WATERSHED WORK PLAN

UPPER BRUSHY CREEK SUBWATERSHED

Williamson County, Texas

Prepared Under The Authority Of the

Watershed Protection And Flood Prevention Act

(Public Law 566, 83rd Congress, 68 Stat. 666)

August 1956

Form TX-914
App'd 7/55

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

WATERSHED WORK PLAN

AGREEMENT

between the

Taylor Soil Conservation District
(name of local organization)

Brushy Creek Watershed Association
(name of local organization)

(name of local organization)

STATE OF TEXAS

and the

SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

Whereas, application has heretofore been made to the Secretary of Agriculture by Taylor Soil Conservation District (name of local organization), Brushy Creek Watershed Association (name of local organization) and (name of local organization)

State of Texas, hereinafter referred to as the local organization, for assistance in preparing a plan for works of improvement for the Upper Brushy Creek SubWatershed, State of Texas, under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat, 666); and

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

Whereas, there has been developed through the cooperative efforts of the local organization and the Service a mutually satisfactory plan for works of improvement for said watershed, designated as the watershed work plan for Upper Brushy Creek SubWatershed, State of Texas, which watershed work plan is annexed to and made a part of this agreement; and

Whereas, the watershed work plan describes the watershed and its problems, and sets forth a plan for works of improvement including a schedule of operations, the kinds and quantities of measures to be installed, the estimated cost, cost-sharing arrangements, maintenance and other responsibilities of those participating in the project, and economic justification for installing, operating and maintaining the works of improvement; and

Whereas, the Watershed Protection and Flood Prevention Act provides (a) that the local organization and the Secretary of Agriculture shall agree on the watershed work plan prior to participation by the Secretary of Agriculture in the installation of the works of improvement as set forth in said plan, and (b) that, at least forty-five days (while Congress is in session) before such installation involving Federal assistance is commenced, the watershed work plan and the justification therefor shall be transmitted by the Secretary of Agriculture to the Congress through the President;

Now, therefore, in view of the foregoing considerations, the 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 will be installed, operated, and maintained substantially in accordance with the terms, conditions, and stipulations provided for therein.

It is further understood that this agreement does not constitute a financial document to serve as a basis for the obligation of Federal funds, and that 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 and on the execution of supplemental agreements setting forth the cost-sharing arrangements and other conditions that are applicable to specific works of improvement.

It is further agreed that the watershed work plan may be amended or revised, and that this agreement may be modified or terminated, only by mutual agreement of the parties hereto.

No member of or Delegate to Congress 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.

Board of Supervisors
Taylor Soil Conservation District
(name of local organization)

By W. F. Voelker

Title Chairman

Date August 25, 1955

The signing of this agreement was authorized by a resolution of the governing body of the Taylor Soil Conservation District
(name of local organization)
adopted at a meeting held on August 25, 1955.

acting A. C. Crumley
(Secretary, local organization)

Date August 25, 1955

Continuation of Form TX-914

Brushy Creek Watershed Association
(name of local organization)

By [signature]

Title President

Date August 10, 1955

The signing of this agreement was authorized by a resolution of the governing body of the Brushy Creek Watershed Association (name of local organization) adopted at a meeting held on August 10, 1955.

Charles L Hairston
(Secretary, local organization)

Date August 10, 1955

_____
(name of local organization)

By _____

Title _____

Date _____, 195_____

The signing of this agreement was authorized by a resolution of the governing body of the _____ (name of local organization) adopted at a meeting held on _____, 195_____.

_____
(Secretary, local organization)

Date _____, 195_____

Soil Conservation Service
United States Department of Agriculture

By _____
Administrator

Date _____, 195_

WATERSHED WORK PLAN

UPPER BRUSHY CREEK SUBWATERSHED

Williamson County, Texas

Prepared Under the Authority of the
Watershed Protection and Flood Prevention Act

Prepared by

Taylor Soil Conservation District

With Assistance by

U. S. Department of Agriculture
Soil Conservation Service

August 1955

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Williamson County, Texas
August, 1955

INTRODUCTION

Authority

The Watershed Work Plan for the Upper Brushy Creek Subwatershed, Williamson County, Texas, hereinafter referred to as the Plan, will be carried out under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666).

