San Gabriel river watershed, Brazos river, Texas

SAN GABRIEL RIVER WATERSHED, BRAZOS RIVER, TEXAS

LETTER

FROM

THE SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY, DATED SEPTEMBER 18, 1962, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A REVIEW OF THE REPORTS ON THE SAN GABRIEL RIVER WATERSHED, BRAZOS RIVER, TEXAS, REQUESTED BY A RESOLUTION OF THE COMMITTEE ON PUBLIC WORKS, HOUSE OF REPRESENTATIVES, ADOPTED JULY 29, 1955

SEPTEMBER 28, 1962.—Referred to the Committee on Public Works and ordered to be printed with four illustrations

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1962

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(Only Plates 1, 1A, 12, and 14 printed)

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LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY
WASHINGTON 25, D.C.

IN REPLY REFER TO:

September 27, 1962

Honorable John W. McCormack

Speaker of the House of Representatives

Dear Mr. Speaker:

I am transmitting herewith a favorable report dated 18 September 1962, from the Chief of Engineers, Department of the Army, together with accompanying papers and illustrations, on a review of the reports on the San Gabriel River Watershed, Brazos River, Texas, requested by a resolution of the Committee on Public Works, House of Representatives, adopted 29 July 1955.

In accordance with Section 1 of Public Law 534, 78th Congress, Public Law 85-624, and Public Law 87-88, the views of the Governor of Texas, the Department of the Interior, and the Public Health Service are set forth in the inclosed communications, together with the reply of the Chief of Engineers to the Governor of Texas. The views of the Department of Commerce and the Federal Power Commission are inclosed also.

The Chief of Engineers concludes that the authorized Laneport Reservoir on San Gabriel River can be modified under existing authority and applicable laws and policies to serve the purposes of additional water supply, fish and wildlife, and recreation, without further Congressional action on authorization. I concur in the conclusions of the Chief of Engineers.

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

Sincerely yours,

Cyrus Vance

Cyrus R. Vance
Secretary of the Army

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

COMMENTS OF THE BUREAU OF THE BUDGET

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

September 27, 1962

Honorable Cyrus R. Vance
Secretary of the Army
Washington 25, D. C.

Dear Mr. Secretary:

Assistant Secretary Schaub's letter of September 26, 1962, submitted the report of the Chief of Engineers on San Gabriel River Watershed, Brazos River, Texas, in response to a resolution of the Committee on Public Works of the House of Representatives, adopted July 29, 1955.

The Chief of Engineers recommends modification of the authorized project for the Brazos River to provide for construction of two multiple-purpose reservoirs on the North and South Forks of the San Gabriel River. He further recommends modification of the authorized Laneport Reservoir to provide additional storage for water supply, and to include fish and wildlife and general recreation as project purposes, but does not believe that modification of the project authorization is needed. The total Federal construction cost of the three reservoirs is estimated to be $45,450,000, of which $20,262,000 allocated to water supply would be reimbursable under the Water Supply Act of 1958, as amended. The increased authorization required would be $20,250,000. The stated benefit-cost ratios for Laneport, North Fork, and South Fork Reservoirs are 2.6, 2.7, and 2.4, respectively.

I am authorized by the Director of the Bureau of the Budget to advise you that there would be 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 modification, 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.
Chief, Resources and
Civil Works Division

EXECUTIVE DEPARTMENT
AUSTIN 11, TEXAS

PRICE DANIEL
GOVERNOR

July 11, 1962

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

Dear General Barney:

This has further reference to your letter forwarding a copy of your proposed report on the San Gabriel River Watershed, Brazos River, Texas.

At my request, the Texas Water Commission reviewed this report, approved feasibility of the project, and made certain recommendations with reference to it. Attached is a copy of the Commission's Order. I concur in the findings and conclusions of the Commission.

Sincerely yours,

Price Daniel

PD:io

Enclosure

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

TEXAS WATER COMMISSION

AN ORDER approving the feasibility of the North San Gabriel, South San Gabriel, and Laneport Reservoirs Project, Texas, as proposed in the report of the Chief of Engineers, U. S. Army, on the San Gabriel River Watershed, Texas

BE IT ORDERED BY THE TEXAS WATER COMMISSION:

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

Section 2. Statement of Jurisdiction. (a) By letter dated March 20, 1962, the Honorable Price Daniel requested the Texas Water Commission to review the report of the Corps of Engineers, U. S. Army, entitled "San Gabriel River Watershed, Texas", and to enter its order finding the project recommended therein to be feasible or not feasible. (b) In accordance with Article 7472e, and after due notice by publication, the Commission caused a public hearing to be held on April 30, 1962, at 2:30 o'clock P.M., in the offices of the Texas Water Commission, 201 East 14th Street, Austin, Texas, on said report, at which time all those interested or who may be affected should the project recommended in said report be initiated and completed were requested to come forward and give testimony.

Section 3. After fully considering all the evidence presented by persons and groups who may be affected should the project be initiated and completed, including the matters set forth in Section 4 of Article 7472e, the assurance of financial participation in the project by local interests, and the recommendations by the

Chief Engineer of the Texas Water Commission, the Texas Water Commission finds that the project is feasible and the public interest will be served thereby.

Section 4. The Commission recommends:

(1) That the reservoirs comprising said project, consisting of the Laneport, North Fork of the San Gabriel River and South Fork of the San Gabriel River Reservoirs, be considered as an inseparable unit and that Congress so authorize and make available the necessary funds for planning, designing and constructing the reservoirs as a single project.

(2) If construction of said three reservoirs cannot be prosecuted simultaneously, that the North Fork of the San Gabriel River Reservoir be authorized and constructed first, the South Fork of the San Gabriel River Reservoir, second, and the Laneport Reservoir last.

(3) That in the final project design of the Laneport Dam consideration be given to effecting possible economies in design and that a portion of the conservation storage planned for the Laneport project be for the additional purpose of water quality maintenance in the Brazos River. A water quality problem exists on the Brazos River as shown by the Report of the Public Health Service contained as an appendix to said Report of the Corps of Engineers; since the preparation of the Public Health Service Report, Congress has enacted the Federal Water Pollution Control Act of 1961, which authorizes the recognition of water quality maintenance as a desired federal project purpose. The benefits would be widespread or national in scope and the costs of such features for water quality management should be nonreimbursable Federal costs.

(4) That ownership by the State of Texas of the waters involved be fully recognized by all interested parties and that lawful rights to the use of such waters, vested pursuant to State law, be respected, protected and preserved.

Section 5. It is further ordered that a certified copy of this order be transmitted to the Governor.

Section 6. This order shall take effect on the 25th day of June, 1962, the date of its passage, and it is so ordered.

SIGNED IN THE PRESENCE OF THE
TEXAS WATER COMMISSION

Joe D. Carter, Chairman

ATTEST:

Ben F. Looney, Jr., Secretary

I certify that the foregoing order was adopted by the Texas Water Commission at a meeting held on the 25th day of June, 1962, upon motion of Commissioner Dent, seconded by Commissioner Beckwith, Commissioner Dent voting "aye", Commissioner Beckwith voting "aye", and Chairman Carter voting "aye".

Ben F. Looney, Jr., Secretary

STATE OF TEXAS

COUNTY OF TRAVIS

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

Given under my hand and the seal of the Texas Water Commission, this the 25th day of June, A.D., 1962.

Ben F. Looney, Jr., Secretary

LETTER TO THE GOVERNOR OF TEXAS

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

IN REPLY REFER TO
ENGCW-PD

30 August 1962

Honorable Price Daniel
Governor of Texas
Austin, Texas

Dear Governor Daniel:

Reference is made to your letter dated 11 July 1962, inclosing an Order of the Texas Water Commission dated 25 June 1962, commenting on my proposed report on San Gabriel River Watershed, Texas.

The Texas Water Commission finds that the proposed project is feasible and in the public interest, and they recommend that the reservoirs comprising the proposed project, consisting of Laneport, North Fork, and South Fork, be considered as an inseparable unit for authorization, design, and construction. Further, that if simultaneous construction cannot be prosecuted, the North Fork reservoir be authorized and constructed first, the South Fork second, and Laneport last. The Commission also recommends that in the final design of Laneport Reservoir, consideration be given to possible storage for the purpose of water quality maintenance in the Brazos River.

Studies made in connection with our report clearly indicate the economic advantages of stage development compared to simultaneous development. Our analyses were based upon an economic and assumed useful life of 50 years during the period 1970-2020. Accordingly, on the basis of current studies and findings, we cannot at this time specifically recommend simultaneous construction of the three reservoirs.

As pertains to stage development, our studies indicate that the three-reservoir plan is economically justified on the basis of stage development regardless of the sequence of construction of the individual reservoirs. The plan and sequence proposed in our report, however, is considered the best plan in the interests of all purposes to be served, particularly in view of the immediate importance of Laneport in controlling floods on the San Gabriel and Brazos Rivers. Thus, we cannot at this time concur in your recommended sequence of stage construction.

It is recognized that economic and physical conditions in the future might indicate the desirability of stage construction in a different sequence than is now proposed in the reports of the District and Division Engineers. In consideration of this factor and the expressed desires of the State of Texas, the proposed report of the Chief of Engineers has been

revised to delete from the recommendations a specific sequence of stage construction. Thus, the overall plan of improvement could properly be developed on the basis of stage construction, the most desirable and best sequence of which would be finally determined in the pre-construction planning phase of the project. During pre-construction planning, consideration also would be given to the need and justification for reservoir storage for the purpose of water quality maintenance in the Brazos River.

Also, the report of the Chief of Engineers has been revised to delete the recommendation to Congress that the proposed modification of Laneport Reservoir be authorized. Following a careful examination of the existing authority and other pertinent and applicable laws and policies it is concluded that Laneport Reservoir can be modified as now proposed without further Congressional action on authorization. Accordingly, only the reservoirs proposed to be added to the project are recommended for authorization.

Your comments on the inclosed proposed report of the Chief of Engineers will be appreciated.

Sincerely yours,

(Signed)

1 Incl
Rev CofEngrs Rept

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

COMMENTS OF THE GOVERNOR OF TEXAS

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LT GEN W K WILSON JR, CHIEF OF ENGINEERS

US ARMY CORPS OF ENGINEERS WASHDC

RE PROPOSED REPORT ON SAN GABRIEL RIVER WATERSHED. STATE OF TEXAS HAS NO OBJECTION TO SUBMISSION OF NORTH FORK AND SOUTH FORK RESERVOIRS TO CONGRESS FOR AUTHORIZATION WITH SIMULTANEOUS CONSTRUCTION OR SEQUENCE OF CONSTRUCTION TO BE FINALLY DETERMINED IN PRE-CONSTRUCTION PLANNING PHASE OF PROJECT, AS PROPOSED IN YOUR LETTER OF AUGUST 30, 1962. BEST REGARDS

PRICE DANIEL GOVERNOR OF TEXAS.

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

June 8, 1962

Dear General Wilson:

This is in reply to General Barney's letter of March 20, transmitting for our comments reports on the San Gabriel River Watershed, Brazos River, Texas. The reports recommend construction of reservoirs for water supply, flood control, and allied purposes, at an estimated net Federal cost of $25,188,000.

The Fish and Wildlife Service reports that the project will result in losses to wildlife and stream fishery habitat but will create high-quality reservoir fishing. In addition, the reservoirs will provide important habitat for migrating waterfowl. We are pleased to note that essential facilities for hunting and fishing as recommended in the Bureau of Sport Fisheries and Wildlife report have been included in the project plans.

The project will not affect any area administered by the National Park Service or any State park. The District Engineer should keep the National Park Service, through its Regional Director, Region Three, Santa Fe, New Mexico, advised as to progress on the project, so that any necessary surveys, salvage and preservation of historical or archeological evidence can be programmed and accomplished as provided in PL 86-523, June 27, 1960.

The District Engineer's report was prepared prior to the Joint Policies of February 21, relating to acquisition of project lands.

Significant cost and benefit allocations are made to recreation; however, lands and facilities for that specific purpose are not identifiable.

In March 1960, the National Park Service Region Three office recommended the acquisition of additional lands for access and development sites. At that time it was also recommended that "after the project is authorized, it will be necessary to select recreation sites and to determine the extent of development and amount of land required." The Joint Policies of February 21 make that recommendation even more important in order to provide the lands and facilities to accommodate the immediate and foreseeable future needs for public recreation purposes at the reservoirs involved in the project. We reiterate with emphasis that recommendation.

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We appreciate the opportunity to present our views.

Sincerely yours,

Assistant Secretary of the Interior

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

COMMENTS OF THE PUBLIC HEALTH SERVICE

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

PUBLIC HEALTH SERVICE — WASHINGTON 25, D. C.

BUREAU OF STATE SERVICES

June 4, 1962

Refer to:

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

Dear General Wilson:

This is in reply to General Barney's letter of March 20, 1962, requesting comments on the U. S. Army Engineers' Report on Brazos River and Tributaries, covering San Gabriel River Watershed.

The Public Health Service report included in Appendix IV contains an evaluation of anticipated municipal and industrial water supply needs to the year 2010. It also reports the need for storage for water quality control, in accordance with results of studies by the U. S. Study Commission--Texas. In order to maintain downstream water quality, any releases from the reservoirs should be made at such elevations as to provide sufficient dissolved oxygen.

With regard to vector control, it is recommended that:

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

2. That plans for clearing of the reservoir basins 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 reservoirs:

   a. As a general principle, waterside recreational areas, particularly those which have facilities for overnight occupancy, should be located along sections of the reservoirs which have a low potential for production of mosquitoes and other aquatic insects which may create public health problems.

   b. Proper storage collection, and disposal of refuse should be practiced in order to prevent and control flies, wasps, other noxious insects, rats, wild rodents, and other small mammals.

c. All buildings should be rodentproofed at recreational areas where rodents are prevalent which may create public health hazards.

d. Debris, rubbish, and other materials which may serve as harborage for rodents and other small mammals should be removed periodically.

e. Brush and weeds along paths, trails, roadways, and other areas of frequent use by visitors should be removed in order to reduce the likelihood of tick infestation.

f. In situations where adequate vector control is not obtained through the prevention and source reduction measures outlined above, provision should be made for supplemental use of insecticides and rodenticides to achieve the desired level of control.

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

Sincerely yours,

Keith S. Krause

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

COMMENTS OF THE DEPARTMENT OF COMMERCE

THE UNDER SECRETARY OF COMMERCE
FOR TRANSPORTATION
WASHINGTON 25

April 12, 1962

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

Dear General Wilson:

As requested in General Barney's letter of March 20, 1962, I am transmitting herein the comments of the interested Department of Commerce agencies on your proposed report on "San Gabriel River Watershed, Brazos River, Texas."

The Coast and Geodetic Survey advises that the vertical geodetic control presently existing along the Southern Pacific and the Missouri-Kansas-Texas Railroads is considered adequate for project purposes. Horizontal geodetic control is widely spaced in the general area. If additional control is required or if any of the existing control monuments will be endangered by construction operations, the Coast and Geodetic Survey requests that they be advised as soon as possible.

The Bureau of Public Roads feels that the information contained in the report regarding highway relocations is insufficient to properly evaluate the adequacy of the relocations. It is suggested, therefore, that the final decision in regard to the abandonment or relocation of particular highways be deferred until the project planning phase and that the planning of the restoration of the highway facilities be fully correlated with the local highway authorities at that time.

Your courtesy in providing us the opportunity to review this report is appreciated.

Sincerely yours,

Frank L. Barton

Frank L. Barton
Deputy Under Secretary
for Transportation

COMMENTS OF THE FEDERAL POWER COMMISSION

FEDERAL POWER COMMISSION
WASHINGTON 25

4 June 1962

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

Reference: ENGCW-PD

Dear General Wilson:

This is in response to General Barney's letter of March 20, 1962, inviting comments by the Commission relative to your proposed report and to the reports of the Board of Engineers for Rivers and Harbors and of the District and Division Engineers on the San Gabriel River Watershed, Brazos River, Texas.

The cited reports recommend that the authorized plan of improvement for the Brazos River basin be modified to provide for the modification and construction of the authorized Laneport reservoir as the first-stage unit for the San Gabriel watershed, and the subsequent construction of the upstream North Fork and South Fork reservoirs, as second and third-stage units, respectively. The recommended reservoir projects would be constructed for flood control, water supply, and recreation purposes. The federal construction cost of the ultimate development of the San Gabriel watershed is estimated to be $45,450,000, of which $20,262,000 would be repaid by local interests for water supply purposes.

The Commission staff has cooperated with your Department in studies of the Brazos River basin and the Commission has previously given consideration to the power potentialities of projects proposed therein. In its letter of July 25, 1949 to your Department commenting on the proposed development plans for the basin, the Commission concluded that the development of hydroelectric power at the Laneport project as then proposed would not be economically justified.

The Commission staff has reviewed the current reports of your Department and has studied the possibility of developing hydroelectric power at the three proposed projects. The studies show that the Laneport project could provide about 4,500 kilowatts of capacity but that the ratio of power benefits to incremental power costs would be considerably less than unity. The limited dependable water yield from the North Fork and South Fork projects would preclude the economic development of hydroelectric power at these two projects.

Based on its consideration of the reports of your Department and the studies by its own staff, the Commission concludes that the development of hydroelectric power is not feasible in connection with the recommended Laneport, North Fork, and South Fork reservoir projects.

Sincerely yours,

Joseph C. Swidler
Chairman

SAN GABRIEL RIVER WATERSHED, BRAZOS RIVER, TEXAS

REPORT OF THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY

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

IN REPLY REFER TO
ENGCW-PD

18 September 1962

SUBJECT: San Gabriel River Watershed, 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 the San Gabriel River watershed, Texas, in response to a resolution of the Committee on Public Works of the House of Representatives, United States, adopted 29 July 1955, requesting the Board to review the reports on Brazos River and Tributaries, Texas, printed in House Document Numbered 535, Eighty-first Congress, second session, with a view to giving further study to the location of the Laneport Reservoir on San Gabriel River and to determining if a change in the site of this reservoir from that recommended is advisable at this time. The report considers the advisability of providing one or more dams and reservoirs in the San Gabriel River watershed in lieu of constructing the authorized Laneport project for flood control, water conservation, and related uses.

2. The District and Division Engineers find that the most suitable plan of improvement for the San Gabriel River watershed would consist of the Laneport Project, modified to increase the authorized water-supply storage, and a multiple-purpose reservoir on each of the North and South Forks of San Gabriel River immediately upstream from Georgetown. They recommend the construction in three stages with Laneport Reservoir comprising the first stage and North and South Fork Reservoirs following in that order as the need for water supply develops, and with provisions for the transfer of flood-control storage to the upstream reservoirs as each is constructed. They estimate the cost for the ultimate development at $45,450,000 for construction and $235,000 annually for operation, maintenance, and replacements, which represent increases of $16,750,000 in construction cost, and $171,300 in annual operation, maintenance, and replacement costs over the presently estimated costs of the authorized project. They recommend repayment by local interests of all costs allocated to water supply in accordance with the Water Supply Act of 1958, as amended. They estimate the total net cost to the United States at $25,188,000

for construction and $137,000 annually for operation, maintenance, and replacements, after such financial participation by local interests.

3. The Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the reporting officers. Subject to certain requirements of local cooperation, the Board recommends modification of the authorized project for Brazos River and Tributaries, Texas, to provide for improvements generally as planned by the District Engineer.

4. After due consideration, I concur generally in the plan and proposels set forth in the accompanying reports. I conclude, however, that clarification is indicated in the recommendations as pertain to the authorized Laneport Reservoir. Under the proposed plan of improvement, Laneport Reservoir, authorized for flood control and water supply, would be modified to include additional water supply, together with fish and wildlife and recreation as project purposes. The inclusion of additional water supply in Laneport Reservoir as planned would not seriously affect the flood control services of the project nor would it entail significant structural changes; accordingly, modification of the authorized reservoir for water supply purposes can be accomplished under the provisions of the Water Supply Act of 1958. Similarly, the appropriate provisions of the Fish and Wildlife Coordination Act, Public Law 85-624 approved 12 August 1958, which permit modification of authorized water control projects under certain conditions, would be applicable to the Laneport Reservoir. As pertains to recreation, I conclude that under current revised standards for recreation planning, set forth in Senate Document No. 97, 87th Congress, 2d Session, the incorporation of features for recreation in Laneport Reservoir to the extent proposed in the subject report is possible without further Congressional action. In view of the foregoing, the modifications of the authorized Laneport Reservoir as proposed in the accompanying reports will be incorporated in the design of the project. The construction cost of Laneport Reservoir, as now envisioned to serve the purposes of flood control, water supply, fish and wildlife, and recreation, is estimated at $25,200,000, a decrease of $3,500,000 from the estimated cost of the authorized project, now $28,700,000, such decrease being the result of certain economies in design and construction under the plan as now proposed.

Also, since local interests would be required to reimburse the United States for the project costs allocated to water supply, currently estimated at $10,185,200, the net cost to the United States for the Laneport Reservoir project would be $15,014,800, or $13,685,200 less than now estimated.

5. In view of all the foregoing, I recommend that the project for Brazos River and Tributaries, Texas, be modified by the addition of North Fork and South Fork Reservoirs on the North Fork and South Fork, respectively, of San Gabriel River for flood control, water supply, fish and wildlife, and recreation; and, that such reservoirs be constructed and operated in conjunction with the authorized Laneport Reservoir as now proposed, 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 increase in cost of $20,250,000 for Federal construction and an increase of $134,300 annually for operation, maintenance, and replacements; provided that local interests will: (a) At the appropriate time, consummate the necessary agreements and assurances for repayment of the project costs allocated to the water supply function in accordance with the terms of the Water Supply Act of 1958, as amended, these costs presently estimated at $10,077,000 for construction and $62,500 annually for operation, maintenance, and replacements; and, (b) Hold and save the United States free from water rights claims resulting from construction and operation of the reservoirs.

The ultimate net costs to the United States for the recommended modification are estimated at $10,173,000 for construction and $71,800 annually for operation, maintenance, and replacements.

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

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

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

ENGBR 24 January 1962

SUBJECT: San Gabriel River Watershed, Texas

TO: Chief of Engineers
Department of the Army

1. Authority.--This report is in response to the following resolution adopted 29 July 1955:

> Resolved by the Committee on Public Works of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors be, and is hereby requested to review the reports on Brazos River and Tributaries, Texas, printed in House Document Numbered 535, Eighty-first Congress, second session, with a view to giving further study to the location of the Laneport Reservoir on San Gabriel River and to determine if a change in the site of this reservoir from that recommended is advisable at this time.

It considers the desirability of substituting one or more suitable dams and reservoirs in the San Gabriel River watershed for the authorized Laneport project for flood control, water conservation, and related water uses.

2. Basin description.--The San Gabriel River watershed is in east-central Texas immediately north of Austin. It has a length of about 80 miles, a maximum width of 26 miles, and an area of about 1,319 square miles. It extends generally in a west-to-east direction from the eastern part of the Edwards Plateau, a segment of the Great Plains, across the Balcones escarpment, at about its midpoint, into the West Gulf Coastal Plain. Average annual precipitation over the watershed varies from 29 inches in the headwaters to 35 inches at the mouth, with a weighted average of 32 inches. The mean annual evaporation rate from a free water surface in the watershed is about 55 inches. The San Gabriel River is formed by its North Fork and South Fork at Georgetown, Texas, and flows eastward about 62.5 miles to its junction with the Little River, a tributary of Brazos River. Its important tributaries are listed below:

Tributary	San Gabriel (river mile)	Drainage area (square miles)
North Fork	62.5	263
South Fork	62.5	126
Berry Creek	57.8	124
Willis Creek	29.7	80
Brushy Creek	5.2	510

Channel capacity of the river varies from about 6,100 cubic feet per second in the downstream 17 miles to 8,000 cubic feet per second in the next 13 miles to the Laneport Dam site.

3. The population of the three counties encompassing the watershed was 66,643 in 1960, including 23,371 in its six largest communities. The economy is based primarily on farming, ranching and diversified industries.

4. Existing improvements.--The authorized, but unconstructed, Laneport Dam and Reservoir at mile 29.7 on San Gabriel River is one of eight such projects in the Brazos River basin planned to operate as a system for flood control and other water-related purposes. Pertinent data relative to the other seven reservoirs are given in the following tabulation:

Project	Stream	Miles above mouth	Status
Whitney	Brazos River	442	In operation
Belton	Leon River	17	In operation
Waco	Bosque River	5	Under construction
Proctor	Leon River	239	Under construction
Stillhouse Hollow	Lampasas River	15	Planning underway
Ferguson	Navasota River	36	Not started
Somerville	Yegua Creek	20	Planning underway

The Soil Conservation Service, Department of Agriculture, has constructed 21 small reservoirs, and plans construction of 37 others as well as about 42 miles of channel improvement, in the Brushy Creek basin. That agency has received applications for assistance in watershed improvements in the basins of the North Fork, South

Fork and lower main stem of San Gabriel River. Fifty-nine small reservoir sites have been preliminarily investigated, of which 22 are on the North Fork, 14 on the South Fork, and 33 on tributaries of the San Gabriel River between Georgetown and the proposed Laneport Reservoir, but no detailed planning has been initiated. There are no existing flood-control improvements or water-conservation reservoirs constructed by local interests in the San Gabriel River watershed.

5. Water-resource problems.--Floods occur on the San Gabriel River at any time of the year and contribute substantially to flooding in the lower Brazos River. The minimum channel capacity in the lower Little River is about 10,000 cubic feet per second, and that of the lower Brazos River is 60,000 cubic feet per second. During the 48-year period, 1903-1950, inclusive, 25 floods occurred which produced peak discharges at the Richmond gage ranging from 78,800 to 300,000 cubic feet per second. The parts of the Little River and Brazos River flood plains affected by flood flows from San Gabriel River consist of about 1,080,000 acres, of which 598,000 are improved agricultural lands, 480,000 acres are unimproved grazing lands, and 2,552 acres are in several communities along the reach. The value of property in these reaches, based on July 1961 prices, is estimated at over $350 million. Average annual damages in the reaches, assuming none of the eight authorized projects in operation, are estimated at $9,703,300. Construction and operation of the eight authorized reservoirs would prevent average annual damages estimated at $4,117,000. Of this benefit, $1,382,300 would be attributable to the authorized Laneport Reservoir on San Gabriel River.

6. In connection with the studies for this report, the United States Public Health Service prepared a report on the alternative cost of conservation storage and on the existing and future needs of municipal and industrial water supply in the area which could be served by storage in the San Gabriel River watershed. The service area extends from the vicinity of Waco to the Freeport-Velasco area, generally within the Brazos River basin. The report shows that the usage in the service area in 1958 was about 228 million gallons per day and that the needs in the year 2010, exclusive of return flow for reusage, is estimated at 1,102 million gallons per day. In comparison, the report shows the estimated yield from existing and proposed sources (exclusive of the reservoirs being investigated in this report) to meet the need in the year 2010 as 603 million gallons per day, including 117 million gallons per day from ground water. Because of the indicated future shortage of water in the area, a demand exists for the maximum feasible amount of municipal and

industrial water-supply storage that can be economically developed in the lower Brazos River tributary system.

7. Improvements desired.--In addition to the desire of State authorities for improvements for flood control, water conservation, and allied purposes in the San Gabriel River, Little River, and Brazos River valleys, representatives of the cities of Taylor, Georgetown, and Granger have requested consideration of upstream reservoirs to extend flood control to the vicinity of Georgetown, Texas, and to provide conservation storage where it would more economically serve the water-supply needs of the areas downstream. Landowners within the project limits of Laneport Reservoir are opposed to its construction on the grounds that it would remove from use highly developed agricultural lands. Landowners in the areas downstream from the Laneport site are opposed to elimination of the reservoir on the grounds that the alternate upstream reservoirs would not provide sufficient flood protection in the lower San Gabriel and Little River valleys.

8. Improvements considered.--After considering various scales of development at alternative dam and reservoir sites on the North and South Forks of San Gabriel River and on Berry Creek, and various combinations of such improvements, including the authorized Laneport project, the District Engineer reports that the most suitable plan for the San Gabriel River watershed and the Brazos River basin would consist of the Laneport project, modified to increase the authorized water-supply storage, and a multiple-purpose reservoir on each of the North and South Forks of San Gabriel River immediately upstream from Georgetown. He finds that the authorized storage for flood control in the Laneport project should not be changed, and provides for three-stage construction of the Laneport, North Fork, and South Fork Reservoirs in that order. The North Fork and South Fork Reservoirs would be constructed as the need for water supply develops. As each of the second and third stages are completed, a part of the flood-control storage at Laneport would be transferred to the upstream reservoirs and the vacated storage at Laneport reallotted to water-supply storage, as shown in the following tabulation:

Stage of development	Storage, 1,000 acre-feet						Water yield (MGD)
	Laneport		North Fork		South Fork		
	Flood Control	Water Supply	Flood Control	Water Supply	Flood Control	Water Supply	
1st (1970)	236.1	68.1	--	--	--	--	24.6
2nd (1985)	161.1	147.9	87.9	126.7	--	--	38.8
3rd (1990)	116.5	193.2	87.9	126.7	45.5	89.0	45.2

9. The District Engineer estimates the first cost on the basis of July 1961 prices, and the economics of the improvements based on 50-year periods of analysis, as shown in the following tabulation. The first costs and annual costs of operation, maintenance, and major replacements allocated to flood control, recreation, and fish and wildlife would be assigned as Federal costs, and those allocated to water supply would be assigned as non-Federal costs to be repaid in accordance with the Water Supply Act of 1958, as amended.

Item	Laneport	North Fork	South Fork	Total
First cost	$25,244,000	$12,610,000	$7,660,000	$45,514,000
(includes preauthorization study costs)	(44,000)	(10,000)	(10,000)	(64,000)
Annual charges	1,072,700	544,000	351,900	1,968,600
Annual benefits	2,777,200	1,466,300	856,300	5,099,800
Benefit-cost ratio	2.6	2.7	2.4	2.6

The District Engineer recommends modification of the authorized project for Brazos River and tributaries, Texas, to provide for improvement of the San Gabriel River and its North and South Forks, in accordance with his plan, subject to certain conditions of local cooperation. The Division Engineer concurs.

10. 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. Several hundred communications were received, the majority of which were from opponents of the proposed Laneport Dam and Reservoir. The Board has given careful consideration to the communications received.

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

11. Views.--The Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the reporting officers. The Board notes that the waters of the Brazos River increase in salt content progressively upstream to the extent that much of the stream flow is of mediocre to poor quality for municipal and industrial uses and that, in contrast, the water in the San Gabriel River watershed is of good quality for such purposes. It further notes that the 50-year outlook for municipal and industrial water-supply needs in the area are estimated at 1,102 million gallons per day, whereas the known sources in the area, exclusive of the proposed reservoirs on the San Gabriel River, can supply only about 603 million gallons per day. Accordingly, the Board agrees that the San Gabriel watershed should be developed for the maximum practicable economic water-conservation storage. The basin plan is properly formulated, is economically justified, and the requirements of local cooperation are appropriate, except that local interests should be required to hold and save the United States free from water-rights claims due to construction and operation of the project. On the basis of present estimates, the costs for the various phases of development would be apportioned as shown in the following table:

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COST APPORTIONMENT
(Thousands of Dollars)

Item	1st Stage	2nd Stage	3rd Stage
LANEPORT:			
Construction costs -			
Federal	18,202.0	16,791.0	15,014.8
Non-Federal	6,998.0	8,409.0	10,185.2
Total	25,200.0	25,200.0	25,200.0
Percent non-Federal	27.8	33.4	40.4
Annual operation, maintenance, and replacement -			
Federal	63.9	68.7	65.1
Non-Federal	36.8	32.0	35.6
Total	100.7	100.7	100.7
Percent non-Federal	36.5	31.8	35.4
NORTH FORK:			
Construction costs -			
Federal		6,368.0	6,359.0
Non-Federal		6,232.0	6,241.0
Total		12,600.0	12,600.0
Percent non-Federal		49.5	49.5
Annual operation, maintenance, and replacement -			
Federal		38.7	38.7
Non-Federal		31.6	31.6
Total		70.3	70.3
Percent non-Federal		45.0	45.0
SOUTH FORK:			
Construction costs -			
Federal			3,814.0
Non-Federal			3,836.0
Total			7,650.0
Percent non-Federal			50.1
Annual operation, maintenance, and replacement -			
Federal			33.2
Non-Federal			30.9
Total			64.1
Percent non-Federal			48.2

12. Recommendations.--The Board therefore recommends:

a. That the authorized project for Brazos River and tributaries, Texas, be modified to provide for modification and immediate construction of the authorized Laneport Reservoir as the first-stage unit, and the subsequent construction of the North Fork and South Fork Reservoirs as second- and third-stage units, respectively, to provide for controlled storage of 331,900 acre-feet at Laneport, 221,600 acre-feet at North Fork, and 138,500 acre-feet at South Fork, each for flood control, water supply, fish and wildlife, and recreation; and

b. That the foregoing be accomplished generally in accordance with the plan of the District Engineer and with such modifications thereof, including reasonable adjustments in the storage capacity for water supply and other purposes, as in the discretion of the Chief of Engineers may be advisable, at an estimated cost for the ultimate development of $45,450,000 for construction and $235,000 annually for operation, maintenance, and major replacements, of which $25,200,000 and $100,000, respectively, would be for the Laneport Reservoir: Provided that, prior to construction of each reservoir, local interests give assurances satisfactory to the Secretary of the Army that they will:

(1) Pay the United States in accordance with the Water Supply Act of 1958, as amended, the first costs and the annual operation, maintenance, and replacement costs allocated to municipal and industrial water-supply storage, presently estimated at $20,262,000 and $98,000, respectively, for the ultimate development, of which $6,998,000 and $36,800, respectively, would be for the first-stage Laneport development; and

(2) Hold and save the United States free from all water-rights claims resulting from construction and operation of the projects.

FOR THE BOARD:

KEITH R. BARNEY
Major General, USA
Chairman

REPORT OF THE DISTRICT ENGINEER

REVIEW OF REPORTS
ON
BRAZOS RIVER AND TRIBUTARIES, TEXAS
COVERING
SAN GABRIEL RIVER WATERSHED

S Y L L A B U S

The District Engineer finds from his investigations that major floods originating on the San Gabriel River watershed cause a flood problem within the investigated flood plain reaches on the San Gabriel River downstream from the vicinity of Georgetown, Texas, and augment appreciably the flood conditions within the lower reaches of the Little and Brazos Rivers; and that an important water supply problem exists throughout the lower Brazos River Basin, including the San Gabriel River area. He concludes that certain of the flood and water supply problems can best be solved at this time by the modification and construction of the Laneport Reservoir in conjunction with the construction of the North Fork and South Fork Reservoirs in stages in lieu of the authorized Laneport Reservoir project. He concludes further that there is an immediate need for the Laneport Reservoir project on the San Gabriel River as the initial and primary unit for flood control purposes, but containing sufficient water conservation storage for present water supply needs; that the North Fork and South Fork Reservoirs should be constructed as second-stage and third-stage units at such time that additional water conservation storage is needed; that these reservoirs are fully justified as units in the system of authorized reservoir projects for flood control, water conservation, and allied purposes in the Brazos River Basin.

Accordingly, the District Engineer recommends that the authorized project for Brazos River and tributaries, Texas, be modified to provide for construction of the Laneport, North Fork, and South Fork Reservoir projects in stages, substantially as outlined in this report, at an estimated additional Federal construction cost to the United States of $16,750,000 and an increase of $171,300 in annual maintenance and operation costs, subject to the conditions that local interests reimburse the United States for the project costs allocated to water conservation.

U. S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS
October 16, 1961

SUBJECT: Review of Reports on Brazos River and Tributaries, Texas, Covering San Gabriel River Watershed

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

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

INTRODUCTION

1. AUTHORITY.- This report is submitted in response to the following congressional resolution adopted July 29, 1955:

"Resolved by the Committee on Public Works of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the reports on Brazos River and Tributaries, Texas, printed in House Document Numbered 535, Eighty-first Congress, second session, with a view to giving further study to the location of the Laneport Reservoir on San Gabriel River and to determine if a change in the site of this reservoir from that recommended is advisable at this time."

2. SCOPE.- This review report authorized by the above-cited resolution considers the desirability of modifying the authorized plan (the Laneport Reservoir project) for flood control, water conservation, and related purposes on the San Gabriel River watershed. This report includes a reinvestigation of the authorized Laneport Reservoir project on the San Gabriel River to determine its adequacy and desirability with respect to location, size, and purpose, and in connection therewith, to determine the advisability of constructing an alternate dam and reservoir project in lieu of or in combination with the presently authorized project. This report is limited to the investigation of improvements on the San Gabriel River watershed, with consideration given to other streams and watershed areas only to the extent necessary to develop complete economic analyses for the plans under study.

3. SUMMARY OF STUDIES.- 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 plan of improvement. Field surveys consisted of establishing highwater

marks for the floods of April-June 1957 and prior floods, delineating the flood plain, conducting topographic surveys to obtain necessary valley sections and dam site profiles, subsurface explorations consisting of 8 borings at investigated upstream dam sites to determine subsurface conditions and the availability of construction materials, and conducting an economic survey to determine the character and value of the physical property in the flood plains and the damages resulting from floods. Office studies consisted of analyses of hydrologic, hydraulic, and economic data, engineering studies to develop alternate feasible plans of improvement, and determinations of costs and benefits for various plans of improvement investigated.

4. A public hearing was held at Georgetown, Texas, on March 19, 1958, as discussed in paragraph 33. Also, during the investigation, the District Engineer made a reconnaissance of the area under investigation and held conferences with local interests to discuss the plans of improvement being considered and the probable requirements of local cooperation.

5. The Soil Conservation Service, Department of Agriculture, has been authorized under the Watershed Protection and Flood Prevention Act, Public Law 566, as amended, to undertake a planned program of runoff and waterflow retardation and soil erosion prevention on the Brushy Creek subwatershed, a principal tributary area of the San Gabriel River watershed. In addition, the Soil Conservation Service has received applications for planning assistance on the North San Gabriel River, the South San Gabriel River, and the lower San Gabriel River watershed. During the investigation, the planning of the Corps of Engineers and Soil Conservation Service was coordinated at field level.

6. REPORTS REVIEWED.- This report is a review of the comprehensive "Report on Survey of Brazos River and Tributaries, Texas, Oyster Creek, Texas, Jones Creek, Texas," printed as House Document No. 535, 81st Congress, 2d Session. The reports contained in House Document No. 535 recommended improvements for the Brazos River Basin which included the Laneport Reservoir project on the San Gabriel River. The recommended improvements contained in House Document No. 535 were authorized by Congress in Public Law 780, 83d Congress, 2d Session. The reports under review in House Document No. 535 are the only prior reports concerned with flood control on the San Gabriel River. In partial response to congressional authorizations for preparation of the comprehensive report covering the Brazos River Basin, two interim reports were previously prepared covering Whitney Dam, on the Brazos River, Texas; and Leon River, Texas. The reports are printed as House Document No. 390, 76th Congress, 1st Session, and House Document No. 88, 81st Congress, 1st Session, respectively. Congressional action taken on the above three reports resulted in authorization of a system of eight reservoirs for flood control and allied purposes and of three local flood protection projects in the Brazos River Basin. The name,

location, and status of the authorized projects are shown in the following tabulation:

Project	Location	Status
House Document No. 390, 76th Congress, 1st Session		
Whitney Reservoir	Brazos River	Authorized - constructed and in operation
House Document No. 88, 81st Congress, 1st Session		
Belton Reservoir	Leon River	Authorized - constructed and in operation
Local flood protection works	Eastland, Texas N.Fork Leon River	Authorized
House Document No. 535, 81st Congress, 1st Session		
Waco Reservoir	Bosque River	Authorized - under construction
Proctor Reservoir	Leon River	Authorized - under construction
Stillhouse Hollow Reservoir (formerly Lampasas Reservoir)	Lampasas River	Authorized - advance planning initiated
Laneport Reservoir	San Gabriel River	Authorized
Somerville Reservoir	Yegua Creek	Authorized - advance planning initiated
Ferguson Reservoir	Navasota River	Authorized
Modification of Belton Reservoir	Leon River	Authorized
Local flood protection works	Lampasas, Texas Sulphur Creek	Authorized
Local flood protection works	Burleson County Improvement District No. 1 - Brazos River	Authorized

7. GEOGRAPHY.- The San Gabriel River watershed is located in the south central portion of Texas and immediately north of Austin, Texas, as shown on plate 1. The San Gabriel River watershed is a principal tributary area of the lower Brazos River Basin. The watershed is bounded on the north by the Lampasas and Little River watersheds of the Brazos River Basin, on the west and southwest sides by the Colorado River Basin, and on the south by the Yegua Creek watershed of the Brazos River Basin. The San Gabriel River watershed has a total length of about 80 miles, a maximum width of about 26 miles, and an area of about 1,319 square miles. The watershed includes large portions of Burnet, Williamson, and Milam Counties and small portions of Bell and Travis Counties. Taylor, Georgetown, Granger, Round Rock, Thorndale, and Rockdale are the principal urban centers on the watershed. The component drainage areas of the watershed are shown on plate 2.

8. PHYSIOGRAPHY.- The San Gabriel River watershed is divided into two physiographic areas by the Balcones escarpment, which crosses the watershed about 4 or 5 miles east of Georgetown. The watershed area east of the Balcones escarpment is a part of the West Gulf Coastal Plain section of the Coastal Plain province, the latter being a part of the Atlantic Plain major physiographic division. The watershed area west of the Balcones escarpment is classified as part of the Central Texas section of the Great Plains province which are subdivisions of the Interior Plains major physiographic division.

9. Topographically, the watershed area east of the Balcones escarpment is rolling or hilly with little or no timber on the hills. The general land elevations for this area vary from about 750 feet near the escarpment line to about 300 feet near the confluence of the San Gabriel and Little Rivers. The watershed area west of the Balcones escarpment is a plateau and timbered area, having generally rugged topography and containing steeply eroded hills, spurs, knobs, and escarpments. The valleys in this portion are narrower than in the other portion of the watershed. Land elevations vary from about 1,800 feet along the western divide to about 750 feet at the Balcones escarpment area.

10. SOILS.- Soils in the San Gabriel watershed are mostly of the Grand Prairie, Blackland Prairie, and Post Oak classifications, and are generally black, brown, or dark gray, and friable.

11. GEOLOGY.- The watershed lies within the outcrops of the Lower Cretaceous, Upper Cretaceous, and Eocene strata. The Balcones escarpment is crossed by the San Gabriel River approximately 4 to 5 miles east of Georgetown, and the north-northeast strike of the fault bisects the watershed. Proceeding downstream from their origin in the western portion of the watershed, the headwater tributaries traverse

the Fredericksburg and Trinity groups of the Lower Cretaceous strata to the immediate vicinity of Georgetown; thence the San Gabriel River traverses the younger Washita group of the Lower Cretaceous to the major fault line escarpment east of Georgetown. East of the Balcones fault, the San Gabriel River traverses in consecutive order the Eagle Ford, Austin, Taylor, and Kemp formations of the Upper Cretaceous strata to about river mile 10.9, thence the Kincaid, Wills Point, and the Wilcox groups of the Eocene strata. The outcrops consist principally of marls, shales, limestones, chalks, and clays.

12. STREAMS.- The San Gabriel River is formed by the North Fork and the South Fork of the San Gabriel River, which have their origin in Burnet County. The North and South Forks of the San Gabriel River flow from their origin in an easterly to southeasterly direction for distances of about 46 and 39 miles, respectively, to their confluence at about river mile 62.5 of the San Gabriel River at Georgetown, Texas. The San Gabriel River then flows easterly to northeasterly to river mile 5.2 where it is joined by Brushy Creek, another principal tributary. Thence, the San Gabriel River flows easterly to join the Little River at mile 44.3. The Little River flows northeasterly to join the Brazos River at mile 315.8. Other important tributaries are Berry Creek, which is confluent with the San Gabriel River at river mile 57.8, just east of Georgetown, and Willis Creek, which is confluent with the San Gabriel River at river mile 29.7, at the Laneport Dam site. The San Gabriel River is affected by backwater from flood flows on the Little River as far upstream as about river mile 7.3. The average stream bed slopes of the San Gabriel River, North Fork and South Fork of the San Gabriel River, and Berry Creek are about 6, 17, 21, and 13 feet per mile, respectively. The channel capacities of the streams within the investigated reaches are given in paragraph 21. The natural profiles of the investigated reaches of the San Gabriel River and its tributaries are shown on plates 3 and 4.

13. ECONOMIC DEVELOPMENT.- The economy of the San Gabriel watershed is based on farming, ranching, and diversified industries. In the upstream portions of the watershed, in Burnet County, and in Williamson County upstream from the confluence of the North and South Forks of the San Gabriel River, the economy is based on ranching supplemented by farming with some oil production and graphite mining. However, the entire watershed is a farming and ranching area. Principal farm crops in the watershed include oats, corn, grain sorghums, cotton, wheat, hay, and black-eyed peas. Livestock raised include beef cattle, dairy cattle, sheep, goats, poultry, and swine. In the downstream portion of the watershed, farming and livestock raising are better balanced with manufacturing industry than they are in the upstream portion of the watershed. Outstanding mineral deposits in the area are graphite, lignite, granite, and limestone. The manufacturing industries include oil production, limestone quarrying, cottonseed oil and feed milling, bedding and school furniture production, poultry packing, lignite mining, brick production, graphite

mining, and aluminum production. The Aluminum Company of America owns and operates one of the largest aluminum plants in the United States near Rockdale in Milam County.

14. Pertinent business information for the three-county area of the San Gabriel watershed for the year 1956 is given below:

Income	$66,598,000
Manufacturing value	25,252,000
Wholesale sales	25,204,000
Retail sales	63,405,000

The watershed is served by transportation facilities consisting of several airports, four railroads, and a network of Federal, State, and county highways.

15. Population data for the San Gabriel watershed, based on the 1950 census and preliminary figures of the 1960 census are shown in the following tabulation:

Item	1950 Census	1960 Census
Counties:		
Burnet	10,356	9,126
Milam	23,585	22,149
Williamson	38,853	35,368
Total	72,794	66,643
Cities:		
Taylor	9,071	9,564
Georgetown	4,951	5,210
Granger	1,637	1,338
Round Rock	1,438	1,857
Thorndale	855	955
Rockdale	2,321	4,447
Total	20,273	23,371

CLIMATOLOGICAL, RUNOFF, AND FLOOD DATA

16. CLIMATOLOGICAL DATA.- The San Gabriel River watershed has a temperate climate characterized by hot summers and cool winters. Freezing temperatures and snowfall are experienced occasionally along with the passage of cold high-pressure air masses from the northwestern polar regions and the continental western highlands. The mean annual temperature in the watershed is about 68 degrees Fahrenheit. Temperatures in and near the watershed have ranged from a maximum of 114 degrees to a minimum of minus 12 degrees. January, the coldest month, has an average minimum daily temperature of 38.3 degrees. August, the warmest month, has an average maximum daily temperature of 97.1 degrees. The average length of growing season between killing frosts is about 238 days.

17. PRECIPITATION.- The mean annual precipitation over the San Gabriel River watershed is about 32.3 inches, and various from about 29 inches in the headwater region to about 35 inches in the lower part of the watershed. Extremes in annual precipitation on the watershed have ranged from a minimum of 12.13 inches recorded at Liberty Hill in 1954 to a maximum of 60.03 inches recorded at Georgetown in 1919. The normal seasonal distribution of rainfall over the watershed is generally favorable for agricultural purposes, with the heaviest rainfall occurring during the period April through June. Plate 5 shows the location, type, and period of record of precipitation stations in and adjacent to the San Gabriel River watershed; the isohyets of mean annual precipitation; and the mean monthly precipitation at Taylor, Burnet, and Cameron.

18. STORMS.- The San Gabriel River watershed lies within an area of high storm rainfall. The storms that cause precipitation on this watershed are of three general types: (1) thunderstorms; (2) frontal storms; and (3) cyclonic storms, originating in the tropics of the western Gulf of Mexico. The greatest storms of record that have been experienced on the San Gabriel River watershed are of the frontal type. The major flood-producing storms that have occurred over the San Gabriel River watershed are those of December 1-5, 1913; September 8-10, 1921; April 23-26, 1957; and October 1-4, 1959. Isohyetal maps and typical mass curves of precipitation for these major watershed storms are shown on plate 6. The storm of September 8-10, 1921, was centered at Thrall 2N in the San Gabriel River watershed. The average depth of precipitation over the watershed during the 1921 storm was about 24 inches.

19. EVAPORATION.- The mean annual evaporation rate from a free water surface in the San Gabriel River watershed is about 55 inches, based on measurements by the Texas Agricultural Experiment Station at Temple, Texas.

20. RUNOFF.- Streamflow records are available from two stream-gaging stations on the San Gabriel River. The locations of these stream-gaging stations are shown on plate 2, and the annual runoff data for the stations are summarized in the following tabulation:

Gaging station	Drainage area (sq.mi.)	Period of record: From	To	Length (yr-mo)	Annual runoff (inches): Maximum (1)	Minimum (1)	Mean
Georgetown (2)	390	1934	1959	25-0	17.36	0.10	4.41
Circleville	589	1924	1934	10-8	7.20	0.83	3.37

(1) Water year
(2) Records are also available for the period February 1924 through August 1925 at former gage location upstream, drainage area 389 square miles

21. CHANNEL CAPACITY.- Channel capacities on the San Gabriel River watershed are as follows: 6,100 second-feet from the mouth to river mile 17.0; 8,000 second-feet from river mile 17.0 to Laneport Dam site; and 10,000 second-feet from Laneport Dam site to the North Fork, South Fork, and Berry Creek Dam sites. During the floods of April-June 1957, April-May 1958, and October 1959, it was found that the channel capacity on the Little River in the reach represented by the Cameron gage was only 6,000 second-feet. However, this low channel capacity is localized and causes flooding on certain sloughs along the Little River near the mouth of the San Gabriel River. With the exception of this area, the minimum channel capacity in the reach represented by the Cameron gage is 10,000 second-feet. It was proposed in Design Memorandum No. 5 on Stillhouse Hollow Reservoir, General, dated March 1960, to improve the channel within this area so as to increase the capacity to about 14,000 second-feet above and 18,000 second-feet below the mouth of the San Gabriel River. The minimum channel capacity on the Lower Brazos River below the mouth of the Bosque River is 60,000 second-feet in the vicinity of East Columbia, about 61 miles downstream from Richmond.

22. FLOODS.- The topography of the San Gabriel River 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 the San Gabriel River at Georgetown occurred in September 1921. This flood produced a peak discharge of 160,000 second-feet, as determined by indirect methods from highwater marks. The maximum flood during the period of record at the Georgetown gage was that of April 1957, with a peak discharge of 155,000 second-feet. It is estimated that this peak discharge would be reduced to 135,000 second-feet at the Laneport Dam site. During the flood of April 1957, the U. S. Geological Survey made indirect determinations of peak discharges on the North and South San Gabriel Rivers. These peak discharges and the drainage areas above the points of measurement are as follows: North San Gabriel River, 102,000 second-feet,

240 square miles; South San Gabriel River, 78,800 second-feet, 120 square miles. The isohyetal maps and mass curves of rainfall for the September 1921 and the April 1957 storms (plate 6) show a greater volume and higher intensity of rainfall above the Georgetown gage in 1921 than in 1957. This would indicate the peak discharge produced by the 1921 storm would have been considerably greater than that produced by the 1957 storm. This difference was taken up with the U. S. Geological Survey at Austin, Texas. The Geological Survey indicated that both the 1921 and 1957 peak discharge determinations were made by indirect methods and were based on high water marks. The maximum stages reached were 36.1 and 34.1 feet during the 1921 and 1957 floods, respectively. The Geological Survey considered the accuracy of the two determinations was comparable, and the peak discharges as determined for the two floods were adequate as published. The maximum flood during the period of record at the Circleville gage on the San Gabriel River was that of May 1929 with a peak discharge of 53,400 second-feet and a peak stage of 34.20 feet. Peak discharges for the floods of September 1921 and April 1957 at Circleville are unknown. However, historical information indicates that these floods reached maximum stages of 40.6 and 37.5 feet, respectively, in the vicinity of the gage. The following tabulation gives the peak discharges in second-feet and volumes in acre-feet for the larger floods occurring during the period of record at the Georgetown gage (1934-1959):

Flood date	Peak discharge (cfs)	Volume (ac-ft)
September 15-24, 1936	32,400	20,400
June 29-July 11, 1940	34,500	53,300
November 22-30, 1940	30,000	58,700
June 6-11, 1944	37,500	16,400
April 22-26, 1957	155,000	65,200
October 4-6, 1959	71,500	88,500

FLOODED AREAS AND FLOOD DAMAGES

23. AREAS INVESTIGATED.- The areas investigated in detail for the preparation of this report consist of the flood plain of the San Gabriel River from North and South San Gabriel Dam sites to the mouth, the flood plain of Berry Creek from the Berry Creek Dam site to the mouth, the flood plain of the Little River from the mouth of the San Gabriel River to the mouth of the Little River, and the flood plain of the Brazos River from the mouth of Little River to the mouth of the Brazos. For convenience in analyzing the property values and damages and estimating the benefits creditable to the recommended improvements, the flood plains were divided into reaches as shown on plates 7 and 8 and in tables 1 and 2.

24. CHARACTER OF FLOODED AREAS.- The flood plain areas investigated total 1,107,569 acres, of which 2,924 acres are urban or suburban and 1,104,645 acres are improved lands (crop and pasture) and unimproved grazing lands. The land acreage and classification of each reach are shown in table 1.

25. The flood plains of the San Gabriel River, the Little River below the mouth of the San Gabriel River, and the Brazos River below the mouth of the Little River are devoted principally to agriculture. Urban damages occur at Georgetown, Cameron, Hearne, Rosenburg, Richmond, Brazoria, Sugarland, West Columbia, East Columbia, and other communities. Other property subject to damage within the flood plain studied in this report includes transportation facilities, utilities, oil fields, sulphur mines, water supply facilities, sand and gravel plants, and rural churches and schools. The total value of physical property in the flood plains is estimated at about $362,991,300, based on July 1, 1961, price levels. These valuations are summarized in table 2 and are shown in detail in tables 24 through 33 in appendix II.

26. FLOOD DAMAGES.- The authorized Laneport Reservoir project is a unit of an eight-reservoir system consisting of Whitney, Belton, Waco, Proctor, Stillhouse Hollow, Somerville, Ferguson, and Laneport Reservoirs, authorized for flood control and allied purposes in the Brazos River Basin. The total flood plain area which will receive protection by the system of reservoirs is about 1,343,350 acres. The total damages that would be caused by a recurrence of the maximum flood of record in the reaches of the Brazos River and tributaries to receive protection from the proposed system of reservoirs is $108,556,800. These damages are based on a condition assuming that none of the eight authorized flood control reservoirs in the Brazos River Basin are in operation, but that all other developments and price levels are those existing as of July 1, 1961. Under these conditions, the average annual damages for this area are estimated at $14,879,000.

TABLE 1

LAND AREAS IN THE FLOOD PLAIN

Reach	River mile From	River mile To	Land area in acres: Agricultural: Improved	Agricultural: Unimproved grazing	Urban or suburban & rural development	Total
			San Gabriel River			
2	4.0 N 4.7 S	29.7	5,705	6,361	372	12,438
1	29.7	7.3	8,257	5,361	--	13,618
	Total San Gabriel River		13,962	11,722	372	26,056
			Berry Creek			
1	6.7	1.1	445	439	--	884
	Total Berry Creek		445	439	--	884
			Little River			
2	48.9	15.0	29,266	4,319	--	33,585
	Total Little River		29,266	4,319	--	33,585
			Brazos River			
4	317.9	249.9	129,992	27,432	245	157,669
5	249.9	236.0	20,540	17,432	31	38,003
6	236.0	157.5	67,769	37,667	16	105,452
7	157.5	70.8	123,202	68,772	453	192,427
8A	70.8	0.0	71,162	244,267	1,064	316,493
8B	70.8	0.0	156,036	80,221	743	237,000
	Total Brazos River		568,701	475,791	2,552	1,047,044
	TOTAL		612,374	492,271	2,924	1,107,569

27. The total damages that would be caused by a recurrence of the maximum flood of record in the reaches of Berry Creek, the San Gabriel River, the Little River, and the Brazos River as studied in this report are estimated at $70,964,800. These damages are based on the same conditions as set forth in paragraph 26 above. Under these conditions, the average annual damages for this area are estimated at $10,029,000.

TABLE 2

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN

Stream	Reach	River mile From	River mile To	Agricultural property	Rural non-agricultural property	Transportation facilities	Utilities	Urban properties	Total
San Gabriel River	2	4.0 N 4.7 S	29.7	$ 2,504,800	$ --	$ 1,235,500	$ 85,500	$ 681,000	$ 4,506,800
	1	29.7	7.3	3,038,000	--	450,500	2,900	--	3,491,400
Total San Gabriel River				$ 5,542,800	$ --	$ 1,686,000	$ 88,400	$ 681,000	$ 7,998,200
Berry Creek	1	6.7	1.1	$ 199,100	$ --	$ 244,600	$ 23,800	$ --	$ 467,500
Total Berry Creek				$ 199,100	$ --	$ 244,600	$ 23,800	$ --	$ 467,500
Little River	2	48.9	15.0	$ 6,285,100	$ --	$ 3,520,200	$ 175,300	$ 290,300	$ 10,270,900
Total Little River				$ 6,285,100	$ --	$ 3,520,200	$ 175,300	$ 290,300	$ 10,270,900
Brazos River	4	317.9	249.9	$ 28,741,600	$ 348,600	$12,191,100	$ 824,300	$ 1,329,600	$ 43,435,200
	5	249.9	236.0	5,851,200	--	3,948,000	168,300	222,100	10,189,600
	6	236.0	157.5	17,320,500	486,000	6,946,800	1,060,400	124,800	25,938,500
	7	157.5	70.8	34,277,100	1,721,500	16,964,800	5,814,500	26,062,000	84,839,900
	8A	70.8	0.0	39,729,100	14,842,200	17,492,300	7,602,000	17,794,300	97,459,900
	8B	70.8	0.0	41,057,900	7,936,900	10,824,900	6,563,900	16,008,000	82,391,600
Total Brazos River				$166,977,400	$25,335,200	$68,367,900	$22,033,400	$61,540,800	$344,254,700
TOTAL				$179,004,400	$25,335,200	$73,818,700	$22,320,900	$62,512,100	$362,991,300

EXISTING CORPS OF ENGINEERS' PROJECT

28. AUTHORIZED LANEPORT RESERVOIR.- The only authorized Corps of Engineers' project on the San Gabriel River watershed is the Laneport Reservoir project. This project was authorized by the Flood Control Act of September 3, 1954 (Public Law 780, 83rd Congress, 2d Session), as a part of a comprehensive plan of improvement for the Brazos River Basin for flood control and water conservation purposes. The location of the authorized Laneport Reservoir project is shown on plate 1. The reservoir area of the Laneport project as authorized is shown on plate 1A.

29. The Laneport Dam site is located at river mile 29.7 on the San Gabriel River, about 8 miles east of Granger, Texas. The flood control portion of the Laneport Reservoir would provide for the control of major flood flows originating on 711 square miles of drainage area upstream from Laneport Dam. The water conservation portion of the authorized project would provide part of the water required for municipal water supply to cities within the lower Brazos River Basin. The authorized project provides for a dam about 13,640 feet in length, including 873 feet of gate-controlled spillway, 427 feet of concrete gravity nonoverflow sections, and 12,340 feet of earth fill embankment. The spillway would consist of an ogee section 873 feet long with the crest at elevation 497.0, controlled by eighteen 40- by 30-foot tainter gates. Below the top of the flood control pool, elevation 527.0, the authorized Laneport Reservoir has a total storage capacity of 281,100 acre-feet, including 236,100 acre-feet for flood control, 28,400 acre-feet for water conservation, and 16,600 acre-feet for sedimentation. The authorized Laneport Reservoir project has a current approved first cost estimate of $28,700,000 based on July 1960 prices. On the basis of the currently approved estimated first cost, the annual charges are $1,132,900, including $63,800 for maintenance and operation.

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30. IMPROVEMENTS BY OTHER FEDERAL AGENCIES.- The Soil Conservation Service, U. S. Department of Agriculture, has been authorized to develop a program providing for soil and water conservation and improved plant management on the Brushy Creek subwatershed of the San Gabriel watershed under the provisions of the Watershed Protection and Flood Prevention Act, approved August 4, 1954 (Public Law 566, 83d Congress, 2d Session, as amended), and by Public Law 1018, 84th Congress, 2d Session, approved August 7, 1956. The planned program on the Upper Brushy Creek and Lower Brushy Creek subwatersheds has a total estimated Federal cost of $3,703,259. Under the above authorized program, the Soil Conservation Service plans construction on the Upper Brushy Creek subwatershed of 33 floodwater retarding structures and 6.42 miles of channel improvement at an estimated total Federal cost of $2,479,173. The Service plans construction on the Lower Brushy Creek subwatershed of 25 floodwater retarding structures and 35.7 miles of channel improvement at an estimated total Federal cost of $1,224,086. The reservoirs provide a total storage in the two subwatersheds of 77,381 acre-feet, of which 62,960 is for flood detention and 14,420 is for sedimentation. Seven structures in the Lower Brushy Creek subwatershed and 14 structures in the Upper Brushy Creek subwatershed have been completed as of July 1, 1960, with a total Federal construction cost of $911,243. The completed reservoirs provide a total storage of 18,944 acre-feet, of which 16,244 is for flood detention and 2,701 is for sedimentation. Participation of local interests in the cost of the reservoirs will consist of furnishing the required lands. Locations of the completed reservoirs are shown on plates 1 and 2.

31. The Soil Conservation Service has received applications for assistance under Public Law 566 on the North, South, and Lower San Gabriel River watersheds, and the applications have been approved by the Texas State Soil Conservation Board, but no detailed planning has been initiated on any of the watersheds. Based on a reconnaissance survey, a total of 59 structures have been investigated, providing a total flood detention storage of 66,560 acre-feet and a total sedimentation storage of 12,880 acre-feet. Twenty-two of these structures would be on the North Fork of the San Gabriel River above an investigated dam site; 14 would be on the South Fork of the San Gabriel River above an investigated dam site; and 23 would be on tributary streams in the area between the authorized Laneport Dam site and the investigated dam sites on the North and South Forks.

32. IMPROVEMENTS BY NON-FEDERAL AGENCIES.- There are no existing flood control improvements or water conservation reservoirs constructed by non-Federal interests on the San Gabriel River watershed.

IMPROVEMENTS DESIRED

33. PUBLIC HEARING.- A public hearing was held at Georgetown, Texas, on March 19, 1958, to permit local interests to cite the nature of water problems on the San Gabriel River watershed and to ascertain their proposed solutions for the problems. A record of the hearing is available for review in the Office, Chief of Engineers, Washington, D. C., in the U. S. Army Engineer Division Office, Dallas, Texas, and in the U. S. Army Engineer District Office, Fort Worth, Texas. The following State and Federal governmental representatives and agencies submitted statements prior to, during, or subsequent to the hearing, indicating the extent of their interests in the water-problem studies for the San Gabriel watershed: Honorable Homer Thornberry and W. R. Poage, United States House of Representatives; Honorable Lyndon B. Johnson, United States Senate; various Federal and State agencies consisting of the Southwestern Power Administration, Bureau of Sport Fisheries and Wildlife, and the Brazos River Authority of Texas. The Federal and State governmental agencies represented at the public hearing were the U. S. Soil Conservation Service, U. S. Fish and Wildlife Service, U. S. Department of Agriculture, and the Texas State Board of Water Engineers.

34. IMPROVEMENTS DESIRED BY LOCAL INTERESTS.- Local interests presented information at the hearing either by written or oral statements concerning water problems, floods experienced, and desired improvements and investigations. Their principal requests for improvements are briefly summarized as follow:

a. Construction of two reservoirs for flood control and water conservation purposes just west of Georgetown, one on the North Fork of the San Gabriel River and one on the South Fork of the San Gabriel River.

b. Construction of the two above mentioned multiple-purpose reservoirs on the North and South Forks of the San Gabriel River and a third reservoir on Berry Creek just north of Georgetown.

c. Construction of the two above-mentioned reservoirs on the North and South Forks of the San Gabriel River in combination with a flood control reservoir on the San Gabriel River at the Laneport Reservoir site.

d. Construction of Laneport Reservoir as recommended by the U. S. Army Corps of Engineers and as authorized by the Congress.

35. Local interests, consisting of representatives of the cities of Taylor, Georgetown, and Granger and of the Brazos River Authority, requested consideration of upstream reservoirs to extend flood control upstream to the vicinity of Georgetown, Texas, and to provide water conservation storage where it would more economically serve the water

supply needs of the cities of the watershed downstream from the vicinity of Georgetown and the potential irrigation requirements of the downstream areas. Landowners within the Laneport Reservoir area stated that the land areas within the reservoir project limits are highly developed agriculturally and therefore they are opposed to construction of the authorized project. Representatives from Milam County and other individuals of the watershed area downstream from the authorized Laneport project stated that they are opposed to elimination of the Laneport Reservoir project and that the alternate upstream reservoir projects would not provide sufficient flood protection for the lower San Gabriel and Little River valleys.

WATER PROBLEMS

36. GENERAL.- The principal water problems on the San Gabriel River watershed result from the frequent occurrence of floods and insufficient water supply. Major floods originating on the San Gabriel River watershed cause appreciable damages along the San Gabriel River, and in addition, augment considerably the flood conditions and damages along the lower Little and Brazos Rivers. Periods of prolonged drought, upward trends in population, and expansion of industrial and municipal developments have made evident the increasing need for the conservation of surface runoff for all beneficial purposes in the lower Brazos River Basin.

37. FLOOD PROBLEM ON THE SAN GABRIEL RIVER.- The flood problem on the San Gabriel River is the result of frequent floods caused by heavy and frequent storm rainfall and inadequate channel capacities. During the period of record from 1924 to 1959, thirty-one major floods occurred producing peak discharges varying from 22,500 to 135,000 second-feet at the Laneport Dam site. Prior to the period of record, the maximum known flood occurred in September 1921, producing an estimated peak discharge of about 250,000 second-feet at the Laneport Dam site. The channel capacity of the San Gabriel River is insufficient to contain these floods, being about 6,100 second-feet downstream from river mile 17.0 and varying from 8,000 to 10,000 second-feet between river miles 17.0 and 62.5. The lower San Gabriel River flood plain, as far upstream as river mile 7.3, is subject to varying degrees of flooding due to the backwater effects of major flood flows on the Little River, as well as to a combination of coincident flood conditions on the San Gabriel and Little Rivers. As a result of these backwater conditions, the 7.3-mile reach is considered to be a portion of the Little River flood plain area.

38. The flood problem area on the San Gabriel River watershed investigated for this report includes the following principal flood plain reaches: (a) the total 62.5-mile reach of the San Gabriel River from its mouth to its formation at Georgetown; (b) the lower 4.0-mile reach of the North Fork of the San Gabriel River; (c) the lower 4.7-mile reach of the South Fork of the San Gabriel River; and (d) the lower 6.7-mile reach of Berry Creek. The problem area of the San Gabriel River between its mouth and Georgetown is a highly developed agricultural area devoted principally to farming and to the production of beef and dairy products. The problem area upstream from the Laneport Dam site contains the major portion of non-agricultural improvements, including highways, railroads, and a small amount of urban development. Within the investigated problem areas of the San Gabriel River watershed, exclusive of the 7.3-mile backwater reach, the estimated value of physical property is about $8,465,700, and the estimated average annual damages are about $325,700.

39. FLOOD PROBLEM ON THE LITTLE AND BRAZOS RIVERS.- The need for the reduction of flood flows on the lower Little and Brazos Rivers is an important flood problem to be considered in conjunction with the investigation of flood control improvements on the San Gabriel River watershed. The numerous major floods which originate on the San Gabriel River watershed contribute appreciably to the flood problem on the Little and Brazos Rivers. As the result of prior investigations covering the flood problems on the Brazos River Basin, a system of eight reservoirs, including the Laneport Reservoir on the San Gabriel River, was recommended and authorized by the Federal Government to facilitate control of floods originating on the Brazos River and its principal tributaries and to provide principally for the protection of urban development and highly-developed agricultural lands within the flood plains of the lower Brazos River. The construction of the authorized Laneport Reservoir project, located on the San Gabriel River at about river mile 29.7, would provide a high degree of flood control on the lower San Gabriel, Little, and Brazos Rivers with respect to flood flows originating on the San Gabriel River watershed.

40. The flood problem areas on the Little and Brazos Rivers investigated for this report are the lower 48.9-mile and 317.9-mile flood plain reaches, respectively, which are affected by flood flows from the San Gabriel River. The channel capacity of the Little River in the vicinity of the mouth of the San Gabriel River is about 6,000 second-feet. However, this is localized and the minimum channel capacity in the remainder of the reach represented by the Cameron gage on the Little River is about 10,000 second-feet. During the period of record (1917-1959), 46 floods occurred on the Little River producing peak discharges ranging from 20,600 to 647,000 second-feet at the Cameron gage. The minimum channel capacity of the Brazos River below Waco is 60,000 second-feet at East Columbia, about 61 miles downstream from Richmond. During the period of record (1903-1959) 25 major floods have occurred on the Brazos River producing peak discharges ranging from 78,800 second-feet to 300,000 second-feet at the Richmond gage. The Little and Brazos River problem areas contain urban and highly-developed agricultural areas, as well as numerous transportation facilities, utilities, and rural non-agricultural properties. Within the investigated Little and Brazos River problem areas, the estimated value of physical property is about $354,525,600 and the estimated annual damages, assuming that none of the eight authorized flood control reservoirs are in operation, are about $9,703,300. Construction and operation of the system of eight authorized reservoir projects would prevent average annual damages estimated to be about $4,116,700, of which about $1,382,300 would be credited to the authorized Laneport Reservoir project.

41. Certain local interests have expressed opposition to the authorized Laneport Reservoir project, asking consideration for alternate upstream multiple-purpose reservoirs. Landowners within the limits of the Laneport Reservoir area state that they are opposed to

the project since it would inundate highly developed agricultural lands.

42. WATER SUPPLY PROBLEMS.- At the public hearing held by the Corps of Engineers at Georgetown, Texas, on March 19, 1958, local interests stated the need for conservation of water for municipal, industrial, and agricultural purposes on the lower Brazos River Basin, including the San Gabriel River watershed. The Brazos River Authority has requested the inclusion of conservation storage in any Federally constructed reservoirs, with assurance that it will purchase such conservation storages included. Representatives of the cities of Cameron, Granger, Georgetown, Thorndale, Rockdale, and Taylor have stated their need for sources of additional water supply, preferably in reservoir sites located upstream from Georgetown, Texas.

43. The U. S. Public Health Service, in cooperation with the Corps of Engineers, has prepared a report covering the municipal and industrial water requirements for the San Gabriel River watershed and for the lower Brazos River Basin. The report, which is presented in appendix IV, states the following conditions and problems:

a. The projected water requirements for the local area, consisting of the cities of Georgetown, Taylor, Thrall, and Thorndale, and for the lower Brazos River area will be about 8.2 million gallons daily and 1,102 million gallons daily, respectively, by the year 2010.

b. Of the 8.2 million gallons daily needed by the local area, it is probable that 2.7 million gallons daily will be supplied by ground water from the Edwards formation.

c. The aggregate firm yield from existing and proposed surface reservoirs in the lower Brazos River Basin totals only about 539 million gallons daily.

d. The maximum capability of ground water in the Brazos River Basin, although not definitely known, is estimated to be about 117 million gallons daily for municipal and industrial purposes.

e. The water originating in the main channel of the Brazos River above Whitney Reservoir generally possesses a high salt content and is largely unsatisfactory for municipal and industrial purposes.

f. The water originating in the main channel of the Brazos River above Whitney Reservoir, even though it is diluted by water of good quality from tributary streams as it moves downstream, is still high in salt content and is mediocre to poor quality on reaching Richmond, Texas, on the lower Brazos River.

g. The water from the San Gabriel River watershed is of good quality.

The report presents the conclusions that the maintenance of acceptable stream quality in the main stem of the lower Brazos is an important problem and that storage for water supply in the maximum amount which can be economically provided should be included in any multiple-purpose projects planned by the Corps of Engineers on the lower Brazos River tributary system. The report also contains economic analyses of a regional alternative plan for water supply upon which are based the present values of benefits for water supply storage at multiple-purpose reservoir project sites planned or proposed by the Corps of Engineers on the principal tributaries of the lower Brazos River.

PROJECT FORMULATION AND SOLUTIONS CONSIDERED

44. PRIMARY CONSIDERATIONS.- The authorized Laneport Reservoir project on the San Gabriel River is a unit in the system of eight Federally authorized reservoirs in the Brazos River Basin. The reservoirs were designed to facilitate control of floods originating on the Brazos River and its major tributaries to provide principally for protection of urban development and highly developed agricultural lands within the flood plains of the lower Brazos River Basin from the vicinity of Waco to the mouth and to provide a source of water supply for municipal, industrial, and other uses. Each reservoir is planned to function as a unit in the system to provide maximum reduction of flood stages on certain portions of the principal tributaries of the river and on the lower Brazos River downstream from Waco. In the investigation of the desirability of modifying the plan for flood control, water conservation, and related water uses on the San Gabriel River watershed, it was concluded that any project or group of projects considered as an alternate for the authorized Laneport Reservoir project should be of a type which could be integrated into the authorized Brazos reservoir system. It should provide for a maximum reduction of flood stages in the Brazos River Basin downstream from Waco to the mouth at least equivalent to that afforded by the system as now authorized; and should also provide for the optimum development of the water supply resources of the San Gabriel River watershed to fulfill the needs of the area as they develop.

45. SOLUTIONS CONSIDERED.- Solutions considered for the combination of flood and water supply problems on the San Gabriel River and the lower portions of the Little and Brazos Rivers involved investigated reservoir projects at the following dam sites: (a) Laneport Dam, San Gabriel River, mile 29.7; (b) North Fork Dam, North Fork of San Gabriel River, mile 4.0; (c) South Fork Dam, South Fork of San Gabriel River, mile 4.7; and (d) Berry Creek Dam, Berry Creek, mile 6.7. Various plans consisting of combinations of these four reservoirs were investigated under two conditions of development: (1) that the reservoir units would be constructed about the same time or within a few years of each other and (2) that the reservoir units would be constructed on the basis of stage development. In accordance with the objective stated in paragraph 44, the more favorable plans which were formulated and investigated included the Laneport Reservoir project as an essential flood control unit in the San Gabriel River watershed. For purposes of project formulation, economic analyses, and cost allocation studies, the reservoir units involved in the investigated plans were analyzed as single-purpose reservoirs for flood control and for water conservation; as dual-purpose reservoirs for flood control and water conservation; as multiple-purpose reservoirs for flood control, water conservation, and fish and wildlife; and as multiple-purpose reservoirs for flood control, water conservation, fish and wildlife, and general recreation. A summary of all of the plans studied, including pertinent information on required controlled storages, dependable yields for

water supply, economic and cost analyses, and maximization of excess benefits over costs for flood control and for water conservation is presented in appendix II. These studies show that stage development of reservoirs considered would be the most practical way to solve the flood control problem and at the same time to meet future water supply needs of the area as they develop.

