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WORK PLAN

COW BAYOU WATERSHED

Of the Brazos River Watershed
Mc Lennan and Falls Counties, Texas

Prepared By
SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE
Temple, Texas
June 1954

C
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UNITED STATES
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

P. O. Box 417
Temple, Texas
June 2, 1954

Chairman, County ASC Committee, Falls County
Chairman, County ASC Committee, McLennan County
County Extension Agent, Falls County
County Extension Agent, McLennan County

In accordance with the specific request of the farmers and others living in the Cow Bayou Watershed, a work plan has been prepared primarily for flood prevention, and a copy will be provided you as soon as final printing is complete.

As a result of the discussion held during the development of the plan and reviewed finally with various members of the group on May 14, 18 and 20, it is our understanding that the unit costs and schedules shown are in harmony with those currently used by the agencies and organizations which will participate in carrying out the plan. The Governing Bodies of the McLennan County and Central Texas Soil Conservation Districts have concurred in the work plan and have incorporated the same in their respective district work plans.

We have in the Soil Conservation Service budget for the fiscal year 1954 the money for initiating our part of the work as set forth in the schedule of the work plan for 1954. The remaining Federal contribution, up to the designated amount, will be submitted for inclusion in the Soil Conservation Service budget request for each of the remaining fiscal years as set forth in the schedule of the work plan.

If any significant changes should be needed during the application of this plan, it is expected that the revision will be brought to your attention.

/s/ L. W. Stasney
L. W. Stasney, Area Conservationist

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May 19, 1954

Mr. Carl L. Young
Work Unit Conservationist
Soil Conservation Service
Temple, Texas

Dear Mr. Young:

The Supervisors of the Central Texas Soil Conservation District have reviewed carefully the work plan for the prevention of floods in the Cow Bayou of McLennan and Falls Counties, Texas.

We believe that the development of the watershed work plan by the joint effort of the landowners, the District Supervisors of the McLennan County and Central Texas Soil Conservation Districts and the Soil Conservation Service technicians has resulted in a plan which we thoroughly subscribe to and wish to push through to completion according to terms of cooperation and the schedule in the plan.

We are officially incorporating into our District Work Plan the portion of the Cow Bayou flood prevention plan that directly concerns our District.

We wish to commend Mr. E. W. Buchtein and his party and your own staff of the splendid performance and cooperation that you have shown through the development of this program.

Yours very truly,

/s/ K. W. Barth
K. W. Barth, Chairman

cc: Louis Sigut
SCS, Rosebud

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May 10, 1954

Mr. William J. Thomas
Work Unit Conservationist
Soil Conservation Service
Waco, Texas

Dear Mr. Thomas:

The Supervisors of the McLennan County Soil Conservation District have reviewed carefully the work plan for the prevention of floods in the Cow Bayou of McLennan and Falls Counties Texas.

We believe that the development of the watershed work plan by the joint effort of the landowners, the District Supervisors of the McLennan County and Central Texas Soil Conservation Districts and the Soil Conservation Service Technicians has resulted in a plan which we thoroughly subscribe to and wish to push through to completion according to terms of cooperation and the schedule in the plan.

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We wish to commend Mr. E. W. Buchtein and his party and your own staff for the splendid performance and cooperation that you have shown through the development of this program.

Yours very truly,

/s/ Dave Simons
Dave Simons, Chairman

DS:kh

cc:
Mr. E. W. Buchtein
2604 Herring Ave.,
Waco, Texas.

May 10th, 1954

Mr. Leon Stasney, Area Conservationist
Soil Conservation Service
Temple, Texas

Dear Mr. Stasney:

The Cow Bayou Watershed Improvement Association and the governing bodies of the McLennan County and Central Texas Soil Conservation Districts and the cooperators of the districts have actively participated in the development of the attached work plan for the prevention of flood in the Cow Bayou Watershed. This plan represents the common understanding and agreement between the parties concerned on the kinds and amounts of measures needed for the prevention of flood in the Cow Bayou Watershed and the preservation and improvement of the soils of the watershed. Our common objective is to conserve our soil and prevent flood and improve our soils to bring about a permanent agriculture in this area. We believe that carrying out the objectives in this plan will accomplish this end.

The work plan for the Cow Bayou Subwatershed of the Brazos River has been incorporated with and made a part of the District Work Plan of our Districts.

A supplemental memorandum of understanding has been entered into between the Soil Conservation Service and each district covering the general terms of cooperation and stating the responsibilities of each party pursuant to this program.

Yours very truly,

5/14/54
Date

/s/ Carroll Bailey
Chairman, Cow Bayou Watershed
Improvement Association.

5/18/54
Date

/s/ Dave Simons
Chairman, McLennan Co. Soil
Conservation District, Board
of Supervisors

5/20/54
Date

/s/ K. W. Barth
Chairman, Central Texas Soil
Conservation District, Board
of Supervisors.

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C O P Y

Washington 25, D. C.
Sept. 29, 1953

TO: Louis P. Merrill, Regional Director, SCS
Fort Worth, Texas

FROM: Robt. M. Salter, Chief, SCS

SUBJECT: Designation of Cow Bayou Watershed, Texas

This is to inform you that I have designated Cow Bayou watershed in McLennan and Falls Counties, Texas, as a project eligible for Federal assistance in the installation of improvement measures under the Watershed Protection item in the appropriate bill for fiscal year 1954.

Cow Bayou watershed has been designated on the basis of the formal assurance of the McLennan County Soil Conservation District and Central Texas Soil Conservation District No. 509, that they are ready to sponsor the program on the watershed and to cooperate with the Federal Government, state and local agencies and individuals in carrying it out.

Cow Bayou watershed, with an area of 103 square miles, is to be completely treated within 5 years at an estimated cost of \$462,000 to the Federal Government. The program is based on local interests making at least an equal contribution. The treatment will consist of interrelated land treatment and structural measures designed to prevent the formation of damaging floods, soil erosion and to retard runoff and thereby conserve and improve the agricultural resources of the area.

Local interests will be assisted by the Federal Government in the development of a watershed plan and in the installation of watershed protection measures in accordance with this plan. This assistance will consist of (1) providing technical services to accelerate planning and applying land-treatment measures on watershed lands, (2) designing and supervising the construction of control measures, and (3) issuing invitations to bid and entering into contracts for the installation of structural and related measures.

It is also intended to initiate studies in the Cow Bayou watershed that will provide factual information on the effects of a watershed protection program on crop yields, soil loss and sediment production, runoff, and flood flows. The cooperation of the Geological Survey and other agencies will be sought in carrying out these evaluations. The installation of this program will also serve to demonstrate the willingness and ability of local interests to cooperate with the Federal Government in solving their watershed problems.

The Congress has fixed a ceiling of \$28,706,000 in Federal costs to be expended in a five-year period throughout the Nation on the Watershed Protection program. The ceiling for this project as indicated above is \$462,000 and cannot be exceeded.

I am sure you have plans to get the work started at once in this watershed and I hope you will do so.

/s/ J. C. Dykes

**WORK PLAN
COW BAYOU WATERSHED
Of the Brazos River Watershed
Falls and McLennan Counties, Texas**

Participating Agencies

**McLennan County Soil Conservation District
Central Texas Soil Conservation District
Agricultural Conservation Program Service, USDA
Extension Service, USDA
Soil Conservation Service**

**Prepared By
Soil Conservation Service
United States Department of Agriculture
June 1954**

Work Plan
COW BAYOU WATERSHED
Of the Brazos River Watershed
Falls and McLennan Counties, Texas
June, 1954

Introduction

Authority

The Cow Bayou Watershed Protection Project will be carried out under the authority of the Soil Conservation Act of 1935 (Public Law No. 46, 74th Congress) as implemented by the Watershed Protection item in the Department of Agriculture Appropriation Act, 1954. 1/

Purpose and Scope of Plan

The purpose of this plan is to state specifically the feasible practices and measures needed and how they will be carried out to achieve the maximum practicable reduction of erosion, floodwater, and sediment damages. Application of this mutually developed plan will provide the protection to and improvement of land and water resources which can be undertaken at this time with the combined facilities of local interest and State and Federal agencies. Upon completion and continued maintenance of the measures set forth in this plan a material contribution will be made toward increasing agricultural production to the maximum level consistent with the capability of the land, thereby promoting the welfare of the landowners and operators, the community, the State, and the Nation. The area in the watershed includes parts of two counties, McLennan and Falls, and contains 71,250 acres (111.3 square miles).

SUMMARY OF PLAN

This plan is a combination of land treatment practices and measures which contribute directly to erosion control and flood prevention, and of measures primarily for flood prevention. The works of improvement as listed in Tables 1 and 2 are planned to be installed during a 5-year period at an estimated total cost of \$2,026,435 of which \$1,309,840 is to be borne by State and local interests and \$716,595 by the Federal Government. These estimates are inclusive of the current costs of local interests and State and Federal agencies under the going National programs pertaining to the objectives of this plan. It is estimated that the Federal contribution under going agricultural programs will be \$105,272 during the 5-year period.

The McLennan County and Central Texas Soil Conservation Districts, under provisions of State enabling legislation, have agreed to assume responsibility for overall periodic inspection and maintenance of the floodwater retarding structures, and stream channel improvement at an estimated annual cost of \$2,539.

1/ H. R. 5227, "A Bill Making Appropriations for the Department of Agriculture for the Fiscal Year Ending June 30, 1954 and for Other Purposes," House of Representatives Report No. 900; Senate Amendment No. 26.

The landowners and operators will maintain the land treatment measures at an estimated annual cost of \$54,984 in accordance with provisions of the farmer-district cooperative agreements.

Comparison of Benefit and Cost

When the works of improvement are applied and operating at full effectiveness the ratio of the estimated average annual benefit \$502,035 to the estimated average annual cost \$144,192 is 3.48 to 1, based on current price levels for costs and long-term prices for benefits. Benefits were claimed on the Cow Bayou watershed to its confluence with the Brazos River which includes a portion of the common flood plain. Major damage has been caused three times within the past eleven years by Cow Bayou on this common flood plain on which Lake Whitney Dam is expected to prevent future damage from the Brazos River.

DESCRIPTION OF THE WATERSHED

Cow Bayou rises in the southwestern part of McLennan County, Texas, near the town of Moody and flows in a southeasterly direction approximately 27 miles, entering the Brazos River three and one-quarter miles southeast of Satin in Falls County. North Cow and South Cow Bayous are the major tributaries. The towns of Lorena and Bruceville in McLennan County are located in the central part of the watershed. Mooreville, Chilton and Satin in Falls County are located near the lower end of the watershed.

The watershed is served by the Atchison, Topeka, and Santa Fe; the Missouri, Kansas and Texas, and the Texas and New Orleans Railroads; and by 144 miles of roads, of which 27 miles are paved (U.S. Highway #81 and #77, State Highway #317 and Farm to Market Highway #107).

The watershed has an area of 71,250 acres (111.33 square miles), of which 69,705 acres are in farms and ranches and 1,545 acres are in urban areas, roads, and miscellaneous uses. There are 5,625 acres of bottomland in the watershed, of which 5,053 acres are flood plain and 572 acres are stream channel. These figures include the bottomland common to the Brazos River. Under present conditions the entire flood plain would be inundated by the design storm which would produce 5.5 inches of runoff.

The Cow Bayou Flood Plain is somewhat intensely utilized; 79.8 percent is cultivated, 14.6 percent is pasture and 5.6 percent is in miscellaneous uses.

The watershed lies entirely within the Blackland Prairie Problem Area in Soil Conservation. The soils are dark colored, fine textured and have been developed from shales, limestones, marls and chalks. Approximately 84 percent of the soils are deep, 10 percent shallow and 4 percent very shallow, all of which are used for agricultural purposes. The remaining 2 percent consists mostly of deep soils in urban areas, roads and miscellaneous uses.

The soils of the area, in general, are in fair physical condition. The

land now in cultivation has lost approximately six inches of topsoil and much organic matter through long, intensive cultivation. A considerable acreage of land formerly cultivated is now covered with grass. However, approximately 3,935 acres of Class VII land remain in cultivation.

The principal crop is cotton, although a considerable acreage is planted to small grains, chiefly oats, and to row crops such as grain sorghums and corn.

