 (Face p. 130)

APPENDIX

Benefit Calculations

The most reasonable alternative to the proposed Aquilla Creek Reservoir is two smaller single-purpose reservoirs near the project site having a total yield equal to the multiple-purpose project and constructed in step with water needs.

Dependable yield of Aquilla Creek project = 9.7 mgd

From Figure IX-1:

Build first reservoir in 1975; yield = 5.0 mgd

Build second reservoir in 2025; yield = 4.7 mgd

First Unit - 5.0 mgd dependable yield

Estimated first cost	$3,100,000
Estimated interest during construction	124,000
Estimated total investment	$3,224,000

Amortize private investment for 25 years @ 4%

(3,224,000)(.06401) = $206,368/year

Convert to equivalent Federal investment to provide for same annual payment

Present worth of 1 per period @ 3 1/8% = 17.17308

Then equivalent Federal investment

(206,368)(17.17308) = $3,543,974

Amortize Federal investment for 100 years at 3 1/8%

Annual cost = (3,543,974)(0.03276)	=	116,100
Estimated annual operation and maintenance	=	15,000
Total Annual Cost	=	131,100

Date of first use is 1975, therefore no discounting of benefits is necessary.

Annual value of benefits for first unit = $ 131,100

Second Unit - 4.7 mgd dependable yield

Estimated first cost	=	$2,950,000
Estimated interest during construction	=	118,000
Estimated total investment	=	$3,068,000

Amortize private investment for 25 years @ 4%

(3,068,000)(.06401)	=	$ 196,383/yr.

Convert to equivalent Federal investment to provide for same annual payment

Present worth of 1 per period @ 3 1/8%	=	17.17308

Then equivalent Federal investment

(196,383)(17.17308)	=	$3,372,500

Amortize Federal investment for 100 years at 3 1/8%

Annual cost = (3,372,500)(0.03276)	=	$ 110,483
Estimated annual operation & maintenance	=	15,000
Total annual cost	=	$ 125,483

Date of first use is the year 2025, therefore discount estimate to present (1975)

(125,483)(0.214685)	=	$ 26,939
Say	=	$ 26,900

Therefore, annual value of benefits for second unit = $ 26,900

Total annual value of benefits - first unit plus second unit

$131,100 + $26,900 = $158,000

Therefore annual value of benefits = $ 158,000

APPENDIX VII

VIEWS AND COMMENTS OF OTHER AGENCIES

INTERIM REVIEW OF REPORTS
ON
BRAZOS RIVER AND TRIBUTARIES, TEXAS
COVERING
AQUILLA RESERVOIR ON AQUILLA CREEK

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

COPY

A RESOLUTION designating the Brazos River Authority as the agency of the Texas Water Commission to negotiate with the Corps of Engineers of the United States Army, for acquisition of storage space in the Aquilla Creek Project and providing certain conditions.

BE IT RESOLVED AND ORDERED BY THE TEXAS WATER COMMISSION:

1. In keeping with the policy of the State of Texas in the construction of dams, that each project contemplated develop the optimum of the site which is reasonably required under all existing circumstances; and further to encourage and facilitate the beneficial use of the unappropriated public waters of this State, the Brazos River Authority is hereby designated as the agency for the Texas Water Commission to negotiate with the Corps of Engineers of the United States Army, for the acquisition of the conservation storage space (inclusive of sediment deposit) in the proposed Aquilla Creek Project and may enter into preliminary agreements therefor; provided, however, such agreements shall not affect existing or vested rights of any kind or character.

2. The Brazos River Authority shall report in writing to the Texas Water Commission from time to time, the status of all such negotiations and furnish a copy of all such preliminary agreements made by them with the Corps of Engineers of the U. S. Army and other interested parties. No agreements entered into shall be construed to authorize the appropriation of any water from said project until and unless a permit therefor has been obtained

pursuant to the laws of this State.

3. This resolution passed and adopted by the Texas Water Commission on the 30th day of March, 1965, the date of its passage, and the Secretary is ordered to send a copy of the same to the Brazos River Authority and to the U. S. Army Corps of Engineers, Fort Worth District.

TEXAS WATER COMMISSION

/s/Joe D. Carter
Joe D. Carter, Chairman

/s/O. F. Dent
O. F. Dent, Commissioner

/s/William E. Berger
William E. Berger, Commissioner

ATTEST:

/s/ Audrey Strandtman
Audrey Strandtman, Secretary

COPY

THE STATE OF TEXAS §

COUNTY OF TRAVIS §

I, the undersigned, Secretary of the Texas Water Commission, hereby certify that the foregoing is a true and correct copy of a resolution duly adopted by said Commission on the date indicated therein, which resolution is filed of record in the official records of said Commission on file in my office.

WITNESS my hand and seal of said Commission, this 2nd day of April, 1965.

/s/ Audrey Strandtman
Audrey Strandtman, Secretary

BRAZOS RIVER AUTHORITY

4400 COBBS DRIVE P. O. BOX 7555 TELEPHONE AREA CODE 817 PL 2-6633
WACO, TEXAS · 76710

April 9, 1965

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

Aquilla Creek Project

Dear Colonel Koisch:

Reference is made to your letter of February 12, 1965, in which you requested that the Brazos River Authority indicate the amount of water supply storage desired in the proposed Aquilla Creek Reservoir currently under study by the Corps of Engineers, and further that the Authority express its willingness to act as the responsible agency for project costs allocated to water supply.

After careful consideration of this matter, and after coordinating with the Texas Water Commission, the Brazos River Authority has determined that the amount of water supply storage space which should be included in the Aquilla Creek project is approximately 59,700 acre-feet. This is the medium-sized of the three different amounts of water conservation storage space proposed by the Corps of Engineers. According to your estimates this storage space will produce a dependable yield of 15 cfs. The motion adopted by the Board of Directors of the Authority on this matter reads as follows:

> "That the Authority inform the Corps of Engineers that it supports the medium-sized reservoir containing approximately 59,700 acre-feet of conservation storage space on Aquilla Creek, a tributary of the Brazos River."

The Brazos River Authority requested that the Texas Water Commission designate the Authority as the agency to represent the state and local interests in cooperating with the Corps of Engineers with respect to the water conservation aspects of a multiple-purpose project to be developed on Aquilla Creek. By resolution adopted on March 30, 1965, the Texas Water Commission designated the Authority as the agency to

negotiate with the Corps of Engineers for acquisition of the conservation storage space in the proposed Aquilla Creek project. A copy of the Commission's resolution was forwarded to you by copy of letter to me dated April 2, 1965. The Authority is willing to assume the obligations and requirements of local cooperation for the water conservation portion of the project.

The Authority appreciates the opportunity of participating in the Aquilla Creek project, and we offer our complete cooperation to the Corps of Engineers in efforts to assure proper coordination in the planning and development of this project.

Sincerely yours,

WALTER J. WELLS
General Manager

WJW:dg

cc: Texas Water Commission

TEXAS HIGHWAY DEPARTMENT

AUSTIN, TEXAS 78701

May 26, 1965

IN REPLY REFER TO
FILE NO. D-5

Hill County
Proposed Aquilla Reservoir

District Engineer
U.S. Army Engineer District, Ft. Worth
Corps of Engineers
P. O. Box 1600
Fort Worth, Texas 76101

USED File:
SWFGB

Dear Sir:

Reference is made to your letter of April 29, 1965, concerning proposed water resource improvements in the Aquilla Creek watershed including tentative plans for a multi-purpose reservoir near Aquilla, Texas. The plates showing the reservoir area and details of the proposed structure have been examined, and the following comments are offered for your consideration.

Two farm to market roads, F.M. 1133 and F.M. 1304, were recently constructed between Aquilla and Menlow, thereby completing the road system south of the reservoir area. For this reason, the need of an additional road across the dam is questionable. It is conceivable that such a road would have scenic value; however, benefits to the existing road system would be negligible. Moreover, the horizontal alignment of the dam and the restricted width at its crest, not to mention the structure which would be required across the spillway at the east end, precludes further consideration of a farm to market road across the dam.

It is noted on the layout of the reservoir area that substantial portions of F.M. 310 and F.M. 1947 will be inundated

by the water level corresponding to a spillway elevation of 551.00. Backwaters will extend north of State Highway 22 at the Aquilla Creek and Hackberry Creek crossings; however, it appears that the reservoir will be confined to the natural streambed at these locations. Our principal interest at this time concerns your plans for the adjustment of F.M. 310 and F.M. 1947 in the reservoir area. A statement of your tentative plans in this regard would be appreciated.

Yours truly,

D. C. Greer
State Highway Engineer

By: Clyde F. Silvus

Clyde F. Silvus
Bridge Engineer

REGION SIX
ARKANSAS
LOUISIANA
OKLAHOMA
TEXAS

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
Austin, Texas 78701

06-41

June 2, 1965

IN REPLY REFER TO:

Water Resources Development Projects
Proposed Aquilla Reservoir

Mr. C. F. Swenson
Chief, Engineering Division
Corps of Engineers
U.S. Army Engineer District, Fort Worth
100 West Vickery Blvd.,
Fort Worth, Texas 76101

Dear Sir:

Reference is made to your letter dated 29 April 1965 in which you requested an expression from this office regarding the desirability of a roadway across the top of the proposed Aquilla Reservoir Dam.

The Texas Highway Department's lack of interest in providing for a roadway across the top of the dam precludes this office from recommending in favor of a highway crossing.

Thank you for the opportunity to review this proposal.

Sincerely yours,

Chas. W. Ruckman

FOR L. S. Coy
Division Engineer

COPY

SWFGB

4 June 1965

Mr. Clyde F. Silvus
Bridge Engineer
Texas Highway Department
Austin, Texas 78701

Dear Mr. Silvus:

Receipt is acknowledged of your reply dated 26 May 1965, to our letter of 29 April 1965 regarding tentative plans for a multiple-purpose Aquilla Reservoir.

The tentative cost estimate for the proposed Aquilla Reservoir includes costs for FM 310 and FM 1947 relocations and alterations. About 0.8 miles of FM 1947 will be relocated to cross Hackberry Creek approximately 1,000 feet upstream from the existing crossing. The roadway will be graded to clear elevation 556.0, controlling elevation for land acquisition and relocations. The estimated cost is approximately $1,069,000. FM 310 will be relocated to a route from Vaughn to the general direction of Menlow, following an existing county road, crossing the Cobb Creek arm of the reservoir, passing near the proposed spillway structure, and joining FM 933 about one mile southwest of Aquilla. The controlling elevation for this road will also be elevation 556.0. The estimated cost for FM 310 is about $944,400.

Your cooperation in planning the development of the water resources of the Aquilla Creek watershed is appreciated.