46. FLOOD CONTROL.- Four reservoirs were studied operating alone and in various combinations to determine the possibility of providing flood control equivalent to that provided by the authorized Laneport Reservoir. The headwater reservoirs were investigated to determine the advisability of providing flood protection in the basin upstream from the authorized Laneport Reservoir. Studies were also made of an upstream system of reservoirs without a lower reservoir at the Laneport site. These studies show conclusively that a lower main stem reservoir at the Laneport site is required to provide control of floods equivalent to that provided by the authorized Brazos Basin project and that the Laneport Reservoir should be considered as the initial flood control unit in any plan of improvement recommended for the San Gabriel River watershed. Studies also show that the North Fork Reservoir and the South Fork Reservoir would provide needed flood protection in the basin above Laneport at a cost commensurate with the flood control benefits. It was also found that the North Fork and South Fork Reservoirs would be desirable adjuncts for flood control to the Laneport Reservoir should there be a need to interchange the flood control storage capacity in the Laneport Reservoir for water supply as the demand therefor develops. Data on the flood control aspects of the six most favorable reservoir plans considered are shown in table 3 following paragraph 51. Studies of the investigated reservoirs were based on adopted flood storage capacities which would provide control of flood volumes having a frequency of occurrence of one or more in 50 years at the respective dam sites.

47. WATER SUPPLY.- The report prepared by the U. S. Public Health Service indicates that the total projected water supply requirements for municipal and industrial purposes in the lower Brazos River Basin will be about 1,102 million gallons daily by year 2010. The report also states that the projected water requirements for the local area, consisting of the cities of Georgetown, Granger, Taylor, Thrall, and Thorndale, will be 8.2 million gallons daily, but that of this total amount, the projected need of 2.7 million gallons daily by Georgetown could be supplied by ground water from the Edwards formation. The Service indicates that the aggregate of firm yield from existing and proposed surface reservoirs, exclusive of the reservoirs being investigated on the San Gabriel River watershed, and from estimated ground water sources for municipal and industrial purposes, will be only about 603 million gallons daily, or about 55 percent of the total demand by year 2010. Because of this apparent deficit in future water supply sources, consideration should be given to the full development

of the good quality water resources of the lower Brazos River Basin during the investigation of multiple-purpose reservoirs. Thus, during the investigation of possible reservoirs on the San Gabriel River watershed, particular consideration has been given to the full development of the water resources upstream from the Laneport Dam site. In view of the Service's report statement that the city of Georgetown could be adequately served by good quality ground water resources from the nearby Edwards formation, the construction of the Laneport project as a first-stage reservoir unit would not preclude resolution of the water supply problems at Georgetown by other means. On the other hand, the Laneport Reservoir project would be satisfactorily located with respect to serving the water supply needs of the Taylor, Granger, Thrall, and Thorndale areas, and possibly the Rockdale area, where generally the ground water resources are not of good quality. On the basis of the supply-demand curve presented in the report prepared by the U. S. Public Health Service, the years of need for the various amounts of storages were considered as follows: (a) first unit (Laneport Reservoir), year 1970; (b) second unit, year 1985; and (c) third unit (or third and fourth units), year 1990.

48. The amount of water conservation storage and estimated dependable yield formulated for the North Fork, South Fork, and Berry Creek Reservoir units represent the approximate maximum as well as the optimum economical development of the water resources of the San Gabriel River watershed above their respective dam sites. In the case of the Laneport Reservoir project, however, the storage capacity of that reservoir is limited to a maximum design water surface not exceeding about elevation 540.0 because of encroachment limitations with respect to the city of Granger, Texas. Economic and cost analyses were also made of a smaller-sized Laneport project.

49. Studies show that conservation storage can be feasibly developed at the investigated reservoir sites that would provide an aggregate dependable yield in the magnitude of 50 million gallons per day. With the storage potential of these and other reservoirs in adjacent basins being in excess of near future water demands, consideration of stage development of water supply in these reservoirs showed this approach to be the most practical. One plan would be to construct the Laneport Reservoir initially with the addition of North Fork Reservoir and South Fork Reservoir as second- and third-stage developments, respectively. Under this concept, the Laneport Reservoir could be first constructed with flood control capacity the same as the authorized project at this site, and with water supply storage having a dependable yield of about 27.8 mgd. As need for additional water from San Gabriel River Basin develops, the storage capacity in Laneport Reservoir could be interchanged between flood control and water supply as the second and other stage elements of the plan were undertaken. This type of development would be a reasonable approach to solving the water supply problem of the area since the initial development would meet the near future demand for water from the

San Gabriel River (and also provide needed flood protection) and the second and other stage developments have the potential for meeting more distant future needs as they develop.

50. DEPENDABLE RESERVOIR YIELDS.- For this report the dependable reservoir yield is defined as the maximum continuous rate at which water may be withdrawn from a reservoir in order that the total conservation storage provided in the reservoir will just be depleted under maximum drought conditions of record. Estimates of dependable reservoir yields for projects investigated on the San Gabriel River watershed are based on estimated monthly resources under present conditions of watershed development.

51. SUMMARY.- Twelve different reservoir systems under stage development were given detailed consideration for purposes of this study. These studies show that the Laneport project, the second-stage North Fork Reservoir, and the third-stage South Fork Reservoir, is the most practical plan (designated plan 10B) for flood control and water conservation. This plan would provide the maximum degree of flood protection for the lower Little and Brazos Rivers against floods originating on the San Gabriel River watershed, as well as substantial flood protection for the San Gabriel River downstream from the vicinity of Georgetown, Texas; and would provide for the maximum economical conservation of the good quality water available on the San Gabriel River watershed, and thus would contribute very favorably toward fulfillment of the present and future water supply requirements for the lower Brazos River Basin, including the lower San Gabriel River area. In addition, this plan would provide substantial opportunities for sport fishing and wildlife hunting and for general recreation. Table 3 that follows contains pertinent data on six stage-development plans that are more favorable than other plans investigated. Plan 10B is the selected plan of improvement that is covered in more detail in the remainder of this report.

TABLE 3

SUMMARY OF ECONOMIC AND COST ANALYSES - SOLUTIONS CONSIDERED
STAGE DEVELOPMENT PLANS
SAN GABRIEL RIVER WATERSHED
(Laneport Reservoir with Total Controlled Storage of 331,900 Acre-feet -
To Provide Maximum Water Supply Resource Development Allowable within Reservoir Site Limitations)

Plan No.	Reservoir units	Period of use or stage	Reservoir storage (acre-feet)				Dependable yield		Annual charges (1000 dollars)			Average annual benefits over 50 years (1000 dollars)							Benefit-cost ratio			Excess benefits (1000 dollars)		
			Sediment	Flood control	Water conservation	Total	cfs	mgd	FC & WC	FC,WC,FW	FC,WC,FW,R	FC	WC	FW	R	Total FC & WC	Total FC,WC,FW	Total FC,WC,FW,R	FC & WC	FC,WC,FW	FC,WC,FW,R	FC & WC	FC,WC,FW	FC,WC,FW,R
1B	Laneport	1970-2020	27,700	236,100	68,100	331,900	43	27.8	941.2	953.5	994.3	2,206.6	559.4	50.0	585.0	2,766.0	2,816.0	3,401.0	2.9	3.0	3.4	1,824.8	1,862.5	2,406.7
	Incremental between plans 1B & 7B								256.5	260.4	275.1					240.3	250.3	428.7	0.94	0.96	1.6	-16.1	-10.1	153.6
7B	Laneport	1970-1985	27,700	236,100	68,100	331,900	43	27.8	941.9	954.2	995.0	2,081.1	579.3	50.0	433.4	2,660.4	2,710.4	3,143.8	2.8	2.8	3.2	1,718.5	1,756.2	2,148.8
	Laneport	1985-2020	26,700	216,800	88,400	331,900	45	29.1																
	Berry Creek	1985-2035	2,800	26,800	14,400	44,000	6	3.9	255.7	259.7	274.4	238.2	107.7	10.0	330.0	345.9	355.9	685.9	1.4	1.4	2.5	90.2	96.2	411.5
	Total		29,500	243,600	102,800	375,900	51	33.0	1,197.6	1,213.9	1,269.4	2,319.3	687.0	60.0	763.4	3,006.3	3,066.3	3,829.7	2.5	2.5	3.0	1,808.7	1,852.4	2,560.3
	Incremental between plans 1B & 8B								303.4	310.0	339.5					483.0	502.8	901.2	1.6	1.6	2.7	179.6	192.8	561.7
8B	Laneport	1970-1985	27,700	236,100	68,100	331,900	43	27.8	945.0	957.3	998.1	2,029.5	569.3	47.8	433.4	2,598.8	2,646.6	3,080.0	2.8	2.8	3.1	1,653.8	1,689.3	2,081.9
	Laneport	1985-2020	26,000	198,400	107,500	331,900	44	28.4																
	South Fork	1985-2035	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	345.0	305.2	22.0	550.0	650.2	672.2	1,222.2	2.2	2.2	3.6	350.6	366.0	886.5
	Total		30,000	243,900	196,500	470,400	61	39.4	1,244.6	1,263.5	1,333.8	2,374.5	874.5	69.8	983.4	3,249.0	3,318.8	4,302.2	2.6	2.6	3.2	2,004.4	2,055.3	2,968.4
	Incremental between plans 1B & 9B								474.4	483.0	519.1					816.2	835.0	1,233.4	1.7	1.7	2.4	341.8	352.0	714.3
9B	Laneport	1970-1985	27,700	236,100	68,100	331,900	43	27.8	946.3	958.6	999.4	1,901.8	533.7	47.8	433.4	2,435.5	2,483.3	2,916.7	2.6	2.6	2.9	1,489.2	1,524.7	1,917.3
	Laneport	1985-2020	23,000	161,100	147,800	331,900	39	25.2																
	North Fork	1985-2035	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	633.9	512.8	21.0	550.0	1,146.7	1,167.7	1,717.7	2.4	2.4	3.3	677.4	689.8	1,203.7
	Total		30,000	249,000	274,500	553,500	69	44.6	1,415.6	1,436.5	1,513.4	2,535.7	1,046.5	68.8	983.4	3,582.2	3,651.0	4,634.4	2.5	2.5	3.1	2,166.6	2,214.5	3,121.0
	Incremental between plans 9B & 10B								303.5	310.1	339.6					388.3	401.6	465.4	1.3	1.3	1.4	84.8	91.5	125.8
10B	Laneport	1970-1985	27,700	236,100	68,100	331,900	43	27.8																
	Laneport	1985-1990	23,000	161,100	147,800	331,900	39	25.2	950.2	962.5	1,003.3	1,819.7	508.2	43.8	405.5	2,327.9	2,371.7	2,777.2	2.4	2.5	2.8	1,377.7	1,409.2	1,773.9
	Laneport	1990-2020	22,200	116,500	193,200	331,900	34	22.0																
	North Fork	1985-1990	7,000	87,900	126,700	221,600	30	19.4																
	North Fork	1990-2035	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	582.5	512.8	19.3	351.7	1,095.3	1,114.6	1,466.3	2.3	2.3	2.9	626.0	636.7	952.3
	South Fork	1990-2040	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	274.3	273.0	19.0	290.0	547.3	566.3	856.3	1.8	1.8	2.6	247.7	260.1	520.6
	Total		33,200	249,900	408,900	692,000	81	52.4	1,719.1	1,746.6	1,853.0	2,676.5	1,294.0	82.1	1,047.2	3,970.5	4,052.6	5,099.8	2.3	2.3	2.8	2,251.4	2,306.0	3,246.8
	Incremental between plans 10B & 11B								259.6	263.6	278.3					139.1	144.1	187.0	0.54	0.55	0.67	-120.5	-119.5	-91.3
11B	Laneport	1970-1985	27,700	236,100	68,100	331,900	43	27.8																
	Laneport	1985-1990	23,000	161,100	147,800	331,900	39	25.2	954.1	966.4	1,007.2	1,772.8	487.8	43.8	383.4	2,260.6	2,304.4	2,687.8	2.4	2.4	2.7	1,306.5	1,338.0	1,680.6
	Laneport	1990-2020	20,600	96,300	215,000	331,900	30	19.4																
	North Fork	1985-1990	7,000	87,900	126,700	221,600	30	19.4																
	North Fork	1990-2035	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	554.8	512.8	19.3	301.7	1,067.6	1,086.9	1,388.6	2.3	2.3	2.7	598.3	609.0	874.6
	South Fork	1990-2040	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	256.7	247.2	19.0	290.0	503.9	522.9	812.9	1.7	1.7	2.4	204.3	216.7	477.2
	Berry Creek	1990-2040	2,800	26,800	14,400	44,000	6	3.9	255.7	259.7	274.4	169.8	107.7	5.0	115.0	277.5	282.5	397.5	1.1	1.1	1.4	21.8	22.8	123.1
	Total		34,400	256,500	445,100	736,000	83	53.7	1,978.7	2,010.2	2,131.3	2,754.1	1,355.5	87.1	1,090.1	4,109.6	4,196.7	5,286.8	2.1	2.1	2.5	2,130.9	2,186.5	3,155.5

All plans include flood control (FC), water conservation (WC), fish & wildlife (FW), and recreation (R)

52. PROPOSED PLAN OF IMPROVEMENT.- The proposed plan of improvement on the San Gabriel River watershed is plan 10B, a plan of stage development, which provides for the modification and construction of the authorized Laneport Reservoir project as a first-stage reservoir unit, and the subsequent construction of the North Fork and South Fork Reservoirs, as second-stage and third-stage reservoir units, respectively. The proposed Laneport Dam would be located on the San Gabriel River at about river mile 29.7, about 8 miles east of Granger, Texas, and about 10 miles northeast of Taylor. The proposed North Fork Dam would be located on the North Fork of the San Gabriel River at about river mile 4.0, about 3.5 miles west of Georgetown, Texas, and about 36.8 miles upstream from the Laneport Dam site. The proposed South Fork Dam would be located on the South Fork of the San Gabriel River at about river mile 4.7, about 3 miles south of the proposed North Fork Dam. The proposed Laneport, North Fork, and South Fork Reservoir projects would be constructed for flood control, water conservation, fish and wildlife, and recreation purposes. Pertinent data for the proposed Laneport Reservoir under ultimate development conditions and for the proposed North Fork and South Fork Reservoirs are shown in table 4. Table 4 shows pertinent data for the proposed Laneport Reservoir project for first-stage and second-stage operation, setting forth only the deviations from the ultimate conditions, particularly with respect to data on spillway design flood conditions, reservoir elevations, areas, and storage capacities. The locations of the proposed reservoirs are shown on plate 1. The Laneport, North Fork, and South Fork Reservoir areas are shown on plates 10, 12, and 14, respectively. The detailed layout and typical sections of the appurtenant features of the Laneport, North Fork, and South Fork Dams are shown on plates 11, 13, and 15, respectively.

53. LANEPORT DAM.- The Laneport Reservoir would be formed by a main earth dam having a length of about 15,060 feet and a maximum height above streambed of about 111 feet. The spillway, located on the right abutment, would consist of a gate-controlled concrete ogee structure. The spillway section, 664 feet long, including fourteen tainter gates, each 40 feet wide by 29 feet high, and thirteen 8-foot piers, would be flanked by nonoverflow sections each 142 feet in length. The outlet works would be located in the Willis Creek channel and through the left-bank portion of the earth embankment. The outlet works would consist of an intake tower, operating house, a concrete and steel service bridge, a 19-foot diameter conduit through the embankment with inlet invert at elevation 450.0, a concrete stilling basin, and an excavated outlet channel to the San Gabriel River. Three 5-foot, 9-inch by 19-foot tractor gates, located in the intake tower near the upstream end of the conduit, would control the flows through the conduit.

54. LANEPORT RESERVOIR.- The Laneport Reservoir project would have the following surface areas and elevations at top of conservation pool during the various stages of development set forth by the proposed plan of improvement: first stage, 5,250 acres, elevation 503.8; second stage, 8,270 acres, elevation 515.7; and third or ultimate stage, 9,730 acres, elevation 520.8. For all conditions of stage development, the Laneport Reservoir would have a surface area of 13,440 acres at top of flood control pool (or top of spillway gates), elevation 531.0. For purposes of economy, land and relocation requirements at the Laneport Reservoir site would be based on the ultimate, or third-stage conditions. Lands required for reservoir operation, construction of the proposed dam, and recreation areas and facilities amount to about 13,100 acres in fee simple and 2,900 acres in flowage easements. Of this total land requirement, 90 percent is classified as cropland, 8 percent as pastureland, and 2 percent as woodland. Construction of the Laneport Reservoir project would necessitate the relocation of about 4.4 miles of farm-to-market roads, 2 miles of county roads, 10 miles of power lines, 9 miles of telephone lines, 1 cemetery, and the town of Friendship. Estimated construction costs for the dam include the estimated cost of a county highway across the dam. There are no required relocation of Federal or State highways or railroads.

55. NORTH FORK DAM.- The North Fork Reservoir would be formed by a rock-fill dam having a length of about 12,370 feet and a maximum height above streambed of 188 feet. The spillway, located on the right abutment, would consist of an uncontrolled broadcrested spillway 1,600 feet long, excavated to natural rock. The spillway would discharge into the Middle Fork of the San Gabriel River. The outlet works would be located through the embankment on the right bank of the North Fork of San Gabriel River and would consist of an intake tower, operating house, a concrete and steel service bridge, a 10-foot diameter conduit through the embankment with inlet invert at elevation 700.0, and a concrete stilling basin. Two 5-foot, 8-inch by 10-foot manually operated slide gates, located near the upstream end of the conduit in the intake tower, would control the flows through the conduit.

56. NORTH FORK RESERVOIR.- The North Fork Reservoir would have a surface area of 3,210 acres at top of conservation pool, elevation 832.8, and an area of 5,000 acres at top of flood control pool, or spillway crest, elevation 855.0. Lands required for reservoir operation, construction of the proposed dam, and for recreation areas and facilities amount to about 4,900 acres in fee simple and 1,920 acres in flowage easements. Of this total land requirement, 46 percent is classified as cropland, 34 percent as pastureland, and 20 percent as woodland. About 300 acres of land in flowage easements would be required for the increased discharges being diverted into the Middle Fork of the San Gabriel River. Construction of the North Fork Reservoir would necessitate the relocation of about 14.3 miles

TABLE 4

PERTINENT DATA
MULTIPLE-PURPOSE RESERVOIRS
PLAN 10B - PROPOSED PLAN OF IMPROVEMENT
SAN GABRIEL RIVER WATERSHED

ITEM	LANEPORT RESERVOIR First Stage	LANEPORT RESERVOIR Second Stage	LANEPORT RESERVOIR Ultimate Stage	NORTH FORK RESERVOIR	SOUTH FORK RESERVOIR
DRAINAGE AREA					
Total	711	711	711	236	120
Intercepted by North Fork Reservoir		(236)	(236)		
Intercepted by South Fork Reservoir			(120)		
SPILLWAY DESIGN FLOOD					
Peak inflow, cfs	637,000	631,800	630,700	444,800	304,800
Volume, acre-feet	1,026,700	1,026,700	1,026,700	383,100	207,400
Volume, inches	27.08	27.08	27.08	30.41	32.24
Peak outflow, cfs	546,800 (1)	508,000 (1)	530,000 (1)	326,000 (1)	195,100 (1)

RESERVOIR	Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)(3)	Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)(4)	Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)(5)	Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Elev.(2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
Sediment storage	503.8	--	19,700	0.52	515.7	--	20,200	0.80	520.8	--	20,700	1.09	832.8	--	5,800	0.46	843.4	--	3,500	0.55
	531.0	--	27,700	0.73	531.0	--	22,900	0.90	531.0	--	22,200	1.17	855.0	--	7,000	0.56	860.0	--	4,000	0.63
Top of conservation pool													832.8	3,210	132,500	10.52	843.4	2,340	92,500	14.45
Spillway crest	502.0	4,790	78,900	2.08	502.0	4,790	78,900	3.11	502.0	4,790	78,900	4.17	855.0	5,000	221,600	17.61	860.0	3,210	138,500	21.64
Top of conservation pool	503.8	5,250	87,800	2.32	515.7	8,270	168,100	6.63	520.8	9,730	213,900	11.30								
Top of gates	531.0	13,440	331,900	8.75	531.0	13,440	331,900	13.10	531.0	13,440	331,900	17.53	--	--	--	--	--	--	--	--
Top of flood control pool	531.0				531.0				531.0	13,440	331,900	17.53	855.0				860.0			
Maximum design water surface	540.9	16,960	482,400	12.72	539.0	16,290	450,800	17.79	540.0	16,640	467,300	24.68	872.2	6,400	319,700	25.40	876.6	4,020	198,400	31.00
Top of dam	546.0				546.0				546.0				878.0				882.0			
Maximum tailwater	477.0				476.1				476.6				754.2				755.8			

DAM	SEE ULTIMATE STAGE	SEE ULTIMATE STAGE			
Type			Concrete and earth fill	Rock fill, impervious core	Rock fill, impervious core
Total length, feet			16,000	12,370	7,100
Embankment section:					
Type			Compacted earth fill	Rock fill, impervious core	Rock fill, impervious core
Total length, feet			15,060	10,770	6,100
Height above stream bed, feet			111	188	167
Freeboard, feet			6.0	5.8	5.4
Crown width, feet			42	20	20
Side slope					
Upstream			1 on 2-1/2 & 1 on 3-1/2	1 on 2-1/2	1 on 2-1/2
Downstream			1 on 2-1/2 & 1 on 3-1/2	1 on 2-1/4 & 1 on 2-1/2	1 on 2-1/4 & 1 on 2-1/2
Non-overflow section					
Type			Concrete gravity	None	None
Total length, feet			284		
Height above apron, feet			122		
Top width, feet			24		
Spillway section:					
Type			Concrete ogee	Broadcrested	Broadcrested
Gross length, feet			664	1,600	1,000
Net length, feet			560	1,600	1,000
Crest height above apron, feet			78		
Gates:				Uncontrolled	Uncontrolled
Type			Tainter	--	--
Number			14	--	--
Size (width x height)(feet)			40 x 29	--	--
Spillway discharge, cfs					
Top of gates	335,600	335,600	335,600	--	--
Maximum design water surface	530,400	491,800	513,700	320,200	189,700
OUTLET WORKS	SEE ULTIMATE STAGE	SEE ULTIMATE STAGE			
Type			Gate-controlled conduit	Gate-controlled conduit	Gate-controlled conduit
Number of sluices, conduits			1	1	1
Dimensions			19' diameter	10' diameter	10' diameter
Invert elevation, feet			460.0	700.0	728.0
Sluice control			3 - 5'9" x 19' tractor gates	2 - 5'8" x 10' manually operated slide gates	2 - 5'8" x 10' manually operated slide gates
RELOCATIONS	SEE ULTIMATE STAGE	SEE ULTIMATE STAGE			
U. S. highways, miles			None	None	None
State highways, miles			None	None	None
F. M. roads, miles			4.4	None	None
County roads, miles			2.0	14.3	3.7
Railroads, miles			None	None	None
Power lines, miles			10.0	12.0	4.7
Telephone lines, miles			9.0	4.8	None
Cemeteries, number			1	1	1
Towns, number			None	None	None
LANDS	SEE ULTIMATE STAGE	SEE ULTIMATE STAGE			
Clearing, acres			4,285	4,080	3,193
Land acquisition:					
Fee simple, acres			13,220	4,960	3,360
(Top control elev.)			(526.0)	(839.0)	(847.0)
Flood easements, acres			2,900	1,920	600
(Top control elev.)			(534.0)	(858.0)	(863.0)
(1) Includes discharge through outlet works, cfs	16,400	16,200	16,300	5,800	5,400

(2) All elevations refer to mean sea level
(3) Based on drainage area of 711 square miles
(4) Based on drainage area of 711 - 236, or 475 square miles
(5) Based on drainage area of 711 - 236 - 120, or 355 square miles
(6) Includes 300 acres of flood easement on Middle Fork for spillway discharges

of county roads, about 12 miles of power lines, and 1 cemetery. There are no required relocations of Federal, State, or farm-to-market highways, railroads, or towns.

57. SOUTH FORK DAM.- The South Fork Reservoir would be formed by a rock-fill dam having a length of about 7,100 feet and a maximum height about the streambed of 167 feet. The spillway, located on the right abutment, would consist of an uncontrolled broadcrested spillway 1,000 feet long, excavated to natural rock. The spillway would discharge into a small tributary of the South Fork of San Gabriel River. The outlet works would be located through the embankment on the left bank of the South Fork of San Gabriel River, and would consist of an intake tower, operating house, a concrete and steel service bridge, a 10-foot diameter conduit through the embankment with inlet invert at elevation 728.0, and a concrete stilling basin. Two 5-foot, 8-inch by 10-foot manually operated slide gates, located near the upstream end of the conduit in the intake tower, would control the flows through the conduit.

58. SOUTH FORK RESERVOIR.- The South Fork Reservoir would have a surface area of 2,340 acres at top of conservation pool, elevation 843.4, and an area of 3,210 acres at top of flood control pool, or spillway crest, elevation 860.0. Lands required for reservoir operation, construction of the proposed dam, and for recreation areas and facilities amount to 3,305 acres in fee simple and 600 acres in flowage easements. Of this total land requirement, 78 percent is classified as cropland, 12 percent as pastureland, and 10 percent as woodland. Construction of the South Fork Reservoir would necessitate the relocation of about 3.7 miles of county roads, about 4.7 miles of power lines, and 1 cemetery. There are no required relocations of Federal, State, or farm-to-market highways, railroads, or towns.

59. GENERAL CRITERIA FOR RESERVOIR STORAGE CAPACITIES.- In establishing storage capacities for reservoirs investigated on the San Gabriel River watershed, consideration was given to the following: (1) the location of the reservoir site with respect to the area in which the greatest concentration of flood damages have been experienced; (2) the uncontrolled areas lying below the reservoir site; (3) the ability of the reservoir to control the floods of record from its contributing drainage area and also satisfy regional flood-control storage requirements; (4) the additional flood protection and flexibility of operation that might be obtained by withholding reservoir releases; (5) the regulated releases from other reservoirs in the Brazos River system; (6) the channel capacities of the San Gabriel River below the damsite and of the Little River below the mouth of the San Gabriel River and on the Brazos River below the mouth of the Little River; (7) the existing and proposed regional development of the water resources; and (8) allowance for the reduction in reservoir capacity resulting from anticipated sedimentation.

60. SEDIMENT STORAGE.- Sufficient sediment storage was provided to permit sediment deposition for a period of 50 years in each reservoir investigated on the San Gabriel River watershed. The sediment storage in Laneport Reservoir was varied to correspond with the appropriate state of development. The following tabulation presents pertinent data as to the amount of sediment storage provided in 1,000 acre-feet and its distribution between the water conservation and flood control pools of the proposed reservoir projects.

Reservoir	Stage 1			Stage 2			Stage 3 (ultimate)		
	Total	WC pool	FC pool	Total	WC pool	FC pool	Total	WC pool	FC pool
Laneport	27.7	19.7	8.0	22.9	20.2	2.7	22.2	20.7	1.5
North Fork	-	-	-	7.0	5.8	1.2	7.0	5.8	1.2
South Fork	-	-	-	-	-	-	4.0	3.5	0.5

61. CONSERVATION STORAGE.- In determining the conservation storage capacity which should be provided in reservoirs investigated on the San Gabriel River watershed, cognizance was taken of the requests of local interests and of probable future water requirements in the region. Yield versus storage relationships were established, and cost estimates were developed for several increments of conservation storage. As a result of these studies and with allocation of storage quantities in Laneport Reservoir varied to correspond with the stage of development, the following net conservation storage quantities (in 1,000 acre-feet and in inches) have been provided in the proposed reservoirs.

Reservoir	Stage 1			Stage 2			Stage 3 (ultimate)		
	Conservation storage		Yield	Conservation storage		Yield	Conservation storage		Yield
	(ac-ft)	(in)	(cfs)	(ac-ft)	(in)	(cfs)	(ac-ft)	(in)	(cfs)
Laneport	68.1	1.80	43	147.9	5.84	39	193.2	10.20	34
North Fork	-	-	-	126.7	10.07	30	126.7	10.07	30
South Fork	-	-	-	-	-	-	89.0	13.91	17

The dependable yields shown in the above tabulation are based on the most severe drought period of record on the watershed (1947-1957) and under present conditions of watershed development. The above storage capacities would provide for development of approximately 94 percent of the water supply resources available on the San Gabriel River watershed upstream from the Laneport Dam site. As indicated in

paragraph 11, appendix I, studies indicate that on the basis of 50 years of watershed development, including a potential Soil Conservation Service program on the San Gabriel River watershed, the proposed conservation storage would yield during the critical drought period the following amounts of dependable water supply:

Reservoir	Stage 1 Yield (cfs)	Stage 2 Yield (cfs)	Stage 3 Yield (cfs)
Laneport	38	34	29
North Fork	-	26	26
South Fork	-	-	15

62. FLOOD CONTROL STORAGE.- A regional analysis of flood control storage requirements in the Brazos River Basin indicated that, in order to provide a high and uniform degree of flood protection for the affected areas, each reservoir in the basin should be provided with sufficient flood control storage to regulate the 50-year flood from its watershed area to nondamaging proportions downstream. Flood control storage requirements for reservoirs investigated on the San Gabriel River watershed were based on routings of the hypothetical 50-year floods through the reservoirs. The 50-year hypothetical floods were determined from experienced storms on the watershed and developed for both the entire area above Laneport and the intervening areas from North Fork and South Fork to Laneport. The storms were centered on the watershed to determine the most critical requirements for flood control storage under the various stages of development. The flood control storage in 1,000 acre-feet provided in the proposed reservoirs during each stage of development is shown in the following tabulation.

Reservoir	Stage 1 Flood control storage	Stage 2 Flood control storage	Stage 3 (ultimate) Flood control storage
Laneport	236.1	161.1	116.5
North Fork	-	87.9	87.9
South Fork	-	-	45.5

63. FOUNDATION CONDITIONS - LANEPORT DAM.- In 1946, six core borings were drilled at the Laneport Dam site. Overburden materials penetrated by the borings consist of silts and clays with variable

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amounts of sand and gravel and average about 33 feet in depth. In the flood plain, the embankment foundation consists of sandy clay, approximately thirteen feet thick, overlying a stratum of silty sand and sand that is about seventeen feet thick. The residuum on the abutments and the alluvium in the flood plain area are underlain by the Taylor formation of Upper Cretaceous age. The Taylor is a firm, impervious and massive, calcareous, dark gray shaley clay which has all of the characteristics of shale with the exception of lamination. The shale strata are compact, impervious, and structurally sound. No notable structural features were found in the dam site area. The Taylor strata dip southeastward from 50 to 60 feet per mile in a normal monoclinal structure. The impervious strata of the Taylor formation are structurally sound and should form a satisfactory foundation for the proposed dam.

64. FOUNDATION CONDITIONS - NORTH FORK DAM.- There is no appreciable soil mantle on the hills forming the abutments of the North Fork Dam site, and there are very limited deposits of silty and clayey sands and sandy clays in the river bed. The abutments are covered with broken limestone and clay residuum varying from 5 feet to 10 feet in thickness. One boring located on the stream bank penetrated 11 feet of alluvium consisting of variably sandy silt and silty sand. The two borings located south of the stream were drilled to determine foundation conditions on the right abutment and in a proposed spillway area. Both borings encountered the Edwards limestone immediately underlying the overburden and the core holes were bottomed in the Comanche Peak limestone. The elevations of the contact between these two formations of the Fredericksburg group of Lower Cretaceous formations were 746.9 feet above mean sea level in one boring and 758.3 feet in the second boring, indicating a reversal in the normal direction of dip in primary strata and the probable existence of a fault of small vertical displacement through the proposed spillway saddle. The boring on the left bank of the stream encountered the Comanche Peak limestone beneath the overburden at a depth of 11.0 feet below the ground surface and the boring was drilled into a dark gray calcareous shale between 25.4 feet (elevation 682.9 feet) and the bottom of the boring at 30.8 feet (elevation 677.5 feet). The clay-shale is believed to represent the top of the Walnut clay, which is the basal member of the Fredericksburg group of formations.

65. FOUNDATION CONDITIONS - SOUTH FORK DAM.- The soil mantle on the abutments and abutment slopes is very thin at the South Fork Dam site. Residual clay and weathered limestone boulders, ranging from a few inches to 8 to 10 feet in thickness, cover primary strata of the Fredericksburg group of Lower Cretaceous age. A boring located on the stream bank indicated that alluvial materials consisting of clay, clayey sand, clayey gravel, and sandy silt are about 18 feet thick in the flood plain at the dam site. Two borings drilled on the west (right) abutment showed that the site is underlain by

limestone strata of the Edwards and Comanche Peak formations of the Fredericksburg group. Limited information from these two borings indicate that the dip of the limestone in the dam site area is normal to the east and southeast. The Edwards is a hard, vuggy to honeycombed limestone, whereas the Comanche Peak is a softer, argillaceous, nodular limestone. The borings indicated that leakage may be expected to take place through the Edwards strata unless remedial measures, such as grouting, are performed at the site. The Comanche Peak was found to be impervious. The boring drilled in the flood plain area penetrated very argillaceous limestone and shale strata of the Walnut formation, the oldest member of the Fredericksburg group. The Walnut strata penetrated were also found to be impervious.

66. The borings indicate that leakage may be expected to take place through the Edwards strata. Limited testing has not revealed quantity of seepage that may be anticipated; however, the seepage can be minimized or relieved by remedial measures, such as grouting, to the extent that there would be no material reduction in the estimated dependable water supply yield in the proposed project. The type of relief needed and the areas requiring treatment can be determined during the final planning stage when more detailed investigations are made at the project site. The total estimated cost of the proposed project is sufficient to cover the cost of any remedial work for seepage control at the proposed dam site.

67. AVAILABILITY OF MATERIALS - LANEPORT DAM.- At the Laneport Dam site adequate quantities of fill materials are available from the river valley and the abutments for construction of an earthen embankment. Both pervious and impervious materials are available in quantity. Satisfactory stone for concrete aggregate and protection stone is available from commercial producers at New Braunfels and Burnet. Both sources are limestones, the Burnet stone being dolomitic. It may be possible to develop sources of satisfactory stone near Austin, but the Cretaceous sections in that area contain numerous interbedded strata of unsatisfactory material. Rail-haul costs are moderately high. There is little possibility of developing sources nearer the site. Gravel of approximately 3-inch maximum size can be obtained from commercial producers at Austin. The gravel is chiefly siliceous with some limestone particles in the larger sizes. Quality is satisfactory. There is a possibility of developing local sources somewhat nearer the site. Siliceous sand containing a small percentage of granitic particles is available from commercial producers near Austin. Quality and grading are satisfactory for concrete. There is a possibility of developing local sources nearer the site.

68. AVAILABILITY OF MATERIALS - NORTH AND SOUTH FORK DAMS.- At the North Fork and South Fork Dam sites a large portion of the embankment will be rolled rock fill, constructed of material taken from required excavation for the spillways. The rock is not of suitable

quality for a sluiced rock fill. Suitable material for an impervious core may be obtained from an area northeast of Georgetown, approximately four to five haul-miles from the dam sites.

69. FISH, WILDLIFE, AND RECREATIONAL FACILITIES.- In conformance with reports and recommendations prepared by the National Park Service and the Bureau of Sport Fisheries and Wildlife, essential facilities would be included in the Laneport, North Fork, and South Fork Reservoir projects for development of the potential aspects for fishing, hunting, and general recreation activities. Basic facilities to be provided in the development of the proposed project include necessary access roads, parking areas, 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 add to the visitors' enjoyment of 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.

COSTS, CHARGES, AND BENEFITS

70. FIRST COST AND ANNUAL CHARGES.- Estimates of first costs and annual charges for multiple-purpose reservoir projects at the Laneport, North Fork, and South Fork sites, proposed under stage-development plan 10B, are summarized in table 5. The estimates are based on July 1, 1961 price level. Detailed estimates of first cost for the three proposed reservoir projects are shown in tables 21, 22, and 23, appendix II. **(See paragraph 103.)**

71. FLOOD CONTROL BENEFITS.- The average annual damages in the area receiving protection from the authorized eight-reservoir system in the Brazos River Basin are estimated at $14,879,000, based on the present state of development and price levels of July 1, 1961. It is further estimated that $12,204,600 of these damages would be prevented by the system of reservoirs. In accordance with the projections developed in the economic base study presented as appendix III of this report, a development factor of 1.60 was applied to these prevention of damage benefits, bringing the total benefits to $19,527,400. These benefits were distributed among the eight reservoirs by crediting each project with benefits based on its service as an integral unit of the plan for flood protection in the Brazos River Basin. In determining these benefits for the Laneport Reservoir as authorized, the reservoir was credited with the benefits it would produce independently along the reaches of the San Gabriel River below the dam site, and an equitable share of the benefits it will provide along the Little River and Brazos River in conjunction with other units of the plan. Flood control benefits for Laneport Reservoir were thus determined to be $2,206,600. Adding the North and South Fork Reservoirs to the system in accordance with the proposed plan of improvement for the San Gabriel River watershed provides additional flood control benefits of $113,900, bringing the total flood control benefits for the combined Laneport, North Fork, and South Fork Reservoirs to $2,320,500. However, under the proposed plan of stage development, the system of three reservoirs would provide composite annual flood control benefits amounting to $2,676,500, as determined by the method described in paragraph 12 of appendix II.

72. WATER CONSERVATION BENEFITS.- The estimate of water supply benefits for Laneport Reservoir as contained in the project document was $20,200 annually. These benefits were based upon a dependable regulated flow of 20.2 second-feet at an estimated value of $1,000 per second-foot, or $0.00424 per 1,000 gallons. For this report, the benefits creditable to Laneport, the North Fork, and South Fork Reservoirs were evaluated on the basis of values of water supply storage as furnished by the U. S. Public Health Service in its report dated July 1960. As explained in paragraph 17 of appendix II, the water conservation benefits were estimated on the basis of a unit value of $0.0761 per 1,000 gallons of dependable yield for

TABLE 5
SUMMARY OF FIRST COSTS AND ANNUAL CHARGES
PROPOSED PLAN OF IMPROVEMENT - PLAN 10B
SAN GABRIEL RIVER WATERSHED
(July 1, 1961 price level)

Item	Costs in thousand dollars		
	Laneport	North Fork	South Fork
FIRST COSTS *			
1. FEDERAL FIRST COST			
Lands and damages	5,240.0	1,595.0	1,273.0
Relocations	327.0	393.0	56.0
Reservoirs	411.0	392.0	306.7
Dam	14,400.0	7,360.0	4,030.0
a. Embankment	(4,071.0)	(1,230.0)	(1,380.0)
b. Slope protection	(29.0)	--	--
c. Spillway	(7,890.0)	(4,720.0)	(1,470.0)
d. Outlet works	(2,410.0)	(1,410.0)	(1,180.0)
Fish and wildlife facilities	155.0	98.0	73.3
Access road	9.0	16.0	14.0
Recreation facilities	365.0	285.0	261.0
Buildings and grounds	118.0	121.0	120.0
Operating equipment	65.0	59.0	55.0
Preauthorization costs	44.0	10.0	10.0
Engineering and design	1,050.0	663.8	487.4
Supervision and administration	1,260.0	817.2	543.6
Total net Federal first cost	23,444.0	11,810.0	7,230.0
2. NON-FEDERAL FIRST COST	none	none	none
3. TOTAL ESTIMATED FIRST COST OF PROJECT	23,444.0	11,810.0	7,230.0
4. LESS PREAUTHORIZATION COST	44.0	10.0	10.0
5. TOTAL CONSTRUCTION COST OF PROJECT	23,400.0	11,800.0	7,220.0
ANNUAL CHARGES *			
(Interest rate - 2.625%) (Amortization period - 50 years)			
Construction period, years	5	3	3
1. FEDERAL INVESTMENT			
a. Federal first cost	23,444.0	11,810.0	7,230.0
b. Interest during construction	1,532.0	465.0	285.0
Total Federal investment	24,976.0	12,275.0	7,515.0
2. NON-FEDERAL INVESTMENT	none	none	none
3. FEDERAL ANNUAL CHARGES			
a. Interest on investment	655.6	322.3	197.3
b. Amortization of investment	247.0	121.4	74.3
c. Maintenance and operation (including replacement of parts)	100.7	70.3	64.1
Net Federal annual charges	1,003.3	514.0	335.7
4. NET NON-FEDERAL ANNUAL CHARGES	none	none	none
5. TOTAL ESTIMATED ANNUAL CHARGES	1,003.3	514.0	335.7

*See paragraph 103

storage not made available until the year of need and on a discounted value of $0.0488 per 1,000 gallons for storage made available by the year 1970 but not needed until the period between the years of 1985 and 1990. By applying these unit values to the water requirements at the various stages of reservoir development, it was determined that the composite water conservation benefits creditable to Laneport, North Fork, and South Fork Reservoirs are $508,200, $512,800, and $273,000, respectively.

73. FISH AND WILDLIFE BENEFITS.- The Bureau of Sport Fisheries and Wildlife presents in its report estimates of net fish and wildlife benefits for the proposed stage-development plan 10B as follows: First stage, Laneport Reservoir, $50,000; second stage, Laneport and North Fork Reservoirs, $67,000; and third stage, Laneport, North Fork, and South Fork Reservoirs, $75,000. For purposes of economic analysis under stage-development conditions, the total net fish and wildlife benefits estimated by the Bureau were apportioned (as shown in table 5, appendix II) to the three reservoir units of the proposed plan 10B as follows: First stage, Laneport, $50,000; second-stage, Laneport, $46,000 and North Fork, $21,000; third stage, Laneport, $37,000, North Fork, $19,000, and South Fork, $19,000. Construction of the proposed reservoir units would result in losses to existing fishing resources in the channels downstream from the dam sites and to upland game and deer resources in the upstream reservoir sites; and increases in fishing resources at all reservoir sites and in upland game and waterfowl resources at the Laneport unit. The proposed reservoir does not provide benefits of any significance with respect to commercial fishing or to natural resource conservation of national interest.

74. Based upon the above available data, the total estimated composite annual fish and wildlife benefits under stage-development conditions for the proposed reservoir plan are $82,100, of which $43,800 is credited to the Laneport Reservoir, $19,300 to the North Fork Reservoir, and $19,000 to the South Fork Reservoir.

75. RECREATION BENEFITS.- The general recreation benefits creditable to the proposed reservoir plan 10B are based on studies by the Corps of Engineers summarized in appendix II. The recreation studies established on annual visitation trend for the San Gabriel River project areas varying from 1,200,000 persons in year 1970 to about 2,900,000 persons in year 2040; and on an average value of $0.50 per visitor-day. The recreation benefits assigned to each reservoir unit during the various stage-development periods are as set forth in appendix II and as follows: First stage, Laneport, $350,000; second stage, Laneport, $410,000 and North Fork, $410,000; third stage, Laneport, $460,000, North Fork, $340,000, and South Fork, $290,000.

76. Based upon the above available data, the total estimated composite annual recreation benefits under stage-development conditions for the proposed reservoir plan are $1,047,200, of which is credited $405,500 to the Laneport Reservoir, $351,700 to the North Fork Reservoir, and $290,000 to the South Fork Reservoir.

77. SUMMARY OF BENEFITS.- The total estimated composite average annual benefits for the proposed plan 10B (Laneport, North Fork, and South Fork Reservoir projects), as estimated under price levels of July 1, 1961, are summarized as follows:

Item	Laneport Reservoir	North Fork Reservoir	South Fork Reservoir	Total Plan 10B
Flood control	$1,819,700	$582,500	$274,300	$2,676,500
Water conservation	508,200	512,800	273,000	1,294,000
Fish and wildlife	43,800	19,300	19,000	82,100
Recreation	405,500	351,700	290,000	1,047,200
Total annual benefits	$2,777,200	$1,466,300	$856,300	$5,099,800

78. In addition to the primary benefits creditable to the project, it is recognized that certain secondary benefits would be realized. However, for the purpose of economic justification, the secondary benefits have been disregarded.

79. COMPARISON OF BENEFITS AND COSTS.- The average annual benefits, the average annual charges, and the ratio of benefits to charges for the proposed plan 10B (Laneport, North Fork, and South Fork Reservoir projects) are given below.

Reservoir	Average annual benefits	Annual charges	Ratio of benefits to charges
Laneport	$2,777,200	$1,003,300	2.8
North Fork	1,466,300	514,000	2.9
South Fork	856,300	335,700	2.6
Total	$5,099,800	$1,853,000	2.8

LOCAL COOPERATION

80. PROPOSED LOCAL COOPERATION.- The local cooperation proposed in the construction of the proposed Laneport, North Fork, and South Fork Reservoir projects consists of reimbursement to the Federal Government of project costs chargeable to the water conservation features provided in each project. In this connection, the Brazos River Authority, an agency designated by the Texas State Board of Water Engineers to negotiate with the Corps of Engineers in matters pertaining to conservation storage in Corps projects in the Brazos River Basin, informed the District Engineer by letter dated July 28, 1960, and by supplement thereto dated December 22, 1960, of its acceptance of the proposed plan of improvement and that at the proper time it will enter into agreements with the Federal Government to fulfill the requirements of local cooperation for the water conservation portion of each project. The Authority stated, however, that at the present time it favors construction of the proposed projects on the San Gabriel River watershed in stages, with construction of the proposed Laneport Reservoir project as the first-stage unit. Also, the Brazos River Authority indicated its desire to contract for the total cost of the water supply provisions in the proposed first-stage Laneport Reservoir project prior to the initiation of construction, thus indicating no desire to defer payment for the cost of any portion of the storage space for future water supply as set forth by the Water Supply Act of 1958.

81. ALLOCATION OF COSTS.- The costs of the proposed Laneport, North Fork, and South Fork Reservoirs have been tentatively allocated between flood control, water conservation, fish and wildlife, and recreation in accordance with the Separable Costs-Remaining Benefits method of cost allocation. Separate cost allocation studies were made of each project involved under each of the three stages of development. A summary of the cost allocation studies for first-stage, second-stage, and ultimate-stage conditions is shown in table 6. Computations concerning the allocation of project costs to the separate purposes under each stage of development are shown in tables 19 and 20, appendix II. The total amounts of construction costs and of maintenance and operation costs allocated to water conservation under each stage of development would be chargeable to local interests.

82. Under first-stage conditions as established by the proposed plan of improvement, Laneport Reservoir would operate alone on the San Gabriel River watershed as a multiple-purpose unit for flood control, water conservation, fish and wildlife, and recreation purposes. The proposed first-stage Laneport project would have a total usable storage of 314,200 acre-feet, of which 236,100 acre-feet would be allocated to flood control and 68,100 acre-feet would be allocated to water conservation. The water conservation storage

TABLE 6

SUMMARY OF COST ALLOCATION STUDIES
PLAN 10B - LANEPORT, NORTH FORK, AND SOUTH FORK RESERVOIRS
SAN GABRIEL RIVER WATERSHED
(SEPARABLE COST-REMAINING BENEFIT METHOD)

Item	First stage	Second stage			Ultimate stage			
	Laneport	Laneport	North Fork	Total	Laneport	North Fork	South Fork	Total
PERTINENT DATA								
Total project first cost (dollars)*	23,444,000	23,444,000	11,810,000	35,254,000	23,444,000	11,810,000	7,230,000	42,484,000
Total project annual charges (dollars)*	1,003,300	1,003,300	514,000	1,517,300	1,003,300	514,000	335,700	1,853,000
Total controlled storage, acre-feet	331,900	331,900	221,600	553,500	331,900	221,600	138,500	692,000
Flood control storage, acre-feet	(236,100)	(161,100)	(87,900)	(249,000)	(116,500)	(87,900)	(45,500)	(249,900)
Water conservation storage, acre-feet	(68,100)	(147,800)	(126,700)	(274,500)	(193,200)	(126,700)	(89,000)	(408,900)
Sediment storage, acre-feet	(27,700)	(23,000)	(7,000)	(30,000)	(22,200)	(7,000)	(4,000)	(33,200)
Dependable flow								
Second-feet	43	39	30	69	34	30	17	81
Million gallons daily	27.8	25.2	19.4	44.6	22.0	19.4	11.0	52.4
Million gallons per year	10,143.945	9,200.322	7,077.171	16,277.494	8,020.794	7,077.171	4,010.397	19,108.362
Benefits (dollars)	3,401,000	2,916,700	1,717,700	4,634,400	2,777,200	1,466,300	856,300	5,099,500
Flood control (dollars)	(2,206,600)	(1,901,800)	(633,900)	(2,535,700)	(1,819,700)	(582,500)	(274,300)	(2,676,500)
Water conservation (dollars)	(559,400)	(533,700)	(512,800)	(1,046,500)	(508,200)	(512,800)	(273,000)	(1,294,000)
Fish and wildlife (dollars)	(50,000)	(47,800)	(21,000)	(68,800)	(43,800)	(19,300)	(19,000)	(81,800)
Recreation (dollars)	(585,000)	(433,400)	(550,000)	(983,400)	(405,500)	(351,700)	(290,000)	(1,047,200)
FLOOD CONTROL ALLOCATIONS								
Annual charges**	555,900	471,500	182,100	653,600	424,700	182,400	116,000	723,200
Construction cost**	13,340,300	10,916,100	4,433,000	15,349,100	9,762,500	4,439,000	2,576,000	16,779,500
Annual maintenance & operation cost	42,200	51,200	15,600	66,800	48,800	15,600	19,300	83,700
Construction cost per acre-foot**	56.50	67.76	50.43	61.64	83.80	50.50	56.62	67.16
WATER CONSERVATION ALLOCATIONS								
Annual charges**	296,300	369,300	243,700	613,000	404,400	243,900	159,800	808,200
Construction cost**	6,746,200	8,777,300	5,654,000	14,431,300	9,575,300	5,659,000	3,447,000	18,684,300
Annual maintenance & operation cost	36,600	31,300	15,200	46,500	35,800	15,200	30,300	97,400
Construction cost per acre-foot**	99.06	59.39	44.63	52.57	49.56	44.66	38.73	45.69
Cost per 1000 gallons**	0.02926	0.03641	0.03443	0.03555	0.03987	0.03446	0.03985	0.03787
FISH AND WILDLIFE ALLOCATIONS								
Annual charges**	27,900	28,900	13,400	42,300	29,000	12,800	12,300	53,900
Construction cost**	669,300	713,700	304,000	1,017,700	720,700	287,000	274,000	1,276,700
Annual maintenance & operation cost	2,200	1,500	2,000	3,500	1,200	2,000	2,000	5,200
RECREATION ALLOCATIONS								
Annual charges**	121,500	131,900	74,400	206,300	143,500	74,500	47,200	265,200
Construction cost**	2,644,200	2,992,900	1,409,000	4,401,900	3,341,500	1,415,000	923,000	5,679,500
Annual maintenance & operation cost	19,700	16,700	21,400	38,100	14,900	21,400	12,500	48,800

*Including preauthorization costs
**Excluding preauthorization costs

of 68,100 acre-feet would provide an estimated dependable yield of about 43 second-feet, or about 27.8 million gallons daily. Under first-stage conditions, the summary in table 6 indicates that the total project construction cost (exclusive of preauthorization costs) of $23,400,000 would be allocated as follows: $13,340,300 or 57.01 percent to flood control; $6,746,200 or 28.83 percent to water conservation; $669,300 or 2.86 percent to fish and wildlife; and $2,644,200 or 11.30 percent to recreation. Although the maintenance and operation functions of the proposed first-stage Laneport project would be the responsibility of the Corps of Engineers, the total cost of such maintenance and operation would be apportioned to Federal and non-Federal interests. The first-stage summary presented in table 6 indicates that the total estimated cost of $100,700 for maintenance and operation would be allocated as follows: $42,200 or 41.91 percent to flood control; $36,600 or 36.35 percent to water conservation; $2,200 or 2.18 percent to fish and wildlife; and $19,700 or 19.56 percent to recreation.

COORDINATION WITH OTHER AGENCIES

83. NOTICE OF INITIATION OF STUDIES.- During the initiation of studies on the subject watershed, the regional offices of other interested Federal agencies were advised by letter dated November 20, 1957, of the general investigations program for fiscal year 1958. In response to the above letter, the Federal agency comments, in general, included statements of interest in the investigations program and information on available basic and general data. The Soil Conservation Service advised the Fort Worth District by letter dated January 28, 1958, that applications for planning assistance on the San Gabriel River watershed for Burnet, Williamson, and Milam Counties had been received and that preliminary field examinations indicated a favorable benefit-to-cost ratio would be possible. The Bureau of Reclamation indicated that studies had been made of the authorized Laneport Reservoir with respect to use of its conservation storage capacity for supplying downstream water requirements, including potential irrigation developments along the Little and Brazos Rivers. Interested agencies requested that copies of the proposed report be submitted for field-level review and comment.

84. PUBLIC HEARING.- Participation of other agencies in the public hearing is discussed in paragraph 33.

85. U. S. PUBLIC HEALTH SERVICE.- During the preparation of this report, the investigations and studies in connection with the water supply aspects of the San Gabriel River watershed and the Brazos River Basin were closely coordinated with the U. S. Public Health Service through correspondence and by means of various conferences. The Service was furnished necessary basic data, including results of cost and yield studies of projects on the Brazos River Basin which

are in the advance planning stage of investigated reservoir plans on the San Gabriel River under conditions of maximum water resource development. On the basis of the cost and yield data, the Service determined the value of water supply storage in the lower Brazos River Basin, including the San Gabriel River watershed. The Service prepared a detailed report, as presented in appendix IV, of the municipal and industrial water requirements for the Navasota and lower Brazos River areas. However, the value of water supply storage and the estimates of water supply benefits utilized in the analyses of investigated reservoir plans were based on studies by the Corps of Engineers as described in appendix II.

86. BUREAU OF SPORT FISHERIES AND WILDLIFE.- During the preparation of this report, the investigations and studies in connection with the fish and wildlife aspects of investigated reservoir plans on the San Gabriel River were closely coordinated with the Bureau of Sport Fisheries and Wildlife through correspondence and by various conferences with representatives of the Bureau's Fort Worth office. The Bureau was furnished necessary basic data on investigated reservoir plans, including pertinent reservoir design data, surface areas, and capacities. The original report furnished by the Bureau for inclusion in this report included an evaluation of the San Gabriel Reservoir plans on the basis of annual expenditures by sport hunters and fishermen. Subsequently, the Bureau provided a revised report with fish and wildlife benefits based on evaluation as proposed by the Panel on Recreational Values, established by the Subcommittee on Evaluation Standards of the Inter-Agency Committee on Water Resources. The comments of the Bureau, summarized in paragraph 91d of this report, are based on a review of the original draft of the report in which the annual benefits for fish, wildlife, and general recreation were combined. A detailed report prepared by the Bureau, evaluating the fish and wildlife aspects in investigated reservoir plans on the San Gabriel River, is presented in appendix IV.

87. NATIONAL PARK SERVICE.- The National Park Service was consulted with respect to recreation aspects and potentialities of the San Gabriel River watershed. A reconnaissance of the area was made by a representative of the Region Three office, National Park Service, and a report of the findings was submitted. The report contained an appraisal of the recreational potentials and indicated the type of recreational development and estimated monetary evaluation of recreation benefits applicable to the investigated reservoir plans. The report of the National Park Service is presented in appendix IV. However, the general recreation benefits utilized in the analyses of investigated reservoir plans were based on studies by the Corps of Engineers described in appendix II.

88. BUREAU OF PUBLIC ROADS AND STATE HIGHWAY DEPARTMENT.- In accordance with provisions of Public Law No. 562, the Bureau of Public Roads and the Texas State Highway Department were consulted regarding the advisability of providing a highway crossing at each of the investigated dam sites. The State Highway Department has recommended that a highway crossing be considered in design of the Laneport Dam since there appears to be a definite need of rerouting an improved county road across this dam. The estimated increase in project costs to provide the recommended highway crossing at the Laneport site is about $61,200, which has been included in the total estimated project costs.

89. SOIL CONSERVATION SERVICE.- The Soil Conservation Service, Department of Agriculture, has been authorized to undertake a program of runoff and waterflow retardation and soil erosion prevention on the San Gabriel River watershed. As of July 1, 1960, a total of 21 planned reservoirs in the Brushy Creek subwatershed have been completed. In addition, the Soil Conservation Service has received applications for planning assistance on the North San Gabriel River, the South San Gabriel River, and the lower San Gabriel River watersheds. Reconnaissance surveys by the Soil Conservation Service have indicated the possibility that 59 flood detention reservoirs are economically justified. Construction of the items in the entire Soil Conservation Service program would have an effect on the requirements for flood control improvements proposed in this report. In the interest of over-all planning, the effects of any existing or definitely planned reservoirs of the Soil Conservation Service will be considered in the advance planning of the improvements proposed herein.

90. BUREAU OF RECLAMATION.- During the preparation of this report, a representative of the Bureau of Reclamation verbally stated that no Federal irrigation project is currently contemplated on the San Gabriel River watershed, but that in the event of the future development of an irrigation project along the San Gabriel River, the recommended multiple-purpose reservoir projects would contain sufficient water conservation storage to provide for any future irrigation needs.

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

a. The Bureau of Mines stated that an office study of available records indicates that the proposed construction will have no adverse effect on mineral industries in the area; therefore, the Regional Office of the Bureau of Mines has no objection to the proposed project.

b. The Bureau of Public Roads stated that it concurs with the Texas Highway Department's recommendation that only the Laneport location merits consideration for a roadway on the dam and that the Laneport Reservoir will require relocation of FM Road 971.

c. The Bureau of Reclamation stated that it has no objection to the proposed development and will consider the findings of the report in connection with any future studies that may be made in the Brazos River Basin.

d. The Bureau of Sport Fisheries and Wildlife stated that it appreciated the consideration given to fish and wildlife in the report and was especially pleased to note that essential facilities for hunting and fishing as recommended by the Bureau in its report will be included in the proposed projects. The Bureau also stated that it was difficult to understand how its estimate of $230,000 for fishing and $17,000 to $21,000 for hunting, and the estimate of $240,000 for other recreation benefits furnished by the National Park Service were used in developing the estimated $1,047,200 for the over-all annual recreation benefits shown in the report. The Bureau offered assistance in preparation of a specific evaluation of fish and wildlife resources for plan 10B if such an evaluation was considered desirable. (The above comments are based on the initial draft of the report in which the annual benefits for fish and wildlife and general recreation were combined.)

e. The Federal Power Commission stated that examination of the power potentialities at the Laneport site in 1949 and a review of the project in 1957 disclosed that inclusion of power could not be justified. Also, that examination of the recommended project comprised of Laneport and North and South Fork Reservoirs indicates that inclusion of power facilities in the Laneport Reservoir project cannot be justified.

f. The U. S. Geological Survey stated all available streamflow data had been utilized in the report. Also, that it is interesting to note that the San Gabriel River drains an area that is subject to some of the highest floodflow rates in the Southwest, and that the report gives consideration to these unusually high flood flows.

g. The National Park Service stated that although there is a difference in the Corps' approach to estimating potential attendance and the benefit factor used by the Service, the resulting annual benefits are not significantly different and no specific recommendations were made for changing the report. The Service stated also that the proposed reservoirs are within areas rich in archeological sites, that surveys are scheduled for fiscal year 1962 for all three reservoir sites, and that excavations cannot be made until the archeological surveys are completed.

h. The Public Health Service suggested minor revisions in the report draft relative to statements on the dates of projected need for the various water supply units, the interest rate used for conversion of capital costs to annual costs, and the amount of available water resources in the lower Brazos River area. The revisions suggested by this agency have been incorporated in the report with the exception of the dates of projected need for the various water supply storage units and the interest rate for conversion of capital costs to annual costs.

i. The Soil Conservation Service suggested revisions in wording relative to status of applications for planning assistance on the North Fork San Gabriel River, South Fork San Gabriel River, and the Lower San Gabriel River watershed since no detail planning has been initiated in any of the watersheds, and that no upstream watershed protection and flood prevention projects could be justified with the installation of the planned North and South Fork Reservoirs. Appropriate revisions were made in the report to reflect the status of applications for assistance on the San Gabriel River watershed. The Service also stated that the amount of depletion attributed to the upstream soil and water conservation program on the San Gabriel River at Laneport for the present (1958) and future (2010) appears to be excessive, and recommended that the report be revised to agree with the data prepared by the Bureau of Reclamation which was adopted by the U. S. Study Commission - Texas after concurrence by all State and Government agencies. In reply to the above comment, the yield computations under existing conditions used in this report were based on observed flows at gages on the watershed. Therefore, all existing watershed factors, including depletion by the existing Soil Conservation Service structures, are reflected in the adopted yield values. The estimate of an additional 28 percent reduction in resources is based on preliminary data furnished by the Bureau of Reclamation. Subsequent preliminary data furnished the U. S. Study Commission - Texas in February 1961, after preparation of this report, indicate that the preliminary plan of development proposed by the Soil Conservation Service for the San Gabriel River watershed above the Laneport Dam site has been materially reduced in scope. Because the estimates of reduction in resources are based on 50 years of watershed development and in view of the uncertainty of the amount of

future development, it is considered that the yields for future (2010) conditions as presented in appendix I, page 4, are satisfactory for the purpose of this report.

j. The U. S. Forest Service stated that there are no National Forest lands in the area and that the proposed improvements will not adversely affect any non-Federal forest land.

k. The Southwestern Power Administration stated that in view of the rapidly increasing power market and future need for water supply, it is recommended that consideration be given to power facilities in the initial projects with provision made for future reallocation of storage to higher priority purposes as the needs develop. Preliminary investigations made by the Corps of Engineers indicate that the construction of facilities for hydroelectric development does not appear feasible.

92. DISCUSSION.- This report considers the desirability of modifying the authorized plan of improvement for flood control, water conservation, and related water uses on the San Gabriel River watershed. The authorized plan consists of a multiple-purpose reservoir project, Laneport Reservoir, located at river mile 29.7, which is a unit in a system of eight Federally authorized reservoirs in the Brazos River Basin. Each reservoir is planned to function as a unit in the system and to provide maximum reduction of flood stages on certain portions of the principal tributaries of the river and on the lower Brazos River downstream from the vicinity of Waco.

93. Local interests requested that the restudy of the authorized Laneport project include consideration of alternate project sites to extend flood control upstream from the Laneport site and to include sufficient water conservation storage space in any project adopted to permit optimum development of the water resources of the San Gabriel River watershed to meet current and future water needs. Periods of prolonged drought, upward trends in population, and expansion of industrial and municipal developments have made evident the increasing need for the conservation of surface runoff for all beneficial purposes throughout the lower Brazos River Basin, including the San Gabriel River watershed. The U. S. Public Health Service, the Texas State Board of Water Engineers, the Brazos River Authority, and representatives of municipalities and industries have requested generally that water conservation storage space, in maximum amounts which can be economically provided, be included in all multiple-purpose reservoir projects planned and constructed by the Corps of Engineers on the lower Brazos River tributary system. In its report, the U. S. Public Health Service emphasized the following problems: that the water originating in the main channel of the Brazos River above Whitney Reservoir possesses a high salt content and is largely unsatisfactory for municipal and industrial purposes; that water of good quality is limited in source and amount to the lower Brazos River tributary system; that the projected water requirements for municipal and industrial purposes for the lower Brazos River Basin will be about 1,102 million gallons daily by the year 2010, including 8.2 million gallons daily for the San Gabriel River watershed downstream from the vicinity of Georgetown; and that the aggregate firm yield from existing and proposed surface reservoirs (exclusive of reservoirs on the San Gabriel River watershed) and estimated existing and future ground water resources are only about 603 million gallons daily.

94. Detailed investigations and studies were made of plans 1A and 1B through 11A and 11B involving one or more reservoir units under simultaneous and stage development conditions. These plans involved reservoirs at the following sites: (a) Laneport site,

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San Gabriel River, river mile 29.7; (b) North Fork site, North Fork of San Gabriel River, river mile 4.0; (c) South Fork site, South Fork of San Gabriel River, river mile 4.7; and (d) Berry Creek site, Berry Creek, creek mile 6.7. Multiple-purpose reservoirs were developed at each of the sites to include flood control storage capacity which would provide a high degree of control of the flood runoff from the contributing drainage area and to which, for purposes of analysis, was added various incremental amounts of water conservation storage space. The analyses of the various plans mentioned above included Laneport Reservoir as the primary unit because of its importance for flood control purposes and two sizes, one with a total controlled storage of 281,100 acre-feet and another with 331,900 acre-feet, were investigated to determine the maximum economical amount of water conservation storage which could be developed at that site. The analysis indicated that the most favorable plan would be a plan containing the largest controlled storage, 331,900 acre-feet, at the Laneport site and that stage development of such a plan would provide the maximum amount of excess of benefits over costs. Plan 10B, which provides for the immediate construction of the Laneport Reservoir as the first stage unit, followed by the addition of North Fork and South Fork Reservoirs as second- and third-stage units, respectively, was found to be the most practical plan of improvement. Development of this plan, in the sequence given, is considered to be the most suitable and practicable plan on the basis that it would provide the greatest amount of excess benefits over costs, the maximum development of the water supply resources on the San Gabriel River watershed, and would contribute favorably toward the fulfillment of the present and future water needs.

95. During the course of the investigation of the various plans being considered, full consideration was given to the many complex factors involved in the development of the water resources of the San Gabriel River. Included among the numerous problems which required consideration were the views of proponents who favored full development of the storage potentialities of reservoir sites of the watershed in the interest of providing maximum control of flood runoff and optimum development of the water resources for municipal, industrial, and allied uses, and the expressions of opposition by certain groups and of some landowners on the watershed to the Laneport Reservoir project under consideration. The major objections expressed by the opponents were in regard to the displacement or relocation of people who reside or own land within the proposed Laneport Reservoir area; the inundation of lands which they classify as the best and most highly developed portions of the watershed; the loss of tax revenue to school districts and county governments; and the development of a project on the San Gabriel River, the maximum benefits from which would be to landowners and water users on the lower Brazos River.

96. Investigations of the potential reservoir areas for the Laneport, North Fork, and South Fork sites have revealed that about 335 permanent homes would be affected by the construction of the reservoirs, of which approximately 225 are in the Laneport area, 70 are in the North Fork area, and 40 are in the South Fork area. Of the total 26,580 acres required for the three reservoir units, about 78 percent is classified as cropland, 14 percent as open pastureland, and 8 percent as woodland.

97. During this investigation, a survey was made to determine the value of property and improvements in the flood plains of the San Gabriel River and in the flood plains of the Little and Brazos Rivers affected by discharges from the San Gabriel River. Based on this survey, it was estimated that the total value of physical developments and property at this time within the flood plains of the lower Little and Brazos Rivers is $354,525,600, of which $173,262,500 is classified as agricultural property, $25,335,200 as rural nonagricultural property, $61,831,100 as urban property, and $94,096,800 as transportation facilities and utilities. The value of physical property in the flood plain of the San Gabriel River under present conditions in the reach downstream from the Laneport Dam site has been estimated at $3,491,400, of which $3,038,000 is classified as agricultural property and $453,400 as transportation facilities and utilities. The value of physical property in the flood plain of the San Gabriel River between the Laneport Dam site and the North Fork and South Fork Dam sites is $4,506,800, of which $2,504,800 is classified as agricultural property, $681,000 as urban properties, and $1,321,000 as transportation facilities and utilities. Land areas in the lower Little and Brazos River flood plains which are devoted to agricultural pursuits total about 1,080,630 acres, of which about 597,970 acres are classified as improved agricultural lands, 480,110 acres as unimproved grazing lands, and about 2,550 acres as urban area. In the San Gabriel River flood plain downstream from the Laneport Dam site, there is a total of about 13,620 acres of land, of which 8,260 acres are classified as improved agricultural and 5,360 acres as unimproved grazing land. In the investigated San Gabriel River flood plain upstream from the Laneport Dam site, there is a total of about 12,440 acres of land, of which 5,710 are classified as improved agricultural lands, 6,360 as unimproved grazing lands, and 370 as urban area. The average unit values of property and improvements within the investigated flood plain reaches are as follows: Brazos River, $329 per acre; Little River, $306 per acre; and San Gabriel River, $307 per acre. The lower Little and Brazos River areas are considered to be highly developed areas of the Brazos River Basin. On the basis of the comparison of the above-average unit values, it is concluded that the flood plain of the San Gabriel River is also a highly developed area, principally for agricultural purposes.

98. Representatives of the State of Texas and of State constituted agencies delegated the responsibility for the development of water resources of the river basins of the State have stressed the necessity for the maximum development of all potential reservoir sites in the State in the interest of providing a source of water supply to meet anticipated future needs. Estimates of future economic development and the resultant water requirements have been prepared by various State agencies, consulting engineering firms, and the Public Health Service. The Public Health Service has stated in its report that the estimated total industrial and municipal water requirements for the entire lower Brazos River Basin by the year 2010 would be approximately 1,102 million gallons daily. The Service concludes from comparing the expected total water requirements with the total estimated yields to be anticipated from existing and proposed reservoirs that to meet the forecasted demand would necessitate the maximum feasible and economically justified development of water resources of all the water-producing streams in the lower Brazos River Basin, including the San Gabriel River.

99. It is recognized that construction of a reservoir project in any area requires a readjustment in the tax- and revenue-producing enterprises which are lost as a result of the inundation of lands. It is also recognized that the impact on the present economy of the area concerned varies with the size of the area dedicated to the conservation of water for municipal and industrial uses. However, in most cases these losses would be compensated by new improvements and enterprises which normally would be developed in the general project area.

100. Based on the reports prepared by the Bureau of Sport Fisheries and Wildlife and by the National Park Service and experience gained in the operation of the existing Corps of Engineers reservoirs in Texas, it has been determined that development of the proposed plan - the Laneport, North Fork, and South Fork Reservoir - will provide composite average annual benefits for fish and wildlife and for general recreation purposes in the aggregate amount of $1,130,300. The benefits derived from fish, wildlife, and general recreation activities will be a valuable asset to the area and will more than compensate for the anticipated reduction in taxes and the replacement of present sources of income with new enterprises.

101. The Brazos River Authority, an agency designated by the Texas State Board of Water Engineers to negotiate with the Corps of Engineers in matters pertaining to water conservation storage in Corps projects in the Brazos River Basin, has expressed the opinion that water conservation storage sufficient to produce about 10 second-feet or 6.46 million gallons daily of dependable yield would be adequate to serve the immediate needs of the lower San Gabriel River watershed, and that the immediate needs for water supply in the remainder of the

lower Brazos River Basin will be adequately served by other Corps of Engineers reservoir projects which are under construction or in the advance planning stage. However, the Authority has indicated its willingness to contract for (prior to the initiation of construction) the total amount of water supply storage to be provided in the first-stage Laneport project.

102. The proposed Laneport, North Fork, and South Fork Reservoirs would have a gross controlled storage capacity of 692,000 acre-feet, of which 33,200 acre-feet would be for sedimentation, 408,900 acre-feet for water conservation, and 249,900 acre-feet for flood control. The water conservation storage included in the proposed plan of improvement would provide an estimated dependable yield of about 81 second-feet or 52.4 million gallons daily. The proposed stage-development plan as set forth in this report provides sediment storage sufficient for a 70-year, 65-year, and 50-year period in the case of the Laneport Reservoir, North Fork Reservoir, and South Fork Reservoir, respectively. It is estimated that each unit of the proposed plan would have a useful life in excess of 100 years. During the preconstruction planning, consideration will be given to providing sediment storage to serve the estimated useful life of each reservoir unit.

103. FINAL REVISIONS AND COST ESTIMATES.- In a final revision of the cost estimate it was concluded that allowances over and above the normal contingency items should be added to take care of the possible remedial foundation treatment at the North and South Fork dam sites and to move the spillway location at the Laneport site further into the abutment if a more suitable foundation condition is required as a result of more detailed studies. The additional costs, including contingencies, engineering and design, and supervision and administration, are estimated as $1,800,000, $800,000, and $430,000 for the Laneport, North Fork, and South Fork sites, respectively. A reanalysis of the over-all study on the basis of the above additional costs indicates that there would be no change as to the project formulation and that plan 10B would provide for the most beneficial and economical development of the water resources of the San Gabriel River watershed. A summary of the construction cost, annual charges, and benefits for the proposed plan of improvement, including increased cost as given above, is as follows:

Reservoir	Total Construction Cost (1)	Annual Charges (2)	Average Annual Benefits	Ratio of Benefits to Charges
Laneport	$25,200,000	$1,072,700	$2,777,200	2.6
North Fork	12,600,000	554,000	1,466,300	2.7
South Fork	7,650,000	351,900	856,300	2.4
Total	$45,450,000	$1,968,600	$5,099,600	2.6

(1) Excluding preauthorization costs
(2) Including preauthorization costs

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

CONCLUSIONS

105. CONCLUSIONS.- The District Engineer concludes:

a. That a serious flood problem exists on the San Gabriel River within the investigated flood plain reaches between the mouth and the vicinity of Georgetown, Texas, where a highly developed agricultural area is subject to frequent damage by flood flows originating on the San Gabriel River watershed.

b. That a serious flood problem exists along the lower Little and Brazos Rivers where damages to urban and highly developed agricultural areas are considerably increased during flood stages on the Little and Brazos Rivers by major flood flows discharging from the San Gabriel River.

c. That an urgent water supply need exists throughout the lower Brazos River Basin, necessitating that maximum economical development of good-quality water supply resources of the San Gabriel River watershed be provided in any multiple-purpose reservoir project constructed on the San Gabriel River watershed.

d. That a Laneport Reservoir project is required to provide control of floods equivalent to that provided by the authorized project for Brazos River and tributaries, Texas, and that it should be constructed as the initial project in any plan of improvement recommended for the San Gabriel River watershed.

e. That a plan of stage development, setting forth the construction of Laneport Reservoir as a first-stage unit, the North Fork Reservoir as a second-stage unit, and the South Fork Reservoir as a third-stage unit, is the most favorable plan on the San Gabriel River watershed for flood control, water conservation, fish and wildlife, and recreation purposes.

f. That the investigated stage development plan, consisting of the Laneport, North Fork, and South Fork Reservoirs, is the

most suitable and practicable reservoir plan on the basis that it would provide the maximum amount of annual benefits for flood control and water conservation in excess of the annual costs, and the maximum economical development of the water supply resources of the San Gabriel River watershed.

g. That the authorized plan for flood control, water conservation, and related water uses on the San Gabriel River watershed should be modified to provide for modification and construction of the authorized Laneport Reservoir project and for the construction of the investigated North Fork and South Fork Reservoirs.

h. That the Laneport, North Fork, and South Fork Reservoirs would be important elements in the system of authorized reservoir projects for flood control, water conservation, and other allied purposes on the lower Brazos River Basin.

i. That there is an immediate need for the proposed first-stage Laneport Reservoir project to be used as a primary unit for flood control purposes, but containing sufficient water conservation storage to provide for the present water supply needs.

j. That the North Fork and South Fork Reservoirs should be constructed as second-stage and third-stage units, respectively, at such time that additional water conservation storage is needed.