Total land use in the watershed is estimated as follows:

<u>Land Use</u>	<u>Acres</u>	<u>Percent</u>
Cultivation	53,050	74
Pasture	12,770	18
Wooded Pasture	1,885	3
Formerly Cultivated	2,000	3
Miscellaneous <u>1/</u>	<u>1,545</u>	<u>2</u>
Total	71,250	100

1/ Includes roads, highways, farmsteads, railroad rights-of-way, and villages.

The topography of the watershed ranges from steeply rolling to very gently rolling. The upper one-third of the watershed is underlain by the Eagle Ford shale of upper eretaceous age and is characterized by steep slopes and stream gradients. The central portien is occupied by the Austin chalk formation, and is moderately rolling. The Taylor marl topography is gently rolling, with the exception of the narrow area south of the main stem of Cow Bayou which is characterized by short, moderately steep slopes. Elevations range from 850 feet above mean sea level in the extreme upper headwaters to 350 feet where Cow Bayou enters the Brazos River. The main alluvial valley of Cow Bayou ranges from approximately 4,000 feet wide at its junction with the flood plain of the Brazos River to less than 150 feet wide near the headwaters.

Mean temperatures range from 86 degree Fahrenheit in the summer to 48 degrees in winter. The extreme recorded temperatures are 5 degrees below zero and 111 degrees above zero. The average date of the last killing frost is March 10 and that of the first killing frost is November 15, a normal frostfree period of 249 days.

The mean annual precipitation of 34.29 inches is well distributed, with the larger average monthly rainfall occurring in April, May and June. Individual rains of excessive amounte, which may occur during any season, cause erosion and serious flood damage. The minimum recorded annual rainfall was 13.39 inches; the maximum annual rainfall was 60.20 inches.

Water for domestic and livestock uses in the rural area is supplied largely by shallow wells and small farm ponds. The towns of Moody, Bruceville, Lerena, Mooreville, Chilton and Satin obtain water from wells.

Livestock operations within the Cow Bayou watershed are limited by both water and forage resources. Of the crepland, an estimated 58 percent has been used

for production of cotton. The remaining cropland is used for production of corn, grain sorghums and small grains.

The Cow Bayou watershed is served by two Soil Conservation Service Work Units which are assisting the Central Texas and McLennan County Soil Conservation Districts. These work units have assisted farmers and ranchers in preparing 164 conservation plans on 40,684 acres within the watershed. Where land treatment measures have been applied and maintained for as long as 10 years, crop yields have increased 25 to 35 percent.

The 144 miles of roads provide adequate access to the watershed. Of the 106 bridges, 24 span the larger streams. However, floods frequently make some of the roads impassable. Detours thus occasioned cause delay and extra travel to places of employment and markets. Three railroads cross the watershed and provide ample loading facilities for carload lot shipments.

FLOOD, EROSION AND SEDIMENTATION PROBLEMS AND DAMAGES

Flood Damages

Cow Bayou has flooded frequently and caused high annual damage. Devastating floods have occurred at frequent intervals, the recent ones occurring April 21, 1945 and May 11-12, 1953. During the 20-year period 1923 to 1942, inclusive, there were 82 floods in the watershed, 42 occurring during the growing season. Since 1942 nearly all of the large floods have occurred during the growing season. Had these floods been counted in the evaluation period the estimated average annual crop and pasture damage would have been much higher. For the floods experienced during the 20-year period studied the total direct flood-water and sedimentation damages were estimated to average \$51,415 annually under present conditions, of which \$31,217 is crop and pasture damage. Excluding the area of flood plain which would be inundated by the proposed floodwater retarding structures, these damages would be \$51,083 and \$30,886 respectively. In addition, there are numerous indirect damages such as interruption of travel, initial losses sustained by dealers and industries in the area and similar items. The total annual value of these indirect damages are estimated to be \$5,108. The average annual monetary flood damages are summarized in table 4.

Erosion

Erosion rates in Cow Bayou watershed are high, since 70 percent of the upland area is in cultivation and a high percentage of the pasture land has only fair or poor cover. Sheet erosion is the major source of sediment. Seventy-eight percent of the total gross erosion in the watershed results from this process. Gully and streambank erosion produce eight percent of the total, and flood plain scour accounts for the remaining 14 percent. The percentage of sediment yield from these sources varies considerably at the mouth of the watershed due to different delivery rates.

Reservoir and Pond Sedimentation

No large reservoirs exist in the watershed. Farm ponds, in general, have

suffered moderate losses in storage capacity from sedimentation. This constitutes an insignificant annual damage due to the number and small size of these ponds.

Channel Enlargement

The channels of Cow Bayou and its major tributaries are entrenching slightly over most of their lengths. Bank erosion occurs throughout the flood plain area, but is of only slight to moderate consequence. The most severe bank erosion occurs in the sharp bends of the streams. Lateral erosion of the banks in these areas ranges from 0.2 to 0.5 foot annually. The average annual land loss from this process is slightly over one acre. It is estimated that bank erosion contributes approximately seven percent of the total sediment yield at the mouth of the watershed.

Overbank Deposition

Most of the flood plain on Cow Bayou and its major tributaries has received substantial amounts of sediment deposition, but only 27 percent of the total flood plain is considered damaged by this process. Practically all of the damaging sediment is deposited below the proposed floodwater retarding structures. Approximately 1,346 acres have been damaged 10 to 25 percent in 50 years. The estimated annual damages are as follows: 12.5 acres, damaged 10 percent; 9.5 acres, damaged 15 percent; 4.3 acres, damaged 20 percent; and 0.64 acres, damaged 25 percent.

Most of the damaging sediment deposits consist of silt and clay produced from erosion of the upland subsoil. It is low in organic matter and tends to seal the surface of the flood plain soil. Since the area affected by deposition is also affected by flood plain scour, the total effective depth of the sediment deposits has not been great.

Estimated benefits, based on the reduction in sedimentation damages effected by land treatment measures and floodwater retarding structures, were limited to the flood plain area below structures that was inundated by the largest storm considered in the 20-year rainfall series investigated. Sediment damage, chiefly in the form of infertile sediment deposition on bottomland, will be reduced 22 percent by the floodwater retarding structures and channel improvement, and 62 percent by the entire program.

Alluvial Fans

Many short tributaries with high gradients emerge on the flood plain of the main stem in the lower reaches of Cow Bayou. This has caused the formation of numerous small alluvial fans at the outer edge of the flood plain. They range in area from one to five acres and from 0.5 to 1.0 feet in thickness. The texture of the sediment is usually coarser than the flood plain soil and a reduction in productivity results. The total area of these fans is 164 acres. For evaluation purposes this acreage was included with overbank deposition.

Flood Plain Scour

Frequent flooding has caused considerable scour damage. Forty-four percent (2,205 acres) of the flood plain has been scoured by flood water, with resulting damages ranging from 10 to 50 percent. The most severe damage is caused by deep scour channels but the greatest area of damage results from sheet scour. Sheet scour occurring on freshly plowed fields has eroded the soil down to plow depth during peak flood flows. The average annual damages caused by flood plain scour are estimated as follows: 47 acres, damaged 10 percent; 62 acres, damaged 15 percent; 53 acres, damaged 20 percent; 57 acres, damaged 25 percent and 2 acres, damaged 50 percent.

It is estimated that scour damage occurs in about a 10-year cycle, from the original damage to recovery, and that the amount of damage is not increasing appreciably. Flood plain scour produces an estimated 24 percent of the total annual sediment yield at the mouth of the watershed because of its location and higher delivery rate than sediment produced by other sources.

EXISTING OR PROPOSED WATER MANAGEMENT PROJECTS

During the past 40 or 50 years numerous attempts have been made to control floods on Cow Bayou from the mouth of the stream to a point approximately two miles above Highway 77 with varying degrees of success. The stream originally emptied into what was known as Jackson's Lake which had an outlet into the Brazos River. Convict labor was used to divert the stream to its present point of entry into the Brazos River. Individual landowners have removed trees, debris, and brush from the channel and eliminated sharp bends. The course of Kling Branch was changed just above the T. & N. O. Railroad. This resulted in considerable damage to the railroad embankment and caused the Railroad Company to purchase additional right-of-way to protect their roadbed. An old slough was opened up from the T & N. O. Railroad to Highway 77. This channel now has more capacity than the original Cow Bayou channel. Head-cutting has caused the enlarged channel to extend to a point approximately two miles above Highway 77 where it again joins the old channel. Numerous unorganized attempts by individual landowners have been made to levee the stream. The most recent and successful of these attempts is a system of levees immediately below Highway 77 which were constructed after the 1945 flood. During the past 10 years 11 small community groups of farmers have cooperated with the McLennan County and Central Texas Soil Conservation Districts in the preparation and application of soil and water conservation plans for their farms. The Steering Committee of the Cow Bayou watershed, composed of the leaders of the various communities in the watershed, has exerted its influence toward a higher degree of participation in this program on the part of the farmers, ranchers, and other interested parties.

FLOOD PREVENTION WORKS OF IMPROVEMENT TO BE INSTALLED

Measures Primarily for Flood Prevention

The floodwater retarding structures and other measures needed to provide flood protection for flood plain lands, highways, and urban improvements are listed with their costs in Table 2.

A system of 11 floodwater retarding structures and 2.56 miles of stream channel improvement are to be installed to protect the flood plain lands along Cow Bayou and its major tributaries. The locations of the structures and stream channel improvement are shown on the Work Plan Map, Fig. 2. Data concerning the stream channel improvement is summarized in Table 3. The system of floodwater retarding structures will detain runoff from 36 percent of the Cow Bayou watershed. Sufficient detention storage can be developed at all structure sites to make possible the use of vegetated spillways, thereby effecting a substantial reduction in cost over concrete or similar structural type spillways.

Sites for the floodwater retarding structures will be provided by local interests. The value of these sites is estimated to be \$52,908, based on market values as determined by two agricultural appraisers of local banks. Site costs were determined by adding the full value of the land in the sediment pool and one-half the value of the land in the flood pool, since the latter will remain in productive use as pasture. The amortized current value of the structure sites, \$2,463 annually, exceeds the average annual value of the loss of production within the sites at long-term price levels. Therefore, in accordance with sound procedures, the larger of the two figures was used in determining the economic evaluation of the program.

The total estimated cost of installing these structures and the stream channel improvement is \$751,788. The annual cost, including installation and maintenance is \$29,720.

Foundation and Borrow Investigations

In order to have data on the suitability of foundation conditions and construction materials at the proposed 11 floodwater retarding structure sites in advance of detailed design and the procuring of easements, reconnaissance investigations were made on representative sites throughout the watershed.

Measures for Conservation of Water and Watershed Lands

A major phase of work is the seeding or improvement of 13,088 acres of idle land and pasture land which has been so overgrazed that re-seeding is necessary to establish adequate cover. Two thousand three hundred and sixteen miles of terraces are to be built on 27,792 acres of cultivated land, and 48 miles of diversion terraces are needed to protect lower lying fields. One thousand five hundred and sixteen acres of protected outlets are needed to carry the runoff water from these terraces and diversions. Other land treatment measures include 252 farm ponds, 40,269 acres of cover cropping and 5,789 acres of pasture and range improvement. In addition, landowners should apply all other needed land treatment measures applicable to the watershed area. The estimated total cost of planning and installing these measures is \$1,308,769 as shown in Table 5. The annual cost, including installation and maintenance is \$114,472.

Instrumentation

The effects of the watershed program have been computed by sound hydraulic,

hydrologic, and economic principles and procedures. However, as a part of the operations of this watershed, necessary rain gages and stream gages will be installed to provide information on the actual effect of the recommended watershed protection program on runoff, erosion, sedimentation and evaporation. It is anticipated that cooperative arrangements will be made with the U. S. Geological Survey, the Weather Bureau and other agencies to assist in installing and operating the gages and analyzing the effects of the flood-water retarding structures and land treatment measures.

Effect of These Measures on Damages and Benefits

The combined program of land treatment and flood prevention measures described above would eliminate damage on the Cow Bayou flood plain from all of the 65 minor floods such as occurred in the 20-year period 1923 to 1942, inclusive. Of the 17 major floods, 12 would be reduced to minor floods.

Average annual flooding throughout the watershed will be reduced from 2,151 to approximately 286 acres on Cow Bayou. The estimated average annual flood-water damage, based on the floods experienced in the 20-year period of study, will be reduced from \$50,177 to \$6,268, or 87.5 percent.