Sincerely yours,

C. F. SWENSON
Chief, Engineering Division

85-251 O-67—11

TEXAS HIGHWAY DEPARTMENT

AUSTIN, TEXAS 78701

June 23, 1965

IN REPLY REFER TO
FILE NO. D-5

Hill County
Proposed Aquilla Reservoir

District Engineer
U. S. Army Engineer District, Ft. Worth
Corps of Engineers
P. O. Box 1600
Fort Worth, Texas 76101

USED File:
SWFGB

Dear Sir:

Reference is made to your letter of June 4, 1965, wherein we are advised of tentative plans and estimated costs for the relocation and alteration of farm to market roads in the Aquilla Reservoir area. Prior to the initiation of detailed planning by your office, we would appreciate the opportunity of discussing the necessary adjustments with you or members of your staff. Our interest in this matter extends beyond a personal desire to provide an adequate highway system in the affected area; we are required by law to provide the necessary service to highway users, to wit:

> "WHEREAS, the laws of the State of Texas impose upon the Texas Highway Department the responsibility for the construction and maintenance of a connected system of State Highways and State-operated Farm to Market Roads; and .....
>
> ..... where existing highways and roads provide a satisfactory traffic facility in the opinion of the Texas Highway Department and no immediate rehabilitation or reconstruction is contemplated, it shall be the responsibility of the reservoir agency at its expense to replace the existing road facility in accordance with the current design standards of the Highway Department, based upon the road classification and the traffic needs."

The above is quoted from Minute Order 37679, which was passed by the Texas Highway Commission on February 18, 1955.

The rather vague description of the routes to be followed by the relocated portions of F.M. 310 and F.M. 1947 will require further analysis. It appears that the route to be followed by F.M. 1947 has some merit; however, the relocation of F.M. 310 along a route south of Vaughan warrants further investigation, particularly at the connection with F.M. 933 one mile southwest of Aquilla. If the latter route is followed, the severed portions of the existing route will present a problem. Also, if the new route becomes a reality, there is a possibility of requests for a scenic drive across the dam.

In the interest of coordination and planning, we are willing to render any assistance you may desire in the development of this project. A conference might be arranged prior to further consideration of the necessary adjustments, thereby avoiding the possibility of wasted effort or duplication in planning.

Yours truly,

D. C. Greer
State Highway Engineer

By: Clyde F. Silvus

Clyde F. Silvus
Bridge Engineer

COPY

SWFGB 30 June 1965

Mr. Clyde F. Silvus
Bridge Engineer
Texas Highway Department
Austin, Texas 78701

Dear Mr. Silvus:

Receipt is acknowledged of your letter of 23 June 1965 concerning the tentative plans and estimated costs for the relocation and alteration of farm to market roads in the Aquilla Reservoir area.

Your letter indicates the possibility that further analysis would be required with regard to the routes to be followed by relocated portions of FM 310 and FM 1947. The letter also states that the possibility of a scenic drive across the dam might warrant further investigation depending on the routes to be followed by FM 310 and FM 1947.

We have reviewed the subject tentative plans and estimated costs, and it is believed that the plans and costs are adequate at the present time for purposes of our current preauthorization studies. You may be assured, however, that subsequent to authorization of the proposed project and appropriation of funds for preconstruction planning, this office will coordinate with your agency on planning highway relocations and alterations, and future needs in the vicinity of the proposed Aquilla Reservoir project.

Your cooperation in planning the development of water resources of the Aquilla Creek watershed is appreciated.

Sincerely yours,

W. E. HOLLAND, JR.
Lt Col, CE
Deputy District Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
AREA IV
Mineral Resource Office

Office of
AREA DIRECTOR

ROOM 204 FEDERAL BUILDING
BARTLESVILLE, OKLAHOMA 74004

July 28, 1965

Mr. C. F. Swenson, Chief
Engineering Division
U.S. Army Engineer District, Fort Worth
P.O. Box 1600
Fort Worth, Tex. 76101

Refer to: SWFGB

Dear Mr. Swenson:

Referring to your letter of April 2, 1965, this office has completed the mineral review of the Aquilla Creek Reservoir Project, Aquilla Creek, Hill County, Tex.

The proposed Aquilla Creek Reservoir site on Aquilla Creek extends 11 miles upstream from the damsite. The damsite in Hill County, Tex., is approximately 10 miles southwest of Hillsboro, Tex. This project provides for flood control and water conservation benefits. The reservoir will have a potential total volume of 364,400 acre feet comprising 199,300 acre feet for flood control at pool elevation of 551.0 feet, and 82,200 acre feet at normal pool elevation of 533.5 feet. The normal pool will provide a lake of 4,560 acres and the flood control pool will provide a lake of 9,180 acres.

The purpose of the study is to determine the effects on existing and potential mineral resource development in the Aquilla Creek Reservoir area. It is not the purpose of this report to evaluate petroleum and mineral properties or existing facilities. Other factors concerning the nature of petroleum operational problems on the lake, should petroleum be discovered, are discussed.

From the study of office maps and other information on hand, no productive oil and gas wells, or other mineral developments, exist within the limits of the reservoir site.

Although no productive wells now exist in the lake site, present practices of the oil industry make it possible to drill wells and produce oil and gas on inundated land by operating from elevated platforms. These elevated platforms will require a permanent derrick on the well and heavy barges

for transporting equipment to and from the well. For wells drilled near shore or in shallow water, access may be had by a raised roadway. Directional drilling from shoreline locations may be practical, providing depth and location of the wells are suitable to obtain the required horizontal drift. These operating measures on inundated land would add to both the development cost and the producing cost.

The Bureau of Mines does not object to the proposed construction, providing a detailed field examination is made by a qualified engineer during preconstruction planning for the purpose of recommending adequate protective measures for petroleum and mineral resources in the Aquilla Creek Reservoir area.

Sincerely yours,

Robert S. Sanford

Robert S. Sanford
Area Director

SWFGB

26 July 1965

Mr. H. N. Smith
State Conservationist
U. S. Soil Conservation Service
P. O. Box 648
Temple, Texas 76502

Dear Mr. Smith:

Reference is made to our letter of 7 May 1964 indicating the approval and authorization of an interim study of the Aquilla Creek watershed by the Corps of Engineers.

Your letter of 21 May 1964, in answer to our letter, indicated that the Soil Conservation Service is interested in the investigation and a coordinated plan of development for the watershed areas of Aquilla and Hackberry Creek.

A newspaper article dated 20 May 1965, appearing in the Hillsboro Reporter, indicated that a series of 18 flood retention dams are contemplated for the Aquilla-Hackberry watershed.

Our studies on Aquilla Reservoir and the preparation of an interim review report are nearing completion. The Aquilla Creek studies were made with recognition of a potential Soil Conservation Service program on the Aquilla Creek watershed as set forth in the report of the U. S. Study Commission - Texas. For the purposes of finalizing our studies and for the inclusion of the information in our report, a statement from your agency in regard to the status of your studies on the Aquilla Creek program, including information on storages, costs, and location of proposed works, would be helpful.

Your cooperation in this matter will be appreciated.

Sincerely yours,

C. F. SWENSON
Chief, Engineering Division

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P. O. Box 648
Temple, Texas 76502

August 4, 1965

Colonel J. W. Fickessen
District Engineer
U. S. Army Corps of Engineers
P. O. Box 1600
100 West Vickery Blvd.
Fort Worth, Texas 76101

Dear Colonel Fickessen:

This is in reply to Mr. C. F. Swenson's letter of July 26, 1965, requesting a statement from this agency in regard to the status of our studies on Aquilla-Hackberry Creeks.

The local sponsoring organizations originally requested assistance on two watershed projects. One was on Aquilla Creek and the other on Hackberry Creek. These applications were received in September, 1954.

Based on the probability of the installation of the Aquilla reservoir, the local sponsors amended their applications for assistance by combining the drainage area of the two streams above the mouth of Hackberry Creek, thus forming Aquilla-Hackberry Creek Watershed. This watershed has a drainage area of approximately 165,260 acres (258 square miles).

Field examination studies with the sponsoring local organizations indicate that a system of 18 floodwater retarding structures will provide the desired protection to agricultural lands and to other agricultural and non-agricultural properties. In addition, these structures in combination with land treatment will reduce sediment deposition in the proposed Aquilla reservoir site. The estimated total cost of the 18 floodwater retarding structures is $1,500,000. Our study indicates that a feasible benefit-cost ratio would be obtained with the Aquilla reservoir in place. Should construction of the planned Aquilla reservoir follow installation of the upstream project by several years, the average annual benefits attributable to floodwater retarding structures during this period will be in excess of these estimates, because of the protection provided the intensively used flood plain lands, which will be inundated by the Aquilla reservoir.

The State Soil Conservation Board has recommended a planning priority for the Aquilla-Hackberry Watershed and detailed planning will begin in October, 1965. Please let me know if I can furnish additional information to you.

Sincerely yours,

H. N. Smith

H. N. Smith
State Conservationist

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE

1114 Commerce Street
Dallas, Texas 75202

PUBLIC HEALTH SERVICE

September 30, 1965

Colonel Jack W. Fickessen, District Engineer
U.S. Army Engineer District, Fort Worth
Corps of Engineers
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Fickessen:

In accordance with your letter of August 5, 1965, this office has examined the maps and data furnished for the multipurpose Aquilla Creek Reservoir.

We believe the following recommendations concerning public health safeguards against vector problems should be brought to your attention.

1. That vector prevention and control measures be incorporated into the design or planning stage of the reservoir project.

2. That plans for reservoir clearing be concurred in by the Texas State Department of Health.

3. That consideration be given to the following measures in connection with development of recreational areas along the shores of the reservoir:

   a. Locating such areas, particularly those developed for overnight occupancy, along sections where the mosquito potentials are low.

   b. Providing for proper storage, collection, and disposal of refuse for the prevention of flies, wasps, rats, and wild rodents.

   c. Providing for rodentproofed buildings at recreational areas where rodents may create public health hazards.

   d. Providing for periodic removal of debris, rubbish, and other matherials which may serve as harborage for rodents and other mammals.

e. Providing for removal of brush and weeds along paths, trails, and roadways for the prevention of tick infestations.

f. Providing for supplemental use of insecticides and rodenticides in situations where adequate vector control is not obtained through source reduction measures outlined above.

4. That postimpoundage vector control surveys be conducted to determine what additional measures are needed for adequate public health safeguards.

The opportunity to provide you with the above recommendations for vector controls in the Aquilla Creek report prior to field level review is appreciated.