106. RECOMMENDATIONS.- The District Engineer recommends that the authorized project for Brazos River and tributaries, Texas, be modified to provide for modification and immediate construction of the authorized Laneport Reservoir project as a primary first-stage unit and the subsequent construction of the North Fork and South Fork Reservoirs as second-stage and third-stage units, respectively, under a plan of stage development at an estimated additional Federal construction cost of $16,750,000 and an increase in annual maintenance and operation costs of $171,300; that the proposed stage-development plan be constructed to provide a total controlled storage of about 692,000 acre-feet, including total controlled storages of 331,900, 221,600, and 138,500 acre-feet at the Laneport, North Fork, and South Fork reservoir sites, respectively, to be utilized for purposes of flood control, water conservation, fish and wildlife, and general recreation; and that the proposed reservoir plan be constructed with such changes as in the discretion of the Chief of Engineers may be advisable.

107. The District Engineer further recommends that construction of each reservoir unit of the proposed stage-development plan be subject to the conditions that prior to initiation of construction and in accordance with repayment provisions of the Water Supply Act of 1958, as amended, local interests shall (a) enter into a contract, satisfactory to the Secretary of the Army, whereby local interests will reimburse the Federal Government the amount of construction, maintenance, operation, and major replacement costs of the multiple-purpose reservoir project allocated to immediate water supply, and (b) give reasonable assurances that they will reimburse the Federal Government the costs of conservation storage allocated to anticipated future water supply.

108. In regard to the recommended over-all stage development plan, including the Laneport, North Fork, and South Fork Reservoirs, the currently estimated total Federal construction costs and total annual maintenance and operation costs are $45,450,000 and $235,100, respectively. Based on the Separable Costs-Remaining Benefits method of cost allocation, local interests will be required to bear 44.58 percent of the total Federal construction costs, such share being currently estimated at $20,262,200, and 41.73 percent of the total maintenance and operation costs, such share being currently estimated at $98,100. The Federal Government will be responsible for project costs which are allocated to the flood control, fish and wildlife, and recreation purposes and which are equal to 55.42 percent of the total Federal construction costs and 58.27 percent of the annual maintenance and operation costs, such shares, considered as net Federal costs, being currently estimated at $25,187,800 and $137,000, respectively.

109. In regard to the first-stage Laneport Reservoir unit of the recommended stage-development plan the currently estimated total Federal construction costs and total annual maintenance and operation costs are $25,200,000 and $100,700, respectively. Based on the Separable Costs-Remaining Benefits method of cost allocation, local interests will be required to bear 27.77 percent of the total Federal construction costs, such share being currently estimated at $6,998,000, and 36.54 percent of the total maintenance and operation costs, such share being currently estimated at $36,800. The Federal Government will be responsible for project costs which are allocated to the flood control, fish and wildlife, and recreation purposes and which are equal to 72.23 percent of the total Federal construction costs and 63.46 percent of the annual maintenance and operation costs, such shares being currently estimated at $18,202,000 and $63,900, respectively.

110. The amount of local participation for the proposed stage-development plan is tentatively established on the basis of July 1, 1961 price levels, and is subject to modification at the time of initiation of construction to reflect the prevalent price levels, and further, at the time of completion of construction of each reservoir unit to reflect the actual total project costs.

R. P. WEST
Colonel, CE
District Engineer

[First endorsement]

SWDGW-4 (16 Oct 61)
SUBJECT: Review of Reports on Brazos River and Tributaries, Texas, Covering San Gabriel River Watershed

US Army Engr Div, Southwestern, Dallas, Tex, 23 Oct 61

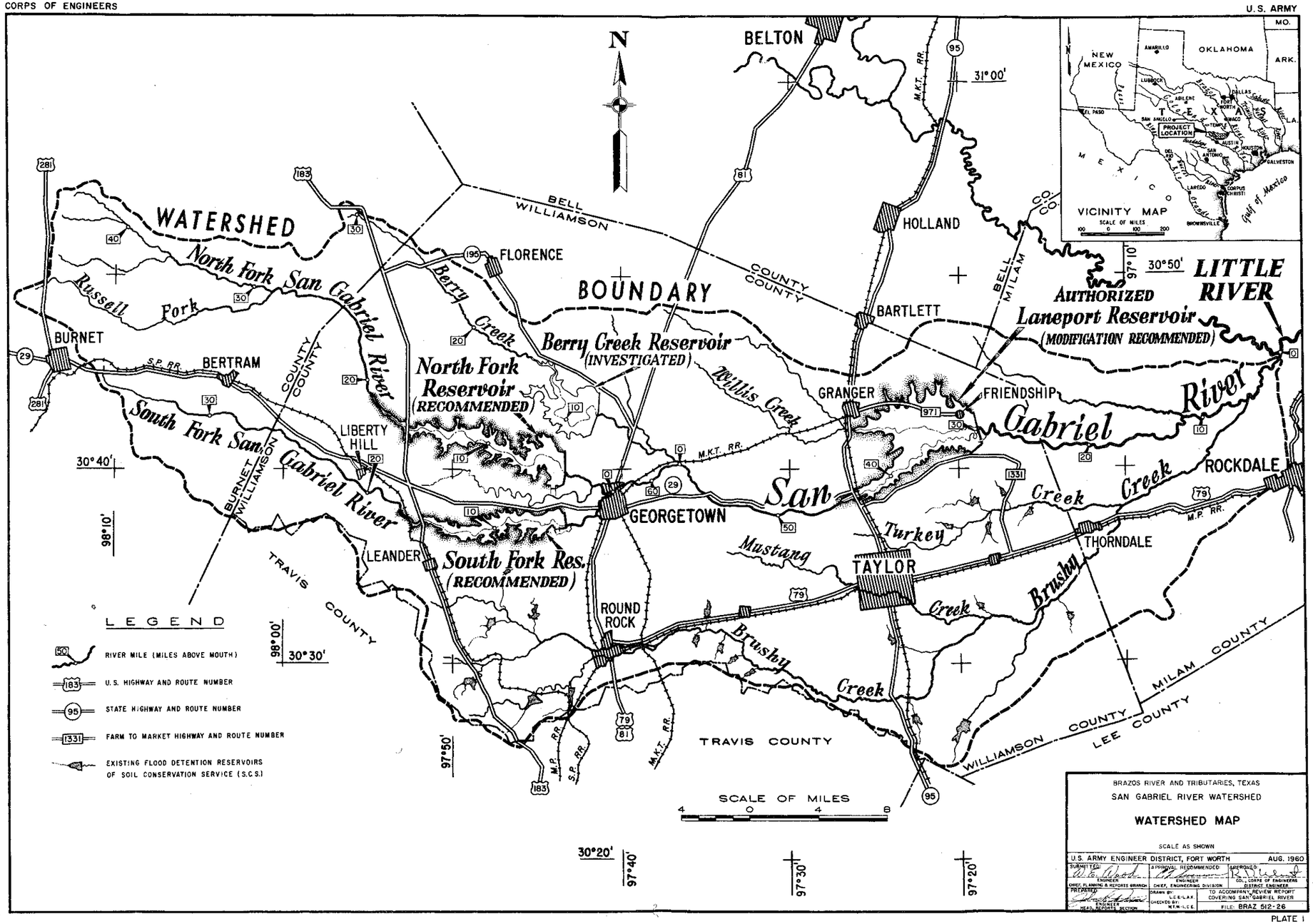
TO: Chief of Engineers

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

ROBERT J. FLEMING, JR.
Major General, USA
Division Engineer

CORPS OF ENGINEERS

U.S. ARMY



LEGEND

- RIVER MILE (MILES ABOVE MOUTH)
- U.S. HIGHWAY AND ROUTE NUMBER
- STATE HIGHWAY AND ROUTE NUMBER
- FARM TO MARKET HIGHWAY AND ROUTE NUMBER
- EXISTING FLOOD DETENTION RESERVOIRS OF SOIL CONSERVATION SERVICE (S.C.S.)

BRAZOS RIVER AND TRIBUTARIES, TEXAS

SAN GABRIEL RIVER WATERSHED

WATERSHED MAP

SCALE AS SHOWN

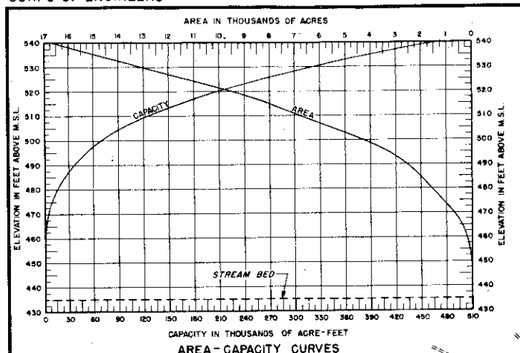
U.S. ARMY ENGINEER DISTRICT, FORT WORTH		AUG. 1960
SUBMITTED: ENGINEER	APPROVAL RECOMMENDED: ENGINEER	APPROVED: COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
CHIEF, PLANNING & REPORTS BRANCH	CHIEF, ENGINEERING DIVISION	
PREPARED: ENGINEER, HEAD, REPORTS SECTION	DRAWN BY: LEE BLAIR; CHECKED BY: WM. LEE	TO ACCOMPANY REVIEW REPORT COVERING SAN GABRIEL RIVER; FILE: BRAZ 512-26

PLATE 1

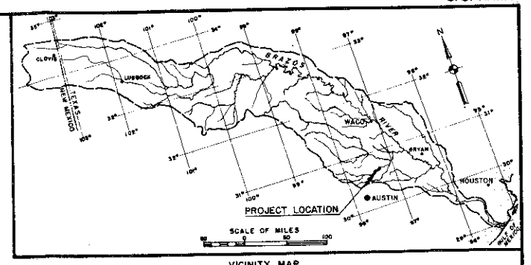
80982 O-62 (Face p. 66) No. 1

CORPS OF ENGINEERS

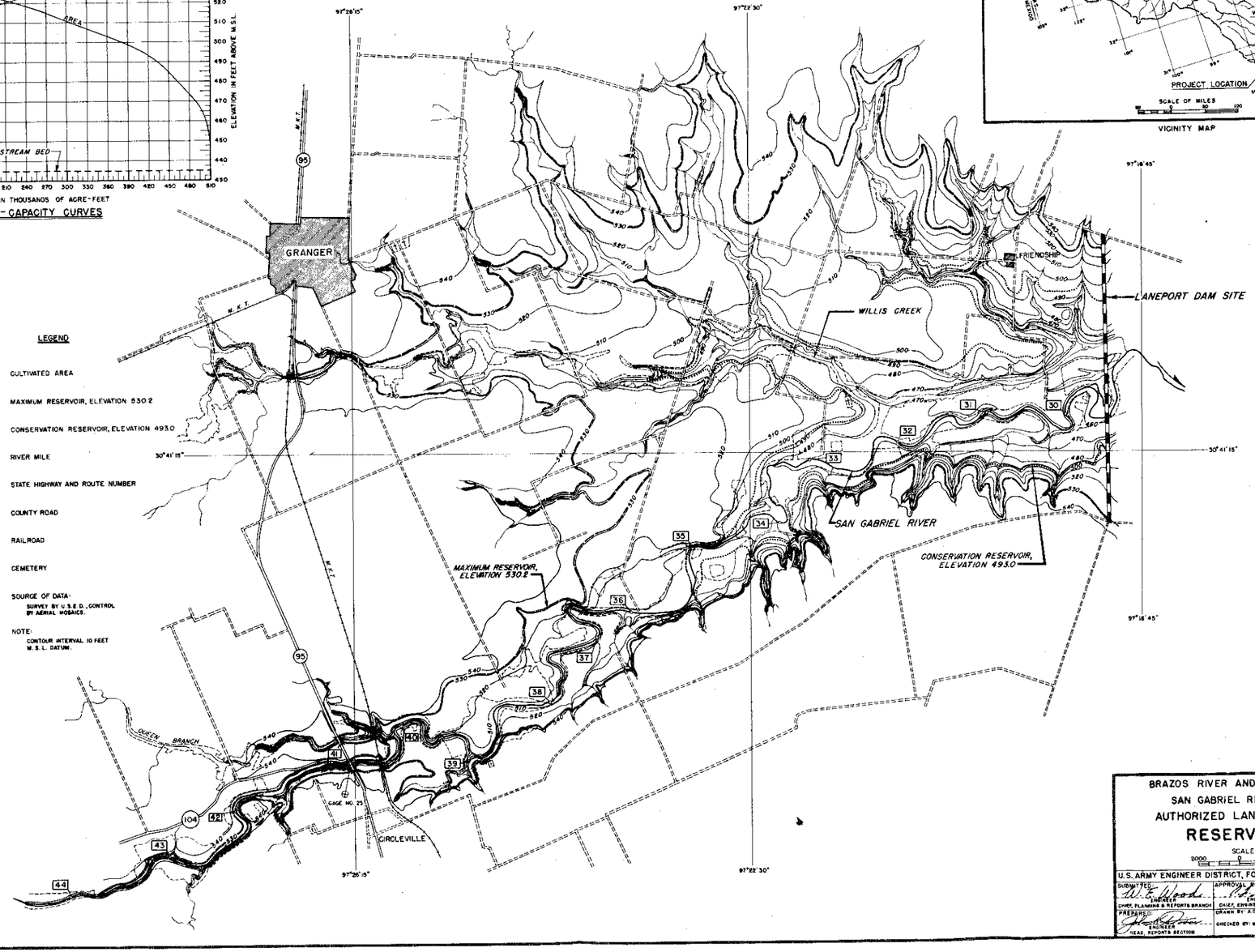
U.S. ARMY



AREA-CAPACITY CURVES



VICINITY MAP



LEGEND

- CULTIVATED AREA
- MAXIMUM RESERVOIR, ELEVATION 530.2
- CONSERVATION RESERVOIR, ELEVATION 493.0
- 55 RIVER MILE
- 95 STATE HIGHWAY AND ROUTE NUMBER
- COUNTY ROAD
- RAILROAD
- CEMETERY

SOURCE OF DATA:
SURVEY BY U.S.E.D., CONTROL BY AERIAL MOSAICS.

NOTE:
CONTOUR INTERVAL 10 FEET M.S.L. DATUM.

BRAZOS RIVER AND TRIBUTARIES, TEXAS
SAN GABRIEL RIVER WATERSHED
AUTHORIZED LANEPORT RESERVOIR

RESERVOIR MAP

SCALE OF FEET
2000 0 2000 4000

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — AUG. 1960

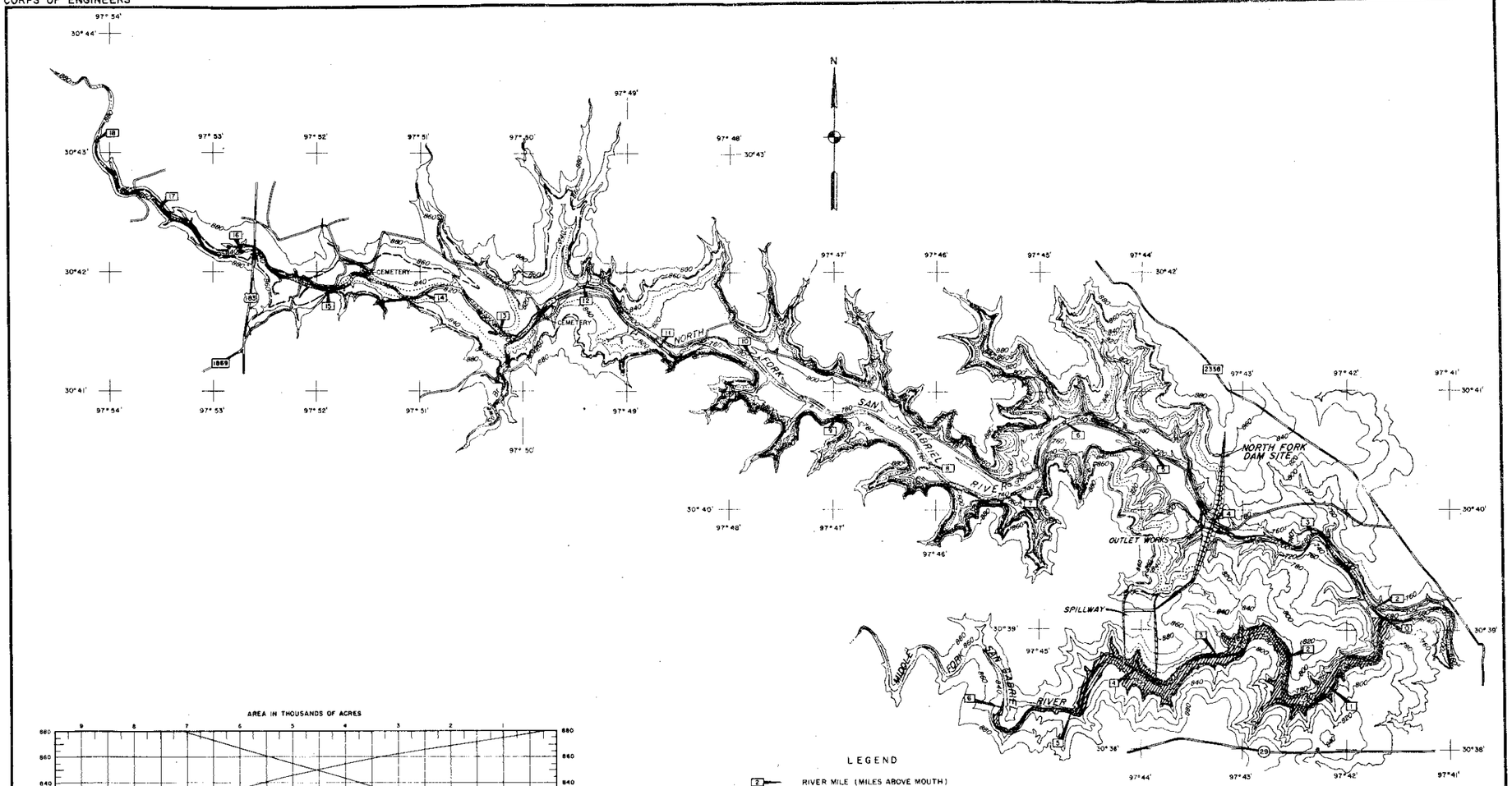
SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
ENGINEER, CHIEF, PLANNING & REPORTS BRANCH	ENGINEER, CHIEF, ENGINEERING DIVISION	COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
PREPARED: ENGINEER, HEAD, REPORTS SECTION	DRAWN BY: A.O.W. CHECKED BY: W.T.W.	TO ACCOMPANY REVIEW REPORT COVERING SAN GABRIEL RIVER
		FILE: BRAZ 512-26

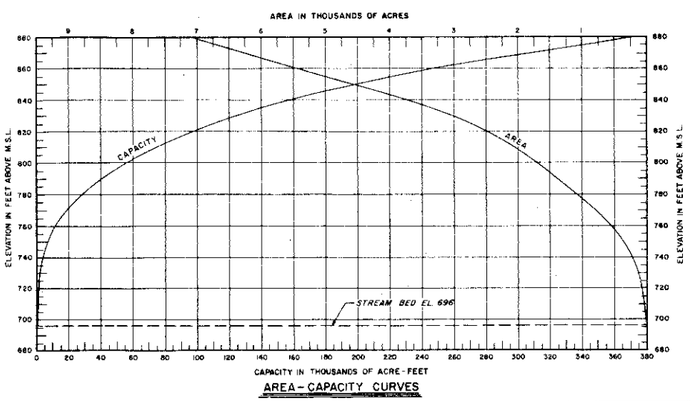
PLATE 1A

89982 O-62 (Face p. 66) No. 2

CORPS OF ENGINEERS

U. S. ARMY





AREA – CAPACITY CURVES

LEGEND

- RIVER MILE (MILES ABOVE MOUTH)
- U.S. HIGHWAY AND ROUTE NUMBER
- STATE HIGHWAY AND ROUTE NUMBER
- FARM TO MARKET HIGHWAY AND ROUTE NUMBER
- COUNTY ROAD
- TOP OF FLOOD CONTROL POOL EL. 855.0
- TOP OF CONSERVATION POOL EL. 832.8
- SPILLWAY FLOWAGE EASEMENT AREA

BRAZOS RIVER AND TRIBUTARIES, TEXAS

SAN GABRIEL RIVER WATERSHED

PROPOSED NORTH FORK DAM AND RESERVOIR

RESERVOIR MAP

IN 2 SHEETS — SHEET NO. 1

SCALE OF FEET: 2000 0 2000 4000

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — AUG. 1960

SUBMITTED: W. E. Wood, ENGINEER, CHIEF, PLANNING & REPORTS BRANCH

APPROVAL RECOMMENDED: [illegible], ENGINEER, CHIEF, ENGINEERING DIVISION

APPROVED: [illegible], DIV. CORPS OF ENGINEERS, DISTRICT ENGINEER

PREPARED: [illegible], ENGINEER, HEAD, REPORTS SECTION

DRAWN BY: L.A.V. - B.D.J. CHECKED BY: W.T.W.

TO ACCOMPANY REVIEW REPORT COVERING SAN GABRIEL RIVER

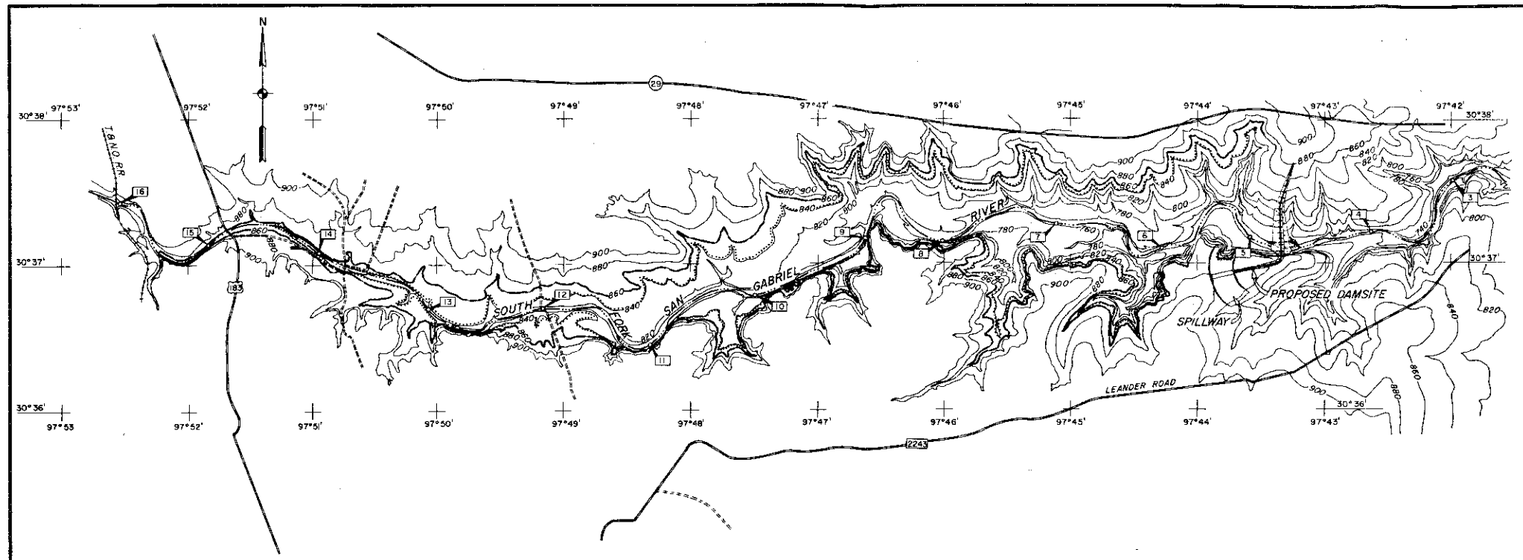
FILE: BRAZ 512-26

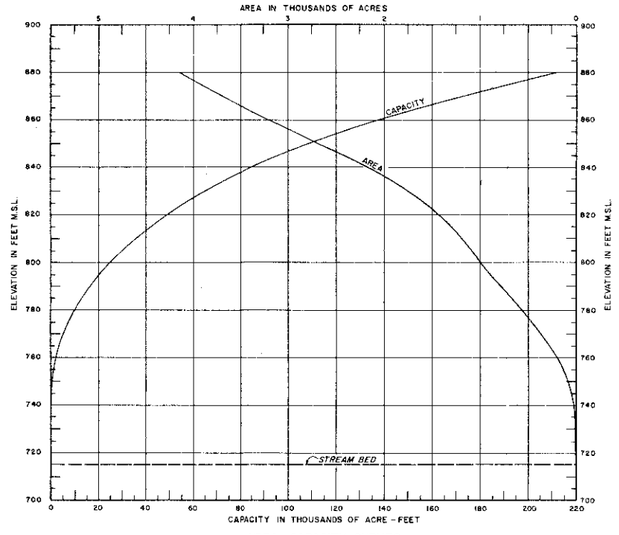
PLATE 12

89982 O-62 (Face p. 66) No. 3

CORPS OF ENGINEERS

U. S. ARMY





AREA-CAPACITY CURVES

LEGEND

- RIVER MILE (MILES ABOVE MOUTH)
- U.S. HIGHWAY AND ROUTE NUMBER
- STATE HIGHWAY AND ROUTE NUMBER
- FARM TO MARKET HIGHWAY AND ROUTE NUMBER
- COUNTY ROAD
- TOP OF FLOOD CONTROL POOL EL. 860.0
- TOP OF CONSERVATION POOL EL. 843.4

BRAZOS RIVER AND TRIBUTARIES, TEXAS

SAN GABRIEL RIVER WATERSHED

PROPOSED SOUTH FORK DAM AND RESERVOIR

RESERVOIR MAP

SCALE OF FEET 2000 0 2000 4000

U.S. ARMY ENGINEER DISTRICT, FORT WORTH — NOV. 1960

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

PREPARED: CHIEF, PLANNING & REPORTS BRANCH — DRAWN BY: G.E.S. — CHECKED BY: R.T.H. — TRACED: CHIEF, REPORTS SECTION

TO ACCOMPANY REVIEW REPORT COVERING SAN GABRIEL RIVER

FILE: BRAZ. 512-26

PLATE 14

89982 O-62 (Face p. 66) No. 4

APPENDIX I

HYDROLOGY AND HYDRAULIC DESIGN

REVIEW OF REPORTS ON BRAZOS RIVER AND TRIBUTARIES, TEXAS COVERING SAN GABRIEL RIVER WATERSHED

HYDROLOGY

1. INTRODUCTION.- This appendix contains hydrologic and hydraulic design data pertinent to Laneport, North Fork, and South Fork Reservoirs, which have been used in the preparation of this report. The Laneport Dam site is located on the San Gabriel River at river mile 29.7, about 10 miles northeast of Taylor, Texas. The North Fork Dam site is located on the North San Gabriel River at river mile 4.0, about 3.5 miles west of Georgetown, Texas. The South Fork Dam site is located on the South San Gabriel River at river mile 4.7, about 2.0 miles southwest of Georgetown, Texas. The San Gabriel River has a total drainage area of 1,319 square miles, of which 711 square miles are tributary to Laneport Reservoir, and of that amount, 236 and 120 square miles are tributary to the North Fork and South Fork Reservoirs, respectively. The plan of development presented in this report assumes Laneport Reservoir would be in operation in 1970, North Fork Reservoir would be added in 1985, and South Fork Reservoir in 1990. Under this plan the allocation of storage requirements in Laneport Reservoir varies as each stage is added. The storage requirements at each stage of development were established so that if stages 2 and 3 were not constructed as presently planned there would be adequate storage to meet all requirements for the 50-year period representing the economic life of the project.

2. DRAINAGE AREAS.- A drainage area map of the San Gabriel River watershed is shown on plate 2, and the drainage areas and river miles for selected points in the watershed are given in table 1.

3. EVAPORATION.- The evaporation from Laneport, North Fork, and South Fork Reservoirs has been based upon evaporation records of the Texas Agricultural Experiment Station at Temple and the U. S. Weather Bureau station at Belton Dam, Texas. The average monthly evaporation data for the above stations are shown in table 2.

4. AREA AND CAPACITY OF THE RESERVOIRS.- Topography for the Laneport Reservoir was based upon a plane table survey made by the Corps of Engineers in 1946 and topography for the North Fork and South Fork Reservoirs was based upon maps prepared by the Brazos River Conservation and Reclamation District from surveys made in 1936 and 1937. Area curves were determined for the Laneport, North Fork, and South Fork Reservoirs by planimetering the area within each 10-foot contour on maps of each reservoir prepared to a scale of 1:12,000.

A smooth curve was drawn through the plotted area points for each reservoir and the capacities were computed for one-foot intervals by the average end-area method using the area curves. Tabulations of the initial areas and capacities for Laneport, North Fork, and South Fork Reservoirs are given in tables 3, 4, and 5, respectively.

5. DETERMINATION OF FLOWS AT LANEPORT, NORTH FORK, AND SOUTH FORK DAM SITES.- Monthly flows at the Laneport, North Fork, and South Fork Dam sites (and other sites investigated in the San Gabriel River watershed) for the period February 1924 through September 1959 were estimated from streamflow records at the Circleville and Georgetown gages. Drainage area factors were applied to the observed flows at Circleville gage on the San Gabriel River for the period February 1924 through September 1934, and to the observed flows at the Georgetown gage on the San Gabriel River for the period October 1934 through September 1959. A study of the period of concurrent record at the Georgetown and Circleville gages was made for the purpose of checking the above method for the determination of monthly flows. This study indicated that application of a drainage area factor to the observed monthly flows at the Georgetown gage would produce estimated flows at the Circleville gage that were within two percent of observed Circleville flows. The estimated monthly and annual natural flows at Laneport, North Fork, and South Fork Dam sites are given in tables 6, 7, and 8, respectively.

6. GENERAL CRITERIA FOR RESERVOIR STORAGE CAPACITIES.- The general criteria for reservoir storage capacities are set forth in paragraph 58 of the main text. Further data on reservoir storage requirements are presented in the following paragraphs.

7. SEDIMENT STORAGE.- The annual rate of sediment production for the watershed of the San Gabriel River above the Laneport, North Fork, and South Fork Reservoir was determined by use of the data and methodology set forth in Bulletin 5912 entitled "Inventory and Use of Sedimentation Data in Texas," published by the Texas Board of Water Engineers in January 1959. Taking into consideration the major land resource areas of the San Gabriel River watershed above the proposed reservoirs and an estimated trap efficiency of 99.8 percent for Laneport, North Fork, and South Fork Reservoirs, the computed sediment deposition for the 50-year period representing the economic life of the projects is presented in the following tabulation. The sediment storage in Laneport was varied to correspond with the appropriate stage of development.

Reservoir	Stage 1	Stage 2	Stage 3
Laneport	27,700	22,900	22,200
North Fork	--	7,000	7,000
South Fork	--	--	4,000

8. CONSERVATION STORAGE.- As a result of the ever-increasing water demands for municipal and other uses, consideration was given to providing varying amounts of conservation storage in Laneport, North Fork, and South Fork Reservoirs. Therefore, operation studies, with allowances for evaporation, were made to determine the streamflow regulation that could be obtained from a wide range of conservation storages in the reservoirs. The following tabulation presents data on the average annual inflow, average annual evaporation, and the yield from the reservoirs during the critical period.

	Laneport			North Fork	South Fork
	Stage 1	Stage 2	Stage 3		
Critical period	Jan 54-Nov 56	Jun 47-Mar 57	Jun 47-Mar 57	Jun 47-Mar 57	Jun 47-Mar 57
Average annual inflow (ac-ft)	22,700	29,230	22,040	14,540	7,390
Average annual evaporation (in)	45.8	34.5	34.5	34.5	34.5
Conservation storage (ac-ft)	68,100	147,900	193,200	126,700	89,000
Conservation storage (in)	1.80	5.84*	10.20*	10.07	13.91
Yield (cfs)	43	39	34	30	17

*Conservation storage in inches based on 475 and 355 square miles for stage 2 and stage 3 development, respectively.

Conservation storage-dependable yield curves for the reservoirs are presented on plate 16.

9. An improvement program for the San Gabriel River watershed upstream and downstream from the proposed reservoirs is indicated in Senate Document No. 111, 85th Congress, 2nd Session, dated July 24, 1958. The improvements on the Upper and Lower Brushy Creek watershed, which is tributary to the San Gabriel River downstream from the Laneport Dam site, were authorized for operation by Public Law 566, 83rd Congress, 68 Stat. 666. Data available as of July 1, 1960, indicate that twenty-one retardation reservoirs have been completed, fourteen on Upper Brushy Creek and seven on Lower Brushy Creek. An additional thirty-seven retardation structures are authorized on Brushy Creek. When constructed, the fifty-eight authorized retarding structures on Brushy Creek would have a total detention storage of 62,960 acre-feet, a combined release rate of 1,030 second-feet, and will retard runoff from 201.1 square miles. Upon completion of the Soil Conservation Service program, the total discharge from the structures on Brushy Creek of 1,030 second-feet will reduce the maximum allowable release rate from Laneport Reservoir during flood periods by a corresponding amount. The locations of the Soil Conservation structures on Brushy Creek, completed as of July 1, 1960, are shown on plate 2.

10. Preliminary data, presented to the United States Study Commission - Texas by the Soil Conservation Service in March 1960 in connection with the "Flood Hydrology for Economic Evaluations on the Brazos River Basin" for use in first stage planning, indicate that twenty-two retardation structures are proposed on the North San Gabriel watershed above the North Fork Dam site, fourteen are proposed on the South San Gabriel watershed above the South Fork Dam site, and twenty-three are proposed for the remainder of the watershed above the Laneport Dam site. The twenty-two proposed structures above the North Fork Dam site, if constructed, would have a total detention storage of 25,920 acre-feet, a combined release rate of 860 second-feet, and would retard the runoff from 108 square miles. The fourteen proposed structures above the South Fork Dam site, if constructed, would have a total detention storage of 16,800 acre-feet, a combined release rate of 560 second-feet, and would retard the runoff from 70 square miles. The twenty-three proposed structures on the remainder of the watershed above Laneport Dam site, if constructed, would have a total detention storage of 23,840 acre-feet, a combined release rate of 720 second-feet, and would retard runoff from 88.4 square miles.

11. There are no Soil Conservation Service reservoirs on the watershed above Laneport Reservoir at present; however, it is estimated that present land treatment practices and existing small ponds have depleted the natural runoff from the watershed above Laneport Reservoir by about 8 percent during recent years and that this depletion is reflected in the observed streamflow at the Georgetown gage. It is further estimated that the proposed Soil Conservation Service land treatment practices, small ponds, and retardation structures above the reservoir during the next 50 years will result in an additional 28 percent depletion of runoff. Depleted resources were estimated assuming 50 years of watershed development by applying a factor of 0.72 to the runoff under present conditions. Utilizing these data and the initial area and capacity of the reservoirs, yield determinations were made for Laneport, North Fork, and South Fork Reservoirs. The results of this study indicated that the proposed conservation storages in Laneport, North Fork, and South Fork Reservoirs would yield the amounts shown in the following tabulation during the critical period after 50 years of watershed development.

Reservoir	Stage 1 yield (cfs)	Stage 2 yield (cfs)	Stage 3 yield (cfs)
Laneport	38	34	29
North Fork	-	26	26
South Fork	-	-	15

12. FLOOD-CONTROL STORAGE.- In the preparation of the Brazos River Survey Report dated August 15, 1947, a regional statistical

analysis of flood-control storage capacities was made assuming that hypothetical reservoirs of unlimited storage capacity, located at the principal gaging stations in the Brazos River and adjacent basins, would control releases to a rate of two second-feet per square mile of drainage area. Based upon the foregoing analysis, a relationship was established between flood-control storage requirements and drainage area for a range of frequencies. This relationship indicated that, in order to provide a high and uniform degree of flood protection for the affected areas, each area investigated in the Brazos River Basin should be provided with sufficient flood-control storage to regulate the 50-year flood from its watershed area to non-damaging proportions downstream. As a safety factor and to provide flexibility of operation, an additional amount of storage was provided sufficient to allow for withholding of releases for a period of seven days. Based upon the regional analysis (with an allowance for withholding), 236,100 acre-feet or 6.23 inches of flood-control storage were provided in Laneport Reservoir in the project document.

13. As a further check on the flood-control storage requirement for Laneport Reservoir as presented in the project document, a hypothetical 50-year flood hydrograph was developed at the damsite based upon a volume-frequency study of flows at the Georgetown gage. The hypothetical 50-year flood was then routed through the reservoir with Laneport Reservoir operated as a unit in a system which included: the existing Whitney and Belton Reservoirs; the Waco and Proctor Reservoirs now under construction; the authorized Stillhouse Hollow and Somerville Reservoirs; and the recommended Millican Reservoir. The hypothetical 50-year flood on the area above Laneport Reservoir was assumed to occur coincident with the April-May 1957 flood on the remainder of the Brazos River Basin. Releases from all reservoirs in the system were limited to such rates as would produce flows not to exceed downstream channel capacities on those tributary streams where the reservoirs were located and on the Brazos River between Whitney Reservoir and the mouth. The flood-control storage requirement thus determined for Laneport Reservoir was almost identical with that determined by the regional analysis presented in the project document.

14. Hypothetical 50-year flood hydrographs were then used to establish the flood-control storage requirements for North Fork and South Fork Reservoirs, and for Laneport Reservoir in combination with North Fork Reservoir (stage 2) and in combination with both North and South Fork Reservoirs (stage 3). To obtain the 50-year flood hydrographs, various storm transpositions were studied and in each case that transposition was adopted which would produce the most critical requirement for flood-control storage at each of the upstream reservoirs and at Laneport Reservoir for stages 2 and 3 of development. Routings of the hypothetical 50-year floods through the reservoirs utilizing routing assumptions identical with those set forth in the preceding paragraphs indicated the flood-control storage requirements during each stage of development as shown in the following tabulation:

Reservoir	Stage 1 FC storage		Stage 2 FC storage		Stage 3 FC storage	
	ac-ft	inches	ac-ft	inches	ac-ft	inches
Laneport	236,100	6.23	161,100	6.36*	116,500	6.15*
North Fork	--	--	87,900	6.98	87,900	6.98
South Fork	--	--	--	--	45,500	7.11

*Flood-control storage in inches based on 475 and 355 square miles for stage 2 and stage 3 development, respectively.

15. The maximum flood of record on the San Gabriel River watershed occurred in April-June 1957. A routing was made of the April-June 1957 flood under the three stages of development with the reservoirs operated as units in a system which was assumed to include: the existing Whitney and Belton Reservoirs; the Waco and Proctor Reservoirs, now under construction; the authorized Stillhouse Hollow and Somerville Reservoirs; and the recommended Millican Reservoir. The reservoir level at the beginning of the flood was assumed to be at the top of the conservation pool for all reservoirs in the Brazos River system except Whitney and Waco Reservoirs. Due to the geographical location of Whitney and Waco Reservoirs and the improbability of having full conservation pools at all reservoirs in the basin concurrent with the beginning of the maximum flood of record, the initial levels for Whitney and Waco Reservoirs were established from hypothetical reservoir regulation studies for the period of record. Releases from all reservoirs in the system were limited to such rates as would produce flows not to exceed downstream channel capacities, existing or proposed, on those tributary streams where the reservoirs were located, and on the Brazos River between Whitney Reservoir and the mouth. The results of routings for the April-June 1957 flood are shown on plates 17 through 19 and the amounts of flood-control storage utilized in the reservoirs under the three stages of development are given in the following tabulation:

Reservoir	Stage 1 FC storage utilized		Stage 2 FC storage utilized		Stage 3 FC storage utilized	
	ac-ft	inches	ac-ft	inches	ac-ft	inches
Laneport	208,100	5.49	138,000	5.45*	101,700	5.37*
North Fork	--	--	69,300	5.51	69,300	5.51
South Fork	--	--	--	--	37,200	5.81

*Flood-control storage utilized in inches based on 475 and 355 square miles for stage 1 and stage 2 development, respectively.

16. FLOOD-CONTROL EFFECTS.- In order to evaluate the flood-control effects of each of the reservoirs investigated on the San

Gabriel River watershed, the peak discharges for the damaging floods of record were determined on the watershed itself, and at the principal gaging stations within the affected areas on the Little River and the Brazos River below the mouth of the San Gabriel River, by use of gage records and routing procedures. In determining the reduction in peak discharges, it was assumed that each of the reservoirs, or system of reservoirs, investigated on the San Gabriel River watershed would in turn be operated as a unit in a system which would include: the existing Whitney and Belton Reservoirs; the Waco and Proctor Reservoirs, now under construction; the authorized Stillhouse Hollow and Somerville Reservoirs; and the recommended Millican Reservoir. Releases from all the reservoirs in the system were limited to such rates as would produce flows not to exceed downstream channel capacities, existing or proposed, on those tributary streams where the reservoirs were located and on the Brazos River between Whitney Reservoir and the mouth.

17. SPILLWAY DESIGN STORM.- The spillway design storm rainfall for each of the various reservoirs studied in the San Gabriel River watershed was computed following a method described in Hydrometeorological Report No. 33, dated April 1956, subject "Seasonal Variations of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1000 Square Miles and Durations of 6, 12, 24, and 48 Hours." The computed reduction for basin shape was less than two percent; therefore, no such adjustment was made. Based on this analysis a total rainfall of 32.14, 35.57, and 37.44 inches were adopted as the spillway design storm rainfall over the ares of 711 (stage 1 development), 236, and 120 square miles above the Laneport, North Fork, and South Fork Dam sites, respectively. Two storm patterns were considered for Laneport Reservoir under stage 2 and stage 3 development. One pattern assumed the storm centered over the total drainage area, 711 square miles above Laneport Dam site, and required a uniform total rainfall of 32.14 inches on the areas above the damsites. The second pattern assumed the spillway design storm centered on the local area between the upstream and Laneport Dam sites. This pattern for stage 2 development required a total rainfall for the 475-square mile area between Laneport and North Fork Dam sites of 33.17 inches and a residual of 30.07 inches for the 236 square miles above the North Fork Dam site. The second pattern for stage 3 development required a total rainfall for the 355-square mile area between Laneport and North Fork and South Fork Dam sites of 34.63 inches and a residual of 29.66 inches for the 356-square mile area above North Fork and South Fork Dam sites. Routing the two storm patterns through the proposed reservoirs indicated that the latter storm pattern was more critical and was adopted for the spillway design storm for Laneport Reservoir when considered in a system under stage 2 and stage 3 development. The 6-hour increments of spillway design storm rainfall and areas to which they are applicable under the three stages of development are given in table 9.

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18. RUNOFF FACTORS AND INFILTRATION INDICES.- Runoff factors and infiltration indices were computed for the San Gabriel River watershed above the Georgetown and Circleville gages following a method described in EM 1110-2-1405, "Flood-Hydrograph Analyses and Computations." Initial losses on the watershed have ranged from a minimum of 0.90 inch to a maximum of 1.25 inches. The range in infiltration indices was from 0.10 to 0.30 inch per hour, and runoff coefficients varied from 24.9 to 54.2 percent. The results of these computations, together with the storm rainfall and runoff data, are given in table 10. In estimating the rainfall-excess for the spillway design storms for Laneport, North Fork, and South Fork Reservoirs, an initial loss of 1.0 inch and a uniform infiltration rate of 0.10 inch per hour were assumed. Application of these assumed losses to the adopted spillway design storms produced an estimated rainfall-excess of 26.94 inches or 83.8 percent of the total rainfall for the area above Laneport Reservoir; 30.41 inches or 85.5 percent of the total rainfall for North Fork Reservoir; 32.24 inches or 86.1 percent of total rainfall for South Fork Reservoir; Laneport Reservoir in system with the North Fork Reservoir, 27.97 inches or 84.3 percent of the total rainfall on the area between Laneport and North Fork Dam sites and 24.87 inches or 82.7 percent of the total rainfall applicable to the area above North Fork Dam site; and in the case of Laneport Reservoir in system with the North Fork and South Fork Reservoirs, 29.43 inches or 85.0 percent of the total rainfall on the area between Laneport and North Fork and South Fork Dam sites and 24.46 inches or 82.5 percent of the total rainfall applicable to the area above North Fork and South Fork Dam sites. The rainfall and rainfall-excesses for the spillway design flood for Laneport, North Fork, and South Fork Reservoirs and Laneport Reservoir in system with the North Fork Reservoir and in system with the North Fork and South Fork Reservoirs are given in table 9.

19. UNIT HYDROGRAPH STUDIES.- Unit hydrograph determinations were made for selected storms for which hydrographs were available at the Georgetown and Circleville gages on the San Gabriel River. These studies, made in accordance with EM 1110-2-1405, were submitted to the Office, Chief of Engineers, with letter SWFGP, subject "Unit Hydrograph Compilation," dated June 29, 1960. Unit hydrograph pertinent data for the storms studied are summarized on plates 20 and 21 for the Georgetown and Circleville gages, respectively.

20. SYNTHETIC UNIT HYDROGRAPHS.- As a result of the foregoing analysis, a C_t coefficient of 0.90 and C_p640 value of 500 were adopted for use in Snyder's equations for the derivation of synthetic 6-hour unit hydrographs for the San Gabriel River watershed above Laneport Dam site excluding the area above the North Fork and South Fork Dam sites. A C_t coefficient of 0.80 and a C_p640 value of 530 were adopted for use in Snyder's equations for the areas above the North Fork, South Fork, and other damsites investigated in the upper portion of the watershed. The synthetic 6-hour unit hydrographs for natural flow

at Laneport, North Fork, and South Fork Dam sites and for flow into full reservoir for the area above North Fork and South Fork Dam sites and the area between Laneport and North Fork Dam sites and the area between Laneport and North Fork and South Fork Dam sites are given in table 11.

21. REPRODUCED FLOOD HYDROGRAPHS.- The synthetic unit hydrographs for the several damsites investigated on the San Gabriel River and tributary streams were based upon the coefficients set forth in paragraph 20. The combined drainage area above the North and South Fork Dam sites (356 square miles) approaches the drainage area of the Georgetown gage (390 square miles). The adopted coefficients for reservoirs in the upper portion of the watershed (C_t = 0.80 and C_p640 = 530) were tested by combining the synthetic unit hydrographs for the North and South Fork Reservoirs with the synthetic unit hydrograph for the area lying between the damsites and the Georgetown gage. This composite synthetic 6-hour unit hydrograph was converted to a 1-hour unit hydrograph following the S-curve method described in EM 1110-2-1405, dated August 31, 1959, and the resulting 1-hour unit hydrograph was used to reproduce the flood of April 24, 1957, at the Georgetown gage. The observed and reproduced hydrographs, the storm isohyetal map, and typical mass curves of rainfall for the storm of April 24, 1957, are shown on plate 24. The area above head of reservoir for the Laneport Dam site has a drainage area of 589 square miles which is identical to the drainage area above the Circleville gage. The adopted coefficients for the Laneport Reservoir (C_t = 0.90 and C_p = 500) were tested by converting the synthetic 6-hour unit hydrograph for the area above head of Laneport Reservoir to a 3-hour unit hydrograph by the S-curve method referred to above, and utilizing the 3-hour unit hydrograph to reproduce two of the larger floods of record on the San Gabriel River at the Circleville gage. The observed and reproduced hydrographs, the storm isohyetal maps, and typical mass curves of rainfall for the storms of October 1-2, 1927, and May 10, 1930, are shown on plates 22 and 23, respectively.

22. SPILLWAY DESIGN FLOOD HYDROGRAPHS.- The spillway design flood hydrographs representing natural flow at damsite and flow into full reservoir were determined for the North Fork and South Fork Reservoirs using the appropriate 6-hour rainfall-excess values and unit hydrographs given in tables 9 and 11, respectively; and, in the case of their flow into full reservoir hydrographs, runoff at a rate equal to the rate of rainfall over the reservoir surfaces of the North Fork and South Fork Reservoirs (8 and 5 square miles, respectively). The resulting spillway design flood hydrographs for natural flow at damsite and flow into full reservoir for North Fork and South Fork Reservoirs have peak discharges and volumes as given in the following tabulation:

Reservoir	Spillway design flood hydrographs			
	Flow into full reservoir		Natural flow at dam site	
	Peak discharge (cfs)	Volume (ac-ft)	Peak discharge (cfs)	Volume (ac-ft)
North Fork	444,800	383,100	435,500	382,800
South Fork	304,800	207,400	270,500	206,300

The spillway design flood hydrographs representing natural flow at damsite for Laneport Reservoir and flow into full reservoir for Laneport Reservoir (Stage 1) were determined using the appropriate 6-hour rainfall-excess values and unit hydrographs given in tables 9 and 11, respectively; and, in the case of flow into full reservoir, the runoff from the 21 square miles of reservoir surface at a rate equal to the rate of rainfall. The resulting spillway design floods representing natural flow at damsite and flow into full reservoir for Laneport Reservoir (Stage 1) have peak discharges of 634,500 and 637,000 second-feet and volumes of 1,021,600 and 1,026,700 acre-feet, respectively. The spillway design flood representing flow into full reservoir for Laneport Reservoir (Stage 2) was determined as follows. The appropriate rainfall-excess values for the area above North Fork Dam site and the area between North Fork and Laneport Dam sites given in table 9 were applied to the unit hydrographs for flow into full reservoir for these areas given in table 11. Runoff at a rate equal to the rate of rainfall over the reservoir surfaces of the North Fork and Laneport Reservoirs (8 and 21 square miles, respectively) was added to the hydrograph for the area affected. The hydrograph thus constructed for the area above North Fork Reservoir was routed through the reservoir on a full flood-control pool and the outflows routed to head of Laneport Reservoir and combined with the hydrograph determined for the area between the two damsites. The resulting hydrograph has been adopted as the spillway design flood representing flow into full reservoir for the Laneport Reservoir in combination with North Fork Reservoir. The spillway design flood representing flow into full reservoir for Laneport Reservoir in a system with North Fork Reservoir has a peak discharge of 631,800 second-feet and a volume of 1,026,700 acre-feet. The spillway design flood representing flow into full reservoir for Laneport Reservoir (Stage 3) was determined as follows. The appropriate rainfall-excess values for the area above North Fork and South Fork Dam sites and the area between Laneport and North Fork and South Fork Dam sites given in table 10 were applied to the unit hydrographs for flow into full reservoir for these areas given in table 11. Runoff at a rate equal to the rate of rainfall over the reservoir surfaces of the North Fork, South Fork, and Laneport Reservoirs (8, 5, and 21 square miles, respectively) was added to the

hydrograph for the area affected. The hydrographs thus constructed for the areas above North Fork and South Fork Reservoirs were routed through the respective reservoirs on a full flood-control pool and the outflows obtained were routed to the head of Laneport Reservoir and combined with the hydrograph developed for the area between Laneport Dam site and the North Fork and South Fork Dam sites. The resulting hydrograph has been adopted as the spillway design flood representing flow into full reservoir for the Laneport Reservoir in combination with the North Fork and South Fork Reservoirs. The spillway design flood representing flow into full reservoir for Laneport Reservoir in a system with North Fork and South Fork Reservoirs has a peak discharge of 630,700 second-feet and a volume of 1,026,700 acre-feet.

23. SPILLWAY DESIGN FLOOD ROUTING CONDITIONS.- The spillway design flood hydrographs for flow into full reservoir for Laneport, North Fork, and South Fork Reservoirs were routed through the reservoirs assuming that the reservoir levels at the beginning of the flood would be at top of gates (top of flood control pool) in the case of Laneport Reservoir, and at spillway crest (top of flood control pool) in the case of North Fork and South Fork Reservoirs. The outlet works of all reservoirs were assumed operative during the passage of their respective spillway design floods. The routing of the spillway design floods through North Fork and South Fork Reservoirs produced maximum elevations of 872.2 and 876.6 and peak outflows of 326,000 and 195,100 second-feet, respectively. The spillway design flood inflow-outflow hydrographs and reservoir elevations for North Fork and South Fork Reservoirs are shown on plates 25 and 26, respectively. Induced surcharge routings of the spillway design floods through Laneport Reservoir under Stage 1, Stage 2, and Stage 3 development, using 95 percent of the inflow to establish the outflow for the following periods, produced maximum reservoir elevations and peak outflows of 540.9 and 546,800 second-feet (Stage 1), 539.0 and 508,000 second-feet (Stage 2), and 540.0 and 530,000 second-feet (Stage 3). The spillway design flood inflow-outflow hydrographs and reservoir elevations for Laneport Reservoir under Stage 1 development, which produced the maximum reservoir level and discharge, are shown on plate 27.

24. FREEBOARD REQUIREMENTS.- The freeboard requirements for the proposed Laneport and North Fork and South Fork Dams were determined in accordance with the method set forth in the minutes of a "Conference on Determination of Freeboard Requirements for the McGee Bend Dam, Angelina River, Texas," held in the Fort Worth District Office on June 15, 1956. Computations of wave height and wave runup for Laneport Dam were based upon a computed effective fetch of 4.3 miles at maximum water surface elevation 540.9. The computed wave height and total freeboard required for an overland wind velocity of 40 miles per hour (52 miles per hour over water) were 4.6 and 5.0 feet, respectively.

The top of Laneport Dam was, therefore, set at elevation 846.0. Computations of wave height and wave runup for North Fork Dam were based on an effective fetch of 1.8 miles at maximum water surface elevation 872.2. The computed wave height and total freeboard required for an overland wind velocity of 40 miles per hour (52 miles per hour over water) were 3.0 and 3.2 feet, respectively. However, in view of the minimum freeboard requirement of 5.0 feet, the top of North Fork Dam was set at elevation 878.0. Computations of wave height and wave runup for South Fork Dam were based on an effective fetch of 1.7 miles at maximum water surface elevation 876.6. The computed wave height and total freeboard required for an overland wind velocity of 40 miles per hour (52 miles per hour over water) were 2.8 and 2.9 feet, respectively. However, in view of the minimum freeboard requirement of 5.0 feet, the top of South Fork Dam was set at elevation 882.0.

25. STANDARD PROJECT FLOOD.- The standard project storm rainfall of 18.3, 20.1, and 21.1 inches for the area above Laneport, North Fork, and South Fork Dam sites, respectively, were determined in accordance with procedures described in EM 1110-2-1411 (Civil Works Engineer Bulletin No. 52-8, dated March 26, 1952, subject "Standard Project Flood Determinations"). An initial loss of 1.00 inch and a uniform infiltration rate of 0.10 inch per hour were applied to the 6-hour increments of standard project storm rainfall for the reservoirs to obtain a total runoff of 12.9 inches above Laneport Dam site, 14.7 inches above North Fork Dam site, and 15.8 inches above South Fork Dam site. The standard project flood hydrographs for Laneport (Stage 1), North Fork and South Fork Reservoirs, representing flow into full reservoir, were then computed by applying the resulting 6-hour increments of rainfall-excess to the appropriate unit hydrographs for flow into full reservoir given in table 11, and adding to each of the resulting hydrographs runoff from the corresponding reservoir surface (Laneport = 21 square miles, North Fork = 8 square miles, South Fork = 5 square miles) at a rate equal to the respective rates of rainfall. The computed standard project flood hydrographs for Laneport (Stage 1), North Fork and South Fork Reservoirs have peak discharges and volumes as given in the following tabulation:

Reservoir	Peak discharge (cfs)	Volume (ac-ft)
Laneport (Stage 1)	309,600	495,200
North Fork	204,700	186,500
South Fork	127,400	102,500

In the case of Laneport Stage 2 and Stage 3 developments, the standard project flood hydrographs were developed similar to the method used in developing the spillway design floods for these two stages, with the exception that the routings were made with the reservoir levels at top of conservation pool in North Fork and South Fork Reservoirs, at the beginning of the routings. The standard project flood hydrographs for Laneport under Stage 2 and Stage 3 development have peak discharges and volumes as given in the following tabulation:

Reservoir	Peak discharge (cfs)	Volume (ac-ft)
Laneport Stage 2	229,400	493,800
Laneport Stage 3	204,700	495,200

26. GUIDE TAKING LINE AND RELOCATION CRITERIA.- The guide taking lines for Laneport, North Fork, and South Fork Reservoirs have been based upon the policy for real estate acquisition set forth in EM 405-2-150. No continuous hypothetical operation was made for the period of record of the reservoirs. However, routings were made for the ten larger floods of record assuming a full pool at the beginning of each flood in the North Fork, South Fork, and Laneport Reservoirs under Stage 1, Stage 2, and Stage 3 development. Pool elevation-frequency curves were constructed for Laneport, under the three stages of development, and the North and South Fork Reservoirs from the results of these routings. Based upon the corresponding pool elevation-frequency curves, the 5-year pool elevations for Laneport were established at elevations 514.0, 522.0, and 526.0 under Stage 1, Stage 2, and Stage 3 development, respectively; and the 5-year pool elevations for the North Fork and South Fork Reservoirs were established at elevation 839.0 and 847.0, respectively. More detailed studies of the pool elevation-frequency relation will be made during the design stage of planning. Sufficient flood-control storage has been provided in Laneport and North Fork Reservoirs to control the maximum flood of record; therefore, the upper guide contour has been established three feet above the top of the flood-control pool in all reservoirs or at elevation 534.0 in Laneport Reservoir, 858.0 in North Fork Reservoir, and 863.0 in South Fork Reservoir. For the purpose of this report, the upper guide contour elevations of 534.0, 858.0, and 863.0 for Laneport, North Fork, and South Fork Reservoirs, respectively, have been adopted throughout their entire reservoir areas and have also been used as a basis for relocation estimates.

HYDRAULIC DESIGN

27. WATER SURFACE PROFILES.- Water surface profiles for the April 1957 flood, having an estimated peak discharge of 155,000 second-feet in the San Gabriel River at Georgetown and peak discharges of 102,000 second-feet and 78,800 second-feet, respectively, on the North and South Forks of the San Gabriel River, were developed by backwater computations, correlated with observed high water data and the U. S. Geological Survey stream gage at Georgetown (San Gabriel River mile 61.4). Coefficients of roughness (n) of 0.040 for the channel and 0.080 for the overbank were used in the Manning formula for developing the water surfaces. Plates 3 and 4 show the river profiles for the San Gabriel, Berry Creek, and North and South Forks of the San Gabriel River, including the estimated 1957 high water profile as well as the 1921 high water profile, based on observed data.

28. TAILWATER RATING CURVES.- Tailwater rating curves at the proposed damsites on the San Gabriel River (at Laneport), the North Fork and South Fork of the San Gabriel River are shown on plate 28. These rating curves were developed by the method described in the preceding paragraph.

29. DAMSITES.- Possible damsites, individually and in conjunction with other sites, were investigated at the Laneport Dam site on the San Gabriel River at river mile 29.7, on the North and South Forks of the San Gabriel River, and on Berry Creek. Dams at the Laneport site on the San Gabriel River, river mile 4.0 on the North Fork, and river mile 4.7 on the South Fork are recommended.

30. LANEPORT DAM - SPILLWAY.- The Laneport Dam would be located on the San Gabriel River at river mile 29.7 with the spillway on the right bank. The spillway would consist of a 560-foot ogee weir at elevation 502.0 controlled by fourteen 40- by 29-foot tainter gates separated by thirteen 8-foot piers. Under conditions of the spillway design discharge (531,500 second-feet), the reservoir would be at elevation 540.9. An approach channel having a bottom width of 664.0 feet at elevation 480.0 would extend for a distance of about 2,000 feet to natural ground in the reservoir. The spillway rating curve is shown on plate 29.

31. LANEPORT DAM - SPILLWAY STILLING BASIN.- A rectangular stilling basin would be provided to dissipate energy by the formation of a hydraulic jump for all discharges up to the spillway design discharge. The stilling basin would be 170 feet long with apron at elevation 424.0. Two rows of 9-foot high baffle piers and a 9-foot high end sill would be provided, along with 48-foot high training walls, and 45-degree wing walls. Riprap protection of the discharge channel would extend a distance of 100 feet beyond the end sill and adjacent

to the training walls to elevation 478.0. A rock-protected dike, to elevation 480.0, would be provided for a distance of about 1,000 feet adjacent to the left training wall.

32. LANEPORT DAM - OUTLET WORKS.- The flood-control outlet works would consist of a 19-foot diameter conduit controlled by three 5-foot 9-inch by 19-foot slide gates with intake invert at elevation 450.0 and outlet invert at elevation 448.0. The conduit would be located in the main embankment about 1,200 feet to the left of the existing river channel. The conduit, including the gate passages, would be 450 feet long. The conduit would be used for diversion during construction, for the passage of flood releases, and for the passage of low-flow discharges. The capacity of the flood-control conduit at various reservoir levels for all gates fully open is shown in the following tabulation:

Reservoir feature	Res. el. (ft msl)	Discharge (cfs)
Spillway crest	502.0	11,200
Top of conservation pool (Stage 1)	503.8	11,500
Top of conservation pool (Stage 2)	515.7	13,700
Top of conservation pool (Stage 3)	520.8	14,000
Top of gates	531.0	15,300
Maximum design water surface (Stage 1)	540.9	16,400

The outlet works rating curve is shown on plate 29. The 19-foot diameter conduit has a capacity in excess of the downstream river channel capacity (about 6,100 second-feet), therefore additional studies (which will include diversion requirements) will be made after authorization to determine if the size of the outlet works conduit can be reduced.

33. NORTH FORK DAM - SPILLWAY.- The North Fork Dam would be located on the North Fork of the San Gabriel River at river mile 4.0, with the spillway in a saddle on the right bank. The spillway would consist of a 1,600-foot uncontrolled broadcrested weir with crest at elevation 855.0. Under conditions of the spillway design discharge (320,200 second-feet), the reservoir would be at elevation 872.2. An approach channel having a bottom width of 1,600 feet would be horizontal for a distance of 100 feet upstream from the control section, then slope downward at a uniform grade of 1.0 percent to natural ground in the reservoir. The spillway discharge channel would slope downward at a uniform grade of 0.70 percent to a natural draw discharging into the Middle Fork of San Gabriel River at river mile 4.0 and thence to the North Fork at about river mile 1.9. Flowage easement would be required for the increased discharges being diverted into the Middle Fork. The spillway rating curve is shown on plate 30.

34. NORTH FORK DAM - OUTLET WORKS.- The flood-control outlet works would consist of a 10-foot-diameter conduit controlled by two 5-foot 8-inch by 10-foot hydraulically operated slide gates with intake inverts at elevation 700.0 and outlet invert at elevation 695.0. The conduit would be located in the main embankment about 400 feet to the right of the main river channel. The conduit, including gate passages, would be about 730 feet long. The conduit would be used for diversion during construction, for the passage of flood releases, and for the passage of low-flow discharges. The capacity of the flood-control conduit is 5,100 second-feet at top of conservation pool (elevation 832.8), 5,500 second-feet at spillway crest (elevation 855.0), and 5,800 second-feet at maximum design water surface (elevation 872.2). The outlet works rating curve is shown on plate 30.

35. SOUTH FORK DAM - SPILLWAY.- The South Fork Dam would be located on the South Fork of the San Gabriel River at river mile 4.7, with the spillway in a saddle on the right bank. The spillway would consist of a 1,000-foot uncontrolled broadcrested weir with crest at elevation 860.0. Under conditions of the spillway design discharge (189,900 second-feet), the reservoir would be at elevation 876.6. An approach channel having a bottom width of 1,000 feet would be horizontal for a distance of 100 feet upstream from the control section, then slope downward at a uniform grade of 1.0 percent to natural ground in the reservoir. The spillway discharge channel would slope downward at a uniform grade of 0.70 percent to a natural draw discharging into the South Fork of San Gabriel River about 1.0 mile downstream from the damsite. The spillway rating curve is shown on plate 30.

36. SOUTH FORK DAM - OUTLET WORKS.- The flood-control outlet works would consist of a 10-foot-diameter conduit controlled by two 5-foot 8-inch by 10-foot hydraulically operated slide gates, with intake inverts at elevation 728.0 and outlet invert at elevation 721.0. The conduit would be located in the main embankment about 350 feet to the left of the main river channel. The conduit, including gate passages, would be 658 feet long. The conduit would be used for diversion during construction, for the passage of flood releases, and for the passage of low-flow discharges. The capacity of the flood-control conduit is 4,800 second-feet at top of conservation pool (elevation 843.4), 5,100 second-feet at spillway crest (elevation 860.0), and 5,400 second-feet at maximum design water surface (elevation 876.6). The outlet works rating curve is shown on plate 30.

TABLE 1
DRAINAGE AREAS AND MILEAGES
SAN GABRIEL RIVER WATERSHED

Point of measurement	Drainage area in sq mi: Component	Total	River above mouth
North Fork San Gabriel River			
Source	0	0	46.3
Above North Fork Dam site	236	236	4.0
Above Middle Fork San Gabriel River	5	241	1.9
Middle Fork San Gabriel River	21		1.9
Below Middle Fork San Gabriel River		262	1.9
Above mouth North Fork San Gabriel River	1	263	0.0
South Fork San Gabriel River			
Source	0	0	39.3
Above South Fork Dam site	120	120	4.7
Above mouth South Fork San Gabriel River	6	126	0.0
Berry Creek			
Source	0	0	30.8
Above Berry Creek Dam site	77	77	6.7
Above mouth Berry Creek	47	124	0.0
San Gabriel River			
Below confluence North and South Forks San Gabriel River		389	62.5
Above USGS gage at Georgetown (discontinued)	0	389	62.5
Above USGS gage at Georgetown (active)	1	390	61.4
Above mouth of Berry Creek	23	413	57.8
Berry Creek	124		57.8
Below mouth of Berry Creek		537	57.8
Above USGS gage at Circleville (discontinued)	52	589	44.4
San Gabriel River above Laneport Dam site	42	631	29.7
Willis Creek above Laneport Dam site	80		
Above Laneport Dam site (total)		711	29.7
San Gabriel River above mouth Brushy Creek	90	801	5.2
Brushy Creek	510		5.2
San Gabriel River below mouth Brushy Creek		1,311	5.2
Above mouth San Gabriel River	8	1,319	0.0

TABLE 2
AVERAGE MONTHLY EVAPORATION DATA
TEMPLE AND BELTON DAM, TEXAS

Month	Temple - 1924-1953 Bureau of Plant Industry pan coefficient = 0.94			Belton Dam - 1953-1959 United States Weather Bureau pan coefficient = 0.69		
	Observed pan evaporation (inches)	Evaporation from res. surface (inches)	Observed* precipitation (inches)	Observed pan evaporation (inches)	Evaporation from res. surface (inches)	Observed* precipitation (inches)
January	2.06	1.94	2.58	2.77	1.91	1.56
February	2.48	2.33	2.49	3.30	2.28	3.12
March	4.21	3.96	2.50	5.58	3.85	1.77
April	4.97	4.67	3.40	6.16	4.25	3.91
May	5.62	5.28	4.08	8.03	5.54	3.26
June	6.83	6.42	2.89	9.95	6.87	3.88
July	7.76	7.29	1.70	11.72	8.09	1.54
August	8.00	7.52	1.90	11.25	7.76	2.57
September	6.03	5.67	3.08	8.11	5.60	3.41
October	4.67	4.39	2.53	5.80	4.00	4.03
November	3.11	2.92	2.74	3.83	2.64	1.65
December	2.22	2.09	2.85	3.17	2.19	2.72
Annual	57.96	54.48	32.74	79.67	54.98	33.42

*Taylor precipitation used.