Approximately 80 percent of the expected reduction in average annual flood damages caused by the storms in the 20-year period studies would result from the system of floodwater retarding structures and from channel improvement. The annual value of this reduction is estimated to be \$39,136 out of the total of \$48,917 from all measures, as shown in Table 4. Of this reduction in damages \$32,612 is from floodwater retarding structures and \$6,524 is from stream channel improvement.

Owners and operators of flood plain lands say that if adequate flood protection is provided they will intensify their use of these lands by growing more high value crops such as cotton and alfalfa and shifting some land now in pasture to cultivation. It is estimated that this more intensive use would increase the net income, after all associated expenses are deducted, by \$11,313 (long-term prices) annually.

The total flood prevention benefits, including both the reductions in flood damages and the benefits from more intensive use of flood plain lands, are estimated to be \$60,230 annually. In addition, it is estimated that the conservation benefits to landowners and operators in upland areas of the watershed from the application of land treatment measures would be \$41,805 annually. The total expected benefit from the combined program would amount to \$502,035 annually.

The installation of the proposed watershed protection program on Cow Bayou and the expansion of this program to the other tributaries of the Brazos River will give added protection to flood plain lands along the Brazos River and greatly reduce the sediment load carried by the stream. The proposed watershed protection program on Cow Bayou will have no known detrimental effect on any downstream projects that might be constructed in the future.

The expected conservation benefits due to land treatment were determined by estimating the increased net income which would result from the application of the needed practices and measures. Although the total area used for cropland would be decreased by the retirement of idle cropland and steep and severely eroded areas to pasture, it was assumed that the percentage of cropland used for each crop would not change. The total number of cattle would be increased materially because of the increased acreage of pasture and the greater pasture carrying capacity to be expected from the application of land treatment measures.

The estimated increase in annual net income to the farmers from the application of land treatment measures is \$369,710 from crops and \$72,095 from pasture, or a total of \$441,805 annually.

Comparison of Costs and Benefit

The ratio of the average annual benefit from measures primarily for flood prevention, \$50,449, to the average annual value of the cost of the measures, \$29,720, is about 1.70:1.

The ratio of the average annual benefit, \$451,586, from the land treatment measures and practices to their average annual cost \$114,472 is about 3.95:1.

The estimated ratio of total average annual benefits, \$502,035, to total average annual value of the costs, \$144,192 is 3.48:1. See Table 5.

In addition to the monetary benefits, there are other substantial values which will accrue from the program such as increased opportunity for recreation, better living conditions, sense of security, etc., which have not been evaluated.

ACCOMPLISHING THE PLAN

The Cooperative Extension Service will conduct general information meetings and local farm meetings, make radio and television broadcasts, prepare radio and press releases, and use other forms of disseminating information to the landowners and operators in the Cow Bayou watershed to help achieve understanding and stimulate participation in the entire plan to be carried out, including the land treatment practices and measures and the measures primarily for flood prevention.

The Soil Conservation Service will assign additional technicians and aids as needed to the McLennan County and Central Texas Soil Conservation Districts to assist landowners and operators cooperating with the districts in the preparation and application of soil and water conservation plans. Agricultural Conservation Program Service payments will assist the farmers in carrying out the land treatment practices and measures needed in the watershed within the 5-year period specified for completion of the program.

The governing body of the McLennan County and Central Texas Soil Conservation Districts will arrange for meetings according to a definite schedule, and by individual contacts encourage the landowners and operators within the Cow Bayou watershed to adopt and carry out soil and water conservation plans on their farms. District owned equipment will be made available to the landowners in accordance with the existing arrangements for equipment usage in the district. The district governing bodies will make periodic inspections of the completed conservation measures within their districts and follow through to see that needed maintenance is performed.

Professional specialists will be provided by the Soil Conservation Service to assist in the planning, design, supervision of construction, certification of payments and related duties for the measures primarily for flood prevention. Since most of this work on private lands will be done by contract, the Soil Conservation Service will be responsible for preparing specifications and discharging the various steps involved in the letting of contracts in accordance with customary Federal procedures.

Table 1 and Figure 1 indicate the schedule of operations for each phase of the program which the cooperating parties have agreed should be followed to achieve the most efficient prosecution of the work. This schedule will be adjusted year by year on the basis of any significant changes in the plan found to be mutually desired and in light of appropriations and accomplishments actually made.

The various features of cooperation between the cooperating parties have been covered in appropriate memoranda of understanding and working agreements.

PROVISIONS FOR MAINTENANCE

Estimated annual maintenance costs after the land treatment measures and flood prevention measures have been installed are shown in Table 3.

The floodwater retarding structures will be maintained by the McLennan County and Central Texas Soil Conservation Districts, assisted by a maintenance association, membership of which is made up primarily by benefited landowners. The land treatment measures will be maintained by the landowners or operators of the farms on which the measures are installed.

Table 1
Estimated Installation Cost by Years - Total Needed Program
COW BAYOU WATERSHED
(Brazos River Watershed)

Measures	Unit	FY 1954		Estimated Cost Fiscal Year 1954			
		No. to be Applied	:	Federal	Non-Federal Public	Private	Total
				(dollars)	(dollars)	(dollars)	(dollars)
A-Measures Primarily for Flood Prevention (SCS)							
Floodwater Retarding Structures Each	No.	1	37,738	-	3,045 ^{1/}		40,783
Total A-Measures			37,738	-	3,045		40,783
B-Measures for Conservation of Watershed Lands Which Contribute Directly to Flood Prevention (SCS)							
Cover Cropping	Acre	6,054	-	-	45,405		45,405
Pasture Seeding	Acre	2,118	-	-	63,540		63,540
Terraces	Mile	155	-	-	23,250		23,250
Diversion Terraces	Mile	5	-	-	2,166		2,166
Farm Ponds	Each	41	-	-	16,400		16,400
Waterway Development	Acre	355	-	-	15,975		15,975
Pasture & Range Improvement	Acre	648	-	-	1,296		1,296
Farm & Ranch Planning & Application Asst. (Aool.)	Acre	2,666	4,359	-	-		4,359
Total B-Measures			4,359	-	168,032		172,391
Total A and B-Measures			42,097	-	171,077		213,174
Facilitating Measures							
Program Evaluation (SCS)			2,950	-	-		2,950
Work Plan Development (SCS)			19,012	-	-		19,012
Local Asst. for Easements etc.			-	-	750		750
Total W. P. Funds (SCS)			64,059	-	-		-
Grand Total			64,059	-	171,827		235,886
Going Program (SCS)	Acre	1,834	2,751	-	-		2,751

^{1/} Value of land easements and rights-of-way, including \$600 for powerline relocation.

Table 1 - Continued
 Estimated Installation Cost by Years - Total Needed Program
 COW BAYOU WATERSHED
 (Brazos River Watershed)

Measures	Unit	FY 1955:		Estimated Cost Fiscal Year 1955			
		No. to be Applied:		Federal	Non-Federal Public	Private	Total
				(dollars)	(dollars)	(dollars)	(dollars)
<u>A-Measures Primarily for Flood Prevention (SCS)</u>							
Floodwater Retarding Structures Each	Nos.	3, 143,072 4,8		-		10,190 ^{1/}	153,262
Total A-Measures			143,072	-		10,190	153,262
<u>B-Measures for Conservation of Watershed Lands Which Contribute Directly to Flood Prevention (SCS)</u>							
Cover Cropping	Acre	8,654	-	-		64,905	64,905
Pasture Seeding	Acre	3,938	-	-		118,140	118,140
Terraces	Mile	430	-	-		64,500	64,500
Diversion Terraces	Mile	11	-	-		4,860	4,860
Farm Ponds	Each	55	-	-		22,000	22,000
Waterway Development	Acre	475	-	-		21,375	21,375
Pasture & Range Improvement	Acre	1,435	-	-		2,870	2,870
Farm & Ranch Planning & Application Asst. (Acol.)	Acre	2,666	4,359	-		-	4,359
Total B-Measures			4,359	-		298,650	303,009
Total A & B-Measures			147,431	-		308,840	456,271
<u>Facilitating Measures</u>							
Program Evaluation (SCS)			1,700	-		-	1,700
Work Plan Development (SCS)			-	-		-	-
Local Asst. for Easements etc.			-	-		600	600
Total W. P. Funds (SCS)			149,131	-		-	-
Grand Total			149,131	-		309,440	458,571
Going Program (SCS)	Acre	8,334	12,501	-		-	12,501

^{1/} Value of land easements and rights-of-way.

Table 1 - Continued
 Estimated Installation Cost by Years - Total Needed Program
 COW BAYOU WATERSHED
 (Brazos River Watershed)

Measures	Unit	: FY 1956: : No. to : Applied:	Estimated Cost Fiscal Year 1956			
			Federal	Non-Federal	Private	Total
			(dollars)	(dollars)	(dollars)	(dollars)
<u>A-Measures Primarily for Flood Prevention (SCS)</u>						
Floodwater Retarding Structures	Each	Nos. 2, 5, 6	182,964	-	11,105 ^{1/}	194,069
Total A-Measures			182,964	-	11,105	194,069
<u>B-Measures for Conservation of Watershed Lands Which Contribute Directly to Flood Prevention (SCS)</u>						
Cover Cropping	Acre	8,650	-	-	64,905	64,905
Pasture Seeding	Acre	3,118	-	-	93,540	93,540
Terraces	Mile	580	-	-	87,000	87,000
Diversion Terraces	Mile	14	-	-	5,970	5,970
Farm Ponds	Each	60	-	-	24,000	24,000
Waterway Development	Acre	463	-	-	20,835	20,835
Pasture & Range Improvement	Acre	1,435	-	-	2,870	2,870
Farm & Ranch Planning & Application Asst. (Abol.)	Acre	2,666	4,359	-	-	4,359
Total B-Measures			4,359	-	299,120	303,479
Total A & B-Measures			187,323	-	310,225	497,548
<u>Facilitating Measures</u>						
Program Evaluation (SCS)			1,700	-	-	1,700
Work Plan Development (SCS)			-	-	-	-
Local Asst. for Easements etc.			-	-	600	600
Total W. P. Funds (SCS)			189,023	-	-	-
Grand Total			189,023	-	310,825	499,848
Going Program (SCS)	Acre	8,334	12,501	-	-	12,501

^{1/} Value of land easements and rights-of-way, including \$680 for powerline relocation.

Table 1 - Continued
 Estimated Installation Cost by Years - Total Needed Program
 COW BAYOU WATERSHED
 (Brazos River Watershed)

Measures	Unit	FY 1957: No. to Applied:	Estimated Cost Fiscal Year 1957			
			Federal	Non-Federal: Public	Private	Total
			(dollars)	(dollars)	(dollars)	(dollars)
<u>A-Measures Primarily for Flood Prevention (SCS)</u>						
Floodwater Retarding Structures Each		Nos. 7, 9, & 10	144,801	6,000 ^{2/}	22,693 ^{1/}	173,494
Total A-Measures			144,801	6,000	22,693	173,494
<u>B-Measures for Conservation of Watershed Lands Which Contribute Directly to Flood Prevention (SCS)</u>						
Cover Cropping	Acre	8,554	-	-	64,155	64,155
Pasture Seeding	Acre	2,707	-	-	81,210	81,210
Terraces	Mile	630	-	-	94,500	94,500
Diversion Terraces	Mile	13	-	-	5,442	5,442
Farm Ponds	Each	60	-	-	24,000	24,000
Waterway Development	Acre	183	-	-	8,235	8,235
Pasture & Range Improvement	Acre	1,436	-	-	2,872	2,872
Farm & Ranch Planning & Application Asst. (Aool.)	Acre	2,666	4,359	-	-	4,359
Total B-Measures			4,359	-	280,414	284,773
Total A & B Measures			149,160	6,000	303,107	458,267
<u>Facilitating Measures</u>						
Program Evaluation (SCS)			1,700	-	-	1,700
Work Plan Development (SCS)			-	-	-	-
Local Asst. for Easements, etc.			-	-	-	-
Total W. P. Funds (SCS)			150,860	-	-	-
Grand Total			150,860	6,000	303,107	459,967
Going Program (SCS)	Acre	7,334	11,001	-	-	11,001

^{1/} Value of land easements and rights-of-way, including \$1600 for powerline relocation.
^{2/} Relocation of roads.

