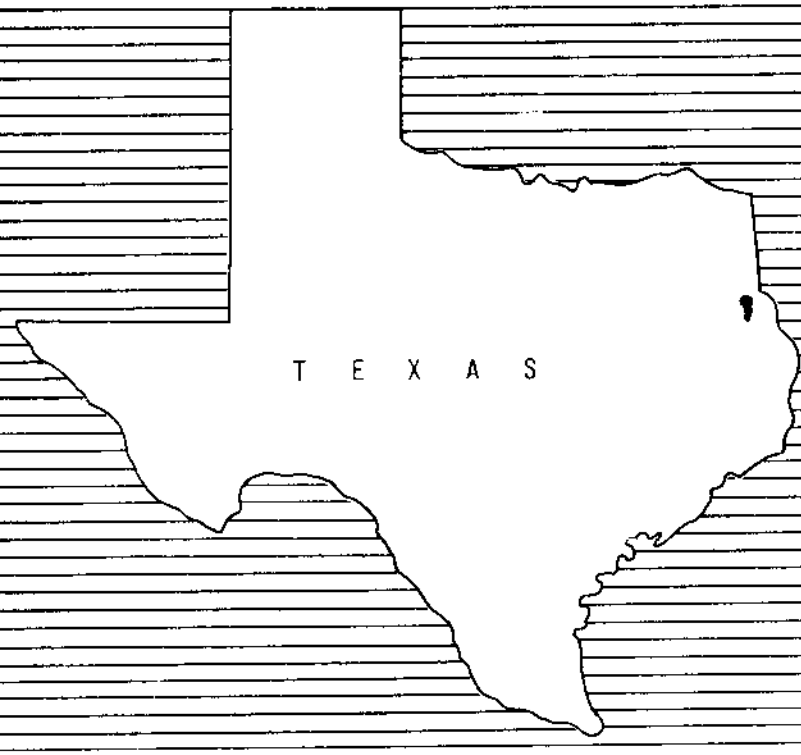
WORK PLAN

- FOR WATERSHED PROTECTION, FLOOD PREVENTION AND RECREATIONAL DEVELOPMENT

ATTOYAC BAYOU WATERSHED

NACOGDOCHES, RUSK, SHELBY, AND SAN AUGUSTINE COUNTIES, TEXAS



May 1964

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WATERSHED WORK PLAN AGREEMENT

between the

Attoyac Bayou Watershed Authority
Local Organization

Nacogdoches County Commissioners Court
Local Organization

Rusk County Commissioners Court
Local Organization

Shelby County Commissioners Court
Local Organization

Nacogdoches Soil Conservation District
Local Organization

Rusk Soil Conservation District
Local Organization

Shelby Soil Conservation District
Local Organization

Piney Woods Soil Conservation District
Local Organization

State of Texas
(hereinafter referred to as the Sponsoring Local Organization)

and the

Soil Conservation Service
United Stated Department of Agriculture
(hereinafter referred to as the Service)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the Attoyac Bayou Watershed, State of Texas under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666), as amended; and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Sponsoring Local Organization and the Service a mutually satisfactory plan for works of improvement for the Attoyac Bayou Watershed, State of Texas, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about 5 years.

It is mutually agreed that in installing and operating and maintaining the works of improvement substantially in accordance with the terms, conditions, and stipulations provided for in the watershed work plan:

1. The Sponsoring Local Organization will acquire such land, easements or rights-of-way as will be needed in connection with the works of improvement. (Estimated Cost $910,580). The percentages of this cost to be borne by the Sponsoring Local Organization and the Service are as follows:

Works of Improvement	Sponsoring Local Organizations (Percent)	Service (Percent)	Estimated Land, Easements, and Rights-of-Way Cost (Dollars)
Multiple-Purpose Structure No. 23 and Basic Recreational Facilities			
Payments to landowners for 1,100 acres and cost of relocation or modification of improvements	50.0	50.0	101,980
Legal fees, survey costs, flowage easements, and other costs	100.0	0	7,500
All other structural measures	100.0	0	801,100

2. The Sponsoring Local Organization will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to State law as may be needed in the installation and operation of the works of improvement (Estimated cost $500).

3. The percentages of construction costs of structural measures to be paid by the Sponsoring Local Organization and by the Service are as follows:

Works of Improvement	Sponsoring Local Organizations (Percent)	Service (Percent)	Estimated Construction Cost (Dollars)
Multiple-Purpose Structure No. 23	27.4	72.6	287,100
Basic Recreational Facilities	50.0	50.0	77,450
Single-Purpose Floodwater Retarding Structures Nos. 1-22	0	100.0	1,453,210
49.0 miles of Channel Improvement	0	100.0	1,584,550

4. The percentages of the cost for installation services to be borne by the Sponsoring Local Organization and the Service are as follows:

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Installation Service Cost (dollars)
Multiple-Purpose Structure No. 23	0	100	52,790
Basic Recreational Facilities	50	50	6,230
Single-Purpose Floodwater Retarding Structures Nos. 1 thru 22	0	100	358,629
49.0 miles of Channel Improvement	0	100	299,978

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 14,500 .)

6. The Sponsoring Local Organization will obtain agreements from owners of not less than 50% of the land above each reservoir and floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.

7. The Sponsoring Local Organization will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.

8. The Sponsoring Local Organization will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.

9. The Sponsoring Local Organization will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.

10. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred in the installation of works of improvement will be used.

11. This agreement does not constitute a financial document to serve as a basis for the obligation of Federal funds, and financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the appropriation of funds for this purpose.

Where there is a Federal contribution to the project costs, separate agreements in connection with each phase will be entered into between the Service and the Sponsoring Local Organization prior to the obligation of any financial obligations. Such agreements will set forth in detail the financial and working arrangements and other conditions that are applicable.

12. The watershed work plan may be amended or revised, and this agreement may be modified or terminated, only by mutual agreement of the parties hereto.

13. No member of Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

Attoyac Bayou Watershed Authority
Local Organization

By _____
Gilmer Tyson

Title Chairman

Date November 4, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Attoyac Bayou Watershed Authority
Local Organization

adopted at a meeting held on November 4, 1964

_____
Ass't (Secretary, Local Organization)
A. M. Boles

Date November 4, 1964

Nacogdoches County Commissioners Court
Local Organization

By F. L. Harris
F. L. Harris
Title County Judge

Date November 4, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Nacogdoches County Commissioners Court
Local Organization

adopted at a meeting held on November 4, 1964

Susie Massey
(~~Secretary, Local Organization~~) County Clerk
Susie Massey
Date November 4, 1964

Rusk County Commissioners Court
Local Organization

By Paul Colley
Paul Colley
Title County Judge

Date November 4, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Rusk County Commissioners Court
Local Organization

adopted at a meeting held on October 27, 1964

Calvin H. Barber
(~~Secretary, Local Organization~~) County Clerk
Calvin H. Barber
Date November 4, 1964

Rusk Soil Conservation District
Local Organization

By Reagan Taylor

Title Reagan Taylor
Chairman

Date November 4, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Rusk Soil Conservation District
Local Organization

adopted at a meeting held on September 2, 1964

(Secretary, Local Organization)
J. H. Clendenen

Date November 4, 1964

Shelby Soil Conservation District
Local Organization

By John F. Childs

Title John F. Childs
Chairman

Date November 4, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Shelby Soil Conservation District
Local Organization

adopted at a meeting held on September 4, 1964

(Secretary, Local Organization)
W. I. Davis

Date November 4, 1964

Shelby County Commissioners Court
Local Organization

By John W. Creech
John W. Creech
Title County Judge

Date November 4, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Shelby County Commissioners Court
Local Organization

adopted at a meeting held on November 4, 1964

Obie Henry
(~~Secretary, Local Organization~~) County Clerk
Obie Henry
Date November 4, 1964

Nacogdoches Soil Conservation District
Local Organization

By Belton Latimer
Belton Latimer
Title Chairman

Date November 4, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Nacogdoches Soil Conservation District
Local Organization

adopted at a meeting held on September 2, 1964

Hugh Jones
(Secretary, Local Organization)
Hugh Jones
Date November 4, 1964

Piney Woods Soil Conservation District
Local Organization

By L. B. Mitchell
L. B. Mitchell
Title Vice Chairman

Date November 4, 1964

The signing of this agreement was authorized by a resolution of the governing body of the Piney Woods Soil Conservation District
Local Organization
adopted at a meeting held on September 8, 1964

W. O. "Bill" Low
(Secretary, Local Organization)
W. O. "Bill" Low
Date November 4, 1964

_____
Local Organization

By _____

Title _____

Date _____

The signing of this agreement was authorized by a resolution of the governing body of the _____
Local Organization
adopted at a meeting held on _____

_____
(Secretary, Local Organization)

Date _____

Soil Conservation Service
United States Department of Agriculture

By _____

Date 7-14-65

WORK PLAN

FOR

WATERSHED PROTECTION, FLOOD PREVENTION

AND RECREATIONAL DEVELOPMENT

ATTOYAC BAYOU WATERSHED
Nacogdoches, Rusk, Shelby, and San Augustine Counties, Texas

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act, (Public Law 566, 83rd Congress, 68 Stat. 666), as amended.

Prepared By:

Attoyac Bayou Watershed Authority
(Sponsor)
Nacogdoches County Commissioners Court
(Sponsor)
Rusk County Commissioners Court
(Sponsor)
Shelby County Commissioners Court
(Sponsor)
Nacogdoches Soil Conservation District
(Sponsor)
Rusk Soil Conservation District
(Sponsor)
Shelby Soil Conservation District
(Sponsor)
Piney Woods Soil Conservation District
(Sponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
U. S. Forest Service

May 1964

WATERSHED WORK PLAN

ATTOYAC BAYOU WATERSHED
Nacogdoches, Rusk, Shelby, and San Augustine Counties, Texas
May 1964

SUMMARY OF PLAN

The work plan for watershed protection, flood prevention and recreational development in the Attoyac Bayou watershed, Texas, was prepared by the Attoyac Bayou Watershed Authority, the Nacogdoches, Rusk, and Shelby Counties Commissioners Courts, and the Nacogdoches, Rusk, Shelby, and Piney Woods Soil Conservation Districts, the local sponsoring organizations. Technical assistance was provided by the Soil Conservation Service and the Forest Service of the United States Department of Agriculture.

The Attoyac Bayou watershed comprises an area of 333.5 square miles in portions of Rusk, Shelby, San Augustine, and Nacogdoches Counties, Texas. About 56 percent of the project area is woodland, 37 percent is pasture, 3 percent is cropland and 4 percent is non-agricultural, such as roads, towns and water areas. All of the agricultural land is privately owned.

The principal problem in the watershed is prolonged flooding of 19,000 acres of bottomland on the Attoyac Bayou and its tributaries. Overflows average 4 per year on some portions of the flood plain.

The work plan proposes the installation of land treatment measures at an accelerated rate during a 5-year installation period for the protection of the watershed. Measures needed are those which will improve the hydrologic condition of the grass and forest land. The installation cost of these measures is $1,031,100. Of this amount, $92,400 is Public Law 566 funds to provide for technical assistance at an accelerated rate to complete the mapping of soils and to plan and apply the needed land treatment measures on forest and non-forest land.

Twenty-two floodwater retarding structures, one multiple-purpose structure and 49.0 miles of channel improvement will be installed. The multiple-purpose structure, to be known as Lake Naconiche, will have basic facilities to accommodate water-based recreation. The estimated cost of these structures is $5,045,517. The Public Law 566 share of the cost is $4,050,422. The sponsoring local organizations will furnish all needed land easements, rights-of-way, and relocation for the structural measures. The local share of the cost to develop Lake Naconiche into a recreational development is $180,495. All of the structural measures will be installed during a 5-year installation period.

The estimated average annual floodwater damage without the project is $128,443 of which $110,343 is to crops, pastures, livestock, fences, and farm equipment; $18,100 is to roads and bridges. Indirect damages are estimated to be $12,844 annually.

With the project installed, the annual crop, pasture, fence and other agricultural damages will be reduced to $33,111; damages to roads and bridges will be reduced to $5,638. Indirect damages will be reduced to $3,875 per year.

Total damage reduction benefits will be $98,663 annually. Secondary benefits will average $35,750 annually. Benefits in the form of increased net income from more intensive use of protected flood plain will amount to $111,990 annually. The use of recreational facilities in the multiple-purpose structure will produce about $75,000 per year in benefits. In addition, approximately $4,466 annually will result from incidental recreational use of the floodwater retarding structures open to the general public. Redevelopment benefits from project employment of presently unemployed local labor are expected to total $14,243. The ratio of the average annual benefits accruing to structural measures ($332,931) to the average annual cost of these measures ($203,753) is 1.63 to 1.0.

The land treatment measures will be operated and maintained by the landowners and operators of the land on which the measures will be installed under agreements with the Nacogdoches, Rusk, and Shelby Soil Conservation Districts. The structural measures will be operated and maintained by the Attoyac Bayou Watershed Authority and the Nacogdoches, Rusk, and Shelby Counties Commissioners Courts. These local organizations have the authorities under applicable State laws to operate and maintain the planned works of improvement. The cost of operation and maintenance is estimated to be $38,462 annually.

DESCRIPTION OF THE WATERSHED

Physical Data

Attoyac Bayou is a tributary of the Angelina River, Neches River basin in East Texas. It heads approximately 2 miles northeast of Mount Enterprise in Rusk County and flows in a south to southeasterly direction into the Sam Rayburn Reservoir in the vicinity of Chireno near the Nacogdoches and San Augustine County line. The watershed area included in the project drains southeast Rusk County, western Shelby County, and northeast Nacogdoches County. The project ends near the Shelby and San Augustine County line east of the village of Martinsville. The larger tributaries include Caney and Golondrino Creeks to the northwest, Wanders and Naconiche Creeks to the west, Turkey and Terrapin Creeks to the southwest, Blackwater Creek to the north, and West Creek to the east of the mainstem. Garrison is the largest town in the watershed. Other towns and cities near the watershed include Timpson, on the northeastern watershed divide; Henderson, 18 miles north; Mount Enterprise, 2 miles northwest; Nacogdoches, 8 miles southwest; Center, 7 miles east; and San Augustine, 20 miles southwest. The total drainage area is 213,440 acres, or 333.5 square miles.

The watershed lies within the western part of the Forested Coastal Plain physiographic area. It is heavily timbered with pine and hardwood forests. The topography ranges from gently rolling to steeply rolling or hilly. Most of the streams have well developed alluvial flood plains with flat or nearly flat surfaces. Elevations range from 220 feet above mean sea level on the mainstem flood plain near Martinsville to 700 feet on hills in the headwaters near Mount Enterprise.

Poorly consolidated sedimentary rocks of Eocene age cover all of the watershed area except the alluvial flood plains. These rocks were deposited under swampy, nearshore, and shallow marine conditions. The geologic units occurring in the watershed and their major characteristics are listed below:

Group	Formation	Characteristics
Claiborne	Weches	Fossiliferous greensand interbedded with shales and clay
	Queen City	Fine sand with interbedded shale and sandy shales
	Reklaw	Glauconitic sands in base with shale and sands in upper part
	Carrizo	Quartz sands with interbedded thin shales
Wilcox	Sabinetown	Lignitic shales, sandy shales and sands
	Rockdale	Sand, sandy shales, shale, and beds of lignite

The structure of these beds is simple, with a dip of approximately 50 feet per mile to the south.

A major fault zone, the Mount Enterprise fault system, extends across the northern part of the watershed from Rusk to Shelby County. The Claiborne group crops out north of the fault and the Wilcox group south of the fault. The Wilcox beds extend across the central and eastern parts of the watershed. They occupy approximately 60 percent of the total watershed area. The Reklaw formation crops out in a small area north of the fault and in a narrow margin along the southwestern watershed divide. The Carrizo sands crop out along the main Attoyac Bayou valley north of the fault and in a wide belt in the upper drainage areas of Golondrino, Naconiche, and Terrapin Creeks and in the southeastern part of the West Creek drainage. The Weches and Queen City formations are confined to small outcrop areas immediately north of the fault. The Carrizo sand and sands of the Wilcox group are important aquifers in East Texas. The cities of Nacogdoches and Lufkin, as well as other smaller towns obtain water from these beds. Permanent streamflow in Attoyac Bayou and its tributaries originates from springs flowing out of these sands.

The mineral resources are varied but are not extensively developed. The Wilcox group contains extensive lignite and clay deposits. The clays are being utilized for the manufacture of brick at Garrison. Lignite was produced from beds in the vicinity of Timpson until the 1920's, when lignite mining became unprofitable.

Residual surface accumulations of iron-bearing gravels and rock are being utilized for road and highway construction. These materials are found in both the Wilcox and Claiborne formations. Petroleum production in the watershed is not important.

Soils of the East Texas Timberlands land resource area cover the watershed. These soils are generally sandy and were developed under humid forest conditions. The Susquehanna, Boswell, Sawyer, and Kirvin series are very slowly to slowly permeable soils which have developed on the shale and sandy shale parent materials. Moderately permeable soils of the Bowie and Ruston series are found on the more sandy parent materials. Shallow soil development of the Cuthbert and Bub series is found on the steeper slopes and on concretionary iron-bearing deposits. Extensive areas of sandy, rapidly permeable soils of the Eustis and Lakeland series occur on the Carrizo sands and to a lesser extent on the Wilcox sands. Soils found on the alluvial flood plain include the moderately well drained Iuka series and small areas of poorly drained Bibb series.

Pine forests covered the watershed under natural conditions before settlement by Spanish missionaries and colonists beginning in the early 1700's. More intensive colonization began after the 1820's when American colonists received grants from the Mexican government for settlement in this area. Clearing of the forest increased as population growth demanded more lands for tobacco and cotton production. Cotton production dominated later with the peak in clearing and cultivation being reached in the early 1900's. Drastic land use changes in the 1950's resulted in conversion of most of this cropland to grassland and forest. Only 3 percent of the watershed land area is now in cultivation and is used mainly for truck crops and corn. The present land use in the watershed is as follows:

Land Use	Acres	Percent
Cropland	6,526	3
Pasture	78,895	37
Forest	119,948	56
Miscellaneous 1/	8,071	4
	213,440	100

1/ Area in roads, towns, stream channels, and water area.

The forest land has an area of about 119,948 acres, of which 23,500 acres are in industrial ownership and the remaining 96,448 acres are in small private ownerships. None of the land is under Forest Service jurisdiction.

The forest types consist of pine, pine-hardwoods, and hardwood. Major species are shortleaf and loblolly pine, red, post and white oaks, hickory, sweetgum, blackgum, yellow poplar, ash and beech. About 79 percent of the forest land is medium to poorly stocked and about 17 percent is of sawtimber size.