TABLE 3
AREA AND CAPACITY DATA
LANEPORT RESERVOIR
River mile 29.7
Drainage area = 711 square miles

Elev	0	1	2	3	4	5	6	7	8	9
					Area - Acres					
430						0	1	3	4	5
440	7	8	9	11	12	13	15	16	17	19
450	20	25	30	40	55	70	85	110	130	160
460	180	220	250	300	350	400	460	520	580	650
470	720	810	890	980	1,060	1,150	1,230	1,310	1,400	1,490
480	1,570	1,670	1,760	1,850	1,940	2,040	2,130	2,220	2,310	2,400
490	2,500	2,620	2,750	2,890	3,050	3,230	3,410	3,620	3,830	4,050
500	4,290	4,530	4,790	5,040	5,300	5,550	5,800	6,040	6,290	6,540
510	6,800	7,040	7,300	7,550	7,810	8,070	8,350	8,620	8,910	9,200
520	9,480	9,800	10,160	10,520	10,890	11,250	11,600	11,960	12,320	12,700
530	13,060	13,440	13,800	14,150	14,500	14,850	15,220	15,570	15,940	16,290
540	16,640									
					Capacity - Acre-feet					
430						0	1	3	7	11
440	17	25	33	43	55	67	81	97	113	130
450	150	170	200	240	280	350	420	520	640	800
460	900	1,200	1,400	1,700	2,000	2,400	2,800	3,300	3,800	4,400
470	5,100	6,000	6,700	7,700	8,700	9,800	11,000	12,300	13,600	15,100
480	16,600	18,200	19,900	21,700	23,600	25,600	27,700	29,900	32,100	34,500
490	37,000	39,500	42,200	45,000	48,000	51,100	54,400	58,000	61,700	65,600
500	69,800	74,200	78,900	83,800	89,000	94,400	100,100	106,000	112,100	118,600
510	125,200	132,100	139,300	146,700	154,400	162,400	170,600	179,100	187,800	196,900
520	206,200	215,800	225,800	236,200	246,900	257,900	269,400	281,100	293,300	305,800
530	318,700	331,900	345,500	359,500	373,800	388,500	403,600	419,000	434,700	450,800
540	467,300									

TABLE 4

AREA AND CAPACITY DATA
NORTH FORK RESERVOIR
River mile 4.0
Drainage area = 236 square miles

Elev.:	0	1	2	3	4	5	6	7	8	9
					Area - Acres					
690	0	2	2	3	4	5	6	7	8	9
700	10	12	14	17	18	20	22	25	27	29
710	31	35	39	42	46	52	55	59	62	66
720	72	78	83	89	95	101	108	118	121	130
730	140	150	160	170	180	190	200	210	220	240
740	250	260	270	280	300	310	330	340	360	370
750	380	400	420	440	450	470	490	510	530	550
760	570	600	620	650	670	700	720	750	770	800
770	820	850	880	900	930	960	980	1,010	1,040	1,070
780	1,100	1,120	1,150	1,180	1,210	1,220	1,280	1,300	1,330	1,360
790	1,390	1,420	1,450	1,480	1,500	1,540	1,560	1,590	1,620	1,640
800	1,670	1,700	1,740	1,770	1,800	1,840	1,870	1,910	1,940	1,980
810	2,020	2,060	2,110	2,140	2,190	2,230	2,280	2,320	2,360	2,410
820	2,450	2,500	2,560	2,600	2,660	2,720	2,780	2,840	2,880	2,960
830	3,020	3,080	3,150	3,220	3,290	3,360	3,430	3,500	3,570	3,630
840	3,720	3,810	3,900	3,980	4,070	4,150	4,230	4,320	4,400	4,480
850	4,570	4,660	4,740	4,820	4,900	5,000	5,080	5,160	5,250	5,330
860	5,410	5,500	5,580	5,650	5,740	5,810	5,900	5,980	6,060	6,130
870	6,220	6,300	6,380	6,460	6,540	6,620	6,700	6,780	6,860	6,940
880	7,010									
					Capacity - Acre-feet					
690	0	1	3	5	8	12	18	25	33	42
700	52	63	76	90	110	130	150	170	200	230
710	260	290	330	370	410	460	510	570	630	670
720	740	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600
730	1,800	1,900	2,100	2,200	2,400	2,600	2,800	3,000	3,200	3,400
740	3,700	3,900	4,200	4,400	4,700	5,000	5,400	5,700	6,000	6,400
750	6,800	7,200	7,600	8,000	8,500	8,900	9,400	9,900	10,400	11,000
760	11,500	12,000	12,600	13,200	13,900	14,600	15,300	16,000	16,800	17,600
770	18,400	19,200	20,100	21,000	21,900	22,800	23,800	24,800	25,800	26,900
780	27,900	29,100	30,200	31,400	32,600	33,800	35,000	36,300	37,600	39,000
790	40,400	41,800	43,200	44,700	46,100	47,700	49,200	50,800	52,400	54,000
800	55,700	57,400	59,100	60,800	62,600	64,400	66,300	68,200	70,100	72,100
810	74,100	76,100	78,200	80,300	82,500	84,700	86,900	89,200	91,600	94,000
820	96,400	98,900	101,400	104,000	106,600	109,300	112,000	114,900	117,700	120,600
830	123,600	126,700	129,800	133,000	135,200	138,500	142,000	145,400	149,000	152,600
840	156,200	160,000	163,900	167,800	171,800	175,900	180,100	184,400	188,700	193,200
850	197,700	202,300	207,000	211,800	216,700	221,600	226,700	231,800	237,000	242,300
860	247,700	253,100	258,600	264,200	269,900	275,700	281,500	287,500	293,500	299,600
870	305,800	312,100	318,400	324,800	331,300	337,900	344,600	351,300	358,100	365,000
880	372,000									

TABLE 5
AREA AND CAPACITY DATA
SOUTH FORK RESERVOIR
River mile 4.7
Drainage area = 120 square miles

Elev	0	1	2	3	4	5	6	7	8	9
					AREA CURVE DATA - ACRES					
710						0	2	2	2	2
720	4	4	5	6	7	8	9	9	10	11
730	12	13	15	16	18	20	21	24	26	28
740	30	32	36	40	44	48	53	60	67	72
750	82	92	100	109	120	131	142	153	167	180
760	190	208	224	245	261	280	295	314	332	352
770	368	390	409	428	448	468	488	507	527	546
780	566	590	610	630	652	672	692	717	737	757
790	778	795	820	840	860	880	905	925	946	967
800	988	1,008	1,030	1,050	1,068	1,089	1,117	1,132	1,155	1,175
810	1,195	1,217	1,244	1,265	1,287	1,317	1,338	1,360	1,392	1,415
820	1,435	1,467	1,492	1,528	1,558	1,592	1,623	1,660	1,694	1,728
830	1,763	1,800	1,840	1,880	1,920	1,960	2,000	2,040	2,080	2,120
840	2,160	2,215	2,268	2,320	2,373	2,425	2,480	2,527	2,580	2,632
850	2,680	2,738	2,787	2,840	2,890	2,945	3,000	3,055	3,100	3,160
860	3,210	3,270	3,325	3,372	3,425	3,475	3,528	3,572	3,620	3,670
870	3,712	3,765	3,810	3,860	3,900	3,945	3,990	4,035	4,077	4,115
880	4,155									
					CAPACITY CURVE DATA - ACRE-FEET					
710							1	3	5	7
720	10	14	18	24	30	38	46	55	65	75
730	86	99	113	128	145	164	184	206	231	258
740	287	318	352	390	432	478	528	585	648	718
750	795	882	978	1,083	1,198	1,323	1,459	1,607	1,767	1,940
760	2,125	2,324	2,540	2,774	3,027	3,297	3,585	3,889	4,212	4,554
770	4,914	5,293	5,692	6,111	6,549	7,007	7,485	7,983	8,500	9,036
780	9,592	10,170	10,770	11,390	12,031	12,693	13,375	14,080	14,807	15,554
790	16,322	17,109	17,916	18,746	19,596	20,466	21,353	22,273	23,208	24,164

TABLE 5 (CONT'D)

Elev	0	1	2	3	4	5	6	7	8	9
				CAPACITY CURVE DATA - ACRE-FEET (CONT'D)						
800	25,142	26,140	27,159	28,199	29,258	30,336	31,439	32,564	33,708	34,873
810	36,058	37,264	38,494	39,748	41,024	42,326	43,653	45,002	46,378	47,781
820	49,206	50,657	52,136	53,646	55,189	56,764	58,371	60,012	61,689	63,400
830	65,145	66,926	68,746	70,606	72,506	74,446	76,426	78,446	80,506	82,606
840	84,746	86,934	89,225	91,519	93,866	96,265	98,717	101,220	103,773	106,379
850	109,030	111,739	114,501	117,314	120,179	123,096	126,068	129,095	132,173	135,303
860	138,488	141,728	145,026	148,374	151,772	155,222	158,723	162,273	165,869	169,514
870	173,205	176,943	180,731	184,566	188,446	192,068	196,036	200,048	204,104	208,200
880	212,335									

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TABLE 6

ESTIMATED MONTHLY AND ANNUAL NATURAL FLOWS IN ACRE-FEET FOR THE TOTAL DRAINAGE AREA OF 711 SQUARE MILES ABOVE LANEPORT DAMSITE

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1924	--	17,866	37,300	30,299	48,285	21,728	6,615	2,668	2,463	1,292	1,630	1,714	171,860*
1925	1,823	1,169	1,161	1,811	12,433	304	267	2,789	5,118	24,746	19,797	3,464	74,882
1926	27,885	13,037	32,713	59,029	59,994	14,244	12,071	3,621	1,907	7,569	2,499	4,466	239,035
1927	4,708	34,162	27,885	37,542	11,576	21,608	3,174	853	655	52,269	4,032	2,535	200,999
1928	2,414	10,067	9,874	4,660	5,058	6,857	1,606	572	501	470	740	1,267	44,086
1929	1,280	1,113	2,982	10,780	97,295	13,882	5,227	1,762	905	898	1,835	1,798	139,757
1930	1,787	2,583	4,623	2,511	113,591	8,474	2,221	839	1,098	25,229	5,662	8,088	176,706
1931	29,575	41,646	28,609	15,934	9,730	3,971	3,235	1,009	733	558	826	1,412	137,238
1932	4,672	4,225	18,228	6,700	19,314	4,466	1,992	3,464	10,707	1,267	1,013	1,557	77,605
1933	5,867	4,503	6,482	3,404	4,116	628	8,534	987	905	711	569	663	37,369
1934	3,730	18,711	9,053	15,693	5,287	1,485	666	193	1,449	485	12,014	782	69,548
1935	764	3,282	1,057	5,615	58,831	71,884	9,535	2,516	55,112	12,816	7,000	49,332	277,744
1936	16,189	9,316	7,821	3,974	110,187	26,745	12,524	3,464	91,938	28,458	24,885	53,671	389,172
1937	47,692	26,799	36,498	15,387	6,235	3,555	21,202	1,699	1,138	1,708	15,150	42,477	219,540
1938	84,189	35,295	21,166	45,960	42,259	15,241	8,605	3,537	1,628	1,165	1,245	1,323	261,613
1939	1,969	1,378	1,677	1,338	1,307	2,297	423	417	368	7,876	657	527	20,234
1940	500	4,248	1,493	12,962	15,077	72,558	49,551	4,375	2,024	5,451	111,080	101,473	380,792
1941	51,648	74,710	68,712	82,695	80,197	57,427	16,790	5,068	2,935	8,915	3,063	3,372	455,532
1942	2,881	2,406	1,951	32,560	15,441	41,402	3,427	1,878	14,767	30,117	10,155	8,423	165,408
1943	7,803	5,232	5,469	4,594	5,451	1,375	1,526	501	1,119	1,110	671	336	35,187
1944	15,514	36,279	47,236	21,676	85,940	49,004	5,725	2,407	10,282	2,224	8,240	32,998	317,525
1945	50,007	47,017	41,001	60,708	27,219	37,100	9,571	5,269	5,469	5,013	7,821	4,576	300,771
1946	10,300	25,888	28,203	21,239	25,778	10,446	2,808	2,242	14,056	9,845	29,935	43,098	223,838
1947	52,924	28,586	26,690	21,294	11,868	4,922	2,261	2,224	1,273	1,079	1,172	1,349	155,642
1948	1,283	1,632	1,497	20,728	23,955	1,420	1,896	3,099	532	1,116	649	602	58,409
1949	758	1,223	4,685	24,247	6,217	8,386	2,826	800	760	753	500	1,118	52,273
1950	990	4,248	2,005	4,467	8,404	5,415	1,344	467	1,221	510	458	487	30,016
1951	439	618	926	1,220	1,145	729	153	155	3,555	509	401	397	10,247
1952	463	1,023	1,808	15,897	26,125	4,357	1,231	264	286	286	315	20,145	72,200
1953	5,816	5,415	5,633	25,268	25,797	2,953	702	1,632	6,508	29,187	4,758	4,284	117,953
1954	2,880	1,969	1,398	660	1,107	133	11	18	55	217	208	232	8,888
1955	576	1,969	2,024	633	16,973	9,061	4,849	5,797	472	64	115	137	42,670
1956	272	292	233	111	5,506	4	0	237	188	1,803	5,633	4,230	18,509
1957	489	1,201	3,318	162,582	64,719	83,442	6,946	2,498	4,084	36,699	30,427	26,745	423,150
1958	23,791	83,716	48,731	19,707	24,940	10,902	4,284	2,662	9,407	5,633	5,232	4,594	243,599
1959	3,683	5,834	6,071	11,485	7,712	9,188	3,446	6,964	4,813	--	--	--	59,196**
Mean	13,359	15,549	15,173	22,371	30,141	17,433	6,035	2,193	72,342	8,801	9,154	12,391	160,416

*Total for last 11 months of 1924.
**Total for first 9 months of 1959.

TABLE 7

ESTIMATED MONTHLY AND ANNUAL NATURAL FLOWS IN ACRE-FEET
FOR THE TOTAL DRAINAGE AREA OF 236 SQUARE MILES
ABOVE NORTH FORK DAMSITE

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1924	--	5,930	12,381	10,057	16,027	7,212	2,196	886	818	429	541	569	57,046*
1925	605	388	385	601	4,127	101	89	926	1,699	8,214	6,571	1,150	24,856
1926	9,256	4,327	10,858	19,593	19,914	4,728	4,007	1,202	633	2,512	829	1,482	79,341
1927	1,563	11,339	9,256	12,461	3,842	7,172	1,054	283	217	17,349	1,338	841	66,715
1928	801	3,342	3,277	1,547	1,679	2,276	533	190	166	156	246	421	14,634
1929	425	369	990	3,578	32,295	4,608	1,735	585	300	298	609	597	46,389
1930	593	857	1,534	833	37,704	2,813	737	278	364	8,374	1,879	2,685	58,651
1931	9,817	13,823	9,496	5,289	3,230	1,318	1,074	335	243	185	274	469	45,553
1932	1,551	1,402	6,050	2,224	6,411	1,482	661	1,150	3,554	421	336	517	25,759
1933	1,947	1,495	2,152	1,130	1,366	208	2,833	328	300	236	189	220	12,404
1934	1,238	6,211	3,005	5,209	1,755	493	221	64	481	161	3,988	260	23,086
1935	254	1,089	351	1,864	19,528	23,860	3,165	835	18,293	4,254	2,323	16,375	92,191
1936	5,374	3,092	2,595	1,320	36,574	8,877	4,157	1,150	30,517	9,446	8,260	17,815	129,177
1937	15,830	8,895	12,115	5,107	2,070	1,180	7,038	564	378	567	5,029	14,099	72,872
1938	27,945	11,715	7,026	15,255	14,027	5,059	2,856	1,174	540	387	413	439	86,836
1939	654	457	557	444	434	762	140	138	122	2,614	218	175	6,715
1940	166	1,410	496	4,302	5,004	24,084	16,447	1,452	672	1,809	36,870	33,682	126,394
1941	17,143	24,798	22,807	27,449	26,620	19,062	5,573	1,682	974	2,959	1,017	1,119	151,203
1942	956	799	648	10,808	5,125	13,742	1,138	623	4,902	9,997	3,371	2,796	54,905
1943	2,590	1,737	1,815	1,525	1,809	456	507	166	371	368	223	112	11,679
1944	5,150	12,042	15,679	7,195	28,526	16,266	1,900	799	3,413	738	2,735	10,953	105,396
1945	16,599	15,606	13,609	20,151	9,035	12,314	3,177	1,749	1,815	1,664	2,596	1,519	99,834
1946	3,419	8,593	9,361	7,050	8,556	3,467	932	744	4,666	3,268	9,936	14,305	74,297
1947	17,567	9,488	8,859	7,068	3,939	1,634	750	738	423	358	389	448	51,661
1948	426	542	497	6,880	7,951	471	629	1,029	177	370	215	200	19,387
1949	252	406	1,555	8,048	2,064	2,784	938	266	252	250	166	371	17,352
1950	329	1,410	666	1,483	2,790	1,797	446	155	405	169	152	162	9,964
1951	146	205	307	405	380	242	51	51	1,180	169	133	132	3,401
1952	154	340	600	5,277	8,672	1,446	409	88	95	95	105	6,687	23,968
1953	1,930	1,797	1,870	8,387	8,563	980	233	542	2,160	9,688	1,579	1,422	39,151
1954	956	654	464	219	367	44	4	6	18	72	69	77	2,950
1955	191	654	672	210	5,634	3,008	1,610	1,924	157	21	38	45	14,164
1956	90	97	77	37	1,828	1	0	79	62	598	1,870	1,404	6,143
1957	162	399	1,101	53,965	21,482	27,697	2,306	829	1,356	12,181	10,100	8,877	140,455
1958	7,897	27,788	16,175	6,541	8,278	3,619	1,422	884	3,122	1,870	1,737	1,525	80,858
1959	1,222	1,936	2,015	3,812	2,560	3,050	1,144	2,312	1,598	--	--	--	19,649**
Mean	4,434	5,161	5,036	7,426	10,005	5,786	2,003	728	2,401	2,921	3,038	4,113	53,246

*Total for last 11 months of 1924.
**Total for first 9 months of 1959.

TABLE 8

ESTIMATED MONTHLY AND ANNUAL NATURAL FLOWS IN ACRE-FEET
FOR THE TOTAL DRAINAGE AREA OF 120 SQUARE MILES
ABOVE NORTH FORK DAM SITE

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1924		3,015	5,385	4,985	6,800	4,585	1,160	603	775	477	243	275	28,303*
1925	242	161	108	235	2,142	131	84	563	864	4,177	3,341	585	12,633
1926	4,706	2,200	5,521	9,963	10,126	2,404	2,037	611	322	1,277	422	754	40,343
1927	795	5,766	4,706	6,336	1,954	3,647	536	144	111	8,822	680	428	33,925
1928	407	1,699	1,667	786	854	1,157	271	97	85	79	125	214	7,441
1929	216	188	503	1,819	16,421	2,343	882	297	153	152	310	304	23,588
1930	302	436	780	424	19,171	1,430	375	142	185	4,258	956	1,365	29,824
1931	4,992	7,029	4,829	2,689	1,642	670	546	170	124	94	139	238	23,162
1932	788	713	3,076	1,131	3,260	754	336	585	1,807	214	171	263	13,098
1933	990	760	1,094	575	695	106	1,440	167	153	120	96	112	6,308
1934	630	3,158	1,528	2,649	892	251	112	108	486	82	2,028	132	12,056
1935	129	554	178	948	9,929	12,132	1,609	425	9,302	2,163	1,182	8,326	46,877
1936	2,732	1,572	1,320	671	18,597	4,514	2,114	585	15,517	4,803	4,200	9,058	65,683
1937	8,049	4,523	6,160	2,597	1,052	600	3,578	287	192	288	2,557	7,169	37,052
1938	14,209	5,957	3,572	7,757	7,132	2,572	1,452	597	275	197	210	223	44,153
1939	332	232	283	226	221	388	71	70	62	1,329	111	89	3,414
1940	84	717	252	2,188	2,545	12,246	8,363	738	342	920	18,748	17,126	64,269
1941	8,717	12,609	11,597	13,957	13,535	9,692	2,834	855	495	1,505	517	569	76,882
1942	486	406	329	5,495	2,606	6,988	578	317	2,492	5,083	1,714	1,422	27,916
1943	1,317	883	923	775	920	232	258	85	189	187	113	57	5,939
1944	2,618	6,123	7,972	3,658	14,505	8,271	966	406	1,735	375	1,391	5,569	53,589
1945	8,440	7,935	6,920	10,246	4,594	6,262	1,615	889	923	846	1,320	772	50,762
1946	1,738	4,369	4,760	3,585	4,351	1,763	474	378	2,372	1,662	5,052	7,274	37,778
1947	8,932	4,825	4,505	3,594	2,003	831	382	375	215	182	198	228	26,270
1948	217	275	253	3,498	4,043	240	320	523	90	188	110	102	9,859
1949	128	206	791	4,092	1,049	1,415	477	135	128	127	84	189	8,821
1950	167	717	338	754	1,418	914	227	79	206	86	77	82	5,065
1951	74	104	156	206	193	123	26	26	600	86	68	67	1,729
1952	78	173	305	2,683	4,409	735	208	45	48	48	53	3,400	12,185

TABLE 8 (CONT'D)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1953	982	914	951	4,265	4,354	498	118	275	1,098	4,926	803	723	19,907
1954	486	332	236	111	187	22	2	3	9	37	35	39	1,499
1955	97	332	342	107	2,865	1,529	818	978	80	11	19	23	7,201
1956	46	49	39	19	929	1	0	40	32	304	951	714	3,124
1957	82	203	560	27,440	10,923	14,083	1,172	422	689	6,194	5,135	4,514	71,417
1958	4,015	14,129	8,225	3,326	4,209	1,840	723	449	1,588	951	883	775	41,113
1959	622	985	1,025	1,938	1,302	1,551	582	1,175	812	-	-	-	9,992**
Mean	2,253	2,618	2,533	3,770	5,051	2,970	1,021	379	1,238	1,493	1,544	2,091	27,002

*Total for last 11 months of 1924.
**Total for first 9 months of 1959.

TABLE 9

SPILLWAY DESIGN STORM RAINFALL AND RAINFALL-EXCESS

6-hour period	Design storm centered over total area above Laneport Dam site (1)			Design storm centered over area above North Fork Dam site (2)			Design storm centered over area above South Fork Dam site (3)			Design storm centered over area between Laneport and North Fork Dam sites (4)						Design storm centered over area between Laneport and North Fork and South Fork Dam sites (5)					
	Area above Laneport Dam site			Area above North Fork Dam site			Area above South Fork Dam site			Area between Laneport and North Fork Dam sites			Area above North Fork Dam site			Area between Laneport and North and South Fork dam sites			Area above North and South Fork Dam sites		
	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (in/hr)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (in/hr)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (in/hr)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (in/hr)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (in/hr)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (in/hr)	6-hour increment of rainfall (inches)	Loss (inches)	Rainfall-excess (in/hr)
1	1.15	1.00	0.15	0.96	0.96	0.00	1.06	1.00	0.06	1.12	1.00	0.12	1.21	1.00	0.21	1.08	1.00	0.08	1.22	1.00	0.22
2	1.19	0.60	0.59	1.06	0.60	0.46	1.17	0.60	0.57	1.20	0.60	0.60	1.17	0.60	0.57	1.15	0.60	0.55	1.23	0.60	0.63
3	1.28	0.60	0.68	1.22	0.60	0.62	1.21	0.60	0.61	1.30	0.60	0.70	1.24	0.60	0.64	1.25	0.60	0.65	1.25	0.60	0.65
4	1.38	0.60	0.78	1.44	0.60	0.84	1.24	0.60	0.64	1.47	0.60	0.87	1.20	0.60	0.60	1.51	0.60	0.91	1.31	0.60	0.71
5	1.76	0.60	1.16	1.79	0.60	1.19	1.31	0.60	0.71	1.83	0.60	1.23	1.62	0.60	1.02	1.81	0.60	1.21	1.71	0.60	1.11
6	4.99	0.60	4.39	5.61	0.60	5.01	5.62	0.60	5.02	5.24	0.60	4.64	4.49	0.60	3.89	5.30	0.60	4.70	4.68	0.60	4.08
7	17.47	0.60	16.87	21.22	0.60	20.62	23.71	0.60	23.11	18.41	0.60	17.81	15.58	0.60	14.98	19.97	0.60	19.37	14.98	0.60	14.38
8	2.92	0.60	2.32	2.27	0.60	1.67	2.12	0.60	1.52	2.60	0.60	2.00	3.56	0.60	2.96	2.56	0.60	1.96	3.28	0.60	2.68
Total	32.14	5.20	26.94	35.57	5.16	30.41	37.44	5.20	32.24	33.17	5.20	27.97	30.07	5.20	24.87	34.63	5.20	29.43	29.66	5.20	24.46

(1) Used to develop natural flow at damsite and flow into full reservoir, spillway design flood for Laneport Reservoir.

(2) Used to develop both natural flow at damsite and flow into full reservoir, spillway design floods for North Fork Reservoir.

(3) Used to develop both natural flow at damsite and flow into full reservoir, spillway design floods for South Fork Reservoir.

(4) Used to develop flow into full reservoir, spillway design flood for Laneport Reservoir in system with North Fork Reservoir.

(5) Used to develop flow into full reservoir, spillway design flood for Laneport Reservoir in system with North Fork and South Fork Reservoirs.

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TABLE 10

INFILTRATION AND RUNOFF DATA
SAN GABRIEL RIVER WATERSHED

Date of storm	Rainfall (inches)	Runoff (inches)	Runoff (percent)	Initial loss (inches)	Infiltration index (in/hr)	Conditions preceding each storm
San Gabriel River at Georgetown (drainage area = 390 sq.mi.)						
May 17, 1935	2.40	0.76	31.7	1.00	0.19	Wet; Heavy rain May 15-16; light rain May 13-14; moderate rain May 9-10; heavy rain May 4-5; moderate rain May 2-3; light rain Apr 27 - May 1; moderate rain Apr 26.
Jan 22-23, 1938	2.35	1.05	44.7	1.00	0.10	Wet; moderate rain Jan 22; light rain Jan 20-21; light rain Jan 9-11; moderate rain Jan 5-6; light rain Jan 4.
Nov 22, 1940	3.09	0.77	24.9	1.25	0.20	Wet; moderate rain Nov 21; light rain Nov 20; light rain Nov 9-11; moderate rain Nov 7-8; light rain Nov 4-6; heavy rain Nov 1.
Nov 23-24, 1940	2.24	0.95	42.4	1.00	0.12	Wet; heavy rain Nov 22; moderate rain Nov 21; light rain Nov 20; light rain Nov 9-11; moderate rain Nov 7-8; light rain Nov 4-6; heavy rain Nov 1.
Dec 11, 1940	1.72	0.45	26.2	1.10	0.10	Moist; light rain Dec 6-7; light rain Nov 26; heavy rain Nov 22-25; moderate rain Nov 21; light rain Nov 20.
Feb 21-23, 1958	2.27	1.23	54.2	0.90	0.10	Wet; moderate rain Feb 20; light rain Feb 19; light rain Feb 14-15; light rain Feb 9-12.
San Gabriel River at Circleville (drainage area = 589 sq.mi.)						
Oct 1-2, 1927	4.18	1.16	27.8	1.10	0.30	Moist; moderate rain Sep 26-28; light rain Sep 21; moderate rain Sep 19-20; light rain Sep 18; moderate rain Sep 14-15.
May 10, 1930	3.70	1.27	34.3	1.10	0.27	Wet; heavy rain May 6-8; light rain May 1-5; moderate rain Apr 28-29; light rain Apr 25-26.

TABLE 11

SYNTHETIC UNIT HYDROGRAPHS FOR A UNIFORM 6-HOUR RAINFALL

Time in 3-hour periods	Laneport Dam and Reservoir				N Fork Dam & Res.		S Fork Dam & Res.	
	Flow into full reservoir (1)	Flow into full reservoir (2)	Flow into full reservoir (3)	Natural flow at damsite	Flow into full reservoir	Natural flow at damsite	Flow into full reservoir	Natural flow at damsite
1	9,300	9,600	9,300	1,200	5,900	1,200	4,600	1,100
2	13,700	16,200	14,700	2,600	8,600	5,500	12,400	3,600
3	26,100	14,600	18,200	28,200	20,400	20,000	4,000	11,200
4	32,600	21,400	14,700	33,500	10,000	14,900	2,000	5,900
5	29,100	12,400	7,100	31,000	2,500	3,800	1,200	1,900
6	9,000	6,700	3,800	8,200	1,400	2,200	700	1,100
7	6,000	4,200	2,000	6,200	700	1,400	300	600
8	4,500	3,200	1,000	5,300	300	900	0	300
9	3,700	2,400	800	4,800	0	500		100
10	3,100	1,900	500	4,300		300		0
11	2,600	1,500	300	3,900		100		
12	2,100	1,100	100	3,500		0		
13	1,800	900	0	3,200				
14	1,500	700		2,800				
15	1,200	500		2,500				
16	900	400		2,200				
17	700	300		2,000				
18	500	200		1,800				
19	400	100		1,500				
20	200	0		1,200				
21	100			1,000				
22	0			800				
23				600				
24				400				
25				200				
26				0				

(1) Total area above Laneport Dam site (Stage 1)
(2) Excluding area above North Fork Dam site (Stage 2)
(3) Excluding area above North Fork and South Fork Dam sites (Stage 3)

APPENDIX II

FORMULATION OF THE PLAN OF IMPROVEMENT
REVIEW OF REPORTS ON BRAZOS RIVER AND TRIBUTARIES, TEXAS
COVERING SAN GABRIEL RIVER WATERSHED

1. GENERAL OBJECTIVES.- The report considers the desirability of modifying the authorized plan of improvement for flood control, water conservation, and related water uses on the San Gabriel River watershed. Local interests requested that the restudy of the authorized Laneport project include consideration of alternate project sites to extend flood control upstream from the Laneport site and to include sufficient water conservation storage space in any project adopted to permit optimum economical development of the water resources of the San Gabriel River.

2. WATER PROBLEMS.- The principal water problems on the San Gabriel River watershed result from the frequent occurrence of floods and insufficient water supply. Major floods originating on the San Gabriel River watershed cause appreciable damages along the San Gabriel River, and in addition, augment considerably the flood problems along the lower Little and Brazos Rivers. The investigated flood plain of the San Gabriel River, downstream from the city of Georgetown, is a highly developed area, principally for agricultural purposes. The flood plains of the lower Little and Brazos Rivers, which are affected by discharges from the San Gabriel River, are highly developed areas containing considerable agricultural and urban developments, as well as a considerable amount of transportation facilities and utilities. Periods of prolonged drought, upward trends in population, and expansion of industrial and municipal developments have made evident the increasing need for the conservation of surface runoff for all beneficial purposes throughout the lower Brazos River Basin, including the San Gabriel River watershed. The U. S. Public Health Service, the Texas State Board of Water Engineers, the Brazos River Authority, and representatives of municipalities and industries have requested generally that water conservation storage space, in maximum amounts which can be economically provided, be included in all multiple-purpose reservoir projects planned and constructed by the Corps of Engineers on the lower Brazos River tributary system. In its report, the U. S. Public Health Service emphasized the following problems: that the water originating in the main channel of the Brazos River above Whitney Reservoir possesses a high salt content and is largely unsatisfactory for municipal and industrial purposes; that water of good quality is limited in source and amount to the lower Brazos River tributary system; that the projected water requirements for municipal and industrial purposes for the lower Brazos River Basin will be about 1,102 million gallons daily by the year 2010, including 8.2 million gallons daily for the San Gabriel River watershed downstream from the vicinity of Georgetown; and that the aggregate firm yield from existing

and proposed surface reservoirs (exclusive of reservoirs on the San Gabriel River watershed) and estimated existing and future ground water resources are only about 603 million gallons daily.

3. PRIMARY CONSIDERATION.- The authorized Laneport Reservoir project on the San Gabriel River is a unit in the system of eight Federally authorized reservoirs in the Brazos River Basin. The reservoirs were designed to facilitate control of floods originating on the Brazos River and its major tributaries to provide principally for protection of urban development and highly developed agricultural lands within the flood plains of the lower Brazos River Basin from the vicinity of Waco to the mouth and to provide a source of water supply for municipal, industrial, and other uses. Each reservoir is planned to function as a unit in the system to provide maximum reduction of flood stages on certain portions of the principal tributaries of the river and on the lower Brazos River downstream from Waco. In the investigation of the desirability of modifying the plan for flood control, water conservation, and related water uses on the San Gabriel River watershed, it was concluded that any project or group of projects considered as an alternate for the authorized Laneport Reservoir project should be of a type which could be integrated into the authorized Brazos River Basin reservoir system. It should provide for a maximum reduction of flood stages in the Brazos River Basin downstream from Waco to the mouth at least equivalent to that afforded by the system as now authorized; and should also provide for the optimum development of the water supply resources of the San Gabriel River watershed to fulfill the needs of the area as they develop.

4. SOLUTIONS CONSIDERED.- Solutions considered for the combination of flood and water supply problems on the San Gabriel River and the lower portions of the Little and Brazos Rivers involved investigated reservoir projects at the following dam sites: (a) Laneport Dam, San Gabriel River, mile 29.7; (b) North Fork Dam, North Fork of San Gabriel River, mile 4.0; (c) South Fork Dam, South Fork of San Gabriel River, mile 4.7; and (d) Berry Creek Dam, Berry Creek, mile 6.7. In accordance with the objective stated in paragraph 3, the principal plans which were formulated and investigated included the Laneport Reservoir project as a primary flood control unit on the San Gabriel River watershed. Plans 1A and 1B through 6A and 6B were considered on the basis of simultaneous development, whereby each reservoir unit in a plan would be constructed about the same time or within a few years of each other. Plans 7A and 7B through 11A and 11B were considered on the basis of stage development, whereby the primary Laneport Reservoir would be the first unit to be constructed to provide essential flood protection to the lower San Gabriel River, Little River, and Brazos River flood plains and to provide for the immediate water supply needs of the San Gabriel River area, and whereby any additional reservoir unit of a stage-development plan would be constructed at such time that there would be a demand for additional

water supply in the lower Brazos River Basin. A summary of the plan of improvement studies, setting forth the plans of improvement investigated, and presenting pertinent information on required controlled storages, on dependable yields for water supply, and on economic and cost analyses, is presented in tables 7A and 7B.

5. For purposes of project formulation, economic analyses, and cost allocation studies, the reservoir units involved in the investigated plans were analyzed as single-purpose projects for flood control or water conservation; as dual-purpose projects for flood control and water conservation; as multiple-purpose reservoirs for flood control, water conservation, and fish and wildlife; and as multiple-purpose reservoirs for flood control, water conservation, fish and wildlife, and recreation. Single-purpose reservoirs for flood control were investigated as dry-pool reservoirs, containing no permanent pool capacity below flood control storage levels. Also, single-purpose reservoirs for recreation purposes were investigated for the purpose of cost allocation studies.

6. The U. S. Public Health Service, the Bureau of Sport Fisheries and Wildlife, and the National Park Service, at the request of the Corps of Engineers, furnished reports pertaining to the water supply, fishing, hunting, wildlife, and recreation aspects of the investigated reservoir projects. The reports of the three Federal agencies, which are presented in appendix IV of this report, provide information and criteria which were useful with respect to the development and evaluation of the water supply, sport fishing and hunting, and recreation potentials of the investigated reservoir sites. Pertinent data, reservoir capacities and surface areas, and estimates of costs for the investigated reservoir plans as needed for the various analyses were furnished the Federal agencies. The value of water supply storage and the benefits for recreation utilized in the economic and cost analyses of the investigated reservoir plans were based on studies by the Corps of Engineers.

7. FLOOD CONTROL STUDIES AND ANALYSES.- The Flood Control Act of 1954 approved a comprehensive plan for flood control and allied purposes in the Brazos River Basin, including a system of eight reservoir projects. The authorized Laneport Reservoir on the San Gabriel River is a unit in the approved system. The authorized eight-reservoir system of the Brazos River Basin was designed and authorized on the basis of providing 50-year flood control storage or additional storage as necessary to control the maximum flood of record at the respective dam sites. The flood control studies leading to the authorization, construction, and operation of the reservoir projects included in the comprehensive plan have been on a system basis. However, the flood control benefits credited to the system of reservoirs have been assigned to the individual projects in an equitable manner and separate benefit-cost ratios have been determined for each project in the system. In

connection with determining a reasonable distribution of flood control benefits to these interrelated projects, flood routing studies were made to determine the effectiveness of individual projects as a percentage of the total system flood control benefits by river reaches where more than one reservoir is effective. The benefits assigned to the system of eight reservoir projects, including an allowance for future development, are shown in table 1.

TABLE 1

FLOOD CONTROL BENEFITS FOR AUTHORIZED
EIGHT-RESERVOIR SYSTEM OF THE BRAZOS RIVER BASIN
(System-adjustment basis)

Project	Equitable share of system benefits (including future development)
Whitney Reservoir	$4,081,300
Belton Reservoir	2,001,400
Waco Reservoir	3,944,500
Proctor Reservoir	1,737,900
Stillhouse Hollow Reservoir	2,519,000
Somerville Reservoir	1,230,200
Ferguson Reservoir	1,796,500
Laneport Reservoir	2,206,600
Total	$19,527,400

Similarly, the flood control benefits as creditable to each individual reservoir on the San Gabriel River are based on each investigated reservoir acting as an alternate San-Gabriel-River-watershed unit within the authorized eight-reservoir system in the Brazos River Basin and with the benefits for each reservoir being determined by an adjustment of the benefits formerly assigned to the authorized Laneport Reservoir in the system distribution described above. In making this adjustment, consideration was given to the degree of flood control exercised on the lower Little and Brazos Rivers by moving the dam site upstream or downstream, as well as the amount of flood protection gained or lost on the San Gabriel River. Also, the flood control benefits creditable to each reservoir as a last-added unit within the authorized system of the Brazos River Basin were derived and utilized to substantiate on an incremental basis the economic justification of the flood control function in each investigated reservoir on the San Gabriel River watershed. A comparison of flood control benefits creditable to each investigated reservoir on a system-adjustment basis and on a last-added basis is presented in table 2. The flood control benefits utilized in the analysis of each investigated reservoir were based on an economic survey of the investigated flood plains, with consideration being given to the future development anticipated in the flood plains during the period 1960 to 2010. An economic base study is presented in appendix III.

TABLE 2

FLOOD CONTROL BENEFITS
(in thousands of dollars)
INVESTIGATED RESERVOIR SITES
SAN GABRIEL RIVER WATERSHED

Flood-frequency storage	Laneport	North Fork	South Fork	Berry Creek
System-Adjustment Basis within Brazos River Reservoir System				
25-year	2,181.8	818.7	389.0	269.6
50-year	2,206.6	839.5	405.1	270.5
100-year	2,230.6	855.2	419.7	271.7
Last-Added Basis within Brazos River Reservoir System				
25-year	2,007.8	765.3	361.4	251.8
50-year	2,031.7	785.1	377.0	252.8
100-year	2,054.9	800.5	390.7	253.9

8. The flood control studies and investigations determined that the channel capacities of the San Gabriel River, North Fork, South Fork, and Berry Creek are sufficient to contain proposed flood releases from the investigated reservoirs. Considering each reservoir separately and on the basis that flood releases could be made continuously at a rate of 6,000 second-feet (the minimum channel capacity on the San Gabriel River), the time of evacuation of the total flood storage capacity involved in each reservoir under existing channel conditions would be as follows: Laneport Reservoir, 20 days; North Fork Reservoir, 8 days; South Fork Reservoir, 4 days; and Berry Creek Reservoir, 3 days.

9. Flood control analyses were made of each investigated reservoir site to determine flood 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 storage capacities which would control flood volumes having frequencies of occurrence of once or more in 25 years to once or more in 100 years. The flood storage capacities for investigated reservoir sites were analyzed on the basis of the following: (a) dual-purpose reservoirs for flood control and water conservation; (b) Laneport Reservoir operating alone on the San Gabriel River watershed; (c) the North Fork, South Fork, and Berry Creek Reservoirs operating as alternate next-added units in combination with a flood-control-only Laneport Reservoir unit; and (d) each reservoir containing water conservation storage to develop approximately the the maximum water resources at the site, or in the case of the analysis for the Laneport Reservoir site, to develop the maximum amount of water resources allowable under existing reservoir-site limitations. The flood control analyses and studies determined that flood control as a

last-added function is economically justified in each investigated reservoir under the conditions set forth in the above items (a) through (d). The maximum amounts of excess flood control benefits over costs at the various reservoir sites would be realized by flood storage capacities which would control flood volumes having a frequency of occurrence of once in 25 years. The studies indicate, however, that there is no appreciable difference in the amounts of excess flood control benefits over costs for 25-year and 50-year storage space in the investigated reservoirs. The provision of 50-year storage in the investigated Laneport, North Fork, South Fork, and Berry Creek Reservoirs would be sufficient to control the maximum flood of record (April 1957) on the San Gabriel River watershed at the respective dam sites. The studies indicate that the April 1957 flood has a frequency of occurrence of about once in 50 years. The eight-reservoir system of the Brazos River Basin was designed and authorized on the basis of providing 50-year control storage or additional storage as necessary to control the maximum flood of record at the respective dam sites. Based on the above criteria for individual reservoir units of the Brazos River reservoir system and on record floods experienced on the San Gabriel River watershed, 50-year-frequency flood storage has been adopted for the investigated reservoir plans. A summary of flood control analyses for the investigated dual-purpose reservoirs with 25-year, 50-year, and 100-year flood-storage space is presented in table 3. The summary indicates that the flood control function is incrementally justified as a next-added function to water conservation reservoirs on the San Gabriel River watershed.

10. The flood control analyses determined that single-purpose flood control reservoirs at the Laneport, North Fork, South Fork, and Berry Creek sites were economically justified on the basis that each would be the only flood control unit on the San Gabriel River watershed and the last constructed unit in the authorized eight-reservoir system of the Brazos River Basin. A summarized comparison of flood control analyses of the investigated reservoirs as single-purpose flood control units in the authorized reservoir system, utilizing benefits derived on an adjusted-system basis and a last-added basis (in thousands of dollars), is presented in the following tabulation:

TABLE 3

MAXIMIZATION OF FLOOD CONTROL BENEFITS
INVESTIGATED RESERVOIR PLANS FOR FLOOD CONTROL AND WATER CONSERVATION
SAN GABRIEL RIVER

Plan	Total Controlled Storage (1000 ac-ft)	Annual Benefits ($1,000) Flood Control	Water Supply	Total	Total Annual Charges ($1,000)	Benefit-Cost Ratio	Excess Benefits ($1,000) Total	Flood Control
North Fork Reservoir Analysis (with Laneport for Flood Control Only)								
Without flood control storage	272.3	2,206.6	409.7	2,616.3	1,202.4	2.2	1,413.9	0.0
Flood control - incremental	64.7	85.8	0.0	85.8	-25.6 (1)	Infinity	111.4	
With 25-year flood control storage	337.0	2,292.4	409.7	2,702.1	1,176.8	2.3	1,525.3	111.4
Flood control - incremental	23.9	0.9	0.0	0.9	18.3	0.05	-17.4	
With 50-year flood control storage	360.9	2,293.3	409.7	2,703.0	1,195.1	2.3	1,507.9	94.0
Flood control - incremental	20.7	1.2	0.0	1.2	32.7	0.04	-31.5	
With 100-year flood control storage	381.6	2,294.5	409.7	2,704.2	1,227.8	2.2	1,476.4	62.5
South Fork Reservoir Analysis (with Laneport for Flood Control Only)								
Without flood control storage	230.8	2,206.6	260.1	2,466.7	1,125.8	2.2	1,340.9	0.0
Flood control - incremental	34.6	25.8	0.0	25.8	-19.2 (1)	Infinity	45.0	
With 25-year flood control storage	265.4	2,232.4	260.1	2,492.5	1,106.6	2.3	1,385.7	45.0
Flood control - incremental	12.4	1.4	0.0	1.4	3.6	0.32	-2.2	
With 50-year flood control storage	277.8	2,233.8	260.1	2,493.9	1,110.2	2.2	1,383.7	42.8
Flood control - incremental	9.9	1.4	0.0	1.4	17.4	0.08	-16.0	
With 100-year flood control storage	287.7	2,235.2	260.1	2,495.3	1,127.6	2.2	1,367.7	26.8
Berry Creek Reservoir Analysis (with Laneport for Flood Control Only)								
Without flood control storage	155.7	2,206.6	107.7	2,314.3	1,086.3	2.1	1,228.0	0.0
Flood control - incremental	22.5	12.2	0.0	12.2	-11.3 (1)	Infinity	23.5	
With 25-year flood control storage	178.2	2,218.8	107.7	2,326.5	1,075.0	2.2	1,251.5	23.5
Flood control - incremental	5.1	0.9	0.0	0.9	3.6	0.25	-2.7	
With 50-year flood control storage	183.3	2,219.7	107.7	2,327.4	1,078.6	2.2	1,248.8	20.8
Flood control - incremental	9.4	1.2	0.0	1.2	24.6	0.025	-23.4	
With 100-year flood control storage	192.7	2,220.9	107.7	2,328.6	1,103.2	2.1	1,225.4	-2.6
Laneport Reservoir Analysis (Operating Alone)								
Without flood control storage	94.4	0.0	559.4	559.4	595.8	0.94	-36.4	0.0
Flood control - incremental	198.9	2,181.8	0.0	2,181.8	306.5	7.12	1,875.3	
With 25-year flood control storage	293.3	2,181.8	559.4	2,741.2	902.3	3.0	1,838.9	1,875.3
Flood control - incremental	38.6	24.8	0.0	24.8	39.9	0.62	-15.1	
With 50-year flood control storage	331.9	2,206.6	559.4	2,766.0	942.2	2.9	1,823.8	1,860.2
Flood control - incremental	87.1	24.0	0.0	24.0	219.8	0.11	-195.8	
With 100-year flood control storage	419.0	2,230.6	559.4	2,790.0	1,162.0	2.4	1,628.0	1,664.4

(1) Incremental cost for added flood storage capacity in upstream reservoir unit is less than cost reduction resulting from reduced flood storage requirements in Laneport unit

Item	Laneport	North Fork	South Fork	Berry Creek
	Adjusted-System Basis			
Annual benefits	2,206.6	839.5	405.1	270.5
Annual charges	840.6	300.2	235.7	232.9
Benefit-cost ratio	2.6	2.8	1.7	1.2
	Last-Added Basis			
Annual benefits	2,031.7	785.1	377.0	252.8
Annual charges	840.6	300.2	235.7	232.9
Benefit-cost ratio	2.4	2.6	1.6	1.1

11. The annual flood control benefits (in thousands of dollars) which would be realized upstream and downstream from the Laneport Dam site by individual flood control reservoirs containing 50-year-frequency flood storage at the four most favorable sites on the San Gabriel River watershed are presented in the following tabulation:

Reach	Laneport	North Fork	South Fork	Berry Creek
Upstream from Laneport Reservoir site	0.0	86.7	27.2	13.1
Within Laneport Reservoir site	0.0	24.3	7.8	5.9
Downstream from Laneport Dam site	2,206.6	728.5	370.1	251.5
Total	2,206.6	839.5	405.1	270.5

12. For the purpose of economic analysis, the total average annual flood control benefits for each investigated reservoir system on the San Gabriel River watershed were distributed to the individual reservoir units in proportion to the flood control benefits presented in the above tabulation. Thus, the total annual flood control benefits (in thousands of dollars) assigned to each individual reservoir under six principal conditions for simultaneous and stage-development plans are as shown in the following tabulation:

Condition number	Laneport	North Fork	South Fork	Berry Creek	Total
1	2,206.6	--	--	--	2,206.6
2	1,659.4	633.9	--	--	2,293.3
3	1,888.8	--	345.0	--	2,233.8
4	1,981.5	--	--	238.2	2,219.7
5	1,474.0	572.2	274.3	--	2,320.5
6	1,368.1	539.0	256.7	169.8	2,333.6

Under stage development, the addition of a next-added project to operate in combination with the first-stage Laneport Reservoir project involved a reallocation of the total controlled storage in Laneport Reservoir for flood control, water conservation, and sediment purposes, and a reassignment of flood control benefits in accordance with the tabulation presented above. The composite annual flood control benefits (as well as the composite annual benefits for other purposes) for each reservoir project over an economic life of 50 years were determined as the annual value of the total present worth of the flood control benefits for individual stage periods, reduced to the same time basis, established as the year of completion of the individual reservoir unit. Thus, flood control benefits shown in tables 7A and 7B opposite the individual reservoir units are composite benefits for an assumed economic life extending 50 years from the year of completion of the individual reservoir unit.

13. A summary of economic and cost analyses of basic reservoir plans under conditions of simultaneous development is presented in table 4. The summary presents analyses of the Laneport, North Fork, South Fork, and Berry Creek Reservoirs under the conditions of (a) operating alone as single-purpose and dual-purpose reservoirs for flood control and water conservation and (b) Laneport Reservoir operating as a single-purpose unit for flood control in combination with upstream single-purpose and dual-purpose reservoirs for flood control, and for flood control and water conservation, respectively.

14. For the purpose of making a comparison of flood control benefits afforded by upstream reservoir systems in lieu of the Laneport Reservoir project, economic and cost analyses were made of the following upstream reservoir plans: (a) the North Fork and South Fork Reservoirs, and (b) the North Fork, South Fork, and Berry Creek Reservoirs. Economic and cost analyses of the upstream reservoirs summarized in table 4 indicate that the plans in items (a) and (b) are economically justified and that the total flood control benefits would amount to $1,236,800 and $1,507,400, respectively. On the other hand, the Laneport project, operating alone, would provide total annual flood control benefits of about $2,206,600, and thus, would provide an increase in total average annual flood control benefits of $969,800

TABLE 4

SUMMARY OF COST AND ECONOMIC STUDIES - SOLUTIONS CONSIDERED
INVESTIGATED BASIC PLANS
SAN GABRIEL RIVER WATERSHED

Reservoir & type	Dependable flow (cfs)	Estimated first cost	Benefits: Flood control	Benefits: Water conservation	Benefits: Total	Total annual charges	Benefit to cost ratio	Excess benefits
RESERVOIR PLANS - OPERATING ALONE								
Laneport								
a. Flood control	--	$20,444,000	$2,206,600	$ --	$2,206,600	$ 840,600	2.6	$1,366,000
b. Water conservation	43	14,300,000	--	559,400	559,400	595,800	0.9	-36,400
c. Dual-purpose, FC and WC	16	20,944,000	2,206,600	248,600	2,455,200	892,200	2.8	1,563,000
d. Dual-purpose, FC and WC	43	22,244,000	2,206,600	559,400	2,766,000	941,200	2.9	1,824,800
North Fork								
a. Flood control	--	6,940,000	839,500	--	839,500	300,200	2.8	539,300
b. Water conservation	17	5,390,000	--	260,100	260,100	254,100	1.0	6,000
c. Water conservation	20	6,350,000	--	294,600	294,600	291,000	1.0	3,600
d. Water conservation	30	8,160,000	--	409,700	409,700	361,800	1.1	47,900
e. Dual-purpose, FC and WC	17	7,900,000	839,500	260,100	1,099,600	349,200	3.1	750,400
f. Dual-purpose, FC and WC	20	8,730,000	839,500	294,600	1,134,100	381,100	3.0	753,000
g. Dual-purpose, FC and WC	30	11,010,000	839,500	409,700	1,249,200	469,300	2.7	779,900
South Fork								
a. Flood control	--	5,220,000	405,100	--	405,100	235,700	1.7	169,400
b. Water conservation	9	5,510,000	--	161,600	161,600	260,500	0.6	-98,900
c. Water conservation	17	6,220,000	--	260,100	260,100	285,200	0.9	-25,100
d. Dual-purpose, FC and WC	9	5,780,000	405,100	161,600	566,700	270,600	2.1	296,100
e. Dual-purpose, FC and WC	17	6,550,000	405,100	260,100	665,200	299,600	2.2	365,600
Berry Creek								
a. Flood control	--	5,160,000	270,500	--	270,500	232,900	1.2	37,600
b. Water conservation	6	5,370,000	--	107,700	107,700	245,700	0.4	-138,000
c. Dual-purpose, FC and WC	6	5,460,000	270,500	107,700	378,200	255,700	1.5	122,500
RESERVOIR PLANS - SIMULTANEOUS DEVELOPMENT PLANS								
Laneport, FC	--	19,944,000	1,981,500	--	1,981,500	822,900	2.4	1,158,600
Berry Creek, FC	--	5,160,000	238,200	--	238,200	232,900	1.0	5,300
Total	--	25,104,000	2,219,700	--	2,219,700	1,055,800	2.1	1,163,900
Laneport, FC	--	19,944,000	1,981,500	--	1,981,500	822,900	2.4	1,158,600
Berry Creek, FC and WC	6	5,460,000	238,200	107,700	345,900	232,900	1.5	113,000
Total	6	25,404,000	2,219,700	107,700	2,327,400	1,055,800	2.2	1,271,600
Laneport, FC	--	19,644,000	1,888,800	--	1,888,800	810,600	2.3	1,078,200
South Fork, FC	--	5,220,000	345,000	--	345,000	235,700	1.5	109,300
Total	--	24,864,000	2,233,800	--	2,233,800	1,046,300	2.1	1,187,500
Laneport, FC	--	19,644,000	1,888,800	--	1,888,800	810,600	2.3	1,078,200
South Fork, FC and WC	17	6,550,000	345,000	260,100	605,100	299,600	2.0	305,500
Total	17	26,194,000	2,233,800	260,100	2,493,900	1,110,200	2.2	1,383,700
Laneport, FC	--	17,744,000	1,659,400	--	1,659,400	725,800	2.3	933,600
North Fork, FC	--	6,940,000	633,900	--	633,900	300,200	2.1	333,700
Total	--	24,684,000	2,293,300	--	2,293,300	1,026,000	2.2	1,267,300
Laneport, FC	--	17,744,000	1,659,400	--	1,659,400	725,800	2.3	933,600
North Fork, FC and WC	30	11,010,000	633,900	409,700	1,043,600	469,300	2.2	574,300
Total	30	28,754,000	2,293,300	409,700	2,703,000	1,195,100	2.3	1,507,900
North Fork, FC	--	6,940,000	839,500	--	839,500	300,200	2.8	539,300
South Fork, FC	--	5,220,000	405,100	--	405,100	235,700	1.7	169,400
Total	--	12,160,000	1,244,600	--	1,244,600	535,900	2.3	708,700
North Fork, FC and WC	30	11,010,000	839,500	409,700	1,249,200	469,300	2.7	779,900
South Fork, FC and WC	17	6,550,000	405,100	195,800	600,900	299,600	2.0	301,300
Total	47	17,560,000	1,244,600	605,500	1,850,100	768,900	2.4	1,081,200
Laneport, FC	--	16,244,000	1,474,000	--	1,474,000	661,600	2.2	812,400
North Fork, FC	--	6,940,000	572,200	--	572,200	300,200	1.9	272,000
South Fork, FC	--	5,220,000	274,300	--	274,300	235,700	1.2	38,600
Total	--	28,404,000	2,320,500	--	2,320,500	1,197,500	1.9	1,123,000
Laneport, FC	--	16,244,000	1,474,000	--	1,474,000	661,600	2.2	812,400
North Fork, FC and WC	30	11,010,000	572,200	409,700	981,900	469,300	2.1	512,600
South Fork, FC and WC	17	6,550,000	274,300	195,800	470,100	299,600	1.6	170,500
Total	47	33,804,000	2,320,500	605,500	2,926,000	1,430,500	2.0	1,495,500
North Fork, FC	--	6,940,000	839,500	--	839,500	300,200	2.8	539,300
South Fork, FC	--	5,220,000	405,100	--	405,100	235,700	1.7	169,400
Berry Creek, FC	--	5,160,000	270,500	--	270,500	232,900	1.2	37,600
Total	--	17,320,000	1,515,100	--	1,515,100	768,800	2.0	746,300
North Fork, FC and WC	30	11,010,000	839,500	409,700	1,249,200	469,300	2.7	779,900
South Fork, FC and WC	17	6,550,000	405,100	195,800	600,900	299,600	2.0	301,300
Berry Creek, FC and WC	6	5,460,000	270,500	69,100	339,600	255,700	1.3	83,900
Total	53	23,020,000	1,515,100	674,600	2,189,700	1,024,600	2.1	1,165,100
Laneport, FC	--	15,244,000	1,368,100	--	1,368,100	622,400	2.2	745,700
North Fork, FC	--	6,940,000	539,000	--	539,000	300,200	1.8	238,800
South Fork, FC	--	5,220,000	256,700	--	256,700	235,700	1.1	21,000
Berry Creek, FC	--	5,160,000	169,800	--	169,800	232,900	0.7	-63,100
Total	--	32,564,000	2,333,600	--	2,333,600	1,391,200	1.7	942,400
Laneport, FC	--	15,244,000	1,368,100	--	1,368,100	622,400	2.2	745,700
North Fork, FC and WC	30	11,010,000	539,000	409,700	948,700	469,300	2.0	479,400
South Fork, FC and WC	17	6,550,000	256,700	195,800	452,500	299,600	1.5	152,900
Berry Creek, FC and WC	6	5,460,000	169,800	69,100	238,900	255,700	0.9	-16,800
Total	53	38,264,000	2,333,600	674,600	3,008,200	1,647,000	1.8	1,361,200

over the plan in item (a), and of $699,200 over the plan in item (b). In view of this large increase in annual flood control benefits, it is apparent that the Laneport project must be considered as a primary flood control unit to be constructed as the initial project in any plan of improvement recommended for the San Gabriel River watershed.

15. WATER SUPPLY STUDIES AND ANALYSES.- The report prepared by the U. S. Public Health Service indicates that the total projected water supply requirements for municipal and industrial purposes in the lower Brazos River Basin will be about 1,102 million gallons daily by year 2010. The report also states that the projected water requirements for the local area, consisting of the cities of Georgetown, Granger, Taylor, Thrall, and Thorndale, will be 8.2 million gallons daily, but that of this total amount, the projected need of 2.7 million gallons daily by Georgetown could be supplied by ground water from the Edwards formation. The Service indicates that the aggregate of firm yield from existing and proposed surface reservoirs, exclusive of the projects being investigated on the San Gabriel River watershed, and from estimated ground water sources for municipal and industrial purposes, will be only about 603 million gallons daily, or about 55 percent of the total demand by year 2010. Because of this apparent deficit in future water supply sources, consideration should be given to the full development of the good quality water resources of the lower Brazos River Basin during the investigation of multiple-purpose reservoir projects. Thus, during the investigation of possible reservoir projects on the San Gabriel River watershed, particular consideration has been given to the full development of the water resources upstream from the Laneport Dam site. In view of the Service's report statement that the city of Georgetown could be adequately served by good quality ground water resources from the nearby Edwards formation, the construction of the Laneport project as a first-stage reservoir unit would not eliminate all possibility of solving the water supply problems at Georgetown. On the other hand, the Laneport Reservoir project would be adequately located with respect to serving the water supply needs of the Taylor, Granger, Thrall, and Thorndale areas, and possibly the Rockdale area where, generally, the ground water resources are not of good quality.

16. On the basis of the demand curve presented in the report prepared by the U. S. Public Health Service, and in the interest of providing a logical completion schedule for construction of the Laneport, North Fork, South Fork, and Berry Creek Reservoir units, under stage development, the years of need for the various amounts of storage were established as follows: (a) first unit (Laneport Reservoir), year 1970; (b) second unit, year 1985; and (c) third unit (or third and fourth units), year 1990.

17. The water conservation benefits to be realized by construction of the investigated reservoir plans were derived on the basis of information presented in the report prepared by the U. S. Public Health

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Service. The report provided a basis for determining that water supply storage at the Laneport, North Fork, and South Fork sites, of sufficient amount to provide a total dependable yield of about 53 million gallons daily, or about 82 second-feet, would have an average unit cost of about $0.0761 per 1,000 gallons of dependable yield, provided the water supply storage is not made available prior to the estimated year of need. The water supply benefits for the various reservoir plans have been based on the following values: (a) a full value of $0.0761 per 1,000 gallons of dependable yield for storage not made available until the year of need; and (b) a discounted value of $0.0488 per 1,000 gallons for storage made available by year 1970 but not needed until the period between years 1985 and 1990. An interest rate of 3 percent was used in computing the values listed above. The Brazos River Authority, an agency designated by the Texas State Board of Water Engineers to negotiate with the Corps of Engineers in matters pertaining to water conservation storage in Corps projects in the Brazos River Basin, has expressed the opinion that water conservation storage sufficient to produce about 10 second-feet or 6.46 million gallons daily of dependable yield would be adequate to serve the immediate needs of the lower San Gabriel River watershed, and that the immediate needs for water supply in the balance of the lower Brazos River Basin will be adequately served by other Corps of Engineers reservoir projects which are under construction or in the advance planning stage. On the basis of this present limited demand for water supply storage on the San Gabriel River watershed, the annual benefits for water supply storages in each reservoir plan under simultaneous development plans and in each first-stage Laneport project under the stage-development plans were based on a full value of $0.0761 per 1,000 gallons in the case of the first 10 second-feet of dependable yield for water supply, and on the discounted value of $0.0488, item (b), in the case of any excess amount of dependable yield.

18. The amount of water conservation storage and estimated dependable yield associated with the multiple-purpose North Fork, South Fork, and Berry Creek Reservoir units in plans 2A through 11A and 2B through 11B, as shown in tables 7A and 7B, represent the approximate maximum development, as well as the optimum-economical development, of the water resources of the San Gabriel River watershed above the respective dam sites. Under the maximum and optimum-economical development conditions, water conservation storage of about 126,700 acre-feet in the North Fork Reservoir, about 89,000 acre-feet in the South Fork Reservoir, and about 14,400 acre-feet in the Berry Creek Reservoir, would provide estimated dependable yields of about 30, 17, and 6 second-feet, respectively. In the case of the Laneport Reservoir project, however, the size of a multiple-purpose reservoir is limited to a maximum design water surface not exceeding about elevation 540.0 because of encroachment limitations with respect to the city of Granger, Texas. It was determined that the maximum size of a multiple-purpose Laneport Reservoir should be limited to a total controlled storage (for flood control, water supply, and sedimentation) of about 331,900 acre-feet. Under these controlled storage conditions, a multiple-purpose Laneport project, operating alone, would

have a total water conservation storage of about 68,100 acre-feet, thus providing a dependable yield of about 43 second-feet; and a multiple-purpose Laneport project operating in combination with the above-size North and South Fork Reservoirs, would have a total water supply storage of about 193,200 acre-feet, thus providing a dependable water supply yield of about 35 second-feet. In order to provide a comparison for determining if the maximum-size Laneport project would provide for the most economical development of the water resources at the Laneport site, economic and cost analyses were made of a smaller-size Laneport project containing a total controlled storage of 281,100 acre-feet. For each of the four reservoir sites, the addition of the optimum amount of water conservation space to the single-purpose project for flood control was found to be economically justified on the basis of a favorable ratio of incremental benefits to incremental costs.

19. Studies concerning the maximization of water conservation benefits at each investigated reservoir site on the San Gabriel River watershed are summarized in table 5. The analyses are based on the conditions that each reservoir would operate alone on the San Gabriel River watershed as a dual-purpose project for flood control and water conservation, and would contain a constant amount of flood storage capacity which would control flood volumes having a frequency of occurrence of once in 50 years. The studies indicate that the optimum-economical water supply development would be realized at the North Fork and South Fork Reservoirs by development of the maximum resources at the respective dam sites and at the Laneport Reservoir by development of the maximum water supply resources allowable by reservoir site limitations cited above in paragraph 18. Since the studies determined that maximum development of the water supply resources at the Berry Creek Reservoir site would provide a dependable water supply yield of only about 6 second-feet, the analysis of the water conservation function in the Berry Creek Reservoir was limited to a maximum-size reservoir. The average unit cost of water supply as a last-added function in each dual-purpose reservoir is presented in table 5.

20. DEPENDABLE RESERVOIR YIELDS.- For this report the dependable reservoir yield is defined as the maximum continuous rate at which water may be withdrawn from a reservoir in order that the total conservation storage provided in the reservoir will just be depleted under maximum drought conditions of record. Estimates of dependable reservoir yields for projects investigated on the San Gabriel River watershed are based on estimated monthly resources under present conditions of watershed development.

21. FISH AND WILDLIFE STUDIES.- The report of the U. S. Bureau of Sport Fisheries and Wildlife, as presented in appendix IV, contains estimates of net fish and wildlife benefits creditable to investigated reservoir plans involving the Laneport, North Fork, South Fork, and Berry Creek Reservoirs. The total fish and wildlife benefits furnished

TABLE 5

MAXIMIZATION OF WATER CONSERVATION BENEFITS
INVESTIGATED RESERVOIR PLANS FOR FLOOD CONTROL AND WATER CONSERVATION
SAN GABRIEL RIVER

Plan	Yield (cfs)	Total Controlled Storage (acre-feet)	Total Annual Benefits ($1,000)	Total Annual Charges ($1,000)	Benefit-Cost Ratio	Excess Benefits Over Costs ($1,000)	Water Cost Per 1,000 Gallons ($)
LANEPORT							
Flood control only	0	269,400	2,206.6	840.6	2.6	1,366.0	
Incremental			248.6	51.6	4.8	197.0	0.013671
Dual purpose	16		2,455.2	892.2	2.8	1,563.0	0.013671
Incremental			310.8	49.0	6.3	261.8	0.007693
Dual purpose	43	331,900	2,766.0	941.2	2.9	1,824.8	0.009917
NORTH FORK							
Flood control only	0	89,400	839.5	300.2	2.8	539.3	
Incremental			260.1	49.0	5.3	211.1	0.012218
Dual purpose	17		1,099.6	349.2	3.1	750.4	0.012218
Incremental			34.5	31.9	1.1	2.6	0.045075
Dual purpose	20		1,134.1	381.1	3.0	753.0	0.017147
Incremental			115.1	88.2	1.3	26.9	0.037388
Dual purpose	30	221,600	1,249.2	469.3	2.7	779.9	0.023894
SOUTH FORK							
Flood control only	0	41,000	405.1	235.7	1.7	169.4	
Incremental			161.6	34.9	4.6	126.7	0.016438
Dual purpose	9		566.7	270.6	2.1	296.1	0.016438
Incremental			98.5	29.0	3.4	69.5	0.015366
Dual purpose	17	138,500	665.2	299.6	2.2	365.6	0.015934
BERRY CREEK							
Flood control only	0	29,600	270.5	232.9	1.2	37.6	
Incremental			107.7	22.8	4.7	84.9	0.016108
Dual purpose	6	44,000	378.2	255.7	1.5	122.5	0.016108

by the Bureau for each reservoir plan and the apportionments by the Corps of Engineers of these total plan benefits to the individual reservoir units (under simultaneous and stage-development plans 1A and 1B through 11A and 11B) are presented in table 6. The fish and wildlife benefits creditable to each reservoir plan are net benefits, reflecting losses caused by construction of the project, such as to fishing downstream from the dam sites and to wildlife hunting due to inundation of natural wildlife-habitat areas within the reservoir limits. The fish and wildlife studies by the Bureau indicate that the investigated reservoir plans would not provide benefits of any significance with respect to commercial fishing or to natural-resource conservation of national significance. The fish and wildlife analyses indicate that fish and wildlife, as a last-added function in each individual reservoir unit, is economically justified.

TABLE 6

SUMMARY OF NET FISH AND WILDLIFE BENEFITS
(in thousands of dollars)
INVESTIGATED RESERVOIR PLANS 1A AND 1B THROUGH 11A AND 11B
SAN GABRIEL RIVER WATERSHED

Plan & reservoir units	Fishing	Wildlife	Total
Total - plans 1A, 1B	41.0	9.0	50.0
(Laneport)	(41.0)	(9.0)	(50.0)
Total - plans 2A, 2B, 7A, 7B	51.0	9.0	60.0
(Laneport)	(41.0)	(9.0)	(50.0)
(Berry Creek)	(10.0)	(0.0)	(10.0)
Total - plans 3A, 3B, 8A, 8B	61.0	7.0	68.0
(Laneport)	(37.0)	(9.0)	(46.0)
(South Fork)	(24.0)	(-2.0)	(22.0)
Total - plans 4A, 4B, 9A, 9B	61.0	6.0	67.0
(Laneport)	(37.0)	(9.0)	(46.0)
(North Fork)	(24.0)	(-3.0)	(21.0)
Total - plans 5A, 5B, 10A, 10B	71.0	4.0	75.0
(Laneport)	(28.0)	(9.0)	(37.0)
(North Fork)	(22.0)	(-3.0)	(19.0)
(South Fork)	(21.0)	(-2.0)	(19.0)
Total - plans 6A, 6B, 11A, 11B	76.0	4.0	80.0
(Laneport)	(28.0)	(9.0)	(37.0)
(North Fork)	(22.0)	(-3.0)	(19.0)
(South Fork)	(21.0)	(-2.0)	(19.0)
(Berry Creek)	(5.0)	(0.0)	(5.0)

22. RECREATION STUDIES.- The report of the National Park Service, as presented in appendix IV, contains estimates of general recreation benefits for investigated reservoir plans on the San Gabriel River. The National Park Service conservatively estimated that the annual use of any investigated reservoir plan for recreation purposes would be about 150,000 visitor-days. Based on a monetary value of $1.60 per visitor-day for all types of general recreation, the National Park Service has estimated that the monetary recreation benefits of each investigated reservoir plan would be about $240,000 annually. The recreation benefits established by the National Park Service were not utilized in the economic analyses of the investigated reservoir plans. The recreation benefits creditable to the Laneport, North Fork, South Fork, and Berry Creek Reservoirs were based on studies by the Corps of Engineers as described in the following paragraphs 23 through 25.

23. Visitor attendance data compiled by the Corps of Engineers on the number of persons visiting reservoir projects under its jurisdiction for hunting, fishing, and other recreation purposes indicate that nine reservoir projects within the boundaries of the Fort Worth District attracted 44,505,000 visitors during the 3-year period of 1957, 1958, and 1959. On the basis of the above data, the average total annual visitation to the nine reservoirs is about 13,835,000 persons, or an average annual visitation of about 1,537,000 persons per reservoir project. The surface area of the nine reservoirs at top-of-conservation storage varies in size from 510 acres to 23,470 acres. The San Gabriel River project area is similar to the Belton project area with respect to the total population of surrounding areas, relative location of large urban areas, and competing reservoir facilities. The Belton project, which has a surface area of about 7,400 acres, attracted an estimated 2,407,000 visitors during 1959. The inundated area at the conservation pool level in the Laneport, North Fork, and South Fork Reservoirs under ultimate conditions of development would total about 15,175 surface acres in size. The total population within 50-mile and 100-mile radii of the project area is about 397,000 and 895,000 persons, respectively, based on preliminary 1960 census data. It is estimated that the population within these distances will be at least doubled by the year 2010. The above estimated population increase is based on projected population data contained in the report entitled "Water for the Future," prepared by the Bureau of Business Research, University of Texas. On the basis of the above reservoir visitation and other data, including allowances for competing reservoir projects and investment of non-Federal funds on project lands or waters, or adjoining lands, for facilities enhancing or developing the recreation resources of the investigated plans, it is conservatively estimated that the annual attendance at the San Gabriel River project areas will vary from 1,200,000 persons in the year 1970 to 2,900,000 persons in 2040.

24. The general recreational benefits assigned to the reservoir plans under simultaneous and stage development are based on a projected

total annual visitation trend for San Gabriel River project areas varying from 1,200,000 persons in the year 1970 to about 1,600,000 persons in year 1985, 1,700,000 persons in year 1990, 2,400,000 persons in year 2020, 2,800,000 persons in year 2035, and 2,900,000 persons in year 2040. The average annual visitation for 50-year periods under simultaneous development, or for the various periods under stage-development, have been derived on the basis of the above projected visitations. In the case of a multiple-purpose Laneport Reservoir project, operating along, it was assumed that 65 percent of the total potential average annual visitation to the San Gabriel River project areas would be credited to the Laneport project. It was assumed that two or more reservoir units in a plan would receive the total average annual visitation to the project areas, divided as follows: (a) Laneport 50 percent, North Fork or South Fork 50 percent; (b) Laneport 45 percent, North Fork 30 percent, South Fork 25 percent (or in reverse order for stage development, South Fork 30 percent, North Fork 25 percent); and (c) Laneport 40 percent, North Fork 25 percent, South Fork 25 percent, and Berry Creek 10 percent.

25. The benefits of recreational facilities are manifold; they include intangible values of health, pleasure, skill, and esthetics; and tangible values of the recreational facilities to the individual, comparable to a fee an individual would pay for admission to private recreational areas. The average value to the individual for general recreational activities at the investigated project sites is conservatively estimated at about $0.50 per visitor-day.

26. ANALYSES OF INVESTIGATED RESERVOIR PLANS.- The selection of the most favorable multiple-purpose plan of improvement for flood control, water conservation, fish and wildlife, and recreation was based on the conditions that the investigated reservoir or combination of investigated reservoirs would provide an annual benefit-to-cost ratio at least equal to 1.0; would provide the maximum amount of excess annual benefits over annual costs; and would provide the maximum amount of flood control and water conservation benefits. A combination plan of improvement was considered to be a worthy Federal undertaking if the addition of the flood control, water conservation, and fish and wildlife functions of a last-added reservoir would provide an incremental benefit-to-cost ratio of 0.85 or greater, and thence, if the addition of the recreation function would increase the economic ratio to 1.0 or greater. For this reason, the summary of economic and cost analyses presented in tables 7A and 7B includes analyses of plans 1A through 11A and 1B through 11B as multiple-purpose plans for flood control, water conservation, and fish and wildlife; and as multiple-purpose plans for flood control, water conservation, fish and wildlife, and recreation. The summary sets forth the incremental annual charges, annual benefits, benefit-cost ratio, and excess benefits over costs for the last-added reservoir unit of a combination plan of improvement.

27. The summary presented in table 4 includes economic and cost analyses of various plans of improvement under simultaneous development on the basis that the Laneport Reservoir would operate as a flood-control-only unit. The analyses of 2-unit reservoir plans presented in table 4 indicate that the addition of upstream reservoir units as flood-control-only projects is not economically justified; and that the addition of upstream reservoir units as maximum-size dual-purpose projects for flood control and water conservation purposes are economically justified except in the case of the Berry Creek Reservoir project. Also, the analyses indicate that the Laneport-North Fork combination is the most feasible plan of the 2-unit reservoir plans since it provides the larger amount of excess benefits over cost. Analyses of the 3-unit and 4-unit reservoir plans indicate that the South Fork and Berry Creek Reservoir units for flood control, or for flood control and water conservation, are not economically justified since they cause a decrease in total excess benefits creditable to the Laneport-North Fork Reservoir plan.

28. The analyses of plans 1A through 11A and 1B through 11B, as presented in tables 7A and 7B, are a continuation of studies summarized in table 4, with a view to determining the maximum economical amount of water conservation storage in the Laneport project, operating alone or in combination with the maximum-size upstream reservoir units described in paragraph 18. The analyses of the various multiple-purpose plans of improvement under simultaneous and stage development were based on the Laneport Reservoir as the basic reservoir unit because of its importance for flood control purposes, as previously stated in paragraph 14. Therefore, plans 1A and 1B, consisting of the Laneport Reservoir project operating alone, are considered to be the basic plans of improvement. Plan 1B is the maximum-size Laneport project, limited to a maximum total controlled storage of 331,900 acre-feet because of encroachment limitations with respect to the city of Granger. Plan 1A is a smaller-size Laneport Reservoir project having a total controlled storage of 281,100 acre-feet.