Table 1 - Continued
 Estimated Installation Cost by Years - Total Needed Program
 COW BAYOU WATERSHED
 (Brazos River Watershed)

Measures	Unit	No. to be Applied	FY 1958: Estimated Cost Fiscal Year 1958			
			Federal	Non-Federal	Private	Total
			(dollars)	(dollars)	(dollars)	(dollars)
<u>A-Measures Primarily for Flood Prevention (SCS)</u>						
Floodwater Retarding Structures	Each	No. 11	123,177	1,000 ^{2/}	8,755	132,932
Stream Channel Improvement	Mile	2.56	34,286	-	2,000	36,286
Total A-Measures			157,463	1,000	10,755 ^{1/}	169,218
<u>B-Measures for Conservation of Watershed Lands Which Contribute Directly to Flood Prevention (SCS)</u>						
Cover Cropping	Acre	8,353	-	-	62,648	62,648
Pasture Seeding	Acre	1,207	-	-	36,210	36,210
Terraces	Mile	521	-	-	78,150	78,150
Diversion Terraces	Mile	5	-	-	2,008	2,008
Farm Ponds	Each	36	-	-	14,400	14,400
Waterway Development	Acre	40	-	-	1,800	1,800
Pasture & Range Improvement	Acre	835	-	-	1,670	1,670
Farm & Ranch Planning and Application Asst. (Acol.)	Acre	2,666	4,359	-	-	4,359
Total B-Measures			4,359	-	196,886	201,245
Total A & B-Measures			161,822	1,000	207,641	370,463
<u>Facilitating Measures</u>						
Program Evaluation (SCS)			1,700	-	-	1,700
Work Plan Development (SCS)			-	-	-	-
Local Asst. for Easements etc.			-	-	-	-
Total W. P. Funds (SCS)			163,522	-	-	-
Grand Total			163,522	1,000	207,641	372,163
Going Program (SCS)	Acre	3,412	5,118	-	-	5,118

^{1/} Value of land easements and rights-of-way, including \$2000 for powerline relocation.

Table 1 - Continued
 Estimated Installation Cost by Years - Total Needed Program
 COW BAYOU WATERSHED
 (Brazos River Watershed)

Measures	Unit	No. of Units to be Applied	Estimated Total Cost			
			Federal	Non- Federal Public	Private	Total
			(dollars)	(dollars)	(dollars)	(dollars)
A-Measures Primarily for Flood Prevention (SCS)						
Floodwater Retarding Structures	Each	11	631,752	7,000 ^{2/}	55,788	694,540
Stream Channel Improvement	Mile	2.56	34,286	-	2,000	36,286
Total A-Measures			666,038	7,000	57,788 ^{1/}	730,826
B-Measures for Conservation of Watershed Lands Which Contribute Directly to Flood Prevention (SCS)						
Cover Cropping	Acre	40,269	-	-	302,018	302,018
Pasture Seeding	Acre	13,088	-	-	392,640	392,640
Terraces	Mile	2,316	-	-	347,400	347,400
Diversion Terraces	Mile	48	-	-	20,446	20,446
Farm Ponds	Each	252	-	-	100,800	100,800
Waterway Development	Acre	1,516	-	-	68,220	68,220
Pasture & Range Improvement	Acre	5,789	-	-	11,578	11,578
Farm & Ranch Planning and Application Asst. (Accl.)	Acre	13,330	21,795	-	-	21,795
Total B-Measures			21,795	-	1,243,102 ^{2/}	1,264,897
Total A & B-Measures			687,833	7,000	1,300,890	1,995,723
Facilitating Measures						
Program Evaluation (SCS)			9,750	-	-	9,750
Work Plan Development (SCS)			19,012	-	-	19,012
Local Asst. for Easements etc.			-	-	1,950	1,950
Total W. P. Funds (SCS)			716,595	-	-	-
Grand Total			716,595	7,000	1,302,840	2,026,435
Going Program (SCS)	Acre	29,248	43,872	-	-	43,872

^{1/} Value of land easements and rights-of-way, including \$4880 for powerline relocation.
^{2/} Includes \$61,400 that may be available from other Federal Funds (A.C.P.S.) to reimburse private interests.

Table 2
Status of Conservation Job in the Watershed
COW BAYOU WATERSHED
(Brazos River Watershed)

Measures	Unit	Number	Total Conservation Job : Total Cost	Applied : to Date	Estimated Cost to Date		Remaining : to be Applied
					Federal : 1/	Non-Federal : 2/	
				(dollars) (dollars) (dollars) (dollars)			
A-Measures							
Floodwater Retarding Structures	Each	11	713,519	0	-	-	11
Stream Channel Improvement	Mile	2.56	38,269	0	-	-	2.56
Subtotal A-Measures			<u>751,788</u>				
B-Measures							
Cover Cropping Terraces	Acre	52,994	397,455	12,725	38,175	57,263	40,269
Diversions Terraces	Mile	2,530	379,500	214	16,050	16,050	2,316
Waterway Development (Upland)	Mile	64	26,524	16	4,382	1,696	48
Farm Ponds	Acre	1,964	88,380	448	8,064	12,096	1,516
Pasture Seeding	Each	427	170,800	175	35,000	35,000	252
Pasture and Range Improvement	Acre	16,855	505,650	3,767	37,670	75,340	13,088
Farm and Ranch Planning & Application Assistance	Acre	16,444	32,888	10,655	-	21,310	5,789
Subtotal B-Measures			<u>106,357</u>	<u>27,127</u>	<u>40,690</u>	<u>218,755</u>	<u>42,578</u>
Total A and B Measures			<u>1,707,554</u>		<u>180,031</u>	<u>218,755</u>	<u>218,755</u>

1/ ACPS Payments are included.
2/ ACPS payments have been deducted.

Material included on this page in the preliminary work plan is not applicable to the final work plan.

Table 3
Annual Costs
COW-BAYOU WATERSHED
(Brazeos River Watershed)

Measures	Amortization of Installation Costs 3/		Operation & Maintenance 4/		Other 5/	Grand Total
	Federal 1/	Private 2/	Federal 1/	Non-Federal 2/		
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
A-Measures						
Floodwater Retarding Structures	22,888	247	2,669	25,804	-	825
Stream Channel Improvement	1,265	-	112	1,377	-	1,714
Sub-Total	24,153	247	2,781	27,181	-	2,539
B-Measures						
Total A and B Measures	4,480 7/	-	55,008	59,488	-	54,984 6/
	28,633	247	57,789	86,669	-	57,523

1/ 3.5258 percent of Federal and Non-Federal Public Installation Costs for A and B Measures (50-year period) including interest at 2.5 percent on investment.
2/ 4.6550 percent of Private Installation Costs for A & B Measures, including interest at 4 percent on investment.
3/ 1952 prices, the last complete year for which information is available.
4/ Long-term prices (B.A.E.)
5/ Based on estimated average annual maintenance cost of \$75 per structure during the 50-year period following installation, 5 percent of Federal cost for Stream Channel Improvement.
6/ Based on estimated average annual maintenance costs of individual land treatment measures during the 50-year period following application.
7/ Includes \$1,547 for Going Program and \$2,165 for anticipated ACPS assistance.

Table 4
 Summary of Average Annual Monetary Floodwater and Sediment Damage
 and Flood Prevention Benefit from the Plan 1/
 COW BAYOU WATERSHED
 (Brazos River Watershed)
 (Long-term Prices)

Damages	Average Annual Damage		Average Annual Benefit		Total
	(dollars)	(dollars)	(dollars)	(dollars)	
		With A & B Measures	From A-Measures	Stream	Flood
		B-Measures	Floodwater	Channel	Prevention
	Under	Retarding	Retarding	Improvement	Benefit from
	Present	Structures	Structures	ment	A & B Meas-
	Conditions:	Channel	Improvement	Only	ures
		(dollars)	(dollars)	(dollars)	(dollars)
Floodwater Damage					
Crop and Pasture	30,886	28,130	4,832	2,756	18,773
Other Agricultural	6,791	5,263	1,501	1,528	4,525
Roads, Bridges and			754		747
Railroads	9,394	5,701	342	3,693	5,080
Flood Plain Scour	3,106	2,553	340	553	1,833
Subtotal	50,177	41,647	12,199	6,268	29,448
Sediment Damage					
Valley Sediment	906	544	344	362	200
Deposition	906	544	344	362	200
Subtotal	5,108	4,219	1,255	889	2,964
Indirect Damage	56,191	46,410	13,798	7,274	593
Total Damage					
Benefit from Reduction					
of Damage					
Benefit from More Intensive					
Use of Flood Plain Lands					
Total Flood Prevention Benefit					

1/ Exclusive of flood plain areas inundated by the proposed floodwater retarding structures.

Table 5
 Distribution of Costs and Benefits by Measures and Groups of Measures
 COW BAYOU WATERSHED
 (Brazos River Watershed)

Item	Average Annual Benefit		Intensive Conservation	Use of Land	Benefit	Total	Benefit-Cost Ratio
	(dollars)	(dollars)					
A-Measures							
1. Floodwater Retarding Structure Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11	713,519	26,629	32,612	10,438	-	43,050	1.62:1
Stream Channel Improvement	38,269	3,091	6,524	875	-	7,399	2.39:1
Sub-Total	751,788	29,720	39,136	11,313	-	50,449	1.70:1
B-Measures							
	1,308,769	114,472	9,781	-	441,805	451,586	3.95:1
Total All Measures	2,060,557	144,192	48,917	11,313	441,805	502,035	3.48:1

Table 6
 Floodwater Retarding Structure and Stream
 Channel Improvement Data
 COW BAYOU WATERSHED
 (Brazos River Watershed)

Site No.	Drainage Area (Acres)	Storage (Ac-Ft)	Inches of Runoff (Top of Sed.)	Det. (Sed.)	Pool (Total)	Surface Area (Acres)	Flood Plain Area (Acres)	Max. Inundated (Acres)	Volume (Cu. Yds.)	Draw (Type)	Estimate (dollars)					
1	1.51	147	425	572	1.8	5.3	7.1	27	62	30	0	0	69,244	8	40,833	
2	4.22	405	1,159	1,564	1.8	5.1	6.9	52	123	42	0	0	124,412	21	76,935	
3	1.37	137	394	531	1.9	5.4	7.3	20	56	36	0	0	56,766	7	34,432	
4	5.19	304	1,439	1,743	1.1	5.2	6.3	42	119	46	0	0	130,034	26	74,229	
5	3.51	197	965	1,162	1.0	5.2	6.2	19	60	63	0	0	121,708	18	67,676	
6	1.98	159	549	708	1.5	5.2	6.7	17	52	57	0	0	88,858	10	50,008	
7	5.65	573	1,559	2,132	1.9	5.2	7.1	67	162	43	7	0	111,080	28	72,694	
8	1.69	122	473	595	1.3	5.3	6.6	21	68	34	0	0	75,718	8	44,926	
9	1.53	110	419	529	1.3	5.2	6.5	20	68	33	0	0	63,958	8	38,502	
10	2.52	287	740	1,027	2.1	5.5	7.6	46	116	36	0	0	90,652	13	62,798	
11	10.78	920	4,080	5,000	1.6	7.1	8.7	103	324	50	45	78	226,012	74	133,057	
Total	39.95	3,361	12,202	15,563	434	1,210	52	78	130	1,158	442					696,090
Stream Channel Improvement												183,036	3/			
Total Cost												732,776	4/			

1/ Excluding the areas from which runoff is controlled by floodwater retarding structures.
 2/ May be reduced in final design.
 3/ Amount of excavation.