Fifty percent of the forest land is in fair hydrologic condition, 16 percent is poor and 34 percent is in good to very good hydrologic condition. The poor hydrologic condition is due to past treatment and use such as overgrazing, burning, and uncontrolled cutting. Due to the low potential for improving hydrologic condition, the rate of recovery is slow. Nevertheless, under proper management and protection, this forest land can be brought into good and very good hydrologic condition. Forest land grazing is still a problem. The present level of fire protection is good.

Cover conditions on the grassland areas range from fair to good. Improved pastures consisting of bermudagrass and clovers have been established on a high percent of the formerly cultivated lands. This good cover is effectively controlling erosion and improving the physical conditions and infiltration rates of the soil.

The average annual rainfall is 47 inches, based on U. S. Weather Bureau records of gage readings at Nacogdoches and Henderson, Texas. Rainfall is highest in the spring months and lowest in the winter months. The mean temperature ranges from 48 degrees in January to 82 degrees in July. The average growing season of 234 days extends from March 23 to November 12.

Economic Data

The economy of this watershed is supported primarily by agriculture. Agricultural enterprises are directed mainly toward beef cattle, dairying, poultry, and wood products. Flood plain use during the 1930's was about 60 percent cropland, with the remainder used primarily as pasture and woodland. The present flood plain land use is approximately 5 percent cropland, 52 percent pasture, 42 percent woodland pasture and 1 percent miscellaneous. The trend toward open pasture has taken place during the past two decades. The shift is due largely to damaging overflows and labor shortages. Many farm operators also have found net income from livestock enterprises to be equal to or in excess of that obtained from continuous cropping with cotton and corn under existing conditions of floodings. Small acreages of woodland pasture have been cleared recently for use as open pasture. High land clearing cost and frequent flooding make this a risky venture under existing conditions.

In Nacogdoches, Shelby, and Rusk Counties the average farm size approximated 127 acres in 1954 and 172 acres in 1959. This increase was accompanied by an increase in the estimated value of land and buildings from

$7,200 in 1954 to $14,200 in 1959, an increase of 97 percent. The increase in average size and value of operating agricultural units is expected to continue. The census shows an increase in value per acre over the same period from about $57 to $83, an increase of 46 percent. Both the values per farm and per acre are low for a healthy agricultural economy.

The cities of Nacogdoches, Henderson, and Center are the county seats of their respective counties. Their combined population increased from 16,985 in 1940 to 26,850 in 1960. This is an increase of 58 percent. It can be expected that their growth will continue, although perhaps at a somewhat reduced rate. They are located near the watershed and each serves as a trade center for the poultry, dairying, and livestock-producing area. Commercial products produced or sold include finished lumber and other wood products, poultry feeders and related items, soft drinks, fertilizers, feed, foundry products, mattresses, candy, milk, ice cream and dairy equipment. Stephen F. Austin College, in Nacogdoches, is one of the leading and most beautiful educational centers of East Texas.

The towns of Garrison, Martinsville, Concord, Lawsonville, and Stockman, with populations of 951, 120, 100, 50, and 40, respectively, are located within the watershed. Population within the watershed has decreased slightly in recent years due in part to the increase in farm size. Most rural areas are sparsely settled since many of the operators and owners of agricultural lands reside in urban areas. Operation of rural agricultural land from a town residence has become a popular and common practice. Rural population is more dense along the flood plain of the major tributaries than elsewhere in the watershed.

The watershed is served by 110 miles of State Highways and 260 miles of county roads. Railway facilities are available in and near the watershed. Roads are accessible to all parts of the watershed except during periods of heavy rains or flash floods when low water crossings and some sections of county roads are impassable for short periods of time.

It is expected that more and more of the flood plain, once used for row crops, will be utilized for feed and hay production in connection with the anticipated growth in beef cattle and dairy enterprises. Reduction of the existing flood hazard will serve as an added stimulus in these changes. Approximately 50 percent of the agricultural land in the watershed is owner-operated. Corporate holdings by a paper manufacturing firm and two lumber-producing companies account for about 23,500 acres of watershed land.

Over 182,000 people live within 50 miles of the watershed. It is immediately accessible to people in Nacogdoches, Henderson, and Center. The watershed also is accessible through Interstate and U. S. Highways to more than 2 million people within a 200-mile radius. People from centers such as Houston already are purchasing tracts in or near the watershed for use as

weekend retreats from the crowds. As these centers grow, their inhabitants will not hesitate to drive up to 200 miles over excellent highways for a quiet weekend.

The scenic splendor of this area attracts many recreational minded people. Water-based recreational facilities in the watershed include Lake Timpson, owned by a local water district, and several privately owned lakes. Limited accommodations are available for overnight visitors. Fishing, boating, and water skiing are permitted on most of the lakes. Several youth and church groups have camps in the watershed.

Nacogdoches, Shelby, and Rusk Counties have been designated as areas of underemployment under the Area Redevelopment Act. Shortage of jobs for unskilled labor is most acute. Farm resources presently are insufficient to provide full employment for the typical farm operator. Therefore the lack of employment for unskilled labor is particularly damaging to the agricultural economy.

Land Treatment Data

The watershed is located in the Nacogdoches, Rusk, Shelby, and Piney Woods Soil Conservation Districts. The Nacogdoches-Rusk Soil Conservation District, organized in October 1940, was the first soil conservation district in Texas. It was reorganized in 1958 into the present Rusk and Nacogdoches Soil Conservation Districts.

The watershed drainage area in each district is as follows: Rusk, 44,864 acres; Nacogdoches, 102,784 acres; Shelby, 65,408 acres; and Piney Woods, 384 acres. Technical assistance is furnished by Soil Conservation Service work units located in Henderson, Nacogdoches, Center and San Augustine.

Forest fire prevention and suppression, forest management assistance, insect and disease control and cooperative forestation are provided private landowners by the Texas Forest Service in cooperation with the U. S. Forest Service through the various Federal-State cooperative forestry programs.

Basic soil and water conservation plans have been prepared for 628 farms in the watershed. The number of cooperators, basic conservation plans, and percent of watershed area in each soil conservation district covered by district agreement is as follows:

Soil Conservation Districts	Cooperators	Basic Conservation Plans	Percent of Land Area
Rusk	244	217	57
Nacogdoches	204	194	60
Shelby	233	216	58
Piney Woods	1	1	100
Totals	682	628	59

Approximately 30 percent of the planned cropland and 40 percent of the planned pastureland practices have been applied. Over 50 percent of the crop and grass land has adequate watershed protection.

About 9 percent of the needed forestry practices has been applied on the 119,948 acres of forest land. Approximately 32 percent of the forest land is considered to be treated adequately. The conservation practices which have been applied by the landowners in this watershed, and their costs, are itemized in table 1A.

The application of needed conservation practices and land use changes have reduced erosion to the extent that runoff waters are almost sediment-free from the adequately treated areas.

WATERSHED PROBLEMS

Floodwater Damages

An estimated 19,000 acres of the watershed, excluding stream channels, is flood plain (figure 1). The flood plain as described herein is the area that will be inundated by the largest flood considered in the 23-year series used for evaluation. This flood approximates a 25-year frequency event.

Devastating floods occurred on Attoyac Bayou in 1957 and 1958. The flood of September 1958, with a recurrence interval of 15 years, inundated approximately 16,000 acres in the watershed area. Monetary floodwater damages from this flood were estimated to be $128,000. These damages would have been much higher had the flood occurred in the spring or early summer.

During the 23-year evaluation period, 1940-1962, there were 86 floods, of which 26 were major floods inundating more than half the 19,000 acres of flood plain in the project area. An average of about 4 floods per year occurs in the watershed, causing damage to crops and pastures, roads and bridges, and other agricultural properties, such as fences and farm equipment.

When recurrent flooding during a single year is considered, the cumulative area flooded (22,491 acres) is so great that it is equivalent to flooding the entire flood plain about 1.3 times annually.

The length of time that floodwater remains on the flood plain is a major problem. This ranges from about 2 days in the headwater area to more than 2 weeks downstream from the mouth of Naconiche Creek. Duration of flooding, more than the depth of inundation, results in production losses to grasses, hay crops and corn. Grass will normally cure on the stalk during the fall season after frost. If a flood occurs at this time, the grass will sour

Flooding from Attoyac River in November 1957. Hegari heads showing just above the water. Cotton stalks are seen on higher ground in the background.

and become unfit for feed. Growing grass which becomes flooded is laden with silt. Livestock will not eat this grass until a rain falls and washes the silt from the grass. There also exists the problem of fertilizer loss due to flooding. Operators of flood plain lands are not able to fertilize to the optimum extent since floods may occur at any time and reduce fertilizer effectiveness. If flooding is reduced to the extent that operators could use more fertilizer, then yields and profits could be increased. Local efforts to reduce flooding have been few and unsuccessful.

The value of flood plain land is $150 per acre. The composite damageable value of flood plain land was calculated to be $19.18 per acre. Under non-project conditions the average annual direct monetary floodwater damage is $128,443, of which $76,526 is to crops and pasture, $33,817 is other agricultural, and $18,100 is non-agricultural, such as damage to roads and bridges. Indirect damage, such as interruption of travel, rerouting of school buses and mail routes, losses sustained by businessmen in the area and similar losses, is estimated to average $12,844 annually.

Due primarily to flooding, the land use of the flood plain is limited to open pasture, woodland pasture, or hay crops. If flooding were reduced, a considerable amount of woodland pasture would be cleared and used as open pasture.

Damages also occur immediately below and outside of the watershed.

Sediment Damage

Sediment loads and deposition by streams of the watershed are extremely low due to the increasing effectiveness of upland cover. However, sediment loads and deposition in the past were serious. Identified recent flood plain deposits of sand and silts average 3 feet or more in depth. Sandy channel fill averages 4 to 6 feet deep on the mainstem channel and up to 8 feet deep in portions of the Naconiche channel. Lesser amounts occur in the channels of other tributaries. This has increased flooding. The present overbank deposition is limited to thin films of sand and silt which are deposited on flood plain vegetation. Damage to the flood plain soil is minor. However, the pasture grasses and plants are damaged by these deposits. This is reflected in the estimates of crop and pasture floodwater damages.

Sediment contribution from the watershed to the Sam Rayburn Reservoir is insignificant. Therefore, no attempt was made to evaluate this damage.

Erosion Damage

Erosion rates in the uplands are low. Conversion of cultivated lands to improved pastures and woodland, along with better forestry management on existing forest lands, has drastically reduced upland erosion damage since the 1950's. Of the present total gross erosion, 83 percent is derived from

sheet erosion; 11 percent from roads, highways, farmsteads, etc.; 3 percent from inactive old gullies; and 3 percent from streambank erosion. The relatively high erosion in miscellaneous areas does not mean that these areas are critical but reflects the effectiveness of cover conditions on the other normally more erodible lands. The present annual gross erosion rate is estimated to be 0.85 acre-foot per square mile.

Flood plain erosion is low. Old scour channels are in evidence throughout the watershed. These have become inactive with the establishment of bermuda-grass pastures on nearly all formerly cultivated lands. Streambank erosion is low. Minor bank cutting is confined to sharp bends and meanders.

Problems Relating to Water Management

Drainage problems are limited to those farms having naturally low areas in the flood plain. Local efforts to improve drainage in these areas have been hindered by the frequency and duration of flooding. The existing stream channels are adequate to serve as major outlets for these on-farm drainage systems. Needs for drainage can be met by on-farm systems.

Very little irrigation is being practiced in the watershed. There is no interest in developing storage for irrigation.

Small towns and communities within the watershed obtain water from wells located in the Carrizo sands and sands of the Wilcox group. There is no interest in developing storage of water for municipal and industrial use.

Shallow wells, farm ponds, and perennial streams furnish water for rural households and livestock use.

The cities of Garrison and Timpson have sewage treatment plants that are now discharging their effluent into water courses which find their way into the Attoyac Bayou. A report by the State of Texas Department of Health indicates that the quality of river water is good and there is no pollution problem.

The Attoyac Bayou provides a considerable amount of hunting and fishing, mostly to local people. At present, the frequency and duration of floods seriously damage the stream fish and wildlife and hinder development of these resources in the flood plain.

Water-based recreational facilities in the watershed include Lake Timpson, owned by a local water district, and several privately-owned lakes. Murvaul Reservoir is located just outside the watershed to the north. Sam Rayburn Reservoir, located about 20 miles south of the watershed, is under construction. Fishing, boating, and water skiing are permitted on most of these lakes. The local sponsors feel that additional recreational resources are needed.

PROJECTS OF OTHER AGENCIES

Lake Timpson, located in Shelby County, is owned by the Shelby County Fresh Water District and was constructed as a water supply for proposed industrial development. It is presently being used for recreation, fish and wildlife. Sam Rayburn Reservoir, located downstream on the Angelina River, is under construction by the U. S. Army Corps of Engineers for flood control, hydroelectric power and water conservation purposes.

BASIS FOR PROJECT FORMULATION

A reconnaissance and preliminary investigation of the watershed was made by representatives of the Soil Conservation Service. A map was prepared to show the extent of all areas subject to flood damage and the location of all possible floodwater retarding structure sites.

Representatives of the Texas Water Commission were invited to make a study of the water needs of the small communities in and near the watershed. Representatives of the Texas Parks and Wildlife Board were invited to make a study of the fish and wildlife problems and the potential for development of floodwater retarding structure sites into multiple-purpose structures to include recreational development.

Meetings were held with the sponsoring local organizations and representatives of the State agencies to discuss existing flood problems, water resource development needs, and to formulate project objectives. Initially, the local sponsors had requested a level of development which would provide complete protection to agricultural land from the 24-hour, 5-year frequency storm. However, subsequent analysis of the possible locations for floodwater retarding structures and other available data indicated that it would not be practical or feasible to attempt to attain this level of protection.

Prior to the initiation of detailed investigations, the following specific objectives were agreed to:

1. Establish land treatment measures which contribute directly to watershed protection and flood prevention.

2. Attain complete protection to agricultural land from the one-year frequency storm and to attain a reduction of at least 70 percent in average annual flood damages by floodwater retarding structures supplemented by channel improvement.

3. Develop the large floodwater retarding structure site on the Naconiche Creek into a multiple-purpose structure for recreational use.

In selecting floodwater retarding structure sites for detailed surveys and

analysis, priority was given to those locations which, in combination with channel improvement, had the greatest potential for providing the desired level of protection. Preliminary layouts of the surveyed structure sites were prepared. These were reviewed in the field with the sponsors to determine the extent of easement and right-of-way problems. Alternate locations were investigated as the need arose and comparisons made to determine the most feasible system of floodwater retarding structures. The location, number, design, and cost of the structures were influenced by the physical, topographic, and geologic conditions in the watershed, the proximity of the structures to the damaged areas and their effect on the extent of channel improvement which would be required to meet the project objectives.

After agreement was reached on the location of all the needed floodwater retarding structures, flood routing studies determined the limits of channel improvement.

Area-capacity curves, cost-capacity curves, results of reservoir operations studies, and the financial ability of the local interests formed the basis for determining the degree of recreational development to include in the multiple-purpose site.

The system of structural measures included in this plan will provide complete protection to 15,546 acres of flood plain from the one-year frequency storm and satisfy the recreational needs at the least cost. Approximately 690 acres of the 16,236 acres in the benefited area will not have full protection from the one-year frequency storm. In these areas, which are scattered throughout the flood plain, damage will be limited to shallow flooding of small, isolated areas which would continue to flood from local storms. Therefore, for all practical purposes, it was considered that the project objective to provide protection from the one-year frequency flood had been met. This planned project will achieve the desired objectives.

The Attoyac project is an important part of the comprehensive plan for the Neches River basin.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

Landowners and operators, cooperating with the Nacogdoches, Rusk, Shelby, and Piney Woods Soil Conservation Districts, have applied many of the needed conservation practices on their farms. The use of each acre of agricultural land within its capabilities and its treatment in accordance with its needs is necessary for a sound watershed protection and flood prevention project on the watershed.

Cropland treatment measures are needed to reduce erosion and provide more protective cover during critical seasons. High residue soil improving crops,

A 4-year old planting of slash pine in deep sandy soil.

Crop Residue Management. Corn stalks providing an effective land cover area used in planting vetch for soil improvement.

Proper use on Common Bermudagrass pasture. This is an upland soil (soil units 5 and 6) which has been limed and fertilized according to soil test. Crimson clover is used in combination with Bermudagrass.

cover cropping, crop residue use, terracing, and the use of grasses and legumes in rotation will be increased by 1,400 acres during the 5-year installation period.

The application of pasture treatment measures will improve cover conditions for reducing erosion and runoff. These measures include proper pasture use, brush and weed control, pasture and hayland planting, pasture and hayland renovation, and the installation of farm ponds. Proper pasture use will be increased from the 38,000 acres presently treated to 54,200 acres during the 5-year installation period. This increase also reflects the approximate area which will be treated by the other grassland measures and the area upon which approximately 160 ponds are to be installed.

The land treatment measures on forest land will reduce soil erosion, sediment production and storm runoff by improving the soil-water relations in the forest stands. The forest litter produced under proper forest management protects the soil and is the source of good forest humus needed for the increase of infiltration and water storage capacities of forest soils. About 6,100 acres of forest land will be treated by installing such measures as hydrologic stand improvement, tree planting, release of preferred tree species, removal or eradication of low value trees, proper harvesting and livestock control.

Structural Measures

Twenty-two floodwater retarding structures, one multiple-purpose structure, and 49.0 miles of channel improvement will be constructed to provide flood protection to 16,236 acres of the 19,000 acres of agricultural land in the flood plain of Attoyac Bayou and its tributaries. The locations of the planned structural measures are shown on the project map (figure 5).

The multiple-purpose structure will provide storage capacity for sediment, floodwater detention and recreation. It will be known as Lake Naconiche and will have two prongs located in canyon-like gorges over 100 feet deep, surrounded by tall pine trees. The lake will be fed by several large springs flowing out of the Carrizo sands. The surface area of the recreation pool will be 585 acres and the maximum depth will be 28 feet.

The proposed system of floodwater retarding structures will detain runoff from 45 percent of the entire watershed. The total capacity of the 22 floodwater retarding structures and 1 multiple-purpose structure is 60,607 acre-feet, of which 4,950 acre-feet is provided for sediment accumulation over a 100-year period and 6,617 acre-feet of storage is provided in Lake Naconiche (site 23) for recreation. The floodwater retarding structures will detain an average of 6.12 inches of runoff from the watershed area above them. This is equivalent to 2.76 inches of runoff from the entire 213,440-acre watershed. Sites 3 and 4 are planned in series because of storage limitations at site 4. The amount of runoff controlled by each structure is shown in table 3. Figures 1, 2 and 2A illustrate features which are typical of the floodwater retarding structures to be installed. In general, the topography of this watershed is well suited for dam site locations. Embankment volumes per acre-foot of capacity will be less than average. High water tables will make it necessary to locate most borrow areas outside the flat valleys and above the area required for sediment pools. Foundation drainage systems will be needed at all sites because the alluvium in the valley is composed primarily of sands or sand mixtures, sandy bedrock foundations, or because of springflow from the sandy material in the abutments. Additional detention storage was used in some of the floodwater retarding structure sites to decrease the frequency of operation where emergency spillways must be constructed in sandy, noncohesive soils.