29. Under the category of the simultaneous-development plans presented in tables 7A and 7B, the economic and cost analyses indicate that plans 1A and 1B, Laneport Reservoir operating alone, are economically justified, but that the maximum-size Laneport Reservoir, plan 1B, is the most favorable plan since it provides the maximum amount of annual benefits in excess of the annual costs. Likewise, the analyses indicate that plans 2A through 4A, the smaller-size Laneport Reservoir operating in combination with either Berry Creek, South Fork, or North Fork Reservoir, are economically justified since the total amount of excess benefits provided by each of these plans is greater than the total excess benefits creditable to plan 1A and because the incremental benefit-cost ratios relative to adding the upstream multiple-purpose reservoir units for flood control, water conservation, and fish and wildlife, are greater than 0.85. In the case of plans 2B through 4B,

TABLE 7A

SUMMARY OF ECONOMIC AND COST ANALYSES - SOLUTIONS CONSIDERED
INVESTIGATED RESERVOIR PLANS
SAN GABRIEL RIVER WATERSHED
(Laneport Reservoir with Total Controlled Storege of 281,100 Acre-feet -
To Provide Less Than Maximum Water Supply Development Allowable within Reservoir Site Limitations)

Plan No.	Reservoir Units	Period of use or stage	Reservoir storage (acre-feet) Sediment	Flood control	Water Conservation	Total	Dependable yield cfs	Dependable yield mgd	Annual charges (1000 dollars) FC & WC	FC,WC,FW	FC,WC,FW,R	Average annual benefits over 50 years (1000 dollars) FC	WC	FW	R	Total FC & WC	Total FC,WC,FW	Total FC,WC,FW,R	Benefit-Cost ratio FC & WC	FC,WC,FW	FC,WC,FW,R	Excess benefits (1000 dollars) FC & WC	FC,WC,FW	FC,WC,FW,R
											SIMULTANEOUS DEVELOPMENT													
1A	Laneport	1970-2020	27,700	236,100	17,300	281,100	16	10.3	892.2	904.5	945.3	2,206.6	248.6	50.0	585.0	2,455.2	2,505.2	3,090.2	2.8	2.8	3.3	1,563.0	1,600.7	2,144.9
	Incremental between plans 1A & 2A								260.4	264.4	279.1					231.8	241.8	376.8	0.89	0.91	1.4	-28.6	-22.6	97.7
2A	Laneport	1970-2020	26,300	216,800	38,000	281,100	29	18.7	896.9	909.2	950.0	1,981.5	359.6	50.0	450.0	2,341.1	2,391.1	2,841.1	2.6	2.6	3.0	1,444.2	1,481.9	1,891.1
	Berry Creek	1970-2020	2,800	26,800	14,400	44,000	6	3.9	255.7	259.7	274.4	238.2	107.7	10.0	270.0	345.9	355.9	625.9	1.4	1.4	2.3	90.2	96.2	321.5
	Total		29,100	243,600	52,400	325,100	35	22.6	1,152.6	1,168.9	1,224.4	2,219.7	467.3	60.0	720.0	2,687.0	2,747.0	3,467.0	2.3	2.4	2.8	1,534.4	1,578.1	2,212.6
	Incremental between plans 1A & 3A								305.5	312.1	341.6					441.7	459.7	774.7	1.4	1.5	2.3	136.2	147.6	433.1
3A	Laneport	1970-2020	25,300	198,400	57,400	281,100	35	22.7	898.1	910.4	951.2	1,888.8	403.0	46.0	450.0	2,291.8	2,337.8	2,787.8	2.6	2.6	2.9	1,393.7	1,427.4	1,836.6
	South Fork	1970-2020	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	345.0	260.1	22.0	450.0	605.1	627.1	1,077.1	2.0	2.0	3.2	305.5	320.9	741.4
	Total		29,300	243,900	146,400	419,600	52	33.7	1,197.7	1,216.6	1,286.9	2,233.8	663.1	68.0	900.0	2,896.9	2,964.9	3,864.9	2.4	2.4	3.0	1,699.2	1,748.3	2,578.0
	Incremental between plans 1A & 4A								478.0	486.6	522.7					650.8	667.8	982.8	1.4	1.4	1.9	172.8	181.2	460.1
4A	Laneport	1970-2020	20,800	161,100	99,200	281,100	35	22.7	900.9	913.2	954.0	1,659.4	403.0	46.0	450.0	2,062.4	2,108.4	2,558.4	2.3	2.3	2.7	1,161.5	1,195.2	1,604.4
	North Fork	1970-2020	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	633.9	409.7	21.0	450.0	1,043.6	1,064.6	1,514.6	2.2	2.2	2.9	574.3	586.7	1,000.6
	Total		27,800	249,000	225,900	502,700	65	42.1	1,370.2	1,391.1	1,468.0	2,293.3	812.7	67.0	900.0	3,106.0	3,173.0	4,073.0	2.3	2.3	2.8	1,735.8	1,781.9	2,605.0
	Incremental between plans 3A & 5A								476.0	484.6	520.7					397.3	404.3	404.3	0.8	0.8	0.8	-78.7	-80.3	-116.4
	Incremental between plans 4A & 5A								303.5	310.1	339.6					188.2	196.2	196.2	0.6	0.6	0.6	-115.3	-113.9	-143.4
5A	Laneport	1970-2020	19,600	116,500	145,000	281,100	32	20.7	904.8	917.1	957.9	1,474.0	368.3	37.0	405.0	1,842.3	1,879.3	2,284.3	2.0	2.0	2.4	937.5	962.2	1,326.4
	North Fork	1970-2020	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	572.2	409.7	19.0	270.0	981.9	1,000.9	1,270.9	2.1	2.1	2.5	512.6	523.0	756.9
	South Fork	1970-2020	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	274.3	195.7	19.0	225.0	470.0	489.0	714.0	1.6	1.6	2.1	170.4	182.8	378.3
	Total		30,600	249,900	360,700	641,200	79	51.1	1,673.7	1,701.2	1,807.6	2,320.5	973.7	75.0	900.0	3,294.2	3,369.2	4,269.2	2.0	2.0	2.4	1,620.5	1,668.0	2,461.6
	Incremental between plans 5A & 6A								259.6	263.6	278.3					36.2	41.2	41.2	0.1	0.2	0.1	-223.4	-222.4	-237.1
6A	Laneport	1970-2020	20,600	96,300	164,200	281,100	28	18.1	908.7	921.0	961.8	1,368.1	322.3	37.0	360.0	1,690.4	1,727.4	2,087.4	1.9	1.9	2.2	781.7	806.4	1,125.6
	North Fork	1970-2020	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	539.0	409.7	19.0	225.0	948.7	967.7	1,192.7	2.0	2.0	2.3	479.4	489.8	678.7
	South Fork	1970-2020	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	296.7	195.7	19.0	225.0	492.4	471.4	696.4	1.5	1.5	2.1	152.8	165.2	360.7
	Berry Creek	1970-2020	2,800	26,800	14,400	44,000	6	3.9	255.7	259.7	274.4	169.8	59.1	5.0	90.0	238.9	243.9	333.9	0.9	0.9	1.2	-16.8	-15.8	59.5
	Total		34,400	256,500	394,300	685,200	81	52.4	1,933.3	1,964.8	2,085.9	2,333.6	996.8	80.0	900.0	3,330.4	3,410.4	4,310.4	1.7	1.7	2.1	1,397.1	1,445.6	2,224.5
											STAGE DEVELOPMENT													
1A	Laneport	1970-2020	27,700	236,100	17,300	281,100	16	10.3	892.2	904.5	945.3	2,206.6	248.6	50.0	585.0	2,455.2	2,505.2	3,090.2	2.8	2.8	3.3	1,563.0	1,600.7	2,144.9
	Incremental between plans 1A & 7A								260.4	264.4	279.1					350.3	360.3	538.7	1.3	1.4	1.9	89.9	95.9	259.6
7A	Laneport	1970-1985	27,700	236,100	17,300	281,100	16	10.3																
	Laneport	1985-2020	26,700	216,800	37,600	281,100	29	17.4	896.9	909.2	950.0	2,081.1	378.5	50.0	433.4	2,499.6	2,509.6	2,943.0	2.7	2.8	3.1	1,562.7	1,600.4	1,993.0
	Berry Creek	1985-2035	2,800	26,800	14,400	44,000	6	3.9	255.7	259.7	274.4	238.2	107.7	10.0	330.0	345.9	355.9	685.9	1.4	1.4	2.5	90.2	96.2	411.5
	Total		29,500	243,600	52,000	325,100	35	21.3	1,152.6	1,168.9	1,224.4	2,319.3	486.2	60.0	763.4	2,865.5	2,865.5	3,628.9	2.4	2.5	3.0	1,652.9	1,696.6	2,404.5
	Incremental between plans 1A & 8A								305.5	312.1	341.6					662.9	682.7	1,081.1	2.2	2.2	3.2	357.4	370.6	739.5
8A	Laneport	1970-1985	27,700	236,100	17,300	281,100	16	10.3																
	Laneport	1985-2020	26,000	198,400	56,700	281,100	35	22.6	898.1	910.4	951.2	2,029.5	438.4	47.8	433.4	2,467.9	2,515.7	2,949.1	2.7	2.8	3.1	1,569.8	1,605.3	1,997.9
	South Fork	1985-2035	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	345.0	305.2	22.0	550.0	650.2	672.2	1,222.2	2.2	2.2	3.6	350.6	366.0	886.5
	Total		30,000	243,900	145,700	419,600	52	33.6	1,197.7	1,216.6	1,286.9	2,374.5	743.6	69.8	983.4	3,118.1	3,187.9	4,171.3	2.6	2.6	3.2	1,920.4	1,971.3	2,884.4
	Incremental between plans 1A & 9A								478.0	486.6	522.7					1,057.5	1,076.3	1,474.7	2.2	2.2	2.8	579.5	589.7	952.0
9A	Laneport	1970-1985	27,700	236,100	17,300	281,100	16	10.3																
	Laneport	1985-2020	23,000	161,100	97,000	281,100	35	22.6	900.9	913.2	954.0	1,901.8	438.4	47.8	433.4	2,340.2	2,388.0	2,821.4	2.6	2.6	3.0	1,439.3	1,474.8	1,867.4
	North Fork	1985-2035	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	633.9	538.6	21.0	550.0	1,172.5	1,193.5	1,743.5	2.5	2.5	3.4	703.2	715.6	1,229.5
	Total		30,000	249,000	223,700	502,700	65	42.0	1,370.2	1,391.1	1,468.0	2,535.7	977.0	68.8	983.4	3,512.7	3,581.5	4,564.9	2.6	2.6	3.1	2,142.5	2,190.4	3,096.9
	Incremental between plans 9A & 10A								303.5	310.1	339.6					406.3	419.6	483.4	1.3	1.4	1.4	102.8	109.5	143.8
10A	Laneport	1970-1985	27,700	236,100	17,300	281,100	16	10.3																
	Laneport	1985-1990	23,000	161,100	97,000	281,100	35	22.6	904.8	917.1	957.9	1,819.7	398.7	43.8	405.5	2,218.4	2,262.2	2,667.7	2.5	2.5	2.8	1,313.6	1,345.1	1,709.8
	Laneport	1990-2020	22,200	116,500	142,400	281,100	30	19.4																
	North Fork	1985-1990	7,000	87,900	126,700	221,600	30	19.4																
	North Fork	1990-2035	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	582.5	538.6	19.3	351.7	1,121.1	1,140.4	1,492.1	2.4	2.4	2.9	651.8	662.5	978.1
	South Fork	1990-2040	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	274.3	305.2	19.0	290.0	579.5	598.5	888.5	1.9	2.0	2.6	279.9	292.3	552.8
	Total		33,200	249,900	358,100	641,200	77	49.8	1,673.7	1,701.2	1,807.6	2,676.5	1,242.5	82.1	1,047.2	3,919.0	4,001.1	5,048.3	2.3	2.4	2.8	2,245.3	2,299.9	3,240.7
	Incremental between plans 10A & 11A								259.6	263.6	278.3					153.4	158.4	201.3	0.6	0.6	0.7	-106.2	-105.2	-77.0
11A	Laneport	1970-1985	27,700	236,100	17,300	281,100	16	10.3																
	Laneport	1985-1990	23,000	161,100	97,000	281,100	35	22.6	908.7	921.0	961.8	1,772.8	366.8	43.8	383.4	2,139.6	2,183.4	2,566.8	2.4	2.4	2.7	1,230.9	1,262.4	1,605.0
	Laneport	1990-2020	20,600	96,300	164,200	281,100	26	16.8																
	North Fork	1985-1990	7,000	87,900	126,700	221,600	30	19.4																
	North Fork	1990-2025	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	554.8	538.6	19.3	301.7	1,093.4	1,112.7	1,414.4	2.3	2.3	2.8	624.1	634.8	900.4
	South Fork	1990-2040	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	256.7	305.2	19.0	290.0	561.9	580.9	870.9	1.9	1.9	2.6	262.3	274.7	535.2
	Berry Creek	1990-2040	2,800	26,800	14,400	44,000	6	3.9	255.7	259.7	274.4	169.8	107.7	5.0	115.0	277.5	282.5	397.5	1.1	1.1	1.4	21.8	22.8	123.1
	Total		34,400	256,500	394,300	685,200	79	51.1	1,933.3	1,964.8	2,085.9	2,754.1	1,318.3	87.1	1,090.1	4,072.4	4,159.5	5,249.6	2.1	2.1	2.5	2,139.1	2,194.7	3,163.7

All plans include flood control (FC), water conservation (WC), fish & wildlife (FW), and recreation (R)

TABLE 7B

SUMMARY OF ECONOMIC AND COST ANALYSES - SOLUTIONS CONSIDERED
INVESTIGATED RESERVOIR PLANS
SAN GABRIEL RIVER WATERSHED
(Laneport Reservoir with Total Controlled Storage of 331,900 Acre-feet -
To Provide Maximum Water Supply Resource Development Allowable within Reservoir Site Limitations)

Plan No.	Reservoir Units	Period of use or stage	Reservoir storage (acre-feet)				Dependable yield		Annual charges (1000 dollars)			Average annual benefits over 50 years (1000 dollars)							Benefit-Cost ratio			Excess benefits (1000 dollars)		
			Sediment	Flood control	Water conservation	Total	cfs	mgd	FC & WC	FC,WC,FW	FC,WC,FW,R	FC	WC	FW	R	Total FC & WC	Total FC,WC,FW	Total FC,WC,FW,R	FC & WC	FC,WC,FW	FC,WC,FW,R	FC & WC	FC,WC,FW	FC,WC,FW,R
												SIMULTANEOUS DEVELOPMENT												
1B	Laneport	1970-2020	27,700	236,100	68,100	331,900	43	27.8	941.2	953.5	994.3	2,206.6	559.4	50.0	585.0	2,766.0	2,816.0	3,401.0	2.9	3.0	3.4	1,824.8	1,862.5	2,406.7
	Incremental between plans 1B & 2B								256.4	260.4	275.1					105.2	115.2	250.2	0.41	0.44	0.91	-151.2	-145.2	-24.9
2B	Laneport	1970-2020	26,700	216,800	88,400	331,900	45	29.1	941.9	954.2	995.0	1,981.5	543.8	50.0	450.0	2,525.3	2,575.3	3,025.3	2.7	2.7	3.0	1,583.4	1,621.1	2,030.3
	Berry Creek	1970-2020	2,800	26,800	14,400	44,000	6	3.9	255.7	259.7	274.4	238.2	107.7	10.0	270.0	345.9	355.9	635.9	1.4	1.4	2.3	90.2	96.2	351.5
	Total		29,500	243,600	102,800	375,900	51	33.0	1,197.6	1,213.9	1,269.4	2,219.7	651.5	60.0	720.0	2,871.2	2,931.2	3,651.2	2.4	2.4	2.9	1,673.6	1,717.3	2,381.8
	Incremental between plans 1B & 3B								303.4	310.0	339.5					234.5	252.5	567.5	0.77	0.81	1.7	-68.9	-57.5	228.0
3B	Laneport	1970-2020	25,300	198,400	108,200	331,900	44	28.4	945.0	957.3	998.1	1,888.8	506.6	46.0	450.0	2,395.4	2,441.4	2,891.4	2.5	2.6	2.9	1,450.4	1,484.1	1,893.3
	South Fork	1970-2020	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	345.0	260.1	22.0	450.0	605.1	627.1	1,077.1	2.0	2.0	3.2	305.5	320.9	741.4
	Total		29,300	243,900	196,200	470,400	61	39.4	1,244.6	1,263.5	1,333.8	2,233.8	766.7	68.0	900.0	3,000.5	3,068.5	3,968.5	2.4	2.4	3.0	1,755.9	1,805.0	2,634.7
	Incremental between plans 1B & 4B								474.4	483.0	519.1					386.0	403.0	718.0	0.81	0.83	1.4	-88.4	-80.0	198.9
4B	Laneport	1970-2020	20,800	161,100	150,000	331,900	39	25.2	946.3	958.6	999.4	1,659.4	449.0	46.0	450.0	2,108.4	2,154.4	2,604.4	2.2	2.2	2.6	1,162.1	1,195.8	1,605.0
	North Fork	1970-2020	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	633.9	409.7	21.0	450.0	1,043.6	1,064.6	1,514.6	2.2	2.2	2.9	574.3	586.7	1,000.6
	Total		27,800	249,000	276,700	553,500	69	44.6	1,415.6	1,436.5	1,513.4	2,293.3	858.7	67.0	900.0	3,152.0	3,219.0	4,119.0	2.2	2.2	2.7	1,736.4	1,782.5	2,605.6
	Incremental between plans 3B & 5B								474.5	483.1	519.2					328.4	335.4	335.4	0.69	0.69	0.65	-146.1	-147.7	-183.8
	Incremental between plans 4B & 5B								303.5	310.1	339.6					176.9	184.9	184.9	0.58	0.60	0.54	-126.6	-125.2	-154.7
5B	Laneport	1970-2020	19,600	116,500	195,800	331,900	34	22.0	950.2	962.5	1,003.3	1,474.0	403.0	37.0	405.0	1,877.0	1,914.0	2,319.0	2.0	2.0	2.3	926.8	951.5	1,315.7
	North Fork	1970-2020	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	572.2	409.7	19.0	270.0	981.9	1,000.9	1,270.9	2.1	2.1	2.5	512.6	523.0	756.9
	South Fork	1970-2020	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	274.3	195.7	19.0	225.0	470.0	489.0	714.0	1.6	1.6	2.1	170.4	182.8	378.3
	Total		30,600	249,900	411,500	692,000	81	52.4	1,719.1	1,746.6	1,853.0	2,320.5	1,008.4	75.0	900.0	3,328.9	3,403.9	4,303.9	1.9	1.9	2.3	1,609.8	1,657.3	2,450.9
	Incremental between plans 5B & 6B								259.6	263.6	278.3					24.6	29.6	29.6	0.09	0.11	0.11	-235.0	-234.0	-248.7
6B	Laneport	1970-2020	20,600	96,300	215,000	331,900	30	19.4	954.1	966.4	1,007.2	1,368.1	345.4	37.0	360.0	1,713.5	1,750.5	2,110.5	1.8	1.8	2.1	759.4	784.1	1,103.3
	North Fork	1970-2020	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	539.0	409.7	19.0	225.0	948.7	967.7	1,192.7	2.0	2.0	2.3	479.4	489.8	678.7
	South Fork	1970-2020	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	256.7	195.7	19.0	225.0	452.4	471.4	696.4	1.5	1.5	2.1	152.8	165.2	360.7
	Berry Creek	1970-2020	2,800	26,800	14,400	44,000	6	3.9	255.7	259.7	274.4	169.8	69.1	5.0	90.0	238.9	243.9	333.9	0.93	0.94	1.2	-16.8	-15.8	59.5
	Total		34,400	256,500	445,100	736,000	83	53.7	1,978.7	2,010.2	2,131.3	2,333.6	1,019.9	80.0	900.0	3,353.5	3,433.5	4,333.5	1.7	1.7	2.0	1,374.8	1,423.3	2,202.2
												STAGE DEVELOPMENT												
1B	Laneport	1970-2020	27,700	236,100	68,100	331,900	43	27.8	941.2	953.5	994.3	2,206.6	559.4	50.0	585.0	2,766.0	2,816.0	3,401.0	2.9	3.0	3.4	1,824.8	1,862.5	2,406.7
	Incremental between plans 1B & 7B								256.5	260.4	275.1					240.3	250.3	428.7	0.94	0.96	1.6	-16.1	-10.1	153.6
7B	Laneport	1970-1985	27,700	236,100	68,100	331,900	43	27.8																
	Laneport	1985-2020	26,700	216,800	88,400	331,900	45	29.1	941.9	954.2	995.0	2,081.1	579.3	50.0	433.4	2,660.4	2,710.4	3,143.8	2.8	2.8	3.2	1,718.5	1,756.2	2,148.8
	Berry Creek	1985-2035	2,800	26,800	14,400	44,000	6	3.9	255.7	259.7	274.4	238.2	107.7	10.0	330.0	345.9	355.9	685.9	1.4	1.4	2.5	90.2	96.2	411.5
	Total		29,500	243,600	102,800	375,900	51	33.0	1,197.6	1,213.9	1,269.4	2,319.3	687.0	60.0	763.4	3,006.3	3,066.3	3,829.7	2.5	2.5	3.0	1,808.7	1,852.4	2,560.3
	Incremental between plans 1B & 8B								303.4	310.0	339.5					483.0	502.8	901.2	1.6	1.6	2.7	179.6	192.8	561.7
8B	Laneport	1970-1985	27,700	236,100	68,100	331,900	43	27.8																
	Laneport	1985-2020	26,000	198,400	107,500	331,900	44	28.4	945.0	957.3	998.1	2,029.5	569.3	47.8	433.4	2,598.8	2,646.6	3,080.0	2.8	2.8	3.1	1,653.8	1,689.3	2,081.9
	South Fork	1985-2035	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	345.0	305.2	22.0	550.0	650.2	672.2	1,222.2	2.2	2.2	3.6	350.6	366.0	886.5
	Total		30,000	243,900	196,500	470,400	61	39.4	1,244.6	1,263.5	1,333.8	2,374.5	874.5	69.8	983.4	3,249.0	3,318.8	4,302.2	2.6	2.6	3.2	2,004.4	2,055.3	2,968.4
	Incremental between plans 1B & 9B								474.4	483.0	519.1					816.2	835.0	1,233.4	1.7	1.7	2.4	341.8	352.0	714.3
9B	Laneport	1970-1985	27,700	236,100	68,100	331,900	43	27.8																
	Laneport	1985-2020	23,000	161,100	147,800	331,900	39	25.2	946.3	958.6	999.4	1,901.8	533.7	47.8	433.4	2,435.5	2,483.3	2,916.7	2.6	2.6	2.9	1,489.2	1,524.7	1,917.3
	North Fork	1985-2035	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	633.9	512.8	21.0	550.0	1,146.7	1,167.7	1,717.7	2.4	2.4	3.3	677.4	690.8	1,203.7
	Total		30,000	249,000	274,500	553,500	69	44.6	1,415.6	1,436.5	1,513.4	2,535.7	1,046.5	68.8	983.4	3,582.2	3,651.0	4,634.4	2.5	2.5	3.1	2,166.6	2,214.5	3,121.0
	Incremental between plans 9B & 10B								303.5	310.1	339.6					388.3	401.6	465.4	1.3	1.3	1.4	84.8	91.5	125.8
10B	Laneport	1970-1985	27,700	236,100	68,100	331,900	43	27.8																
	Laneport	1985-1990	23,000	161,100	147,800	331,900	39	25.2	950.2	962.5	1,003.3	1,819.7	508.2	43.8	405.5	2,327.9	2,371.7	2,777.2	2.4	2.5	2.8	1,377.7	1,409.2	1,773.9
	Laneport	1990-2020	22,200	116,500	193,200	331,900	34	22.0																
	North Fork	1985-1990	7,000	87,900	126,700	221,600	30	19.4																
	North Fork	1990-2035	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	582.5	512.8	19.3	351.7	1,095.3	1,114.6	1,466.3	2.3	2.3	2.9	626.0	636.7	952.3
	South Fork	1990-2040	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	274.3	273.0	19.0	290.0	547.3	566.3	856.3	1.8	1.8	2.6	247.7	260.1	520.6
	Total		33,200	249,900	408,900	692,000	81	52.4	1,719.1	1,746.6	1,853.0	2,676.5	1,294.0	82.1	1,047.2	3,970.5	4,052.6	5,099.8	2.3	2.3	2.8	2,251.4	2,306.0	3,246.8
	Incremental between plans 10B & 11B								259.6	263.6	278.3					139.1	144.1	187.0	0.54	0.55	0.67	-120.5	-119.5	-91.3
11B	Laneport	1970-1985	27,700	236,100	68,100	331,900	43	27.8																
	Laneport	1985-1990	23,000	161,100	147,800	331,900	39	25.2	954.1	966.4	1,007.2	1,772.8	487.8	43.8	383.4	2,260.6	2,304.4	2,687.8	2.4	2.4	2.7	1,306.5	1,338.0	1,680.6
	Laneport	1990-2020	20,600	96,300	215,000	331,900	30	19.4																
	North Fork	1985-1990	7,000	87,900	126,700	221,600	30	19.4																
	North Fork	1990-2035	7,000	87,900	126,700	221,600	30	19.4	469.3	477.9	514.0	554.8	512.8	19.3	301.7	1,067.6	1,086.9	1,388.6	2.3	2.3	2.7	598.3	609.0	874.6
	South Fork	1990-2040	4,000	45,500	89,000	138,500	17	11.0	299.6	306.2	335.7	256.7	247.2	19.0	290.0	503.9	522.9	812.9	1.7	1.7	2.4	204.3	216.7	477.2
	Berry Creek	1990-2040	2,800	26,800	14,400	44,000	6	3.9	255.7	259.7	274.4	169.8	107.7	5.0	115.0	277.5	282.5	397.5	1.1	1.1	1.4	21.8	22.8	123.1
	Total		34,400	256,500	445,100	736,000	83	53.7	1,978.7	2,010.2	2,131.3	2,754.1	1,355.5	87.1	1,090.1	4,169.6	4,196.7	5,286.8	2.1	2.1	2.5	2,130.9	2,186.5	3,155.5

All plans include flood control (FC), water conservation (WC), fish & wildlife (FW), and recreation (R)

however, the analyses indicate that the addition of the Berry Creek, South Fork, or North Fork Reservoirs to the maximum-size Laneport project is not worthy of Federal participation since the incremental benefit-cost ratios of the added upstream multiple-purpose reservoir units for flood control, water conservation, and fish and wildlife are less than 0.85. The summary indicates that plan 3A, consisting of the smaller-size Laneport Reservoir in combination with the South Fork Reservoir, is the most favorable of the 2-unit reservoir plans since it provides a greater amount of incremental excess benefits, when compared to the corresponding basic plan. Thus, on the basis of the analyses of plans 2A and 2B through 4A and 4B, it is concluded that the amount of water conservation storage which can be economically provided in a 2-unit reservoir plan prior to the time of need would be limited to an intermediate-size Laneport reservoir containing controlled storage of more than 281,100 acre-feet but less than 331,900 acre-feet. The analyses of plans 5A and 5B and of plans 6A and 6B indicate that the addition of the South Fork Reservoir, and thence, the addition of the Berry Creek Reservoir, respectively, are not economically justified since the incremental benefits-cost ratios for flood control, water conservation, fish and wildlife, and recreation resulting by the addition of these multiple-purpose reservoir units are less than unity.

30. Under the category of the stage-development plans, presented in tables 7A and 7B, the economic and cost analyses of plans 7A through 9A and plans 7B through 9B indicate that the addition of either the Berry Creek, South Fork, or North Fork Reservoir units in year 1985 as a next-added project, subsequent to an assumed completion date of year 1970 for the Laneport Reservoir project, is economically justified. The summary indicates that plans 9A and 9B, consisting of the Laneport-North Fork combinations, are the most favorable of the 2-unit reservoir plans since such plans would provide the greatest amounts of excess benefits over costs. Plans 9A and 9B, therefore, were adopted as the basis for the formulation of additional stage-development plans. The analyses indicate that plans 10A and 10B would provide a greater amount of total excess benefits than would be provided by plans 9A and 9B, and, therefore, the addition of the South Fork Reservoir as a third-stage unit to be completed by year 1990 is economically justified. The analyses of plans 11A and 11B indicate that the total amount of excess benefits provided by plans 11A and 11B are less than the total excess benefits provided by plans 10A and 10B, and, therefore, the addition of the Berry Creek Reservoir as a last-added project to the system of reservoirs is not economically justified.

31. In summary, the economic and cost analyses indicate that plan 3A was found to be the most favorable of the simultaneous-development plans and plan 10B was found to be the most favorable of the stage-development plans. A comparison of the various plans under simultaneous and stage development determined, however, that the construction of multiple-purpose reservoir units in accordance with the construction sequences set forth under stage development would provide for the most

beneficial and economical development of the water resources of the San Gabriel River watershed. Under the category of stage-development plans, the summary presented in tables 7A and 7B indicates that the maximum-size Laneport project under the "B" plan series provides by a narrow margin the maximum amount of excess benefits over costs. A brief summary of the stage-development plans under the "A" and "B" plan series, showing total amounts with respect to storage, yields, annual costs, annual benefits, benefit-cost ratios, and excess benefits, as well as the incremental amounts between the various plans, is presented in table 8. An over-all analysis indicates that plan 10B under stage-development, consisting of the maximum-size Laneport project, the second-stage North Fork Reservoir, and the third-stage South Fork Reservoir, is the most suitable and practical plan for flood control, water conservation, fish and wildlife, and recreation purposes. Plan 10B would provide the maximum degree of flood protection for the lower Little and Brazos Rivers against floods originating on the San Gabriel River watershed, as well as substantial flood protection for the San Gabriel River downstream from the vicinity of Georgetown, Texas; and would provide for the maximum economical conservation of the good-quality water available on the San Gabriel River watershed, and thus would contribute very favorably toward fulfillment of the present and future water supply requirements for the lower Brazos River Basin, including the lower San Gabriel area. In addition, plan 10B would provide a substantial amount of annual benefits for sport fishing, wildlife hunting, and general recreation.

32. SUPPORTING DATA.- Supporting data on design, first cost, annual charges, and cost allocation studies for investigated reservoir plans are presented in tables 9 through 23 of this appendix. In addition, detailed data on the value of physical property in the investigated flood plains of the San Gabriel and lower Little and Brazos Rivers are presented in tables 24 through 33.

TABLE 8

BRIEFED SUMMARY OF MULTIPLE-PURPOSE PLANS
UNDER STAGE DEVELOPMENT
SAN GABRIEL RIVER WATERSHED

Plan No.	Reservoir units	Total controlled storage (ac-ft)	Ultimate yield cfs	Ultimate yield mgd	Total annual charges ($1000)	Total annual benefits ($1000)	Total excess benefits ($1000)
1A	Laneport	281,100	16	10.3	945.3	3,090.2	2,144.9
	Incremental between plans 1A & 7A	44,000	19	11.0	279.1	538.7	259.6
7A	Laneport & Berry Creek	325,100	35	21.3	1,224.4	3,628.9	2,404.5
	Incremental between plans 1A & 8A	138,500	36	23.3	341.6	1,081.1	739.5
8A	Laneport & South Fork	419,600	52	33.6	1,286.9	4,171.3	2,884.4
	Incremental between plans 1A & 9A	221,600	49	31.7	522.7	1,474.7	952.0
9A	Laneport & North Fork	502,700	65	42.0	1,468.0	4,564.9	3,096.9
	Incremental between plans 9A & 10A	138,500	12	7.8	339.6	483.4	143.8
10A	Laneport, North Fork, & South Fork	641,200	77	49.8	1,807.6	5,048.3	3,240.7
	Incremental between plans 10A & 11A	44,000	2	1.3	278.3	201.3	-77.0
11A	Laneport, North Fork, South Fork & Berry Creek	685,200	79	51.1	2,085.9	5,249.6	3,163.7
1B	Laneport	331,900	43	27.8	994.3	3,401.0	2,406.7
	Incremental between plans 1B & 7B	44,000	8	5.2	275.1	428.7	153.6
7B	Laneport & Berry Creek	375,900	51	33.0	1,269.4	3,829.7	2,560.3
	Incremental between plans 1B & 8B	138,500	18	11.6	339.5	901.2	561.7
8B	Laneport and South Fork	470,400	61	39.4	1,333.8	4,302.2	2,968.4
	Incremental between plans 1B & 9B	221,600	26	16.8	519.1	1,233.4	714.3
9B	Laneport & North Fork	553,500	69	44.6	1,513.4	4,634.4	3,121.0
	Incremental between plans 9B & 10B	138,500	12	7.8	339.6	465.4	125.8
10B	Laneport, North Fork, & South Fork	692,000	81	52.4	1,853.0	5,099.8	3,246.8
	Incremental between plans 10B & 11B	44,000	2	1.3	278.3	187.0	-91.3
11B	Laneport, North Fork, South Fork & Berry Creek	736,000	83	53.7	2,131.3	5,286.8	3,155.5

All plans include flood control, water conservation, fish & wildlife, and recreation

TABLE 9

PERTINENT DATA
SINGLE PURPOSE RESERVOIRS - LANEPORT RESERVOIR
DAM AT RIVER MILE 29.7 ON SAN GABRIEL RIVER
(IN SYSTEM WITH NORTH AND SOUTH FORK RESERVOIRS)

ITEM	FLOOD CONTROL ONLY				WATER CONSERVATION ONLY			
DRAINAGE AREA, square miles								
Total	711				711			
Intercepted by North Fork Reservoir	(236)				(236)			
Intercepted by South Fork Reservoir	(120)				(120)			
SPILLWAY DESIGN FLOOD								
Peak inflow, cfs	630,700				630,700			
Volume, acre-feet	1,026,700				1,026,700			
Volume, inches	27.08				27.08			
Peak outflow, cfs	578,000 (1)				546,000			
RESERVOIR	Elev. (2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)(3)	Elev. (2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)(3)
Sediment storage	512.0	--	22,200	1.03	523.0	--	22,200	1.04
Spillway crest	483.0	1,850	21,700	1.15	494.0	3,050	48,000	2.54
Top of conservation pool					523.0	10,520	236,200	12.48
Top of gates	512.0	7,300	139,300	7.36	523.0			
Top of flood control pool	512.0				--			
Maximum design water surface	523.6	10,740	242,700	12.82	533.6	14,360	368,100	19.44
Top of dam	529.0				539.0			
Maximum tailwater	477.7				477.0			
DAM								
Type	Concrete and earth fill				Concrete and earth fill			
Total length, feet	15,300				14,500			
Embankment section:								
Type	Concrete and earth fill				Concrete and earth fill			
Total length, feet	14,360				13,560			
Height above stream bed, feet	94				104			
Freeboard, feet	5.4				5.4			
Crown width, feet	42				42			
Side slopes:								
Upstream	1 on 2-1/2 & 1 on 3-1/2				1 on 2-1/2 & 1 on 3-1/2			
Downstream	1 on 2-1/2 & 1 on 3-1/2				1 on 2-1/2 & 1 on 3-1/2			
Non-overflow section:								
Type	Concrete gravity				Concrete gravity			
Total length, feet	276				276			
Height above apron, feet	100				110			
Top width, feet	24				24			
Spillway section:								
Type	Concrete ogee				Concrete ogee			
Gross length, feet	664				664			
Net length, feet	560				560			
Crest height above apron, feet	54				65			
Gates:								
Type	Tainter				Tainter			
Number	14				14			
Size (width x height)(feet)	40 x 29				40 x 29			
Spillway discharge, cfs								
Top of gates	337,200				335,600			
Maximum design water surface	563,600				546,000			
OUTLET WORKS								
Type	Gate-controlled conduit				Gate-controlled sluice			
Number of sluices, conduits	1				1			
Dimensions	19' diameter				3' x 4'6"			
Invert elevation, feet	450.0				445.0			
Sluice or conduit control	3 - 5'9" x 19' tractor gates				1 - 3' x 4'6" hand-operated sluice gate			
RELOCATIONS								
U. S. highways, miles	None				None			
State highways, miles	None				None			
F. M. roads, miles	3.6				3.8			
County roads, miles	1.3				2.0			
Railroads, miles	None				None			
Power lines, miles	5.5				8.0			
Telephone lines, miles	4.6				8.0			
Cemeteries, number	1				1			
Towns, number	None				None			
LANDS								
Clearing, acres	None				2,200			
Land acquisition:								
Fee simple, acres	1,200				12,800			
(Top control elev.) (2)	--				(526.0)			
Flood easements, acres	7,670				--			
(Top control elev.) (2)	(515.0)				--			
(1) Includes discharge through outlet works, cfs	14,400				--			

(2) All elevations refer to mean sea level
(3) Based on drainage area of 711 - 236 - 120, or 355 square miles

TABLE 10

PERTINENT DATA
SINGLE PURPOSE RESERVOIRS - NORTH FORK RESERVOIR
DAM AT RIVER MILE 4.0 ON NORTH SAN GABRIEL RIVER

ITEM	FLOOD CONTROL ONLY				WATER CONSERVATION ONLY			
DRAINAGE AREA								
Square miles	236				236			
SPILLWAY DESIGN FLOOD								
Peak inflow, cfs	444,800				444,800			
Volume, acre-feet	383,100				383,100			
Volume, inches	30.41				30.41			
Peak outflow, cfs	335,000 (1)				334,000 (1)			
	Elev. (2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Elev. (2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
RESERVOIR								
Sediment storage	820.0	--	7,000	0.56	833.0	--	6,830	0.54
					841.0	--	7,000	0.56
Spillway crest (service)					833.0	3,220	133,000	10.57
Top of conservation pool					841.0	3,810	160,000	12.71
Spillway crest	820.0	2,450	96,400	7.66				
Top of flood control pool	820.0							
Maximum design water surface	842.1	3,910	164,300	13.05	858.1	5,260	237,500	18.87
Top of dam	847.0				863.0			
Maximum tailwater	755.0				754.8			
DAM								
Type	Rock fill, impervious core				Rock fill, impervious core			
Total length, feet	5,795				7,468			
Embankment section:								
Type	Rock fill, impervious core				Rock fill, impervious core			
Total length, feet	5,795				7,468			
Height above stream bed, feet	151				173			
Freeboard, feet	4.9				4.9			
Crown width, feet	20				20			
Side slopes:								
Upstream	1 on 2-1/2				1 on 2-1/2			
Downstream	1 on 2-1/4 & 1 on 2-1/2				1 on 2-1/4 & 1 on 2-1/2			
Spillway section:								
Type	Broadcrested				Emergency spillway: Broadcrested			
Gross length, feet	1,100				--			
Net length, feet	1,100				1,600 feet uncontrolled			
Gates:								
Type	Uncontrolled				45 ft. diameter ogee morning glory service spillway discharging into 1 - 15-ft. diameter conduit			
Spillway discharge, cfs								
Maximum design water surface	329,700				324,000			
OUTLET WORKS								
Type	Gate-controlled conduit				Gate-controlled conduit			
Number of conduits	1				1			
Dimensions	10' diameter				3' diameter			
Invert elevation, feet	700.0				700.0			
Conduit control	2 - 5'8" x 10' hydraulically operated slide gates				Manually-operated slide gate			
RELOCATIONS								
U. S. highways, miles	None				None			
State highways, miles	None				None			
F. M. roads, miles	None				None			
County roads, miles	11.5				9.6			
Railroads, miles	None				None			
Power lines, miles	10.0				8.2			
Telephone lines, miles	4.0				3.0			
Cemeteries, number	1				1			
Towns, number	None				None			
LANDS								
Clearing, acres	None				2,000			
Land acquisition:								
Fee simple, acres	1,200				4,700			
(Top control elev.) (2)	--				(836.0)			
Flood easements, acres	2,450				640			
(Top control elev.) (2)	(823.0)				(844.0)			
(1) Includes discharge through outlet works, cfs	5,300				10,000 (through morning glory spillway)			

(2) All elevations refer to mean sea level

TABLE 11

PERTINENT DATA
SINGLE PURPOSE RESERVOIRS - SOUTH FORK RESERVOIR
DAM AT RIVER MILE 4.7 ON SOUTH SAN GABRIEL RIVER

ITEM	FLOOD CONTROL ONLY				WATER CONSERVATION ONLY			
DRAINAGE AREA								
Square miles	120				120			
SPILLWAY DESIGN FLOOD								
Peak inflow, cfs	304,800				304,800			
Volume, acre-feet	207,400				207,400			
Volume, inches	32.24				32.24			
Peak outflow, cfs	127,000 (1)				205,000 (1)			
	Elev. (2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)	Elev. (2) (feet)	Area (acres)	Capacity (ac-ft)	Capacity (inch)
RESERVOIR								
Sediment storage	817.0	--	4,000	0.63	843.0	--	3,900	0.61
					849.0	--	4,000	0.63
Spillway crest (service)					843.0	2,320	91,500	14.30
Top of conservation pool					843.0			
Spillway crest	858.0	3,100	132,200	20.66	849.0	2,630	106,400	16.63
Top of flood control pool	817.0	1,360	45,000	7.03				
Maximum design water surface	870.6	3,740	175,400	27.41	866.2	3,540	159,400	24.91
Top of dam	876.0				872.0			
Maximum tailwater	751.4				757.8			
DAM								
Type	Rock fill, impervious core				Rock fill, impervious core			
Total length, feet	7,370				6,370			
Embankment section:								
Type	Rock fill, impervious core				Rock fill, impervious core			
Total length, feet	7,370				6,370			
Height above stream bed, feet	161				157			
Freeboard, feet	5.4				5.8			
Crown width, feet	20				20			
Side slopes:								
Upstream	1 on 2-1/2				1 on 2-1/2			
Downstream	1 on 2-1/4 & 1 on 2-1/2				1 on 2-1/4 & 1 on 2-1/2			
Spillway section:								
Type	Broadcrested				Emergency spillway: Broadcrested			
Gross length, feet	1,000				--			
Net length, feet	1,000				1,000 feet uncontrolled			
Gates:								
Type	Uncontrolled				40 ft. diameter ogee morning glory service spillway discharging into 1 - 11-ft. diameter conduit			
Spillway discharge, cfs								
Maximum design water surface	121,700				200,000			
OUTLET WORKS								
Type	Gate controlled conduit				Low flow: Gate-controlled conduit			
Number of conduits	1				1			
Dimensions	10' diameter				3' diameter			
Invert elevation, feet	728.0				728.0			
Conduit control	2 - 5'8" x 10' hydraulically operated slide gates				Manually operated slide gate			
RELOCATIONS								
U. S. highways, miles	None				None			
State highways, miles	None				None			
F. M. roads, miles	None				None			
County roads, miles	1.0				2.8			
Railroads, miles	None				None			
Power lines, miles	2.0				3.3			
Telephone lines, miles	None				None			
Cemeteries, number	1				1			
Towns	None				None			
LANDS								
Clearing, acres	None				1,500			
Land acquisition:								
Fee simple, acres	900				2,950			
(Top control elev.) (2)	--				(845.0)			
Flood easements, acres	1,035				360			
(Top control elev.) (2)	(820.0)				(852.0)			
(1) Includes discharge through outlet works, cfs	5,300				5,000 (through morning glory spillway)			

(2) All elevations refer to mean sea level

TABLE 12

PERTINENT DATA
SINGLE AND MULTIPLE-PURPOSE RESERVOIRS
BERRY CREEK RESERVOIR PROJECT
SAN GABRIEL RIVER

Item	Flood Control	Water Conservation	Multiple-Purpose
MISCELLANEOUS			
Dam location, river mile	6.7	6.7	6.7
Drainage area, square miles	77	77	77
Conservation storage, acre-feet	0	13,000	13,800
Yield, cfs	0	6	6
SPILLWAY DESIGN FLOOD			
Peak inflow, cfs	265,300	265,300	265,300
Volume, acre-feet	137,360	137,360	137,360
Volume, inches	33.18	33.18	33.18
Peak outflow, cfs	157,000	178,000	156,100
TYPE OF DAM	Earth fill	Earth fill	Earth fill
SPILLWAY			
Type	Broadcrested	Broadcrested	Broadcrested
Length in feet at crest (net)	1,100	1,100	1,100
Control	None	None	None
Spillway discharge, cfs			
Maximum design water surface	153,500	174,500	152,600
OUTLET WORKS			
Type	Gate controlled conduit	Gate controlled conduit	Gate controlled conduit
Number of sluices, conduits	1	1	1
Dimensions (width x height)	9' diameter	36" diameter	9' diameter
Invert elevations, feet (1)	722.0	722.0	722.0
Sluice or conduit control	2 - 4'x 9' manually operated gates	1 - 36" manually operated gate valve	2 - 4'x 9' manually operated gates

RESERVOIR	Flood Control: Elev. (1) (feet)	Flood Control: Area (acres)	Flood Control: Capacity (ac-ft)	Flood Control: Capacity (inch)	Water Conservation: Elev. (1) (feet)	Water Conservation: Area (acres)	Water Conservation: Capacity (ac-ft)	Water Conservation: Capacity (inch)	Multiple-Purpose: Elev. (1) (feet)	Multiple-Purpose: Area (acres)	Multiple-Purpose: Capacity (ac-ft)	Multiple-Purpose: Capacity (inch)
Sediment storage	--	--	2,800	0.68	--	--	2,800	0.68	--	--	2,800	0.68
Top of conservation storage (2)	--	--	--	--	782.5	830	15,600	3.80	783.0	850	16,000	3.90
Top of flood control storage	795.0	1,300	28,800	7.01	--	--	--	--	805.0	1,750	44,000	10.71
Spillway crest	804.0	1,700	42,200	10.28	792.0	1,180	25,100	6.11	805.0	1,750	44,000	10.71
Guide taking line	798.0	1,420	32,900	8.01	795.0	1,300	28,800	7.01	808.0	1,910	49,500	12.05
Maximum design water surface	817.6	2,400	70,100	17.07	806.8	1,850	47,200	11.49	818.6	2,460	72,500	17.65
Top of dam	823.0	2,790	84,000	20.45	812.0	2,110	57,500	14.00	824.0	2,860	86,900	21.16

(1) All elevations refer to mean sea level
(2) Crest elevation of service spillway - 20-foot diameter ogee morning glory spillway discharging into 10-foot diameter conduit

TABLE 13

SUMMARY OF ESTIMATE OF FIRST COST
PLAN 10B - PROPOSED PLAN OF IMPROVEMENT
(ULTIMATE OR THIRD STAGE CONDITIONS)
SAN GABRIEL RIVER
(July 1, 1961 price level)

Item	Laneport Reservoir			North Fork Reservoir			South Fork Reservoir		
	Flood control only	Water conservation	Multiple-purpose	Flood control only	Water conservation	Multiple-purpose	Flood control only	Water conservation	Multiple-purpose
PERTINENT INFORMATION									
Top of dam, elevation	529.0	539.0	546.0	847.0	863.0	878.0	876.0	872.0	882.0
Top of gates, elevation	512.0	523.0	531.0	--	--	--	--	--	--
Spillway crest, elevation	483.0	494.0	502.0	820.0	841.0	855.0	858.0	849.0	860.0
Storage capacity (1)	117,100	214,000	309,700	89,400	153,000	214,600	128,200	102,400	134,500
A. FEDERAL FIRST COST, DAMS AND RESERVOIRS									
(01.0) Lands and damages									
a. Land costs	$ 2,593,000	$ 3,870,000	$ 4,840,000	$ 947,900	$ 1,220,000	$ 1,404,000	$ 408,700	$ 1,027,000	$ 1,125,000
b. Land acquisition expense	227,000	230,000	230,000	52,100	80,000	86,000	23,300	43,000	45,000
Total - Lands and damages	2,820,000	4,100,000	5,070,000	1,000,000	1,300,000	1,490,000	432,000	1,070,000	1,170,000
(02.0) Relocations									
a. Roads	230,000	252,000	288,000	288,000	240,000	358,000	12,000	33,000	44,000
b. Cemeteries and utilities	24,000	33,000	39,000	30,000	25,000	35,000	7,000	10,000	12,000
Total - Relocations	254,000	285,000	327,000	318,000	265,000	393,000	19,000	43,000	56,000
(03.0) Reservoirs									
a. Clearing	--	211,000	211,000	--	192,000	192,000	--	144,000	163,000
(04.0) Dams									
a. Embankment	2,948,000	3,521,000	4,055,000	524,000	1,454,000	1,234,000	1,178,000	1,056,000	1,380,000
b. Slope protection	20,000	29,000	29,000	--	--	--	--	--	--
c. Spillway (emergency)	--	--	--	--	2,244,000	--	--	1,804,000	--
d. Spillway (service)	8,132,000	7,180,000	7,924,000	2,746,000	1,532,000	4,715,000	1,469,000	1,040,000	1,470,000
e. Outlet works	--	2,270,000	2,392,000	1,280,000	--	1,411,000	1,183,000	--	1,180,000
Total - Dams	11,100,000	13,000,000	14,400,000	4,550,000	5,230,000	7,360,000	3,830,000	3,900,000	4,030,000
(08.0) Access road	9,000	9,000	9,000	22,000	16,000	16,000	14,000	21,000	14,000
(19.0) Buildings, grounds, and utilities	118,000	118,000	118,000	123,000	121,000	121,000	120,000	122,000	120,000
(20.0) Permanent operating equipment	30,000	65,000	65,000	25,000	59,000	59,000	25,000	55,000	55,000
(29.0) Preauthorization costs	44,000	--	44,000	10,000	--	10,000	10,000	--	10,000
(30.0) Engineering and design	889,000	934,000	1,000,000	428,000	438,000	614,000	365,000	419,000	440,000
(31.0) Supervision and administration	980,000	1,040,000	1,200,000	464,000	539,000	755,000	405,000	446,000	492,000
Subtotal - first cost - dams and reservoirs	16,244,000	19,762,000	22,444,000	6,940,000	8,160,000	11,010,000	5,220,000	6,220,000	6,550,000
TOTAL ESTIMATED FIRST COST - FLOOD CONTROL AND/OR WATER CONSERVATION PROJECT	16,244,000	19,762,000	22,444,000	6,940,000	8,160,000	11,010,000	5,220,000	6,220,000	6,550,000

B. ESTIMATES OF FIRST COST, FISH AND WILDLIFE									
(01.0) Lands and damages									
a. Land costs	--	--	50,000	--	--	23,000	--	--	22,200
b. Land acquisition expense	--	--	2,000	--	--	1,000	--	--	800
Total - Lands and damages	--	--	52,000	--	--	24,000	--	--	23,000
(03.0) Reservoir (clearing)	--	--	60,000	--	--	46,000	--	--	31,700
(06.0) Fish and wildlife	--	--	155,000	--	--	98,000	--	--	73,300
(30.0) Engineering and design	--	--	15,000	--	--	13,800	--	--	10,400
(31.0) Supervision and administration	--	--	18,000	--	--	18,200	--	--	11,600
Subtotal - first cost - fish and wildlife	--	--	300,000	--	--	200,000	--	--	150,000
TOTAL ESTIMATED FIRST COST - FLOOD CONTROL, WATER CONSERVATION, AND FISH AND WILDLIFE	16,244,000	19,762,000	22,744,000	6,940,000	8,160,000	11,210,000	5,220,000	6,220,000	6,700,000
C. ESTIMATES OF FIRST COST, RECREATION									
(01.0) Lands and damages									
a. Land costs	--	--	113,000	--	--	77,000	--	--	77,000
b. Land acquisition expense	--	--	5,000	--	--	4,000	--	--	3,000
Total - Lands and damages	--	--	118,000	--	--	81,000	--	--	80,000
(03.0) Reservoir (clearing)	--	--	140,000	--	--	154,000	--	--	112,000
(14.0) Recreation facilities	--	--	365,000	--	--	285,000	--	--	261,000
(30.0) Engineering and design	--	--	35,000	--	--	36,000	--	--	37,000
(31.0) Supervision and administration	--	--	42,000	--	--	44,000	--	--	40,000
Subtotal - first cost - recreation	--	--	700,000	--	--	600,000	--	--	530,000
D. NON-FEDERAL FIRST COST	None	None	None	None	None	None	None	None	None
E. TOTAL ESTIMATED FIRST COST OF PROJECT	16,244,000	19,762,000	23,444,000	6,940,000	8,160,000	11,810,000	5,220,000	6,220,000	7,230,000

(1) Top of gates, or spillway crest, less sedimentation storage, acre-feet

TABLE 14

SUMMARY OF FIRST COSTS AND ANNUAL CHARGES
SOLUTIONS CONSIDERED
INVESTIGATED RESERVOIR PROJECTS
SAN GABRIEL RIVER WATERSHED
(July 1, 1961 price level)

Item	Laneport Plan 1A	Laneport Plan 2A & 7A	Laneport Plan 3A & 8A	Laneport Plan 4A & 9A	Laneport Plan 5A & 10A	Laneport Plan 6A & 11A	Laneport Plan 1B	Laneport Plan 2B & 7B	Laneport Plan 3B & 8B	Laneport Plan 4B & 9B	Laneport Plan 5B & 10B	Laneport Plan 6B & 11B	Berry Creek
						FIRST COSTS							
A. FEDERAL FIRST COST, DAMS AND RESERVOIRS													
(01.0) Lands and damages													
a. Land costs	$ 4,300,000	$ 4,510,000	$ 4,450,000	$ 4,590,000	$ 4,665,000	$ 4,745,000	$ 4,680,000	$ 4,730,000	$ 4,720,000	$ 4,780,000	$ 4,840,000	$ 4,910,000	$ 354,000
b. Land acquisition expense	200,000	210,000	210,000	210,000	215,000	215,000	220,000	220,000	220,000	220,000	230,000	230,000	15,000
Total - Lands and damages	4,500,000	4,720,000	4,660,000	4,800,000	4,880,000	4,960,000	4,900,000	4,950,000	4,940,000	5,000,000	5,070,000	5,140,000	369,000
(02.0) Relocations													
a. Roads	291,000						291,000						9,000
b. Cemeteries and utilities	36,000						36,000						--
Total - Relocations	327,000	327,000	327,000	327,000	327,000	327,000	327,000	327,000	327,000	327,000	327,000	327,000	9,000
(03.0) Reservoirs													
a. Clearing	211,000	211,000	211,000	211,000	211,000	211,000	211,000	211,000	211,000	211,000	211,000	211,000	86,000
(04.0) Dams													
a. Embankment	3,180,000						4,071,000						537,000
b. Slope protection	20,000						29,000						--
c. Spillway	8,110,000						7,890,000						2,586,000
d. Outlet works	2,340,000						2,410,000						777,000
Total - Dams	13,650,000	13,650,000	13,650,000	13,650,000	13,650,000	13,650,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	3,900,000
(08.0) Access road	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	40,000
(19.0) Buildings, grounds, and utilities	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000	128,000
(20.0) Permanent operating equipment	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	46,000
(29.0) Preauthorization cost	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	44,000	10,000
(30.0) Engineering and design	920,000	935,000	935,000	935,000	935,000	935,000	986,000	986,000	1,000,000	986,000	1,000,000	1,000,000	422,000
(31.0) Supervision and administration	1,100,000	1,125,000	1,125,000	1,125,000	1,125,000	1,125,000	1,184,000	1,234,000	1,210,000	1,184,000	1,200,000	1,230,000	450,000
Subtotal - first cost - dams and reservoirs	20,944,000	21,204,000	21,144,000	21,284,000	21,364,000	21,444,000	22,244,000	22,344,000	22,324,000	22,344,000	22,444,000	22,544,000	5,460,000
TOTAL ESTIMATED FIRST COST - DUAL PURPOSE RESERVOIR	20,944,000	21,204,000	21,144,000	21,284,000	21,364,000	21,444,000	22,244,000	22,344,000	22,324,000	22,344,000	22,444,000	22,544,000	5,460,000
B. ESTIMATES OF FIRST COST, FISH AND WILDLIFE													
(01.0) Lands and damages													
a. Land costs	50,000						50,000						10,300
b. Land acquisition expense	2,000						2,000						300
Total - Lands and damages	52,000	52,000	52,000	52,000	52,000	52,000	52,000	52,000	52,000	52,000	52,000	52,000	10,600
(03.0) Reservoir (clearing)	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	13,700
(06.0) Fish and wildlife	155,000	155,000	155,000	155,000	155,000	155,000	155,000	155,000	155,000	155,000	155,000	155,000	43,000
(30.0) Engineering and design	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	6,000
(31.0) Supervision and administration	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	6,700
Subtotal - first cost - fish and wildlife	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	80,000
TOTAL ESTIMATED FIRST COST - FC, WC, AND FW	21,244,000	21,504,000	21,444,000	21,584,000	21,664,000	21,744,000	22,544,000	22,644,000	22,624,000	22,644,000	22,744,000	22,844,000	5,540,000

C. ESTIMATES OF FIRST COST, RECREATION													
(01.0) Lands and damages													
a. Land costs	113,000						113,000						30,000
b. Land acquisition expense	5,000						5,000						1,000
Total - Lands and damages	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000	118,000	31,000
(03.0) Reservoir (clearing)	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	41,000
(14.0) Recreation facilities	365,000	365,000	365,000	365,000	365,000	365,000	365,000	365,000	365,000	365,000	365,000	365,000	130,000
(30.0) Engineering and design	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	18,000
(31.0) Supervision and administration	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	20,000
Subtotal - first cost - recreation	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	700,000	240,000
D. NON-FEDERAL FIRST COST	None	None	None	None	None	None	None	None	None	None	None	None	None
E. TOTAL ESTIMATED FIRST COST OF PROJECT	21,944,000	22,204,000	22,144,000	22,284,000	22,364,000	22,444,000	23,244,000	23,344,000	23,324,000	23,344,000	23,444,000	23,544,000	5,780,000
ANNUAL CHARGES													
Interest rate, 2-5/8%; amortization period, 50 years													
Construction period, years	5	5	5	5	5	5	5	5	5	5	5	5	3
A. ESTIMATES OF ANNUAL CHARGES, DAMS AND RESERVOIRS													
1. Federal investment													
a. Federal first cost	20,944,000	21,204,000	21,144,000	21,284,000	21,364,000	21,444,000	22,244,000	22,344,000	22,324,000	22,344,000	22,444,000	22,544,000	5,460,000
b. Interest during construction	1,374,000	1,392,000	1,388,000	1,397,000	1,402,000	1,407,000	1,460,000	1,466,000	1,465,000	1,466,000	1,473,000	1,479,000	215,000
c. Gross investment	22,318,000	22,596,000	22,532,000	22,681,000	22,766,000	22,851,000	23,704,000	23,810,000	23,789,000	23,810,000	23,917,000	24,023,000	5,675,000
2. Non-Federal investment	None	None	None	None	None	None	None	None	None	None	None	None	None
3. Federal annual charges													
a. Interest on investment	585,800	593,100	591,500	595,400	597,600	599,800	622,200	625,000	624,500	625,000	627,800	630,600	149,000
b. Amortization of investment	220,700	223,500	222,800	224,300	225,200	226,000	234,400	235,500	235,300	235,500	236,500	237,600	56,100
c. Maintenance and operation	85,700	80,300	83,800	81,200	82,000	82,900	84,600	81,400	85,200	85,800	85,900	85,900	50,600
(1) Reservoir	(81,800)	(76,400)	(79,900)	(77,300)	(78,100)	(79,000)	(80,700)	(77,500)	(81,300)	(81,900)	(82,900)	(82,000)	(50,000)
(2) Replacement of parts	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	(3,900)	(600)
Subtotal - annual charges - dams and reservoirs	892,200	896,900	898,100	900,900	904,800	908,700	941,200	941,900	945,000	946,300	950,200	954,100	255,700
TOTAL ANNUAL CHARGES - DUAL PURPOSE PROJECT	892,200	896,900	898,100	900,900	904,800	908,700	941,200	941,900	945,000	946,300	950,200	954,100	255,700
B. ESTIMATES OF ANNUAL CHARGES, FISH AND WILDLIFE													
1. Federal investment													
a. Federal first cost	300,000						300,000						80,000
b. Interest during construction	13,000						13,000						3,000
c. Gross investment	313,000	313,000	313,000	313,000	313,000	313,000	313,000	313,000	313,000	313,000	313,000	313,000	83,000
2. Non-Federal investment	None	None	None	None	None	None	None	None	None	None	None	None	None
3. Federal annual charges													
a. Interest on investment	8,200						8,200						2,200
b. Amortization of investment	3,100						3,100						800
c. Maintenance and operation	1,000						1,000						1,000
Subtotal - annual charges - fish and wildlife	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	12,300	4,000
TOTAL ANNUAL CHARGES - FC, WC, AND FW	904,500	909,200	910,400	913,200	917,100	921,000	953,500	954,200	957,300	958,600	962,500	966,400	259,700
C. ESTIMATES OF ANNUAL CHARGES, RECREATION													
1. Federal investment													
a. Federal first cost	700,000						700,000						240,000
b. Interest during construction	46,000						46,000						9,000
c. Gross investment	746,000	746,000	746,000	746,000	746,000	746,000	746,000	746,000	746,000	746,000	746,000	746,000	249,000
2. Non-Federal investment	None	None	None	None	None	None	None	None	None	None	None	None	None
3. Federal annual charges													
a. Interest on investment	19,600						19,000						6,500
b. Amortization of investment	7,400						7,400						2,500
c. Maintenance and operation	13,800						13,800						5,700
Subtotal - annual charges - recreation	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	14,700
D. NON-FEDERAL ANNUAL CHARGES	None	None	None	None	None	None	None	None	None	None	None	None	None
E. TOTAL ESTIMATED ANNUAL CHARGES	945,300	950,000	951,200	954,000	957,900	961,800	994,300	995,000	998,100	999,400	1,003,300	1,007,200	274,400

TABLE 15

SUMMARY OF ESTIMATE OF ANNUAL CHARGES
PLAN 10B - PROPOSED PLAN OF IMPROVEMENT
(ULTIMATE OR THIRD STAGE CONDITIONS)
SAN GABRIEL RIVER
(July 1, 1961 price level)

Item	Laneport Reservoir			North Fork Reservoir			South Fork Reservoir		
	Flood control only	Water conservation	Multiple-purpose	Flood control only	Water conservation	Multiple-purpose	Flood control only	Water conservation	Multiple-purpose
Interest rate 2-5/8%; amortization period 50 years Construction period, years	3	4	5	3	3	3	3	3	3
A. ESTIMATES OF ANNUAL CHARGES, DAM AND RESERVOIRS									
1. Federal investment									
a. Federal first cost	$16,244,000	$19,762,000	$22,444,000	$ 6,940,000	$ 8,160,000	$11,010,000	$ 5,220,000	$ 6,220,000	$ 6,550,000
b. Interest during construction	640,000	1,038,000	1,473,000	273,000	321,000	434,000	205,500	245,000	258,000
c. Gross investment	16,884,000	20,800,000	23,917,000	7,213,000	8,481,000	11,444,000	5,425,500	6,465,000	6,808,000
2. Non-Federal investment	None	None	None	None	None	None	None	None	None
3. Federal annual charges									
a. Interest on investment	443,200	546,000	627,800	189,300	222,600	300,400	142,400	169,700	178,700
b. Amortization of investment	167,000	205,700	236,500	71,300	83,900	113,200	53,700	63,900	67,300
c. Maintenance and operation	51,400	40,000	85,900	39,600	55,300	55,700	39,600	51,600	53,600
(1) Reservoir	(46,100)	(40,000)	(82,000)	(38,500)	(55,300)	(54,600)	(38,500)	(51,600)	(52,500)
(2) Replacement of parts	(5,300)	--	(3,900)	(1,100)	--	(1,100)	(1,100)	--	(1,100)
Subtotal - annual charges - dams and reservoirs	661,600	791,700	950,200	300,200	361,800	469,300	235,700	285,200	299,600
TOTAL ANNUAL CHARGES - FLOOD CONTROL AND/OR WATER CONSERVATION	661,600	791,700	950,200	300,200	361,800	469,300	235,700	285,200	299,600
B. ESTIMATES OF ANNUAL CHARGES, FISH AND WILDLIFE									
1. Federal investment									
a. Federal first cost	--	--	300,000	--	--	200,000	--	--	150,000
b. Interest during construction	--	--	13,000	--	--	8,000	--	--	6,000
c. Gross investment	--	--	313,000	--	--	208,000	--	--	156,000
2. Non-Federal investment	None	None	None	None	None	None	None	None	None
3. Federal annual charges									
a. Interest on investment	--	--	8,200	--	--	5,500	--	--	4,100
b. Amortization of investment	--	--	3,100	--	--	2,100	--	--	1,500
c. Maintenance and operation	--	--	1,000	--	--	1,000	--	--	1,000
Subtotal - annual charges - fish and wildlife	--	--	12,300	--	--	8,600	--	--	6,600
TOTAL ANNUAL CHARGES - FLOOD CONTROL, WATER CONSERVATION, AND FISH AND WILDLIFE	--	--	962,500	--	--	477,900	--	--	306,200
C. ESTIMATES OF ANNUAL CHARGES, RECREATION									
1. Federal investment									
a. Federal first cost	--	--	700,000	--	--	600,000	--	--	530,000
b. Interest during construction	--	--	46,000	--	--	23,000	--	--	21,000
c. Gross investment	--	--	746,000	--	--	623,000	--	--	551,000
2. Non-Federal investment	None	None	None	None	None	None	None	None	None
3. Federal annual charges									
a. Interest on investment	--	--	19,600	--	--	16,400	--	--	14,500
b. Amortization of investment	--	--	7,400	--	--	6,100	--	--	5,500
c. Maintenance and operation	--	--	13,800	--	--	13,600	--	--	9,500
Subtotal - annual charges - recreation	--	--	40,800	--	--	36,100	--	--	29,500
D. NON-FEDERAL ANNUAL CHARGES	None	None	None	None	None	None	None	None	None
E. TOTAL ESTIMATED ANNUAL CHARGES	661,600	791,700	1,003,300	300,200	361,800	514,000	235,700	285,200	335,700

TABLE 16

SUMMARY OF FIRST COSTS AND ANNUAL CHARGES
INVESTIGATED SINGLE PURPOSE RESERVOIRS FOR COST ALLOCATIONS
SAN GABRIEL RIVER WATERSHED

Item	Laneport Reservoir			
	First stage		Second stage	
	Flood control	Water conservation	Flood control	Water conservation
PERTINENT DATA				
Top of dam, elevation	541.0	525.0	534.0	536.0
Top of gates, elevation	526.0	505.0	518.0	512.0
Spillway crest, elevation	497.0	476.0	489.0	483.0
Flood control storage, acre-feet	241,700	--	164,900	--
Water conservation storage, acre-feet	--	66,700	--	116,300
Sediment storage, acre-feet	27,700	27,700	22,900	23,000
FIRST COST				
1. FEDERAL FIRST COST				
Lands and damages	$ 3,970,000	$ 2,300,000	$ 3,300,000	$ 4,020,000
Relocations	327,000	251,000	299,000	253,000
Reservoir	--	211,000	--	211,000
Dam	13,900,000	9,970,000	12,000,000	11,100,000
a. Embankment	(3,135,000)	(2,300,000)	(3,010,000)	(2,800,000)
b. Slope protection	(25,000)	(20,000)	(23,000)	(23,000)
c. Spillway (emergency)	(8,400,000)	(7,650,000)	(8,967,000)	(8,277,000)
d. Outlet works	(2,340,000)	--	--	--
Access road	9,000	9,000	9,000	9,000
Buildings and grounds	118,000	118,000	118,000	118,000
Operating equipment	30,000	65,000	30,000	65,000
Preauthorization cost	44,000	--	44,000	--
Engineering and design	926,000	650,000	914,000	830,000
Supervision and administration	1,120,000	726,000	1,030,000	994,000
Total estimated first cost of project	$20,444,000	$14,300,000	$17,744,000	$17,600,000
ANNUAL CHARGES				
(Interest rate - 2-5/8%) (Amortization period - 50 years)				
Construction period, years	4	3	3	3
1. INVESTMENT COST				
a. First cost	$20,444,000	$14,300,000	$17,744,000	$17,600,000
b. Interest during construction	1,073,000	563,000	699,000	693,000
Total gross investment	21,517,000	14,863,000	18,443,000	18,293,000
2. ANNUAL CHARGES				
a. Interest on investment	564,800	390,200	484,100	480,200
b. Amortization of investment	212,800	147,000	182,400	180,900
c. Maintenance and operation	63,000	58,600	59,300	42,000
Total annual charges	$ 840,600	$ 595,800	$ 725,800	$ 703,100

TABLE 17

SUMMARY OF FIRST COSTS AND ANNUAL CHARGES
INVESTIGATED RESERVOIRS FOR RECREATION PURPOSES
SAN GABRIEL RIVER WATERSHED
(July 1, 1961 price level)

Item	Costs in thousand dollars		
	Laneport	North Fork	South Fork
FIRST COST			
1. FIRST COST - DAM AND RESERVOIR			
Lands and damages	1,780.0	940.0	459.0
Relocations	83.0	75.0	32.0
Reservoir	211.0	192.0	163.0
Dam	2,930.0	1,454.0	461.0
a. Embankment	(1,615.0)	(704.0)	(196.0)
b. Slope protection	(15.0)	--	--
c. Spillway	(900.0)	(450.0)	(147.0)
d. Outlet works (low flow)	(400.0)	(300.0)	(118.0)
Access road	9.0	16.0	14.0
Recreation facilities	365.0	285.0	261.0
Buildings and grounds	32.0	44.0	15.0
Engineering and design	222.0	134.0	66.0
Supervision and administration	268.0	160.0	79.0
Total - estimated first cost of project	5,900.0	3,300.0	1,550.0
ANNUAL CHARGES			
(Interest rate - 2-5/8%) (Amortization period - 50 years)			
Construction period, years	2	2	2
1. INVESTMENT COST			
a. First cost	5,900.0	3,300.0	1,550.0
b. Interest during construction	none	none	none
Total gross investment	5,900.0	3,300.0	1,550.0
2. ANNUAL CHARGES			
a. Interest on investment	154.9	86.6	40.7
b. Amortization of investment	58.4	32.6	15.3
c. Maintenance and operation	21.7	15.8	12.0
Total annual charges	235.0	135.0	68.0

TABLE 18

SUMMARY OF FIRST COST AND ANNUAL CHARGES
INVESTIGATED RESERVOIRS FOR FISH AND WILDLIFE PURPOSES
WILLIS CREEK SITE
CREEK MILE 3.5
SAN GABRIEL RIVER WATERSHED
(July 1, 1961 price level)

Item	Cost in thousand dollars: Reservoir with 800 acres surface area	Reservoir with 380 acres surface area
FIRST COST		
1. First cost - dam and reservoir		
Lands and damages	580.0	513.0
Relocations	25.0	15.0
Clearing	10.0	5.0
Dam, spillway, outlet works	1,136.1	828.0
Building and grounds	92.0	68.0
a. Powerline to site	(17.0)	(15.8)
b. Water supply	(7.0)	(5.0)
c. Access road	(40.0)	(33.8)
d. Boat launching ramps	(3.0)	(2.0)
e. Picnic facilities	(16.0)	(5.6)
f. Sanitary facilities	(4.0)	(2.0)
g. Fencing	(8.0)	(3.8)
Operating equipment	30.0	20.0
Engineering and design	118.6	93.0
Supervision and administration	128.3	98.0
Total estimated first cost of project	2,120.0	1,640.0
ANNUAL CHARGES		
(Interest rate - 2-5/8%) (Amortization period - 50 years)		
Construction period, years	2	2
1. Investment cost		
a. First cost	2,120.0	1,640.0
b. Interest during construction	none	none
Total gross investment	2,120.0	1,640.0
2. Annual charges		
a. Interest on investment	55.7	43.1
b. Amortization of investment	21.0	16.2
c. Maintenance and operation	25.0	20.0
Total annual charges	101.7	79.3

TABLE 19

ALLOCATION OF COSTS
PLAN 10B - SAN GABRIEL RIVER
(SEPARABLE COSTS-REMAINING BENEFITS METHOD)
(July 1, 1961 price level)

	Laneport Reservoir - First Stage					Laneport Reservoir - Second Stage					North Fork Reservoir - Second Stage				
	Single-purpose					Single-purpose					Single-purpose				
	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose
PERTINENT INFORMATION															
First costs, dollars*	20,444,000	14,300,000	(1)	5,900,000	23,444,000	17,744,000	17,600,000	(1)	5,900,000	23,444,000	6,940,000	8,160,000	(1)	3,300,000	11,810,000
Annual charges, dollars	840,600	595,800	(1)	235,000	1,003,300	725,800	703,100	(1)	235,000	1,003,300	300,200	361,800	(1)	135,000	514,000
Annual maintenance & operation, dollars	63,000	58,600	--	21,700	100,700	59,300	42,000	--	21,700	100,700	39,600	55,300	--	15,800	70,300
Dependable stream flow, second-feet	--	43	--	--	43	--	39	--	--	43	--	30	--	--	30
Dependable stream flow, million gallons daily	--	27.8	--	--	27.8	--	25.2	--	--	27.8	--	19.4	--	--	19.4
Total annual benefits, dollars	2,206,600	559,400	50,000	585,000	3,401,000	1,901,800	533,700	47,800	433,400	2,916,700	633,900	512,800	21,000	550,000	1,717,700
Flood control storage,acre-feet	241,700	--	--	--	236,100	164,900	--	--	--	161,100	89,400	--	--	--	87,900
Water conservation storage, acre-feet	--	66,700	--	--	68,100	--	147,800	--	--	147,800	--	126,170	--	--	126,700
Dead storage, acre-fect (sediment)	27,700	27,700	--	--	27,700	22,900	22,900	--	--	22,900	7,000	7,000	--	--	7,000
	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose
COST ALLOCATIONS															
Allocation of annual charges															
1. Benefits	2,206,600	559,400	50,000	585,000	3,401,000	1,901,800	533,700	47,800	433,400	2,916,700	633,900	512,800	21,000	550,000	1,717,700
2. Alternate cost	840,600	595,800	(1)	235,000	--	725,800	703,100	(1)	235,000	--	300,200	361,800	(1)	135,000	--
3. Benefits limited by alternate cost	840,600	559,400	50,000	235,000	--	725,800	533,700	47,800	235,000	--	300,200	361,800	21,000	135,000	--
4. Separable costs	354,400	109,600	12,300	40,800	517,100	247,100	224,400	12,300	40,800	524,600	107,500	169,100	8,600	36,100	321,300
5. Remaining benefits	486,200	449,800	37,700	194,200	1,167,900	478,700	309,300	35,500	194,200	1,017,700	192,700	192,700	12,400	98,900	496,700
6. % distribution of item 5	41.63	38.51	3.23	16.63	100.00	47.04	30.39	3.49	19.08	100.00	38.80	38.80	2.50	19.90	100.00
7. Allocated joint cost	202,400	187,200	15,700	80,900	486,200	225,200	145,500	16,700	91,300	478,700	74,800	74,800	4,800	38,300	192,700
8. Total allocation*	556,800	296,800	28,000	121,700	1,003,300	472,300	369,900	29,000	132,100	1,003,300	182,300	243,900	13,400	74,400	514,000
9. % distribution of item 8	55.50	29.58	2.79	12.13	100.00	47.07	36.87	2.89	13.17	100.00	35.47	47.45	2.61	14.47	100.00
10. Total allocation**	555,900	296,300	27,900	121,500	1,001,600	471,500	369,300	28,900	131,900	1,001,600	182,100	243,700	13,400	74,400	513,600
Allocation of operation and maintenance costs															
11. Separable costs	27,300	22,900	1,000	13,800	65,000	43,900	26,600	1,000	13,800	85,300	400	16,100	1,000	13,600	31,100
12. % joint costs, item 6	41.63	38.51	3.23	16.63	100.00	47.04	30.39	3.49	19.08	100.00	38.80	38.80	2.50	19.90	100.00
13. Allocated joint costs	14,900	13,700	1,200	5,900	35,700	7,300	4,700	500	2,900	15,400	15,200	15,200	1,000	7,800	39,200
14. Total allocation	42,200	36,600	2,200	19,700	100,700	51,200	31,300	1,500	16,700	100,700	15,600	31,300	2,000	21,400	70,300
15. % distribution of item 14	41.91	36.35	2.18	19.56	100.00	50.79	31.06	1.53	16.62	100.00	22.19	44.52	2.85	30.44	100.00
Allocation of initial investment															
16. Allocated annual charges	556,800	296,800	28,000	121,700	1,003,300	472,300	369,900	29,000	132,100	1,003,300	182,300	243,900	13,400	74,400	514,000
17. Allocated O&M costs	42,200	36,600	2,200	19,700	100,700	51,200	31,300	1,500	16,700	100,700	15,600	31,300	2,000	21,400	70,300
18. Remainder	514,600	260,200	25,800	102,000	902,600	421,100	338,600	27,500	115,400	902,600	166,700	212,600	11,400	53,000	443,700
19. Allocation in percent	57.01	28.83	2.86	11.30	100.00	46.65	37.51	3.05	12.79	100.00	37.57	47.92	2.57	11.94	100.00
20. Allocated investment*	14,238,800	7,200,600	714,300	2,822,300	24,976,000	11,651,300	9,368,500	761,800	3,194,400	24,976,000	4,612,000	5,882,000	315,000	1,466,000	12,275,000
21. Allocated first costs*	13,365,400	6,758,900	670,500	2,649,200	23,444,000	10,936,700	8,793,800	715,000	2,998,500	23,444,000	4,437,000	5,659,000	304,000	1,410,000	11,810,000
22. Allocated preauthorization costs	25,100	12,700	1,200	5,000	44,000	20,600	16,500	1,300	5,600	44,000	4,000	5,000	--	1,000	10,000
23. Allocated construction costs**	13,340,300	6,746,200	669,300	2,644,200	23,400,000	10,916,100	8,777,300	713,700	2,992,900	23,400,000	4,433,000	5,654,000	304,000	1,409,000	11,800,000
Ratio of annual benefits to allocated annual charges	4.0	1.9	1.8	4.8	3.4	4.0	1.4	1.7	3.3	2.9	3.5	2.1	1.6	7.4	3.3
Allocated unit construction cost (cost/acre-ft. exclusive of O&M and preauthorization)															
Flood control storage					$56.50					$67.76					$50.43
Water conservation storage					99.06					59.39					44.63
Allocated water supply cost per 1000 gallons**					0.02926					0.03641					0.03443

* Including preauthorization cost
** Excluding preauthorization cost
(1) Alternate cost exceeds benefits shown

TABLE 20

ALLOCATION OF COSTS
PLAN 10B - SAN GABRIEL RIVER
(SEPARABLE COSTS-REMAINING BENEFITS METHOD)
(July 1, 1961 price level)