Construction Cost
 Technical Services \$488,541
 Contingencies 73,281
 Land Easements and Rights-of-way and Relocation of Roads and Utilities 48,854
 Foundation Investigations, Design, Cartographic, Administration Etc., 66,738
 Total 55,362
 \$732,776

Table 7
 Summary of Program Data
 COW BAYOU WATERSHED
 (Brazos River Watershed)

Item	Unit	Quantity
Years to Complete Program	Year	5
Total Remaining Installation Cost		
Federal	Dollar	716,595
Non-Federal	Dollar	1,309,840 ^{1/}
Annual O & M Cost		
Federal	Dollar	None
Non-Federal	Dollar	57,523
Annual Benefits	Dollar	502,035
Floodwater Retarding Structures	Each	11
Stream Channel Improvement	Mile	2.56
Maximum Area Subject to Temporary Inundation by Structures		
Flood Plain	Acre	78
Upland	Acre	698
Watershed Area Above Structures	Acre	25,568
Reduction of Floodwater Damage		
A Measures	Percent	71
B Measures	Percent	17
Reduction of Sediment Damage		
A Measures	Percent	22
B Measures	Percent	40
Reduction of Upland Erosion Damage		
A Measures	Percent	None
B Measures	Percent	47
Other Benefits		
A Measures	Dollar	11,313 Annual
B Measuree	Dollar	441,805 Annual

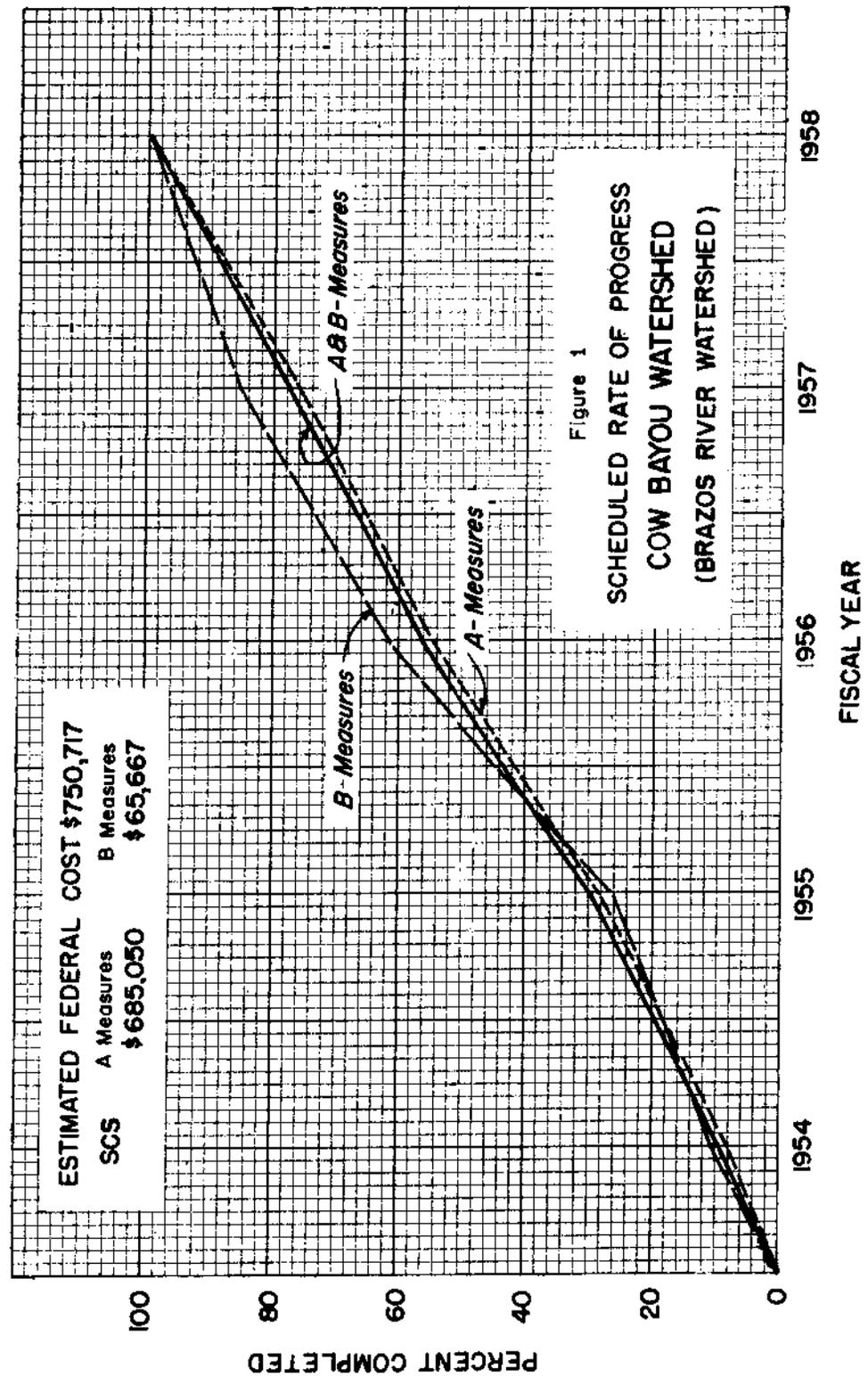
^{1/} Includes \$61,400 that may be available from other Federal funds (ACPS) to reimburse private interests.

Table 8
Summary of Physical Data
COW BAYOU WATERSHED
(Brazos River Watershed)

Item	Unit	Quantity Without Program	Quantity With Program
Watershed Area	Sq.Mi.	111.33	111.33
Watershed Area	Ac.	71,250	71,250
Area of Cropland	Ac.	53,050	44,602
Area of Grassland	Ac.	16,655	25,103
Area of Woodland	Ac.	-	-
Flood Plain Area Subject to Damage by Reservoir Design Storm	Ac.	5,053	3,101
Annual Rate of Erosion			
Sheet	Tons/Yr.	896,700	476,181
Gully	Tons/Yr.	32,053	24,040
Streambank	Tons/Yr.	45,187	40,670
Scour	Tons/Yr.	150,038	56,774
Area Damaged Annually by:			
Sediment	Ac.	27	10
Flood Plain Scour	Ac.	220	68
Swamping	Ac.	-	-
Streambank Erosion	Ac.	1.0	0.9
Sheet Erosion	Ac.	42,840	22,975
Sediment Production ^{1/}	Tons/Ac./Yr.	3.5	1.43
Sediment Accumulation in Existing Reservoirs	Ac./Ft./Yr.	-	-
Frequency of Flooding	Events/Yr.	4.1	0.9
Average Annual Rainfall	Inches	34.29	34.29
Average Annual Surface Runoff	Inches	6.17	5.16 ^{2/}

^{1/} Net leaving watershed.

^{2/} There is no factual information available to indicate that the reduction in surface runoff would cause a corresponding reduction in annual water yield from this watershed.



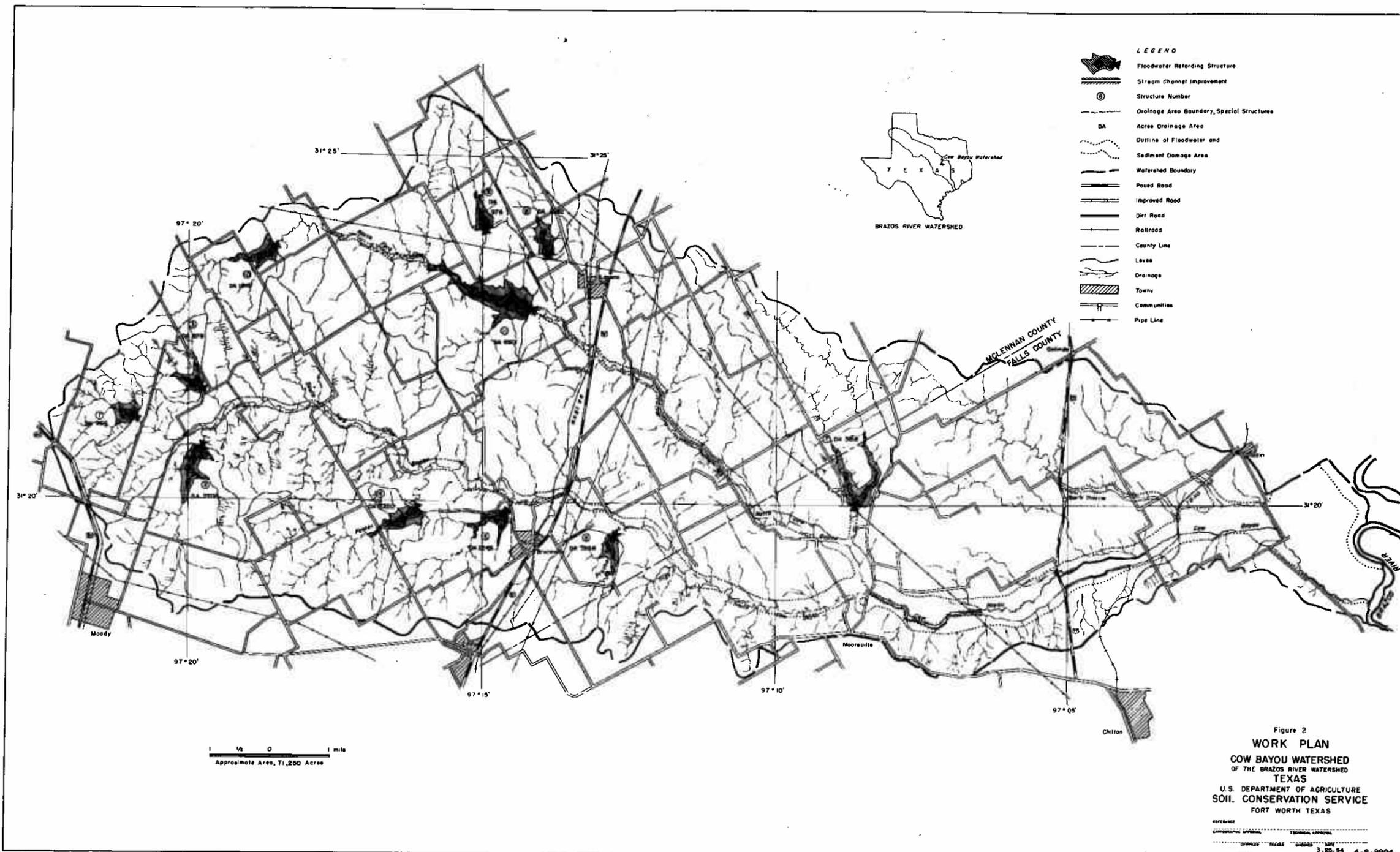


Figure 2
WORK PLAN
 COW BAYOU WATERSHED
 OF THE BRAZOS RIVER WATERSHED
 TEXAS
 U.S. DEPARTMENT OF AGRICULTURE
 SOIL CONSERVATION SERVICE
 FORT WORTH TEXAS

REVISED
 CARTOGRAPHIC SYMBOLS TECHNICAL SYMBOLS
 3-22-54 4-R-8994

Map 327-71-0011, Tex., 1954

A P P E N D I X

- I. HYDRAULIC AND HYDROLOGIC INVESTIGATIONS
- II. SEDIMENTATION INVESTIGATIONS
- III. FOUNDATION AND BORROW INVESTIGATIONS
- IV. ECONOMIC INVESTIGATIONS
- V. PROGRAM DETERMINATION
- VI. TABLES

A P P E N D I X

HYDRAULIC AND HYDROLOGIC INVESTIGATIONS

Methodology

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

1. Tabulation and analysis of basic meteorologic and hydrologic data.
2. Engineering surveys to collect information on stream reaches including valley cross-sections, channel capacities, and other hydraulic characteristics; structure locations and other data for design purposes.
3. Determination of the hydrologic conditions of the watershed, taking into consideration soils, land use, topography, cover, climate, etc.
4. Determination of rainfall-runoff relationships; frequency of occurrence of meteorologic events; and relationship of runoff to flood stage and area inundated.
5. Determination of peak discharges under present watershed conditions, as related to area inundated and damages.
6. Determination of peak discharges and area inundated under conditions which will exist due to:
 - a. Effect of land treatment measures.
 - b. Effect of land treatment measures and floodwater retarding structures.
 - c. Effect of land treatment measures, floodwater retarding structures, and other associated works of improvement.
 - d. Consideration of alternative programs and measures.

Determinations

From a graph showing cumulative departure from normal precipitation the rainfall for the period 1923 to 1942, inclusive, was selected as most representative of a normal rainfall period for the Cow Bayou watershed.

The largest runoff producing rain which occurred during the 20-year period investigated was a storm of 6.35 inches on November 22 and 23, 1940. Under present conditions this rain would produce 2.85 inches of runoff and inundate 2,959 acres of flood plain. If such a rain were to occur after land treatment practices and measures had been applied, it is estimated that the area inundated would be reduced to 2,610 acres. With land treatment applied and the measures primarily for flood prevention in operation, only 922 acres would be flooded.

Approximately 52 acres of flood plain would lie within the sediment pools of proposed structures and 78 additional acres within the detention pools.

The runoff from the 25-year frequency storm was used to establish the minimum detention storage requirements. The 25-year frequency storm which would produce the maximum runoff was found by plotting intensity-frequency and infiltration curves and selecting the maximum ordinate between them. Infiltration rates of 0.10 and 0.15 were assumed on Cow Bayou, which caused the maximum runoff from the design storm to be 5.5 and 5.15 inches in the respective areas.