Purpose and Scope of Plan

The Taylor Soil Conservation District provides through its Program and Work Plan for the application of a complete program of soil and water conservation and improved plant management within this watershed. Its objectives are to use each acre of agricultural land in accordance with its capabilities for sustained agricultural production and to treat each acre in accordance with its needs for protection and improvement. Such a program, when applied and maintained within the watershed, will be effective in reducing runoff from small rains and will effect some reduction in peak flows from excessive rains. An effective land treatment program will have a major effect in the reduction of upland erosion rates which in turn will reduce sediment damages. Additional measures primarily for flood prevention are needed to complete the soil, plant, and water conservation program in the watershed and provide effective reductions in flood damage.

The purpose of this plan is (1) to state specifically the land treatment and structural practices and measures which are designed primarily for, or contribute directly to flood prevention and (2) to specify how, when, and by whom they will be carried out to achieve the maximum practicable reduction of erosion, floodwater and sediment damages. The measures and practices planned herein constitute an integral part of the complete soil, plant, and water conservation program in this watershed and have been incorporated in the work plan of the soil conservation district concerned.

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 interests and State and Federal agencies. Upon completion and continued maintenance of the measures set forth in this plan, a material constribution will be made toward increasing agricultural production to a level consistent with the capabilities of the land, thereby promoting the welfare of the landowners and operators, the community, the State, and the Nation.

The watershed lies in Williamson County, Texas, and contains 191,360 acres (299 square miles).

SUMMARY OF PLAN

This plan is a combination of land treatment practices and flood prevention measures which contribute directly to soil, plant and water conservation and flood prevention. The works of improvement, as listed in Table 1, are planned to be installed during a 10-year period at an estimated total cost of $4,921,510 of which $2,280,696 is to be borne by non-Federal interests and $2,640,814 by the Federal Government. These estimates are inclusive of the current costs of private interests under the going National programs pertaining to the objectives of this plan. It is estimated that the Federal contribution for accelerating the going agricultural program will be $69,564 for technical assistance which will be provided through the Taylor Soil Conservation District.

The Taylor Soil Conservation District, under provisions of State enabling legislation, has agreed to assume responsibility for overall periodic inspection and maintenance of the floodwater retarding structures and channel improvement at an estimated annual cost of $4,731. The landowners and operators will maintain the land treatment measures at an estimated annual cost of $178,880, in accordance with provisions of the farmer-district cooperative agreements.

Comparisons of Benefit and Cost

With the works of improvement applied and operating at full effectiveness the ratio of the estimated average annual benefit ($235,482) to the estimated average annual cost ($94,657) is 2.49 to 1 for structural measures, based on long-term price levels for construction and maintenance costs and for benefits. Benefits accrue to the works of improvement in the Upper Brushy Creek subwatershed from the flood plain of lower Brushy Creek and also from the common flood plain with the San Gabriel River and the Little River.

DESCRIPTION OF WATERSHED

Physical Data

Brushy Creek rises in the extreme southwestern part of Williamson County and flows through Williamson and Milam Counties, Texas, in an easterly direction for approximately eighty-four miles entering the San Gabriel River about five miles north of the town of Rockdale. The Upper Brushy Creek subwatershed consists of that portion of the Brushy Creek watershed west of and including the confluence of Mustang Creek, located approximately six miles southeast of Taylor. This subwatershed is approximately fifty-four miles in length. North Brushy, Lake, Chandler, Stoney, Cottonwood, Boggy, Battleground, and Mustang Creeks are the major tributaries (Figure 2).

The watershed has an area of 191,360 acres (299 square miles), of which 187,533 acres are in farms and ranches and 3,827 acres are in urban areas, roads, railroads and other miscellaneous uses. There are 13,061 acres of bottomland in the watershed, of which 9,804 acres are flood plain and 3,257 acres are in stream channels. Under present conditions the entire flood plain would be inundated by the design storm which would produce 5.50 inches of runoff, and 83 percent of the flood plain would be inundated by a 6.67-inch storm occurring over a 3-day period and producing 4.02 inches of runoff. This is the largest storm that occurred in the 20-year period studied.