	Laneport Reservoir - Ultimate Stage					North Fork Reservoir - Ultimate Stage					South Fork Reservoir - Ultimate Stage				
	Single-purpose					Single-purpose					Single-purpose				
	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose
PERTINENT INFORMATION															
First costs, dollars*	16,244,000	19,762,000	(1)	5,900,000	23,444,000	6,940,000	8,160,000	(1)	3,300,000	11,810,000	5,220,000	6 220,000	(1)	1,550,000	7,230,000
Annual charges, dollars	661,600	791,700	(1)	235,000	1,003,300	300,200	361,800	(1)	135,000	514,000	235,700	285,200	(1)	68,000	335,700
Annual maintenance & operation, dollars	51,400	40,000	--	21,700	100,700	39,600	55,300	--	15,800	70,300	39,600	51,600	--	12,000	64,100
Dependable stream flow, second-feet	--	34	--	--	43	--	30	--	--	30	--	17	--	--	17
Dependable stream flow, million gallons daily	--	22.0	--	--	27.8	--	19.4	--	--	19.4	--	11.0	--	--	11.0
Total annual benefits, dollars	1,819,700	508,200	43,800	405,500	2,777,200	582,500	512,800	19,300	351,700	1,466,300	274,300	273,000	19,000	290,000	856,300
Flood control storage, acre-feet	116,500	--	--	--	116,500	89,400	--	--	--	87,900	41,000	--	--	--	45,500
Water conservation storage, acre-feet	--	214,000	--	--	193,200	--	126,170	--	--	126,700	--	87,600	--	--	89,000
Dead storage, acre-feet (sediment)	22,200	22,200	--	--	22,200	7,000	7,000	--	--	7,000	4,000	4,000	--	--	4,000
	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose	Flood control	Water conservation	Fish and wildlife	Recreation	Multiple-purpose
COST ALLOCATIONS															
Allocation of annual charges															
1. Benefits	1,819,700	508,200	43,800	405,500	2,777,200	582,500	512,800	19,300	351,700	1,466,300	274,300	273,000	19,000	290,000	856,300
2. Alternate cost	661,600	791,700	(1)	235,000	--	300,200	361,800	(1)	135,000	--	235,700	285,200	(1)	68,000	--
3. Benefits limited by alternate cost	661,600	508,200	43,800	235,000	--	300,200	361,800	19,300	135,000	--	235,700	273,000	19,000	68,000	--
4. Separable costs	158,500	288,600	12,300	40,800	500,200	107,500	169,100	8,600	36,100	321,300	14,400	63,900	6,600	29,500	114,400
5. Remaining benefits	503,100	219,600	31,500	194,200	948,400	192,700	192,700	10,700	98,900	495,000	221,300	209,100	12,400	38,500	481,300
6. % distribution of item 5	53.05	23.15	3.32	20.48	100.00	38.93	38.93	2.16	19.98	100.00	45.98	43.44	2.58	8.00	100.00
7. Allocated joint cost	266,900	116,500	16,700	103,000	503,100	75,000	75,000	4,200	38,500	192,700	101,800	96,100	5,700	17,700	221,300
8. Total allocation*	425,400	405,100	29,000	143,800	1,003,300	182,500	244,100	12,800	74,600	514,000	116,200	160,000	12,300	47,200	335,700
9. % distribution of item 8	42.40	40.38	2.89	14.33	100.00	35.51	47.49	2.49	14.51	100.00	34.61	47.66	3.66	14.06	100.00
10. Total allocation**	424,700	404,400	29,000	143,500	1,001,600	182,400	243,900	12,800	74,500	513,600	116,000	159,800	12,300	47,200	335,300
Allocation of operation and maintenance costs															
11. Separable costs	45,900	34,500	1,000	13,800	95,200	400	16,100	1,000	13,600	31,100	2,000	14,000	1,000	9,500	26,500
12. % joint costs, item 6	53.05	23.15	3.32	20.48	100.00	38.93	38.93	2.16	19.98	100.00	45.98	43.44	2.58	8.00	100.00
13. Allocated joint costs	2,900	1,300	200	1,100	5,500	15,200	15,200	1,000	7,800	39,200	17,300	16,300	1,000	3,000	37,600
14. Total allocation	48,800	35,800	1,200	14,900	100,700	15,600	31,300	2,000	21,400	70,300	19,300	30,300	2,000	12,500	64,100
15. % distribution of item 14	48.46	35.55	1.19	14.80	100.00	22.19	44.53	2.84	30.44	100.00	30.11	47.27	3.12	19.50	100.00
Allocation of initial investment															
16. Allocated annual charges	425,400	405,100	29,000	143,800	1,003,300	182,500	244,100	12,800	74,600	514,000	116,200	160,000	12,300	47,200	335,700
17. Allocated O&M costs	48,800	35,800	1,200	14,900	100,700	15,600	31,300	2,000	21,400	70,300	19,300	30,300	2,000	12,500	64,100
18. Remainder	376,600	369,300	27,800	128,900	902,600	166,900	212,800	10,800	53,200	443,700	96,900	129,700	10,300	34,700	271,600
19. Allocation in percent	41.72	40.92	3.08	14.28	100.00	37.62	47.96	2.43	11.99	100.00	35.68	47.75	3.79	12.78	100.00
20. Allocated investment*	10,420,000	10,220,200	769,300	3,566,500	24,976,000	4,618,000	5,887,000	298,000	1,472,000	12,275,000	2,681,000	3,588,000	285,000	961,000	7,515,000
21. Allocated first costs*	9,780,800	9,593,300	722,100	3,347,800	23,444,000	4,443,000	5,664,000	287,000	1,416,000	11,810,000	2,580,000	3,452,000	274,000	924,000	7,230,000
22. Allocated preauthorization costs	18,300	18,000	1,400	6,300	44,000	4,000	5,000	--	1,000	10,000	4,000	5,000	--	1,000	10,000
23. Allocated construction costs**	9,762,500	9,575,300	720,700	3,341,500	23,400,000	4,439,000	5,659,000	287,000	1,415,000	11,800,000	2,576,000	3,447,000	274,000	923,000	7,220,000
Ratio of annual benefits to allocated annual charges	4.3	1.3	1.5	2.8	2.8	3.2	2.1	1.5	4.7	2.9	2.4	1.7	1.5	6.1	2.6
Allocated unit construction cost (cost/acre-ft. exclusive of O&M and preauthorization)															
Flood control storage					$83.80					$50.50					$56.62
Water conservation storage					49.56					44.66					38.73
Allocated water supply cost per 1000 gallons**					0.03987					0.03446					0.03985

* Including preauthorization cost
** Excluding preauthorization cost
(1) Alternate cost exceeds benefits shown

TABLE 21

DETAILED ESTIMATE OF FIRST COST
PLAN 10B - PROPOSED LANEPORT RESERVOIR
SAN GABRIEL RIVER WATERSHED
(July 1, 1961 prices)

Item	Unit quantity	Unit cost	Single-purpose flood control: Quantity	Single-purpose flood control: Cost	Single-purpose water conservation: Quantity	Single-purpose water conservation: Cost	Multiple-purpose FC, WC, FW, & R: Quantity	Multiple-purpose FC, WC, FW, & R: Cost
PERTINENT INFORMATION								
Top of dam, elevation			529.0		539.0		546.0	
Top of gates, elevation			512.0		523.0		531.0	
Spillway crest, elevation			483.0		494.0		502.0	
Lands, fee simple, acres			1,200		12,800		13,220	
(Top control elevation)			—		(526.0)		(526.0)	
Lands, flood easements, acres			7,670		—		2,900	
(Top control elevation)			(515.0)		--		(534.0)	
A. ESTIMATES OF FIRST COST - DAM AND RESERVOIR								
(01.0) Lands and damages								
a. Land costs								
(1) Fee simple lands, improvements, and severance damages	L.S.			$ 411,000		$ 3,160,000		$ 3,240,000
(2) Flood easement lands, improvements, and severance damages	L.S.			1,710,000		—		730,000
(3) Resettlement reimbursement	L.S.			40,000		60,000		60,000
Subtotal - land costs				2,161,000		3,220,000		4,030,000
Contingencies, 20%+				432,000		650,000		810,000
Total - land costs				2,593,000		3,870,000		4,840,000
b. Land acquisition expense	L.S.			227,000		230,000		230,000
Total - Lands and damages				2,820,000		4,100,000		5,070,000
(02.0) Relocations								
a. Roads								
(1) F. M. Highway 971	Mile	50,000.00	3.6	178,000	3.8	190,000	4.4	220,000
(2) Roads, access to isolated tracts	Mile	10,000.00	1.3	12,700	2.0	20,000	2.0	20,000
Subtotal - roads				191,000		210,000		240,000
b. Cemeteries and utilities								
(1) Electric lines	Mile	1,500.00	5.5	8,200	8.0	12,000	10.0	15,000
(2) Telephone lines	Mile	1,250.00	4.6	5,800	8.0	10,000	9.0	11,250
(3) Cemeteries	L.S.			6,000		6,000		6,000
Subtotal - cemeteries and utilities				20,000		28,000		32,250
Subtotal - relocations				211,000		238,000		272,250
Contingencies, 20%+				43,000		47,000		54,750
Total - Relocations				254,000		285,000		327,000
(05.0) Reservoirs								
a. Reservoir clearing	Acre	80.00		—	2,200	176,000	2,200	176,000
Contingencies, 20%+				--		35,000		35,000
Total - Reservoirs				—		211,000		211,000
(04.0) Dams								
a. Embankment								
(1) Diversion and care of water	L.S.			26,075		26,075		26,075
(2) Clearing and grubbing	Acre	200.00	89	17,800	106	21,200	122	24,400
(3) Excavation, stripping	C.Y.	0.25	134,000	33,500	165,500	41,375	187,500	46,875
(4) Excavation, common	C.Y.	0.30	247,000	74,100	212,000	63,600	187,500	56,250
(5) Excavation, borrow	C.Y.	0.40	409,000	163,600	1,313,380	525,350	2,137,000	854,800
(6) Compacted fill	C.Y.	0.07	3,855,000	269,850	5,663,242	396,427	6,304,000	441,280
(7) Drainage blanket	C.Y.	3.00	212,000	636,000	278,430	835,290	326,000	978,000
(8) Riprap	C.Y.	6.00	153,000	918,000	130,000	780,000	111,600	667,600
(9) Flexible base	C.Y.	3.50	7,400	25,900	9,000	31,500	9,400	32,900
(10) Asphalt treatment	Gal.	0.25	35,000	8,750	36,000	9,000	37,250	9,313
(11) Aggregate	C.Y.	6.00	640	3,840	620	3,720	610	3,660
(12) Bedding	C.Y.	4.00	57,500	230,000	49,000	196,000	43,000	172,000
(13) Timber guide posts	Ea.	5.00	1,064	5,320	1,040	5,200	1,020	5,100
(14) Cofferdam	L.S.			38,000		—		38,000
Subtotal - embankment				2,450,735		2,934,737		3,376,253
b. Slope protection	Acre	600.00	28	16,800	40	24,000	40	24,000
c. Spillway								
(1) Care of water during construction	L.S.			29,800		29,800		29,800
(2) Clearing	Acre	150.00	119	17,850	96	14,400	122	18,300
(3) Excavation, common	C.Y.	0.30	5,105,000	1,531,500	4,916,000	1,474,800	4,784,000	1,435,200
(4) Excavation, shale	C.Y.	0.60	355,000	213,000	330,000	198,000	311,000	186,600
(5) Excavation, stripping	C.Y.	0.25	192,000	48,000	—	--	—	--
(6) Line drilling	S.F.	1.75	12,500	21,875	12,600	22,050	—	--
(7) Drilling and grouting anchor holes	L.F.	2.25	23,000	51,750	24,000	54,000	24,600	55,350
(8) Concrete, slab	C.Y.	20.00	19,000	380,000	24,000	480,000	25,350	507,000
(9) Concrete, piers	C.Y.	24.00	10,000	240,000	10,000	240,000	10,220	245,280
(10) Concrete, walls	C.Y.	35.00	7,100	248,500	8,030	281,050	8,030	281,050
(11) Concrete, weir	C.Y.	20.00	41,000	820,000	37,800	756,000	37,860	757,200
(12) Concrete, bridge deck	C.Y.	55.00	340	18,700	345	18,975	345	18,975
(13) Steel, reinforcing	Lb.	0.13	4,935,000	641,550	5,565,000	723,450	5,834,000	758,420
(14) Structural backfill	C.Y.	1.50	74,400	111,600	--	--	56,700	85,050
(15) Drilling drain holes	L.F.	2.00	21,000	42,000	16,400	32,800	16,400	32,800
(16) Concrete, non-overflow	C.Y.	20.00	20,000	400,000	--	--	20,200	404,000
(17) Cement	Bbl.	5.00	121,600	608,000	125,600	628,000	127,500	637,500
(18) Steel, structural	Lb.	0.30	81,000	24,300	--	--	176,000	52,800
(19) Pipe railing	Lb.	0.50	1,030	515	--	--	3,850	1,925
(20) Metals, miscellaneous	Lb.	0.40	23,300	9,320	22,500	9,000	23,300	9,320
(21) Ladders, gratings, and grills	Lb.	0.50	18,700	9,350	--	--	18,700	9,350
(22) Pipe railing, bridge	Lb.	1.50	7,750	11,625	--	--	39,300	58,950
(23) Water stop, copper	Lb.	1.75	2,000	3,500	2,600	4,550	1,900	3,325
(24) Water gages, tile	L.F.	14.00	110	1,540	115	1,610	102	1,428
(25) Tainter gates	Lb.	0.26	1,155,000	300,300	1,155,000	300,300	1,155,000	300,300
(26) Tainter gate hoists, shafts, and hangers	Lb.	1.00	355,000	355,000	355,000	355,000	280,000	280,000
(27) Trunnion anchorages and seals	Lb.	0.24	352,000	84,480	--	--	308,000	73,920
(28) Precast bridge girders	Ea.	670.00	56	37,520	95	63,650	70	46,900
(29) Crane	L.S.			84,000		84,000		84,000
(30) Electrical facilities	L.S.			45,000		45,000		45,000
(31) Standby power unit	L.S.			7,000		7,000		7,000
(32) Riprap	C.Y.	6.00	9,200	55,200	9,080	54,480	9,100	54,600
(33) Bedding	C.Y.	4.50	3,100	13,950	3,100	13,950	3,100	13,950
(34) Slope protection, sodding	Acre	600.00	13	7,800	16	9,600	19	11,400
(35) Asphalt shale treatment	S.Y.	0.75	1,360	1,020	5,100	3,825	--	--
(36) Structural steel for shaft support	Lb.	0.30	46,500	13,950	56,000	16,800	--	--
(37) Sluice gates and operating equipment	Ea.	7,000.00	26	182,000	4	28,000	--	--
(38) Trash racks and guides	Lb.	0.35	29,300	10,255	29,300	10,255	--	--
(39) Emergency bulkheads	Lb.	0.30	63,000	18,900	100,000	30,000	103,800	31,140
Subtotal - spillway				6,760,650		5,990,345		6,598,433
d. Outlet works								
(1) Diversion and care of water	L.S.			--		26,075		26,075
(2) Clearing	Acre	100.00		--	17	1,700	19	1,900
(3) Excavation, common	C.Y.	0.40		--	674,000	269,600	674,000	269,600
(4) Excavation, rock (shale)	C.Y.	0.60		--	63,500	38,100	65,500	39,300
(5) Backfill, structural	C.Y.	1.50		--	44,800	67,200	47,500	71,250
(6) Drilling and grouting anchor holes	L.F.	2.25		--	1,410	3,173	1,410	3,173
(7) Line drilling	S.F.	1.75		--	1,600	2,800	1,600	2,800
(8) Operating house	L.F.			--		30,000		30,000
(9) Concrete control tower	C.Y.	43.00		--	1,680	72,240	1,720	73,960
(10) Concrete, tower base and transition	C.Y.	32.00		--	4,132	132,224	4,240	135,680
(11) Concrete, conduit	C.Y.	23.00		--	4,960	114,080	5,080	116,840
(12) Concrete, slab	C.Y.	22.00		--	975	21,450	975	21,450
(13) Concrete, walls	C.Y.	35.00		--	4,520	158,200	4,520	158,200
(14) Concrete, bridge	C.Y.	55.00		--	245	13,475	245	13,475
(15) Cement	Bbl.	5.00		--	20,000	100,000	21,000	105,000
(16) Steel, reinforcing	Lb.	0.13		--	1,757,000	228,410	1,889,000	245,570
(17) Structural steel	Lb.	0.30		--	57,000	17,100	63,000	18,900
(18) Handrailing	Lb.	1.50		--	3,000	4,500	3,000	4,500
(19) Metal, miscellaneous	Lb.	0.40		--	1,000	400	1,000	400
(20) Gratings and grills	Lb.	0.50		--	5,000	2,500	5,000	2,500
(21) Spiral stairway	L.S.			—		1,500		1,600
(22) Conduit liner	Lb.	0.60		--	357,330	214,398	434,000	260,400
(23) Rubber water stop	L.F.	3.00		--	1,300	3,900	1,490	4,470
(24) Water gages, tile	L.F.	16.00		--	98	1,568	96	1,568
(25) Gates and operating equipment	L.S.			—		338,000		343,000
(26) Electrical facilities	L.S.			—		4,500		4,500
(27) Riprap	C.Y.	6.00		--	4,200	25,200	4,400	26,400
(28) Bedding	C.Y.	4.50		--	1,540	6,930	1,560	7,020
(29) Drilling drain holes	L.F.	2.25		—	690	2,002	910	2,048
(30) Asphalt shale treatment	S.Y.	0.75		--	180	135	180	135
Subtotal - outlet works				--		1,901,360		1,991,714
Subtotal - dams				9,226,185		10,826,442		11,990,400
Contingencies, 20%+				1,871,615		2,173,558		2,409,600
Total - Dams				11,100,000		13,000,000		14,400,000
(06.0) Access road	Mile	30,000.00	0.25	7,500	0.25	7,500	0.25	7,500
Contingencies, 20%+				1,500		1,500		1,500
Total - Access road				9,000		9,000		9,000
(19.0) Buildings and grounds								
(1) Maintenance buildings, operators quarters	L.S.			30,000		30,000		30,000
(2) Power line to site	Mile	10,000.00	0.25	2,500	0.25	2,500	0.25	2,500
(3) Water well and accessories	L.S.			26,000		26,000		26,000
(4) General cleanup, landscaping	L.S.			20,000		20,000		20,000
(5) Visitor overlook facilities	L.S.			20,000		20,000		20,000
Subtotal - buildings and grounds				98,500		98,500		98,500
Contingencies, 20%+				19,500		19,500		19,500
Total - Buildings and grounds				118,000		118,000		118,000
(20.0) Operating equipment								
(1) Stream gages	L.S.			10,000		10,000		10,000
(2) Radio facilities	L.S.			4,000		4,000		4,000
(3) Government work boat	L.S.			--		8,000		8,000
(4) Evaporation and rain gages	L.S.			1,500		1,500		1,500
(5) Farm-type tractor and miscellaneous small tools	L.S.			6,800		7,800		7,800
(6) Sediment and degradation ranges	L.S.			—		20,000		20,000
(7) Office furniture and equipment	L.S.			3,000		3,000		3,000
Subtotal - operating equipment				25,300		54,300		54,300
Contingencies, 20%+				4,700		10,700		10,700
Total - Operating equipment				30,000		65,000		65,000
(29.0) Preauthorization cost				44,000		—		44,000
(30.0) Engineering and design				889,000		934,000		1,000,000
(31.0) Supervision and administration				980,000		1,040,000		1,200,000
Subtotal - estimated Federal first cost - dam and reservoir				16,244,000		19,762,000		22,444,000
TOTAL ESTIMATED FIRST COST OF FLOOD CONTROL AND/OR WATER CONSERVATION				16,244,000		19,762,000		22,444,000
B. FIRST COST - FISH AND WILDLIFE								
(01.0) Lands and damages								
a. Land costs								
(1) Fee simple, including severance	L.S.			--		--	(1)	41,600
Contingencies, 20%+				--		--		8,400
Total - Land costs				--		--		50,000
b. Land acquisition expense	L.S.			--		--		2,000
Total - Lands and damages				--		--		52,000
(03.0) Reservoirs								
a. Clearing	Acre	80.00		--		--	625	50,000
Contingencies, 20%+				--		--		10,000
Total - Reservoirs				--		--		60,000
(06.0) Fish and wildlife facilities								
a. Access road	L.S.			--		--		33,700
b. Parking areas	L.S.			--		--		16,500
c. Picnic facilities	L.S.			--		--		25,400
d. Water supply	L.S.			--		--		21,200
e. Sanitary facilities	L.S.			--		--		20,300
f. Boat launching ramps	L.S.			--		--		4,000
g. Vegetative improvements	L.S.			--		--		5,900
h. Signs	L.S.			--		--		2,000
Subtotal - fish and wildlife facilities				--		--		129,000
Contingencies, 20%+				--		--		26,000
Total - Fish and wildlife facilities				--		--		155,000
(30.0) Engineering and design				--		--		15,000
(31.0) Supervision and administration				--		--		18,000
Subtotal - estimated Federal first cost - fish and wildlife				--		--		300,000
C. FIRST COST - RECREATION								
(01.0) Lands and damages								
a. Land costs								
(1) Fee simple, including severance	L.S.			--		--	(2)	94,300
Contingencies, 20%+				--		--		18,700
Total - Land costs				--		--		113,000
b. Land acquisition expense	L.S.			--		--		5,000
Total - Lands and damages				--		--		118,000
(03.0) Reservoirs								
a. Clearing	Acre	80.00		--		--	1,460	116,800
Contingencies, 20%+				--		--		23,200
Total - Reservoirs				--		--		140,000
(14.0) Recreation facilities								
a. Access roads	L.S.			--		--		79,300
b. Parking areas	L.S.			--		--		39,000
c. Picnic facilities	L.S.			--		--		60,000
d. Water supply	L.S.			--		--		50,000
e. Sanitary facilities	L.S.			--		--		47,000
f. Boat launching ramps	L.S.			--		--		10,000
g. Vegetative improvements	L.S.			--		--		14,000
h. Signs	L.S.			--		--		4,700
Subtotal - recreation facilities				--		--		304,000
Contingencies, 20%+				--		--		61,000
Total - Recreation facilities				--		--		365,000
(30.0) Engineering and design				--		--		35,000
(31.0) Supervision and administration				--		--		42,000
Subtotal - estimated Federal first cost - recreation				--		--		700,000
D. ESTIMATED NON-FEDERAL FIRST COST				None		None		None
E. TOTAL - ESTIMATED PROJECT FIRST COST				16,244,000		19,762,000		23,444,000

(1) Estimated as 120 acres fee simple and the conversion of 130 acres from flood easement to fee simple
(2) Estimated as 300 acres fee simple and the conversion of 310 acres from flood easement to fee simple

TABLE 21

DETAILED ESTIMATE OF FIRST COST
PLAN 10B - NORTH FORK RESERVOIR
SAN GABRIEL RIVER WATERSHED
(July 1, 1961 prices)

Item	Unit quantity	Unit cost	Single-purpose flood control: Quantity	Single-purpose flood control: Cost	Single-purpose water conservation: Quantity	Single-purpose water conservation: Cost	Multiple-purpose FC, WC, FW, & W: Quantity	Multiple-purpose FC, WC, FW, & W: Cost
PERTINENT DATA								
Top of dam, elevation			847.0		863.0		878.0	
Spillway crest, elevation			820.0		841.0		855.0	
Lands, fee simple, acres			1,200		4,700		4,960	
(Top control elevation)			—		(836.0)		(839.0)	
Lands, flood easements, acres			2,450 (1)		640		1,980 (1)	
(Top control elevation)			(823.0)		(844.0)		(858.0)	
A. ESTIMATES OF FIRST COST - DAM AND RESERVOIR								
(01.0) Lands and damages								
a. Land costs								
(1) Fee simple lands, improvements, and severance damages	L.S.	$		$ 260,250		$ 928,000		$ 990,000
(2) Flood easement lands, improvements, and severance damages	L.S.			554,210		114,000		212,000
(3) Resettlement reimbursement	L.S.			9,800		18,000		19,000
Subtotal - land costs				824,260		1,060,000		1,221,000
Contingencies, 15%+				123,640		160,000		183,000
Total - Land costs				947,900		1,220,000		1,404,000
b. Land acquisition expense	L.S.			52,100		80,000		86,000
Total - Lands and damages				1,000,000		1,300,000		1,490,000
(02.0) Relocations								
a. Roads								
(1) County roads	Mile	23,100.00	9.5	220,000	8.0	184,000	11.9	275,000
(2) Roads to isolated tracts	Mile	10,000.00	2.0	20,000	1.6	16,000	2.4	24,000
Subtotal - roads				240,000		200,000		299,000
b. Cemeteries and utilities								
(1) Electric lines	Mile	1,500.00	10.0	15,000	8.2	12,250	12.0	18,000
(2) Telephone lines	Mile	1,250.00	4.0	5,000	3.0	3,750	4.8	6,000
(3) Cemeteries	L.S.			5,000		5,000		5,000
Subtotal - cemeteries and utilities				25,000		21,000		29,000
Subtotal - relocations				265,000		221,000		328,000
Contingencies, 20%+				53,000		44,000		65,000
Total - Relocations				318,000		265,000		393,000
(03.0) Reservoirs								
a. Reservoir clearing	Acre	80.00		—	2,000	160,000	2,000	160,000
Contingencies, 20%+				—		32,000		32,000
Total - Reservoirs				—		192,000		192,000
(04.0) Dams								
a. Embankment								
(1) Diversion and care of water	L.S.			26,075		26,075		26,075
(2) Clearing and grubbing	Acre	200.00	39	7,800	54	10,800	65	13,000
(3) Excavation, stripping	C.Y.	0.25	62,000	15,500	324,000	81,000	104,000	26,000
(4) Excavation, common	C.Y.	0.30	280,000	84,000	300,000	90,000	396,000	118,800
(5) Excavation, borrow	C.Y.	0.40	120,000	48,000	1,212,000	484,800	1,225,000	490,000
(6) Random rock fill	C.Y.	0.08	2,080,000	166,400	3,210,000	256,800	3,325,000	266,000
(7) Select rock fill	C.Y.	0.12	235,000	28,200	747,110	89,653	416,000	49,920
(8) Impervious fill	C.Y.	0.07	490,000	34,300	1,553,750	108,750	—	—
(9) Flexible base	C.Y.	3.50	3,220	11,270	5,800	20,300	5,800	20,300
(10) Asphalt treatment	Gal.	0.25	9,400	2,350	18,800	4,700	19,000	4,750
(11) Aggregate	C.Y.	6.00	170	1,020	350	2,100	—	—
(12) Timber guide posts	Ea.	5.00	695	3,475	900	4,500	970	4,850
(13) Cofferdam	L.S.			8,800		26,400		8,800
Subtotal - embankment				437,190		1,205,878		1,028,495
b. Spillway						Service spillway:		
(1) Clearing	Acre	150.00	89	13,350	5	750	127	19,050
(2) Excavation, common	C.Y.	0.30	282,000	84,600	15,500	4,650	455,000	136,500
(3) Excavation, rock	C.Y.	1.10	1,960,000	2,156,000		—	3,400,000	3,740,000
(4) Excavation, rock	C.Y.	2.75	—	—	117,000	321,750		—
(5) Line drilling	S.F.	1.75	9,600	16,800	13,600	23,800	9,600	16,800
(6) Drilling and grouting anchor holes	L.F.	2.25	1,600	3,600	2,100	4,725	1,600	3,600
(7) Concrete	C.Y.	22.00	360	7,920	—	—	360	7,920
(8) Concrete, slab	C.Y.	20.00	—	—	1,040	20,800	—	—
(9) Concrete, walls	C.Y.	35.00	—	—	4,010	140,350	—	—
(10) Steel, reinforcing	Lb.	0.13	28,000	3,640	1,750,000	227,500	28,000	3,640
(11) Structural backfill	C.Y.	1.50	—	—	7,800	11,700	—	—
(12) Drilling drain holes	L.F.	2.25	—	—	730	1,643	—	—
(13) Cement	Bbl.	5.00	450	2,250	19,500	97,500	450	2,250
(14) Pipe railing	Lb.	1.50	—	—	3,100	4,650	—	—
(15) Riprap	C.Y.	6.00	—	—	3,800	22,800	—	—
(16) Bedding	C.Y.	4.50	—	—	1,300	5,850	—	—
(17) Concrete, conduit	C.Y.	28.00	—	—	7,525	210,700	—	—
(18) Concrete, intake and base	C.Y.	45.00	—	—	3,025	136,125	—	—
(19) Rubber water stop	L.F.	3.00	—	—	1,400	4,200	—	—
(20) Service gates and stands	Ea.	7,500.00	—	—	2	15,000	—	—
(21) Pressure pipe	L.F.	20.00	—	—	840	16,800	—	—
Subtotal - spillway				2,288,160		1,271,293		3,929,760
c. Outlet works						Emergency spillway:		
(1) Diversion and care of water	L.S.			14,900		14,900		14,900
(2) Clearing	Acre	100.00	4	400	88	8,800	4	400
(3) Excavation, common	C.Y.	0.40	16,000	6,400	222,975	89,190	16,000	6,400
(4) Excavation, rock	C.Y.	2.75	47,800	131,450		—	47,800	131,450
(5) Excavation, rock	C.Y.	1.10	—	—	1,480,000	1,628,000	—	—
(6) Backfill, structural	C.Y.	1.50	4,800	7,200	—	—	4,800	7,200
(7) Drilling and grouting anchor holes	L.F.	2.25	1,300	2,925	1,600	3,600	1,300	2,925
(8) Line drilling	S.F.	1.75	13,300	23,275	9,600	16,800	13,300	23,275
(9) Operating house	L.S.			29,660		—		29,660
(10) Concrete, control tower	C.Y.	43.00	2,210	95,030		—	2,980	128,140
(11) Concrete, tower base and transition	C.Y.	32.00	2,170	69,440		—	2,170	69,440
(12) Concrete, conduit	C.Y.	23.00	1,740	40,020		—	2,470	56,810
(13) Concrete, slab	C.Y.	22.00	440	9,680	360	7,920	440	9,680
(14) Concrete, walls	C.Y.	35.00	1,740	60,900	1,700	59,500	1,740	60,900
(15) Concrete, bridge	C.Y.	55.00	66	3,630		—	92	5,060
(16) Cement	Bbl.	5.00	10,520	52,600		—	12,300	61,500
(17) Steel, reinforcing	Lb.	0.13	957,000	124,410	253,000	32,890	1,265,000	164,450
(18) Structural steel	Lb.	0.30	57,000	17,100		—	87,000	26,100
(19) Handrailing	Lb.	1.50	1,350	2,025		—	1,870	2,805
(20) Metal, miscellaneous	Lb.	0.40	1,500	600		—	1,500	600
(21) Gratings and grills	Lb.	0.50	2,000	1,000		—	2,000	1,000
(22) Spiral stairway	L.S.			1,600		—		—
(23) Conduit liner	Lb.	0.60	200,000	120,000		—	200,000	120,000
(24) Rubber water stop	L.F.	3.00	620	1,860		—	800	2,400
(25) Water gages, tile	L.F.	16.00	130	2,080	22	400	160	2,560
(26) Gates and operating equipment	L.S.			220,000		—		220,000
(27) Electrical facilities	L.S.			5,000		—		5,000
(28) Riprap	C.Y.	6.00	2,600	15,600		—	2,600	15,600
(29) Bedding	C.Y.	4.50	950	4,275		—	950	4,275
(30) Drilling drain holes	L.F.	2.25	1,300	2,925		—	1,300	2,925
(31) Asphalt shale treatment	S.Y.	0.75	700	525		—	700	525
Subtotal - outlet works				1,066,510		1,862,000		1,175,980
Subtotal - dams				3,791,860		4,339,171		6,134,235
Contingencies, 20%+				758,140		890,829		1,225,765
Total - Dams				4,550,000		5,230,000		7,360,000
(08.0) Access road	Mile	30,000.00	0.61	18,300	0.44	13,200	0.44	13,200
Contingencies, 20%+				3,700		2,800		2,800
Total - Access road				22,000		16,000		16,000
(19.0) Buildings and grounds								
(1) Maintenance buildings, operators quarters	L.S.			30,000		30,000		30,000
(2) Power line to site	Mile	10,000.00	0.61	6,100	0.44	4,400	0.44	4,400
(3) Water well and accessories	L.S.			26,000		26,000		26,000
(4) General cleanup, landscaping	L.S.			20,000		20,000		20,000
(5) Visitor overlook facilities	L.S.			20,000		20,000		20,000
Subtotal - buildings and grounds				102,100		100,400		100,400
Contingencies, 20%+				20,900		20,600		20,600
Total - Buildings and grounds				123,000		121,000		121,000
(20.0) Operating equipment								
(1) Stream gages	L.S.			10,000		10,000		10,000
(2) Radio facilities	L.S.			4,000		4,000		4,000
(3) Government work boat	L.S.			—		8,000		8,000
(4) Evaporation and rain gages	L.S.			1,500		1,500		1,500
(5) Farm-type tractor and miscellaneous small tools	L.S.			3,000		6,800		6,800
(6) Sediment and degradation ranges	L.S.			—		16,000		16,000
(7) Office furniture and equipment	L.S.			3,000		3,000		3,000
Subtotal - operating equipment				21,500		49,300		49,300
Contingencies, 20%+				3,500		9,700		9,700
Total - Operating equipment				25,000		59,000		59,000
(29.0) Preauthorization cost				10,000		—		10,000
(30.0) Engineering and design				428,000		436,000		614,000
(31.0) Supervision and administration				464,000		539,000		755,000
Subtotal - estimated Federal first cost - dam and reservoir				6,940,000		8,160,000		11,010,000
TOTAL ESTIMATED FIRST COST OF FLOOD CONTROL, AND/OR WATER CONSERVATION				6,940,000		8,160,000		11,010,000
B. FEDERAL FIRST COST - FISH AND WILDLIFE								
(01.0) Lands and damages								
a. Land costs								
(1) Fee simple including severance	L.S.			—		—	(2)	19,100
Contingencies, 20%+	L.S.			—		—		3,900
Total - land costs				—		—		23,000
b. Land acquisition expense	L.S.			—		—		1,000
Total - Lands and damages				—		—		24,000
(03.0) Reservoirs								
a. Clearing	Acre	80.00		—		—	480	38,400
Contingencies, 20%+				—		—		7,600
Total - Reservoirs				—		—		46,000
(06.0) Fish and wildlife facilities								
a. Access roads	L.S.			—		—		32,700
b. Parking areas	L.S.			—		—		8,000
c. Picnic facilities	L.S.			—		—		13,000
d. Water supply	L.S.			—		—		10,000
e. Sanitary facilities	L.S.			—		—		10,000
f. Boat launching ramps	L.S.			—		—		2,000
g. Vegetative improvements	L.S.			—		—		5,000
h. Signs	L.S.			—		—		1,000
Subtotal - fish and wildlife facilities				—		—		81,700
Contingencies, 20%+				—		—		16,300
Total - Fish and wildlife facilities				—		—		98,000
(30.0) Engineering and design				—		—		13,800
(31.0) Supervision and administration				—		—		18,200
Subtotal - estimated Federal first cost - fish and wildlife				—		—		200,000
C. FEDERAL FIRST COST - RECREATION								
(01.0) Lands and damages								
a. Land costs								
(1) Fee simple including severance	L.S.			—		—	(3)	64,100
Contingencies, 20%+	L.S.			—		—		12,900
Total - land costs				—		—		77,000
b. Land acquisition expense	L.S.			—		—		4,000
Total - Lands and damages				—		—		81,000
(03.0) Reservoirs								
a. Clearing	Acre	80.00		—		—	1,600	128,000
Contingencies, 20%+				—		—		26,000
Total - Reservoirs				—		—		154,000
(14.0) Recreation facilities								
a. Access roads	L.S.			—		—		73,000
b. Parking areas	L.S.			—		—		28,000
c. Picnic facilities	L.S.			—		—		43,000
d. Water supply	L.S.			—		—		34,000
e. Sanitary facilities	L.S.			—		—		33,000
f. Boat launching ramps	L.S.			—		—		7,000
g. Vegetative improvements	L.S.			—		—		16,000
h. Signs	L.S.			—		—		3,000
Subtotal - recreation facilities				—		—		237,000
Contingencies, 20%+				—		—		48,000
Total - Recreation facilities				—		—		285,000
(30.0) Engineering and design				—		—		36,000
(31.0) Supervision and administration				—		—		44,000
Subtotal - estimated Federal first cost - recreation				—		—		600,000
D. ESTIMATED NON-FEDERAL FIRST COST				None		None		None
E. TOTAL - ESTIMATED PROJECT FIRST COST				6,940,000		8,160,000		11,610,000

(1) Includes 300 acres of flood easement on Middle Fork of San Gabriel River for spillway discharges
(2) Estimated as 60 acres fee simple and the conversion of 60 acres from flood easement to fee simple
(3) Estimated as 205 acres fee simple and the conversion of 200 acres from flood easement to fee simple

TABLE 23

DETAILED ESTIMATE OF FIRST COST
PLAN 10B - SOUTH FORK RESERVOIR
SAN GABRIEL RIVER WATERSHED
(July 1, 1961 prices)

Item	Unit quantity	Unit cost	Single-purpose flood control: Quantity	Single-purpose flood control: Cost	Single-purpose water conservation: Quantity	Single-purpose water conservation: Cost	Multiple-purpose FC,WC,FW,& R: Quantity	Multiple-purpose FC,WC,FW,& R: Cost
PERTINENT DATA								
Top of dam, elevation			876.0		872.0		882.0	
Spillway crest, elevation			858.0		849.0		860.0	
Lands, fee simple, acres			900		2,950		3,360	
(Top control elevation)			--		(845.0)		(847.0)	
Lands, flood easements, acres			1,035		360		600	
(Top control elevation)			(820.0)		(852.0)		(863.0)	
A. ESTIMATES OF FIRST COST - DAM AND RESERVOIR								
(01.0) Lands and damages								
a. Land costs								
(1) Fee simple lands, improvements, and severance damages	L.S.	$		$ 172,500		$ 783,600		$ 806,250
(2) Flood easement lands, improvements, and severance damages	L.S.			180,875		99,000		160,400
(3) Resettlement reimbursement	L.S.			2,000		10,700		11,000
Subtotal - land costs				355,375		893,300		977,650
Contingencies, 15%+				53,325		133,700		147,350
Total - Land costs				408,700		1,027,000		1,125,000
b. Land acquisition expense	L.S.			23,300		43,000		45,000
Total - Lands and damages				432,000		1,070,000		1,170,000
(02.0) Relocations								
a. Roads (County)	Mile	10,000.00	1	10,000	2.8	28,000	3.7	37,000
b. Cemeteries and utilities								
(1) Electric lines	Mile	1,500.00	2	3,000	3.3	5,000	4.7	7,050
(2) Cemeteries	L.S.			3,000		3,000		3,000
Subtotal - cemeteries and utilities				6,000		8,000		10,050
Subtotal - relocations				16,000		36,000		47,050
Contingencies, 20%+				3,000		7,000		8,950
Total - Relocations				19,000		43,000		56,000
(03.0) Reservoirs								
a. Reservoir clearing	Acre	80.00		--	1,500	120,000	1,700	136,000
Contingencies, 20%+				--		24,000		27,000
Total - Reservoirs				--		144,000		163,000
(04.0) Dams								
a. Embankment								
(1) Diversion and care of water	L.S.			26,075		26,075		26,075
(2) Clearing and grubbing	Acre	200.00	36	7,200	34	6,800	36	7,200
(3) Excavation, common	C.Y.	0.30	198,600	59,580	208,000	62,400	232,000	69,600
(4) Excavation, borrow	C.Y.	0.40	1,686,000	674,400	1,106,600	442,640	1,970,000	788,000
(5) Random rock fill	C.Y.	0.08	709,490	56,760	2,290,000	183,200	829,000	66,320
(6) Select rock fill	C.Y.	0.12	199,400	23,928	183,000	21,960	233,000	27,960
(7) Impervious fill	C.Y.	0.07	1,664,500	116,515	1,734,000	121,380	2,040,000	142,800
(8) Flexible base	C.Y.	3.50	1,880	6,580	1,765	6,178	2,200	7,700
(9) Asphalt treatment	Gal.	0.25	7,870	1,968	5,500	1,375	9,200	2,300
(10) Aggregate	C.Y.	6.00	150	900	90	540	180	1,080
(11) Timber guide posts	Ea.	5.00	400	2,000	384	1,920	466	2,330
(12) Cofferdam	L.S.			7,600		7,600		7,600
Subtotal - embankment				983,506		882,068		1,148,985
b. Spillway						Service spillway:		
(1) Care of water during construction	L.S.			--		14,900		--
(2) Clearing	Acre	150.00	43	6,450	4	600	43	6,450
(3) Excavation, common	C.Y.	0.30	140,000	42,000	13,500	4,050	140,000	42,000
(4) Excavation, rock	C.Y.	1.10	965,000	1,061,500		--	965,000	1,061,500
(5) Excavation, rock	C.Y.	2.75		--	74,000	203,500		--
(6) Line drilling	S.F.	1.75	6,000	10,500	6,600	11,550	6,000	10,500
(7) Drilling and grouting anchor holes	L.F.	2.25	1,000	2,250	1,800	4,050	1,000	2,250
(8) Concrete	C.Y.	22.00	3,400	74,800		--	3,400	74,800
(9) Concrete, slab	C.Y.	20.00		--	950	19,000		--
(10) Concrete, walls	C.Y.	35.00		--	2,335	81,725		--
(11) Steel, reinforcing	Lb.	0.13	57,000	7,410	1,130,000	146,900	57,000	7,410
(12) Structural backfill	C.Y.	1.50		--	24,000	36,000		--
(13) Drilling drain holes	L.F.	2.25		--	1,200	2,700		--
(14) Cement	Bbl.	5.00	4,250	21,250	12,600	63,000	4,250	21,250
(15) Steel, structural	Lb.	0.30		--	20,000	6,000		--
(16) Pipe railing	Lb.	1.50		--	2,600	3,900		--
(17) Riprap	C.Y.	6.00		--	1,500	9,000		--
(18) Bedding	C.Y.	4.50		--	500	2,250		--
(19) Concrete, conduit	C.Y.	28.00		--	4,435	124,180		--
(20) Concrete, intake and base	C.Y.	45.00		--	2,300	103,500		--
(21) Rubber water stop	L.F.	3.00		--	990	2,970		--
(22) Service gates and stands	Ea.	7,500.00		--	2	15,000		--
(23) Pressure pipe	L.F.	20.00		--	720	14,400		--
Subtotal - spillway				1,226,160		869,175		1,226,160
c. Outlet works						Emergency spillway:		
(1) Diversion and care of water	L.S.			14,900		--		14,900
(2) Clearing	Acre	100.00	4	400	47	4,700	4	400
(3) Excavation, common	C.Y.	0.40	15,900	6,360	147,000	58,800	15,900	6,360
(4) Excavation, rock	C.Y.	2.75	47,600	130,900		--	47,600	130,900
(5) Excavation, rock	C.Y.	1.10		--	1,293,000	1,422,300		--
(6) Backfill, structural	C.Y.	1.50	5,000	7,500		--	5,000	7,500
(7) Drilling and grouting anchor holes	L.F.	2.25	1,300	2,925	1,000	2,250	1,300	2,925
(8) Line drilling	S.F.	1.75	13,400	23,450	6,000	10,500	13,400	23,450
(9) Operating house	L.S.			29,660		--		29,660
(10) Concrete, control tower	C.Y.	43.00	2,320	99,760		--	2,320	99,760
(11) Concrete, tower base and transition	C.Y.	32.00	2,170	69,440		--	2,170	69,440
(12) Concrete, conduit	C.Y.	23.00	1,850	42,550		--	1,850	42,550
(13) Concrete, slab	C.Y.	22.00	430	9,460	220	4,840	430	9,460
(14) Concrete, walls	C.Y.	35.00	1,780	62,300		--	1,780	62,300
(15) Concrete, bridge	C.Y.	55.00	70	3,850		--	70	3,850
(16) Cement	Bbl.	5.00	10,760	53,800	280	1,400	10,760	53,800
(17) Steel, reinforcing	Lb.	0.13	978,000	127,140	17,500	2,275	978,000	127,140
(18) Structural steel	Lb.	0.30	61,400	18,420		--	61,400	18,420
(19) Handrailing	Lb.	1.50	1,420	2,130		--	1,420	2,130
(20) Metal, miscellaneous	Lb.	0.40	1,500	600		--	1,500	600
(21) Gratings and grills	Lb.	0.50	2,000	1,000		--	2,000	1,000
(22) Spiral stairway	L.S.			1,600		--		1,600
(23) Rubber water stop	L.F.	3.00	680	2,040		--	680	2,040
(24) Water gages, tile	L.F.	16.00	140	2,240		--	140	2,240
(25) Gates and operating equipment	L.S.			220,000		--		220,000
(26) Electrical facilities	L.S.			5,000		--		5,000
(27) Riprap	C.Y.	6.00	2,600	15,600		--	2,600	15,600
(28) Bedding	C.Y.	4.50	950	4,275		--	950	4,275
(29) Drilling drain holes	L.F.	2.25	13,400	30,150		--	13,400	30,150
(30) Asphalt shale treatment	S.Y.	0.75	700	525		--	700	525
Subtotal - outlet works				987,975		1,507,065		987,975
Subtotal - dams				3,197,641		3,258,308		3,363,100
Contingencies, 20%+				632,359		641,692		666,900
Total - Dams				3,830,000		3,900,000		4,030,000
(08.0) Access road	Mile	30,000.00	0.38	11,400	0.57	17,100	0.38	11,400
Contingencies, 20%+				2,600		3,900		2,600
Total - Access road				14,000		21,000		14,000
(19.0) Building and grounds								
(1) Maintenance buildings, operators quarters	L.S.			30,000		30,000		30,000
(2) Power line to site	L.S.		0.38	3,800	0.57	5,700	0.38	3,800
(3) Water well and accessories	L.S.			26,000		26,000		26,000
(4) General cleanup, landscaping	L.S.			20,000		20,000		20,000
(5) Visitor overlook facilities	L.S.			20,000		20,000		20,000
Subtotal - buildings and grounds				99,800		101,700		99,800
Contingencies, 20%+				20,200		20,300		20,200
Total - Building and grounds				120,000		122,000		120,000
(20.0) Operating equipment								
(1) Stream gages	L.S.			10,000		10,000		10,000
(2) Radio facilities	L.S.			4,000		4,000		4,000
(3) Government work boat	L.S.			--		8,000		8,000
(4) Evaporation and rain gages	L.S.			1,500		1,500		1,500
(5) Farm-type tractor and miscellaneous small tools	L.S.			2,000		6,800		6,800
(6) Sediment and degradation ranges	L.S.			--		12,000		12,000
(7) Office furniture and equipment	L.S.			3,000		3,000		3,000
Subtotal - operating equipment				20,500		45,300		45,300
Contingencies, 20%+				4,500		9,700		9,700
Total - Operating equipment				25,000		55,000		55,000
(29.0) Preauthorization cost				10,000		--		10,000
(30.0) Engineering and design				365,000		419,000		440,000
(31.0) Supervision and administration				405,000		446,000		492,000
Subtotal - estimated Federal first cost - dam and reservoir				5,220,000		6,220,000		6,550,000
TOTAL ESTIMATED FIRST COST OF FLOOD CONTROL AND/OR WATER CONSERVATION				5,220,000		6,220,000		6,550,000
B. FEDERAL FIRST COST - FISH AND WILDLIFE								
(01.0) Lands and damages								
a. Land costs								
(1) Fee simple including severance	L.S.			--		--	(1)	18,500
Contingencies, 20%+				--		--		3,700
Total - Land costs				--		--		22,200
b. Land acquisition expense	L.S.			--		--		800
Total - Lands and damages				--		--		23,000
(03.0) Reservoirs								
a. Clearing	Acre	80.00		--		--	330	26,400
Contingencies, 20%+				--		--		5,300
Total - Reservoirs				--		--		31,700
(06.0) Fish & wildlife facilities								
a. Access roads	L.S.			--		--		15,500
b. Parking areas	L.S.			--		--		10,800
c. Picnic facilities	L.S.			--		--		12,000
d. Water supply	L.S.			--		--		6,800
e. Sanitary facilities	L.S.			--		--		9,300
f. Boat launching ramps	L.S.			--		--		1,400
g. Vegetative improvements	L.S.			--		--		4,300
h. Signs	L.S.			--		--		900
Subtotal - fish and wildlife				--		--		61,000
Contingencies, 20%+				--		--		12,300
Total - Fish and wildlife				--		--		73,300
(30.0) Engineering and design				--		--		10,400
(31.0) Supervision and administration				--		--		11,600
Subtotal - estimated Federal first cost - fish and wildlife				--		--		150,000
C. FEDERAL FIRST COST - RECREATION								
(01.0) Lands and damages								
a. Land costs								
(1) Fee simple including severance	L.S.			--		--	(2)	67,000
Contingencies, 15%+				--		--		10,000
Total - Land costs				--		--		77,000
b. Land acquisition expense	L.S.			--		--		3,000
Total - Lands and damages				--		--		80,000
(03.0) Reservoirs								
a. Clearing	Acre	80		--		--	1,163	93,000
Contingencies, 20%+				--		--		19,000
Total - Reservoirs				--		--		112,000
(14.0) Recreation facilities								
a. Access roads	L.S.			--		--		60,000
b. Parking areas	L.S.			--		--		44,500
c. Picnic facilities	L.S.			--		--		39,000
d. Water supply	L.S.			--		--		22,000
e. Sanitary facilities	L.S.			--		--		30,000
f. Boat launching ramps	L.S.			--		--		4,500
g. Vegetative improvements	L.S.			--		--		14,000
h. Signs	L.S.			--		--		3,000
Subtotal - recreation facilities				--		--		217,000
Contingencies, 20%+				--		--		44,000
Total - Recreation facilities				--		--		261,000
(30.0) Engineering and design				--		--		37,000
(31.0) Supervision and administration				--		--		40,000
Subtotal - estimated Federal first cost - recreation				--		--		530,000
D. ESTIMATED NON-FEDERAL FIRST COST				None		None		None
E. TOTAL - ESTIMATED PROJECT FIRST COST				$5,220,000		$6,220,000		$7,230,000

(1) Estimated as 55 acres fee simple and the conversion of 40 acres from flood easement to fee simple
(2) Estimated as 195 acres fee simple and the conversion of 150 acres from flood easement to fee simple

TABLE 24

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
SAN GABRIEL RIVER - MILE 4.0 NORTH FORK
AND MILE 4.7 SOUTH FORK TO MILE 29.7
SAN GABRIEL RIVER, REACH 2

Item	Value
1. Agricultural property (11,905 acres)	
a. Improved land (5,619 acres @ $250 per acre)	$1,404,800
b. Unimproved grazing land (6,286 acres @ $175 per acre)	1,100,000
Total agricultural property	2,504,800
2. Transportation facilities	
a. Railroads	711,500
b. State highways	446,500
c. County roads	77,500
Total transportation facilities	1,235,500
3. Utilities	
a. Electric power lines	44,000
b. Telephone and telegraph lines	31,500
c. Pipe lines	10,000
Total utilities	85,500
4. Urban property (372 acres)	
a. Jonah (70 acres)	146,500
b. Circleville (5 acres)	40,000
c. Georgetown (297 acres)	494,500
Total urban property	681,000
TOTAL	$4,506,800

TABLE 25

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
SAN GABRIEL RIVER - MILE 29.7 TO MILE 7.3
SAN GABRIEL RIVER, REACH 1

Item	Value
1. Agricultural property (13,784 acres)	
a. Improved land (8,343 acres @ $250 per acre)	$2,085,800
b. Unimproved grazing land (5,441 acres @ $175 per acre)	952,200
Total agricultural property	3,038,000
2. Transportation facilities (county roads)	450,500
3. Utilities (telephone lines)	2,900
TOTAL	$3,491,400

TABLE 26

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
BERRY CREEK - MILE 6.7 TO MILE 1.1
BERRY CREEK, REACH 1

Item		Value
1.	Agricultural property (884 acres)	
	a. Improved land (445 acres @ $250 per acre)	$111,300
	b. Unimproved grazing land (439 acres @ $200 per acre)	87,800
	Total agricultural property	199,100
2.	Transportation facilities	
	a. State highways	207,500
	b. County roads	37,100
	Total transportation facilities	$244,600
3.	Utilities	
	a. Electric power lines	21,100
	b. Telephone lines	2,700
	Total utilities	23,800
	TOTAL	$467,500

TABLE 27

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
LITTLE RIVER - MILE 48.9 TO MILE 15.0
LITTLE RIVER, REACH 2

Item	Value
1. Agricultural property (33,585 acres)	
a. Improved land (29,266 acres @ $200 per acre)	$5,853,200
b. Unimproved grazing land (4,319 acres @ $100 per acre)	431,900
Total agricultural property	6,285,100
2. Transportation facilities	
a. Railroads	2,126,400
b. State highways	868,400
c. County roads	525,400
Total transportation facilities	3,520,200
3. Utilities	
a. Electric power lines	78,400
b. Telephone and telegraph lines	46,100
c. Pipe lines	50,800
Total utilities	175,300
4. Urban property	
a. Cameron water-supply plant and sewage-disposal plant	290,300
Total urban property	290,300
TOTAL	$10,270,900

TABLE 28

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
BRAZOS RIVER - MILE 317.9 TO MILE 249.9
BRAZOS RIVER, REACH 4

Item	Value
1. Agricultural property (157,424 acres)	
a. Improved land (129,992 acres @ $200 per acre)	$25,998,400
b. Unimproved grazing land (27,432 acres @ $100 per acre)	2,743,200
Total agricultural property	28,741,600
2. Rural nonagricultural property	
a. Sand and gravel plant	188,700
b. Churches and schools	159,900
Total rural nonagricultural property	348,600
3. Transportation facilities	
a. Railroads	6,458,000
b. State highways	2,262,800
c. County roads	3,470,300
Total transportation facilities	12,191,100
4. Utilities	
a. Electric power lines	346,600
b. Telephone and telegraph lines	260,600
c. Pipe lines	217,100
Total utilities	824,300
5. Urban property (245 acres)	
a. Hearne (72 acres)	176,500
b. Valley Junction (19 acres)	121,900
c. Tatsie (15 acres)	95,800
d. Nicholas (17 acres)	98,700
e. Whites (17 acres)	118,300
f. Mumford (39 acres)	95,800
g. Steeles Store (16 acres)	220,600
h. Mudville (16 acres)	135,000
i. Simms (19 acres)	119,000
j. Law (10 acres)	110,300
k. Stone City (5 acres)	37,700
Total urban property	1,329,600
TOTAL	$43,435,200

TABLE 29

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
BRAZOS RIVER - MILE 249.9 TO MILE 236.0
BRAZOS RIVER, REACH 5

Item	Value
1. Agricultural property (37,972 acres)	
a. Improved land (20,540 acres @ $200 per acre)	$4,108,000
b. Unimproved grazing land (17,432 acres @ $100 per acre)	1,743,200
Total agricultural property	5,851,200
2. Transportation facilities	
a. Railroads	3,663,000
b. State highways	145,100
c. County roads	139,900
Total transportation facilities	3,948,000
3. Utilities (telephone and telegraph lines)	168,300
4. Urban property (31 acres)	
a. Allen Farm (19 acres)	175,600
b. Rogers Plantation (12 acres)	46,500
Total urban property	222,100
TOTAL	$10,189,600

TABLE 30

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
BRAZOS RIVER - MILE 236.0 TO MILE 157.5
BRAZOS RIVER, REACH 6

Item	Value
1. Agricultural property (105,436 acres)	
a. Improved land (67,769 acres @ $200 per acre)	$13,553,800
b. Unimproved grazing land (37,667 acres @ $100 per acre)	3,766,700
Total agricultural property	17,320,500
2. Rural nonagricultural property	
a. Oilfield surface equipment	457,700
b. Churches and schools	28,300
Total rural nonagricultural property	486,000
3. Transportation facilities	
a. Railroads	3,952,500
b. State highways	2,419,500
c. County roads	574,800
Total transportation facilities	6,946,800
4. Utilities	
a. Electric power lines	377,300
b. Telephone and telegraph lines	177,200
c. Pipelines	505,900
Total utilities	1,060,400
5. Urban property (16 acres)	
a. Navasota (11 acres)	52,200
b. Courtney (5 acres)	72,600
Total urban property	124,800
TOTAL	$25,938,500

TABLE 31

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
BRAZOS RIVER - MILE 157.5 TO MILE 70.8
BRAZOS RIVER, REACH 7

Item	Value
1. Agricultural property (191,974 acres)	
a. Improved land (123,202 acres @ $200 per acre)	$24,640,400
b. Unimproved grazing land (68,772 acres @ $100 per acre)	6,877,200
c. Irrigation property and equipment	725,600
d. State prison farms (buildings and equipment only)	1,622,600
e. Levees	411,300
Total agricultural property	34,277,100
2. Rural nonagricultural property	
a. Oil field surface equipment	1,625,100
b. Churches and schools	96,400
Total rural nonagricultural property	1,721,500
3. Transportation facilities	
a. Railroads	9,341,300
b. State highways	3,643,700
c. County roads	3,979,800
Total transportation facilities	16,964,800
4. Utilities	
a. Electric power lines	1,478,000
b. Telephone and telegraph lines	351,900
c. Pipe lines	3,984,600
Total utilities	5,814,500
5. Urban property (453 acres)	
a. Simonton (46 acres)	235,100
b. Rosenberg (144 acres)	2,374,300
c. Richmond (28 acres)	1,136,000
d. Crabb (13 acres)	21,800
e. Sugar Land (180 acres)	21,919,000
f. Smada (22 acres)	114,600
g. Dewalt (20 acres)	261,200
Total urban property	26,062,000
TOTAL	$84,839,900

TABLE 32

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
BRAZOS RIVER - MILE 70.8 TO MILE 0.0
BRAZOS RIVER, REACH 8A

Item	Value
1. Agricultural property (315,429 acres)	
a. Improved land (71,162 acres @ $200 per acre)	$14,232,400
b. Unimproved grazing land (244,267 acres @ $100 per acre)	24,426,700
c. Irrigation property and equipment	261,200
d. State prison farms (buildings and equipment only)	808,800
Total agricultural property	39,729,100
2. Rural nonagricultural property	
a. Oil field surface equipment	5,583,800
b. Sulphur mine surface equipment	2,902,500
c. Levees	5,805,000
d. Industrial water supply plant	507,900
e. Churches and schools	43,000
Total rural nonagricultural property	14,842,200
3. Transportation facilities	
a. Railroads	8,781,200
b. State highways	3,718,400
c. County roads	4,992,700
Total transportation facilities	17,492,300
4. Utilities	
a. Electric power lines	1,091,300
b. Telephone and telegraph lines	556,200
c. Pipe lines	5,954,500
Total utilities	7,602,000
5. Urban property (1,064 acres)	
a. Thompsons (30 acres)	148,000
b. West Columbia (73 acres)	2,311,600
c. East Columbia (81 acres)	825,900
d. Brazoria (218 acres)	1,197,900
e. Lake Jackson (525 acres)	12,266,700
f. Jones Creek (137 acres)	1,044,200
Total urban property	17,794,300
TOTAL	$97,459,900

TABLE 33

VALUE OF PHYSICAL PROPERTY IN THE FLOOD PLAIN
BRAZOS RIVER - MILE 70.8 TO MILE 0.0
BRAZOS RIVER, REACH 8B

Item	Value
1. Agricultural property (236,257 acres)	
a. Improved land (156,036 acres @ $200 per acre)	$31,207,200
b. Unimproved grazing land (80,221 acres @ $100 per acre)	8,022,100
c. Irrigation property and equipment	1,596,400
d. Levees	232,200
Total agricultural property	41,057,900
2. Rural nonagricultural property	
a. Oil Field surface equipment	555,800
b. Sulphur mine surface equipment	7,328,800
c. Churches and schools	52,300
Total rural nonagricultural property	7,936,900
3. Transportation facilities	
a. Railroads	4,260,900
b. State highways	3,654,200
c. County roads	2,909,800
Total transportation facilities	10,824,900
4. Utilities	
a. Electric power lines	1,818,700
b. Telephone and telegraph lines	387,600
c. Pipe lines	4,357,600
Total utilities	6,563,900
5. Urban property (743 acres)	
a. Juliff (16 acres)	101,600
b. Bonney (18 acres)	100,400
c. Liverpool (14 acres)	445,500
d. Danbury (172 acres)	2,074,100
e. Chenango (13 acres)	108,800
f. Anchor (9 acres)	24,700
g. Angleton (501 acres)	13,152,900
Total urban property	16,008,000
TOTAL	$82,391,600

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APPENDIX III

ECONOMIC BASE STUDY
REVIEW OF REPORTS ON BRAZOS RIVER AND TRIBUTARIES, TEXAS
COVERING SAN GABRIEL RIVER WATERSHED

INTRODUCTION

1. PURPOSE.- The purpose of the economic base study is to determine the probable future development in the area subject to flooding which is to be used in estimating the damage prevention benefits creditable to the proposed plan of improvement. This development and future growth is that which would be anticipated without any further flood control improvements in operation.

2. METHOD.- The development of an economic base study to facilitate the appraisal of future growth depends in great part on judgment and the availability of pertinent data. The economic factors which represent the area are varied in character, and consist of industrial, distributive, educational, agricultural, or a combination of several types of economic activity. In order to best represent the current and projected characteristics of the area being studied in the Brazos River Basin, twelve representative economic indicators were selected. These are:

County population
Urban population
New construction
Value added by manufacture
Mineral production
Retail sales
Bank deposits
Per capita income
Highway traffic
Yield per acre harvested
Rural level of living
Value of farm property

These representative economic indicators were then combined to represent the growth in three categories of flood losses: Rural nonagricultural, urban and suburban, and agricultural.

3. The rural nonagricultural category of losses consists of damages to highways, railroads, pipelines, telephone and telegraph lines, power lines, oil fields, sand and gravel plants, and recreational areas. The following economic indicators were selected as representative of rural nonagricultural losses:

County population
Mineral production
Retail sales
Bank deposits
Per capita income
Highway traffic

4. Urban and suburban flood losses are composed of damages to industrial plants, commercial buildings and contents, residential and personal property, public property, streets, utilities, and recreation areas. The following economic indicators were selected as applicable to urban and suburban losses:

Urban population
New construction
Value added by manufacture
Per capita income
Retail sales
Highway traffic

In both nonagricultural and urban and suburban flood loss categories, the additional losses of interruption to traffic and communications, cost of rescue work and policing, cost of combating disease and insects, and cost of relief and care of flood victims are included.

5. Agricultural losses due to flooding consist of crop damages, loss of livestock, land damage, fence damage, building and equipment losses, and orchard loss and damage. Flood losses in this category are reflected in the following economic indicators:

Rural level of living
Yield per acre
Value of farm property

6. The Brazos River Basin was divided into three parts, Upper, Middle, and Lower. The division is based on physiography, culture, and future probable development of each area. The Upper part consists of Erath, Comanche, Hamilton, Bosque, Hill, Coryell, and Lampasas Counties. The area is basically agricultural and past records indicate a continuance of this activity at a lesser rate of increase than the State of Texas. The Middle section is composed of 12 counties: McLennan, Limestone, Falls, Bell, Williamson, Milam, Robertson, Lee, Burleson, Brazos, Grimes, and Washington. The agricultural nature of this area, due to good soils, appears to be stable and will increase in this economic field and probably will exceed the State agricultural growth by the year 2010. The urban and suburban and nonagricultural categories appear to continue at about the same rate to 2010. The Lower Brazos is composed of Austin, Waller, Fort Bend, and Brazoria Counties lying in the Coastal and Rolling Coastal Plains of the Gulf Region. The southern part of this area is extremely dynamic, and progressive growth in petro-chemicals and industry is indicated.

The nonagricultural and urban and suburban aspects show the highest rates of growth of the three areas, with agriculture approximately the same as the Middle Brazos. For comparative evaluation, the economic indicators of the three areas will be presented in absolute and relative terms of current status and projected conditions. The factors then will be grouped according to types of flood loss and applied to each of the areas.

FUTURE GROWTH FACTORS

7. COUNTY POPULATION.- The year 1910 was the high point of population in the Upper Brazos; from 171,604 in that year it decreased to 104,427 in 1960, and it appears that the decrease will continue. The Middle area indicates an increase of 15% from 1960 to 2010 which is the same rate of increase as was experienced from 1910 to 1960. The lower counties had a 61,304 population in 1910 with a 132% increase to 142,579 in 1960 and a projected increase of 110.4% to 300,000 in 2010.

COUNTY POPULATION

	1960	2010	(f)
Upper	104,427	84,000	.80
Middle	456,203	525,000	1.15
Lower	142,579	300,000	2.10

The factor of increase is the relative value of the 2010 value in terms of the 1960 value. This factor (f) becomes the basis for expressing the growth in economic terms.

8. URBAN POPULATION.- The urban growth of the three sections, on an absolute basis,is varied. The Upper area shows a 74.9% gain in the period 1910-1960 but only 19.7% from 1960-2010. The Middle area shows an increase of 211.6% in 1910-1960 but only 48.2% for the next 50 years. The Lower area indicates extreme growth in year 1960-2010 of 232% increase.

URBAN POPULATION

	1960	2010	(f)
Upper	48,458	58,000	1.20
Middle	296,980	440,000	1.48
Lower	75,292	250,000	3.32

9. NEW CONSTRUCTION.- These data are in the form of building permits, principally from the towns and cities. The current data are deflated to a 1960 basis by use of Engineering News Record, Building Cost Index, 1947-1949 = 100 rebased to 1960 = 100. The Upper and Middle areas indicate nominal growth to 2010 while the Lower area,

with a factor of 4.88 for 2010 over 1960, highlights the industrialization progressing in that area. The annual rates of building permits are as follows:

NEW CONSTRUCTION

	1960	2010	(f)
Upper	$2,171,000	$4,000,000	1.84
Middle	33,868,000	55,000,000	1.62
Lower	8,190,000	40,000,000	4.88

10. VALUE ADDED BY MANUFACTURE.- The projections in this element of economic growth are based on the number of people engaged in manufacturing activities and on production per employee. These are projected and the product represents the value added by manufacture for 2010. Value added is deflated to 1960 by use of the Wholesale Price Index (all other than farm products) B.L.S. - Statistical Abstract, 1960 and Federal Reserve Bulletin. The results emphasize the growth of the Lower area as opposed to the other two. However, the Middle region, while supporting a sound agricultural complex, shows an increase from $165,000,000 in 1960 to $630,000,000 annually in 2010. Comparisons are shown in the following table:

VALUE ADDED BY MANUFACTURE

	1960	2010	(f)
Upper	$5,300,000	$6,000,000	1.13
Middle	165,000,000	630,000,000	3.82
Lower	290,000,000	2,104,000,000	7.26

11. MINERAL PRODUCTION.- The principal items in these data are gas and oil. The absolute increase in the Lower region of $450,000,000 annual production far exceeds the dollar increase of the other areas. However, on a relative 1960 basis, the increase amounts to 2.80 times the 1960 annual production. The Upper and Middle reaches exceed this increase. The data for annual production is deflated to 1960 by use of the Index for Crude Material for Further Processing by the Bureau of Labor Statistics. As is noted in the following table, the Upper area exceeds in increase of production by 2010.

MINERAL PRODUCTION
(annual rate)

	1960	2010	(f)
Upper	$1,360,000	$7,600,000	5.59
Middle	15,500,000	74,000,000	4.77
Lower	250,000,000	700,000,000	2.80

12. RETAIL SALES.- Retail sales as an indicator are used in nonagricultural and urban and suburban categories for flood losses. It is applicable, in a general way, to business conditions and recreational activity. The Upper part increased from $50,000,000 a year in 1940 to $110,000,000 annually in 1960, which is about one half of the annual growth to 2010 sales of $190,000,000. The Middle area for the period 1960-2010 is about 64% of the annual rate of increase for 1940-1960. The Lower counties, starting with an absolute comparable to the Upper counties, by 2010 approach the Middle counties in annual sales. The following data were deflated to 1960 dollars by using the Bureau of Labor Statistics Consumer Index (all items):

RETAIL SALES

	1960	2010	(f)
Upper	$110,000,000	$190,000,000	1.73
Middle	490,000,000	935,000,000	1.91
Lower	162,000,000	720,000,000	4.44

13. BANK DEPOSITS.- While bank deposits do not reflect the exact economic conditions of an area, they are considered as being indicative of the general economy over a period of time. Bank deposits are in the nonagricultural category as being representative of countywide financial activity. The Upper region, due to primacy of agriculture, shows the least increase in this economic element, whereas the Lower section shows 2010 deposits to be almost five times the 1960 figure. Current bank deposits on an annual basis were rebased to 1960 by using Purchasing Power of the dollar as a multiplier, where 1960 = 100. The table gives comparisons for growth in the period 1960 to 2010.

BANK DEPOSITS
(annual)

	1960	2010	(f)
Upper	$73,000,000	$87,000,000	1.19
Middle	370,000,000	1,000,000,000	2.70
Lower	111,000,000	540,000,000	4.86

14. PER CAPITA INCOME.- It is considered that expendable or disposable income would apply to nonagricultural and urban and suburban flood loss categories. The county data were deflated to a 1960 basis by use of Consumer Price Index (all items) as a deflator. The Upper and Middle regions show 167% and 172% increase by the year 2010. The Lower area is noted as having a 220% increase for the same period. This correlates the relative high degree of urbanization projected for the Lower counties. Income is tabulated as follows:

PER CAPITA INCOME

	1960	2010	(f)
Upper	$1,350	$3,600	2.67
Middle	1,250	3,400	2.72
Lower	1,470	4,700	3.20

15. HIGHWAY TRAFFIC.- This element is taken in consideration of interruption and delay of traffic due to floods. Since these are the only available data on a county basis, they necessarily are the basis for all traffic. The data are the traffic counts on highways at the county boundaries for a 24-hour period. It is evident that adjoining counties will duplicate the count where they join; therefore, the value as an indicator is relative. The Middle counties projection exceeds the Upper and Lower for 2010. This is probably due to general traffic movement from the highly industrialized Houston area to the northwest, and the greater number of towns in the Middle counties. The vehicle count can be approximated as 15% trucks and the remainder as automobiles. The 2010 increase over 1960 is noted as follows:

HIGHWAY TRAFFIC

	1960	2010	(f)
Upper	80,410	152,000	1.89
Middle	168,050	400,000	2.38
Lower	89,830	185,000	2.06

16. CROP YIELD PER ACRE.- Data for the current yield of field crops harvested in the period 1924-1949 were deflated to 1960 value by use of Index of Prices Received by Texas Farmers. Acres of field crops harvested was applied as a divisor and the yield per acre in 1960 dollars was obtained. In the period 1920 to 1930 the Upper and Middle areas exceeded the Lower in yield per acre; by 1945 the Lower counties produced $63 per acre as opposed to $37 for the other areas. By 1960 a definite trend of increase is established for the Middle and Lower while the Upper apparently has become static into the year 2010. The tabular data indicate the disparity between the areas.

CROP YIELD PER ACRE

	1960	2010	(f)
Upper	$34.50	$35.00	1.01
Middle	52.00	160.00	3.08
Lower	78.00	240.00	3.08

17. RURAL LEVEL OF LIVING.- These indexes are measures of relative living standards between different areas and different periods of time. They are based on percentage of farms with electricity, percentage with telephones, percentage with automobiles, and average value of products sold or traded in the year preceding the census. The current

data from 1940 to 1954 for each area where extrapolated to 1960 then rebased to that year as being 100. The 1940-1960 period shows the Lower area comparatively lower than the other two but the trend has a definite tendency to exceed these in the future. The Upper area shows a definite decline in the period 1950-1960 and projects to an amount considerably less than the other areas by the year 2010. Following is the 1960-2010 data:

RURAL LEVEL OF LIVING

	1960	2010	(f)
Upper	100	203	2.03
Middle	100	244	2.44
Lower	100	262	2.62

18. VALUE OF FARM PROPERTY.- This factor, due to basis of acquisition, is used as a broad indicator. In many cases farm values are optimistically high, in others the enumerator establishes values; however, the data are sufficiently general in scope to be accepted as a significant indicator of the agricultural conditions in an area. The data from 1910 to 1954 establish a general trend for the three areas which indicates that the Lower area, although comparable to the Upper in early years, has exceeded the others in value per acre by 1940 and continues at a more accelerated growth into the future. The value per acre includes all improvements and is deflated to a 1960 price level to give the following comparisons:

VALUE OF FARM PROPERTY

	1960	2010	(f)
Upper	$75.00	$88.00	1.17
Middle	95.00	175.00	1.84
Lower	143.00	335.00	2.34

19. RURAL NONAGRICULTURAL.- The development of a projection factor in this category of flood losses necessarily must include those economic activities outside of urban and suburban areas. Those activities previously mentioned in this category earlier in this report are summated and reduced to a single factor by use of a geometric mean. This is best explained by giving the mean of the Upper Brazos rural nonagricultural factor, or $\sqrt[6]{.8 \times 5.59 \times 1.73 \times 1.19 \times 2.67 \times 1.89} = 1.90$ which is the n^{th} root of all the indicators multiplied successively. Since the values for 2010 are divided by the 1960 values to arrive at the factor for 2010, it follows that all values for 1960 become 1.00. The tabulated data for this category are as follows:

RURAL NONAGRICULTURAL

a. Upper Brazos Counties

	1960	2010	(f)
Population	104,427	84,000	.80
Mineral Production	$1,360,000	$7,600,000	5.59
Retail Sales	$110,000,000	$190,000,000	1.73
Bank Deposits	$73,000,000	$87,000,000	1.19
Per Capita Income	$1,350	$3,600	2.67
Highway Traffic	80,410	152,000	1.89
Geometric mean	1.00		1.90

b. Middle Brazos Counties

	1960	2010	(f)
Population	456,203	525,000	1.15
Mineral Production	$15,500,000	$74,000,000	4.77
Retail Sales	$490,000,000	$935,000,000	1.91
Bank Deposits	$370,000,000	$1,000,000,000	2.70
Per Capita Income	$1,250	$3,400	2.72
Highway Traffic	168,050	400,000	2.38
Geometric Mean	1.00		2.38

c. Lower Brazos Counties

	1960	2010	(f)
Population	142,579	300,000	2.10
Mineral Production	$250,000,000	$700,000,000	2.80
Retail Sales	$162,000,000	$720,000,000	4.44
Bank Deposits	$111,000,000	$540,000,000	4.86
Per Capita Income	$1,470	$4,700	3.20
Highway Traffic	89,830	185,000	2.06
Geometric Mean	1.00		3.07

20. The 2010 factors represent increase in economic activity in relative terms of 1960 values. By using a straight line development into the future, the average growth for the years 1960-2010 will be obtained by multiplying the difference between the two factors by .405. This establishes the increase for the period on a present worth basis. This present worth of projected development is then added to the present development of 1.00 and the final figure is appied to 1960 nonagricultural losses to obtain the average annual equivalent loss for the years 1960-2010 in terms of 1960 worth.