From a study of the relationship between runoff and flood stage for this watershed it was found that a runoff of 0.21 inches was the minimum that would cause flooding to a depth of six inches at the smallest cross-section. This cross-section, No. 10, is located on Cow Bayou about 9,100 feet below the Mooreville-Cottonwood road. Due to changes in runoff producing characteristics at different seasons of the year rains of 0.96 to 1.62 inches on an average would be required to cause 0.21 inch of runoff and produce a discharge of 1,010 cubic feet per second at cross-section No. 10. This amount of runoff would produce 1,241 cubic feet per second at cross-section No. 1, the reference section, near the mouth of Cow Bayou.

Channel capacity at reference section No. 1 is 15,600 cubic feet per second. The peak discharge at this point for rains that produce 2.85 inches of runoff under present conditions is 16,843 cubic feet per second. After installation and full functioning of the measures in the watershed plan, the discharge at the same point would be reduced to 10,207 cubic feet per second.

Channel capacity at the smallest cross-section on Cow Bayou, No. 10, is 727 cubic feet per second. The peak discharge at this point for rains that would produce 2.85 inches of runoff under present conditions is 13,708 cubic feet per second. After installation and full functioning of the land treatment measures and floodwater retarding structures in the watershed plan, the discharge will be reduced to 7,019 cubic feet per second. After channel improvement the capacity will be 3,730 cubic feet per second.

After all the flood prevention measures are installed flooding will start at cross-section No. S-1 on South Cow Bayou about 2,770 feet above Mooreville-Cottonwood road. No rains were used in flood routing on South Cow Bayou which would produce less than 0.87-inch of runoff and flood less than 6 inches deep. Rains of 2.55 to 3.55 inches on an average will be required to produce 0.87-inches of runoff. This will cause discharges of 4,185 cubic feet per second at cross-section No. S-1 and 5,142 cubic feet per second at the reference section, No. 1.

Channel capacity at cross-section No. S-1 on Cow Bayou is 1,795 cubic feet per second. The peak discharge at this point for rains that produce 2.85 inches of runoff under present conditions is 8,293 cubic feet per second. After installation and full functioning of the measures in the watershed plan the discharge at the same point would be reduced to 4,810 cubic feet per second.

SEDIMENTATION INVESTIGATIONSMethodology

The field surveys of the sedimentation problems in the Cow Bayou watershed were made according to methods described in the revised "Sedimentation Section of Procedures for Developing Flood Prevention Work Plans" Water Conservation 6, SCS, Region 4, March 26, 1952. Field studies included reconnaissance surveys of geology and physiography, studies of overbank sediment deposits, flood plain scour, stream bank erosion, and the nature of the channels and valley on or near all engineering cross-sections. Borings were made where necessary to measure sediment deposition. In the preparation of the report, tabular summaries of all the above findings with explanatory text were prepared. These show the basis for calculation of monetary damages by the economist.

Investigations of sediment sources in the watersheds above seven proposed floodwater retarding structures were made according to standard procedures used in Unit 4. Estimates were then made for both present and future sediment production rates in each proposed basin.

Sediment Source Studies

The sediment derived from sheet erosion was estimated by use of a formula shown in "Suggested Criteria for Estimating Gross Sheet Erosion and Sediment Delivery Rates for the Blackland Prairie Problem Area in Soil Conservation," Soil Conservation Service Region 4, February, 1953. The formula is based on data obtained by watershed surveys and includes the following:

- (1) Soil unit in acres by slope in percent, slope length in feet and present land use (cultivated, pasture or woodland).
- (2) Average farming practices (percent row crop and/or percent small grain, etc.).
- (3) Cover condition classes on pasture or woodland.
- (4) Past history of land use.
- (5) Maximum 30-minute rainfall intensity to be expected once in two years.

Sediment derived from gully and streambank erosion was estimated by field studies: comparison of old and recent aerial photographs, and by interviews with land-owners in the watershed who were able to give information on the history of gully development and channel enlargement.

From these studies, total annual sediment yields above the proposed floodwater retarding structures were calculated to be as follows: 101 acre-feet from sheet erosion, five acre-feet from gully erosion and six acre-feet from channel enlargement. The average yield of sediment above structures is 2.8 acre-feet per square mile annually. The principal source of sediment is sheet erosion on cultivated land. It is estimated that 90 percent of

the total sediment produced above the proposed structures is derived from sheet erosion, 4.5 percent from active gully erosion and 5.5 percent from channel enlargement.

Effect of Watershed Treatment on Sediment Yields

Areas damaged by overbank deposition and flood plain scour will be rendered productive again after they have been protected from flooding and adapted soil-improving crop rotations put into effect.

Deep rooted legumes, such as sweet clover, should be grown in the crop rotations to break up the plow pan, improve percolation rates, and reduce runoff. Field observations indicate that such crops would need the application of commercial fertilizers, which should be applied according to soil tests.

Present analysis indicates that approximately 75 percent of the watershed is in cultivation. Approximately six percent of the cropland has adequate terrace systems. Row crops are grown on about 65 percent of the cultivated acreage. It is recommended that deep rooted legumes be planted on at least one-fourth of the area annually and the acreage of small grain be increased 50 percent. In addition, terraces are recommended on the steeper slopes to reduce erosion and control runoff. The maintenance of present terrace systems should be improved and adequate outlet systems should be installed and maintained where needed. Although cultivated land produces most of the sediment in the watershed, substantial quantities are also derived from pasture land. Much of this land was formerly in cultivation and does not yet have good grass cover. In addition, much of the native pasture has been overgrazed and has only poor or fair grass cover. Proper range management should improve the grass cover on these areas. The application of needed land treatment measures on both cultivated and pasture land will reduce the sediment yields from sheet erosion by an estimated 47 percent. Although gully erosion has been a source of much sediment in the past, many gullies have been stabilized by vegetation, and others are in the process of being stabilized. Land treatment practices are expected to reduce sediment yields on still active gullies by approximately 25 percent. No appreciable reduction in sediment yields from stream bank erosion is expected as a result of land treatment measures. The reduction in sediment yields in the drainage areas of the eleven floodwater retarding structures will increase the life of the sediment pools of the structures by an estimated 33 percent.

FOUNDATION AND BORROW INVESTIGATIONS

Methodology

Reconnaissance geological investigations were made at nine of the eleven floodwater retarding structure locations. These included brief studies of the valley slopes, alluvium, channel banks and exposed rock outcrops, including lithology, stratigraphy and structure. Borings were made on the center line of the dam at two of the sites.

Description of Formations

Of the eleven proposed structures, one is located in the Taylor Marl formation, five in the Austin Chalk and five in the Eagle Ford Shale. Thicknesses of these formations are as follows: Taylor, 1275 feet, Austin, 425 feet, and Eagle Ford, 160 feet. The strike of these formations is southwest to northeast. They dip rather steeply to the southeast with local interruptions caused by lines of folding and faulting. This zone extends in a direction about parallel to the strike of the formations, through the Austin Chalk outcrop from a point a few miles east of Eddy to a point a few miles east of Lorena. Its area of influence extends west of U. S. Highway 81 about two miles. Several faults were observed in the channels of north and south forks of Cow Bayou and other tributaries in this area. However, they seem to involve relatively small displacements.

Foundation Conditions

Keying of dam foundations located in the Eagle Ford Formation may present some problems since, locally, the formation contains thinly laminated gypsiferous and pyritic, bituminous shales. In the middle flag member of the Eagle Ford, which occupies the upper portion of the watershed, shale is interbedded with thin seams of sandstone, sandy limestone, ironstone and bentonite, and locally contains iron salts and selenite crystals.

Foundation conditions in the Austin formation may not be ideal because of the fault problem previously mentioned. Where no faulting exists, foundations keyed into the Austin should be satisfactory. In places the Austin is marl rather than chalk. The Austin chalk is rather watertight except along joints and fault planes, many of which have been re-cemented due to groundwater percolation.

Valley Slopes

The residual soils found on the valley slopes are largely silty clays, underlain by heavy clays, marly clays, shales, chalks or limestones.

Borrow Areas

The borrow materials available at some of the sites consist of silty clay alluvium underlain by heavy clays or marly clays. No deep borings were made in any of the borrow areas of the proposed sites, but it is expected that suitable fill material can be obtained in the alluvium at depths not exceeding a few feet.

Preliminary Recommendations

The rocks of the abutments at some sites in both the Eagle Ford and Austin formations have been exposed to weathering and should be considered more or less unsound. In such instances, the rock should be removed to a sufficient depth to permit the dam to rest on unweathered rock. In some cases shooting may be necessary to remove laid beds of the Austin formation. Since this

formation is extensively jointed, shooting may cause further cracking or shattering of the limestone. Some grouting may be necessary to fill joints and cavities in this formation. Detailed investigation by the core drill should disclose the presence or absence of such openings. Deeper borings will also be made to determine the total depth and extent of alluvium. Laboratory tests will be necessary to determine the quality of materials to be used in the embankment and core walls.

ECONOMIC INVESTIGATIONS

Methodology

The procedures outlined in the Economic Section of Water Conservation-6, Revised, were followed in the economic investigation. The following data have been submitted to the Fort Worth Office to substantiate the findings in this work plan:

1. Map of flood plain showing current land use.
2. Table showing damageable value per acre of flood plain.
3. Table showing crop damage rates by seasons and depths.
4. Tables showing damage by floods in the evaluation series to crops, other agricultural and nonagricultural property.
5. Table summarizing damage at current prices.
6. Table showing intensification of flood plain land use.
7. Table showing conservation benefit.
8. Table showing loss of production in reservoir areas.
9. Table showing individual structure justification.

Determination of Damage

Flood damage information for 100 percent of the flood plain area of Cow Bayou and its major tributaries was obtained from landowners or operators. Most of the specific information as to the amount and extent of damage related to the April 1945 flood and May 1953 flood. Other information obtained included flood plain land use, yields of major crops, property damage which would result from a major flood and general flood problems. The monetary value of the percentage of damage to flood plain lands by sediment deposition and scour was determined on the basis of present values and costs. Damage rates were determined for both season and depth of flooding. Monetary evaluation was based on present prices and costs. After determining the amount of crop damage which would have resulted from single floods during the 20-year rainfall period, this figure was adjusted for recurrence of flooding. Other agricultural damage rates were based on acres inundated by a

given flood. The percentage of damage to flood plain lands by sedimentation and scour was determined on the basis of reduced productivity and increased cost of production.

Determination of Benefits

1. Floodwater Reduction Benefits.

Floodwater and sediment damages were calculated under present conditions and those which will prevail after the installation of each class of measures included in the recommended program. The difference between average annual damages at the time of initiation of each class of measures and those expected after their installation constitutes the benefit brought about by that group through reduction of damage. Benefits from reduction of crop and pasture damages were estimated from the combined effects of reduction in area inundated and depth of inundation. No benefits were estimated for pool areas of the floodwater retarding structures.

Benefits from the reduction of flood plain scour, and other agricultural damages derived from each class of measures were determined on the basis of the reduction in area inundated.

Benefits from reduction of valley sediment damages were determined on the basis of effectiveness of the land treatment program and floodwater retarding structures.

2. Determination of Annual Benefit from Intensified Use of the Flood Plain.

More intensive agricultural use of flood plain soils will be made possible by the reductions in extent and frequency of flooding resulting from the floodwater retarding structures. Determination of the benefit from this source was based on the stated intentions of the flood plain landowners or operators and the degree of flood protection provided.

PROGRAM DETERMINATION

Determination was made first of the conservation measures which contribute directly to flood prevention remaining to be done in the watershed, based on land capability classes developed from soil surveys.

The hydraulic, hydrologic, sedimentation and economic investigations provided data on the effects of land treatment in terms of conservation benefits and the reduction of flood damages resulting from such treatment.

Although significant benefits would result from installation of land treatment measures, it was apparent that additional measures would be required to attain the degree of watershed protection and flood damage reduction desired.

Determination was made secondly of measures primarily for flood prevention which would be feasible to install. The study made and the procedures used

in that determination were as follows:

A base map of the watershed was prepared showing the watershed boundary, drainage pattern, system of roads and railroads, and other pertinent items.