The improved channel will have a trapezoidal cross section with 1½:1 side

slopes. The capacity will be sufficient to carry the peak flow of the one-year frequency flood from the uncontrolled area plus the release flows from the floodwater retarding structures. The spoil from the improved channel will be placed within the right-of-way area in accordance with Service criteria outlined in Texas State Manual Supplement 2441.8. Approximately 350 grade stabilization structures, consisting of standard corrugated metal pipe drops, will be installed as appurtenances to the improved channels. These structures will be installed to prevent erosion where shallow ditches enter the larger and deeper channel. These structures will be designed and installed in accordance with standards and specifications contained in local Work Unit Technical Guides. Basic facilities for recreation use will be installed at selected locations in the area surrounding Lake Naconiche. They will include access roads, parking areas, boat dock and launching ramp, beach area, sanitary facilities, and picnic areas. A schedule of the facilities is shown in table A. Figure 4 shows their location. The estimated installation cost of minimum basic recreational facilities is $87,180.

The estimated cost of all structural measures is $5,045,517 (table 2).

EXPLANATION OF INSTALLATION COSTS

Land Treatment

The estimated cost of installing the land treatment measures is $874,800. The share of this to be borne by Public Law 566 funds is $92,400, of which $82,700 will be used by the Soil Conservation Service and $9,700 by the Forest Service for accelerated technical assistance. The share of the total cost to be borne by local interests and other funds will be $782,400.

The cost of installing the land treatment measures on non-forest land during the 5-year installation period is $821,400. This includes $104,400 for technical assistance. The amount for technical assistance includes $82,700 to be provided by Public Law 566 funds to accelerate the going program and $21,700 of Public Law 46 funds. The Public Law 566 funds include $7,200 to complete the standard soil survey in the watershed. The cost of installing the measures on non-forest land includes Agricultural Conservation Program Service payments based on present program criteria. Costs are based on prices presently being paid by local farmers to establish these land treatment measures. Technical assistance costs are based on present Service costs for developing and servicing conservation plans and for mapping soils.

The cost of installing the land treatment measures on forest land is estimated to be $53,400. This includes $23,900 for technical assistance and $29,500 for measure installation. The $23,900 for technical assistance consists of $7,500 to be provided under the going Cooperative Forest Management program, $9,700 of Public Law 566 funds and $6,700 to be provided by the Texas Forest Service. These cost estimates were developed by the Texas Forest Service and the U. S. Forest Service. The technical assistance costs were based on the present costs of the going Cooperative Forest Management program. The measure of installation costs were based on present prices

being paid by landowners or operators to establish individual measures in the locality. The amount of forest land treatment measures planned to meet treatment goals was based on a field survey of the watershed needs adjusted for expected landowner participation.

Floodwater Retarding Structures

The construction cost of the 22 single-purpose floodwater retarding structures amounting to $1,453,210 and associated installation services cost of $358,629 will be borne by Public Law 566 funds. The total Public Law 566 cost for the installation of these structures is $1,811,839.

Construction costs include the engineer's estimate and contingencies. The engineer's estimate was based on the unit cost of structures in similar areas modified by special conditions inherent to each individual site. Geological investigations were limited to surface observations and borings with a portable power auger at the structure site locations. More detailed foundation and borrow area investigations will be made for the 22 floodwater retarding structures along with the multiple-purpose structure before construction begins. Ten percent of the engineer's estimate was added as a contingency to provide funds for unpredictable construction costs.

Installation services consist of engineering and administrative costs and are based on service experience for similar works. The engineering portion of this cost consists of, but is not limited to, detailed surveys, geological investigations, laboratory reports, designs, cartographic services, and inspection services.

Land, easements and rights-of-way, including relocations, for these structures will be furnished by the local organizations. The estimated value of land easements, changes in utilities, and roads and bridges is $528,100, which includes the value of those easements that will be donated. The cost of legal fees and contract administration, $21,700, will be borne by the local sponsors.

Channel Improvements

Estimated construction cost of $1,584,550 for the channel improvement and associated installation services costs of $299,978 will be borne by Public Law 566 funds. The cost estimate was based on a unit cost of excavation which included an allowance for the appurtenant grade stabilization structures and clearing costs. Ten percent was added for contingencies.

Land, easements, rights-of-way, and relocation costs amounting to $273,000 will be furnished by the sponsors along with the cost of contract administration and legal fees which are estimated at $2,500.

Multiple-Purpose Structure

Construction and installation services costs for the multiple-purpose structure, Lake Naconiche (site 23), were allocated by the use of Facilities Method as follows:

Purpose	Acre-Feet	Percent
Flood Prevention	5,456 1/	45.20
Recreation	6,617	54.80
	12,073	100.00

1/ Includes 462 acre-feet of sediment storage.

The entire cost of the basic recreation facilities, land rights (except the cost of flowage easements), contract administration and the cost of obtaining water rights was allocated to recreation development. The cost of flowage easements was allocated to flood prevention.

The estimated value of land for rights-of-way is based on appraisals made by the sponsors and concurred in by the Service. The County Commissioners Court, utilities companies, and pipeline companies furnished cost estimates for modification of their facilities.

Cost sharing was determined in accordance with Watersheds Memorandum SCS-64 including Supplement 1 thereto.

The following table shows the estimated cost and percent to be paid by Public Law 566 and by other funds:

Multiple-Purpose Structure 23	Public Law 566 Funds		Other Funds	
	Percent	Dollars	Percent	Dollars
Construction	72.60	208,435	27.40	78,665
Installation Services	100.00	52,790	0	0
Land, Easements and R/W				
Fee Simple Title	50.00	36,000	50.00	36,000
Flowage Easements	0	0	100.00	4,000
Relocations	50.00	14,990	50.00	14,990
Recreation Facilities				
Construction	50.00	38,725	50.00	38,725
Installation Services	50.00	3,115	50.00	3,115
Contract Administration	0	0	100.00	1,000
Legal Fees and Land Surveys	0	0	100.00	3,500
Water Rights	0	0	100.00	500

In summary the required local cost for all structural measures, consisting of construction ($117,390), land easements ($665,950), changes in utilities ($1,040), changes in pipelines ($53,300), road and bridge changes

($75,200), administration of contracts ($14,500), water rights ($500), legal fees and land surveys ($20,900), fences and water gaps ($43,200), and installation services ($3,115), are estimated at $995,095 (table 2).

The Public Law 566 share of the cost of structural measures and basic recreational facilities consists of construction ($3,284,920), installation services ($714,512), land ($36,000), relocation of roads ($14,600), relocation of buildings and utilities ($390), and totals $4,050,422 (table 2).

Cost allocation and cost sharing for this project are summarized in table 2A.

The estimated schedule of obligations for the 5-year installation period, covering installation of both land treatment and structural measures is as follows:

Schedule of Obligations

Fiscal Year	Measure	Public Law 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
1st	Site 23, Naconiche Creek and Lower Attoyac Bayou Channel Improvement, and Land Treatment	1,148,917	417,357	1,566,274
2nd	Sites 1, 2, 3, 13, 16, 20, Recreational Facilities, West Creek Channel Improvement and Land Treatment	707,562	358,720	1,066,282
3rd	Sites 4 and 6, Upper Attoyac Bayou Channel Improvement, and Land Treatment	1,165,774	352,458	1,518,232
4th	Sites 5, 9, 10, 14, 15, 21, 22 and Land Treatment	578,841	317,980	896,821
5th	Sites 7, 8, 11, 12, 17, 18, 19, Wanders Creek Channel Improvement and Land Treatment	541,728	330,980	872,708
Total		4,142,822	1,777,495	5,920,317

EFFECTS OF WORKS OF IMPROVEMENT

The installation of the land treatment and structural measures will directly benefit about 150 owners and operators of 16,236 acres of flood plain

land below floodwater retarding structures in the project area. The installation of needed land treatment measures throughout the watershed will bring about a slight reduction in flood damages which are occurring on about 1,110 acres of flood plain land on tributaries and other areas not protected by structural measures. About 1,654 acres of flood plain are within the pool areas of the floodwater retarding structures and the multiple-purpose structure.

Average annual flooding in the watershed would be reduced from 22,491 acres to 7,307 acres, a reduction of 68 percent. This includes the flooding on flood plain lands for which no structural measures are planned but excludes those areas inundated by structural measures. In the benefited area, average annual flooding will be reduced from 21,052 acres to 5,811 acres or 72.4 percent.

The combined program of land treatment and structural measures will prevent flood damage in the benefited area from 40 of the 86 floods such as occurred during the evaluation period. Of the 26 major floods that inundated more than half of the total flood plain, 19 would be reduced to minor floods, inundating less than half of the flood plain.

Expected reductions in flooding in the area protected by structural measures are shown in the following tabulation:

Average Recurrence Interval					
2-Year		5-Year		25-Year	
Without Project	With Project	Without Project	With Project	Without Project	With Project
(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
12,329	5,500	14,210	9,877	16,236	12,627

Much of the interruption, delay, and additional travel caused by flooded roads and washed-out bridges will be eliminated by the project. This is especially important for school buses, mail carriers, and the marketing of agricultural products. The average annual reduction in all non-agricultural damages will be 72 percent.

The 585-acre recreational pool of the multiple-purpose Lake Naconiche and its accompanying recreational facilities will provide needed public facilities for water-based recreation for the inhabitants of the area. The development will be especially attractive to people from urban centers who have purchased tracts in the neighborhood for weekend or vacation retreats. It can be expected that Lake Naconiche, because of its scenic advantages, will have considerable use by those who have come to visit Lake Sam Rayburn. Recreational activities such as fishing, boating, water skiing, swimming, camping, sight seeing, and picnicking will

be enjoyed by an estimated 50,000 visitors annually. Local interests expect an eventual buildup to 200,000 visitor days per year. The most intensive use will be during the period of May through September, with an expected peak use of more than 700 persons per day. The development will provide opportunities for development of non-farm enterprises for farm families. The sediment pools of the floodwater retarding structures open for use by the general public will provide year-round recreational facilities for fishing, picnicking, and boating. These pools also will furnish opportunity for seasonal recreation, such as swimming and water skiing. Favorable temperatures exist for over six months of the year for almost all types of recreation and longer periods for selected types. Based on past experience, it is expected that the sediment pools of the floodwater retarding structures will have an average use of approximately 16,000 visitor days annually for the useful life of the pools.

The facilities of these pools will not be competitive with larger nearby reservoirs. Many people prefer the quiet, uncrowded facilities provided by the smaller structures. These benefits will be incidental to the flood prevention purpose because additional project features will not be needed for their realization. In addition, the pools will provide a source of water supply for livestock and rural domestic use.

Secondary benefits stemming from the project will accrue to the trade area through increased income from sales and service resulting from the increased production as a result of project installation.

Contractors usually have their own machine operators, but they normally hire unskilled labor for construction from local sources. Operation and maintenance of the structural measures, especially the recreational development, will afford additional opportunities for employment of local labor. This will be especially helpful to the agricultural economy of the area as underemployment in this sector is most serious.

It is not expected that changes in restoration of former productivity will take place after installation of the project. The change will be toward more intensive use of flood plain lands by receiving higher yields through proper fertilization and management practices. This will include the clearing of about 2,400 acres of woodland pasture and the use of improved grasses.

The flood prevention program will cause 0.15 percent reduction in average annual runoff from the watershed. The reduction in average annual runoff at the floodwater retarding structures is expected to be 0.33 percent based on a reservoir operation study of the proposed system. The beneficial effect of storage for recreational use in the Lake Naconiche will more than offset the slight reduction in water yield at the lower end of the watershed.

Approximately 8,300 acres of flood plain are located along Attoyac Bayou between the lower limits of the project area and the top of the flood pool of Sam Rayburn Reservoir. The installation of the land treatment and structural measures in the Attoyac Bayou watershed will reduce the average annual acres flooded in this area from 11,690 acres to 9,732 acres, a reduction of 17 percent. However, during certain periods, structure release flows may cause prolonged flooding of sloughs and other low-lying areas.

PROJECT BENEFITS

The estimated average annual monetary floodwater and indirect damages (table 5) within the watershed will be reduced from $141,287 to $42,624, a reduction of 70 percent. The average annual damages in the area benefited by structural measures will be reduced from $134,251 to $36,080, or 73 percent. Land treatment measures will reduce damages in the flood plain not protected by structural measures approximately $492 per year.

The total benefits from structural measures are estimated to be $332,931 annually. It is estimated that benefits from more intensive use of flood plain will be $111,990 annually after discounting for a 5-year lag in accomplishment.

Redevelopment benefits stemming from employment of local labor during the project installation and operation and maintenance will amount to an amortized value of $14,243 annually.

It is estimated that the project will produce secondary benefits averaging $35,750 annually in the local area. Secondary benefits of national significance were not considered pertinent to the evaluation. Therefore, only those benefits of a local or area nature were considered in the economic evaluation.

Recreational developments of the multiple-purpose reservoir will provide facilities for fishing, swimming, boating, water skiing, and picnicking. Relatively short, mild winter seasons will permit some type of recreation throughout most of the year. It is estimated that approximately 50,000 people will benefit from the development annually. It is anticipated that more than 700 people will visit the area on peak days during the special weekends and on holidays during the period May through August. Analysis of available information for existing recreational facilities in this general area of the State and comparison of basic facilities provided with those included in the plan indicated that the value per user day for the multiple-purpose reservoir would be $1.50. Based on basic facilities provided for recreation and the anticipated use of these facilities, the estimated average annual benefits from recreation are calculated as follows:

Number of visitor days annually	50,000
Total per visitor day	$1.50
Total average annual recreation benefits	$75,000

Sediment pools of the floodwater retarding structures will produce incidental recreation for about 16,000 visitor days annually during the first 75 years after installation.

A gross value of 50 cents per visitor day with associated costs of 20 cents was used for evaluation. After discounting for decreased use after 50 years, the annual value of incidental recreation benefits is estimated at $4,466.

Floodwater reduction benefits from outside the project area will amount to approximately $183 annually.

Other substantial benefits will accrue to the project, such as an increased sense of security, better living conditions, and improved wildlife habitat. None of these benefits were evaluated in monetary terms; nor have they been used for project justification.

COMPARISON OF BENEFITS AND COSTS

The total average annual cost of structural measures and basic recreational facilities (amortized total installation cost, plus operation and maintenance) is $203,753. These measures are expected to produce average annual primary benefits of $297,181. The ratio of primary benefits to cost will be 1.46 to 1. The ratio of total average annual project benefits ($332,931) to the average annual cost of structural measures and basic recreational facilities ($203,753) is 1.63 to 1 (table 6).

PROJECT INSTALLATION

Farmers will establish the land treatment measures during a 5-year installation period. The Rusk, Nacogdoches, and Shelby Soil Conservation Districts will cooperate and will assist in the planning and application of the conservation measures in the watershed. The governing bodies of the three districts will assume aggressive leadership in accelerating land treatment.

Landowners and operators within the watershed will be encouraged to adopt and carry out soil and water conservation plans on their farms and ranches. The soil and water conservation loan program of the Farmers Home Administration is available to all eligible farmers and ranchers in the area. Educational meetings will be held in cooperation with other agencies to outline the services available.

The County Agricultural Stabilization and Conservation Committee of each county will cooperate with the governing bodies of the soil conservation districts in selecting and providing financial assistance for those ACPS practices which will accomplish the conservation objectives in the shortest possible time.

The Extension Service will assist in the educational phase of the program by conducting general information meetings, preparing press, radio, and television releases, and by using other methods of getting information to landowners and operators in the watershed. Landowners having forest land will be encouraged to apply and maintain the forestry measures on their farms.

The Texas Forest Service, in cooperation with the U. S. Forest Service provides technical assistance to owners of forest land through the Cooperative Forest Management program. This will be continued during the installation

period. Additional technical assistance for accelerating the installation of the forestry measures will be provided by the Texas Forest Service in cooperation with the U. S. Forest Service. The forester assigned to this project, who will be trained in watershed management, will assist and guide the landowners in the installation of the forestry measures planned for each farm.

The Attoyac Bayou Watershed Authority and the Commissioners Courts of Nacogdoches, Shelby, and Rusk Counties have the right of eminent domain under applicable State law and will obtain the necessary land, easements, and rights-of-way, including utility, pipeline, road and improvement changes. The Commissioners Court of each county will determine the legal adequacy of easements, permits, etc., for the construction of the planned structural measures located within or along the county boundary.

The Attoyac Bayou Watershed Authority and the Service will execute a Land Rights Agreement in which will be set forth terms and provisions governing acquisition and cost sharing for all areas dedicated to public recreational use in Lake Naconiche (Site 23). The Authority will be responsible for the full cost of appraisals ordered by it for its use, title evidence, recording fees, U. S. revenue stamps and other State and local transfer costs, legal fees, salaries and travel of its employees, such as clerical and negotiators, and other associated costs incurred in acquiring land rights. Cost sharing will be limited to the land rights purchase price or the value jointly determined by the Authority and the Service, whichever is the lesser amount; if joint agreement cannot be reached on the value, Service cost sharing will be on the fair market value established by the Service.

The Attoyac Bayou Watershed Authority will make arrangements for necessary legal, administrative, and clerical personnel, facilities, supplies and equipment to advertise, award and administer contracts for all structural measures included in the project. The authority, which will act as Contracting Local Organization, will select and appoint a Contracting Officer. His letter of appointment will include a listing of his duties, responsibilities and authorities. The individual appointed as Contracting Officer shall be available at all times to carry out his duties and be selected on the basis of his administrative ability. Legal, accounting and/or engineering background would be helpful assets to the Contracting Officer. He will be provided with clerk-typist assistance, available to him at all times. He will also be provided with office space at a recognized business location easily accessible to the public and construction contractors in a town within or near the watershed. Arrangements will be made by the Contracting Officer to handle formal construction contract bid openings, publicly conducted and attended by approximately 20 persons. The Contracting Officer will be provided with transportation facilities so that he will be able to make inspection trips to the locations of apparent low bidders' equipment plants and to all construction sites, as necessary to efficiently perform his duties. All costs related to administrative, legal and clerical operations of the Contracting Local Organization and its staff will be borne by the Contracting Local Organization.

The Soil Conservation Service will provide technical assistance in the design, preparation of plans and specifications, supervision of construction, preparation of contract payment estimates, final inspection, execution of certificate of completion and related tasks necessary to establish the planned structural measures.