Example: Upper Brazos, nonagricultural
(1.90 - 1.00) x .405 = .36
Annual Equivalent = 1.00 + .36 = 1.36

SUMMATION FOR ANNUAL EQUIVALENTS
1960 to 2010

	Upper Brazos	Middle Brazos	Lower Brazos
Nonagricultural	1.36	1.56	1.82
Urban and Suburban	1.27	1.49	2.17
Agricultural	1.15	1.58	1.69

APPLICATION OF FACTORS

21. DEVELOPMENT FACTORS.- In the application of the development factors derived above to the Brazos River Basin, a determination was first made of the amount of average annual flood damages occuring in each of the three basic areas. It was found that 6 percent of the damages occur in the upper area, 60 percent in the middle area, and 34 percent in the lower area. It was further determined that the damages in the upper area are 85 percent agricultural and 15 percent nonagricultural; in the middle area the damages are 2 percent urban and suburban, 84 percent agricultural, and 14 percent nonagricultural; and in the lower area the damages are 1 percent urban and suburban, 84 percent agricultural, and 15 percent nonagricultural. Based on all of these facts,the following computation was made:

Upper Brazos Area

85% x 1.15 = .98
15% x 1.36 = .20
1.18 x 6% = .07

Middle Brazos Area

2% x 1.49 = .03
84% x 1.58 = 1.33
14% x 1.56 = .22
1.58 x 60% = .95

Lower Brazos Area

1% x 2.17 = .02
84% x 1.69 = 1.42
15% x 1.84 = .28
1.72 x 34% = .58

Total Basin 100% = 1.60

The resulting factor of 1.60 has been used to project the future economic development for the entire area affected by the Brazos River system of projects.

SOURCES

1. County Population - Bureau of Census
2. Urban Population - Bureau of Census
3. New Construction - Data is in form of building permits from large percentage of towns and cities, compiled monthly by Bureau of Business Research, The University of Texas
4. Value Added by Manufacture - Census of Manufacturers, 1919, 1929, 1958. City and County Data Books, 1947, 1956
5. Mineral Production - Minerals Year Books 1952 thru 1958 - Bureau of Mines, Department of Interior
6. Retail Sales - City and County Data Books 1947 & 1956. U. S. Census of Business 1958. Sales Management Magazine 1959
7. Bank Deposits - Texas Almanac Annual with Federal Reserve Bank of Dallas the prime source. City and County Data Books 1947 & 1956
8. Per Capita Disposable Income - Sales Management Magazine for the years indicated
9. Highway Traffic - Count is taken from annual traffic map published by Texas Highway Department
10. Yield Per Acre - Value Crops Harvested from U. S. Agricultural Census and Cropland Harvested, same source
11. Rural Level of Living - City and County Data Book 1956
12. Value of Farm Property - U. S. Agricultural Census

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APPENDIX IV

REPORTS OF OTHER FEDERAL AGENCIES

MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS

SAN GABRIEL RIVER

LOWER BRAZOS RIVER SYSTEM

TEXAS

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

In Cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer District - Fort Worth, Texas

JULY 1960

INTRODUCTION

General

In a letter dated June 8, 1959, the District Engineer, Fort Worth District, Corps of Engineers, asked for the views and recommendations of the Public Health Service on present and prospective needs for municipal and industrial water supply for Georgetown, Taylor, and Granger, Texas. The Public Health Service was also asked to determine the desirability of meeting these needs from the Laneport project located at mile 29.1 of the San Gabriel River. At a meeting held in the Southwestern Division Office of the Corps of Engineers on December 22, 1959, the decision was made to base the study on proposed M. & I. storage at two upstream sites on the North San Gabriel and South San Gabriel Rivers instead of the Laneport site. At the same time, it was decided that the scope of the study should be broadened to include investigation of downriver needs for water supply. As the work progressed, the desirability of approaching the problem from a regional viewpoint became apparent.

This report, for the San Gabriel River, is one of a series of three companion reports on projects being studied for the tributaries of the lower Brazos River. Other reports of the series will be concerned with the Navasota River and Yegua Creek. These projects are related from a water supply standpoint, in that a common market for municipal and industrial water will exist in the lower Brazos River Basin.

This study was made in accordance with the provisions of the Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare, to provide assistance in implementing the Water Supply Act of 1958.

Acknowledgments

Listed below are the names of individuals and organizations who provided information necessary to the preparation of this report. Their cooperation and assistance are gratefully acknowledged.

Geological Survey, U. S. Department of the Interior, Austin, Texas

U. S. Study Commission - Texas, Houston, Texas

Texas State Department of Health, Austin, Texas

Brazos River Authority, Waco, Texas

City officials - Georgetown, Texas

City officials - Granger, Texas

City officials - Taylor, Texas

Freese, Nichols, and Endress, Consulting Engineers, Fort Worth, Texas

William F. Guyton and Associates, Consulting Ground Water Hydrologists, Austin, Texas

E. Jack Turner, General Water Superintendent, Dow Chemical Company - Plant at Freeport, Texas

R. Sugt, Aluminum Company of America - Plant at Rockdale, Texas

SUMMARY AND CONCLUSIONS

Summary

1. This report is concerned with questions of water supply storage on the San Gabriel River, a tributary of the Brazos. Water requirements are given in two parts -- namely, the local area in the San Gabriel watershed, and the overall area of the lower Brazos River Basin, from Waco to the Gulf.

2. The projected water requirements for the local area, consisting of the cities of Georgetown, Taylor, Thrall, and Thorndale are 8.2 mgd by the year 2010. Of this amount, it is probable that the 2.7 mgd of projected need by Georgetown will be supplied by ground water from the Edwards formation. 7/

3. For the lower Brazos area as a whole, it is projected that about 1,102 mgd will be needed by 2010.

4. The aggregate firm yield from surface reservoirs, existing and proposed, totals slightly over 510 mgd. The maximum capability of ground water in the area is unknown, but is believed to be on the order of 50 mgd.

5. The deficiency of supply to future demand indicated above, is partially offset by the fact that the figures represent gross takeout from sources, a portion of which will be returned to the stream for subsequent re-use. Nevertheless, additional measures will be required to increase the dependable supply if growth is to occur as projected. In this connection it may be noted that a regulated surface supply of 510 mgd is a small part of the average annual runoff of about 4,600 mgd.

Conclusions

1. Storage for water supply, in the maximum amounts which can be economically provided, should be included in all projects planned for the lower Brazos River system.

2. The quality of San Gabriel River water is satisfactory for municipal and industrial water supply purposes. The maintenance of acceptable stream

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quality in the main stem of the lower Brazos is a problem which calls for careful attention by the responsible agencies. Additional information on this problem is needed and should be provided by the studies now in progress for the U. S. Study Commission - Texas.

3. Based on the economic analysis of a regional alternative plan for water supply, the average present values of benefits are shown below the water supply storage of the five reservoirs considered in this study. Further details are given in the last chapter of this report.

Reservoirs	Average Annual Present Value	Yield (mgd)	Present Benefits (¢/1000 gal. of Yield)
Stillhouse Hollow	$ 515,000	63	2.24
Somerville	414,000	34	3.34
North San Gabriel	284,000	19	4.10
Millican	826,000	226	1.00
South San Gabriel	120,000	11	2.99
Sum or Average	$2,159,000	353	1.68

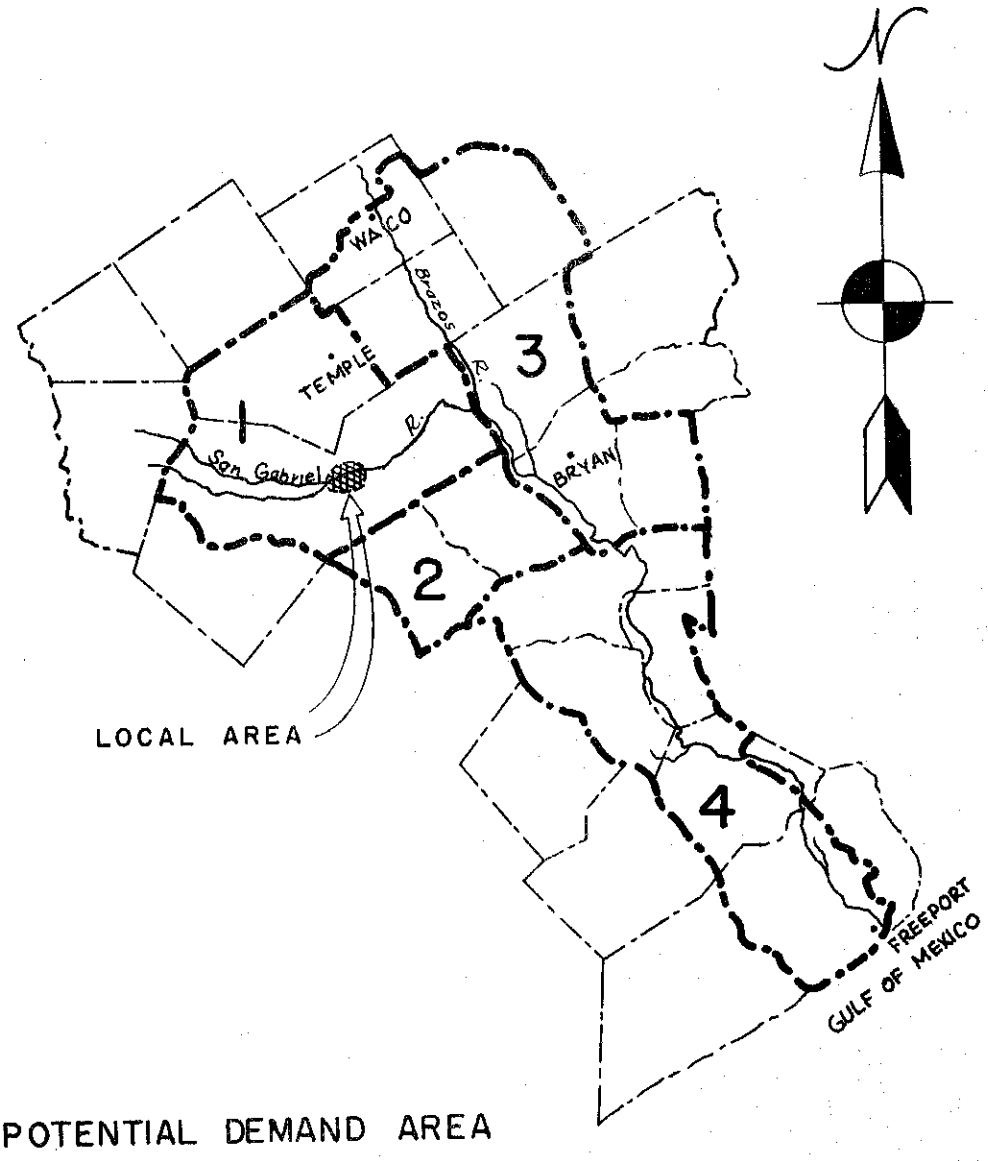
THE STUDY AREA

General Description

The two dam sites on the San Gabriel are located approximately three miles west of Georgetown, Texas, on the North and South Forks of the river. Their locations and the total area encompassed by this study are shown on Figures 1 and 2. The boundary was chosen so as to include the entire area which might be served, through one integrated plan, from reservoirs in the San Gabriel River watershed, Millican Reservoir on the Navasota River, Somerville Reservoir on Yegua Creek, Stillhouse Hollow Reservoir on the Lampasas River, the existing Belton Reservoir on Leon River, and the enlarged Lake Waco. Probably the major water demand centers of this area will develop in the vicinities of Waco and Freeport; therefore, it was decided to make the length of the study area run roughly from Waco in the north to Freeport on the southern coast. The east-west boundaries generally follow the boundary of the Brazos River Basin with consideration being given to the political boundaries which nearly coincide with this basin boundary. It was desirable to make the total study area boundary follow county or precinct lines in order to facilitate the use of U. S. Bureau of Census population data.

The total study area includes Limestone, Falls, Bell, Williamson, Milam, Robertson, Brazos, Grimes, Burleson, Washington, Waller, and Austin Counties. Also included are portions of McClennan, Lee, Fort Bend, and Brazoria Counties.

The local area, as shown on Figure 2, includes those cities immediately downstream from the reservoirs being studied. Specifically, these cities are: Georgetown, Round Rock, Taylor, Thrall, Thorndale, and Granger. Round Rock apparently will not need an additional water supply source. The existing ground water supply there seems adequate to meet all expected future needs. Granger is excluded from the detailed determination of local water requirements because it was found that the population of this city has been declining and probably will continue to decline. The other cities mentioned above were included in this study for two reasons: (1) their apparent need for additional water supply sources beyond what they have developed at present, and (2) the possibility that water from the project(s) under study could be supplied directly to these cities through a pipeline or pipelines. The relative locations of the local area and the total study area are shown on Figure 1.



POTENTIAL DEMAND AREA
LOWER BRAZOS RIVER
NO SCALE

VICINITY MAP

U.S. DEPARTMENT OF
HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 1

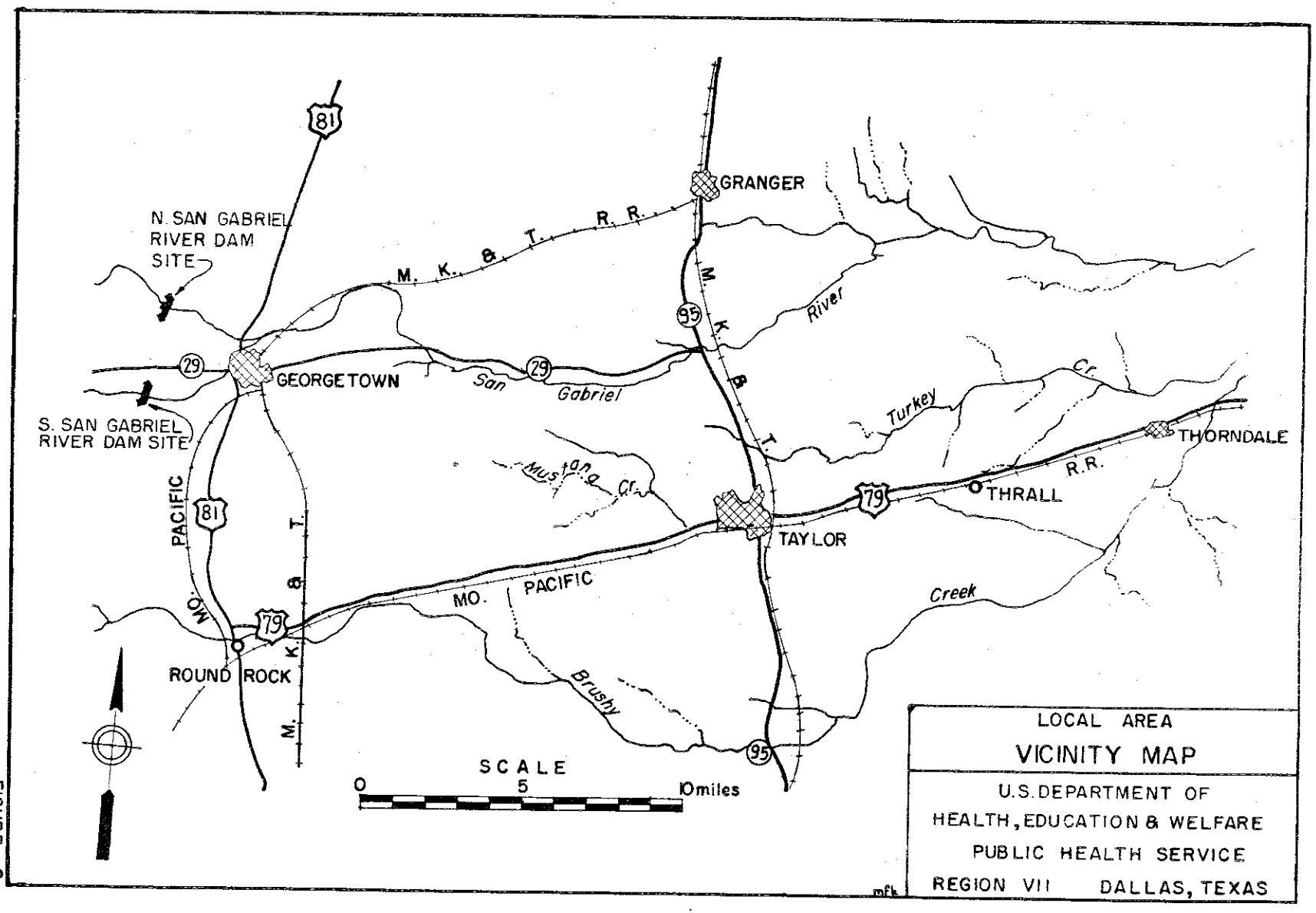

81
N. SAN GABRIEL RIVER DAM SITE
M. K. & T. R. R.
GRANGER
M. K. & T.
95
River
29
GEORGETOWN
San Gabriel
29
Cr.
Turkey
S. SAN GABRIEL RIVER DAM SITE
THORNDALE
Mustang Cr.
PACIFIC
81
T.
R.R.
79
THRALL
TAYLOR
MO. PACIFIC
Creek
MO.
79
K.
ROUND ROCK
M.
Brushy
95
SCALE
0
5
10miles
LOCAL AREA
VICINITY MAP
U.S. DEPARTMENT OF
HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 2

Description of Local Area

The San Gabriel River traverses the local area from west to east where it flows into Little River, which in turn discharges into the Brazos River. The maximum discharge of the San Gabriel River was recorded by the U. S. Geological Survey on September 10, 1921, at their gaging station 1 3/4 miles northeast of Georgetown; this discharge was 160,000 cfs. The river has also been dry for periods of three or four days' duration on several occasions. However, these dry spells have been infrequent because the San Gabriel River is spring-fed. The average flow in this river for the period of 1934-1957 has been 130 cfs. Several smaller streams (Brushy Creek, Mustang Creek, and Turkey Creek) also cross this local area from west to east.

The terrain ranges from hilly in the western portion to level in the eastern part. The soil type varies from a thin limestone soil in the west to a blackland soil in the eastern section.

The climate creates an environment favorable for the growing of plants about 255 days per year.9/ The mean annual temperature is approximately 66 degrees and the normal annual rainfall of this area is approximately 33 inches.9/

The economy of the area is predominately agricultural. There has been a steady decrease in the farm population, number of farms, and cropland harvested. The farm population is decreasing due to the increasing mechanization in farming. However, with relatively greater profitability in livestock production, cattle ranching and dairy farming are replacing field crop production.

With an increased national demand for livestock products, the agricultural economy of the area is expected to stabilize and the agriculture population will cease to decline and will level off.

The economy of the remaining area reveals signs of modest development in the activity of industry and the extracting of minerals. Income to the area is derived from limestone quarrying, the production of aluminum, a small amount of oil production and coal mining.

The aluminum plant depends on coal to produce its necessary electrical energy. With abundant deposits of coal, a significant increase in the number of mining employees will occur; however, due to mechanization in this industry, the level of employment in mining should stabilize by 1975. There will be a decrease in oil production employees, caused by the depletion of oil deposits; therefore, the total number of employees in these industries should show a decrease in the future.

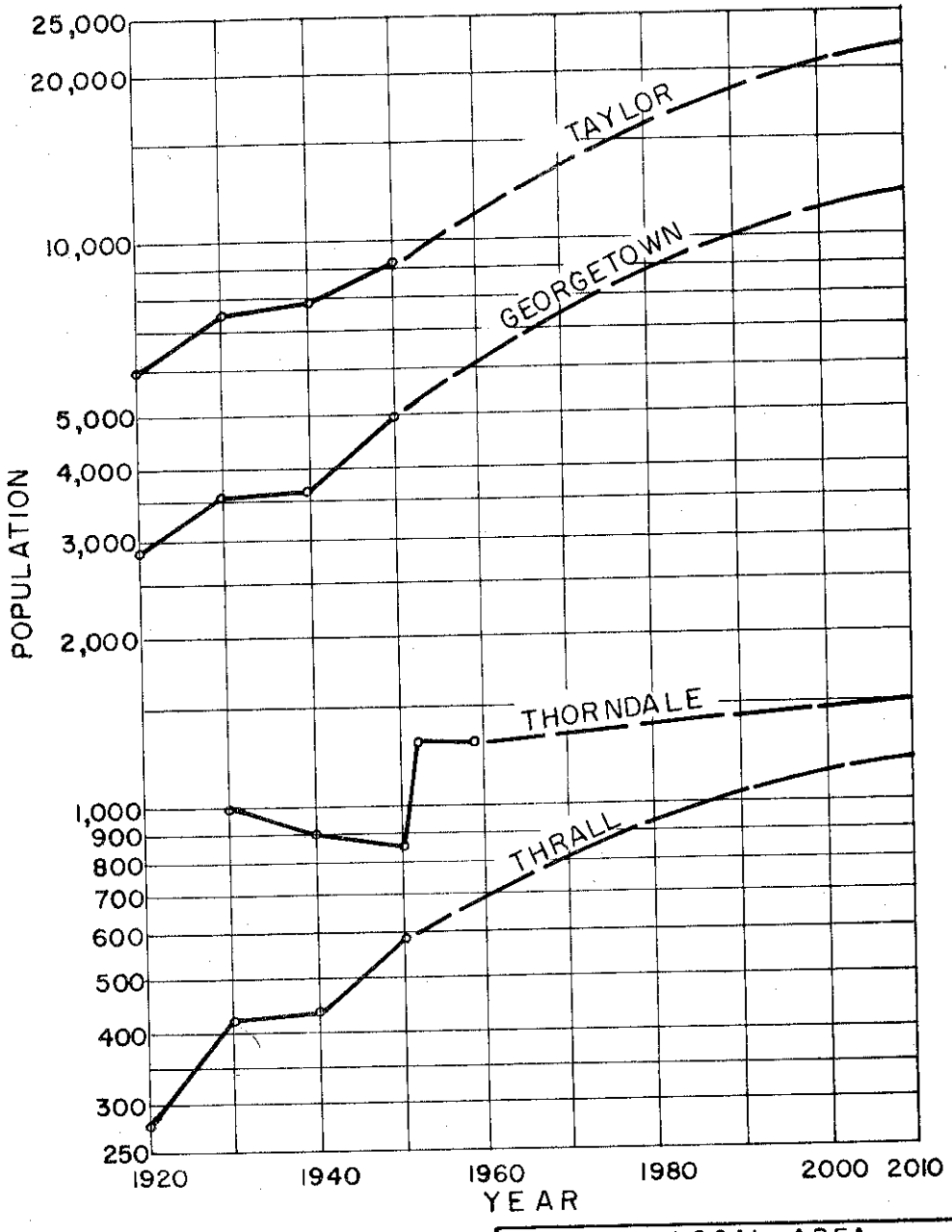
With the presence of excellent livestock production, the potential for milk and poultry industries exists. These industries may take advantage of the existing markets near the study area.

Transportation facilities in this local area are reasonably good, but not exceptionally better than many other places in the state. U. S. Highway 81 runs north and south through this area, while U. S. 79 runs east and west. The Missouri, Kansas and Texas Railroad Company and the Missouri-Pacific Railroad Company have lines that run through this area. Commercial air transportation by scheduled airlines is available in Austin.

The population of this area was approximately 30 per cent urban in 1950. Urbanization has been increasing over the past years and probably will increase in the future. This trend is partially caused by the in-migration of people from the adjacent rural areas. However, not all the population leaving the farms goes to immediately adjacent municipalities; a portion of these people migrate to cities outside this local area. This explains why the total population of the area has been decreasing while the urban population (in absolute numbers and percentage of total population) has been increasing.

The historical and anticipated populations for Georgetown, Taylor, Thrall and Thorndale are shown on Figure 3. The expected growth curves shown for Taylor, Georgetown, and Thrall were based on historical growth, field investigations, and on projections 2,3/ made by the Bureau of Business Research of the University of Texas for the city of Taylor and the Austin Trading Area. Thorndale's population growth has been, and will be, affected by the aluminum plant located nearby. During the construction of the aluminum plant, the population of Thorndale was greatly increased. It is our opinion that, with an ample water supply and because of the presence of the aluminum plant, Thorndale will grow as depicted on Figure 3.

Table 1 presents data concerning the present water supply sources of the cities in the local area under discussion. Comparison of the capacities shown in Table 1 with the average daily water requirements in Table 2 shows that the present facilities can nearly meet the average daily demands. However, during peak demand periods these present facilities have been used to their full capacity and will not be adequate during future droughts and other periods of high demand. The Edwards limestone underground aquifer yields water of acceptable quality for water supply, although somewhat harder than is desirable. In contrast, underground water in the vicinity of the other cities contains dissolved mineral constituents in concentrations so high as to make it unacceptable without prohibitively expensive demineralization.



LOCAL AREA

POPULATION TRENDS

U.S. DEPARTMENT OF
HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

mfk

FIGURE 3

Table 1

Present Water Facilities - Local Area

City	Present Source	Capacity (mgd)	Quality
Georgetown	2 Wells (Edwards Limestone)	2.16 7/	NO_3>20ppm; high hardness; T.S., Cl, and SO_4 are acceptable.
Taylor	3 Wells (Trinity Sand)	3.70 4/	High SO_4; high F; high T.S.; high Fe; Mg, Cl, and NO_3 are acceptable.
Thrall	2 Wells (Trinity Sand)	.06 11/	No data.
Thorndale	Small reservoir	Unknown	No data.

Description of Lower Brazos River Area

The Brazos River flows in a general southeasterly direction through this area to the Gulf of Mexico. In this area of the Brazos River Basin, the terrain changes from rolling hills in the northern portion to a flat coastal plain surrounding Freeport in the southern section. The slope of the river bed varies from approximately 1.2 ft. per mile near Waco to less than 0.5 ft. per mile near the Gulf. The average flow over 35 years of record at Richmond has been 7,173 cfs, as measured by the U. S. Geological Survey. At Juliff, a city below Richmond, the river has, at times, been dry due to heavy pumping withdrawals. 14/ The records of both gaging stations reflect the effect of regulation by upstream reservoirs.

Within the area, three major tributaries enter the main stem of the Brazos River. Proceeding upstream in order of confluence, these are the Navasota River, Yegua Creek, and Little River. The San Gabriel is a tributary of Little River.

The table-like topography of the area below Waco, along the main channel of the Brazos River, does not afford economical reservoir construction sites. 13/ The flood plain has extensive agricultural development, many highways, railroads, and communities which deter the possible use of this area for reservoirs. For the above reasons, the reservoirs, existing and planned, previously mentioned as being possible surface water sources for the area, are located a number of miles upstream from the major potential water customer, that is, the industrial complex centered in the cit of Freeport.

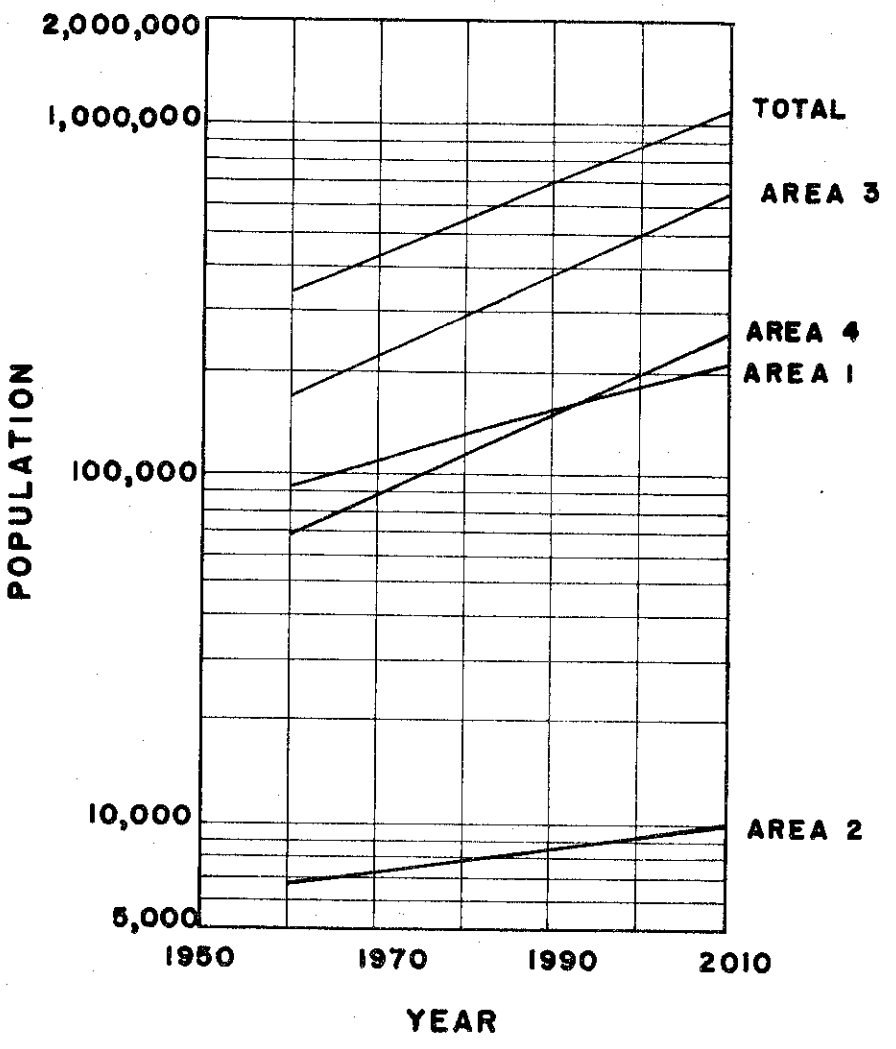
The lower Brazos area is characterized by a mild and fairly uniform climate. The mean annual temperature varies from about 70 degrees in the coastal area to 66 degrees in the vicinity of Waco.[9] From Waco to the Gulf Coast the normal annual rainfall varies from approximately 33 inches to 47 inches.[9] The average length of the growing season ranges from 260 days in the northern portion to 320 days near the coast.[9]

The economy of this area is based upon a wide variety of activities. Agriculture is one of the most important activities and is practiced, to some extent, over the entire area. However, it is most prominent in the northwest and central portions of the study area. The northeast section of the area, surrounding Waco, is underdeveloped industrially, but potential exists.[2] The manufacturing of furniture, apparel, paper, and rubber products also supports the economy of the area near Waco. West of Waco, near Killeen, military installations are an important factor in maintaining that area's economy.[2] In the southern portion of the total study area, the basis for the economy turns from agriculture to the mining of sulphur, the production of oil and gas, oil refining, petrochemical plants, and the extraction of magnesium from seawater.

The future growth of the economy of the area will depend on the growth of its various segments. It is felt that the productivity of the agricultural industry will become stable in the future, but the number of agricultural employees will decrease due to further mechanization in that field of endeavor.[2] It is probable that the industries producing stone, clay, and glass products near Waco will enjoy substantial growth because of the good base already present and because of the availability of supplies of the raw materials necessary for the operation of these industries. The manufacturing activities in the Waco area may also show accelerated growth from the already present base because of the expectation that the markets for these products will expand. Farther south, in the area between Rosenburg and Freeport, it is expected that the petrochemical industries will expand production tenfold by 2010 because of the plants already located there and the plentiful supply of oil and gas in the area. The magnesium extraction could also grow, since all the necessary materials for production are present locally.

Population projections were made for each of the four subdivisions (shown on Figure 1) of the total area. The projected populations given herein include all people who live in organized communities (which would have public water supply systems) and exclude those living outside of such communities. The expected population trends are shown on Figure 4.

In making these forecasts, consideration has been given to published documents,[2,3] historical growth patterns, and information obtained in field investigations. They are, of course, influenced also by the future economic growth just described.



LOWER BRAZOS RIVER AREA

POPULATION TRENDS

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 4

PAST AND FUTURE WATER REQUIREMENTS

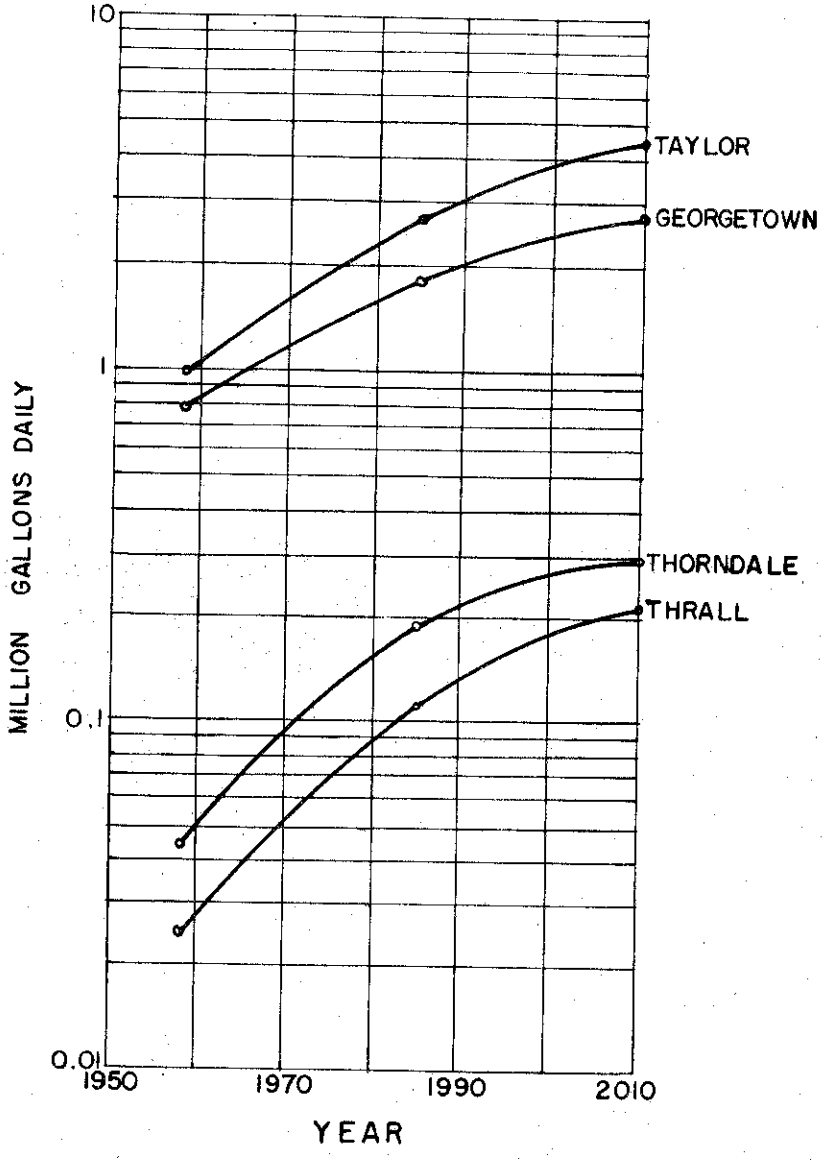
Local Area

Table 2 and Figure 5, following, show the historical and future water requirements of Georgetown, Taylor, Thrall, and Thorndale. The 1958 usage shown was estimated by the city concerned and includes nonindustrial water use plus industrial water use where industry is present. The Public Health Service estimated that these municipalities will have the following amounts of industrial water usage: Georgetown, 20 per cent of total requirement; Taylor, 10 per cent of total; Thrall, no industrial water use; and Thorndale, a constant 0.02 mgd of industrial water usage. The domestic per capita consumption figures shown in Table 2 were arrived at by projecting (for each city) from the present level of per capita use to 180 gpcd, which was considered a common rate of domestic usage for all these cities in the year 2010.

Table 2

Local Area Water Requirements

City	Population	Domestic Use (gpcd)	Total Average Daily Water Requirement (mgd)
		Year 1958	
Georgetown	6,000	---	.789
Taylor	11,000	---	.987
Thrall	550	---	.025
Thorndale	1,300	---	.044
Total	20,450		1.945 mgd
		Year 1985	
Georgetown	9,300	155	1.800
Taylor	17,000	143	2.700
Thrall	990	115	.110
Thorndale	1,400	120	.190
Total	30,940		5.100 mgd
		Year 2010	
Georgetown	12,000	180	2.700
Taylor	22,000	180	4.400
Thrall	1,200	180	.220
Thorndale	1,500	180	.290
Total	39,700		8.210 mgd



LOCAL AREA

WATER REQUIREMENTS

U.S. DEPARTMENT OF
HEALTH, EDUCATION & WELFARE

PUBLIC HEALTH SERVICE

REGION VII DALLAS, TEXAS

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FIGURE 5

Lower Brazos River Area

The municipal and industrial water requirements for this area are shown in Table 3 and on Figures 6 and 7. The requirements are indicative of gross intake by water users and do not reflect that a substantial amount of the water used by upstream consumers will be returned to the stream -- eventually to be re-used by downstream users.

The gross requirements were separated into industrial and nonindustrial water uses. Basic industries (the industrial water users) are defined as those that produce on a relatively large scale and sell their products outside the trading area in which they are located -- thus bringing income into that area. Nonbasic industries (nonindustrial water users) are those which supply goods and services only to residents of the trading area, and are supported primarily by the respending of income generated by basic industries.

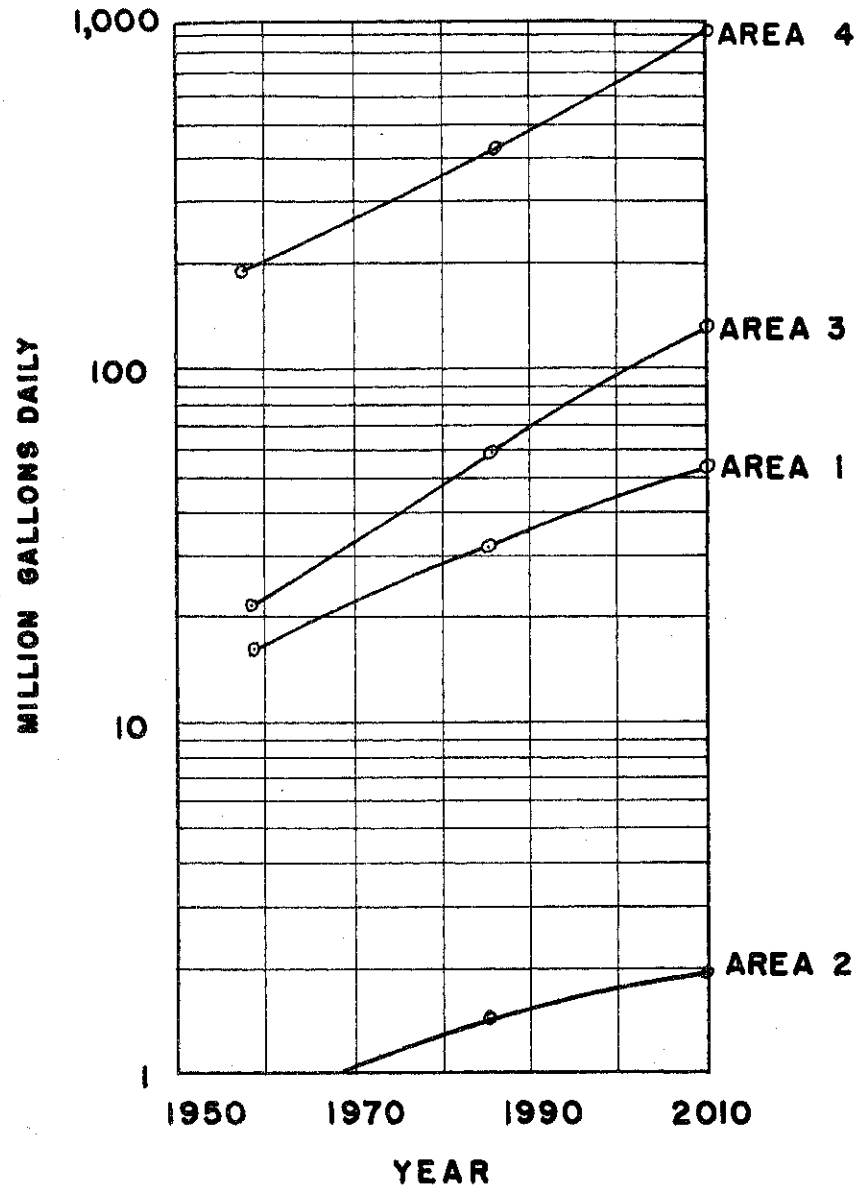
The projected industrial water requirements were obtained after careful consideration of the growth potential in sixteen of the basic industrial categories which use over 90 per cent of the industrial water in the area. The present level of development in each category was compared to development on a national level, so as to obtain an indication of the relative share of the national market that each category holds. Those industrial categories which have less than their share of the national market were projected at a higher rate of growth than expected nationally. Those categories which have more than their share of the national market are expected to maintain their relative percentage of the market in the future. Once a trend in production was assumed for a particular industrial group, a trend in water use was projected. In industries that are large water users this trend, expressed as water requirements per unit of production, was lowered in anticipation of more efficient water use (e.g., cooling towers and other methods of cooling). Data collected in the field were utilized in making these projections. In addition, trends in production and water use as shown in Water Resources Activities in the United States [15] were studied.

The nonindustrial water requirements for this area were prepared through the use of the previously mentioned projected populations and nonindustrial per capita water consumption figures. An average per capita use of 120 gpcd was used for the entire area in 1958 based on data reported to the Texas Health Department by typical cities in the area.

Table 3

Lower Brazos River Area Water Requirements

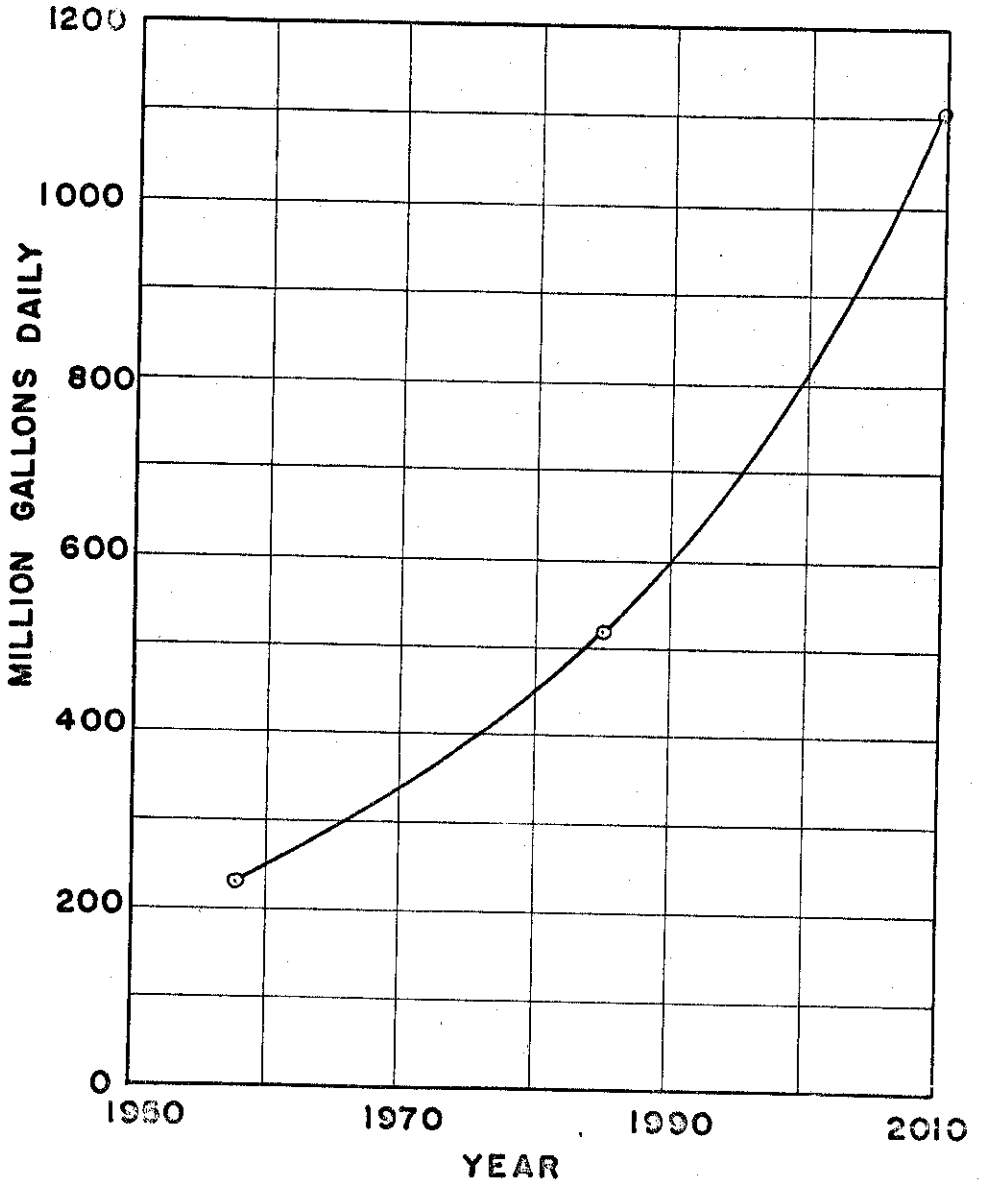
Sub-Area	Forecast Population	Nonindustrial Use (gpcd)	Average Annual Water Requirement (mgd) Nonindustrial	Industrial
		Year 1958		
1	90,000	120	10.8	5.5
2	6,700	120	0.8	0.01
3	163,000	120	19.6	1.9
4	66,500	120	8.0	181.0
	326,200	Estimated Total Requirements, 1958 - 227.6 mgd		
		Year 1985		
1	143,000	162	23.2	9.7
2	8,300	153	1.3	0.06
3	330,000	162	53.5	4.3
4	136,000	149	20.3	406.0
	617,300	Estimated Total Requirements, 1985 - 518.4 mgd		
		Year 2010		
1	213,000	190	40.5	13.0
2	10,200	170	1.7	0.2
3	660,000	190	125.4	7.3
4	260,000	165	42.9	870.7
	1,143,200	Estimated Total Requirements, 2010 - 1,101.7 mgd		



LOWER BRAZOS RIVER AREA
WATER REQUIREMENTS

U.S. DEPARTMENT OF
HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 6



LOWER BRAZOS RIVER AREA
TOTAL MUNICIPAL & INDUSTRIAL
WATER REQUIREMENTS

U.S. DEPARTMENT OF
HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 7

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WASTE DISPOSAL

Local Area

The wastes that are discharged from the municipalities in the local area are primarily organic. They are received by Brushy Creek, Mustang Creek, and Willis Creek, which are small tributaries to the San Gabriel River. Granger discharges its wastes after treatment by an Imhoff tank followed by filtration.[10] Since Willis Creek flows into the upper end of the proposed Laneport Reservoir, there is a possibility that a localized pollution problem may develop where this creek empties into the reservoir. Georgetown treats its waste by the method of land irrigation [10] and it is assumed that none of these wastes will reach the San Gabriel River. Round Rock and Thorndale discharge their wastes, after primary treatment,[10] into Brushy Creek; it is felt that these wastes could possibly create a water quality problem in Brushy Creek. However, the effect of these wastes on the San Gabriel River probably will be insignificant. Taylor treats its wastes similarly to Granger, [10] and then discharges them into Mustang Creek, which remains dry much of the time. It is expected that no problem will arise from waste discharges of Taylor. In the future, the municipal wastes discharged into the receiving streams of the local area are not expected to deteriorate the water quality seriously. The methods of waste treatment and treatment plant operation may be expected to improve, leading to higher quality effluents being discharged from these municipalities located in the local area.

Lower Brazos River Area

Due to high concentrations of dissolved solids, principally caused by salt springs and gypsum outcroppings located in the upper reaches of the Brazos River, the water in the main channel is largely unsatisfactory for municipal and industrial use upstream from Whitney Dam. [13] This point will be more fully discussed later in this report.

In the reach of the Brazos River between Waco and a point near river mile 20 (which marks the approximate limit of upstream intrusion into the main channel by sea water) the disposal of treated organic wastes produced by the population in the area, and to some extent by chemical industries, could degrade the water quality -- unless stream flows are maintained at a level where they are able to assimilate the wastes. It is assumed that these organic wastes will be treated for the removal of 90 per cent of the B.O.D. (biochemical oxygen demand). Studies are now underway which will furnish estimates of the amounts of water needed to maintain quality objectives after the wastes are treated. These studies are being made

as a part of a comprehensive consideration of water quality in Texas intrastate streams for the U. S. Study Commission - Texas. Water quality data being collected by the Texas State Health Department will be greatly utilized in these studies.

In the reach of the Brazos described in the preceding paragraph, manufacturing is the most prevalent type of industry. The existing manufacturing processes do not produce large amounts of organic waste. The mineral wastes resulting from future manufacturing, which is expected to be in the primary metals, will (presumably) be treated to such an extent that no adverse stream conditions will be created.

The petrochemical industry is expected to expand tenfold within the next 50 years along the Gulf Coast of Texas. The segment of the Brazos River which will be affected by the large amounts of wastes from this industry will be principally the area where sea water intrudes the fresh water of the Brazos River. The usefulness of this water probably will not be impaired due to quality characteristics, provided the organic wastes from the petrochemical industry are given adequate treatment before being discharged to the river. This is because a major portion of the water used in this area is for cooling purposes for which it is possible to use a water with a relatively high mineral content.

The foregoing statements are subject to qualification in the event that a salt-water barrier is built, to bring the high quality fresh water channel closer to the coast. In that case, it would be necessary to divert the industrial wastes to a separate channel.

THE SAN GABRIEL RIVER AS A SOURCE OF WATER SUPPLY

Quantity of Water Available

The North and South San Gabriel Reservoirs can furnish a combined yield of 26 cfs (16.8 mgd) or a combined yield of 47 cfs (29.7 mgd), depending on which of two possible construction plans is finally adopted. It is estimated that the combined needs of Georgetown, Taylor, Thrall, and Thorndale will be about 8.2 mgd by the year 2010.

The total municipal and industrial water requirements of the entire Lower Brazos River Area, as defined on Figure 1, are expected to be 1,102 mgd by the year 2010. The existing and proposed water supply sources for this area are presented in Table 4. The estimated yields shown for the surface water impoundments are from only the water supply (conservation) storage volume included in each reservoir. A portion of the yields from this conservation storage space is presently allocated to meet irrigation needs. It is infeasible at this time to estimate whether an increase or a decrease will take place in the volume of water allocated to irrigation uses.

Table 4

Existing and Proposed Water Sources
Lower Brazos River Area

Source	Estimated Yield (mgd)
Lake Waco (existing enlarged)	55
Lake Belton (existing enlarged)	105
Stillhouse Hollow Reservoir (proposed)	63
San Gabriel River Project(s) (proposed)	30
Navasota River Project (proposed)	226
Somerville Reservoir (proposed)	34
Ground Water (present and future development)	50
Total	563 mgd

It can be concluded from comparing the expected total water requirements of 1,102 mgd by 2010 with the total estimated yield of 563 mgd, that a demand exists for the maximum feasible amount of municipal and industrial water supply storage that can be economically developed in the proposed project(s) on the San Gabriel River.

Quality of Water

The chemical quality of San Gabriel River water is good at present and should remain so in the future. Data from the Texas State Department of Health indicate that this water meets the Public Health Service standards for drinking water with respect to the concentrations of total dissolved solids, chlorides, and sulfates. A summary of analyses of these data is shown in Table 5.

Table 5

Chemical Quality - San Gabriel River at Georgetown, Texas
(Period of Record - 9/6/57 through 10/19/59)

	Total Solids (ppm)	Chlorides (ppm)	Sulfates (ppm)
Maximum	426	40	31
Minimum	99	4	14
Arithmetic Average	321	25	24

The high mineral concentrations prevalent in the water of the main channel of the Brazos River above Lake Whitney place severe limitations on using it for municipal and industrial purposes. These high concentrations are caused by salt springs located upstream from Lake Whitney. Table 6 shows data collected by the U. S. Geological Survey.

Table 6 1/

Chemical Quality - Brazos River Near Whitney, Texas

Water Year	Mean Daily Discharge (cfs)	Weighted Average Concentrations (ppm)	
		Chlorides	Sulfates
1948-49	1,566	242	172
1949-50	1,520	244	157
1950-51	840	437	260
1951-52	348	332	167
1952-53	141	209	112
1953-54	912	392	198
1954-55	997	374	205
1955-56	1,571	333	255
1956-57	6,213	126	96

As the water in the main stem proceeds downstream, water of higher quality enters the main channel and dilution takes place. The effects of this dilution water, from the tributaries, on the concentrations of chlorides and sulfates may be seen by comparing Table 6 and Table 7. The data shown in Table 7 are also from the U. S. Geological Survey.

Table 7 1/

Chemical Quality - Brazos River at Richmond, Texas

Water Year	Mean Daily Discharge (cfs)	Weighted Average Concentrations (ppm)	
		Chlorides	Sulfates
1948-49	4,645	103	76
1949-50	5,783	87	58
1950-51	1,418	214	134
1951-52	1,820	85	54
1952-53	4,105	31	25
1953-54	2,727	127	72
1954-55	2,168	145	83
1955-56	2,185	260	185
1956-57	15,290	65	54

As shown by the comparison of Tables 6 and 7, the chemical quality of the water in the main channel of the Brazos River improves as the water moves downstream and is diluted by water from tributary streams. Nevertheless, the concentrations of the chlorides and sulfates as far downstream as Richmond are still high enough to produce water of mediocre to poor quality. Unless and until the upstream sources of contamination are eliminated, the quality of Brazos River water will remain at such a level as to make questionable a decision to use this water for municipal and industrial purposes. Studies made jointly by the Brazos River Authority, the Texas State Department of Health, and the U. S. Geological Survey have located the sources of contamination. It is felt that water quality impairment by these sources will be reduced and that the chemical quality of the Brazos River water will improve in the future. This should make possible the utilization of a substantial portion of the runoff in the main stem, which averages about 1,100 mgd above Waco, Texas.

VALUE OF STORAGE

General

The preceding sections of this report have shown the projected water needs of the lower Brazos River area, and the physical feasibility of meeting a part of the need by storage in the multiple-purpose projects under study. The question of economic feasibility leads to consideration of the monetary value, or benefits, of water supply storage.

Efforts to approach this problem on the basis of market value of water have been notably unsuccessful. The cost of impoundment is typically a very small part of the costs of providing water service experienced by a municipal water supply company. Attempts to assign values for water in different uses encounter a wide diversity of uses. For example, household usage alone ranges from drinking water (whose value is immeasurable) to the recreational use of a lawn sprinkler which is turned on, not because the grass needs irrigation, but so that the children can play in it on a hot summer day.

It has been said that the limiting value of works constructed for the improvement of water supply is the maximum amount prudent users would be willing to pay for the improved or augmented service. However, precise measurement of benefits on this basis is difficult, if not impossible. The concept serves to place a ceiling (based on judgment) on the value of storage determined by the "alternative-cost" method.

The Alternative-Cost Doctrine

The 1958 report[8/] of the Subcommittee on Evaluation Standards states: "From an overall public viewpoint, a...water supply development will be economically justified if it provides water to meet expected needs at a cost not greater than the cost of the alternative source that would likely be utilized in the absence of the project." Applied to the problem at hand, the stumbling block in this quotation is the word "source".

In the overall picture, it seems certain that the increasing need for firm water supply in the lower Brazos Basin will first be met by additional impoundments of the runoff within the basin. It is not reasonable to assume that this water would be allowed to escape to the Gulf while other water was imported from, say, the Mississippi River. (This is not to be interpreted as ruling out the possibility of interbasin transfers of water.)

Nevertheless, the alternative-cost principle may be applied. Although there is considered to be no alternative water, there are ways to impound it other than by multiple-purpose projects. Unless

otherwise qualified in what follows, the word "Project" will mean the system of five federal reservoirs, Stillhouse Hollow, Somerville, Millican, North San Gabriel and South San Gabriel. In like manner, the word "Alternate" will refer to a hypothetical system of reservoirs which might, in the absence of the Project, be built for water supply only.

Alternative Plan for Water Supply

Meeting the water needs of the study area will apparently require the impoundment of water on each of the major tributaries of the lower Brazos. From a regional standpoint, no single reservoir can be regarded as an alternate to any other, because all will be needed. Hence the decision to look at all five together. The alternate is comprised of five single-purpose dams, located at the same sites as the Corps projects, each having a firm yield equal to that of the project dam. These sites are not the only possible ones for accomplishing the purpose, and validity of the method does not require that alternative sites be the same as project sites. They have been selected for convenience, because of known physical feasibility, and because detailed information for analysis is readily available.

The Fort Worth District Office of the Corps of Engineers furnished estimates of the cost of construction of each single-purpose dam. Table 8 shows these costs and the corresponding annual costs. The latter include operation, maintenance, amortization and interest, using a period of 50 years and an interest rate of 3 per cent.

Each of the aforementioned annual costs is considered to be the minimum annual benefit from water supply storage at the site, from and after the date on which the site might first be needed in the alternative plan.

Sequence of Construction

Although there is no reasonable doubt that all dams in the system would be needed in less than 50 years, it is equally clear that not all are needed now. For subsequent use, it is necessary to assume a sequence of construction and date of first utilization of each dam in the alternative system. Mathematically, there are 120 possible combinations of the five dams. Trial calculations to establish extremes indicate that a range of combined present values, on the order of 20 per cent, would result from different combinations.

The problem of adopting a schedule of sequence and date of construction involves a number of factors. There is a wide diversity in the sizes of individual reservoirs, with yields ranging from 11 to 226 mgd. As might be expected, the unit cost per thousand gallons of potential yield varies inversely with the capacity.

Table 8

Alternative Costs and Present Value

	Stillhouse Hollow	Somerville	North San Gabriel	Millican	South San Gabriel	Sum or Average
Order of Construction	(1)	(2)	(3)	(4)	(5)	
Yield, mgd	63	34	19	226	11	353
Construction Cost, Single-Purpose Alternative	$12,220,000	$11,220,000	$8,250,000	$27,060,000	$5,860,000	
Annual Capital Cost (50 years @ 3%)	475,000	436,000	321,000	1,053,000	228,000	
Annual O & M Cost	40,000	30,000	38,400	57,000	37,600	
Combined Annual Costs	$515,000	$466,000	$359,400	$1,110,000	$265,600	
Unit Costs, Cents/1,000 gal.	2.24	3.76	5.18	1.35	6.62	
Year of First Need	1960	1964	1968	1970	1987	
Years Until Utilized	0	4	8	10	27	
Present Worth Factor	1.000	0.888	0.789	0.744	0.450	
Present Annual Value	$515,000	$414,000	$284,000	$826,000	$120,000	$2,159,000
Present Benefits in ¢/1,000 gal. yield	2.24	3.34	4.10	1.00	2.99	1.68

The sequence which gives the lowest present (1960) value of all future costs, is that of scheduling dams in decreasing order of unit cost, i.e., from largest to smallest size. However, it is believed that this is not necessarily the sequence most likely to be chosen. Building the largest dam (Millican) first would give the least favorable capacity factor (ratio of actual use to capacity) over the longest period of time.

At the opposite extreme might be a sequence from smallest to largest size. Reference to Table 8 will show that the smallest, South San Gabriel, would yield 11 mgd at a unit cost of 6.62 cents per thousand gallons. It seems likely that this unit cost would be higher than the ceiling which the prudent user, mentioned in the introduction to this chapter, would be willing to pay. The engineer, making today a plan for meeting future water supply needs, would probably feel that it might some day be necessary to pay a price that high. But, more than likely, he would defer that project as long as possible.

To a somewhat lesser degree, the foregoing statements would apply to the North San Gabriel site. There, a reservoir to yield 19 mgd would cost 5.18 cents per 1,000 gallons. However, at this point, another facet of the problem should be considered.

A decision to defer construction of the dam on any one of the tributaries would involve the question of present need in the area immediately downstream on that tributary. Detailed study of all such local areas has not been completed at this writing. Local areas which have been investigated are Georgetown and Taylor on the San Gabriel, and Bryan-College Station and Navasota for the Navasota River. The present, and probable future, needs of Georgetown and Navasota can be met by ground water. Estimates of relative transmission costs indicate that Bryan-College Station could obtain water more economically from the main stem of the Brazos than from the Navasota River.

This leaves the Taylor area, in which the ground water is too highly mineralized for satisfactory use. This poses a problem for Taylor for which no answer is readily apparent, unless storage can be provided in one of the San Gabriel multiple-purpose reservoirs, at a cost substantially lower than the figures of 5 to 7 cents per 1,000 gallons. Otherwise, it is believed that some expedient would be found for meeting the relatively small needs of Taylor which would not require expenditure of several million dollars for a dam. For example, good quality ground water is available (from the Edwards formation) about eleven miles west of the city. Nevertheless, in consideration of the local area needs, especially Taylor, the North San Gabriel project has been inserted in the sequence for construction by 1968.

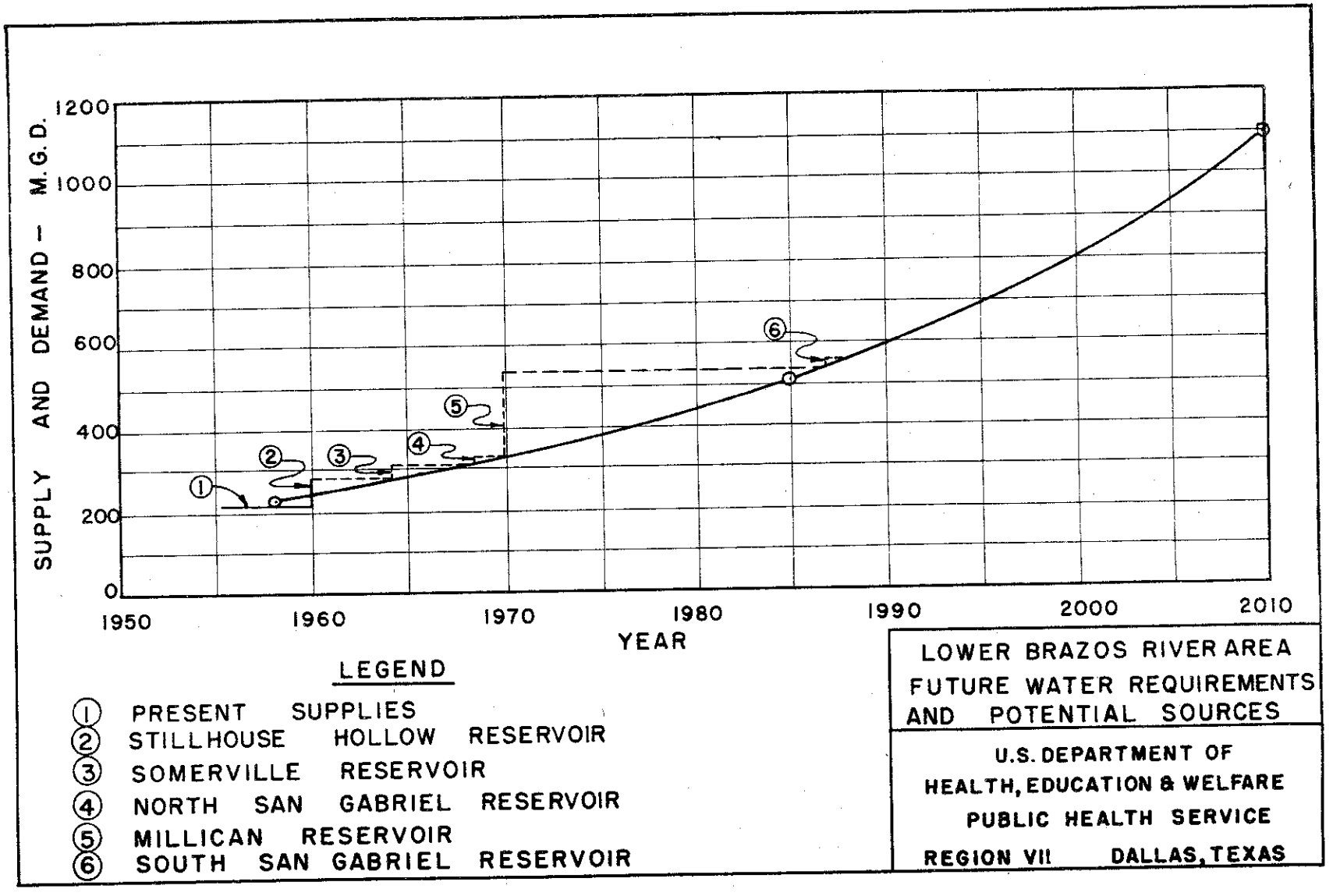
Translation of Alternative Costs to Multiple-Purpose Project Benefits

In spite of complexities and uncertainties, it is essential to formulate an alternative plan for the objective of determining the value of storage in the project. To this end, the sequence of construction of the alternative dams has been assumed to be as indicated in Table 8. The current year (1960) has been selected as the common time base, to which all future benefits are adjusted.

The adjustment of future benefits to present date was made by the method of capitalized costs, as described by Woods and DeGarmo in Introduction to Engineering Economy[16]. Fundamental to the method is the assumption that the physical life of a reservoir (as distinguished from amortization period) is indefinite, but would be longer than 50 years. An interest rate of 3 per cent was used for discounting. Superimposing the yields on a graph of future water requirements, in the adopted sequence, gives the date of first utilization of each reservoir (see Figure 8).

The combined present value of storage in the alternative plan is about 56 million dollars. For a combined yield of 353 mgd, this reduces to a unit value of 1.68 cents per thousand gallons.

It is therefore concluded that the present value (1960) of annual benefits from storage in the several reservoirs of the project will average at least 1.68 cents per thousand gallons of yield. Suggested individual benefits which make up this average are shown in Table 8.


SUPPLY AND DEMAND — M.G.D.
1200
1000
800
600
400
200
0
1950
1960
1970
1980
1990
2000
2010
YEAR
①
②
③
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⑤
⑥
LEGEND
① PRESENT SUPPLIES
② STILLHOUSE HOLLOW RESERVOIR
③ SOMERVILLE RESERVOIR
④ NORTH SAN GABRIEL RESERVOIR
⑤ MILLICAN RESERVOIR
⑥ SOUTH SAN GABRIEL RESERVOIR
LOWER BRAZOS RIVER AREA
FUTURE WATER REQUIREMENTS
AND POTENTIAL SOURCES
U.S. DEPARTMENT OF
HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 8

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SUPPLEMENT

TO REPORT ON

MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS

SAN GABRIEL RIVER

LOWER BRAZOS RIVER SYSTEM

TEXAS

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

In Cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer District - Fort Worth, Texas

DECEMBER 1960

I. INTRODUCTION

Purpose and Scope

The purpose of this supplement is to update and revise certain information presented in the original report.

These corrective measures became necessary when:

1. The non-federal interest rate used for discounting and determining annual costs was changed from 3 to 4 per cent.

2. A structure at the Laneport site was added to the plan which had originally called for just two reservoirs on the San Gabriel River.

3. A revised estimate was made of the amount of ground water that municipal and industrial interests might totally develop in the area by the year 2010.

4. The size and cost of the proposed Somerville project on Yegua Creek were changed.

The information provided herein is intended to revise only those sections or topics of the original report which are related to the four items mentioned above.

II. ADDITIONS AND REVISIONS

Addition of Laneport Reservoir

Laneport Reservoir, as presently planned, will be located at mile 29.1 of the San Gabriel River and will be able to furnish a safe yield from its conservation storage of approximately 23 mgd (million gallons per day). This 23 mgd, when added to the combined safe yield of approximately 30 mgd from the two upstream projects considered in the original plan, brings the total yield from the proposed projects in the San Gabriel watershed to approximately 53 mgd. This additional yield also increased the total yield of all the surface water impoundments considered as sources of supply to the lower Brazos River Basin to approximately 539 mgd.

Revision of Estimate of Ground-Water Availability

A revision of the estimate of the ground water that might be developed for municipal and industrial purposes became appropriate when new data were made available from work now in progress for the U. S. Study Commission - Texas. The original estimate was that on the order of 50 mgd of ground water might be developed by 2010, for the uses of municipal and industrial interests. It has become apparent in the re-evaluation of the ground-water problem that 50 mgd are presently developed for municipal and industrial purposes. It is estimated that in the future on the order of an additional 65 or 70 mgd might be developed in the lower Brazos River area for these uses. The future development of approximately 67 mgd would bring the total to 117 mgd of ground water that might be developed to help satisfy the requirements of municipal and industrial water users.

Revised Tabulation of Potential Sources

Table 4 of the original report (see page 15 of the original report) has been revised to include the additional 67 mgd that might be made available from ground water and the additional 23 mgd that Laneport Reservoir could provide to water users in the lower Brazos River Basin.

It can be concluded from comparing the expected total water requirements of 1,102 mgd by 2010, with the total estimated yield of 656 mgd, that a demand exists for maximum feasible amount of municipal and industrial water supply storage that can be economically developed in the proposed projects on the San Gabriel River.

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Table 4
(Revised)

Existing and Proposed Water Sources
Lower Brazos River Area

	Estimated Yield (MGD)
Lake Waco (existing enlarged)	55
Lake Belton (existing enlarged)	105
Stillhouse Hollow (proposed)	63
San Gabriel Projects (proposed)	53
Millican Reservoir (proposed)	226
Somerville Reservoir (proposed)	37
Ground Water (existing development)	50
Ground Water (future development)	67
	656

Revision of Benefits of Storage

With reference to the original report, the word "Project" now means a system of six federal multipurpose reservoirs and the word "Alternative" refers to a hypothetical system of six single-purpose reservoirs which might, in the absence of the Project, be built for water supply only. The six single-purpose reservoirs are considered to be at the same sites as their Project counterparts. Also, they are assumed to have the same firm yields as their Project counterparts.

After study, it now appears that an interest rate of 4 per cent applied to the financing of a private, non-federal project is a more realistic rate than the 3 per cent used in the original report. For converting capital costs to equivalent annual costs, an economically useful life of 50 years and a non-federal interest rate of 4 per cent were assumed. Also the change from a rate of 3 per cent to a rate of 4 per cent is applicable to the discounting procedures used herein.

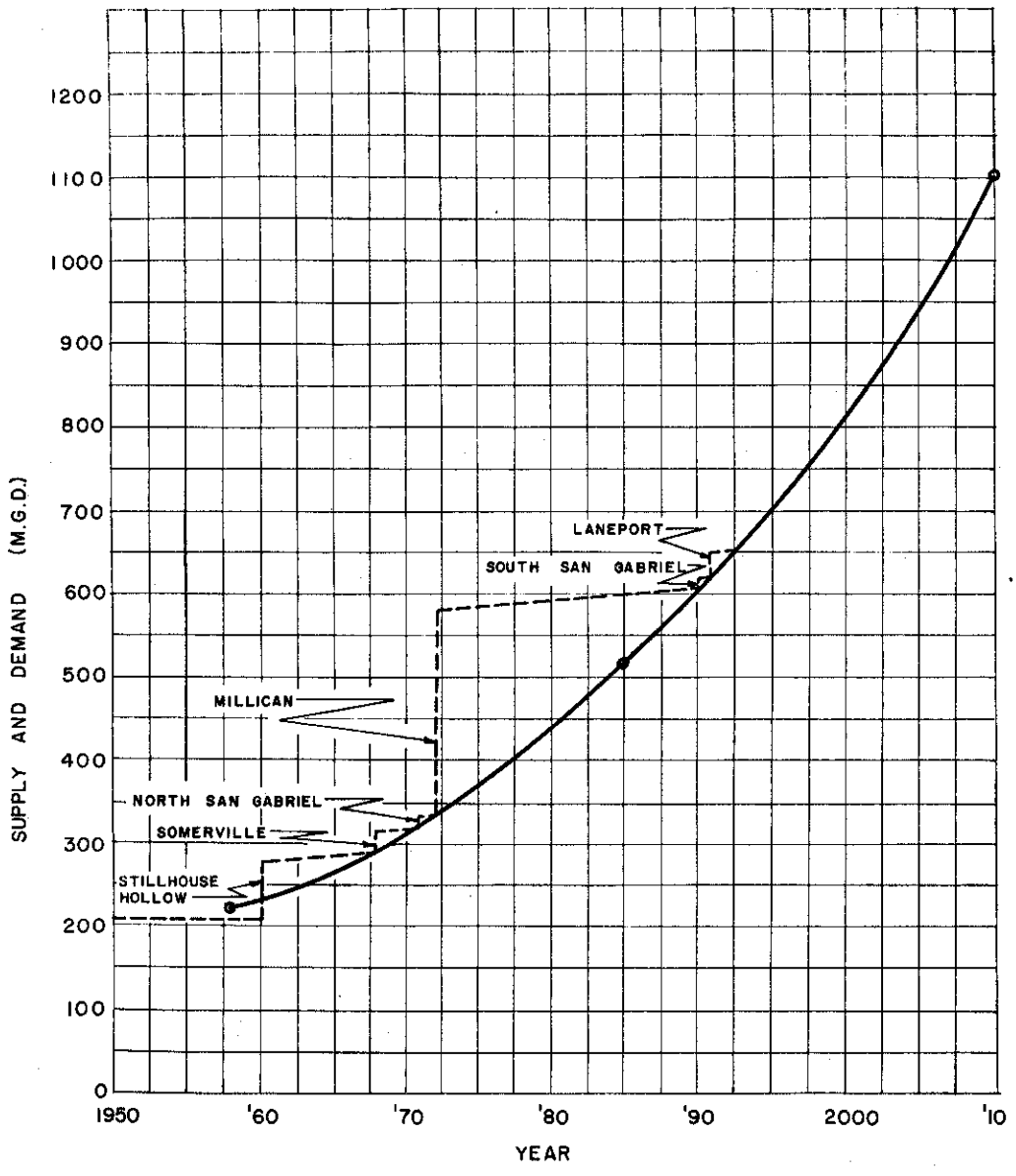
The single-purpose alternative (one of the six reservoirs comprising the Alternative) to the Laneport project has been added last in the hypothetical sequence of construction of the Alternative because it has the highest unit cost of the three alternatives considered in the San Gabriel watershed and because of its low use factor (ratio of actual use to capacity) over the longest period of time.

The 67 mgd from future ground-water development has been added in the hypothetical Alternative plan at a constant rate over a period of approximately 32 years. This accounts for the slope to the supply curve presented on the revised Figure 8. It is concluded that municipal and industrial interests will have completely developed this additional yield by the time that the yield from the last reservoir in the sequence is completely utilized.

Figure 8 has been revised to show also the changes in the quantities of the firm yields from the various sources. Superimposing these yields on a curve of future water requirements, in the previously mentioned sequence, gives the date of first utilization of each reservoir making up the Alternative (see Figure 8).