Using consecutive 4" aerial photographs and a stereoscope, all probable floodwater retarding structure sites were located, the limits and the area of the flood plain delineated, and points marked where valley cross-sections should be taken for the determination of hydraulic characteristics and for flood routing purposes. This information was placed on the watershed base map for use in field surveys. Cross-sections of the flood plain were made at representative places in the valley. Data developed from these cross-sections permitted the computation of stage-area inundated relationships for various flood flows.

A field examination was made of all probable floodwater retarding structure sites previously located on the watershed base map. Sites which did not show good storage possibilities or which would inundate railroads, improved highways or highly developed areas were dropped from further consideration. From the remaining sites a system of reservoirs was selected for further consideration and detailed survey.

A topographic map was made of each proposed reservoir site in order to determine the storage capacity of the site, the estimated cost of the dam, and the areas of flood plain and upland that would be inundated by the sediment and flood pools. The height of the dams and size of the pools were determined by the storage volume needed to detain the runoff from the design storm and additional storage needed for sediment. The limits of the flood pools and sediment pools of all satisfactory sites and the flood plain of the stream were drawn to scale on a copy of the base map. A structure data table was developed to show for each structure the drainage area, storage capacity needed for detention and for sediment storage in acre-feet and inches of runoff from the drainage areas, release rate of the outlet tube, and the acres of flood plain inundated by the sediment and detention pools, volume of fill in the dams and estimated cost of the structures.

Due to the scarcity of economical floodwater retarding structure sites and the extremely low capacity of the stream channel immediately below the Mooreville-Cottonwood road, it was determined that stream channel improvement would be necessary throughout this reach to further reduce the flood hazard.

When the land treatment measures and those measures primarily for flood prevention had been determined (giving consideration to alternate proposals), a table was developed which gave the total cost of each type of measure and the portion of the cost to be borne by the participants. The summation of the total costs for all the needed measures represented the estimated cost of the flood prevention-conservation program for the watershed.

A second cost table was developed to show separately the annual installation cost, annual maintenance cost and total annual cost of the A and B measures. This information was used for comparison with annual expected benefits to determine the benefit-cost ratio of the plan of improvements.

APPENDIX

Table 1
Increases in Income Through More Intensive Use of Flood Plain Lands
COW BAYOU WATERSHED
(Brazos River Watershed)

Land Use	: Acres :	: Yield :	: Production :	: Gross : Income :	: Cost :	: Net : Income
				(dollars)	(dollars)	(dollars)
Present Conditions:						
Cotton	1,394	350 Lbs.	487,900	204,430	73,227	131,203
Corn	79	30 Bu.	2,370	4,337	1,683	2,654
Grain Sorghum	158	20 CWT	3,160	8,595	3,343	5,252
Oats	79	40 Bu.	3,160	3,192	1,023	2,169
Alfalfa	68	3 Tons	204	9,247	1,808	7,439
Wheat	27	15 Bu.	405	883	374	509
Pasture	328	4 AUM	1,312	4,920	-	4,920
Miscellaneous	127	-	-	-	-	-
	2,260	-	-	235,604	81,458	154,146
After Land Treatment and Detention Storage:						
Cotton	1,486	350 Lbs.	520,100	217,922	78,060	139,862
Corn	79	30 Bu.	2,370	4,337	1,683	2,654
Grain Sorghum	158	20 CWT	3,160	8,595	3,343	5,252
Oats	79	40 Bu.	3,160	3,192	1,023	2,169
Alfalfa	160	3 Tons	480	21,758	4,254	17,504
Wheat	27	15 Bu.	405	883	374	509
Pasture	144	4 AUM	576	2,160	-	2,160
Miscellaneous	127	-	-	-	-	-
	2,260	-	-	258,847	88,737	170,110
Net Increase						\$ 15,964
Less Added Damages						136
Less Clearing Cost						224
Less Overhead						574
						\$ 15,030
Discounted to Present Worth						0.926
						\$ 13,918
Long-term Price Adjustment						0.75
						\$ 10,438

APPENDIX

Table 1a
 Increase in Income Through More Intensive Use of Flood Plain Lands
 COW BAYOU WATERSHED
 (Brazos River Watershed)

Land Use	Acreage	Yield	Production	Gross Income	Cost	Net Income
				(dollars)	(dollars)	(dollars)
Present Conditions:						
Cotton	1,524	350 Lbs.	533,400	223,495	80,056	143,439
Corn	87	30 Bu.	2,610	4,776	1,853	2,923
Grain Sorghum	173	20 CWT	3,460	9,411	3,661	5,750
Oats	87	40 Bu.	3,480	3,515	1,127	2,388
Alfalfa	74	3 Tons	222	10,063	1,968	8,095
Wheat	30	15 Bu.	450	981	416	565
Pasture	357	4 AUM	1,428	5,355	-	5,355
Miscellaneous	138	-	-	-	-	-
	2,470	-	-	257,596	89,081	168,515
After Land Treatment, Detention Storage and Stream Channel Improvement:						
Cotton	1,624	350 Lbs.	568,400	238,160	85,309	152,851
Corn	87	30 Bu.	2,610	4,776	1,853	2,923
Grain Sorghum	173	20 CWT	3,460	9,411	3,661	5,750
Oats	87	40 Bu.	3,480	3,515	1,127	2,388
Alfalfa	174	3 Tons	522	23,662	4,627	19,035
Wheat	30	15 Bu.	460	981	416	565
Pasture	157	4 AUM	628	2,355	-	2,355
Miscellaneous	138	-	-	-	-	-
	2,470	-	-	282,860	96,993	185,867
Net Increase						\$17,352
Less Added Damages						215
Less Clearing Cost						224
Less Overhead						624
						16,289
Discounted to Present Worth						.926
						15,084
Long-term Price Adjustment						0.75
						11,313

APPENDIX

Table 2
Individual Justification - Floodwater Retarding Structures
COW BAYOU WATERSHED
(Brazos River Watershed)

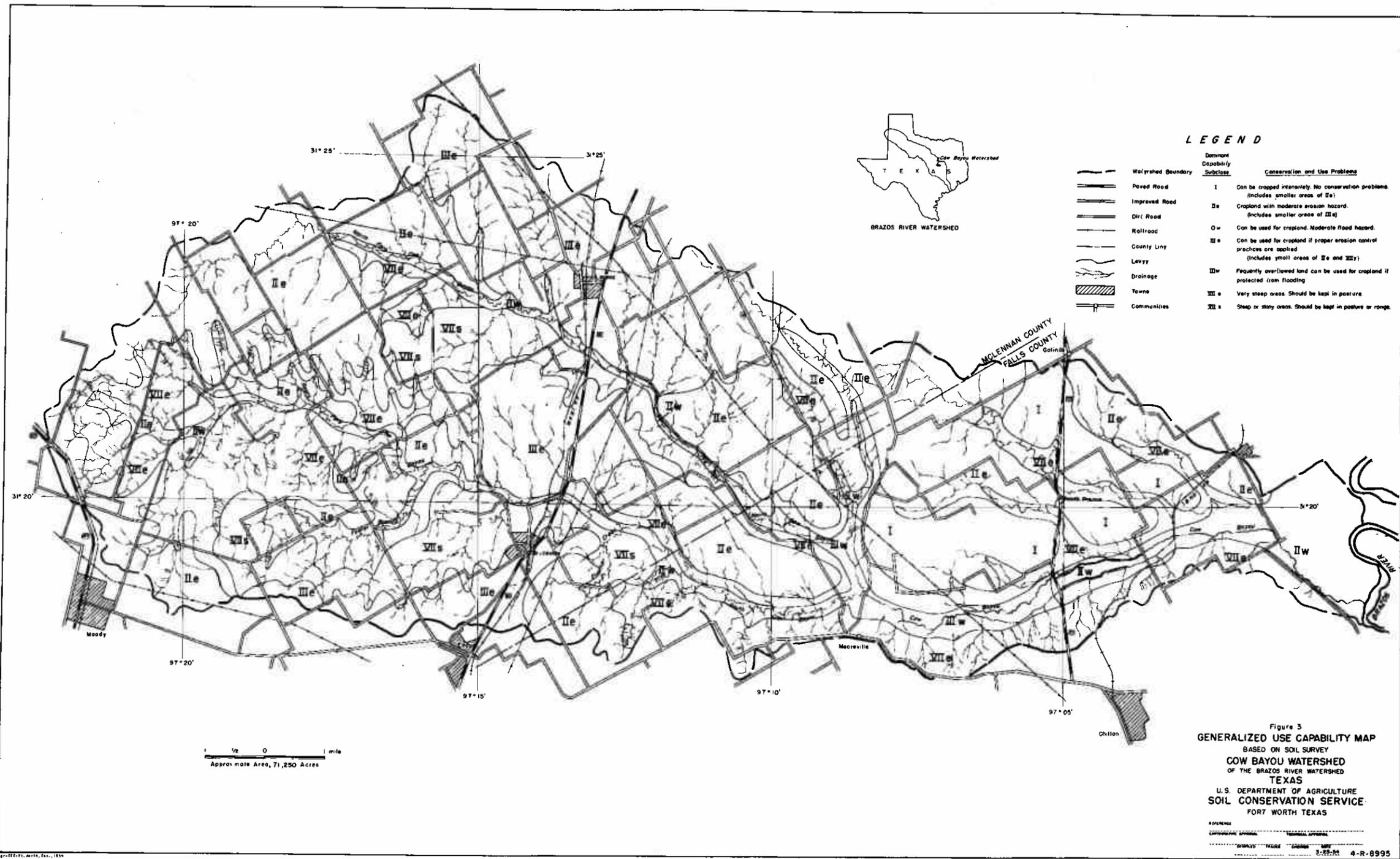
Total Benefits from Floodwater Retarding Structures \$43,050
Drainage Area Controlled (Table 6) - 39.95 square miles
Benefit per Square Mile Controlled - \$1,077.60

Individual Structure Justification

Site No.	Drainage Area : Sq. Mi.	Total : Cost (dollars)	Annual : Cost (dollars)	Annual : Benefit (dollars)	Benefit-Cost : Ratio
1	1.51	41,491	1,572	1,627	1.03:1
2	4.22	78,774	2,952	4,548	1.54:1
3	1.37	35,029	1,349	1,476	1.09:1
4	5.19	76,509	2,810	5,593	1.99:1
5	3.51	69,205	2,530	3,782	1.49:1
6	1.98	50,871	1,885	2,134	1.13:1
7	5.65	75,156	2,862	6,088	2.13:1
8	1.69	45,663	1,727	1,821	1.05:1
9	1.53	39,169	1,497	1,649	1.10:1
10	2.52	63,897	2,412	2,716	1.13:1
11	10.78	137,755	5,033	11,616	2.31:1
Total	39.95	713,519	26,629	43,050	1.62:1

Analysis of Installation Costs

Site No.	Total : Cost (dollars)	Easement		Construction and Other		Total : Annual Cost (dollars)
		Total : (dollars)	Annual : (dollars)	Total : (dollars)	Annual : (dollars)	
1	41,491	2,445	114	39,046	1,383	1,497
2	78,774	7,875	367	70,899	2,510	2,877
3	35,029	3,420	159	31,609	1,115	1,274
4	76,509	3,210	149	72,299	2,586	2,735
5	69,205	1,170	54	68,035	2,401	2,455
6	50,871	1,380	64	49,491	1,746	1,810
7	75,156	10,305	480	64,851	2,307	2,787
8	45,663	3,560	166	42,103	1,486	1,652
9	39,169	3,520	164	35,649	1,258	1,422
10	63,897	7,268	338	56,629	1,999	2,337
11	137,755	8,755	408	129,000	4,550	4,958
Total	713,519	52,908	2,463	660,611	23,341	25,804



LEGEND

Symbol	Feature	Soil Class	Description
---	Watershed Boundary		
==	Paved Road		
---	Improved Road		
- - -	Dirt Road		
—+—	Railroad		
---	County Line		
~	Levy		
~	Drainage		
▨	Towns		
+	Communities		
I	Soil Class	I	Can be cropped intensively. No conservation problems. (Includes smaller areas of IIe)
IIe	Soil Class	IIe	Cropland with moderate erosion hazard. (Includes smaller areas of IIIe)
IIIe	Soil Class	IIIe	Can be used for cropland. Moderate flood hazard. (Includes smaller areas of IIIw)
IIIw	Soil Class	IIIw	Frequently overflowed land can be used for cropland if protected from flooding
VIIe	Soil Class	VIIe	Very steep areas. Should be kept in pasture
VIIIs	Soil Class	VIIIs	Sheep or stony areas. Should be kept in pasture or range