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out works of improvement described in this work plan will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666), as amended.

The needed land treatment measures will be installed by the landowners and operators of private lands under agreements with the Nacogdoches, Rusk, and Shelby Soil Conservation Districts. The cost of installing these measures on non-forest land is $717,000. The cost of technical assistance to plan and apply the land treatment measures on this land is $104,400. This consists of $82,700 of Public Law 566 funds and $21,700 to be provided by Soil Conservation Service from Public Law 46 funds.

The forest landowners will apply the planned forest land treatment measures at an estimated cost of $29,500. The cost of forestry technical assistance is estimated to be $23,900. This consists of $7,500 to be provided under the going Cooperative Forest Management program, $9,700 of Public Law 566 funds and $6,700 to be provided by the Texas Forest Service. The State will begin cooperation with its funds at the earliest feasible date. However, if it does not have funds available for cost sharing during the first year of installation, the forestry technical assistance during this period will be financed wholly from Public Law 566 funds.

The Agricultural Stabilization and Conservation Service will provide financial assistance for the installation of those needed land treatment measures which are eligible. Financing for the landowners and operators' share of the cost can be arranged through local lending institutions and the Farmers Home Administration.

The Commissioners Courts of Nacogdoches, Rusk, and Shelby Counties will provide funds for the local share of the cost of all structural measures located in their respective counties in accordance with existing State laws. The local sponsors estimate that 70 to 80 percent of the land, easements, and right-of-way and needed personal services will be donated. Out-of-pocket costs consist of costs of relocation or modification of roads, pipelines, and utilities; the local share of the cost of installing the multiple-purpose site, Lake Naconiche, and the recreational facilities; and the cost of acquiring those land easements and rights-of-way that are not donated. The local sponsors are investigating the feasibility of obtaining a loan from the Farmers Home Administration or the Texas Water Development Board to finance their share of the cost of Lake Naconiche and the recreational facilities.

The following prerequisite conditions will be met pursuant to the furnishing of Federal funds for the installation of the structural measures:

1. The requirements for land treatment in the drainage area above the floodwater retarding structures and the

multiple-purpose structure have been met.

2. All land, easements, rights-of-way, and permits have been obtained for all structural measures or written statements have been furnished by the Attoyac Bayou Watershed Authority and/or the Commissioners Courts of Nacodgoches, Rusk, and Shelby Counties giving a schedule for remaining non-cleared sites, by site number and the exact date by which all land rights therefor will be obtained or their right of eminent domain will be used to secure any remaining land, easements, or rights-of-way and that sufficient funds are available for purchasing those easements and rights-of-way and for condemnation proceedings and awards.

3. Water rights for storage of water for recreational purposes have been obtained.

4. Court orders have been obtained from the Nacogdoches, Rusk, and Shelby Counties Commissioners Courts that the county roads affected by the single-purpose floodwater retarding structures will be relocated or raised two feet above emergency spillway crest elevation at no expense to the Federal government or closed or permission granted to temporarily inundate the road, provided equal alternate routes can be provided.

5. Court orders have been obtained from the Nacogdoches, Rusk, and Shelby Counties Commissioners Courts stating that all county and private road bridges that are affected by stream channel improvement will be modified or replaced, if needed, concurrently with or prior to the construction of the enlarged channel.

6. Flowage easements outside the project area have been obtained.

7. Funds are available and sufficient to pay for the local share of the cost of installing the multiple-purpose reservoir and the recreational facilities.

8. The contracting agency is prepared to discharge its responsibilities.

9. Project, land rights, and operation and maintenance agreements have been executed.

10. Public Law 566 funds are available.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land treatment measures will be maintained by the landowners and operators of farms on which the measures are installed under agreements with the Nacogdoches, Rusk, Shelby, and Piney Woods Soil Conservation Districts. The districts will make or cause to be made periodic inspection of the completed land treatment measures to determine maintenance needs and to encourage landowners and operators to perform needed maintenance. Technical assistance required for operating and maintaining the forestry measures will be provided by the going Cooperative Forest Management program. The needed forest fire protection will be continued by the going Cooperative Forest Fire Control program.

An Operations and Maintenance Agreement will be executed by the parties hereto prior to the issuance of invitation to bids on construction of the structural measures and/or the acquisition of land rights for Lake Naconiche (Site 23). The agreement will set forth specific details on procedure in line with recognized assignments of responsibility as explained in subsequent paragraphs.

Floodwater Structures Nos. 1 through 23 and all channel improvement will be operated by the Attoyac Bayou Watershed Authority.

The Attoyac Bayou Watershed Authority will finance and accomplish the maintenance of the recreational development associated with Lake Naconiche (Site 23). The Authority will have maintenance inspection and coordinating responsibility for Structures 1 through 23 and for all channel improvement, but accomplishment and financing of maintenance will be the responsibility of the County Commissioners Courts of Nacogdoches, Rusk and Shelby Counties, respectively, for such works of improvement located within the boundaries of each individual county. Where the improved channel is on the county line, maintenance costs will be shared equally by the two counties involved as coordinated by the Authority except that Nacogdoches County will assume all of the maintenance cost where the improved channel is on the Nacogdoches-San Augustine county line.

A representative of the Attoyac Bayou Watershed Authority will be a member of each joint inspection group making scheduled inspections of works of improvement in accordance with procedural details of the Operation and Maintenance Agreement, and the representative will make unscheduled inspections, singly or jointly with others, as necessary. A representative of the County Commissioners Court concerned with the works being inspected will join in scheduled or special inspections at the desire of the Court.

Maintenance needs for Structures 1 through 23 and for improved channel noted by the representative of the Attoyac Bayou Watershed Authority, or those called to his attention by others and confirmed by him, will be referred to the responsible County Commissioners Court for maintenance action. The Authority representative will be furnished with reports on maintenance done by each County and he will keep summary control records in support of proper maintenance having been performed on these works of improvements for the entire watershed.

The following tabulation shows the structural measures and the estimated cost of maintenance to each county.

Measures	Rusk		Shelby		Nacogdoches		Total
	Structure Number or Amount	Annual Cost	Structure Number or Amount	Annual Cost	Structure Number or Amount	Annual Cost	Annual Cost
		(dol.)		(dol.)		(dol.)	(dol.)
Floodwater Retarding Structures	1 thru 5	1,085	6 thru 16	1,942	17 thru 23	1,220	4,247
Channel Improvement	9.54 mi.1/	1,181	25.35 mi.1/	2,764	37.54 mi.1/	7,770	11,715
Totals		2,266		4,706		8,990	15,962

1/ Distances are counted for each county where channel serves as boundary between counties.

In addition to the $15,962 estimated annual cost of operation and maintenance for structures, an amount of $22,500 annually is estimated for maintenance, replacements, and other costs in connection with recreational aspects of Lake Naconiche (site 23).

All of the structural measures will be inspected by representatives of the Attoyac Bayou Watershed Authority and the Rusk, Shelby, and Nacogdoches Counties Commissioners Courts after each heavy streamflow or at least once each year. The Soil Conservation Service will participate in these inspections at least annually. Inspection items are those items which may need maintenance. For the floodwater retarding structures and the multiple-purpose structure, these items will include, but will not be limited to, the conditions of the principal spillway and its outlet channels, the emergency spillway, the earth fill, the vegetative cover of the earth fill and emergency spillway, and fences and gates installed as a part of the structure. For the channel improvement, items of inspection will include, but will not be limited to, the need for removal or control of woody vegetation, removal of sediment bars, corrective measures to prevent gully erosion, or head cutting and the condition of the appurtenant grade stabilization structures.

An annual inspection will be made of all of the recreational facilities and access roads to determine maintenance and replacement needs. The sponsors will arrange for protective services, cleanup of grounds and repair of facilities.

The Soil Conservation Service, through the soil conservation districts, will participate in operation and maintenance only to the extent of furnishing technical assistance to aid in inspections at least annually and technical guidance and information necessary for the operation and maintenance program.

Provisions will be made for free access of representatives of the Attoyac Bayou Watershed Authority, the Commissioners Courts, and Federal representatives to inspect and provide maintenance for all structural measures and their appurtenances at any time.

The Attoyac Bayou Watershed Authority and the Nacogdoches, Rusk, and Shelby Counties Commissioners Courts fully understand their obligations for operation and maintenance. Specific operation and maintenance agreements will be executed prior to the issuance of invitation to bid on construction of the structural measures.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Attoyac Bayou Watershed, Texas

Installation Cost Item	Unit	Number to be Applied	Estimated Cost (Dollars) 1/ Public Law 566 Funds	Other	Total
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acre	1,400	-	39,500	
Grassland	Acre	16,200	-	677,500	6
Technical Assistance			82,700	21,700	1
SCS Subtotal			82,700	738,700	8
Forest Service					
Forest Land	Acre	6,100	-	29,500	
Technical Assistance			9,700	14,200	
FS Subtotal			9,700	43,700	
TOTAL LAND TREATMENT			92,400	782,400	8
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	22	1,453,210	-	1,4
Stream Channel Improvement	Foot	258,525	1,584,550	-	1,5
Multiple-Purpose Structure	No.	1	208,435	78,665	2
Basic Recreational Facilities	No.	1	38,725	38,725	
SCS Subtotal			3,284,920	117,390	3,4
Subtotal - Construction			3,284,920	117,390	3,4
Installation Services					
Soil Conservation Service					
Engineering Service			427,319	1,880	4
Other			287,193	1,235	2
SCS Subtotal			714,512	3,115	7
Subtotal - Installation Services			714,512	3,115	7
Other Costs					
Land, Easements and Rights-of-Way			50,990	859,590	91
Administration of Contracts			-	14,500	1
Water Rights			-	500	
Subtotal - Other Costs			50,990	874,590	92
TOTAL STRUCTURAL MEASURES			4,050,422	995,095	5,04
TOTAL PROJECT			4,142,822	1,777,495	5,92
SUMMARY					
Subtotal SCS			4,133,122	1,733,795	5,86
Subtotal FS			9,700	43,700	5
TOTAL PROJECT			4,142,822	1,777,495	5,92

1/ Price Base: 1964.

May 1964

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(at time of Work Plan Preparation)

Attoyac Bayou Watershed, Texas

Measures	Unit	Applied to Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Cropland			
Cover and Green Manure Crop	Acre	1,920	28,000
Crop Residue Use	Acre	1,320	1,700
Grasses and Legumes in Rotation	Acre	630	11,300
Terrace, Gradient	Foot	220,500	11,000
Grassland			
Brush and Weed Control	Acre	5,740	401,800
Farm Pond	No.	380	105,100
Pasture and Hayland Renovation	Acre	24,880	421,000
Pasture and Hayland Planting	Acre	13,130	646,400
Pasture Proper Use	Acre	38,000	7,600
Forest Land			
Tree Planting	Acre	2,550	45,600
Woodland Weeding	Acre	4,010	28,000
Woodland Harvest Cutting	Acre	3,840	-
Woodland Intermediate Cutting	Acre	4,500	-
Woodland Proper Grazing	Acre	10,340	-
TOTAL LAND TREATMENT			1,707,500

1/ Price Base: 1964

May 1964

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION
Attoyac Bayou Watershed, Texas

(Dollars) 1/

Structure Site Number or Name	Installation Cost - Public Law 566 Funds					Installation Costs - Other Funds							Total Installation Cost
	Construction	Installation Services: Engineering	Installation Services: Other	Easements and Rights-of-Way	Total Public Law 566	Construction	Installation Services: Engineering	Installation Services: Other	Adm. of Contracts	Easements and Rights-of-Way	Water Rights	Total Other	
Floodwater Retarding Structures													
1	90,090	13,514	7,900	-	111,504	-	-	-	500	40,900	-	41,400	152,904
2	54,560	9,821	4,909	-	69,290	-	-	-	500	9,100	-	9,600	78,890
3	73,810	11,072	6,472	-	91,354	-	-	-	500	15,900	-	16,400	107,754
4	117,810	15,315	10,151	-	143,276	-	-	-	500	56,000	-	56,500	199,776
5	70,400	10,560	6,373	-	87,333	-	-	-	500	23,300	-	23,800	110,833
6	59,070	8,860	5,179	-	73,109	-	-	-	500	16,600	-	17,100	90,209
7	38,060	8,373	3,542	-	49,974	-	-	-	500	6,900	-	7,400	57,374
8	54,450	9,801	4,900	-	69,151	-	-	-	500	15,100	-	15,600	84,751
9	43,230	7,781	3,890	-	54,901	-	-	-	500	11,400	-	11,900	66,801
10	47,630	8,573	4,285	-	60,488	-	-	-	500	17,500	-	18,000	78,488
11	59,400	8,910	5,209	-	73,519	-	-	-	500	24,200	-	24,700	98,219
12	46,640	8,395	4,197	-	59,232	-	-	-	500	12,900	-	13,400	72,632
13	74,140	11,121	6,581	-	91,762	-	-	-	500	19,100	-	19,600	111,362
14	108,570	14,114	9,554	-	132,038	-	-	-	500	38,200	-	38,700	170,738
15	76,340	11,651	6,695	-	94,486	-	-	-	500	18,700	-	19,200	113,686
16	116,380	15,129	10,027	-	141,536	-	-	-	500	45,800	-	46,300	187,836
17	50,600	9,108	4,552	-	64,260	-	-	-	500	29,200	-	29,700	93,960
18	57,310	10,316	5,156	-	72,782	-	-	-	500	26,600	-	27,100	99,882
19	39,160	8,615	3,643	-	51,418	-	-	-	500	42,900	-	43,400	94,818
20	72,160	10,824	6,327	-	89,311	-	-	-	500	8,900	-	9,400	98,711
21	58,630	10,593	5,295	-	74,738	-	-	-	500	13,600	-	14,100	88,838
22	44,550	8,019	4,008	-	56,577	-	-	-	500	35,300	-	35,800	92,377
Subtotal	1,453,200	200,265	128,364	-	1,811,839	-	-	-	11,000	528,100	-	539,100	2,350,939
Channel Improvement													
Attoyac Bayou	1,062,600	106,260	89,125	-	1,257,985	-	-	-	1,000	164,700	-	165,700	1,423,685
Naconiche Creek	416,130	41,613	34,903	-	492,646	-	-	-	500	80,400	-	80,900	573,546
Wanders Creek	66,990	10,048	5,874	-	82,912	-	-	-	500	12,700	-	13,200	96,112
West Creek	38,330	8,343	3,612	-	50,985	-	-	-	500	15,200	-	15,700	66,685
Subtotal	1,584,550	166,264	133,514	-	1,884,528	-	-	-	2,500	273,000	-	275,500	2,160,028
Multiple-Purpose Structure 23	208,435	28,710	24,060	49,490	310,715	78,665	-	-	500	56,990	500	136,655	447,370
Basic Recreational Facilities	38,725	1,580	1,235	1,500	43,040	38,725	1,880	1,235	500	1,500	-	43,840	87,180
Subtotal	247,160	30,290	25,315	50,990	354,055	117,390	1,880	1,235	1,000	58,490	500	180,495	534,550
TOTAL	3,284,920	427,819	287,193	50,990	4,050,422	117,390	1,880	1,235	14,500	859,590	500	995,095	5,045,517

1/ Price Base: 1964.

May 1964

TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY

Attoyac Bayou Watershed, Texas

(Dollars) 1/

Item	Purpose: Flood Prevention	Purpose: Recreational Development	Total
	COST ALLOCATION		
Single-Purpose			
Floodwater Retarding Structures and Channel Improvement	4,510,967	-	4,510,96
Basic Recreational Facilities	-	87,180	87,18
Multiple-Purpose			
Structure No. 23	157,631	289,739	447,37
TOTAL	4,668,598	376,919	5,045,51
	COST SHARING		
Public Law 566	3,849,998	200,424	4,050,42
Other	818,600	176,495	995,09
TOTAL	4,668,598	376,919	5,045,51

1/ Price Base: 1964.

May 1964

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Arroyo Bayou Watershed, Texas

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12
Drainage Area	Sq.Mi.	11.41	2.10	6.20	1/ 14.78	5.70	3.12	1.27	3.10	2.20	3.09	5.52	2.56
Storage Capacity													
Sediment Pool (50-year or 200 acre-foot)	Ac.Ft.	140	34	63	166	100	58	34	66	59	76	91	40
Sediment Reserve (Below Riser)	Ac.Ft.	052	33	66	189	107	62	34	69	66	86	100	41
Sediment in Recreation Pool	Ac.Ft.	-	-	-	-	-	-	-	-	-	-	-	-
Sediment in Detention Pool	Ac.Ft.	55	11	26	63	36	21	13	30	23	29	36	13
Recreation Pool	Ac.Ft.	-	-	-	-	-	-	-	-	-	-	-	-
Floodwater Pool	Ac.Ft.	3,913	773	1,637	4,351	2,235	1,490	455	992	807	1,243	2,084	1,093
Total	Ac.Ft.	4,260	851	1,792	4,769	2,478	1,631	536	1,157	950	1,436	2,311	1,187
Surface Area													
Sediment Pool (50-year or 200 acre-foot)	Acre	60	16	23	55	42	23	15	23	18	30	34	17
Sediment Pool (Top of Riser)	Acre	89	24	35	86	63	35	22	36	26	46	50	28
Recreation Pool	Acre	-	-	-	-	-	-	-	-	-	-	-	-
Floodwater Pool	Acre	353	83	157	578	230	158	57	143	104	158	243	125
Volume of Fill	Cu.Yd.	134,000	91,000	119,000	168,000	127,000	94,000	57,000	75,000	60,000	66,000	100,000	83,000
Elevation Top of Dam 2/	Foot	399.1	398.8	432.4	382.0	365.9	371.9	343.7	342.1	354.2	352.4	341.2	305.0
Maximum Height of Dam 3/	Foot	32	26	29	26	26	28	23	24	27	24	27	25
Emergency Spillway													
Crest Elevation	Foot	396.0	395.5	428.0	378.5	363.0	368.0	340.0	339.0	351.0	349.0	338.0	301.5
Bottom Width	Foot	200	100	160	200	300	200	50	180	80	100	120	100
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 4/		3.1	2.8	3.3	4.0	2.5	1.5	4.0	4.0	4.0	2.9	3.7	2.8
Average Curve No. - Condition II		71	71	61	69	74	76	76	76	77	77	78	78
Emergency Spillway Hydrograph													
Storm Rainfall (6-hour) 5/	Inch	7.6	7.7	7.7	7.5	7.7	10.5	7.7	7.7	7.7	7.7	7.7	7.7
Storm Runoff	Inch	4.23	4.32	3.22	3.93	4.66	7.47	4.89	4.89	5.00	5.00	5.12	5.12
Velocity of Flow (V_c)	Ft./Sec.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Discharge Rate	C.F.S.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum Water Surface Elevation	Foot	-	-	-	-	-	-	-	-	-	-	-	-
Freeboard Hydrograph													
Storm Rainfall (6-hour) 6/	Inch	15.7	17.2	16.2	14.8	16.4	23.6	17.3	16.8	17.2	16.8	16.4	17.0
Storm Runoff	Inch	11.7	13.1	10.5	10.5	12.8	20.2	14.0	13.5	14.1	13.7	13.5	14.0
Velocity of Flow (V_c) 7/	Ft./Sec.	7.4	7.7	8.8	7.9	7.0	8.4	8.0	7.3	7.5	7.7	7.4	7.9
Discharge Rate 2/	C.F.S.	2,486	1,408	3,430	3,080	1,047	3,753	827	2,218	1,072	1,444	1,490	1,510
Maximum Water Surface Elevation 2/	Foot	399.1	398.8	432.4	382.0	365.9	371.9	343.7	342.1	354.2	352.4	341.2	305.0
Principal Spillway													
Capacity (Maximum)	C.F.S.	8/ 120	8/ 18	8/ 56	8/ 219	8/ 69	37	13	62	18	31	8/ 56	20
Capacity Equivalents													
Sediment Volume	Inch	.23	.30	.19	.21	.33	.35	.50	.40	.50	.46	.31	.29
Sediment Reserve Volume (Below Riser)	Inch	.25	.30	.20	.24	.35	.37	.50	.42	.56	.52	.34	.30
Sediment in Recreation Pool	Inch	-	-	-	-	-	-	-	-	-	-	-	-
Sediment in Detention Pool	Inch	.09	.10	.08	.08	.12	.13	.20	.18	.20	.18	.12	.10
Recreation Pool	Inch	-	-	-	-	-	-	-	-	-	-	-	-
Detention Volume	Inch	6.43	6.90	4.95	5.52	7.35	8.95	6.71	6.00	6.84	7.54	7.08	8.01
Spillway Storage 9/	Inch	1.05	2.75	2.32	2.85	2.40	4.20	3.50	2.85	2.00	2.68	2.85	3.66