Table 8 has been revised to reflect the change in interest rate, the revised cost estimate and estimated yield from the proposed Somerville Reservoir project, the revised ground water estimate, and the addition of a structure at the Laneport site on the San Gabriel River. The benefits from each of the single-purpose reservoirs, which would begin being utilized at some date after the year 1965, have been discounted to the year 1965, using an interest rate of 4 per cent. Benefits attributable to each of the single-purpose reservoirs which would be utilized in or before the year 1965 have not been discounted. The discount periods used have been changed slightly from those in the original report, due to 67 mgd from ground-water sources being added to the sequence at a constant rate.

The combined 1965 value of storage in the Alternative plan is about 63 million dollars. For a combined yield of 379 mgd, this reduces to unit value of 2.12 cents per thousand gallons of yield. Individual benefits, which make up this average, are shown in the revised Table 8.



SAN GABRIEL RIVER
RESERVOIRS
FUTURE WATER REQUIREMENTS
and POTENTIAL SOURCES

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

HJS

FIGURE 8

Table 8
(Revised)

Alternative Cost and 1965 Value

	Stillhouse Hollow	Somerville	North San Gabriel	Millican	South San Gabriel	Laneport	Sum or Average
Order of Construction	(1)	(2)	(3)	(4)	(5)	(6)	
Yield, mgd	63	37	19	226	11	23	379
Construction Cost, Single-Purpose Alternative	$12,220,000	$11,100,000	$8,250,000	$27,060,000	$5,860,000	$20,800,000	
Annual Capital Cost (50 yrs @ 4%)	570,000	517,000	384,000	1,260,000	273,000	970,000	
Annual O & M Cost	40,000	30,000	38,400	57,000	37,600	40,000	
Combined Annual Cost	$ 610,000	$ 547,000	$ 422,400	$ 1,317,000	$ 310,600	$ 1,010,000	
Unit Cost ¢/1,000 gals.	2.66	4.05	6.09	1.60	7.73	12.0	
Year of First Need	1960	1966	1970	1973	1990	1991	
Discount Period	0	1	5	8	25	26	
Present Worth Factor	1	0.962	0.822	0.731	0.375	0.361	
1965 Annual Value	$ 610,000	$ 526,000	$ 347,000	$ 963,000	$ 116,000	$ 365,000	$2,927,000
1965 Benefits in ¢/1,000 gals. yield	2.66	3.89	5.00	1.17	2.89	4.35	2.12

RECONNAISSANCE REPORT

RECREATIONAL USE AND DEVELOPMENT

SAN GABRIEL RIVER WATERSHED

BRAZOS RIVER BASIN

TEXAS

Prepared by

Region Three Office, National Park Service
Department of the Interior

for

Fort Worth District
U. S. Corps of Engineers

March 1960

River Basin Code No. XXXVI/96

INTRODUCTION

Authority

General authority for National Park Service cooperation stems from the Park, Parkway, and Recreational Area Study Act of June 23, 1936.

The Fort Worth District Office of the Corps of Engineers requested, in their letter of February 17, 1960, the cooperation of the National Park Service in appraising the recreation potentialities of proposed Corps of Engineers reservoir projects. Pursuant to this request, a field reconnaissance of the proposed San Gabriel River Watershed was made on February 29. Messrs. F. K. Mixon and F. E. Clary of the Corps of Engineers Fort Worth District Office and Park Landscape Architect Urban E. Rogers representing the National Park Service made the investigation.

Purpose

This report presents an appraisal of the recreational potentials of the proposed reservoir projects on the San Gabriel River Watershed. The report also includes the type of recreation recommended for development and an estimated monetary evaluation of recreation benefits.

GENERAL DESCRIPTION

Location

The San Gabriel River Watershed, Brazos River Basin, currently under study, is situated in Williamson County. Four reservoir sites are being investigated. Three of the sites, North Fork San Gabriel River, Berry Creek, and South Fork San Gabriel River, are on tributaries of

the San Gabriel River and located immediately west or northwest of Georgetown. The fourth reservoir site, Laneport, is on the San Gabriel River and 15 miles east of Georgetown near Granger.

Federal and State highways in the vicinity link with farm roads to provide access to and through the reservoir basins.

Purpose

The four proposed reservoir projects are being investigated for flood control and conservation storage purposes. The Laneport site was previously authorized as a multiple-purpose project but is under restudy to reconsider alternate sites.

The following preliminary data were supplied by the Corps of Engineers:

(see following page)

The length of each stream inundated will vary depending on which plan is used. The approximate land miles of stream affected by the five-year pool are as follows: Laneport Reservoir, 8 miles of the San Gabriel River and 5 miles of Willis Creek; 7 to 10 miles of the North Fork San Gabriel River; 6 to 8 miles of the South Fork San Gabriel River; and 3 miles of Berry Creek.

Physical Characteristics

Laneport Reservoir site is located in the Blacklands prairie section of Central Texas. The terrain is nearly level to rolling with a few scattered trees along the river bank. The soils are dark and of

RESERVOIR SITES

	LANEPORT		NORTH SAN GABRIEL		SOUTH SAN GABRIEL		BERRY CR.
MAXIMUM DESIGN W.S.							
Elevation (ft.M.S.L.)	537.6	541.1	842.4	870.0	844.8	874.6	817.7
Surface Area (acres)	15,790	17,030	3,932	6,217	2,415	3,927	2,410
Capacity (acre-feet) 1/	400,700	458,000	158,400	298,820	91,790	186,980	67,600
CONSERVATION STORAGE							
Elevation (ft.M.S.L.)	493.0	506.0	780.0	832.5	792.5	843.0	782.0
Surface Area (acres)	2,890	5,800	1,095	3,185	830	2,320	800
Capacity (acre-feet) 1/	28,900	79,900	23,200	124,980	15,500	87,780	13,000
FIVE-YEAR POOL							
Elevation (ft.M.S.L.)	507.0	515.0	795.0	839.0	803.0	847.0	789.0
Surface Area (acres)	6,040	8,070	1,535	3,630	1,050	2,527	1,070

1/ Does not include 50-year sedimentation

Two plans are being considered for each site except Berry Creek.

It will not be known which reservoir or combination of reservoirs will be constructed until the project is congressionally authorized.

heavy clay texture and well adapted to crop production. Cotton, grain sorghums, corn, oats, hay, legumes and peanuts are the principal crops. Scenically the vally has little appeal other than the San Gabriel River. Since the river is spring fed, any water impoundment should be of a high quality.

The three tributary sites are located approximately 15 miles west of the Laneport site and in the Grand Prairie section of Central Texas. This section is characterized by timbered slopes varying from hilly to rolling land and has far more scenic value than the Laneport site. Pecan trees are found along the streams, and cedar, post oak, live oak, mesquite, elm and walnut trees are abundant throughout the area. Ranching and stock farming are the main livelihood and cattle, sheep and goats are the principal livestock. The production of cedar fence posts and oil, the exporting of mistletoe, and the utilization of limestone further enhance the economy. The fertile soils, of limestone origin, encourage native vegetation. These native plants provide good game cover. The perennial flow of the spring-fed streams denotes the quality of water anticipated in any future reservoirs.

Climate

The reservoir sites vary from around 500 feet to 900 feet above mean sea level. At this altitude the relative humidity is high. Southerly winds prevail throughout most of the year and offset to some extent the high humidity. Annual rainfall for Williamson County is 32.66 inches. Rainfall is heaviest in April and May and evenly distributed the remainder of the year. The temperature averages 49 degrees in

January and 83 degrees in July with a mean annual temperature of 66 degrees. The maximum temperature recorded is 110 degrees. According to the U. S. Weather Bureau, Williamson County has a 264-day growing season.

Historical and Archaeological Investigations

Upon authorization of the project and prior to construction, a historical and archaeological survey should be made of the reservoir areas and at the dam construction sites.

Present Recreation Use

Present use of the reservoir basins for recreation purposes, even though readily accessible by road, is limited to hunting and incidental fishing.

FACTORS INFLUENCING RECREATION DEVELOPMENT

The scenic quality of the tributary sites and the close proximity of existing roads makes these sites very desirable for recreation development. The small impoundment proposed on Berry Creek may not have as much appeal as the larger reservoirs proposed on North Fork San Gabriel River and South Fork San Gabriel River.

The nakedness of the landscape in the vicinity of Laneport reservoir and dam makes this site less inviting. However, the size of the proposed impoundment should be an attraction from the outset. A farm road more or less parallels the south shore line and a State highway traverses the upper end thus making the reservoir shore line

easily accessible for potential recreation development.

Of significance to the development of recreational facilities at these reservoirs is the fact that the conservation pool should not fluctuate more than a few feet except in drouth periods. Due to the favorable topography at the tributary sites, this fluctuation would be negligible. The Laneport reservoir shore line, owing to level topography, would be subject to narrow horizontal variations.

The project area has a large rural-farm population. Williamson County, site of the project, had a total population of 38,853 in 1950, which represents a 7% decrease from the 1940 census count. Georgetown, the county seat, had a population of 4,951 representing about a 34 per cent increase over the previous 10 years.

The population within a 50-mile radius of Georgetown, assuming this city the center of the project area, was 310,376 in 1950. Over half of these people reside in Travis County. Approximately 85 per cent of the Travis County residents live in Austin, 27 miles south.

Several existing areas, within one hour's drive, provide excellent recreational opportunities. The scenically beautiful Hill Country lies to the west in Burnet and Llano Counties and attracts many tourists. The Highland Lakes Country of West Texas extends for a distance of approximately 100 miles up the Colorado River above Austin. The Highland Lakes Country is one of Texas' outstanding recreation areas with a series of two large lakes, Travis and

Buchanan, and four small lakes, Inks, Granite Shoals, Marble Falls and Austin. Belton Reservoir on the Leon River near Belton is also a popular recreation center.

Three State Parks are within 50 miles of the project area. Inks Lake State Park is on the east shore of Inks Lake with Longhorn Cavern State Park about 10 miles south. Bastrop State Park lies to the southwest near Bastrop.

Recreational facilities available at the existing areas include: boating, picnicking, fishing, camping, swimming, hiking, dining, golf, playground, group camp and overnight accommodations.

Stillhouse Hollow, a Corps of Engineers reservoir project, is the only proposed area. This project, located about 30 miles north on the Lampasas River near Belton, is authorized but not under construction. The Corps of Engineers plans public recreation use on the future shore line of this reservoir.

ESTIMATE OF RECREATION NEED AND USE

The intensive visitor-use of nearby existing developments demonstrates the popularity of recreation areas. Visitation figures at these areas have shown a definite increase in recent years and it appears this trend will continue. Therefore, it seems logical to conclude that in the near future either the expansion of existing areas or additional recreation outlets are essential to satisfy the increasing number

of outdoor enthusiasts. In the latter case recreational developments on the proposed project reservoirs should relieve to some extent the pressure on existing crowded areas.

It is believed the recreational resources inherent in the project reservoirs are of local significance and the local people would comprise an appreciable portion of the total visitation.

RECREATION ANALYSIS

In analyzing the recreation potentialities of the project, it is believed all the proposed reservoirs are desirable for public recreation use. However, the tributary sites are more favorably endowed with natural features usually associated with recreation areas. Berry Creek, the smallest tributary impoundment, appears to have the least appeal. The Laneport site, on the main stream, has less attractive surroundings. This site will require extensive landscaping to enhance the shore line and provide inviting development sites.

Potential recreation developments should complement rather than compete with existing areas. The present and foreseeable future requirements of the local people should be taken into account. Site selection should consider the topography, existing road locations, tree cover and reservoir views. The extent of recreation development at each reservoir should occur in proportion to its physical possibilities. This will have to be determined after the project is authorized.

Proposed developments should receive some year around use; however, the major use would be in the spring, summer and fall.

RECOMMENDED RECREATION DEVELOPMENT

Public use facilities are recommended primarily for day-use visitation. These facilities are necessary for access, sanitation, and safety of the public and for protection of the areas. Ultimate public use facilities should include: roads, parking areas; trails; signs; water and sanitary facilities; site preparation; boat docks and launching ramps for boating, fishing and water skiing; picnic areas including shelters where there are no shade trees; swimming beaches; campgrounds; and the installation of basic safety features.

Concession facilities are very desirable to complete the recreation development. These facilities could include a marina and fishing supply center, snack bar, additional boat docks and mooring facilities.

The ultimate developments may require limited administration facilities and sites should be selected and reserved for this purpose.

ESTIMATED MONETARY EVALUATION OF RECREATION BENEFITS

Many economic benefits are generated from the availability of adequate recreation facilities at water control projects. However, a long study of the subject has convinced economists of the National Park Service that such benefits cannot be measured scientifically in monetary terms. The Service, however, believes that its experience warrants a "judgement value" approach to assigning certain monetary values to potential recreation benefits of such projects.

An estimate in monetary terms of the recreation values of reservoirs with developments proposed is based on the estimated number of visitor-days of use expected, multiplied by a visitor-day factor. The annual use, in addition to estimated use of the area without these projects, is conservatively estimated at 150,000 visitor-days. Research by statisticians of the National Park Service has produced a factor or derived monetary value of $1.60 per visitor-day for all types of recreation.

Using this value, the estimated monetary recreational benefits of these projects would equal $240,000 annually.

No known existing recreation values will be destroyed by construction of these reservoirs.

LAND NEEDS

Land acquisition for project purposes will only extend to the 5-year flood pool elevation. Therefore, it is recommended that additional lands be purchased for recreation access roads and development sites.

Sufficient land should be purchased to provide a buffer zone beyond each development site to create a more park-like atmosphere. The buffer zone would also screen any undesirable private development and could be used for future expansion. A scenic easement beyond each access road right-of-way would serve the same purpose.

ADMINISTRATION, OPERATION, MAINTENANCE

Since the project reservoirs are considered of local significance, nearby communities should be approached regarding the administration of the recreational resources of these reservoirs.

FURTHER STUDY AND PLANNING

After the project is authorized,it will be necessary to select recreation sites and to determine the extent of development and amount of land required.

89982 O-62—15

REPORT ON
FISH AND WILDLIFE RESOURCES
AFFECTED BY THE PROPOSED
SAN GABRIEL RIVER AND TRIBUTARIES PROJECT
WILLIAMSON COUNTY

PREPARED BY

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

FOR

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

September 12, 1961

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO
September 12, 1961

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

Dear Sir:

This letter constitutes a revision of the Bureau of Sport Fisheries and Wildlife's letter report dated April 26, 1960, on the fish and wildlife resources affected by the proposed San Gabriel River and Tributaries Project, Texas, and is intended to accompany the Corps of Engineers' Fort Worth District revised survey report. This report has been prepared in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U. S. C. 661 et seq.) and has received concurrence from the Texas Game and Fish Commission by letter dated September 1, 1961, from Mr. Howard D. Dodgen, Executive Secretary.

This report presents a project analysis and recommendations substantially the same as those presented in our report of April 26, 1960, except to include the plan of development you have determined most feasible in your Review of Reports on Brazos River and Tributaries, Texas, Covering San Gabriel River Watershed, submitted to us by letter of January 20, 1961. We shall refer to this additional plan as Plan 16.

Evaluations of sport fishing and hunting based upon sportsmen's expenditures in our previous report have been converted to a revised series of evaluations based upon the interim schedule of values adopted by the Inter-Agency Committee on Water Resources. This revision was undertaken at the request of Mr. C. F. Swenson, Chief, Engineering Division, by letter of April 11, 1961, to Field Supervisor John Degani, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Fort Worth, Texas.

It is our understanding that 16 plans were investigated, based upon one to four damsites on the San Gabriel River and its tributaries, to find the most feasible method of controlling floods and providing water storage for municipal and industrial uses. The project will be operated for flood control as a unit in a system which will include Waco, Whitney, Proctor, Belton, and Stillhouse Hollow Reservoirs in the Brazos River Basin.

The four damsites are:

(1) Laneport, on the main stem of the San Gabriel River at river mile 29.7, with a drainage area of 711 square miles.

(2) South San Gabriel, on the South San Gabriel River at river mile 4.7, with a drainage area of 120 square miles.

(3) North San Gabriel, on the North San Gabriel River at river mile 4.0, with a drainage area of 236 square miles.

(4) Berry Creek, on Berry Creek at river mile 6.7, with a drainage area of 77 square miles.

Total flood-control storage investigated ranged from 241,310 acre-feet to 119,600 acre-feet under various plans, while conservation storage ranged from 408,900 acre-feet (15,280 surface acres) to 38,700 acre-feet (1,925 surface acres). Table 1 presents pertinent data for each plan.

Plan 16 would be developed in three stages, beginning with a flood-control and conservation-storage project at Laneport on the mainstem of the San Gabriel River with a total capacity of 331,900 acre-feet. Its conservation pool would cover 5,250 surface acres and would have a capacity of 87,800 acre-feet. Second-stage development would begin fifteen years later with construction of a flood-control and conservation-storage project on the North San Gabriel River with a total capacity of 221,600 acre-feet. At conservation-pool elevation the reservoir would have a capacity of 132,500 acre-feet and a surface area of 3,210 acres. During this 2d phase the conservation pool at the Laneport Reservoir would be increased to a capacity of 168,100 acres with a surface area of 8,270 acres by means of a reduction in flood-control storage. Twenty years after the beginning of first-phase operation a third phase flood-control and conservation-storage project would be constructed on the South San Gabriel River with a total capacity of 138,500 acre-feet. The conservation pool would have an area of 2,340 surface acres and a capacity of 92,500 acre-feet. The conservation pool at the first phase Laneport Reservoir would be increased again by a reduction in flood control storage capacity. Thus Laneport Reservoir would have a conservation pool storage capacity of 213,900 acre-feet with a surface area of 9,730 acres.

Laneport Reservoir would have an earthen dam and a concrete ogee-type spillway. The other reservoirs would have rock-fill dams with broadcrested spillways. Gate-controlled outlet works would be of design capacities to provide for safe release of floodwaters.

In the investigated plans where conservation storage is included, fee title would be acquired to all lands below the five-year flood-frequency line plus additional lands required for structures,

Table 1. Pertinent Data for Investigated Plans, San Gabriel River and Tributaries Project

Plan	Reservoir Site	Flood-Control Storage (acre-feet)	Maximum Conservation Pool Area (surface acres)
1	Laneport	236,700	2,890
2	Same site as Plan 1	237,900	5,800
3	South & North San Gabriel	119,600	1,925
4	Same sites as Plan 3	120,210	5,505
5	South San Gabriel, North San Gabriel & Laneport	239,350	1,925
6	Same sites as Plan 5	239,960	5,505
7	South & North San Gabriel and Berry Creek	145,600	1,925
8	Same sites as Plan 7	146,210	5,505
9	Same sites as Plan 7	146,000	2,745
10	Same sites as Plan 7	146,210	6,325
11	South & North San Gabriel, Laneport, & Berry Creek	240,700	1,925
12	Same sites as Plan 11	241,310	5,505
13	Same sites as Plan 11	241,100	2,745
14	Same sites as Plan 11	241,310	6,325
15	North San Gabriel & Laneport	235,420	3,185
16	Laneport, South San Gabriel, & North San Gabriel	216,400 to 219,900	5,250 to 15,280

maintenance and operation, safety, and public use. Flowage easements would be acquired over all lands lying between the fee-acquisition elevation line and a line three feet above the top of the flood-control pool.

In the plans which include flood control only, fee title for the projects would be acquired on all lands required for structures, safety, and mainenance and operation of the dam. Flowage easements only would be acquired in the reservoir areas.

The North San Gabriel, South San Gabriel, and Berry Creek Project areas are in the Grand Prairie physiographic region. The hilly uplands are covered with thin limestone soils. Vegetal cover is primarily a grass understory with an oak-cedar overstory. The small river valleys have been cleared, where sufficiently level, and put in crops and improved pasture. A narrow bank of bottomland timber, including pecan, ash, willow, and various oaks, has been left along the streams' banks. Land use is based on livestock grazing. Bottom-land cultivation is supplemental to livestock raising.

The Laneport Reservoir site is in the Blackland Prairie physiographic region characterized by intensive cultivation on level to gently rolling, fertile limestone soils. Except for parts of the river flood plain and a few rough places, the area is in clean cultivation. Crops are about evenly divided among cotton, corn, and sorghums. Overflow lands are grazed.

Williamson County is in a moderately humid region with an average annual rainfall of about 33 inches. Mean annual temperature over the watershed is 66° F. Average frost-free period is 264 days.

The San Gabriel River is formed by the confluence of the North San Gabriel, Middle San Gabriel, and South San Gabriel Rivers near Georgetown. Berry Creek joins the river a short distance downstream from Georgetown. Streamflow data at the Georgetown Gaging Station for 23 years of record (1934-1957) show that the daily flow has ranged from a maximum of 155,000 second-feet (April 24, 1957) to zero. The average daily flow has been 130 second-feet. Springs in the headwaters maintain a better than usual flow for streams in this region. Even during the extensive drought of the 1950's, zero flows were recorded only in September 1955 and during the summer of 1956.

North San Gabriel and South San Gabriel Rivers are small, shallow, clear streams with relatively few pools and long bedrock riffles. The average depth of flow in the two rivers is less than a foot; the average width, 20 feet. Stream gradient averages about 10 feet per mile. The flow in Berry Creek is intermittent. From the confluence of its tributaries to the vicinity of Circleville at the upper end of the proposed Laneport Reservoir, the San Gabriel River is a shallow, meandering stream with flows averaging 85 feet wide and less than a foot deep. Pool areas are few, and game-fish habitat is poor. From

Circleville to the confluence of the San Gabriel River with the Little River, the channel becomes narrower and deeper, averaging 30 feet in surface width and 2.5 feet in depth. Short gravel riffle areas are interspersed with long, silt-bottomed pool areas averaging 4 to 6 feet deep. Erosion from surrounding cultivated lands causes slightly turbid water in this reach.

FISH

Fish species in the San Gabriel River watershed include channel catfish, flathead catfish, largemouth bass, spotted bass, warmouth bass, green sunfish, bluegill, longear sunfish, spotted gar, gizzard shad, river carpsucker, grey redhorse sucker, and numerous minnows.

The area of influence of the project will include the entire stretch of the San Gabriel River, 44 miles of the Little River, about 10 miles of the South San Gabriel River, 11 miles of the North San Gabriel River, and the lower portion of Berry Creek.

Fishing is insignificant on the South San Gabriel River due to lack of access. Berry Creek has practically no fishing due to its intermittent flow. Fishing on the North San Gabriel River and the main stem of the San Gabriel River is usually limited to pools, where catfish and grey redhorse suckers predominate in the catch. Suckers are gill-netted; and catfish are usually caught on trotlines. The best stream fishing is on the San Gabriel River from Circleville to its mouth and on the Little River to its confluence with the Brazos River. Catfish predominate in the catch. Approximately 600 man-days of sport fishing annually occur on the North San Gabriel River above the damsite; about 200 man-days annually occur downstream from the damsite. On the San Gabriel River, fishing is estimated at 1,500 man-days per year above the damsite, and 2,700 man-days in the downstream area. Fishing on the Little River from the mouth of the San Gabriel River to its confluence with the Brazos River is estimated at 10,000 man-days annually. The intensity of present fishing is expected to continue without the project through the period of analysis.

Construction and operation of the North San Gabriel and South San Gabriel Reservoirs will eliminate the San Gabriel River fishery.

Construction and operation of Laneport Reservoir will eliminate the downstream fishery in the San Gabriel River and reduce the quality of fishery in the Little River. Conservation-storage reservoirs created will produce high-quality fisheries. The North San Gabriel, South San Gabriel, and Berry Creek Reservoirs will be clear, with deep shoreline areas. Laneport Reservoir will be shallow and fertile.

Initially, largemouth bass, white crappie, and channel catfish will provide the best fishing. Eventually, river carpsuckers will predominate in the North San Gabriel, South San Gabriel, and Berry Creek

Reservoirs; carp and buffalofishes will predominate in Laneport Reservoir. Other important species of fish in the reservoirs will be white bass, bluegill, flathead catfish, and freshwater drum.

All plans will create fisheries of importance. Fishing anticipated on the large conservation-storage reservoirs, as in Plans 1, 2, 4, 6, 8, 9, 10, 12, 13, 14, and 15, will be 50,000 man-days per year. In Plan 16, fishing will account for about 50,000 man-days annually under the first stage of development, 70,000 man-days annually under the second stage of development and 80,000 man-days annually under the third stage of development. For small conservation-storage reservoirs on the North San Gabriel and South San Gabriel Rivers or a combination of these reservoirs with flood-control-only projects on other streams, as in Plans 3, 5, 7, and 11, fishing will account for 38,000 man-days annually. There will be no demand for commercial fishing.

The benefits to fishing which may be assigned to the project under the various plans are as follows: for Plans 1 and 2, $41,000; for Plans 4, 6, 8, 9, 10, 12, 13, 14, and 15, $45,000; for Plans 3, 5, 7, and 11, $33,000; and for Plan 16, 1st stage, a total of $41,000, 2d stage, a total of $61,000, and 3rd stage, a total of $71,000.

WILDLIFE

The area of project influence evaluated for wildlife includes the Laneport, North San Gabriel, South San Gabriel, and Berry Creek Reservoir sites and the flood-protected area downstream from these sites.

The Laneport area is almost devoid of wildlife due to intensive farming, and game species are limited to a few bobwhites and mourning doves. The abundance of wildlife in the North San Gabriel, South San Gabriel, and Berry Creek Project areas presents a sharp contract to the barran Laneport Project area. The South San Gabriel area is in the best deer and turkey habitat in the county. The North San Gabriel area is almost as good. Although the Berry Creek area has good habitat, posting and inaccessibility reduce hunting to practically nil. Game species in the North San Gabriel, South San Gabriel, and Berry Creek areas are white-tailed deer, turkey, mourning dove, and bobwhite. Common, but supporting little hunting, are fox squirrels, cottontails, foxes, and raccoons. Access to lands is posted against public use, and hunting is limited mainly to landowners and their friends. The number of deer leases is increasing.

Extensive uncleared oak-cedar pastures on the South San Gabriel area provide excellent habitat for increasing deer and turkey populations. Although much of the uplands has been cleared on the North San Gabriel area, there is still enough oak-cedar pasture left to support an increasing deer population. Some of the best dove hunting in the county is on the North San Gabriel at road crossings along the river.

Although turkeys nest here, the harvest is negligible; most of the birds winter in the canyons of nearby Travis County.

Approximately 200 man-days of deer hunting and 350 man-days of waterfowl hunting occur annually on the large conservation-storage project area on the South San Gabriel River, as in Plans 4, 6, 8, 10, 12, 14, and 16. The large conservation-storage project area on the North San Gabriel River, as in Plans 4, 6, 8, 10, 12, 14, 15, and 16, receives 100 man-days of deer hunting annually and 1,300 man-days of upland-game hunting annually.

The small conservation-storage project area on the North San Gabriel River, as in Plans 3, 5, 7, 9, 11, and 13, has 650 man-days of upland-game hunting annually. Hunting is insignificant on the small conservation-storage project area on the South San Gabriel River, as in Plans 3, 5, 7, 9, 11, and 13, on the Berry Creek Reservoir site, in the Laneport Reservoir area and within the areas of influence downstream from all projects. The present use is expected to continue over the period of analysis without the project.

Laneport Reservoir, with conservation storage as proposed in Plans 1, 2, and 16, will have about 3,200 acres, 2,300 acres, and 3,370 acres, respectively, in fee title above conservation-pool elevation. Under these plans, there will be significant benefits to wildlife, especially waterfowl, doves, and bobwhites. In actuality, there will be more land exposed most of the time, since the reservoir will seldom be at conservation-pool level. Since this land will not be cultivated, it will quickly grow up in weeds, grass, and shrubs, and will provide bobwhite and dove habitat. The shallow reservoir and indented shoreline will be attractive to waterfowl during spring and fall migrations. It is expected that mallards and pintails will winter on the reservoir, feeding in nearby grainfields. Approximately 930 man-days of upland-game hunting and 2,400 man-days of waterfowl hunting will occur annually in the reservoir area for Plan 1. Plan 2 will have 850 man-days of upland-game hunting and 3,000 man-days of waterfowl hunting annually. There will be 950 man-days of upland-game hunting and 3,500 man-days of waterfowl hunting annually in Plan 16.

Hunting on reservoir areas under Plans 3 through 15 will be insignificant. Inundation by and fluctuation of reservoirs on the North and South San Gabriel River sites will eliminate or reduce wildlife habitat on fee-title areas. Human disturbance will further reduce game populations.

Under all plans, except Plans 1, 2, and 16, there will be a loss of hunting caused by the project.

The benefits to hunting assignable to the project are $7,000 for Plan 1, $8,000 for Plan 2, and $4,000 for Plan 16.

Fish and wildlife benefits are based on the assumption that adequate access roads to the reservoir areas would be provided and that parking areas and boat-launching ramps would be constructed. The conservation-storage projects on the San Gabriel River, as in Plans 1, 2, and 16, and the large conservation-storage projects on the North and South San Gabriel Rivers, as in Plans 4, 6, 8, 10, 12, 14, 15, and 16, would each require a minimum of 4 access-parking sites to meet the minimum sportsman-use requirements. A minimum of 2 access-parking areas would be required on each of the small conservation-storage projects on the North and South San Gabriel Rivers and Berry Creek as in Plans 3, 5, 7, 9, 11, and 13. Parking areas should be at least 3 acres in size on tributary streams and 5 acres in size on the San Gabriel River.

It is recommended:

1. That the report of the District Engineer, Fort Worth District, Corps of Engineers, include conservation and development of fish and wildlife among the purposes for which the project is authorized.

2. That adequate access roads and parking areas be provided.

3. That federally owned land and project waters be open to free use for hunting and fishing except for sections reserved for safety, efficient operation, or prctection of public property.

The investigations preparatory to this report were made in cooperation with the Texas Game and Fish Commission. The report is based upon data available from the Corps of Engineers prior to January 20, 1961, and any modifications should be brought to the attention of the Bureau of Sport Fisheries and Wildlife and the Texas Game and Fish Commission. This report is subject to revision upon receipt of further project information and additional study.

The cooperation of the Fort Worth District Corps of Engineers in furnishing engineering data and planning information is appreciated.

Sincerely yours,

/s/ William T. Krummes

William T. Krummes
Acting Regional Director

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO
September 18, 1961

Air Mail

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

Dear Sir:

This is in regard to a fish and wildlife alternate, single-purpose plan in connection with the San Gabriel River and Tributaries Project, Texas.

We believe the following alternate single-purpose project plan would provide fish and wildlife benefits similar to those anticipated from the Corps of Engineers' subject project investigation.

Fish and wildlife benefits anticipated from the Corps of Engineers' proposed investigations are as follows:

Plan 1:

Sport fishery	41,000 man-days
Waterfowl	2,400 man-days
Bobwhite	260 man-days
Mourning dove	670 man-days

Plan 2:

Sport fishery	41,000 man-days
Waterfowl	3,000 man-days
Bobwhite	190 man-days
Mourning dove	660 man-days

Plans 3, 5, 7, and 11:

Sport fishery	33,000 man-days

Plans 4, 6, 8, 9, 10, 12, 13, 14, and 15:

Sport fishery	45,000 man-days

Plan 16:

Sport fishery	71,000 man-days
Waterfowl	3,500 man-days

To achieve fish and wildlife benefits comparable to those anticipated from the above project plans, we have developed the following criteria to be used in formulating one theoretically feasible project:

A 550-acre reservoir on Williamson Creek, Williamson County, Texas, would provide the same fishery benefits as occur in Plans 1, 2, 4, 6, 8, 9, 10, 12, 13, 14, and 15; and 800-acre reservoir would provide fishery benefits similar to benefits anticipated from Plan 16. For Plans 3, 5, 7, and 11, the reservoir would be 380 surface acres. The damsite would be about 3.0 miles upstream from the Corps of Engineers' Laneport damsite (slightly above a county road). The reservoir would have a maximum depth of about 25 to 30 feet.

We believe that the most economical type dam would be an earthen embankment with either a concrete ogee-type uncontrolled spillway or a broadcrested uncontrolled spillway in the saddle.

A 300-foot horizontal strip above the normal pool elevation with an all-weather two-way road would provide access to all parts of the reservoir. Parking facilities and boat-launching ramps could be provided within the 300-foot strip. Two parking areas, one on each side of the reservoir and each 6 acres in size, would be adequate to take care of anticipated use. These areas would be cleared of all vegetation. Boat-launching ramps near each parking area would consist of reinforced concrete slabs, 20 feet wide, 50 feet long, and 6 inches thick. Access roads from county or farm-to-market roads would be to each side of the reservoir joining the parking areas or to the all-weather road around the reservoir.

Wildlife benefits similar to those anticipated in Plans 1, 2, and 16 could be provided by 1,000 acres of cleared land adjacent to the normal pool at the headwater end of the reservoir. A portion of the 300-foot strip above the normal pool elevation would make up a small portion of the 1,000 acres. About 250 acres would be put into cultivation to provide waterfowl foods and, together with the remaining 750 acres, provide the bobwhite benefits. The 1,000 acres and the 300-foot strip around the reservoir would satisfy the dove requirements.

The reservoir area, 300-foot strip, 1,000 acres of cleared land, land to construct the dam, and access roads to the reservoir would be purchased in fee title.

The above areas would be fenced at an estimated cost of $1,000 a mile. Eight sanitary and two water-supply facilities would be required at a total estimated cost of $2,000 and $5,000, respectively.

Sincerely yours,

/s/ Carey H. Bennett

Carey H. Bennett, Chief
Division of Technical Services

APPENDIX V

VIEWS AND COMMENTS OF OTHER AGENCIES

BRAZOS RIVER AUTHORITY
P.O. DRAWER 7555
WACO, TEXAS

December 22, 1960

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

Re: Conservation Storage Space - Laneport, North and South San Gabriel Reservoirs.

Dear Colonel West:

Under date of July 28, 1960, we advised you of this Authority's desire to acquire the then contemplated conservation storage space in the Laneport and North San Gabriel Reservoirs. We have now been advised that your subsequent studies of the San Gabriel indicate that a reservoir on the South Fork may also be feasible several years hence when there is a demand for the water and that it is your plan to construct the overall development in stages with the Laneport Reservoir first, the North San Gabriel second and the South San Gabriel as the last unit. Further, that such studies, which we understand have not as of this date been approved by the Chief's office, will afford considerably more feasible conservation storage space than originally contemplated with the final three units of the project affording feasible conservation storage space as follows:

Laneport	193,200 acre-feet
North San Gabriel	126,700 "
South San Gabriel	89,000 "

The purpose of this letter is to supplement our offer of July 28, 1960, and reaffirm our long standing position that the Authority is willing and hopes it will be afforded the opportunity of acquiring the total and maximum feasible conservation storage space in each of these reservoirs, including the increased storage made available at Laneport by the upstream flood control of the North and South Fork projects, at such time as they are ready to be placed under construction and subject to such financial arrangements that appear to be most economical and justifiable under then effective Federal and State laws.

Although our Board has at several times in the past adopted resolutions authorizing the management to negotiate with you for the conservation storage space in Brazos Basin Projects, if it is so desired

by you we will have our Board pass an appropriate resolution at its meeting to be held here on January 16, 1961, reaffirming such intentions and this request.

We are pleased with the prospect of your proposed modification of the San Gabriel's development and trust that such will have the approval of the Chief's office in Washington.

Cordially yours,

/s/ R. D. Collins

R. D. COLLINS
Treasurer and
General Manager

TEXAS HIGHWAY DEPARTMENT
AUSTIN 14, TEXAS

March 31,1960

Williamson County
San Gabriel River Dam and Reservoir Study

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

Dear Sir:

Your letter of February 26, 1960 relative to your study of dam site locations on the San Gabriel is acknowledged.

From our study it appears that only the Laneport location merits consideration for a roadway on the dam. This roadbed width should be not less than 36'.

The Laneport Reservoir will require the relocation of FM Road 971 as previously stated.

The Jonah Reservoir will require the relocation of State Highway 29 and a new river crossing on the relocation.

Hydraulic features for the crossing of US 183, US 81, IH 20, and State 95 will have to be investigated when more data on backwater and conservation pool elevations are available.

Yours truly,

D. C. Greer
State Highway Engineer

By: /s/ Randle B. Alexander

Randle B. Alexander
Bridge Engineer

U. S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
REGION SIX
P. O. Box 12037, Ridglea Station
Fort Worth 16, Texas

May 19, 1960

Major W. H. Mathis
Acting District Engineer
U. S. Army Engineer District, Fort Worth
Corps of Engineers
100 West Vickery Boulevard
Fort Worth 4, Texas

Dear Sir:

Your letter of 26 February 1960 asked for our views regarding necessity for constructing any of the five dams under study in the San Gabriel River Watershed so they will serve as foundations for highway crossings.

You wrote a similar letter to the Texas Highway Department and were advised on March 31 that only the Laneport location merits consideration for a roadway on the dam, that the Laneport Reservoir will require relocation of F. M. Road 971, and that the Jonah Reservoir will require relocation of State Highway 29 with a new river crossing.

We concur in the State's recommendation.

Very truly yours,

/s/ Bill L. Andrews

Bill L. Andrews
Assistant Regional Engineer

89982 O-62—16

U. S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
404 VFW Building
Austin 1, Texas
January 24, 1961

Colonel R. P. West
District Engineer
Corps of Engineers
100 West Vickery Blvd.
Fort Worth 4, Texas

Dear Colonel West:

Receipt is acknowledged of your letter dated January 20, 1960 furnishing us with a draft copy (serial number 74) of your "Review of Reports on Brazos River and Tributaries, Texas, Covering San Gabriel River Watershed."

It is noted that highway relocations have been included in project costs and local interests are not required to contribute to costs of the relocations.

Construction of the North and South Fork Reservoirs may result in some benefit to highway interests when the Interstate Highway 35 is constructed through this watershed. The tentative location of the highway is between the reservoirs and the City of Georgetown. Any actual savings in the cost of the bridges will depend upon the relative timing of the construction. Some reduction in waterway area of the structures may be accomplished if the reservoirs were in operation prior to the construction of the highway.

We welcome this opportunity to cooperate in the development of this and other water resources projects.

Very truly yours,

J. M. Page
Division Engineer

By /s/ W. P. Privette

W. P. Privette
Acting Division Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DIVISION OF MINERAL RESOURCES | REGION IV | ROOM 206 FEDERAL BUILDING, BARTLESVILLE, OKLAHOMA

February 7, 1961

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

Your reference: SWFGP

Dear Colonel West:

Thank you for sending us a draft copy of "Review of Reports on Brazos River and Tributaries, Texas, Covering San Gabriel Watershed", dated January 1961, for our field level review.

The proposed plan of improvement on the San Gabriel River watershed, Williamson County, Texas, provides for the modification and construction of Laneport Reservoir project as a first-stage reservoir unit, and the subsequent construction of the North Fork and South Fork Reservoirs, as second- and third-stage reservoir units, respectively. The proposed reservoir projects would be constructed for flood control, water conservation, and recreation purposes. The dams range in height from 111 to 188 feet, length of dams range from 7,100 to 16,000 feet, surface areas range from 4,020 to 16,640 acres, and storage areas range from 198,400 to 467,300 acre feet. The Laneport reservoir has a concrete and earth-fill dam and the North Fork and South Fork Reservoir have rock fill, impervious core dams.

Stone, lime,and petroleum valued at $2,563,909 were produced in Williamson County in 1959.

An office study of available Bureau of Mines records indicates that the proposed construction will have no adverse effect on mineral industries in the area; therefore, the Regional Office of the Bureau of Mines has no objection to the proposed project. No field examination was made.

Sincerely yours,

/s/ I. T. McElvenny

L. T. McElvenny
Acting Chief
Division of Mineral Resources
Region IV

DEPARTMENT
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE

PUBLIC HEALTH SERVICE

Ninth Floor - 1114 Commerce Street
Dallas 2, Texas

February 8, 1961

Colonel R. P. West
District Engineer
U.S. Army Engineer District,
Fort Worth
Corps of Engineers
100 West Vickery Boulevard
Fort Worth 4, Texas

Dear Sir:

We have the following comments to make regarding your report covering the San Gabriel River Watershed, transmitted to this office on January 20, 1961.

(1) P. 19, Par. 43 c

It is suggested that the word "lower" be inserted before ". . Brazos River Basin . ."

(2) P. 22, Par. 47, last sentence, and Appendix III, Par. 12

Apparently these statements were not revised in line with the revised Figure 8 presented in the Public Health Service supplementary report dated December 1960. On the basis of that supplement, the respective years of need for the various units would be about 1970, 1990 and 1991--instead of 1970, 1985 and 1990. The effect of this discrepancy in dates is offset, however, by the fact that in the Corps' analysis, the storage in the first unit (Laneport) has been divided into two parts-- a full-valued present and a discounted-value future increment.

(3) P. 36, Par. 70, and Appendix III, Par. 13

It is noted that an interest rate of 3 percent is used for the conversion of alternative capital costs to equivalent annual costs, as well as for discounting of future benefits. We believe that the time value of money to non-Federal agencies is closer to 4 percent, as indicated by typical interest charges on utility bonds. The use of the lower interest rate does not materially affect the final answer in the particular case, but only because the resulting

lower annual benefit at the year of first need is compensated by a lesser discount of future benefits.

(4) P. 47, Par. 90, last line

The figure 539 should be changed to 603 (see supplement to Public Health Service report, P. 3). The same change should be made in Appendix III, Par. 2 and 11.

(5) P. 49, Par. 95

Beginning with the sentence on the next to the last line, suggested wording is: "Estimates of future economic development and the resultant water requirements have been prepared by various State agencies, consulting engineering firms and the Public Health Service. The Public Health Service has stated in its report that . . ."

Sincerely,

/s/ Jerome H. Svore

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

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

February 13, 1961

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

Dear Sir:

Reference is made to your letter of January 20, 1961, transmitting a draft copy (serial 73) in final form of your "Review of Reports on Brazos River and Tributaries, Texas, Covering San Gabriel River Watershed, dated January 1961, to this office and requesting our comments concerning the recommended modification of the authorized development of the San Gabriel River.

The proposed plan of improvement provides for modification of the authorized Laneport Reservoir project as a first-stage reservoir unit, and the subsequent construction of the North Fork and South Fork Reservoirs as second-stage and third-stage reservoir units, respectively.

The power potentialities at the authorized Laneport project were examined by the staff of the Federal Power Commission at the survey report stage (1949) and it was found that development of power at this project was not justified. A review study was made in 1957, and it was concluded that inclusion of power in the Laneport project could not be justified. A staff member attended the public hearing on the San Gabriel River Watershed, Marcy 19, 1958, at Georgetown, Texas.

We have estimated the power potential for each phase of the modified recommended plan under the assumption that the yield from the proposed conservation storage in excess of that portion needed for area water supply which would be diverted directly from the reservoir could be utilized for power generation purposes as each subsequent stage of construction was completed. Power facilities were considered to be at Laneport with additional power flow and power head made available as first North Fork Reservoir and then South Fork Reservoir were completed. The prime power would be about 200 kw, 500 kw, and 600 kw, respectively, as the projects were completed. Assuming that the power output could be utilized at as low as 5 percent load factor, an initial installation of 6,000 kw is indicated, with an ultimate installation of 12,000 kw provided at the second stage. A comparison of the approximate annual economic costs of such installations, with

the probable benefits of each, result in benefit-cost ratios considerably less than units for each of the three stages of completion. The ratios would be further reduced if a part of the dam and storage costs were allocated to power, but data is not available to permit analysis of the probable storage costs which would be allocated to power. Increased power storage or power head would not be available for the Laneport Reservoir because maximum design water surface is limited by encroachment on the city of Granger. In summary, the results of our approximate studies indicate that installation of power facilities or provisions for generation of power in the future cannot be justified at the Laneport project.

We suggest that the potentialities and economics of a power installation at this site be described and set out in an adequate manner in your final design studies. We will be available to furnish additional data and information as required for the completion of such studies.

Your courtesy in forwarding the Review of Reports, San Gabriel River Watershed, for our review and comments, which are submitted for your consideration at field level and thus are not to be construed as those of the Federal Power Commission, is appreciated.

Sincerely yours,

/s/ Edgar S. Coffman

Edgar S. Coffman
Regional Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

Region Three
Santa Fe, New Mexico

Feb. 14, 1961

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

Dear Sir:

Our comments on the draft of your report on "Review of Reports on Brazos River and Tributaries, Texas, Covering San Gabriel River Watershed" dated January 1961 are as follows:

Although there is a difference in the Corps approach to estimating potential attendance and the benefit factor used, than that of the Service, the resulting annual benefits are not significantly different.

The 50-year amortization used by the Corps to arrive at an annual cost of facilities seems quite long to us. For the physical life of many of the facilities this period may be reasonable. However, our experience is that obsolescence is a big factor in the life of park and recreation facilities - including roads, boat launching ramps, and other long physical life structures and facilities. In many of the areas administered by the National Park Service these kinds of structures have been completely rebuilt two or three times within periods of 30 and 40 years, because of obsolescence. Picnics and campground facilities generally have a comparative short physical life period.

These comments are not to be construed as recommending a change in your report. They are given as information only.

Archeological surveys are scheduled for fiscal year 1962 for all three of these dam and reservoir projects. All are in the area of the Balcones fault which is generally rich in archeological sites. Plans for excavations cannot be made until after the surveys have been completed.

Sincerely yours,

/s/ George W. Miller

George W. Miller
Assistant Regional Director

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

P. O. Box 417
Temple, Texas
February 15,1961

Colonel R. Paul West
District Engineer
U. S. Army Corps of Engineers
100 West Blvd.
P. O. Box 1600
Fort Worth, Texas

Dear Colonel West:

Thanks for the opportunity to review the "Review of Reports on Brazos River and Tributaries, Texas, covering San Gabriel River Watershed," which was prepared by the Fort Worth District Corps of Engineers.

Based on the review of the compiled data and information of technicians of the Soil Conservation Service, the following observations and comments are presented for your consideration.

The survey report covering the San Gabriel River Watershed was found to be well prepared and a comprehensive report. Under Introduction, paragraph 5, page 2, it is suggested that the second sentence be reworded to read "In addition, the Soil Conservation Service has received applications for planning assistance on the North San Gabriel River, the South San Gabriel River and the Lower San Gabriel River Watersheds." The Soil Conservation Service has received applications for assistance under Public Law 566 on the North, South and Lower San Gabriel River Watersheds and the applications have been approved by the Texas State Soil Conservation Board, but no detail planning has been initiated in any of the watersheds.

Based on reconnaissance studies of the San Gabriel River Watershed made by the Soil Conservation Service in 1958, it appears that upstream watershed protection and flood prevention projects could not be justified with the installation of the planned North and South Fork Reservoirs. The justification of an upstream project would be dependent upon flood plain benefits accruing in the reservoir basins and downstream from the proposed projects. The studies also show that some of the tributary watersheds downstream from the proposed reservoirs would be favorable for installation of upstream projects and the installation of the North and South Fork Reservoirs would not adversely affect these projects.

The amount of depletion attributed to the upstream soil and water conservation program on the San Gabriel at Laneport for present (1958) and future (2010) appears to be excessive (Appendix 1 - page 4). As indicated below, an amount considerably less than that shown in this report is reflected in the data prepared by the Bureau of Reclamation for the U. S. Study Commission - Texas, which was concurred in by all State and government agencies. The following summary shows the depletions attributed to the upstream soil and water conservation program for present and future conditions as shown in the two reports.

	Percent of Natural Runoff	
	1958	2010
USSC-Texas	97	82
Corps Report, Page 4, Appendix 1	92	64

It is recommended that the San Gabriel report be revised to agree with the U. S. Study Commission - Texas figures.

I was pleased to note that the sediment storage requirements for design were computed, using Texas Board of Water Engineers Bulletin 5912, which was prepared by the Soil Conservation Service.

Very truly yours,

/s/ H. N. Smith

H. N. Smith
State Conservationist

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
P. O. BOX 1306
ALBUQUERQUE, NEW MEXICO
February 15, 1961

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

Dear Sir:

We reply to your letter of January 20, 1961, file SWFGP, enclosing a draft of your "Review of Reports on Brazos River and Tributaries, Texas, Covering San Gabriel River Watershed," dated January 1961, for our review and comment. It is understood that our comments will be appended to the final report.

We appreciate the consideration you have given to fish and wildlife in your report, and are especially pleased to note that essential facilities for hunting and fishing as recommended in the Bureau of Sport Fisheries and Wildlife report will be included in the Laneport, North Fork, and South Fork Reservoir Projects.

We also note that your report combines general recreation and fishing and hunting benefits for the proposed plan of development 10B to yield a total benefit of $1,047,200 per year. In view of the fact that the Bureau of Sport Fisheries and Wildlife report evaluated fish and wildlife on the basis of expected sportsmen's expenditures at $230,000 per year for fishing and from $17,000 to $21,000 per year for hunting, and the National Park Service report equated other recreational benefits at $240,000, it is difficult to understand how our evaluations were used in developing your estimated $1,047,200 for recreation benefits.

It may be pointed out that our study was based on the anticipated average annual use created by project lands and waters for fishing and hunting over a 100-year period of analysis and not upon short term data reflecting total use on a few similar reservoirs. The investigation was conducted by experienced fish and wildlife biologists of the Texas Game and Fish Commission and this Bureau. Consideration was given to such factors as location of the project area in relation to established and proposed reservoirs, projected population data, the probable quality of the fish and wildlife habitat over the life of the project, and the anticipated demands for hunting and fishing in the project area.

It may be that the discrepancies between your analyses and ours are due in part to the fact that development presented in your January 1961 report provides for a combination of flood control and water conservation storages somewhat different than the plans we were requested to evaluate. As you may recall, we reported upon 15 other plans none of which was exactly like the current plan 10B. If you have need for our assistance in a specific evaluation of fish and wildlife resources for plan 10B, we will be glad to furnish it.

Your courtesy in furnishing the draft of the report for our review and comment is appreciated.

Sincerely yours,

/s/ John C. Gatlin

John C. Gatlin
Regional Director

cc: Executive Secretary, Texas Game and Fish Commission, Austin, Texas
Field Supervisor, Branch of River Basin Studies, Bureau of Sport Fisheries and Wildlife, Fort Worth, Texas
Regional Director, Region 3, National Park Service, Santa Fe, New Mexico

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

Feb. 17, 1961

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

Dear Colonel West:

Thank you for your letter of January 20, 1961, transmitting a draft copy of your "Review of Reports on Brazos River and Tributaries, Texas, covering San Gabriel Watershed," to this office for review and comment.

This office has no objection to the proposed development, and will consider the findings of your report in any studies we may make in the Brazos River Basin.

We shall appreciate receiving a copy of the final draft of your report when it becomes available.

Sincerely yours,

/s/ Leon W. Hill

Regional Director

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SOUTHWEST FIELD COMMITTEE, REGION SIX
807 Brazos Street
Austin 14, Texas

February 21, 1961

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

Re: File SWFGP

Dear Sir:

I have reviewed the Corps of Engineers' report, "Review of Reports on Brazos River and Tributaries, Texas, Covering San Gabriel River Watershed," dated January 1961.

An examination of the report indicates that you have utilized all available streamflow data collected by the U. S. Geological Survey. It is interesting to note that the San Gabriel River drains an area that is subject to some of the highest flood-flow rates in the Southwest. The report gives full consideration to these unusually high flood flows.

Thanks for submitting a copy of the report to me for review.

Very truly yours,

/s/ Trigg Twichell

Trigg Twichell
Geological Survey
Member, SWFC

cc: Douglas R. Woodward,
Washington, D. C.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
AWR Basins Office
Agricultural Office Building, 15 & Quebec
Tulsa 12, Oklahoma
February 21, 1961

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

Dear Colonel West:

I am enclosing copy of letter of comments from Mr. J. K. Vessey, Regional Forester, U. S. Forest Service, relating to the review by his office of the "Review of Reports on Brazos River and Tributaries, Texas, covering San Gabriel River Watershed."

Under date of February 15, 1961, Mr. H. N. Smith, State Conservationist, Texas, transmitted his comments to you. These comments from Mr. Smith and the enclosed comments from the U. S. Forest Service constitute the field level review comments of the Department of Agriculture.

We appreciate the opportunity of reviewing this report.

Yours very truly,

/s/ John A. Short

John A. Short
River Basin Representative

Enclosure

UNITED STATES GOVERNMENT
M E M O R A N D U M

TO: John A. Short, River Basins Representative, AWR Basins Office, Tulsa 12, Oklahoma

DATE: February 13,1961

FROM: J. K. VESSEY, Regional Forester, by Glenn A. Thompson, Acting

SUBJECT: CIPP

Thank you for the opportunity to review the report on the San Gabriel River Watershed.

There are no National Forest lands in this area and it does not appear that the proposed improvements will adversely affect any non-Federal forest land.

The forest type in this area is classed as cedar brakes, having little commercial value.

We have no other comments on this report.

/s/ Glenn A. Thompson

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

March 2, 1961

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

Dear Sir:

The draft copy of your "Review of Reports on Brazos River and Tributaries, Texas, Covering San Gabriel River Watershed", inclosed with your letter of January 20, 1961, file SWFGP, has been reviewed.

The relatively small size of the watershed involved, and the low average runoff reduces the hydroelectric potential in the proposed projects to a minimum. However, in view of the rapidly increasing power market and future need for water supply, it is recommended that consideration be given to power facilities in the initial projects with provision made for future reallocation of storage to higher priority purposes as the needs develop. It is the policy of this Administration, also, to recommend the inclusion of maximum possible storage, for future uses, which can be economically provided in initial construction.

We appreciate the opportunity of reviewing water resource project reports from your office.

/s/ Douglas G. Wright

Douglas G. Wright
Administrator

89982 O-62—17

BRAZOS RIVER AND TRIBUTARIES, TEXAS
(SAN GABRIEL RIVER 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 on the San Gabriel River watershed result from the frequent occurrence of floods and insufficient water supply. Major floods originating on the San Gabriel River watershed cause appreciable damages along the San Gabriel River, the lower Little River, and augment considerably the flood conditions and damages along the main stem of the lower Brazos River. Periods of prolonged drought, upward trends in population, and expansion of industrial and municipal developments have made evident the increasing need for the conservation of surface runoff for all beneficial purposes in the lower Brazos River Basin.

3. Flood problems.- A flood problem exists on the San Gabriel River within the investigated reach between the proposed North and South Fork Reservoir sites and the river mouth, where an agricultural area devoted principally to farming and ranching is subjected to frequent damage by flood flows originating on the San Gabriel River watershed. A serious flood problem also exists along the Little River below the mouth of the San Gabriel River and the lower Brazos River below the mouth of the Little River where damages to urban and highly developed agricultural areas are considerably increased during flood stages on the Little River and lower Brazos River by major flood flows discharging from the San Gabriel River. Urban damages occur at Georgetown, Cameron, Hearne, Rosenberg, Richmond, Brazoria, Sugarland, West Columbia, East Columbia, and other communities.

4. Water supply problem.- A public hearing was held at Georgetown on March 19, 1950, during which local interests stated the need for conservation of water for municipal, industrial, and agricultural purposes on the lower Brazos River Basin, including the San Gabriel River watershed. The water originating in the main channel of the Brazos River above Whitney Reservoir generally possesses a high salt content and is largely unsatisfactory for municipal and industrial purposes. However, the water originating on the tributary streams of the Brazos River below Possum Kingdom Reservoir, including the San Gabriel River, is of good quality. The aggregate firm yield of water supply available from ground water and existing and proposed surface reservoirs is estimated at about 510 million gallons daily. The projected water requirements for municipal and industrial purposes by the year 2010 will be about 8.2 million gallons daily for the cities of

Georgetown, Taylor, Thrall, and Thorndale and 1,102 million gallons daily for the lower Brazos River Basin. In view of the above, storage for water supply purposes, in the maximum amounts which can be economically provided, should be included in all multiple-purpose reservoir projects planned by the Corps of Engineers on the lower Brazos River tributary system.

5. Recommended plan of improvement.- The District Engineer recommends that the authorized project for Brazos River and tributaries, Texas, be modified to provide for modification and immediate construction of the authorized Laneport Reservoir project as a primary first-stage unit, and the subsequent construction of the North Fork and South Fork Reservoirs as second-stage and third-stage reservoir units, respectively, under a plan of stage development, with such changes therein as in the discretion of the Chief of Engineers may be advisable, at an estimated additional Federal construction cost of $13,784,000 and in increase of $171,300 in annual maintenance and operation costs, subject to the conditions that local interests reimburse the United States for the project construction cost and annual maintenance cost allocated to water conservation. The authorized Laneport and recommended North Fork and South Fork Reservoir projects would be constructed for flood control, water conservation, fish and wildlife, and recreation purposes. Pertinent data for the proposed plan is shown in table 1.

6. Project costs and economic analysis.- The recommended San Gabriel River Basin projects would be constructed by the Federal Government at a total estimated construction cost of $42,420,000 (exclusive of $64,000 preauthorization costs) on the basis of July 1, 1961 prices. Individual costs per project are as follows: Laneport Reservoir, $23,400,000 (exclusive of $44,000 preauthorization costs), North Fork Reservoir, $11,800,000 (exclusive of $10,000 preauthorization costs), and South Fork Reservoir, $7,220,000 (exclusive of $10,000 preauthorization costs). The estimated annual charges shown in the report are $1,853,000, consisting of $1,617,900 for interest and amortization, and $235,100 for maintenance and operation. The interest and amortization was computed on a 2.625 percent interest rate, a 50-year life, and a construction period of 5 years for Laneport Reservoir and 3 years for the North and South Fork Reservoirs. The interest and amortization is $902,600 for the Laneport Reservoir, $443,700 for the North Fork Reservoir, and $271,600 for the South Fork Reservoir. The annual operation and maintenance cost is $235,100 including $100,100 for the Laneport Reservoir, $70,300 for the North Fork Reservoir, and $64,100 for the South Fork Reservoir.

7. Benefits and benefit-cost ratio.- The annual charges, annual benefits, and benefit-cost ratios for 50-year and 100-year economic life are summarized in table 2.

TABLE 1

PERTINENT DATA FOR PROPOSED PLAN
SAN GABRIEL RIVER WATERSHED

Item	First stage	Second stage	Ultimate stage		
	Laneport	Laneport	Laneport	North Fork	South Fork
DAM					
Location	Mile 29.7 San Gabriel	Same	Same	Mile 4.0, North San Gabriel	Mile 4.7, South San Gabriel
Type	Concrete & earth fill	Same	Same	Rock fill impervious core	Rock fill impervious core
Length (feet)	16,000	16,000	16,000	12,370	6,100
Height (feet)	111	111	111	188	167
Spillway	Gated	Gated	Gated	Broadcrested uncontrolled	Broadcrested uncontrolled
RESERVOIR					
Storage allocations					
Siltation (ac-ft)	27,700	22,900	22,200	7,000	4,000
Water conservation (ac-ft)	68,100	147,900	193,200	126,700	89,000
Flood control (ac-ft)	236,100	161,100	116,500	87,900	45,500
Total	331,900	331,900	331,900	221,600	138,500

Elevations and areas	Elevation (ft. msl)	Area (acres)	Elevation (ft. msl)	Area (acres)	Elevation (ft. msl)	Area (acres)	Elevation (ft. msl)	Area (acres)	Elevation (ft. msl)	Area (acres)
Spillway crest	502.0	4,790	502.0	4,790	502.0	4,790	855.0	5,000	860.0	3,210
Top water conservation pool	503.8	5,240	515.7	8,270	520.8	9,730	832.8	3,210	843.4	2,340
Top gates	531.0	13,440	531.0	13,440	531.0	13,440	--	--	--	--
Maximum water surface	540.9	16,960	539.0	16,290	540.0	16,640	872.2	6,400	876.6	4,020
Top of dam	546.0		546.0		546.0		878.0		882.0	

TABLE 2

BENEFIT-COST RATIO
(in 1000 dollars)
SAN GABRIEL RIVER WATERSHED

Item	Based on economic life of 50-years				Based on economic life of 100-years			
	Laneport	North Fork	South Fork	Total	Laneport	North Fork	South Fork	Total
Average annual costs								
Investment costs	902.6	443.7	271.6	1,617.9	708.9	348.4	213.3	1,270.6
Maintenance, operation, & replacement	100.7	70.3	64.1	235.1	107.1	75.0	69.1	251.2
Total	1,003.3	514.0	335.7	1,853.0	816.0	423.4	282.4	1,521.8
Average annual benefits								
Flood damage prevention	1,819.7	582.5	274.3	2,676.5	1,819.7	582.5	274.3	2,676.5
Water conservation	508.2	512.8	273.0	1,294.0	508.2	512.8	273.0	1,294.0
Fish & wildlife	43.8	19.3	19.0	82.1	43.8	19.3	19.0	82.1
Recreation	405.5	351.7	290.0	1,047.2	405.5	351.7	290.0	1,047.2
Total	2,777.2	1,466.3	856.3	5,099.8	2,777.2	1,466.3	856.3	5,099.8
Ratio of benefits to costs	2.8	2.9	2.6	2.8	3.4	3.5	3.0	3.4

8. Physical feasibility and provision for future needs.- The development of the San Gabriel River Basin in three stages with Laneport Reservoir the first-stage, North Fork Reservoir the second-stage, and South Fork Reservoir the third or ultimate-stage was found to be the most favorable and practical plan of improvement. The Laneport Reservoir project will provide the greatest amount of flood control benefits and still satisfy present water conservation needs for the most reasonable benefit-cost ratio. The three reservoirs would be credited not only with large flood control benefits in the San Gabriel River Basin but also in the lower Little River and Brazos River Basins, along with the maximum and most economical conservation of good quality water on the San Gabriel River watershed, which would contribute most favorably towards fulfillment of the present and future water supply requirements of local, lower Little River, and lower Brazos River Basins.

9. A regional analysis of flood control storage requirements in the Brazos River Basin indicated that each reservoir should have sufficient flood control storage to regulate the 50-year flood from its watershed area to non-damaging proportions downstream. Flood control requirements were based on routing of the hypothetical 50-year floods through the reservoirs. The 50-year storms were centered upon the watershed to determine the most critical requirements for flood control storage under the various stages of development. The most appropriate solution was a three-stage development plan that would allow development of water conservation as needed and provide the maximum flood protection from the first stage until the entire system is completed. In determining the conservation storage capacity that should be provided in the reservoir, cognizance was taken of the request of local interests which include the probable water requirements of downstream interests in addition to those in the local area. Yield versus storage relationships were established, and cost estimates were developed for several volumes of conservation storage. These studies disclosed that a total of 408,900 acre-feet (193,200 acre-feet in Laneport Reservoir, 126,700 acre-feet in North Fork Reservoir, and 89,000 acre-feet in South Fork Reservoir) of conservation storage could be provided at reasonable cost and this volume of storage was generally in accordance with the desires of those interested in obtaining water from the San Gabriel River area. The Federal Power Commission has concluded that production of power at the proposed sites would not be economically feasible. The reservoirs will provide adequate recreation facilities to meet the anticipated needs of the general public within the surrounding area.

10. Extent of interest in the project.- The Brazos River Authority, acting in behalf of municipalities in the San Gabriel River watershed and in behalf of local interests located in the lower Brazos River Basin, has indicated a desire for flood control and conservation measures on the San Gabriel River watershed, requesting that the Corps

TABLE 3

STORAGE OF PROPOSED RESERVOIRS
SAN GABRIEL RIVER WATERSHED

Reservoir	Stage 1			Stage 2			Stage 3 (Ultimate)		
	Total (ac-ft)	WC pool (ac-ft)	FC pool (ac-ft)	Total (ac-ft)	WC pool (ac-ft)	FC pool (ac-ft)	Total (ac-ft)	WC pool (ac-ft)	FC pool (ac-ft)
Sediment storage									
Laneport	27.7	19.7	8.0	22.9	20.2	2.7	22.2	20.7	1.5
North Fork				7.0	5.8	1.2	7.0	5.8	0.5
South Fork							4.0	3.5	0.5
	Conservation storage (ac-ft)	Conservation storage (in)	Yield (cfs)	Conservation storage (ac-ft)	Conservation storage (in)	Yield (cfs)	Conservation storage (ac-ft)	Conservation storage (in)	Yield (cfs)
Conservation storage									
Laneport	68.1	1.8	43	147.9	5.83	39	193.2	10.21	34
North Fork				126.7	10.06	30	126.7	10.06	30
South Fork							89.0	13.90	17
	Flood control storage (acre-feet)			Flood control storage (acre-feet)			Flood control storage (acre-feet)		
Flood control storage									
Laneport		236.1			161.1			116.5	
North Fork					87.9			87.9	
South Fork								45.5	

NOTE: All storage figures are in 1,000 acre-feet

of Engineers consider including the maximum water conservation in all reservoirs investigated. The Brazos River Authority has indicated its acceptance of the three reservoir projects (Laneport, North Fork, and South Fork) and that at the proper time it will contract for the total cost of the water supply provisions prior to the initiation of construction. The Authority has indicated no desire to defer payment for the cost of any portion of the storage space for future water supply as set forth by the Water Supply Act of 1958. Objections to the location of a reservoir on the San Gabriel River has been expressed by local interests who live in the investigated Laneport Reservoir area. The major objections expressed by the opponents were in regard to the displacement or relocation of people who reside or own land within the proposed Laneport Reservoir area; the inundation of lands which they classify as the best and most highly developed portion of the watershed; reduction in economic returns to the landowners, specifically in the Laneport Reservoir site; the loss of tax revenue to school districts and county governments. Certain local interests who reside within the proposed Laneport Reservoir area have expressed considerable opposition to the Laneport project and have indicated a preference for the North Fork and South Fork Reservoirs on the upstream tributaries.

11. Allocation of costs.- The results of allocation of the costs of the three reservoir projects (Laneport, North Fork, and South Fork) by the Separable Cost-Remaining Benefits method and by alternative methods listed in Senate Resolution 148, based on third-stage conditions and on assumed economic lives of 50 to 100 years, are presented in table 4. Costs allocated to water conservation are the responsibility of local interests. The full local cooperation requirements for the recommended improvement provide that prior to construction local interests give assurances satisfactory to the Secretary of the Army that they will obtain all the necessary water rights and contribute the part of the total first cost of the project and the annual cost of operation, maintenance, and replacements allocated to water conservation. Local cooperation requirements further provide that local interests be permitted to contribute their share of the construction cost (a) in a lump sum prior to initiation of construction (see table 5), (b) in annual amounts during the period of construction, proportional to the annual Federal appropriations for construction, or (c) in equal annual payments, including interest during construction and interest on the unpaid balance, within the economic life of the project but in no event to exceed 50 years from the date on which the project is first available for storage of water for any purpose. Also, that local interests be permitted to contribute their share of the annual cost of operation, maintenance, and replacements (a) on an annual basis as these costs are incurred or (b) in one lump sum on a present-worth basis. (See table 5)

12. Repayment arrangements.- Possible repayment arrangements for the water supply provisions in the recommended San Gabriel River Basin projects are described in paragraph 11 above.

TABLE 5

WATER CONSERVATION COSTS
PROPOSED PLAN OF IMPROVEMENT
SAN GABRIEL RIVER WATERSHED

Reservoir	First costs	Percent	Annual M&O Charge	Percent
Laneport	$ 9,593,300	40.92	$35,800	35.55
North Fork	5,664,000	47.96	31,300	44.53
South Fork	3,452,000	47.75	30,300	47.27
Total	$18,709,300		$97,400	

13. Alternative project considerations.- Preliminary feasibility studies were made for a total of four potential reservoirs on the San Gabriel River watershed: Laneport on the San Gabriel River at river mile 29.7; North Fork Dam on the North Fork of the San Gabriel River at river mile 4.0; South Fork Dam on the South Fork of the San Gabriel River at river mile 4.7; and Berry Creek Dam on Berry Creek at river mile 6.7. Comparison made of the excess benefits over cost for the various stage-and simultaneous-development plans resulted in the selection of plan 10B, a stage-development plan of Laneport, North and South Fork Reservoirs. Comparison of the recommended plan and solutions considered are found in appendix II. Tables 7A and 7B, "Summary of Economic and Cost Analyses - Solutions Considered," and paragraph 26, "Analysis of Investigated Reservoir Plans."

TABLE 4

ALLOCATION OF COSTS
PROPOSED PLAN OF IMPROVEMENT
SAN GABRIEL RIVER WATERSHED
(SENATE RESOLUTION 148)
(in thousand dollars)

Item	Laneport Reservoir				North Fork Reservoir				South Fork Reservoir			
	Separable Cost-Remaining Benefits	Use of Facilities	Priority of Use	Incremental Cost	Separable Cost-Remaining Benefits	Use of Facilities	Priority of Use	Incremental Cost	Separable Cost-Remaining Benefits	Use of Facilities	Priority of Use	Incremental Cost
ECONOMIC LIFE OF 50 YEARS												
Allocations to flood control												
First cost	9,780.8 (41.72%)	7,490.0 (31.95%)	10,210.0 (43.55%)	9,463.0 (40.37%)	4,443.0 (37.62%)	4,180.0 (35.39%)	4,179.0 (35.39%)	4,895.0 (41.45%)	2,580.0 (35.68%)	2,290.0 (31.67%)	2,701.0 (37.35%)	2,775.0 (38.38%)
Annual cost of maintenance, operation, and replacement	48.8 (48.46%)	32.3 (32.08%)	43.8 (43.50%)	48.3 (47.96%)	15.6 (22.19%)	22.8 (32.43%)	24.9 (35.42%)	23.2 (33.00%)	19.3 (30.11%)	18.1 (28.24%)	23.9 (37.29%)	23.3 (36.35%)
Allocations to water conservation												
First cost	9,593.3 (40.92%)	14,704.0 (62.72%)	8,632.0 (36.82%)	12,981.0 (55.37%)	5,664.0 (47.96%)	6,603.0 (55.91%)	5,453.0 (46.17%)	6,115.0 (51.78%)	3,452.0 (47.75%)	4,165.0 (57.61%)	3,439.0 (47.57%)	3,775.0 (52.21%)
Annual cost of maintenance, operation, and replacement	35.8 (35.55%)	53.6 (53.23%)	37.1 (36.84%)	37.6 (37.34%)	31.3 (44.53%)	32.9 (46.80%)	32.4 (46.09%)	32.5 (46.23%)	30.3 (47.27%)	35.5 (55.38%)	30.5 (47.58%)	30.3 (47.27%)
Allocations to fish and wildlife												
First cost	722.1 (3.08%)	296.0 (1.26%)	767.0 (3,27%)	317.0 (1.35%)	287.0 (2,43%)	196.0 (1.66%)	312.0 (2.64%)	363.0 (3.07%)	274.0 (3.79%)	142.0 (1.96%)	239.0 (3.31%)	267.0 (3.69%)
Annual cost of maintenance, operation, and replacement	1.2 (1.19%)	1.0 (0.99%)	3.3 (3.28%)	1.0 (0.99%)	2.0 (2.84%)	1.0 (1.42%)	1.9 (2.70%)	1.0 (1.42%)	2.0 (3.12%)	1.0 (1.56%)	2.1 (3.28%)	1.0 (1.56%)
Allocations to recreation												
First cost	3,347.8 (14.28%)	954.0 (4.07%)	3,835.0 (16.36%)	683.0 (2.91%)	1,416.0 (11.99%)	831.0 (7.04%)	1,866.0 (15.80%)	437.0 (3.70%)	924.0 (12.78%)	633.0 (8.76%)	851.0 (11.77%)	413.0 (5.72%)
Annual cost of maintenance, operation, and replacement	14.9 (14.80%)	13.8 (13.70%)	16.5 (16.38%)	13.8 (13.70%)	21.4 (30.44%)	13.6 (19.35%)	11.1 (15.79%)	13.6 (19.35%)	12.5 (19.50%)	9.5 (14.82%)	7.6 (11.85%)	9.5 (14.82%)
ECONOMIC LIFE OF 100 YEARS												
Allocations to flood control												
First cost	9,427.0 (40.21%)	7,487.0 (31.94%)	9,396.0 (40.08%)	9,463.0 (40.37%)	4,421.0 (37.43%)	4,162.0 (35.24%)	4,162.0 (35.24%)	4,895.0 (41.45%)	2,580.0 (35.68%)	2,273.0 (31.44%)	2,653.0 (36.69%)	2,775.0 (38.38%)
Annual cost of maintenance, operation, and replacement	50.8 (47.48%)	34.2 (31.96%)	42.9 (40.10%)	51.0 (47.66%)	17.3 (23.07%)	24.3 (32.40%)	26.4 (35.20%)	25.0 (33.33%)	19.8 (28.65%)	19.5 (28.22%)	25.4 (36.76%)	25.0 (36.18%)
Allocations to water conservation												
First cost	10,618.0 (45.29%)	14,627.0 (62.39%)	9,628.0 (41.07%)	12,981.0 (55.37%)	5,637.0 (47.73%)	6,555.0 (55.50%)	5,426.0 (45.94%)	6,115.0 (51.78%)	3,580.0 (49.51%)	4,148.0 (57.37%)	3,484.0 (48.19%)	3,775.0 (52.21%)
Annual cost of maintenance, operation, and replacement	35.9 (33.55%)	56.8 (53.08%)	43.9 (41.03%)	40.0 (37.38%)	33.3 (44.40%)	35.1 (46.80%)	34.5 (46.00%)	34.4 (45.87%)	32.8 (47.47%)	38.0 (54.99%)	33.3 (48.19%)	32.5 (47.03%)
Allocations to fish and wildlife												
First cost	779.0 (3.12%)	291.0 (1.24%)	856.0 (3.65%)	317.0 (1.35%)	328.0 (2.78%)	192.0 (1.63%)	359.0 (3.04%)	363.0 (3.07%)	291.0 (4.03%)	138.0 (1.91%)	266.0 (3.68%)	267.0 (3.69%)
Annual cost of maintenance, operation, and replacement	1.8 (1.68%)	1.0 (0.94%)	3.9 (3.64%)	1.0 (0.94%)	2.2 (2.93%)	1.0 (1.33%)	2.3 (3,07%)	1.0 (1.33%)	2.4 (3.47%)	1.0 (1.45%)	2.5 (3.62%)	1.0 (1.45%)
Allocations to recreation												
First cost	2,843.0 (11.38%)	1,039.0 (4.43%)	3,564.0 (15.20%)	683.0 (2.91%)	1,424.0 (12.06%)	901.0 (7.63%)	1,863.0 (15.78%)	437.0 (3.70%)	779.0 (10.78%)	671.0 (9.28%)	827.0 (11.44%)	413.0 (5.72%)
Annual cost of maintenance, operation, and replacement	18.5 (17.29%)	15.0 (14.02%)	16.3 (15.23%)	15.0 (14.02%)	22.2 (29.60%)	14.6 (19.47%)	11.8 (15.73%)	14.6 (19.47%)	14.1 (20.41%)	10.6 (15.34%)	7.9 (11.43%)	10.6 (15.34%)

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