Sincerely yours,

Jerome H. Svore

Jerome H. Svore
Regional Program Director
Water Supply & Pollution Control

cc:
Mr. Leslie D. Beadle
Texas State Department of Health

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

Southwest Region
Santa Fe, New Mexico 87501

IN REPLY REFER TO:

L7423

January 12, 1966

Jack W. Fickessen
Colonel, CE
Fort Worth District, Corps of Engineers,
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Fickessen:

The opportunity to review your report entitled "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek", enclosed in your letter of 5 January, SWFGB, is appreciated. The reservoir project would not appear to affect any state park or other significant existing recreation area. It is not closely related geographically to any National Park Service area.

If the project is authorized, please contact us during the early preconstruction planning so that the customary archeological surveys can be made and site salvage, if indicated, completed before construction and impoundment.

Sincerely yours,

Roger W. Allin
Assistant Regional Director
Cooperative Activities

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
AREA IV
Mineral Resource Office

Office of
AREA DIRECTOR

ROOM 204 FEDERAL BUILDING
BARTLESVILLE, OKLAHOMA 74004

January 17, 1966

Col. Jack W. Fickessen, District Engineer
Fort Worth District, Corps of Engineers
Department of the Army
P.O. Box 1600
Fort Worth, Texas 76101

Dear Col. Fickessen:

Thank you for sending us a draft copy of the report "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek" for field level review.

This office commented on the proposed project in our letter dated July 28, 1965. (See Appendix VII, page 149). As there have been no major revisions in the proposed reservoir since our first review, our comments will also pertain to the report dated December 28, 1965.

Please note the last paragraph of our July 28 letter which reads: "The Bureau of Mines does not object to the proposed construction, providing a detailed field examination is made by a qualified engineer during preconstruction planning for the purpose of recommending adequate protective measures for petroleum and mineral resources in the Aquilla Creek Reservoir Area."

Sincerely yours,

Robert S. Sanford

Robert S. Sanford
Area Director
Area IV Mineral Resource Office

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Atlanta, Georgia 30323

IN REPLY REFER TO
3520

January 17, 1966

Colonel Jack W. Fickessen
District Engineer
Department of the Army
Fort Worth District, Corps of Engineers
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Fickessen:

Your Interim Report on Brazos River and Tributaries, Texas, covering Aquilla Reservoir on Aquilla Creek, was sent to us for field level review and comment.

There are no lands administered by the Forest Service within or adjoining the proposed reservoir area.

Most of the Aquilla Creek watershed lies in the East Cross Timbers Region with post oak and blackjack oak the predominating tree species on the uplands and pecan, cottonwood, elm, and hackberry along the stream courses. The principal uses of these timbers are for fence posts and fuel.

Available data indicates that construction of Aquilla Creek Reservoir will not have any significant effects on timber resources.

Sincerely yours,

J. K. VESSEY
Regional Forester

By Elmer F. Thompson

REGION SIX
ARKANSAS
LOUISIANA
OKLAHOMA
TEXAS

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
P. O. BOX 12037
FORT WORTH 16, TEXAS

January 25, 1966

IN REPLY REFER TO:
06-00.1

Col. Jack W. Fickessen
District Engineer
Fort Worth District, Corps of Engineers
Post Office Box 1600
Fort Worth, Texas 76101

Dear Colonel Fickessen:

Thank you for the copy of your 5 January 1966 letter to Division Engineer Coy and for the draft copy (serial number 93) in final form of your report entitled, "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek," dated 28 December 1965.

We are forwarding Mr. Coy's January 24, 1966 reply to your letter. We have no additional comments to offer.

Sincerely,

G. A. Weisser

G. A. Weisser
Acting Regional Design Engineer

Attachment

cc: Mr. L. S. Coy

REGION SIX
ARKANSAS
LOUISIANA
OKLAHOMA
TEXAS

U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

06-41

Austin, Texas 78701

January 24, 1966

IN REPLY REFER TO:

Col. Jack W. Fickessen
District Engineer
Fort Worth District, Corps of Engineers,
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Fickessen:

We have reviewed your report entitled "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek," submitted with your letter dated January 5, 1966.

It is our interpretation of the report that all cost relating to highway relocation and reconstruction within the reservoir area will be a responsibility of the water resource project.

We thank you for the opportunity to review this report.

Sincerely yours,

L. S. Coy
Division Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF OUTDOOR RECREATION
MID-CONTINENT REGION
BUILDING 56, DENVER FEDERAL CENTER
DENVER, COLORADO 80225

D6427TG

January 26, 1966

Colonel Jack W. Fickessen
District Engineer
Corps of Engineers
Fort Worth District
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Fickessen:

In response to your request of January 5, 1966, we have reviewed your report covering the proposed Aquilla Reservoir on Aquilla Creek, Texas.

Our remarks are based primarily on the relationship of your report to Public Law 89-72, The Federal Water Project Recreation Act.

We believe your estimate of visitation and benefits are reasonable as stated in the report. The project's proposed recreational lands are not deemed to be of National significance; therefore, are not appropriate for Federal administration. Section 3(a) of P.L. 89-72 states that all recreational development other than minimum basic facilities must be carried out by a non-Federal agency. The Texas Statewide Comprehensive Outdoor Recreation Plan was reviewed as provided for in Section 6(a) of the same Act, whereby the following remarks are presented for your consideration:

(1) The proposed Aquilla Reservoir lies within Planning Region II as defined by the Texas Statewide Comprehensive Outdoor Recreation Plan

(2) Planning Region II presently exhibits a surplus of water and related land resources for swimming and boating, and this condition is estimated to continue into the 1970's.

(3) There does exist a deficit of facilities for picnicking and camping in Planning Region II which is expected to continue. Facility expansion, however, is expected to be on existing lands.

(4) Consideration of the above, along with the statement that sufficient monies are not now available to the State for an accelerated program of acquisition and development, makes it a probability that the State of Texas may not wish to commit itself to participation at this time.

If the State does not wish to assume the recreational development responsibility, we encourage you to seek local cooperation on less than the State level. This is encouraged because we believe the subject reservoir will experience considerable visitation regardless of the fact that minimum basic facilities would be the only provision. Should local cooperation not be secured at this time, a recommendation should be made to set aside those lands considered necessary for the preservation of the recreational potential of the project. Such lands could be set aside for 10 years as provided for in Section 3(b) and Section 5 of P.L. 89-72. If non-Federal assumption of the recreational development responsibility is not forthcoming, your estimates of visitation and benefits ascribed to recreation should be revised.

Contact with the National Park Service indicated they are furnishing your office their comments directly.

Thank you for the opportunity to review your report.

Sincerely yours,

E. E. Allen
Regional Director

cc: Director, Bureau of Outdoor Recreation

85-251 O-67—12

COPY

SWFGB

14 February 1966

Mr. E. E. Allen
Regional Director
Mid-Continent Region
Bureau of Outdoor Recreation
Building 56, Denver Federal Center
Denver, Colorado 80225

Dear Mr. Allen:

This is in reply to your letter of 26 January 1966 setting forth your comments on our "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek."

Regarding the Federal Water Project Recreation Act (Public Law 89-72) the Texas Legislature adjourned in 1965 prior to the passage of this act. Therefore, the State of Texas is unable at this time to participate in the Federal recreation program under this act as it is without legislative authority to enter into the required agreements and to commit money for its purposes. The Texas Legislature does not convene in regular session again until January 1967.

The Corps of Engineers has requested the Texas Parks and Wildlife Department (the agency designated by the Governor of Texas to negotiate in matters pertaining to recreation and fish and wildlife enhancement) to provide a letter indicating the State's intention regarding participation in recreation and fish and wildlife enhancement in the proposed Aquilla Reservoir project. This is still under consideration by the Governor of Texas and the Parks and Wildlife Department.

For the purpose of processing the report without further delay and without deleting recreation and fish and wildlife enhancement as a project purpose, the assumption is being made that the State of

Texas will eventually provide the necessary letter of intent to participate in the Federal recreation program under Public Law 89-72. As you probably know, the State has an intense interest in recreation, both for its native population and for the attraction of tourists, and has extensive developments at several Federal reservoir projects.

In the event the State of Texas is unwilling to commit itself to participation under the provisions and requirements of Public Law 89-72, the Aquilla Reservoir project would be revised to provide minimum recreation facilities including lands to preserve the recreation and fish and wildlife enhancement potential of the project for 10 years as provided in Section 3(b) of P.L. 89-72, and as suggested in paragraph 4 of your comments.

Your comments are appreciated and your letter with this reply will be included in the report.

Sincerely yours,

JACK W. FICKESSEN
Colonel, CE
District Engineer

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
SOUTHWESTERN POWER ADMINISTRATION

SPA-RH

POST OFFICE DRAWER 1619
TULSA, OKLAHOMA 74101

January 31, 1966

Your reference:
SWFGB

District Engineer
U. S. Army Engineer District,
Fort Worth
P. O. Box 1600
Fort Worth, Texas 76101

Dear Sir:

Thank you for your letter of January 5, 1966, enclosing a draft copy (serial number 84) in final form of your report entitled "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek," dated December 28, 1965, for review and comments.

The proposed improvements included in this report will not affect the interests of this Administration in the Brazos basin.

Sincerely yours,

Carl E. Roberts
Chief, Division of
Planning and Resources

FEDERAL POWER COMMISSION
REGIONAL OFFICE

100 North University Drive
Fort Worth, Texas 76107
February 2, 1966

In reply refer to:
PWR-FW

District Engineer
Fort Worth District, Corps of Engineers
P. O. Box 1600
Fort Worth, Texas 76101

Dear Sir:

Reference is made to your letter of January 5, 1966 (SWFGB) by which you transmitted your report entitled "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek" for our field level review and comments.

We have reviewed the subject report with particular reference to the possible development of hydroelectric power at the proposed Aquilla Reservoir. Due to the low yield of the reservoir, we find that the development of power at this project would be impractical. Also on a previous occasion in connection with the U. S. Study Commission-Texas report, we studied the power potential at the Aquilla project and concluded at that time that power development would not be favorable. The proposed project would have a negligible effect on any potential downstream hydroelectric development.

Your courtesy in forwarding the subject report for our review and comments is appreciated. It should be noted that these comments are prepared at field level and should not be construed as those of the Federal Power Commission.

Sincerely yours,

Donald L. Martin
Regional Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
REGIONAL OFFICE - REGION 5
P. O. BOX 1609
AMARILLO, TEXAS 79105

IN REPLY
REFER TO: 5-731

February 2, 1966

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

Dear Sir:

As requested by your letter of January 5, 1966, we have reviewed the draft copy of your report entitled "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek," dated December 28, 1965.