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued

Attoyac Bayou Watershed, Texas

Item	Unit	STRUCTURE NUMBER 13	14	15	16	17	18	19	20	21	22	23	Total
Drainage Area	Sq.Mi.	4.20	7.18	4.44	13.64	3.30	3.04	14.52	5.17	3.81	5.62	26.23	150.20
Storage Capacity													
Sediment Pool (50-year or 100 acre-feet)	Ac.Ft.	108	191	71	182	55	47	65	41	51	60	196	2,014
Sediment Reserve (Below Riser)	Ac.Ft.	114	203	76	196	60	52	93	44	55	66	-	1,964
Sediment in Recreation Pool	Ac.Ft.	-	-	-	-	-	-	-	-	-	-	196	196
Sediment in Detention Pool	Ac.Ft.	40	73	28	73	19	18	39	17	20	23	70	770
Recreation Pool	Ac.Ft.	-	-	-	-	-	-	-	-	-	-	6,617	6,617
Floodwater Pool	Ac.Ft.	1,754	3,554	1,696	4,641	1,265	1,391	4,739	1,346	1,351	1,240	4,994	49,040
Total	Ac.Ft.	2,016	4,021	1,871	5,092	1,399	1,508	4,956	1,448	1,477	1,390	12,023	60,607
Surface Area													
Sediment Pool (50-year or 100 acre-feet)	Acre	34	63	25	64	25	29	59	18	16	17	-	706
Sediment Pool (Top of Riser)	Acre	50	97	36	87	42	38	83	28	24	27	-	1,052
Recreation Pool	Acre	-	-	-	-	-	-	-	-	-	-	585	585
Floodwater Pool	Acre	175	369	183	440	144	161	512	132	134	148	883	5,670
Volume of Fill	Cu.Yd.	140,000	226,000	116,000	225,000	80,000	100,000	35,000	94,000	105,000	55,000	230,000	2,380,000
Elevation Top of Dam 2/	Foot	356.7	345.0	340.0	301.5	309.2	296.9	283.0	398.2	320.5	356.8	357.5	xxx
Maximum Height of Dam 3/	Foot	29	28	29	32	26	23	25	29	31	30	42	xxx
Emergency Spillway													
Crest Elevation	Foot	353.5	342.5	337.5	298.5	305.5	294.0	280.0	395.0	316.5	353.0	355.0	xxx
Bottom Width	Feet	120	100	100	200	100	100	160	100	120	80	200	xxx
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use 4/		3.1	1.8	2.6	2.7	2.8	1.6	2.7	1.2	3.1	3.0	2.1	xxx
Average Curve No. - Condition II		79	79	72	68	73	73	67	48	71	70	48	xxx
Emergency Spillway Hydrograph													
Storm Rainfall (6-hour) 5/	Inch	7.7	7.7	7.7	7.6	7.7	7.7	7.5	7.7	7.7	7.7	7.1	xxx
Storm Runoff	Inch	5.23	5.23	4.44	3.90	4.55	4.55	3.72	1.90	4.32	4.20	1.60	xxx
Velocity of Flow (V_c)	Ft./Sec.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	xxx
Discharge Rate	C.F.S.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	xxx
Maximum Water Surface Elevation	Foot	-	-	-	-	-	-	-	-	-	-	-	xxx
Freeboard Hydrograph													
Storm Rainfall (6-hour) 5/	Inch	16.6	15.7	16.6	15.5	16.8	16.9	15.3	16.4	16.8	16.8	14.6	xxx
Storm Runoff	Inch	13.8	12.9	12.7	11.0	13.1	13.1	10.7	8.0	12.7	12.6	6.6	xxx
Velocity of Flow (V_c) 1/	Ft./Sec.	7.5	6.4	6.4	7.2	8.2	7.2	7.3	7.4	8.4	8.0	6.3	xxx
Discharge Rate 2/	C.F.S.	1,581	793	804	2,311	1,739	1,161	1,900	1,255	2,270	1,304	1,552	xxx
Maximum Water Surface Elevation 2/	Foot	356.7	345.0	340.0	301.5	309.2	296.9	283.0	398.2	320.5	356.8	357.5	xxx
Principal Spillway Capacity (Maximum)	C.F.S.	34	57	36	8/ 123	8/ 28	8/ 26	8/ 159	8/ 67	8/ 32	8/ 40	8/ 419	xxx
Capacity Equivalents													
Sediment Volume	Inch	.48	.50	.30	.25	.31	.29	.11	.15	.25	.31	.14	xxx
Sediment Reserve Volume (Below Riser)	Inch	.51	.53	.32	.27	.34	.32	.12	.16	.27	.34	-	xxx
Sediment in Recreation Pool	Inch	-	-	-	-	-	-	-	-	-	-	.14	xxx
Sediment in Detention Pool	Inch	.18	.19	.12	.10	.11	.11	.05	.06	.10	.12	.05	xxx
Recreation Pool	Inch	-	-	-	-	-	-	-	-	-	-	4.73	xxx
Detention Volume	Inch	7.83	9.28	7.16	6.38	7.19	8.58	6.12	4.88	6.65	6.43	3.57	xxx
Spillway Storage 9/	Inch	2.80	2.60	2.12	2.00	3.45	3.20	2.18	1.65	2.98	3.40	1.67	xxx
Class of Structure		A	A	A	A	A	A	A	A	A	A	A	xxx

1/ Excluding the area from which runoff is controlled by Site 3.

2/ Values obtained from routing.

3/ Difference in elevation between the top of the settled dam and the valley floor.

4/ Is the average number of times the emergency spillway will be expected to function in 100 years based on a regional analysis of gaged runoff.

5/ Soil conservation 6-hour rainfall as shown on E.S. Drawing 1020 attached to Advisory Notice 667.

6/ For Class A structures, 1.23 x P for 6-hour rainfall shown on figure 3.21-1, NEH, Section 4, Supplement A, and 1.73 x P for Class B structures, and in all cases the rainfall exceeds the minimum requirement shown in Washington Engineering Memorandum SCS-27.

7/ Obtained from curves drawn from Figure 4-R-11472 revised 3-59 and ES 98 dated 4-27-55, based on flows obtained from graphical routing of the Freeboard Hydrograph.

TABLE 3A - STRUCTURE DATA

CHANNELS

Attoyac Bayou Watershed, Texas

Channel Designation	Station Numbering for Reach: Station (100 ft.)	Station (100 ft.)	Watershed Area (sq.mi.)	Planned Channel Capacity (c.f.s.)	Average Bottom Width (feet)	Average Side Slope	Average Depth (feet)	Average Grade (pct.)	Average Velocity in Channel (ft./sec.)	Volume of Excavation (1,000 cu.yds.)
Attoyac Bayou	400+00	464+50	5.42	440	18	1.5:1	5.1	0.150	3.4	
	464+50	466+50			Transition Section					
	466+50	529+70	8.96	590	24	1.5:1	5.2	0.150	3.5	
	529+70	577+90	11.35	670	26	1.5:1	5.4	0.150	3.7	
	577+90	645+50	13.51	770	30	1.5:1	5.6	0.135	3.6	
	645+50	688+60	16.21	810	32	1.5:1	5.6	0.135	3.6	
	688+60	851+00	20.03	840	32	1.5:1	6.2	0.098	3.3	
	851+00	853+00			Transition Section					
	853+00	903+45	31.34	1,630	45	1.5:1	7.0	0.098	4.2	
	903+45	919+65	39.85	1,720	48	1.5:1	7.0	0.098	4.2	
	919+65	980+10	43.16	1,720	48	1.5:1	7.9	0.065	3.6	
	980+10	1088+80	53.15	1,870	50	1.5:1	8.1	0.065	3.7	
	1088+80	1097+00			Transition Section					
	1097+00	1169+60	56.12	1,880	50	1.5:1	7.4	0.090	4.2	
	1169+60	1262+35	60.96	1,930	50	1.5:1	7.5	0.090	4.2	
	1262+35	1264+35			Transition Section					
	1264+35	1347+00	63.97	1,930	42	1.5:1	9.0	0.065	3.9	
	1347+00	1606+65	77.38	2,030	42	1.5:1	9.2	0.065	3.9	
	1606+65	1608+65			Transition Section					
	1608+65	1672+25	138.07	3,750	50	1.5:1	12.9	0.050	6.2	
	1672+25	1800+10	158.64	4,200	52	1.5:1	13.5	0.050	4.3	
	1800+10	1845+30	159.93	4,200	56	1.5:1	15.0	0.030	3.6	
	1845+30	1915+90	183.21	4,300	56	1.5:1	15.2	0.030	3.6	2,721
Naconiche	200+00	292+90	1.20	420	22	1.5:1	4.6	0.140	3.2	
	292+90	294+90			Transition Section					
	294+90	353+00	5.07	562	28	1.5:1	4.8	0.140	3.3	
	353+00	355+00			Transition Section					
	355+00	435+75	14.34	994	40	1.5:1	5.1	0.140	4.1	
	435+75	588+00	16.94	1,026	40	1.5:1	5.2	0.140	4.1	
	588+00	590+00			Transition Section					
	590+00	864+40	44.37	1,789	42	1.5:1	8.1	0.082	4.1	
	864+40	934+00	57.87	1,878	44	1.5:1	8.1	0.082	4.1	
	934+00	936+00			Transition Section					
Wanders	1395+65	1482+00	12.91	647	14	1.5:1	6.6	0.185	4.1	1,118
	1482+00	1544+00	15.79	746	17	1.5:1	6.6	0.185	4.2	
	1544+00	1586+00	18.65	792	18	1.5:1	6.6	0.185	4.3	
	1586+00	1629+00	21.69	847	20	1.5:1	6.6	0.185	4.3	146
West Creek	538+00	638+00	11.98	996	16	1.5:1	8.0	0.130	4.5	79
									Total Excavation	4,064

TABLE 4 - ANNUAL COST

Attoyac Bayou Watershed, Texas

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Tot
Floodwater Retarding Structures 1 through 22, 49.0 Miles of Channel Improvement and Multiple-Purpose Structure No. 23, including Basic Recreation Facilities	165,291	3/ 38,462	203,
TOTAL	165,291	38,462	203,

1/ Price base: 1964 prices amortized at 3.125 percent for 100 years.

2/ Long-term prices as projected by ARS, September 1957.

3/ Operation, maintenance and replacement costs assigned to the basic recreation facilities, $22,500 annually.

May 1964

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFI

Attoyac Bayou Watershed, Texas

Dollars 1/

Item	Estimated Average Annual Damage		Dam
	Without Project	With Project	Redu Ben
Floodwater			
Crop and Pasture	76,526	23,077	53
Other Agriculture	33,817	10,034	23
Road and Bridge	18,100	5,638	12
Subtotal	128,443	38,749	89
Indirect	12,844	3,875	8
TOTAL	141,287	42,624	98

1/ Price base: Long-term prices as projected by ARS, September 1957.

May

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Attoyac Bayou Watershed, Texas

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/								Average Annual Cost 3/	Benefit Cost Ratio
	Flood Prevention									
	Damage Reduction	Incidental Recreation	More Intensive Land Use	Other 2/	Recreation	Redevelopment	Secondary	Total		
Floodwater Retarding Structures 1 through 22; 49.0 Miles of Channel Improvement; and Multiple-Purpose Structure No. 23, including Basic Recreational Facilities 4/	91,299	4,466	111,990	183	75,000	14,243	35,750	332,931	203,753	1.63:1.0
GRAND TOTAL 5/	91,299	4,466	111,990	183	75,000	14,243	35,750	332,931	203,753	1.63:1.0

1/ Price Base: Long-term prices as projected by ARS, September 1957.
2/ Benefits from outside the watershed.
3/ From table 4.
4/ Interrelated measures.
5/ In addition, it is estimated that land treatment measures will provide flood damage reductio

INVESTIGATIONS AND ANALYSES

Land Use and Treatment

The status of land treatment measures for the watershed was developed by supervisors of the Nacogdoches, Rusk, and Shelby Soil Conservation Districts, with assistance from personnel of the Soil Conservation Service Work Units at Nacogdoches, Henderson, and Center. Sampling of conservation plans covering 10 percent of the watershed area was used to obtain information on conservation treatment already applied and the measures needed. Pasture cover conditions were obtained from proper pasture use reported on plans sampled and experience with clipping plots. A systematic field survery determined the hydrologic condition of the woodland, forest condition, and treatment needs. The amount of remedial measures was determined from this survey supplemented by data and information provided by local agencies and forestry officials. The forest land treatment measures planned are based on total conservation needs adjusted for expected landowner participation. Treatment needs for pasture lands and cropland to be applied during the 5-year installation period were based on total conservation needs with the record of installation during the last 5 years serving as a guide for future expected treatment application.

Engineering Investigations

The procedures used to determine the most feasible plan of structural measures to meet the objectives of the sponsoring local organizations that could not be accomplished by land treatment measures were as follows:

1. A base map of the watershed was prepared showing watershed boundary, drainage pattern, systems of roads and railroads, utility lines, and other pertinent information.

2. A study of photographs, supplemented by field examination, indicated the limits of flood plain subject to flood damage.

3. Stereoscopic photo and topographic map studies and field examinations indicated 50 possible floodwater retarding structure site locations. Field investigations indicated a need for channel enlargement for the main stem of Attoyac Bayou, Naconiche Creek, the lower portion of Wanders Creek, and a part of West Creek.

4. A system of 30 floodwater retarding structure sites and 49.0 miles of channel improvement was recommended to the sponsoring local organizations for further consideration and detailed survey. The ownership and property lines for each floodwater retarding structure site and for channel improvement were located and drawn on the photographs by

the local sponsors prior to the start of engineering surveys.

5. Surveys - Engineering surveys were started after agreement was reached with the sponsoring local organizations on location of channels and floodwater retarding structure sites to be studied.

   a. Horizontal Control - Scale of aerial photographs were determined by using the tellurometer and by chaining between identifiable points. Scales of 4-inch photographs used to obtain drainage areas and the scales of the low altitude photographs made to obtain topography of floodwater retarding structures, using the Kelsh Plotter, were determined by measuring distances with the tellurometer.

   b. Vertical Control - Existing U. S. Coast and Geodetic Surveys and U. S. Geodetic Survey bench marks were supplemented with temporary bench marks set at strategic locations for use in making structural surveys.

   c. Floodwater Retarding Structures - Field surveys were made in two stages. First, topographic maps with a contour interval of 4 feet and a scale of 8 inches equals one mile were made of the reservoir areas. Topography was determined for 16 sites by use of the Kelsh Plotter. Profile surveys were made of roads, pipelines, and utility lines located within the reservoir areas. Second, after preliminary reservoir plans were reviewed and accepted by the local sponsors, detailed topographic maps with a contour interval of 2 feet and a scale of 1 inch equals 100 feet were made of emergency spillway areas. A profile survey was made of the centerline of each structure. Contour lines of water elevations at the lesser of the 50-year sediment pool or 200 acre-feet level, at the top of the riser for 100-year sediment accumulation, the emergency spillway crest, and 2 feet above the emergency spillway crest were located on the ground and recorded on the 8-inch photographs. These surveys provided the data necessary to determine if required sediment and floodwater detention storage capacities could be obtained, determine the most economical design for each structure, estimate the installation cost and to make preliminary land rights maps. Criteria for accuracy of surveys as outlined in Memorandum ENG-P-EWP-1 (FW) were used for floodwater retarding structural measures.

d. Channel Improvement - Channel improvement surveys were made in accordance with procedures outlined in Texas Watersheds Memorandum TX-1. Surveys consisted of 49.0 miles of profiles and cross sections of the existing channel. A base line was surveyed in areas where the existing channel could not be accurately delineated on the 8-inch photograph. Profile and cross sections were made on side inlets with large drainage areas which discharge into the main channels. All side inlets were located on the 8-inch photographs.

6. Designs - Designs of structural measures were initiated as survey data for individual or related groups of structures were completed.

a. Floodwater Retarding Structures - Criteria outlined in Engineering Memorandum SCS-27 and Texas State Manual Supplement 2441 were used to determine the sediment and floodwater detention storage requirements, structure classification, and principal and emergency spillway design. As the topography was determined for each floodwater retarding structure site, storage tables and curves were developed, using one or more centerline of embankment locations. From these alternate locations, the least costly embankment and emergency spillway combination was determined. Preliminary layouts of pools, centerlines of dams, and emergency spillways were prepared and reviewed on the ground with the sponsors. These preliminary layouts showed the approximate surface area of the dam, emergency spillway, and the sediment and detention pools affecting each landowner. After any adjustments found desirable and feasible were made, the final pool elevations were determined, release rates for the principal spillways were established, and emergency spillways were designed.