Figure 3
GENERALIZED USE CAPABILITY MAP
 BASED ON SOIL SURVEY
COW BAYOU WATERSHED
 OF THE BRAZOS RIVER WATERSHED
 TEXAS
 U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
 FORT WORTH TEXAS

REFERENCES
 COOPERATING AGENCIES
 DATE 3-22-54 4-R-6995

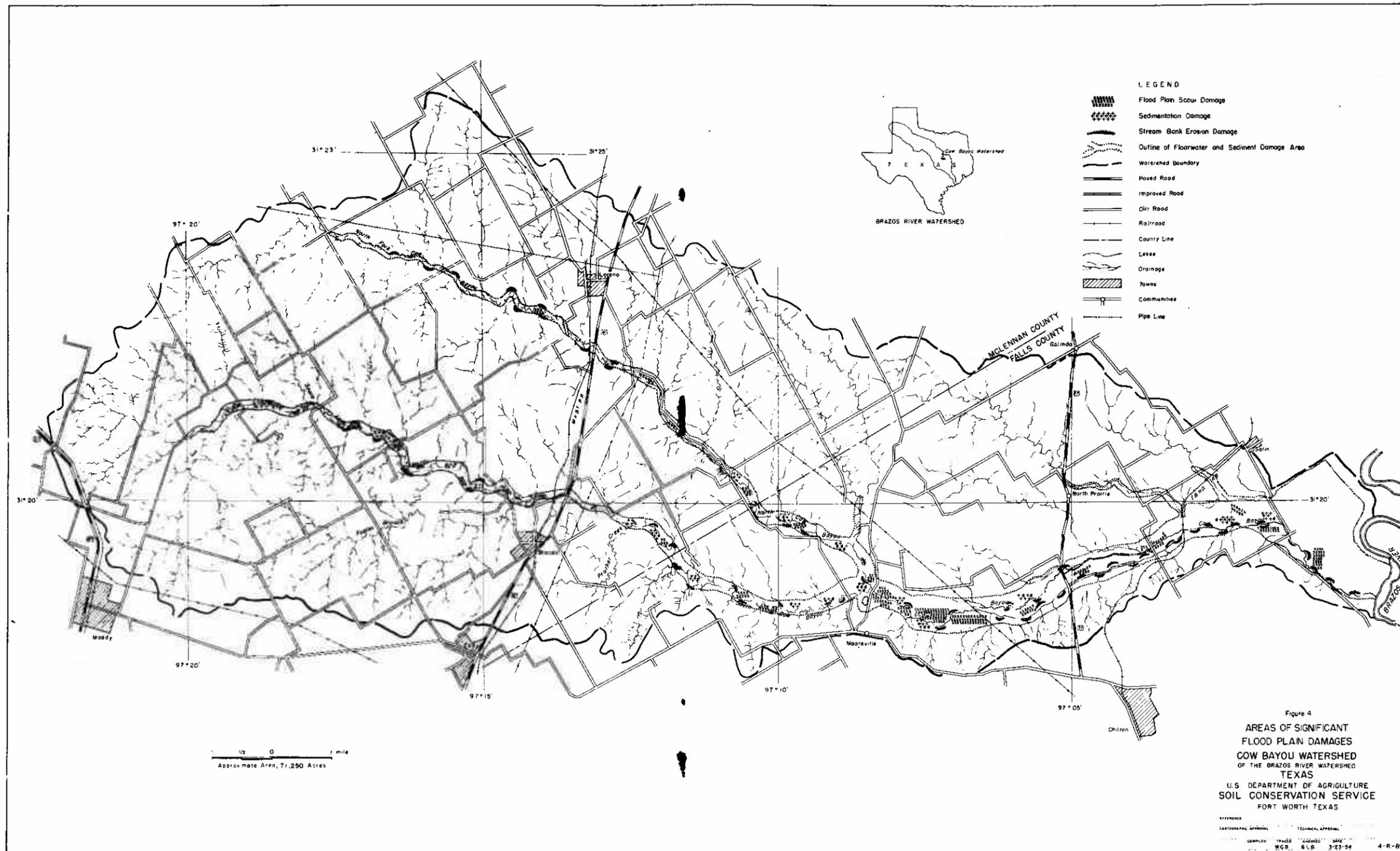


Figure 4
**AREAS OF SIGNIFICANT
 FLOOD PLAN DAMAGES
 COW BAYOU WATERSHED
 OF THE BRAZOS RIVER WATERSHED
 TEXAS**
 U.S. DEPARTMENT OF AGRICULTURE
 SOIL CONSERVATION SERVICE
 FORT WORTH TEXAS

REFERENCE	
CARTOGRAPHIC APPROVAL	TECHNICAL APPROVAL
COMPILED BY WCB, G.L.B.	DATE 3-23-54

4-R-8996



SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

PROGRAM EVALUATION SUPPLEMENT

Objective

Areas in which benefits are expected to accrue.

Hydrologic and sedimentation instrumentation needed to measure the effects of the program.

Plan of Study

Cooperative arrangements with other agencies.

Cost of evaluation program.

Structure and hydrologic gage location map.

EVALUATION OF WATERSHED PROGRAM
COW BAYOU WATERSHED
of the Brazos River Watershed
McLennan and Falls Counties, Texas

Objective

The broad objective of the project evaluation is to evaluate the effect of a watershed protection program in both physical and economic terms. To properly evaluate the effects, it will be desirable to measure various physical and economic factors within the watershed and the changes brought about in them by the application of the program. This will include changes in rainfall-runoff characteristics, erosion, sedimentation and evaporation losses and in agricultural production resulting from soil and water conservation improvements.

This information will be beneficial to (1) the Soil Conservation Service in the planning and design of watershed protection measures on other similar watersheds, (2) other Federal agencies in the planning, design and operation of downstream structures, (3) State and Federal agencies in their assistance to industries, municipalities, etc., in the development of water supplies, and (4) landowners and operators in the proper use and management of watershed lands.

The specific objectives of the evaluation studies will be to determine the relation between estimated and observed benefits expected to accrue annually as a result of the applied program. These annual benefits are estimated to be: 1/

1. Reduction of floodwater and sediment damages	\$48,917
2. More intensive use of flood plain lands	11,313
3. Conservation benefits	<u>441,805</u>
Total all measures	\$502,035

Areas in which benefits are expected to accrue

Benefits from reduction of floodwater and sediment damage are expected to occur below all floodwater retarding structures. The area now subject to damages is shown on Figure 4 of the preliminary work plan.

Benefits from more intensive use of flood plain lands will accrue along the main stem of Cow Bayou and its major tributaries. (See flood plain area, Figure 2 of the preliminary work plan).

Conservation benefits are expected to accrue throughout the watershed as a result of land use adjustments and installation of conservation measures. Records will be maintained on the physical and economic effects of these measures.

The major portion of the "off-site" benefits are expected to accrue primarily as a result of the installation of "A" measures included in the

1/ Table 5 Cow Bayou Preliminary Work Plan.

program. The groups of "B" measures which will contribute to the reduction of "off-site" damage will be primarily instrumental in bringing about increased conservation benefits.

Hydrologic and sedimentation instrumentation needed to measure the effects of the program.

The objective of installing the measuring devices is to measure precipitation in the watershed, and to measure stream flow in such a manner that hydrographs can be computed and the relationship between runoff, stage and area inundated can be determined where applicable. Means must also be provided for determining the amount of sediment carried by the stream flow in determining the reduction in sediment deposition and damages.

To accomplish these objectives it will be necessary to install at the locations shown on the attached map, the following:

1. 8 standard rain gages
1 recording rain gage
2. 1 water stage recorder and staff gage (reservoir)
3. 1 maximum stage stream flow gage.

Plan of Study

The objective of this plan of study is to outline the procedures to be used in relating the measurements and schedules taken in the field to the benefits to be achieved by the installation of the watershed protection program.

1. The reduction in floodwater and sediment damage will be determined in the following manner:

The rain gages, water stage recorder and stream flow gaging station will provide a record of the storms, inflow and outflow hydrographs in key structures, and a record of stream flow for the main stem reaches and major tributaries in which floodwater and sediment damages occur. Measurements of sediment deposition in structures will give a quantitative measurement of sediment movement. Damages will be appraised by qualified personnel after each flood occurring during the period of evaluation. For each event, the following determinations will be made:

- a. Damage with measures installed.
- b. Damage that would have occurred without the measures.
- c. Benefits creditable to the measures.

An annual report will be made of the benefits accruing to the program.

2. More intensive use of land

Annual records will be kept by work unit personnel of land use changes brought about by the protection provided by the floodwater retarding structures and other program measures. Comparison of net returns with and without the program will provide the measurement of benefits.

3. Conservation benefits

Records will be kept by work unit personnel on the quantities of "B" measures installed, the initial cost, and the increased net returns resulting therefrom.

Cooperative arrangements with other agencies

This plan has been formulated in conjunction with representatives of the USGS and the Weather Bureau.

The USGS has agreed to the following: (1) furnish, install and operate a maximum stage stream flow gaging station on the main stem of Cow Bayou, and (2) operate a water stage recorder on Site 4 and analyze rainfall data and make all hydrologic computations of reservoir records and supply to the Soil Conservation Service on a reimbursable basis.

The Weather Bureau has agreed to purchase and install the 8 standard and 1 recording rain gage. The cost will be borne by the Soil Conservation Service.

The Soil Conservation Service, in addition to reimbursing the USGS and Weather Bureau as indicated, will do the following: furnish and install a water stage recorder on floodwater retarding structure No. 4; and maintain and read the rain gages and keep the rainfall records. Once a year, or as often as necessary, an engineering party will rerun cross-sections and take silt deposition measurements in floodwater retarding structures.

Once a year work unit personnel will bring up to date physical inventories and record any other pertinent information available.

With the assistance of the Engineering and Watershed Planning Unit, each calendar year a summary of benefits and costs from works of improvement will be prepared for each independently evaluated single or group of "A" measures installed and for "B" measures as a group. Insofar as possible, these evaluations will be the same as those evaluated in the work plan. This information will be put in report form and made available to the State Conservationist for submission to Washington.

Cost of Evaluation Program

	Costs	
	<u>Installation</u> (Dollars)	<u>Annual</u> <u>Operation</u> (Dollars)
The U. S. Weather Bureau will:		
1. Purchase and install 9 rain gages (8 standard and 1 recording)	0	0
The Soil Conservation Service will:		
1. Furnish, install, and maintain a water stage recorder on Site 4	2,597.00	<u>1/</u>
2. Reimburse USGS for operation of water stage recorder on Site 4 and the hydrologic computation of reservoir records and rainfall analyses.		1,400.00
3. Furnish and install fencing for rain gages	272.00	
4. Operate and maintain gages		600.00
5. Reimburse U. S. Weather Bureau for the cost of installation of rain gages	744.00	
6. Make economic investigations of floodwater and sediment damage, and make periodic resurveys of sedimentation in reservoirs		400.00 <u>2/</u>
7. Make annual inventory of land use and crop yields in the flood plain		250.00 <u>2/</u>
Total Cost SCS	<u>3,613.00</u> <u>3/</u>	<u>2,650.00</u> <u>3/</u>

1/ To be inspected at time of rain gage visit.

2/ Source of funds for economic evaluations: These SCS costs will be a part of the technical services charge included in Table 1 of the work plan. It is anticipated that the ARS, Production Economics Research Branch, will supply a part of the personnel services needed in the collecting, recording, analyzing data and preparing reports from funds allotted to them in the Watershed Protection budget.

3/ Public 46 funds in the amount of \$663 for FY 1954 and \$950 annually thereafter will be used to supplement watershed protection funds (\$2,950 for FY 1954 and \$1,700 annually for the remaining four years covered by the work plan) until State, non-Federal Public or Private funds can be obtained for this purpose.

	Costs	
	<u>Installation</u> (Dollars)	<u>Annual</u> <u>Operation</u> (Dollars)
The U. S. Geological Survey will:		
1. Analyze rainfall data; operate water stage recorder on Site 4 and make hydrologic computations of reservoir records.	0	0
2. Furnish, install and operate a maximum stage stream gage on Cow Bayou	<u>200.00</u>	<u>800.00</u>
Total Cost USGS	200.00	800.00