We note that your investigation included consideration of existing and potential water requirements for irrigation. The appended report of the Public Health Service indicated that the water requirement for irrigation will be satisfied. The Public Health Service report states that the quantities of water for irrigation uses were determined by the Corps of Engineers, based on U.S. Study Commission-Texas values. We believe the report could be improved by including sufficient data to check the irrigation requirements with the U.S. Study Commission - Texas report.

The opportunity to review your report is appreciated.

Sincerely yours,

Regional Director

COPY

SWFGB

9 February 1966

Mr. Leon W. Hill
Regional Director, Region 5
U. S. Department of the Interior
Bureau of Reclamation
P. O. Box 1609
Amarillo, Texas 79105

Dear Mr. Hill:

This is in reply to your letter of 2 February 1966, furnishing comments based on a review of our report draft covering the Aquilla Reservoir on Aquilla Creek, Brazos River Basin, Texas. Your comments are directed to the fact that the Public Health Service report contains irrigation water requirements which are based on U. S. Study Commission-Texas values. You state that the report could be improved by including sufficient data to check the irrigation requirements with the U. S. Study Commission-Texas report.

The irrigation water requirements contained in the report of the Public Health Service (now the Federal Water Pollution Control Administration) are based on a correlation and an interpretation of irrigation data contained in the Bulletin No. 6018 "Irrigation in Texas 1958," by the Texas Board of Water Engineers and the planning report "Irrigation Diversion Requirements and Return Flow, 2010 Conditions," dated August 1960, by the U. S. Study Commission-Texas.

Sincerely yours,

W. E. HOLLAND, JR.
Colonel, CE
Deputy District Engineer

TEXAS WATER DEVELOPMENT BOARD

SAM HOUSTON
STATE OFFICE BUILDING
201 EAST 14TH STREET

P. O. BOX 12386
CAPITOL STATION
AUSTIN, TEXAS 78711

JOE G. MOORE, JR.
EXECUTIVE DIRECTOR

JOHN J. VANDERTULIP
CHIEF ENGINEER

C. R. BASKIN
ASS'T. CHIEF ENGINEER

HOWARD B. BOSWELL
DEVELOPMENT FUND MANAGER

DONALD B. YARBROUGH
GENERAL COUNSEL

GORDON CARLSON
CHIEF, STAFF SERVICES

AREA CODE 512
GREENWOOD 5-3187

February 2, 1966

Colonel Jack W. Fickessen
District Engineer
U. S. Army, Corps of Engineers
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Fickessen:

Thank you for providing us an opportunity to comment on the final draft form of your report entitled "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek".

The project recommended by the report does not conflict with the State Water Plan now being prepared by this agency. The yield of the reservoir exceeds considerably the foreseeable water supply requirement of the local area although the conservation storage of the project is limited to a size that would likely be suitable only to meet local requirements. It is the view of this agency that construction of this project as recommended is desirable.

In accordance with established arrangements for seeking comments of other interested agencies, copies of your report were directed to the Texas Highway Department, the Texas Parks and Wildlife Department, and Texas Department of Health. A letter containing the comments of the Texas Highway Department is attached.

Very truly yours,

Joe G. Moore, Jr.

Joe G. Moore, Jr.
Executive Director

Attachment: 1

TEXAS HIGHWAY DEPARTMENT

AUSTIN, TEXAS 78701

January 31, 1966

IN REPLY REFER TO
FILE NO. D-5

Hill County
Relocation in Proposed Aquilla Reservoir

Mr. Joe G. Moore, Jr.
Executive Director
Texas Water Development Board
P. O. Box 12386
Capitol Station
Austin, Texas 78711

Dear Mr. Moore:

We have reviewed the draft copy in final form of the report prepared by the Corps of Engineers entitled "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek", as requested in a letter dated January 7, 1966, from your agency.

We have no comment that has not been covered by our letters dated May 26, and June 23, 1965, copies of which are included in Appendix VII of the Report.

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

Yours truly,

D. C. Greer
State Highway Engineer

By: Clyde F. Silvus

Clyde F. Silvus
Bridge Engineer

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P. O. Box 648
Temple, Texas 76502

January 31, 1966

Colonel Jack W. Fickessen
District Engineer
U. S. Corps of Engineers
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Fickesson:

Thank you for the opportunity to review a draft copy of the report entitled "Interim Review of Reports on Brazos River and Tributaries, Covering Aquilla Reservoir on Aquilla Creek", dated 28 December 1965. The draft was found to be a comprehensive and well prepared report.

The report states that as a result of investigations the District Engineer determined that "......major floods originating on the Aquilla Creek watershed cause a flood problem on Aquilla Creek, and augment appreciably the flood conditions within the lower 417.1 mile reach of the Brazos River; and that an important water supply problem exists for the cities of Hillsboro and West."

The report proposes solving certain of the flood and water supply problems by construction of the Aquilla Reservoir. An immediate need is recognized for construction of the Aquilla Reservoir to provide for the economical development of the water resources of the watershed. The District Engineer recommends that the authorized project for Brazos River and Tributaries, Texas, be modified to provide for construction of the Aquilla Reservoir at an estimated construction cost to the United States of $23,612,000, and an estimated $70,000, for annual operation and maintenance, subject to the conditions that local interests reimburse the United States for the project costs allocated to water supply and to recreation and fish and wildlife enhancement.

The following comments are offered for your consideration in preparation of the final report.

1. Damage reduction benefits accruing to the proposed Aquilla Reservoir are estimated at $286,000 under present, or existing, flood plain development. However, on page 47, paragraph 76a states the average annual residual damages to be $3,131,500 under present conditions with a reduction to $2,855,500 after project installation. This indicates a reduction of $276,000 instead of $286,000.

It is noted that average annual damage reduction benefits are estimated

to be $725,200 after allowance for flood plain development anticipated during the 1975 - 2075 period. This significant increase of more than 2.6 times the average annual benefits under existing conditions would reflect an extremely high level of development in the predominantly agricultural flood plain. Probably consideration of the river reach which includes the city of Waco accounts for a large portion of the anticipated development and the resultant increase in average annual damage reduction. It would be helpful to a reader of the report if the sentence beginning at the bottom of page 55 were modified to explain that development anticipated will take place in both agricultural and urban areas, if this was the basis for benefit adjustment.

2. On page II - 10, item 22 it is estimated that the Soil Conservation Service land treatment practices, small ponds, and retardation structures upstream from Aquilla Reservoir for the next 100 years will result in a total annual depletion varying from about 8 to 32 percent during the critical drought period. These percentages apparently were taken from Table 45.3, Runoff-Brazos River Basin, prepared for the U. S. Study Commission - Texas by the Bureau of Reclamation. They apply to the 2010 watershed condition only.

Table a-3, Effect on Surface Runoff of Land Treatment, Ponds, and Minor Reservoirs, and Floodwater Retarding Structures, prepared for the USSC-T by the Bureau of Reclamation, indicated that by 2060 floodwater retarding structure sediment pools will be depleted. The 2010 depletions were based on 47 percent of the sediment pool area being subject to pool losses. The 1975 depletions, which varied from 3 to 12 percent, were based on 22 percent of the sediment pool area being subject to pool losses. The 1958 condition runoff, which considered no pool losses but a substantial amount of land treatment established, was 99 percent of natural runoff.

If reductions in runoff are to be based on Study Commission annual depletion factors, as stated, the parameters used by the Study Commission should be considered. In this case, runoff after 100 years of watershed development would not be depleted by floodwater retarding structures.

We are returning draft copy (Serial No. 70) and are retaining copy (Serial No. 90) for use in connection with planning currently underway on the Aquilla Hackberry watershed above your proposed Aquilla Reservoir. Assistance is being furnished by the Soil Conservation Service under provisions of Public Law 566, as amended. If we can furnish additional information on the agricultural aspects of the Aquilla watershed, please let me know.

Sincerely yours,

for H. N. Smith
State Conservationist

Attachment (Copy # 70)

COPY

SWFGB

16 February 1966

Mr. H. N. Smith
State Conservationist
U. S. Department of Agriculture
Soil Conservation Service
P. O. Box 648
Temple, Texas 76502

Dear Mr. Smith:

This is in acknowledgment of your letter dated 31 January 1966 concerning our "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek."

Your comment on the reduction of residual damages from $3,131,000 to $2,855,500 is a typographical error and should be from $3,141,500 to $2,855,500, giving a reduction of $286,000. The report is being revised to reflect this correction. Also, in accordance with your suggestion, page 47 is being modified to state that development anticipated will take place in both the agricultural and urban areas of the flood plain influenced by the proposed Aquilla Reservoir.

Your comment that annual depletion percentages used in our Aquilla Reservoir report were taken from table 45.3, Runoff - Brazos River Basin, prepared for the U. S. Study Commission - Texas, by the Bureau of Reclamation, is correct. It is also true that these depletions reflect 2010 watershed conditions and that the Bureau estimates that the sediment pools above these floodwater retarding structures would be depleted by the year 2060 so that there would be no sediment pool area subject to pool losses in 2075. However, although depletions due to floodwater retarding structures may become minor by the year 2075, it is also probable that depletions due to other causes would increase, and it is considered highly improbable that available resources in the area would be greater in 2075 than in 2010. We have, therefore, assumed that resources under 2010 and 2075 conditions of watershed development would be identical. This assumption is in accord with views expressed by the Bureau with regard to their depletion estimates, wherein they stated:

"- - - the computed depletions should be viewed as a generous allowance for depletions which available data indicates might have happened rather than as a precise determination of what will happen, or has happened."

To further substantiate our assumption it is pointed out that depletions estimated by the Bureau are made up of losses due to three sources: (1) land treatment measures; (2) ponds and minor reservoirs; and (3) floodwater retardation structures; and that losses from the latter source amount to only about 25 percent of the total losses under 2010 watershed conditions. Bureau estimates of depletion due to land treatment measures were based upon the assumption that 80 percent of cultivated land and 50 percent of open range land would be treated by the year 2010. It is possible that further increases in the percentage of land treated might take place between 2010 and 2075. Also, it was estimated by the Bureau that the number of ponds and minor reservoirs per square mile in Hill County would increase from 2.86 in 1957 to 5.77 in 2010. Bureau data for other counties in the vicinity show an estimate of as many as 8.32 such ponds per square mile by 2010 and there is no reason to believe that ponds in Hill County might not equal or exceed this number by 2075. After due consideration of all the above data, it was concluded that, though depletions due to floodwater retardation structures would probably decrease so as to be almost negligible by the year 2075, there was a strong possibility that depletions due to land treatment measures and minor reservoirs would increase by a like amount during the same period, so that the overall depletion from all sources in 2075 would be approximately the same as in 2010.