The elevations of the sediment and detention pools were determined from the storage curves. The lower sediment pool elevation was set, using the lesser of the capacity required for 50 years or 200 acre-feet. Top of riser elevation was set, using the estimated accumulation of sediment for a 100-year period as determined through sedimentation investigations. Storage of permanent water is limited by State law to 200 acre-feet unless a special permit is obtained. Required detention capacity was added to the required sediment storage capacity to locate the emergency spillway. Detention volumes exceed the minimum

criteria set forth in Engineering Memorandum SCS-27. Detention volumes exceed the Texas State Manual Supplement 2441 criteria in all sites, except site 4, to obtain a more economical or desirable emergency spillway or structure design and to reduce the frequency of operation for emergency spillways constructed in non-cohesive sandy soils. All floodwater retarding structure sites will require foundation drainage measures. Principal spillways will consist of standard risers with concrete pipe barrels except for site 23, which will have a 4-foot by 4-foot concrete box barrel. Base flow was added for principal spillway capacity in 14 of the 23 retarding structure sites.

b. Channel Improvement - The design of the improved channel was checked, using the procedure outlined in "Suggested Interim Guide for the Planning and Design of Stable Channels", issued by the Fort Worth Engineering and Watershed Planning Unit, November 1963. Results of this study indicated that the improved channels would be stable except in a few reaches where aggradation or degradation is expected to occur. These conditions were not considered serious enough to warrant grade stabilization measures. A sampling procedure was used to determine that 7 standard corrugated metal pipe drops per mile will be required as inlets to the improved channel to reduce erosion. The exact location of each of these will be determined by the construction engineer of the improved channel. Tables 3 and 3A were prepared to show pertinent design data for each structural measure.

7. Cost Estimates - Construction costs were based on unit prices being expended at similar sites, Service experience, and values furnished by local organizations and companies.

a. Floodwater Retarding Structures - Estimates of cost of fill volumes, core excavation, foundation drainage systems, principal spillways, clearing of dam, spillway, and sediment pools, and vegetation of dam and emergency spillways was based on unit prices being expended at similar sites. Cost of land, easements, and rights-of-way was estimated by representatives of the local sponsors and concurred in by the Soil Conservation Service. A general plan of the reservoir and a profile showing the pool lines was prepared for each road, utility and pipeline that was affected by structural measures. The estimated cost for altering or rerouting these facilities was furnished by county commissioners courts, utility companies and pipeline companies.

b. Channel Improvement - Cost estimates for excavation and spreading of spoil, clearing right-of-way, and for standard pipe drop structures were based on unit prices being expended for works of improvement in similar situations. Cost of land, easements, and rights-of-way was estimated by the local sponsors.

c. Other Costs - The estimated cost of engineering services, administration, legal fees, administration of contracts, and operation and maintenance was based on Service experience.

Table 2 was prepared to show appropriate cost information for each structure and groups of structures.

Hydraulic and Hydrologic Investigations

The following steps were taken as part of the hydraulic and hydrologic investigations.

1. Basic meteorologic and hydrologic data were tabulated from U. S. Weather Bureau Climatogical Bulletins and U. S. Geological Survey records for the stream gage on Attoyac Bayou near Chireno.

2. The present hydrologic conditions for pasture and cropland were determined on 11 sample drainage areas of planned structures by field mapping of cover and treatment conditions and utilization of unpublished soil survey information for soil groups. A systematic field survey determined the hydrologic condition of the forest land. The future condition was determined by considering the changes in land use and treatment that could be expected during the installation period.

3. Adequate checks were made to determine that the 19 valley cross sections which previously had been surveyed by the Corps of Engineers and the Soil Conservation Service represented existing conditions. Fifty-seven additional cross sections were surveyed to represent adequately the stream hydraulics and flood plain area. Preliminary locations for the 57 valley cross sections were made by stereoscopic examination of aerial photographs of the flood plain. The final locations were selected on the ground, giving due consideration to the needs of the economist and geologist.

4. Stage-discharge relationships for each valley cross section were developed by solving water surface profiles for various discharges, using a graphical modification of Leach's method as described in NEH, Section 4, Supplement A, pages 3.14-17.

5. The relationship of peak discharge and flow duration to drainage area was obtained by developing hydrographs for the drainage area above floodwater retarding structures and other incremental areas of the watershed. A storage type of flood routing was used with a variable routing interval for each quantity of flow. Flood volumes produced by a 24-hour duration storm were used in developing the hydrographs.

6. Stage-area inundated relationships were developed for each portion of the flooded area represented by a cross section. Composite area inundated-discharge curves were developed, based on the Chireno gage. Acres inundated by duration increments were determined for selected floods.

7. Determinations were made of the area that would have been inundated by each storm in the evaluation series under each of the following conditions:

   a. The present conditions of the watershed remaining static.

   b. The installation of land treatment on West Creek to serve as a basis for determining reduction in flood damages due to land treatment.

   c. The installation of land treatment measures, floodwater retarding structures, and stream channel improvement.

   d. Alternate systems of structural measures.

8. A tabulation of cumulative departure from normal precipitation showed the period 1940 through 1962 to be representative of normal. This period was used to develop the historical evaluation series from the Chireno gage records.

9. A reservoir operation study was made on Lake Naconiche to determine if the yield would meet the demands for recreation use during critical drouth periods such as those that occurred in 1954 and 1956. The results of the study are shown on figure 3.

   An operation study of all floodwater retarding structures and the multiple-purpose structure was made to determine their effect on the average annual runoff. The studies were made for the period 1941 through 1957. Procedures for making the operation studies are contained in the Texas Engineering

Handbook, Section 4, Hydrology, Chapter 2. Watershed yields were based on runoff at the Chireno stream gage. Reservoir evaporation rates were based on Texas State Board of Water Engineer's Bulletin 6006, Monthly Reservoir Evaporation Rates for Texas. Evaporation rates were adjusted to reflect the effect of solar radiation, wind, dew point, and air temperature by multiplying the appropriate coefficient from U. S. Weather Bureau Technical Paper No. 37 by values contained in Bulletin 6006.

10. The design discharges for channel improvement were determined from routings described in item 5 above. The design discharge consists of the peak discharge from the 1-year frequency flood, the average release flows from the floodwater retarding structures and the base flow of the streams. Table 3A was developed to show pertinent data for the improved channels.

11. Detention volumes were determined in accordance with Texas State Manual Supplement 2441 criteria. Most sites exceed these criteria to obtain a more economical or desirable emergency spillway or structure design. The percent chance of use of emergency spillways was determined by adding to the actual detention storage the volume which would be released by the principal spillway during a 2-day period.

12. The average principal spillway release rate ranges from 6.4 c.s.m. to 16.0 c.s.m. with an average for the entire watershed of 8.3 c.s.m., exclusive of base flow.

13. The emergency spillway and freeboard design storms were in accordance with Texas Manual Supplement 2441 and in all cases equal or exceed the minimum criteria contained in Engineering Memorandum SCS-27.

14. Inflow hydrographs were developed for each site in the watershed using the above rainfall amounts and Moisture Condition II. Since routing of the emergency spillway hydrographs did not produce flow through the emergency spillways, the dimensions of the emergency spillways were determined from the freeboard hydrographs. Hydrographs were developed for each of the floodwater retarding structures by the distribution graph method. An empirical equation was used to develop a curve to estimate a range of values from which the most economical spillway was determined. The final design was made by the flood routing method described on page 5.8-12 of the NEH, Section 5.

Sedimentation Investigations

Sedimentation investigations were made in accordance with procedures outlined in Technical Release No. 12, "Procedures for Computing Sediment Requirements for Retarding Reservoirs", September 1959, U. S. Department of Agriculture, Soil Conservation Service, and Memorandum WS-G-EWP-2(FW) "Sedimentation Investigations in Work Plan Development", August 21, 1959, USDA, Soil Conservation Service, Fort Worth, Texas.

Sediment Source Studies

Sediment source studies were made in the drainage areas of the 22 planned floodwater retarding structures and the multiple-purpose structure to determine the 100-year sediment storage requirements. Detailed investigations were made in the drainage areas of 10 planned floodwater retarding structures and the multiple-purpose structure. Estimates of sediment production rates, based on similarity to drainage areas of structures which had been surveyed in detail, were made for the 12 remaining planned structures.

The detailed investigations and procedures used for determining sediment rates consisted of:

1. Field mapping of land use, cover conditions, treatment, and slope lengths.

2. Field investigations of gullies and stream channels to determine lengths, depths, and estimated rates of annual erosion.

3. Utilization of soils and slope data from unpublished soil survey field sheets.

4. Tabulation of soils by slope in percent, slope length, land use, and cover condition classes for use with the Musgrave equation.

5. Computation of sheet, gully, and streambank erosion.

6. Adjustments of present erosion rates to reflect the installation of planned land treatment.

7. Application of sediment delivery ratios and adjustments for trap efficiency.

Allowance for density differences between soil in place and sediment were made for the required sediment storage volumes. These densities were based on volume weights of 85 pounds per cubic foot (soil in place) and 50 pounds per cubic foot (sediment) for medium textured soils and 95 pounds

per cubic foot (soil in place) and 75 pounds per cubic foot (sediment) for coarse textured soils. Volume weights between the above ranges were used for mixtures of medium and coarse textured soils.

Sediment allocation to the floodwater retarding structure pools was based on the following:

Period of Deposition	Structure Pool	Condition of Sediment	Allocation (Percent)
First 50 Years	Detention	Aerated	10
	Sediment (Above port)	Aerated	20
	Sediment (Below port)	Submerged	70
Last 50 Years	Detention	Aerated	35
	Sediment	Submerged	65

Allocation of sediment in the multiple-purpose structure was based on 20 percent deposition in the detention pool, 40 percent deposition in the recreation pool, and 40 percent deposition in the sediment pool.

Flood Plain Sedimentation, Scour and Swamping Damages

Field examinations for determination of physical damages to the flood plain were made on representative areas of the West Creek flood plain. These damages were found to be minor under present conditions. Investigations on the remainder of the flood plain in the watershed were limited to a reconnaissance type survey to substantiate the similarity of conditions to those found on West Creek.

A high water table was found to exist under most flood plain areas. The lack of historical information and the inability of interviewed landowners to furnish information on degree of natural wetness before modern accelerated deposition began prevented any reliable estimates to be made on damages caused by swamping.

Channel Stability Studies

Channel investigations for stability studies were made on the mainstem and all major tributaries. These studies included the general geology and soils of the drainage basin, depth and nature of the alluvium, thickness and types of modern alluvial deposits, type of bedload carried, amount and depth of channel filling, and the nature of the underlying bedrock. Mechanical analyses of grain size, Atterberg limits, and laboratory test for dispersion were made of 10 disturbed samples.

The streams of the watershed have carried extremely high sediment loads in modern times. These loads have been drastically reduced within the past

10 years as a result of changed land use from cultivation to pastures and woodlands and by conservation treatment. Modern overbank deposits of sandy materials (SM to SC) average 3 feet deep or more, especially on the prominent natural levee deposits along the channel banks. Filling averages from 4 to 8 feet deep in most channels. These materials consist mostly of fine sands and silts (SM, SP, and ML) with a d50 grain size ranging from 0.07 to 0.13 millimeter. Field studies indicate that most streams are capable of moving the present annual bedload contributed from upland sources. The materials of the alluvial flood plain consist of cohesive sandy clays (CL) and clayey sands (SC), with lenses of non-cohesive sands (SM) occurring in the lower horizons. The plasticity index of the clay soils ranges from 9 to 23. Soils with the higher plasticity index values occur on West Creek and the mainstem of Attoyac Bayou. Non-cohesive beds are generally less than 2 feet thick and are found infrequently along the mainstem channel. None were found on West Creek. These materials, however, are found more frequently in the central reaches of Naconiche Creek and increase in thickness progressively downstream. Thicknesses of 6 feet or more occur at depths of 7 to 10 feet below the flood plain in the central and lower reaches of Naconiche Creek.

The bedrock and weathered residual materials underlying the alluvium consist of very firm to hard clays and shales with occasional beds of compact silty sands. These materials occur at depths ranging from 10 to 18 feet below the flood plain. High water tables and permanent flows in the streams prevent alternate wetting and drying of these beds.

Stability studies indicate that the improved channel on West Creek, the mainstem of Attoyac Bayou, Wanders Creek, and the upper reach of Naconiche Creek are located in material that has allowable tractive force values of 0.4 to 0.6 pound per square foot. These values were determined in accordance with "Suggested Interim Guide for the Planning and Design of Stable Channels", issued by the Fort Worth Engineering and Watershed Planning Unit, November 1963. Tractive forces of the designed channel fell within the range of the higher value, indicating possible unstable conditions in some reaches. However, analysis with use of the Schoklitch bedload equation showed that the questionable conditions are not critical enough to warrant the installation of special stabilization measures.

Geologic Investigations

Preliminary geologic investigations were made at each floodwater retarding structure site and the multiple-purpose structure. These investigations included studies of exposed geologic formations, valley slopes, alluvium, and channel banks. Core drill equipment was used at multiple-purpose structure site 23. A portable power auger was used at other sites for making borings to obtain preliminary information on water tables, nature of foundation materials, suitability and extent of borrow materials, and type of material in the emergency spillways.

Description of Problems

All planned structures are located within formations of the Wilcox group and the Carrizo formation. The Wilcox group consists of massive sands, sandy shales, shales, and lignite. The shales usually exhibit laminated bedding of sands, silts, and clays. The thickness of these units varies from less than one foot to many feet. Lignite beds which were observed range from 0.5 foot to 6 feet in thickness and are well consolidated. Sands and silty sands predominate in the Carrizo formation. Some thin shale beds are found in the formation.

Planned floodwater retarding structure sites 1, 2, 6, and 22 are located in the Carrizo formation. The planned multiple-purpose structure and the remaining 18 floodwater retarding structures are located in the Wilcox group.

Groundwater and Foundation - High water tables with associated zones of soft foundation materials occur with varying degrees of severity at all sites. The depths below the flood plain range from 4 to 8 feet with fluctuations due to seasonal wet and dry periods. Firm foundation materials consisting mainly of sandy clays (CL) and clayey sands (SC) occur below the saturated zones at depths ranging from 8 to 12 feet.

Embankment Materials - Borrow for embankment purposes will be limited from the alluvial valleys because of the high water tables at most sites. Adequate materials are available from the hillside areas upstream of the abutments. These materials consist of weathered residual soils classified as CL, SC, and SM under the Unified Soil Classification System. The underlying materials range from sandy and clayey shales to sands. Non-cohesive sandy materials predominate in the borrow areas of sites 1, 17, 19, and 22. These materials will be encountered at other sites in conjunction with cohesive soils.

Springs and Leakage Problems - Spring flow from sandy beds in the abutments occurs at a number of sites. These beds and other sandy members in the abutments and foundations will probably cause leakage and seepage problems at most sites. Saturated sands (SP and SM) were found to be 22 feet deep over impermeable clays in the foundation at site 23.

Emergency Spillways - The emergency spillways of sites 1, 2, 6, and 22 will be located in highly erosive sands (SP) and silty sands (SM). The spillways of sites 3, 5, 7, 8, 9, 10, and 11 are located in areas where excavation will remove the moderately erodible cohesive materials and expose highly erosive non-cohesive materials. Spillways for the remaining sites will be located in low to moderately erosive material.

Additional Investigations

Detailed investigations with core drilling equipment and sampling for laboratory tests to determine suitability of materials will be made at all

sites prior to final design.

Economic Investigations

Basic methods used in the economic investigations and analyses are outlined in the "Economics Guide for Watershed Protection and Flood Prevention", U. S. Department of Agriculture, Soil Conservation Service, March 1964.

Determination of Annual Benefits from Reduction in Damages

Agricultural damage schedules were obtained by interviewing landowners and operators of approximately 40 percent of the flood plain. These schedules covered past, present, and future land use, crop distribution under normal conditions, crop yields, other agricultural losses and duration of flooding. Supplemental data on normal crop yields were obtained from agricultural workers in the area. The present land use on all of the flood plain was obtained by field mapping.

Analyses of this information formed the basis for determining the damageable value and damage rates for various durations and seasons of flooding. The proper rates of damage were applied to the floods, in the historical series, covering the period 1940-1962, inclusive. An adjustment was made to take into account the effect of recurrent flooding when several floods occurred within one year.

Field studies indicated that land use, yields, frequency of flooding and anticipated future use were practically the same for all of the flood plain in the project area. Consequently, the same damageable values were used for all areas. Estimates of damage to other agricultural property such as fences, livestock, on-farm roads, and farm equipment were made from the analysis of information contained in the flood damage schedules.

The monetary value of the physical damage to the flood plain land from erosion and sediment is not measurable. Sediment damage is included in crop and pasture damage as a loss in grazing due to films of sediment on plants.

Indirect damages involve such items as additional travel time for farmers, rerouting of general traffic, school buses and mail deliveries, and costs of extra feed for livestock during and after floods. Based on information and data obtained from watersheds previously analyzed, it was determined indirect damages approximate 10 percent of the direct damages.

Owners and operators were asked what changes they would make in their flood plain land use or cropping systems if flood protection were provided. They indicated that a shift would be made from woodland pasture to open pasture. Consequently, it is not expected that acreages of crops subject

to acreage allotments will be increased as a result of the project. Benefits from more intensive land use in protected areas have been estimated (table B).

Benefits outside the project area were evaluated in the same manner as those in the watershed.

Lake Naconiche, with approximately 585 surface acres, will have recreation storage and facilities installed. Favorable temperatures exist for over six months of the year for almost all types of recreation and longer periods for selected types. Sixteen percent, or more than 1.5 million of the people in Texas, live in the Houston and Beaumont-Port Arthur areas, which are located within 120 miles of the watershed. With the construction of Lake Naconiche vacationers could be attracted from anywhere within a 200-mile radius. During the 1950-1960 decade the population increase in this potential user area averaged more than 40 percent. Several large reservoirs exist or are proposed in the area near the watershed. Analysis of available recreational information and of similar reservoirs indicate that Lake Naconiche will have an average use of 50,000 visitor days annually at a value of $1.50 per visitor day.

A similar method was used for the evaluation of incidental recreation benefits from the sediment pools of floodwater retarding structures that will be open for public use. This analysis indicated that the project will have an average use of 16,000 visitor days annually and net benefits of $0.30 per visitor day, after allowances of $0.20 for associated costs. It was estimated that the capacity of the sediment pools would remain adequate for recreational purposes for 50 years and decline to zero at the end of 75 years. The incidental recreational benefits were discounted to allow for this depletion in capacity. The number of structures on live streams fed by spring flow and the relatively high rainfall in the watershed will minimize depletion of storage by evaporation.

Redevelopment benefits which would accrue during project installation and from operation and maintenance were calculated by applying prevailing wage rates to the amount of local labor by classes and types that will be used by contractors. This estimate was converted to an average annual equivalent value by the application of appropriate amortization factors. The estimate of the amount of local labor which will be used was based on an analysis of recent contracts. Shelby, Rusk, and Nacogdoches Counties have been designated as eligible for assistance under the Area Redevelopment Act.

The value of local secondary benefits stemming from the project was considered to be equal to 10 percent of the direct primary benefits. This excludes all indirect benefits from the computation of secondary benefits. The value of local secondary benefits induced by the project was considered to be equal to 10 percent of the increased costs that primary producers will incur in connection with increased production.

The values of easements were determined through local appraisal, giving full consideration to the current real estate market values. An estimate was made of the value of production lost in the pool areas after installation of the program. In this appraisal it was considered that the sediment pools would yield no production. The land covered by the detention pools would be used as pasture after installation of the structures. The average annual loss in production within the floodwater retarding structures plus secondary costs therefrom were compared with the amortized value of easements. The easement value was found to be greater and therefore was used in economic justification to assure a conservative benefit cost analysis.

Fish and Wildlife Investigations

The following is reproduced from the reconnaissance survey report for the Attoyac Bayou watershed prepared by the Bureau of Sport Fisheries and Wildlife of the Fish and Wildlife Service, U. S. Department of Interior.

> "The Attoyac River provides a considerable amount of fishing, mostly to local people. It is fished for catfishes, white crappie, black crappie, various species of sunfishes, and to a lesser extent, for largemouth bass.
>
> "The principal hunting in the watershed is for squirrels, ducks, white-tailed deer, foxes, raccoons, and opossums. Some minks are trapped. Hunting is generally by permission of the landowners. However, in instances where land is owned by large nonresident lumber companies, there is no restriction placed on hunters and trappers.
>
> "Other species of wildlife found in the area include bobwhite, mourning dove, rabbit, bobcat, skunk, and red wolf.
>
> "Our reconnaissance study of the proposed Attoyac River Watershed Project indicates that fish and wildlife generally will be benefited. Permanent impoundments formed by floodwater retarding structures will increase opportunities for fishing and provide some habitat for waterfowl. Reduced runoff of floodwaters will be beneficial to stream fish and to wildlife of the flood plain. The construction of farm ponds and the application of other land-improvement measures will also offer opportunities for the enhancement of fish and wildlife resources in the watershed.
>
> "Construction clearing of brush and timber for floodwater retarding structures, farm ponds, terraces, diversions, grade stabilization structures, and other structural practices will eliminate wildlife habitat. Wildlife will be displaced from

the permanent pools of farm ponds and floodwater retarding structures. Clearing of bottomland timber and brush probably will be accelerated with flood control thereby further reducing wildlife habitat.

"Serious damage to both fish and wildlife habitat would be wrought by channel improvement measures which would lower the quality of fish habitat through channel clearing and enlarging of channel capacities by widening or deepening or by raising of banks. Streambank brush and tree removal in conjunction with channel improvements would eliminate valuable wildlife habitat.

"Excellent opportunities exist for the development of fish and wildlife in the Attoyac River Watershed under the authority of the Watershed Protection and Flood Prevention Act. Development for fish and wildlife should include measures designed to replace unavoidable habitat losses as well as those designed to produce fish and wildlife benefits.

"Present and future watershed planning and practices, whether on a watershed-wide or individual farm basis, should emphasize that proper water and land management is conducive to good fishing and hunting. With a minimum of planning and expense, many water retarding, erosion prevention, and soil-building practices may be made to produce fish and wildlife in addition to their other conservation functions.

"Impounding new water areas, for example, will not result automatically in additional good fishing in the watershed. Each new water area poses complex problems with respect to analysis of habitat conditions, species and numbers of fish best suited for stocking, and long range management methods. Owners of new water areas or those persons responsible for managing new water areas, should seed professional advice in the preparation of fisheries management plans to insure the establishment and maintenance of good fishing. The same principle applies with respect to development of wildlife habitat.

"Specifications for channel improvements should incorporate measures designed to restore pools and food-producing riffles lost through dredging, to stabilize banks, and to retain or replace as much streambank woody vegetation as possible.

"Wildlife losses would be minimized if care were taken to retain or replace woody vegetation wherever possible when applying land treatment practices. Where habitat losses

are unavoidable, as in construction clearing, they should be replaced by planting following completion of construction, or by habitat development of odd areas or idle lands. Selection of grasses, trees, and shrubs for erosion control plantings should include species valuable as food and cover for wildlife.

"Habitat lost through clearing and inundation in floodwater retarding structures and farm ponds could be replaced and even enhanced through proper management. Floodwater retarding structures and farm ponds should be fenced to exclude livestock. Fencing would prevent soil disturbances around the shorelines, prevent possible contamination of the water from livestock sprays, and prevent the destruction of wildlife food and cover plants. Fenced perimeter lands and flood pools should be planted to wildlife food and cover plants.

"Maximum fishing and hunting would be realized if public access were provided to the floodwater retarding sites.

"In addition to the general steps outlined above, consideration should be given to the inclusion of fishing and hunting measures in multi-purpose reservoir development to prevent or replace habitat losses and to enhance fish and wildlife in the watershed. Fishing and hunting can be a specific objective of multi-purpose reservoir development with additional water storage and perimeter lands purchased for, and allocated to, fish and wildlife purposes. Or, fish and wildlife development can be a supplemental objective in conjunction with multi-purpose development for municipal or industrial water supply.

"It is recommended:

"1. That construction clearing specifications for floodwater retarding structures, diversions, waterways, terraces, farm ponds, and other structural measures allow for the retention or replacement of all possible woody vegetation.

"2. That floodwater retarding structures and farm ponds be fenced against livestock to prevent destruction of food and cover plants and to aid in the stabilization of reservoir shorelines.

"3. That special plantings consisting of species having value as food and cover for wildlife be made near floodwater retarding structures.

"4. That specifications for channel improvements include provisions for restoration of pool and riffle areas,

streambank stabilization, and the retention or replacement of stream bank woody vegetation.

"5. That plant species having value as food and cover for wildlife be included in erosion control plantings.

"6. That public access by provided to the floodwater detention sites.

"No detailed studies are considered necessary at this time. If local interests express a desire to include measures for the enhancement of fish and wildlife in the project development, this office in cooperation with the Texas Game and Fish Commission will be happy to offer advice in the preparation of plans for inclusion of such measures."

Table A - Basic Recreational Facilities

Attoyac Bayou Watershed, Texas
Lake Naconiche (Site 23)

Item	Unit	Number	Unit Cost (dollars)	Amount 1/ (dollars)
1. Land	Acre	20	150	3,000
2. Parking Areas	Number	3	3,000	9,000
3. Access Roads (gravel surface 1.19) (hard surface 3.03)	Mile	4.22	L.S.	39,800
4. Boat Docks and Launching Ramps	Number	1	6,250	6,250
5. Swimming Beach	Acre	2	L.S.	2,400
6. Sanitary Facilities 2/	Number	2	4,000	8,000
7. Sanitary Facilities 3/	Number	6	500	3,000
8. Barbecue Pits	Number	20	75	1,500
9. Picnic Tables and Benches (Concrete)	Number	30	250	7,500
Subtotal				80,450
Installation Services				6,230
Administration of Contract				500
Total				87,180

1/ Cost includes 10 percent for contingencies.
2/ Showers, rest rooms, and septic tank. A public water supply will be available.
3/ Pit type sanitary facility.

May 1964

Table B - More Intensive Use of Land Benefits
Attoyac Bayou Watershed, Texas

Land Use	Unit of Production	Without Project 1/ Acres	Without Project 1/ Yield Per Acre	Without Project 1/ Net Return (dollars)	With Project 1/ Acres	With Project 1/ Yield Per Acre	With Project 1/ Net Return (dollars)
Corn	Bushel	82	65	3,780	82	85	5,710
Hay	Ton	330	4.0	22,175	330	6.0	37,389
Pasture	AUM	4,282	5.0	49,243	6,682	9.0	117,937
Hay 2/	Ton	(1,153)	1.5	21,859	(1,938)	2.5	74,129
Wooded Pasture	AUM	3,459	.6	206	1,059	.6	62
Miscellaneous	-	82			82		
Total		8,235		97,263	8,235		235,227

Increased Net Return With Project	137,964
Less Associated Cost (Land clearing, taxes, added damage)	15,437
Discount for Lag in Accrual (5-year lag)	10,537
Discounted Average Annual Benefits from More Intensive Use of Land (Long-term price)	111,990

1/ Based on flood free-yields.
2/ Hay cut from land used primarily for pasture.

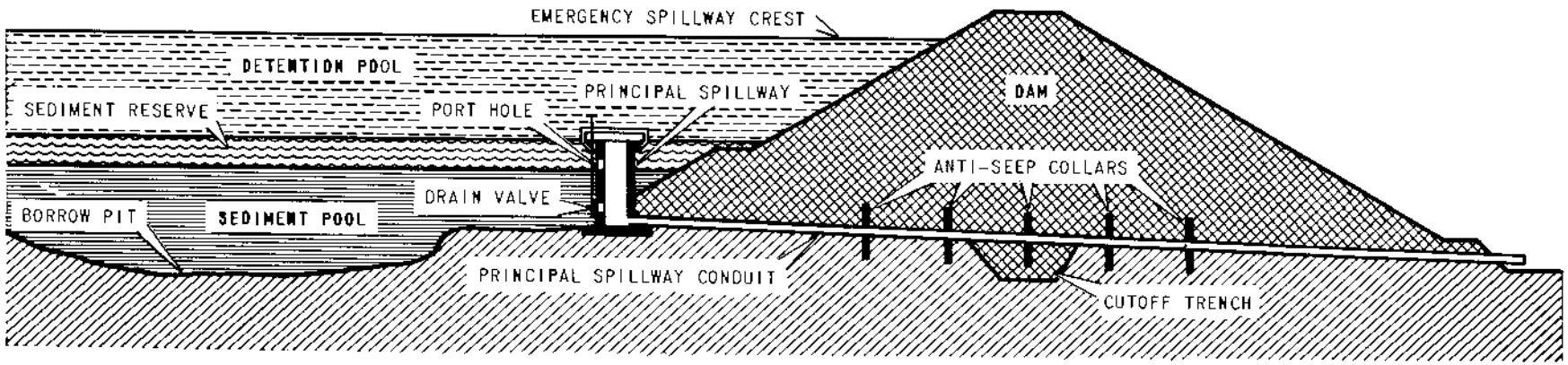
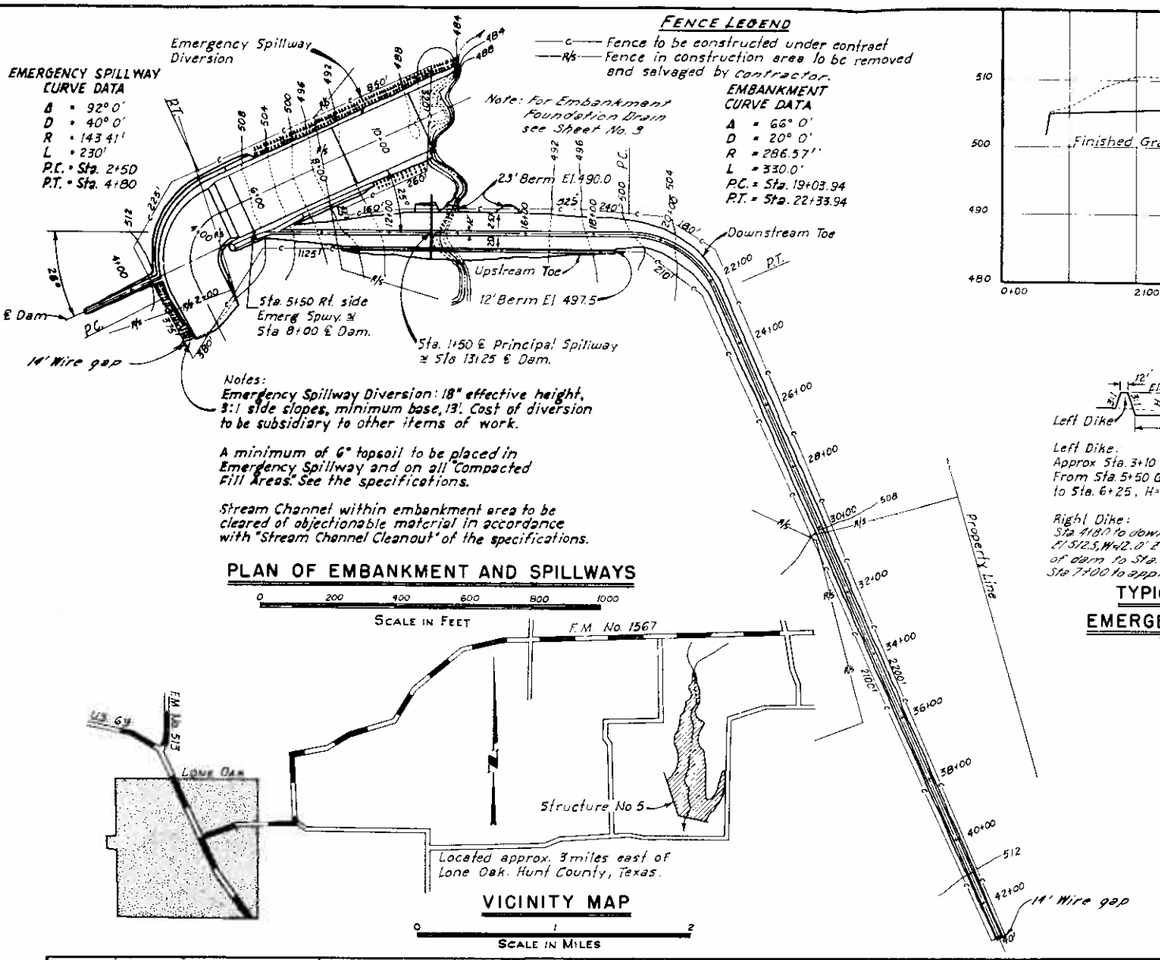


Figure 1

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

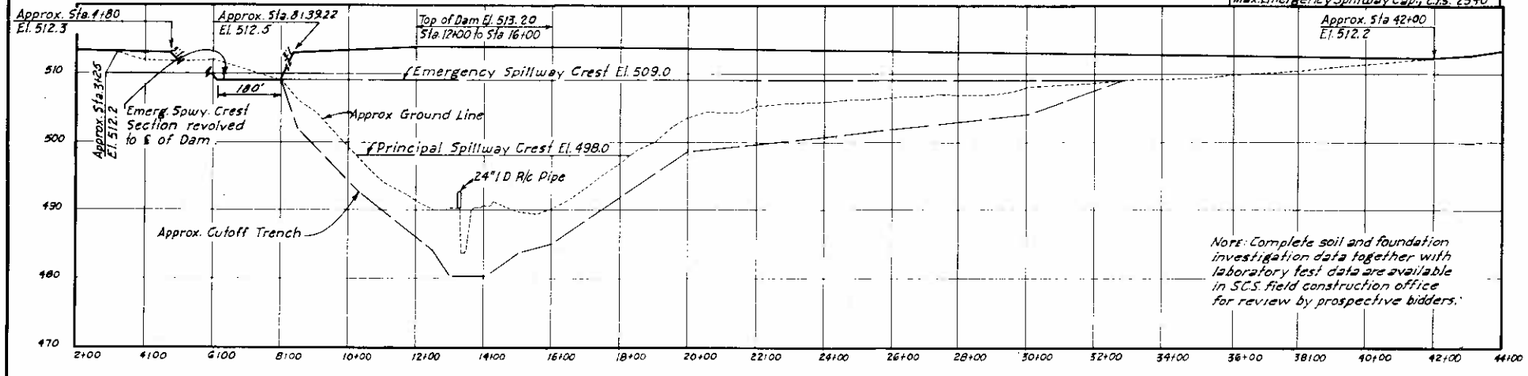


PLAN OF EMBANKMENT AND SPILLWAYS

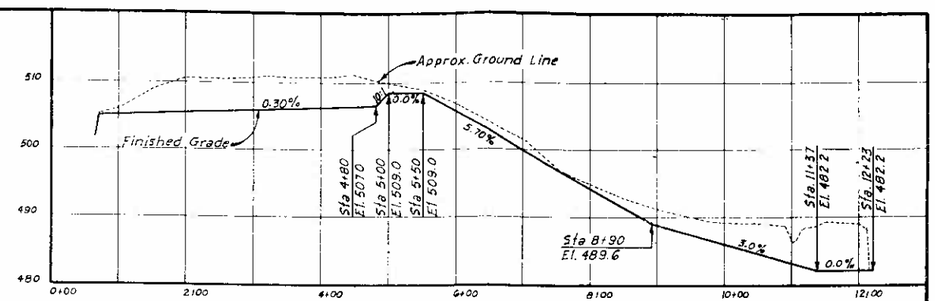
0 200 400 600 800 1000
SCALE IN FEET

VICINITY MAP

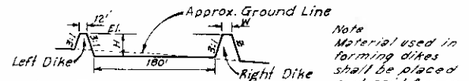
0 1 2
SCALE IN MILES



PROFILE ON ℄ OF DAM



PROFILE ON ℄ OF EMERGENCY SPILLWAY



Left Dike:
Approx Sta. 3+10 to Sta 5+50, El. = 512.3
From Sta 5+50 Grade top of dike uniformly to Sta. 6+25, H=3.0'.

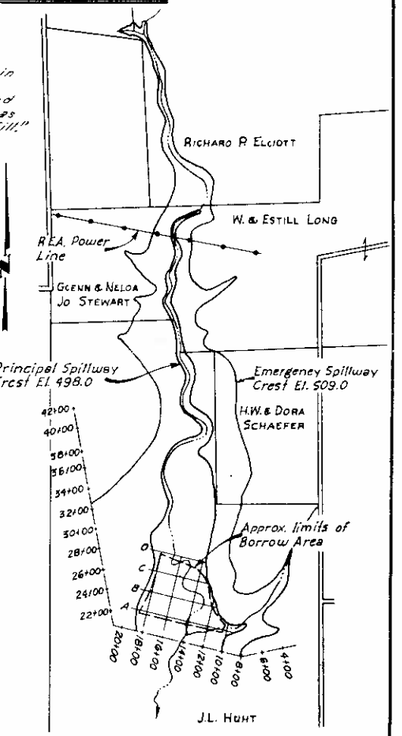
Right Dike:
Sta 4+80 to downstream Crown of dam El 512.5, W=12.0' Z=2.5:1. Downstream Crown of dam to Sta 7+00 is Transition Section.
Sta 7+00 to approx. Sta 9+25, H=3.0', W=10', Z=3:1.

Note
Material used in forming dikes shall be placed and paid for as "Compacted Fill."