Sincerely yours,

JACK W. FICKESSEN
Colonel, CE
District Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
SOUTHWEST REGION
FEDERAL BUILDING, P. O. BOX 1467
MUSKOGEE, OKLAHOMA 74402

February 3, 1966

Colonel Jack W. Fickessen
Department of the Army
Fort Worth District
Corps of Engineers
P. O. Box 1600
Fort Worth, Texas 76101

Dear Col. Fickessen:

This is in comment on your report entitled "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Creek."

Interior's interest is that of our several bureaus which function in Texas. I note that your study has been coordinated with the Bureau of Mines, Bureau of Sport Fisheries and Wildlife, and Geological Survey; but there is no mention of the Bureau of Outdoor Recreation or Bureau of Reclamation, which also have broad interests in Texas Water Resources Development. If these latter two offices have not received copies of your report for review will you please send copies for comment to:

H. P. Burleigh, Area Engineer
Bureau of Reclamation
P. O. Box 1946
Austin, Texas 78767

Ernest E. Allen, Regional Director
Bureau of Outdoor Recreation
Mid-Continent Region 3
Bldg. 56, Denver Federal Center
Denver, Colorado 80225

Sincerely,

Kenneth D. McCall

Kenneth D. McCall
Regional Coordinator

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
POST OFFICE BOX 1306
ALBUQUERQUE, NEW MEXICO 87103

February 3, 1966

AIRMAIL

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

Dear Sir:

By letter dated January 5, 1966, referenced SWFGB, you requested our comments on the draft of your "Interim Review of Reports on Brazos River and Tributaries, Texas, covering Aquilla Reservoir on Aquilla Creek," dated December 28, 1965.

The discussion of fish and wildlife in the Review of Reports accurately reflects our analysis of the project's effects on these resources.

We are pleased to note that Recommendation No. 1 of this Bureau's March 31, 1965, report which requests the project be authorized for purposes of fish and wildlife enhancement is included in the recommendations of the Review of Reports. Your report, however, indicates that Recommendations Nos. 2 and 4 of our report regarding seining areas and reservoir zoning would be given additional study during preconstruction planning of the project. We believe that provisions for seining areas and a zoning plan should be included in project plans. We also are puzzled by the fact that we could find no reference to our Recommendations Nos. 3 and 5 regarding a streamflow release for Aquilla Creek and retention of standing timber in the reservoir. We feel that these recommendations are reasonable and should be discussed as to acceptability.

It is noted that the Review of Reports provides for the development of basic facilities for fishing and hunting and that construction and operation costs for fish and wildlife are combined with recreation costs. Since local interests would be required to pay a portion of the costs as provided for in the Federal Water Project Recreation Act, it is believed that costs for fish and wildlife should be separated from those for recreation. This would make those responsible for repayment aware of the charges to be imposed.

We appreciate the opportunity extended to us to comment on the survey report.

Sincerely yours,

John C. Gatlin
Regional Director

cc:
Executive Director, Texas Parks and Wildlife Department, Austin, Texas
Field Supervisor, Division of River Basin Studies, Bureau of Sport Fisheries and Wildlife

COPY

SWFGB

17 February 1966

Mr. John C. Gatlin
Regional Director
Bureau of Sport Fisheries and Wildlife
U. S. Department of the Interior
P. O. Box 1306
Albuquerque, New Mexico 87103

Dear Mr. Gatlin:

Reference is made to your letter of 3 February 1966 furnishing comments on our draft of "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek."

In paragraph 3 of the above-referenced letter, it is stated that you believe that recommendations 2 and 4 of your report regarding seining areas and reservoir zoning should be included in the project plans. We will incorporate as a part of the project a provision that two seining areas each about 1,000 feet wide be located in the upper portion of the reservoir. However, a zoning plan for the water area is normally not developed at a reservoir until the pattern of public use is established. This usually takes from three to five years after the project becomes operational and is enforced with the cooperation of local interests who desire zoning of the reservoir. The Corps of Engineers has no enforcement action, as such, but must depend on enforcement from State and county officials.

In further reference to paragraph 3, you state there is no reference to recommendations 3 and 5 of your report regarding streamflow release for Aquilla Creek and retention of standing timber in the reservoir. Since the Federal Water Pollution Control Administration (referred to in our report as the U. S. Public Health Service) stated in their report that there will be no need for water quality control, we saw no need for including this recommendation. As you know water in the reservoir is the property of the State, and releases of water will be made from the reservoir at the request of the sponsoring State agency. Clearing requirements for reservoir areas

85-251 O-67—13

as prescribed by the Corps of Engineers are set forth in EM 415-2-301 and with few exceptions must be followed in all reservoir clearing criteria. Vertical limits of clearing vary from 0 to 3 feet above the conservation pool elevation and from 5 to 10 feet below the 10-year drawdown. Horizontal limits are required as follows:

a. Must clear one mile around dam and main structures.

b. Must clear for one mile around all principal recreation areas.

c. Must clear for one mile around all populated areas.

d. Must clear for one-half mile on either side of major highway crossings.

Clearing criteria for Aquilla Reservoir will be determined during preconstruction planning. Your recommendation regarding retention of standing timber will be given consideration where possible.

Since non-Federal interests would pay a portion of the project costs as required under the Federal Water Project Recreation Act, you suggest that costs for fish and wildlife should be separated from those for general recreation for the information of non-Federal interests. Based on discussions with a representative of your field office at Fort Worth, the Fort Worth District is aware of conferences and correspondence between your agency and the Office, Chief of Engineers, in regard to the division of allocated non-Federal recreational cost between the activities classified as general recreation and as sport fishing and hunting. Since instructions from higher authority within the Corps of Engineers have not been received in regard to this matter, revision of the report to incorporate your suggestion cannot be made at this time.

You are advised that additional consideration will be given to the recommendation of the Bureau of Sport Fisheries and Wildlife during the preconstruction stage for Aquilla Reservoir. Paragraph 69 of the report text is being revised to acknowledge consideration of the recommendation of your agency.

Sincerely yours,

JACK W. FICKESSEN
Colonel, CE
District Engineer

TEXAS WATER RIGHTS COMMISSION

SAM HOUSTON
STATE OFFICE BUILDING
P. O. BOX 12396
CAPITOL STATION
AUSTIN, TEXAS 78711

February 3, 1966

Colonel Jack W. Fickessen, District Engineer
U.S. Army Engineer District, Fort Worth
Corps of Engineers
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Fickessen:

We have reviewed the draft copy of your report entitled "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek," dated December 28, 1965, in response to your request of January 5, 1966. We sent a copy of this report to the Brazos River Authority and requested their review and comments. Their comments were received by letter of January 26, 1966, and are submitted herewith.

The Commission reaffirms its resolution of March 30, 1965, naming the Brazos River Authority as the local sponsor of the proposed project, and on the need for acquisition of water rights by the sponsor when the project is developed.

The reservoir capacity at top of conservation storage space is more than adequate to serve the foreseeable water requirements of the Cities of Hillsboro and West and is comparable with optimum size development for the site as estimated in former Commission studies. The total storage capacity is large enough to provide for reallocation of storage space in the future as changing conditions and developments may justify the use of a larger water-supply capacity, and the outlet facilities appear to have sufficient capacity to provide flexibility in a systems operation if needed.

Sincerely yours,

F. R. Booth

F. R. Booth
Executive Director

Attachment: 1

BRAZOS RIVER AUTHORITY

4400 COBBS DRIVE P. O. BOX 7555 TELEPHONE AREA CODE 817 PL 2-5533
WACO, TEXAS - 76710

January 26, 1966

Mr. Louis L. McDaniels
Chief Hydrologist
Texas Water Rights Commission
P. O. Box 12396
Austin, Texas 78711

Dear Mr. McDaniels:

Reference is made to your letter of January 7, 1966, with which you forwarded us one copy of the "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek" by the U. S. Army Engineer District, Fort Worth, Corps of Engineers, Fort Worth, Texas. You asked that we submit by January 27 any field level comments we may care to make, with particular consideration to how the proposed project would fit in with our system of operation.

The project being recommended by the District Engineer in his report contains the volume of conservation storage space recommended by the Brazos River Authority by letter to the District Engineer dated April 9, 1965, a copy of which was sent to the Texas Water Commission. We consider that 59,700 acre-feet of conservation storage space, which will produce an estimated dependable yield of 15 cfs, is entirely adequate for this project.

With regard to the question of fitting this project into our system operation, we see no reason why the project could not be operated as an integral part of our system of water supply reservoirs in the Brazos basin. However, system operation of reservoirs for water supply purposes depends basically on being able to utilize the water principally in the lower reaches of the basin. The estimated cost of water from the proposed Aquilla Creek project is so high in comparison with the cost of water from other reservoirs in the basin as to make it impracticable to sell water from this project in the lower reaches in the foreseeable future. It is anticipated therefore that water from the Aquilla Creek Reservoir will be used primarily to meet present and anticipated future needs in the Waco-Hillsboro area. In the more distant future it is possible that conditions will change so

that it will become economically feasible to utilize water from this project in the lower reaches of the basin. In this case, incorporation of the project into our system will be entirely feasible.

We sincerely appreciate your giving us the opportunity to submit our informal comments on this report.

Sincerely yours,

WALTER J. WELLS
General Manager

WJW:dg

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

1114 Commerce Street
Dallas, Texas 75202

February 4, 1966

Colonel Jack W. Fickessen
District Engineer
U. S. Army Engineer District, Fort Worth
P. O. Box 1600
Fort Worth, Texas 76101

Your Ref: SWFGB

Dear Colonel Fickessen:

We have reviewed your draft report entitled "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek." Our report on water supply and water quality control is included in Appendix VI, while our recommendations regarding public health safeguards against vector problems is in Appendix VII.

Paragraph 51.b., "Water Quality Control" of your report, indicates that "the future organic and mineral qualities of Aquilla Creek watershed waters are expected to remain satisfactory for municipal, industrial, recreational, fish and wildlife, and agricultural uses." Our report to you qualified the findings concerning the suitability of these waters for municipal and industrial purposes. The U. S. Public Health Service Drinking Water Standards provide for use of waters with dissolved solids in excess of 500 mg/l if another more suitable supply is not available.

Page 122 of our report indicates, "U. S. Public Health Service Drinking Water Standards recommend total dissolved solids concentration not exceed 500 mg/l. Although a goal of maintaining total dissolved solids below this figure is desirable, it is not attainable in the watershed; therefore, the practical goal of 1,000 mg/l was selected."

The situation concerning water quality at this site is that it will be useful since a satisfactory source of supply is unavailable. Ground water is of even poorer quality than that to be stored in the proposed reservoir.