TYPICAL SECTION EMERGENCY SPILLWAY

Elevation	Surface Acres	Storage Acre Feet	Storage Inches
490	0.0	0.0	0.0
494	11.5	23.0	0.22
498	25.0	96.0	0.92
502	42.6	231.2	2.22
506	69.0	454.4	4.37
509	96.6	705.0	6.77
510	109.5	811.0	7.80
511	120.5	925.0	8.89
512	134.0	1058.0	10.16
513	150.0	1200.0	11.53
514	167.5	1365.4	13.12

Top of Dam (Effective) Elev.	512.2
Emergency Spillway Crest Elev.	509.0
Principal Spillway Crest Elev.	498.0
Sediment Pool Elev.	498.0
Drainage Area, Acres	1249
Sediment Storage, Acre Feet	104
Floodwater Storage, Acre Feet	601.0
Max. Emergency Spillway Cap., c.f.s.	2540



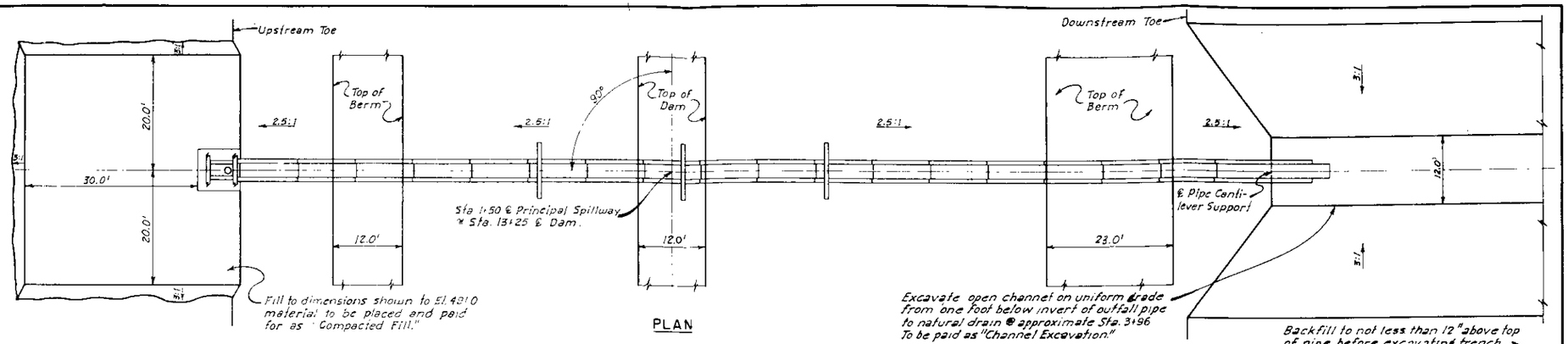
GENERAL PLAN OF RESERVOIR

0 660 1320 1980 2640
SCALE IN FEET

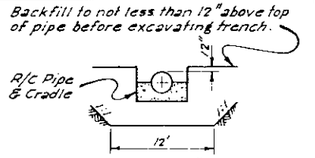
Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed A.E.G.	9-61	Approved by: Area Conservationist, Soil Conservation Service, Fort Worth, Texas	
Drawn A.E.G. & G.H.D.	10-61	State Conservation Engineer	
Traced G.H.D.	11-61	Temple, Texas	
Checked A.E.G. & H.M.K.	11-61	Sheet No. 2 of 8	Drawing No. 4-E-16,122



PLAN



Excavation to be paid as "Cutoff Trench Excavation." Backfill prior to excavating pipe trench to be paid as "Compacted Fill"

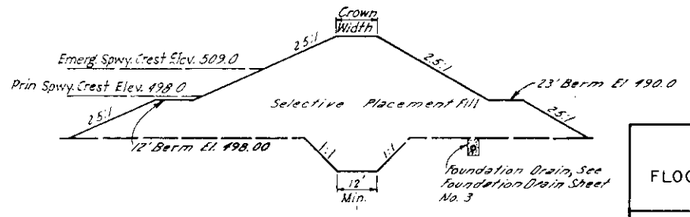
TYPICAL FOUNDATION EXCAVATION

SECTION
PRINCIPAL SPILLWAY

USE OF EXCAVATED MATERIALS					
LAB TEST		COMPACTION REQUIREMENTS			Lab. Curve
Standard		Min. Dry Density	Moisture Range		
Max Dry Den	Opt'm Moist	Lbs Per Cu Ft.	Percent From	To	No.
110.0	15.5	104.5	15.0	>	4
105.0	18.0	99.8	16.0	>	5
110.5	14.0	105.0	14.0	>	2
110.5	14.5	105.0	14.0	>	3
110.5	14.0	105.0	14.0	>	1

The clay materials represented by Laboratory Curves 4 & 5 may be used any place in the embankment. The clay and silty clay materials represented by Curves 2 & 3 shall be used in the outer sections of the Embankment. The silty materials represented by Curve 1 shall be placed in the downstream sections.

EMBANKMENT DATA



TYPICAL SECTION

Figure 2A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE - PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed A.E.G.	Date 9-61	Approved by	
Drawn A.E.G. & G.H.D.	10-61		
Traced G.H.D.	11-61	TEMPLE, TEXAS	
Checked A.E.G. G.H.D. K.	11-61	Sheet No. 4 of 8	Drawing No. 4-E-16,122

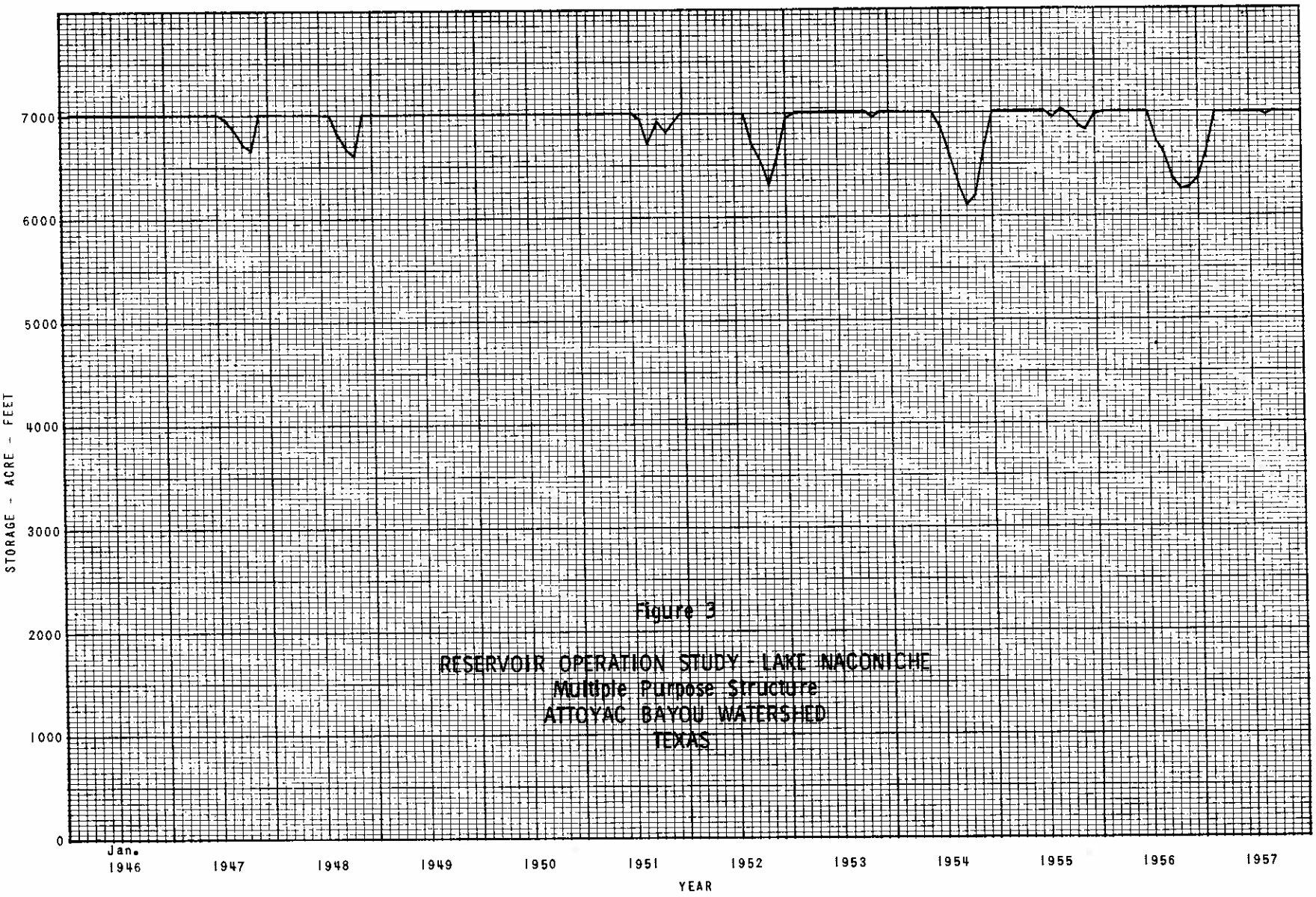
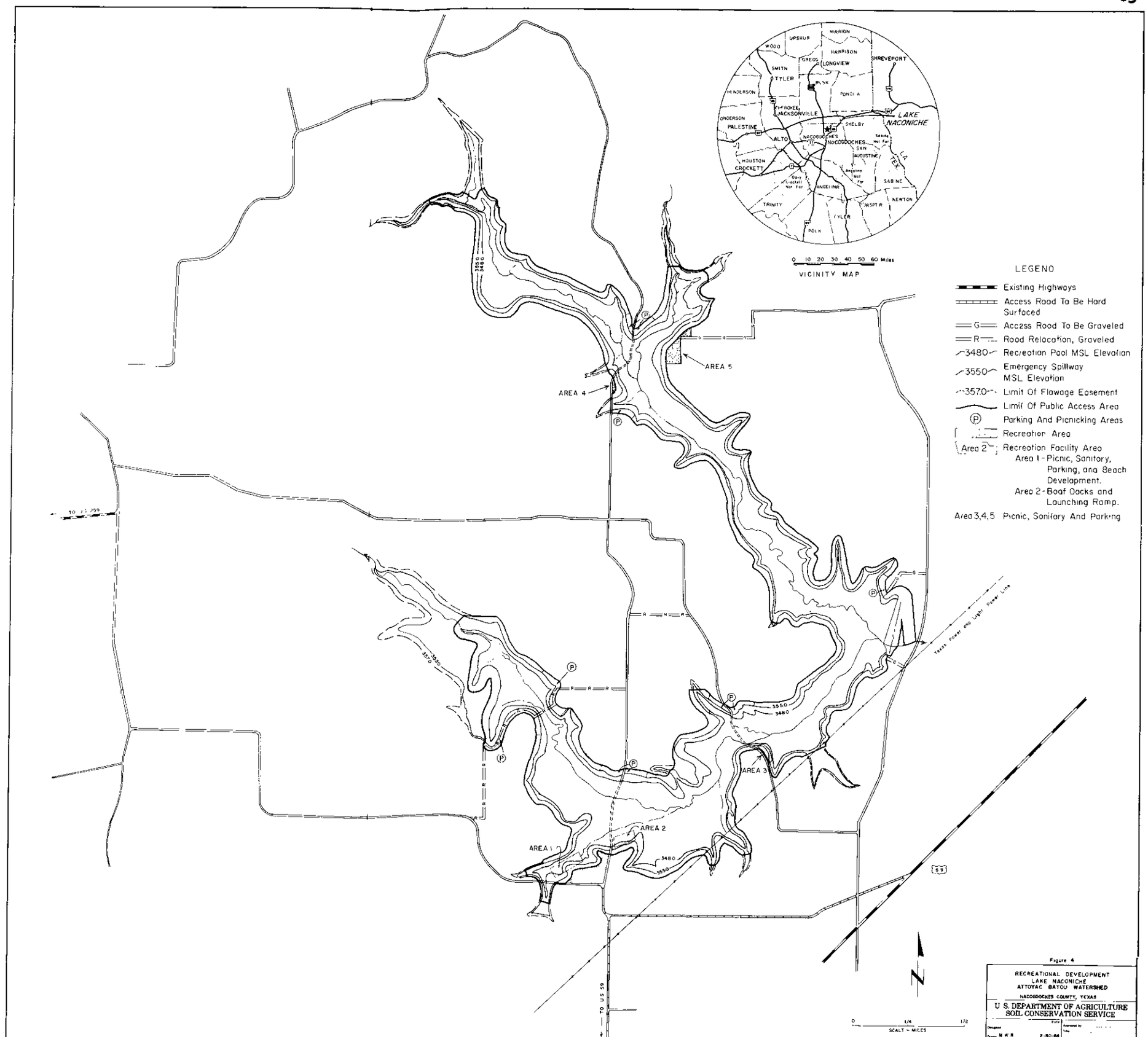


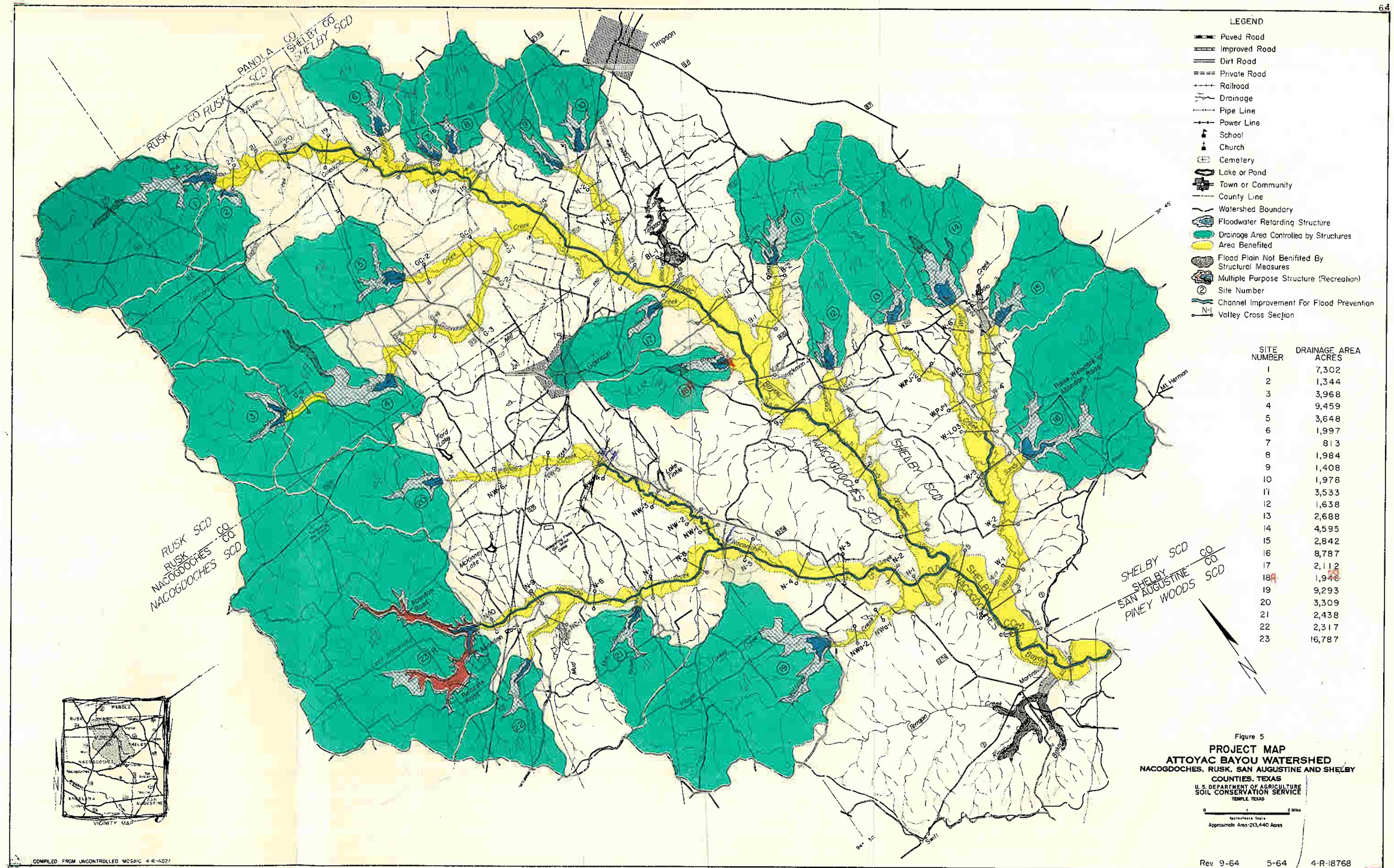
Figure 3

RESERVOIR OPERATION STUDY - LAKE NACONICHE
Multiple Purpose Structure
ATTOYAC BAYOU WATERSHED
TEXAS

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, Temple, Texas

7-64 4-N-19189


VICINITY MAP
0 10 20 30 40 50 60 Miles
LEGEND
Existing Highways
Access Road To Be Hard Surfaced
G Access Road To Be Graveled
R Road Relocation, Graveled
3480 Recreation Pool MSL Elevation
3550 Emergency Spillway MSL Elevation
3570 Limit Of Flowage Easement
Limit Of Public Access Area
P Parking And Picnicking Areas
Recreation Area
Area 2 Recreation Facility Area
Area 1 - Picnic, Sanitary, Parking, and Beach Development.
Area 2 - Boat Docks and Launching Ramp.
Area 3,4,5 Picnic, Sanitary And Parking
AREA 1
AREA 2
AREA 3
AREA 4
AREA 5
TO US 59
Texas Power and Light Power Line
SCALE - MILES
0 1/4 1/2
Figure 4
RECREATIONAL DEVELOPMENT
LAKE NACONICHE
ATTOYAC BAYOU WATERSHED
NACOGDOCHES COUNTY, TEXAS
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed
Drawn M W N
Traced
Date
2-RO-64
Approved by
Title
Date
File
Local Sponsoring Org.



SITE NUMBER	DRAINAGE AREA ACRES
1	7,302
2	1,344
3	3,968
4	9,459
5	3,648
6	1,997
7	813
8	1,984
9	1,408
10	1,978
11	3,533
12	1,638
13	2,688
14	4,595
15	2,842
16	8,787
17	2,112
18R	1,946
19	9,293
20	3,309
21	2,438
22	2,317
23	16,787

Figure 5

PROJECT MAP
ATTOYAC BAYOU WATERSHED
NACOGDOCHES, RUSK, SAN AUGUSTINE AND SHELBY COUNTIES, TEXAS

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

0 1 2 Miles
Approximate Scale
Approximate Area-213,440 Acres

COMPILED FROM UNCONTROLLED MOSAIC 4-R-15027

12-28-62

Rev. 9-64 5-64 4-R-18768

Rev. 5-64 4-R-11693