Under Executive Order No. 11258, the FWPCA has as one of its major responsibilities to review plans for proposed Federal water resources development projects and prepare a report describing the potential impact of each on water quality, including recommendations for any changes considered necessary with respect to the design, construction, and operation of the project. Procedures concerning this have not as yet been received by this office, however, we expect that the results of our review will be presented in report form rather than a letter of comment such as this. We do not expect to recommend any changes in design, construction, or operation for this project.

Effective December 31, 1965, all duties formerly assigned to the Division of Water Supply and Pollution Control, U. S. Public Health Service, were transferred to the newly established Federal Water Pollution Control Administration. Therefore, please address any future correspondence pertaining to water pollution control to our new letterhead address.

We appreciate the opportunity to review this report.

Sincerely yours,

Jerome H. Svore

JEROME H. SVORE
Regional Program Director

COPY

SWFGB

11 February 1966

Mr. Jerome H. Svore
Regional Program Director
Department of Health, Education,
and Welfare
Federal Water Pollution Control
Administration
1114 Commerce Street
Dallas, Texas 75202

Dear Mr. Svore:

This is in acknowledgment of your letter dated 4 February 1966, furnishing the comments of your agency on the "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek," dated 28 December 1965.

Your letter directs attention to your report which qualified the findings concerning the suitability of waters on the Aquilla Creek watershed for municipal and industrial purposes. Your report states that although a goal of maintaining total dissolved solid below 500 mg/l is desirable, it is not attainable on this watershed; and, thus, a practical goal of 1,000 mg/l was selected. Paragraph 51b of our report text is being revised to include this qualificiation.

A copy of the comments by the Federal Water Pollution Control Administration and a copy of this reply will be included in appendix VII of our report.

Sincerely yours,

JACK W. FICKESSEN
Colonel, CE
District Engineer

IN REPLY REFER TO:
Your file:
SWFGB

UNITED STATES
DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY
SOUTHWEST FIELD COMMITTEE, REGION SIX
Federal Building
300 East 8th Street
Austin, Texas 78701

February 9, 1966

Colonel Jack W. Fickessen, District Engineer
Department of the Army
Fort Worth District, Corps of Engineers
P. O. Box 1600
Fort Worth, Texas 76101

Dear Colonel Fickessen:

Thank you for submitting a draft copy of the Corps of Engineers' report on "Interim Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek," dated 28 December 1965.

We have reviewed the report and concur in all recommendations of official concern to the Geological Survey, except for certain long-range planning for hydrologic instrumentation which is described below.

The report provides for the establishment of inflow stream-gaging stations and records of reservoir content before and during the construction of the dam. Although hydrologic studies show that releases of flood flows passing Aquilla Creek Reservoir will be at intermittent periods, the Geological Survey recommends that a streamflow and water-quality station, equipped with a stable weir, be established at or before the dam is built to obtain accurate records of water quality and water discharge for low flow releases and to record similar data during major flood periods when flood flows will be discharged from the reservoir. It is further recommended that streamflow stations that are proposed for measuring inflows to the reservoir be supplemented, where appropriate, with water-quality stations to evaluate municipal and industrial wastes that may enter this water-supply reservoir.

Recognizing that pollution abatement is becoming an increasing problem, it would be desirable that 3 water-quality surveys be made of the reservoir the first year the reservoir fills, and that similar surveys be made on an annual basis in subsequent years. Such surveys will record changes in water quality of reservoir water should industrial, agricultural, or municipal growth release undesirable effluents over long periods of time.

On page 56, paragraph 92. insert after the word data, 4th line, the following: ....historical floods, water-quality data, topographic maps,..... The paragraph will then read as follows:

> 92. U. S. GEOLOGICAL SURVEY.- Coordination work with the U. S. Geological Survey consisted of the acquisition of basic data from that agency. These data included drainage area information, stream gaging data, discharge and runoff data, historical floods, water-quality data, topographic maps, and other pertinent information.

Please be assured that the Geological Survey will cooperate with your agency in any way possible when the reservoir is built.

Very truly yours,

Trigg Twichell
Contact Official
for Geological Survey

TT:mlb

COPY

SWFGB 16 February 1966

Mr. Trigg Twichell
Contact Official
for Geological Survey
U. S. Department of the Interior
Federal Building
Austin, Texas 78701

Dear Mr. Twichell:

This is in reply to your letter of 9 February 1966, concerning your review and comments on our "Review of Reports on Brazos River and Tributaries, Texas, Covering Aquilla Reservoir on Aquilla Creek."

In accordance with the suggestion contained in your letter, paragraph 92 of the report is being revised to reflect the complete coordination between our two agencies with respect to hydrologic information.

With respect to the hydrologic instrumentation for water quality and water discharge discussed in the 3d and 4th paragraphs of your letter, we have revised paragraph 41 of appendix II of the report in line with your recommendations. However, we wish to point out that the actual installation of the hydrologic networks will depend upon authorization of the project by the Congress, availability of funds and hydrologic stationing existing at the time. In view of the official concern of the Geological Survey for the long-range planning for hydrologic instrumentation, we urge that the Department of the Interior initiate funding of certain of these activities as soon as practicable in line with the intent of the Bureau of the Budget Circular No. A-67 (28 August 1964).

Sincerely yours,

JACK W. FICKESSEN
Colonel, CE
District Engineer

Texas State Department of Health

JAMES E. PEAVY, M.D., M.P.H.
COMMISSIONER OF HEALTH

AUSTIN, TEXAS

J. B. COPELAND, M.D.
DEPUTY COMMISSIONER

January 24, 1966

H-CKF

Texas Water Development Board
P. O. Box 12386
Capitol Station
Austin, Texas 78711

Subject: Aquilla Reservoir on Aquilla Creek

Attention: Mrs. Jean Williams

Gentlemen:

This will acknowledge receipt of the "Interim Review of Reports on Brazos River and Tributaries, Texas, covering Aquilla Reservoir on Aquilla Creek".

Engineers of our Divisions of Sanitary Engineering and Water Pollution Control have reviewed the report and the following comments are offered for consideration:

1. Points of diversion should be located below the 520' contour.

2. Waste water discharged into the watershed should receive complete treatment followed by disinfection of the final effluent prior to its being discharged.

3. Vegetation should be cleared and removed from the lake site below the upper contour of the conservation pool.

4. We concur in the recommendations of the U. S. Public Health Service in the measures for control of insect vectors.

Your furnishing us a copy of the "Interim Report" is appreciated.

Sincerely yours,

G. R. Herzik, Jr., P. E., Chief
Environmental Sanitation Services

CKF:ih

cc: U. S. Public Health Service, Region VII

BRAZOS RIVER AND TRIBUTARIES, TEXAS
(AQUILLA CREEK WATERSHED)

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 within the influence of the multiple-purpose project on the Aquilla Creek watershed involve occurrence of floods and insufficient water supply. The major floods originating on Aquilla Creek watershed cause appreciable damages along Aquilla Creek and, in addition, augment the flood conditions and damages along the main stem of the Brazos River. Periods of prolonged drought, upward trends in population, and expansion of industrial and municipal development have made evident the increasing need for the conservation of surface runoff for all beneficial purposes in the Brazos River Basin.

3. FLOOD PROBLEMS.- Frequent floods and damages occur on Aquilla Creek as the result of heavy storm rainfall, high runoff, and inadequate channel capacities. The Aquilla Creek flood plain is principally an agricultural area, and contains agricultural properties, transportation facilities, and utilities. Also, Aquilla Creek floods contribute to damage experienced within the flood plains of the Brazos River from the mouth of Aquilla Creek to the mouth of the Brazos River. The Aquilla Creek floods contribute appreciably to damages experienced at Waco, Texas, located about 3 miles downstream of the mouth of the Bosque River and about 17 miles downstream of the mouth of Aquilla Creek. The channel capacity of the Brazos River is about 65,000 cfs at Waco, and about 27,000 cfs between the mouths of Aquilla Creek and the Bosque River. Because of the smaller channel capacity above the mouth of the Bosque River, flood releases from Whitney Reservoir are limited to 27,000 cfs, during the passage of minor floods but may be as high as 60,000 cfs (minimum channel capacity at Richmond) during the passage of major floods.

4. WATER-SUPPLY PROBLEMS.- At various conferences and at the public hearing held at Waco, Texas, March 13, 1963, local interest stated the need for additional water supply for municipal, industrial, and other related purposes for the middle portion of the Brazos River Basin, including Waco, Hillsboro, and West. The cities of Hillsboro and West, located on the Aquilla Creek watershed requested immediate construction of Aquilla Reservoir as a source of dependable municipal

and industrial water supply to meet present and future needs. The present and future organic and mineral qualities of the Aquilla Creek watershed waters are expected to remain satisfactory for all uses; therefore, storage for water quality control is not required in this reservoir. The supply and demand data in the Public Health Service report show a need for the Aquilla Reservoir by year 1975. The development of the Aquilla Creek water supply resources will adequately assist in meeting future needs of the Aquilla Creek watershed to about year 2075.

5. RECOMMENDED PLAN OF IMPROVEMENT.- The District Engineer recommends that the Aquilla Reservoir be authorized for construction to meet the public demands in the study area; that the authorized project for the Brazos River and Tributaries, Texas, be modified to provide for authorization of Aquilla Reservoir for the purposes of flood control, water supply and recreation and fish and wildlife enhancement, and that the reservoir be constructed to contain a total controlled storage of about 199,300 acre-feet for these purposes. Pertinent data for the proposed plan is shown in table 1.

6. PROJECT COST AND ECONOMIC ANALYSES.- The recommended Aquilla Reservoir would be constructed by the Federal Government at a total estimated construction cost of $23,612,000, based on January 1965 price level. The estimated annual charges are $943,000 of which $120,000 is for operation and maintenance and $823,000 is for interest and amortization. The annual charges for the reservoir are based on an interest rate of 3.125 percent, a 100-year life and evaluation period (1975-2075), and a 5-year construction period. The estimate includes allowance for contingencies and cost for engineering and overhead. The allotted cost for operation and maintenance, including replacement of parts, is based upon past experience for similar projects in this area. Only tangible benefits were used for the project evaluations.

7. BENEFITS AND BENEFIT-COST RATIO.- The first cost, annual charges, annual benefits, and benefit-cost ratio for 50-year and 100-year economic life are summarized in table 2. The summary indicates that the benefit-cost ratio for the proposed Aquilla Reservoir would decrease from 1.6 for the 100-year analysis to 1.0 for the 50-year analysis.

8. PHYSICAL FEASIBILITY AND PROVISION FOR FUTURE NEEDS.- The report studies determined that the Aquilla Reservoir would be a practical undertaking by the Federal Government. Engineering and economic studies indicate that the project is feasible. The proposed Aquilla Reservoir is designed to meet the existing and immediately foreseeable needs of the project area. The project is designed to function as a unit in long-range plans for the Aquilla

TABLE 1

PERTINENT DATA
PROPOSED AQUILLA RESERVOIR
AQUILLA CREEK WATERSHED

Item	Proposed Reservoir
DAM	
Location, river mile	20.7
Drainage area, square mile	294
Type	Concrete and compacted earthfill
Length, feet	12,500
Height, feet	97
Freeboard, feet	4.8
Crown width, feet	34
SPILLWAY	
Type	Broadcrested weir
Control	Uncontrolled
Gross length, feet	1,200
Net length, feet	1,200
OUTLET WORKS	
Type	Gate-controlled conduit
Number of conduits	1
Dimensions	10-diameter
Invert elevation, feet, msl	485.0
Conduit control	2 - 5' x 10' sluice gates

RESERVOIR	Elev. (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inches)
Top of dam	570.0	-	-	-
Maximum design water surface	565.2	14,950	369,000	23.24
Top of flood control pool and spillway crest	551.0	9,180	199,300	12.71
Top of conservation pool	533.5	4,560	82,200	5.24
Sediment storage	-	-	28,100	1.73

TABLE 2

ANNUAL CHARGES, ANNUAL BENEFITS, AND BENEFIT-COST RATIO
50-YEAR AND 100-YEAR ECONOMIC LIFE
AQUILLA CREEK WATERSHED

Item	: Proposed Reservoir
BASED ON ECONOMIC LIFE OF 50 YEARS	
ECONOMIC EVALUATION PERIOD	1975-2025
FIRST COSTS	$23,444,000
	23,225,000*
AVERAGE ANNUAL COSTS	
Investment cost	996,300
Operation, maintenance, and replacement of parts	113,000
Total	1,109,300
AVERAGE ANNUAL BENEFITS	
Flood prevention	546,800
Water supply	158,000
Recreation	403,900
Total	1,108,700
RATIO OF BENEFITS TO COST	1.00
BASED ON ECONOMIC LIFE OF 100 YEARS	
ECONOMIC EVALUATION PERIOD	1975-2075
FIRST COSTS	$23,612,000
	23,300,000*
AVERAGE ANNUAL COSTS	
Investment cost	823,000
Operation, maintenance, and replacement of parts	120,000
Total	943,000*
AVERAGE ANNUAL BENEFITS	
Flood prevention	725,200
Water supply	158,000
Recreation	622,900
Total	1,056,100
RATIO OF BENEFITS TO COST	1.6

*With future recreation facilities discounted to present worth at year 1975 for Aquilla Reservoir.

Creek watershed and the Brazos River Basin. The construction of the reservoir will not preclude the further development of water resource improvements by others for the watershed.

9. The proposed Aquilla Reservoir, providing 111,500 acre-feet of flood control storage, would afford a high degree of protection to physical properties on the watershed, and would add to the protection possible for the physical property in the lower Brazos River Basin. The construction of the Aquilla Reservoir would eliminate about 66 percent of the aggregate average annual damages within the investigated 20.7-mile flood plain reach on Aquilla Creek; and about 7 percent of the residual average annual damages within the flood plain of the Brazos River downstream of Aquilla Creek, when considered as the next-constructed reservoir to the authorized Brazos River system. Flood releases from Aquilla Creek will be adequately served by the existing channel capacity of Aquilla Creek, allowing the emptying of flood storage within a period of about 19 days.

10. The proposed Aquilla Reservoir will meet the overall water supply needs of the Aquilla Creek watershed during the period 1975 through 2075. Based on projections of population and other developments, the municipal and industrial water supply needs on the Aquilla Creek watershed will increase from about 2.7 mgd in year 1975 to 9.1 mgd in year 2075. Construction of the Aquilla Reservoir will solve the critical water supply shortages faced by the cities of Hillsboro and West. Studies of the anticipated needs of these two cities, and the inadequate quality and quantity of ground-water sources, indicate that the Aquilla Reservoir would be required by year 1975.

11. The Aquilla Creek watershed is located in a fast-growing area of urban as well as rural developments. The proposed reservoir would have a beneficial effect in providing facilities for outdoor recreation and fish and wildlife enhancement. The studies of these project features indicate ample justification for water resource improvements to help meet these needs. The Aquilla Reservoir project would have a surface area of about 4,600 acres at top of water conservation pool level. This surface area would have an upstream reach of about 12 miles and a shoreline distance of about 54 miles. The reservoir, with adequate facilities would afford excellent opportunities for sight-seeing, camping, picnicking, boating, skiing, hunting, and fishing and is expected to attract an average annual visitation of 1,000,000 persons during the period 1975 to 2075.

12. EXTENT OF INTEREST IN THE PROJECT.- The subject interim report was requested by the cities of Hillsboro and West to expedite authorization and construction of Aquilla Reservoir for flood control, water supply, and related purposes. The cities of Hillsboro and West indicated an urgent need for this project as an additional source of

water supply to meet existing and future needs of the general Aquilla Creek area. The Brazos River Authority is the agency designated by the Texas Water Commission (now Texas Water Rights Commission) to negotiate with the Corps of Engineers in matters pertaining to water supply storage in the Corps projects in the Brazos River Basin. The Brazos River Authority notified the Corps of Engineers by letter dated April 9, 1965, its approval of the proposed plan and expressed its willingness to assume the requirements of local cooperation for the water-supply storage portion of the project. The flood control function of the Aquilla Reservoir would not conflict with current planning of flood detention structures by the Soil Conservation Service.

13. ALLOCATION OF COSTS.- The results of the allocation of cost of the recommended reservoir project by the separable costs-remaining benefits method and by the alternative method listed in Senate Resolution 148 are presented in table 3. The total costs allocated to water supply are the responsibility of local interests. The full local cooperation requirements for the recommended project provide that prior to construction local interest give assurances satisfactory to the Secretary of the Army that they will obtain all the necessary water rights; and bear the project first cost and annual operation and maintenance cost allocated to water supply; and to bear one-half the separable first cost and the total separable annual operation and maintenance cost allocated to recreation and fish and wildlife enhancement.

14. REPAYMENT ARRANGEMENTS.- Repayment arrangement for non-Federal interests are as follows:

a. Water supply.- The costs allocated to water supply are apportioned to non-Federal interest in accordance with the provisions of the Water Supply Act of 1958, Public Law 580, 85th Congress, as amended. Payment is not required with respect to storage for future water supply until such supply is first used except that payments must begin so as to permit paying out the cost allocated to water supply within the life of the project, but in no event to exceed 50 years after first use. Not more than 30 percent of the total estimated construction cost of each project can be allocated to anticipated future demands. No interest will be charged on the investment cost (construction cost plus interest during construction) allocated to future water supply until use is initiated, but the interest-free period shall not exceed 10 years.

b. Recreation and fish and wildlife.- In accordance with Public Law 89-72 (S. 1229, H.R. 5269), approved July 9, 1965, the non-Federal share of the separable costs of the project allocated to recreation and fish and wildlife enhancement shall be borne by non-Federal interests, under either or both of the following method as

TABLE 3

ALLOCATION OF COSTS
AQUILLA RESERVOIR
100-YEAR EVALUATION PERIOD 1975-2075
SELECTED PLAN
AQUILLA CREEK WATERSHED

Item	Separable Cost-Remaining Benefits	Priority of Use	Incremental Cost
Allocations to flood control			
First cost	$14,625,000 (62.77%)	$13,703,000 (58.81%)	$19,826,000 (85.09%)
Annual cost of operation, maintenance, and replacement	38,000 (31.67%)	71,000 (58.81%)	65,000 (54.17%)
Allocations to water conservation			
First cost	3,386,000 (14.53%)	3,201,000 (13.74%)	2,320,000 (9.96%)
Annual cost of operation, maintenance, and replacement	10,000 (8.33%)	16,000 (13.74%)	5,000 (4.17%)
Allocations to recreation and fish and wildlife enhancement			
First cost*	5,289,000 (22.70%)	6,396,000 (27.45%)	1,154,000 (4.95%)
Annual cost of operation, maintenance, and replacement	72,000 (60.00%)	33,000 (27.45%)	50,000 (41.66%)
Total project			
First cost*	23,300,000	23,300,000	23,300,000
Average annual operation, maintenance, and replacement	120,000	120,000	120,000

*With future recreation facilities discounted to present worth at year 1975.

may be determined appropriate by the head of the Federal agency having jurisdiction over the project: (1) payment, or provision of lands, interests therein, or facilities for the project; or (2) repayment, with interest at a rate comparable to that for other interest-bearing functions of Federal water resource projects, within fifty years or first use of project recreation or fish and wildlife enhancement facilities; provided, that the source of repayment may be limited to entrance and user fees or charges collected at the project by non-Federal interests if the fee schedule and the portion of fees dedicated to repayment are established on a basis calculated to achieve repayment as aforesaid and are made subject to review and renegotiation at intervals of not more than five years.

15. ALTERNATIVE PROJECT CONSIDERATIONS.- Aquilla Reservoir was the only project considered for the Aquilla Creek watershed. However, preliminary feasibility studies for Aquilla Reservoir were based on two dam site locations, one at river mile 23.3 and the other at river mile 20.7. The dam site at river mile 23.3 was investigated in prior studies by the Corps of Engineers, as reported in House Document 535, 81st Congress and was adopted for use in the Brazos River Basin framework plan proposed in the report of the U. S. Study Commission-Texas. Based on preliminary cost and project formulation studies, the site at river mile 20.7 was found to be more economically favorable for flood control and water supply purposes and would control runoff from a larger drainage area including the Cobb Creek tributary which adds greatly to the potential yield of the project. After the site was selected at river mile 20.7, plans involving various amounts of flood control and water supply storage were developed for comparison purposes. Storages and economic evaluations for plans 1 through 8 are summarized in table 4. Plans 1 through 5 and 7 contain 50-year flood storage; and plans 6 and 8 contain 25-year and 100-year flood storage, respectively. Local interests selected plan 3 as the water supply size to meet existing and future municipal and industrial needs. Plans 1 through 5 are based on gated ogee spillway design. Plans 6 through 8 are based on uncontrolled broadcrested spillway design. Plans 5 and 7 are identical in regard to the amount of controlled storage for each purpose. Plan 7 is the recommended plan on the basis of excess flood-control benefits over cost and the amount of dependable water supply yield by local interests.

TABLE 4

SUMMARY OF ECONOMIC AND COST ANALYSES
PLAN-COMPARISON STUDIES
ECONOMIC EVALUATION PERIOD 1975-2075
AQUILLA CREEK WATERSHED

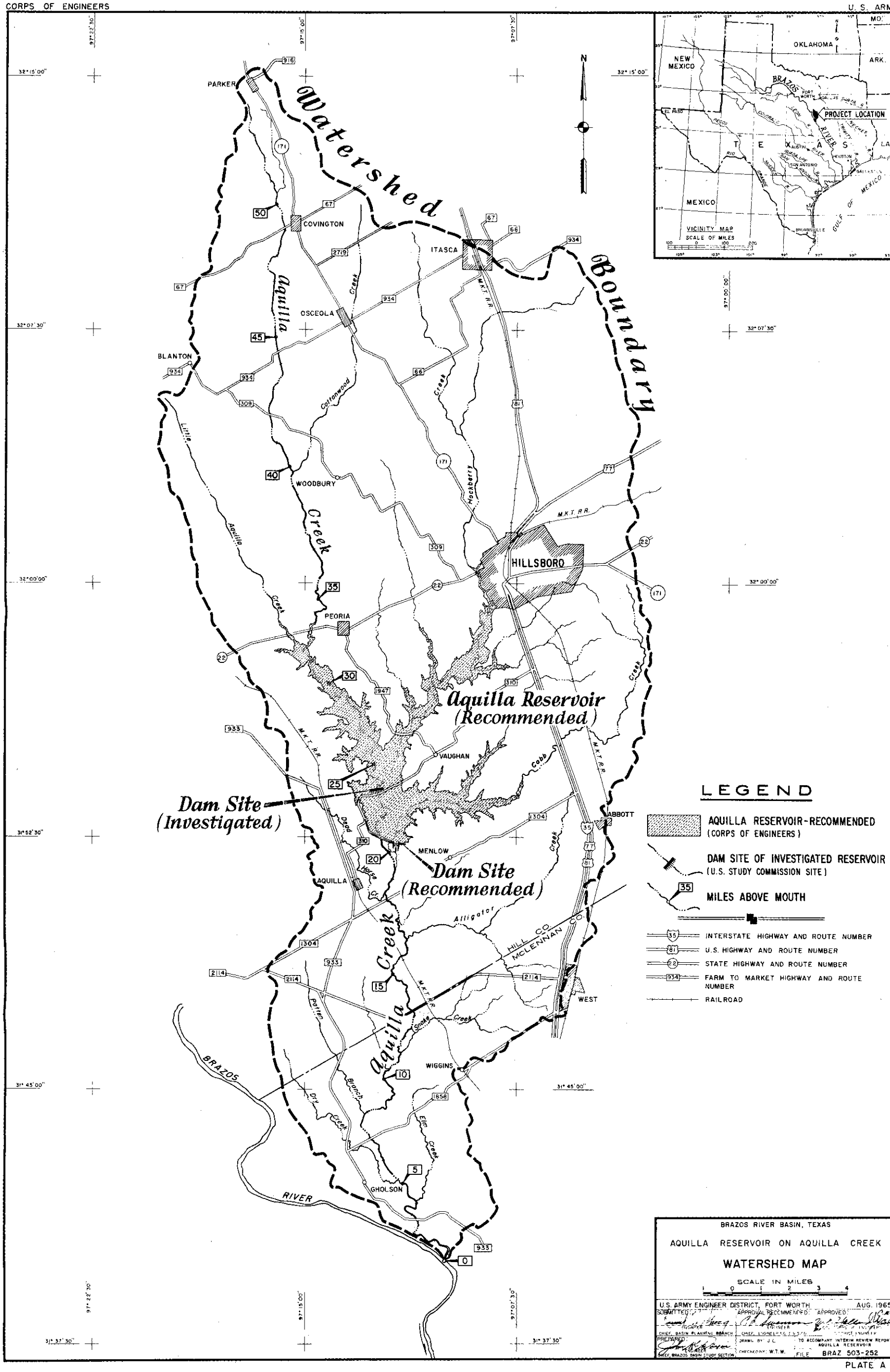
Plan	Storage: FC (acre-feet)	Storage: WC (acre-feet)	Dependable Yield: cfs	Dependable Yield: mgd	First Cost(1)	Annual Charges(2)	Annual Benefits(2)	Benefit-Cost Ratio	Excess Benefits over Cost
1	111,600	-	-	-	17,170,000	656,600	725,200	1.1	68,600
2	104,900	40,200	10	6.5	22,054,000	887,600	1,487,600	1.7	600,000
3	111,500	59,700	15	9.7	23,714,000	957,600	1,506,100	1.6	548,500
4	103,700	86,600	22	14.2	24,964,000	1,001,800	1,532,000	1.5	530,200
5	117,200	317,800	38	24.6	37,324,000	1,467,300	1,591,200	1.1	123,900
6	78,800	58,300	15	9.7	22,494,000	893,000	1,304,400	1.5	411,400
7	111,500	59,700	15	9.7	23,300,000	943,000	1,506,100	1.6	563,100
8	132,300	58,000	15	9.7	23,964,000	971,400	1,525,200	1.6	553,800

(1) With future expenditures discounted to 1975 worth.

(2) Based on average annual equivalent values for the period 1975-2075.

CORPS OF ENGINEERS

U. S. ARMY



BRAZOS RIVER BASIN, TEXAS

AQUILLA RESERVOIR ON AQUILLA CREEK

WATERSHED MAP

SCALE IN MILES 1 0 1 2 3 4

U.S. ARMY ENGINEER DISTRICT, FORT WORTH AUG. 1965

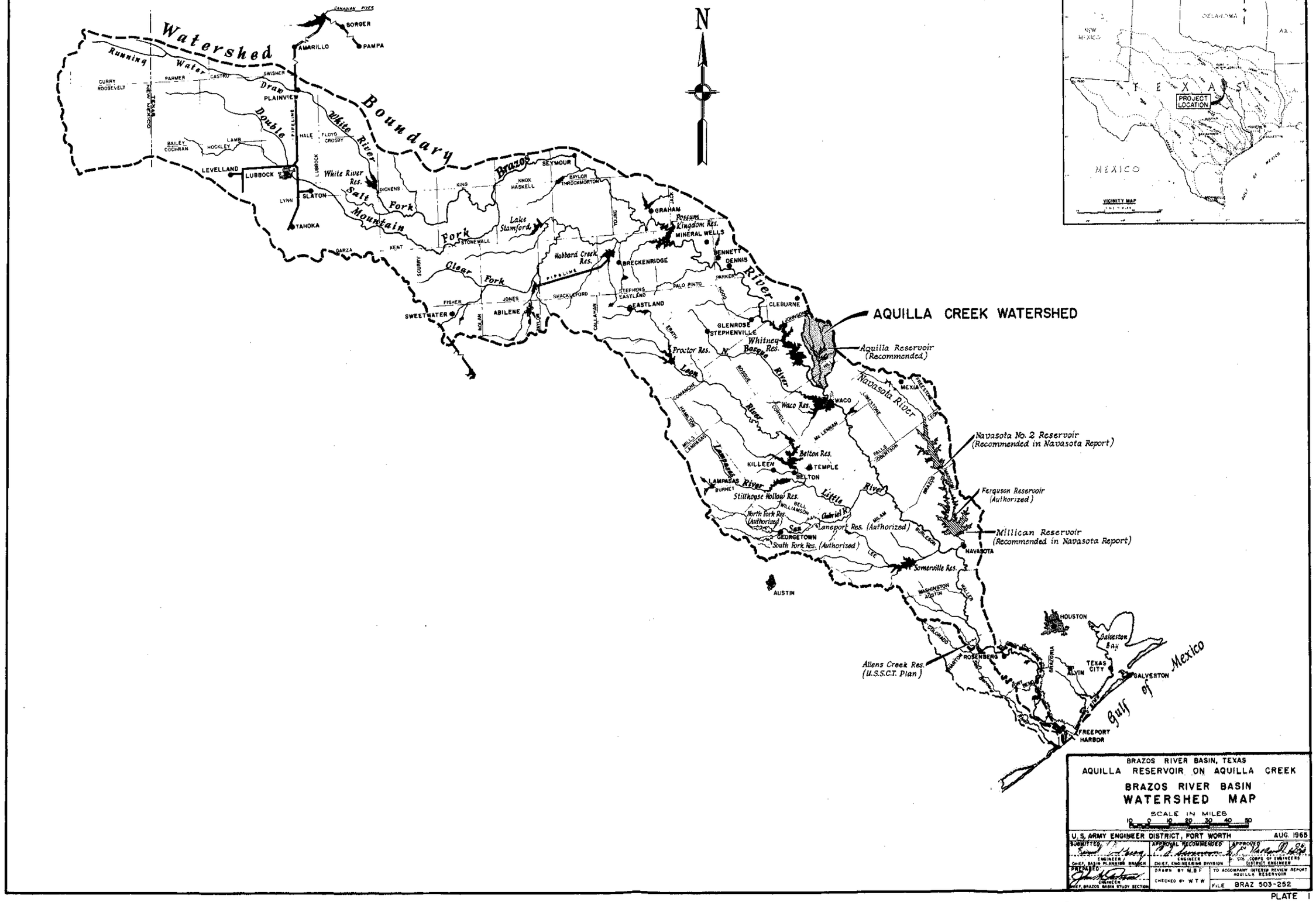
SUBMITTED: APPROVAL RECOMMENDED: APPROVED:

CHIEF, BASIN PLANNING BRANCH CHIEF, ENGINEERING DIVISION DISTRICT ENGINEER

PREPARED: DRAWN BY: J.C. TO ACCOMPANY INTERIM REVIEW REPORT AQUILLA RESERVOIR

CHIEF, BRAZOS BASIN STUDY SECTION CHECKED BY: W.T.W. FILE BRAZ 503-252

PLATE A



BRAZOS RIVER BASIN, TEXAS
AQUILLA RESERVOIR ON AQUILLA CREEK
BRAZOS RIVER BASIN
WATERSHED MAP
SCALE IN MILES 10 0 10 20 30 40 50

U.S. ARMY ENGINEER DISTRICT, FORT WORTH AUG. 1965

SUBMITTED — CHIEF, BASIN PLANNING BRANCH
APPROVAL RECOMMENDED — ENGINEER, CHIEF, ENGINEERING DIVISION
APPROVED — DIV. CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED — ENGINEER, CHIEF, BRAZOS BASIN STUDY SECTION
DRAWN BY M.B.F. CHECKED BY W.T.W.
TO ACCOMPANY INTERIM REVIEW REPORT AQUILLA RESERVOIR
FILE BRAZ 503-252

PLATE I

85-251 O-67 (Face blank p. 198) No. 2