About 40 percent of the watershed lies within the Grand Prairie and 60 percent in the Blackland Prairie Problem Areas in Soil Conservation. The soils are dark colored and fine textured, and have been developed from shales, limestones, marls and chalks. Approximately 65 percent of the soils are deep, 9 percent shallow, and 24 percent very shallow, all of which are used for agricultural purposes. The remaining 2 percent are in urban areas, roads and miscellaneous uses. The soils, in general, are in fair to poor physical condition. The land now in cultivation has lost approximately five inches of topsoil and much organic matter through long, intensive cultivation. A small acreage of land formerly cultivated is now covered with grass. However, 3,450 acres of land remain in cultivation which are best suited for grass production.

The topography of the watershed ranges from steeply to very gently rolling. The upper one-third of the watershed is underlain by rocks of the Fredericksburg and Washita groups of Lower Cretaceous age and is characterized by steeply to moderately rolling topography. The central and lower portions of the watershed are occupied by the Eagle Ford shale, Austin chalk, Taylor marl and Kemp clay formations of Upper Cretaceous age which lie in north-south bands across the watershed. The topography of this part of the watershed ranges from gently rolling to nearly level, except for a narrow area south of Brushy and Mustang Creeks which has relatively steep slopes. Elevations range from 1,130 feet above mean sea level in the extreme upper headwaters to 450 feet on the flood plain in the lower limits of the watershed. The main alluvial valley of Brushy Creek ranges from approximately 2,700 feet wide in the lower reaches to less than 150 feet wide near the headwaters.

At the present time approximately 55 percent of the watershed is in cultivation. The flood plain is intensely utilized; 56 percent is cultivated; 17 percent is open pasture; 23 percent is in wooded pasture; 1.0 percent is idle; 1.0 percent is in woods; and 2 percent is in miscellaneous uses. Total land use in the watershed is estimated as follows:

Land Use	Acres	Percent
Cultivation	105,959	55
Pasture and Range	74,263	39
Formerly Cultivated	4,054	2
Stream Channels	3,257	2
Miscellaneous 1/	3,827	2
Total	191,360	100

1/ Includes roads, highways, railroad rights-of-way, towns, etc.

The Upper Brushy Creek subwatershed is underlain by rocks of Lower and Upper Cretaceous age, with a small area of Lower Tertiary age in the extreme southeastern section. The Lower Cretaceous rocks are found in the headwater area generally west of Round Rock, and include the Fredericksburg and Washita groups. Rocks of the Upper Cretaceous age occur in the central and lower reaches of the watershed and include the following formations, from west to east: Eagle Ford Shale, Austin Chalk, Taylor Marl (including Pecan Gap member) and Kemp Clay. The small fringe area of Tertiary age is composed of the Kincaid formation. All these formations dip to the southeast approximately 40 feet per mile and strike northeast-southwest.

The Fredericksburg and Washita groups consist of limestones of the Edwards and Georgetown formations. The Edwards limestone in the area is a reef deposit containing small cavities and is often cavernous. Some of the limestone is quarried for building stone and for lime. Faulting occurs generally along the contact between the Edwards and Georgetown formations of the Washita group. The general strike of the faults is north-south. The bedrock of the Washita group is composed of sandy shales, clayey shales, and thin bedded limestones. The limestone members of the Georgetown are generally light gray, compact, somewhat nodular and crystalline, with a considerable intermixture of shell fragments and fossils.

The Eagle Ford shale is composed chiefly of light-colored, compressed and laminated shales. These shales are somewhat silty and soft and are interbedded with thin, hard limestone.

The Austin formation consists of alternating beds of chalk, shaly limestones and marls. It is characterized by small-scale faulting and jointing. Shallow soils dominate the area and overlie hard limestone along the valley slopes. The Taylor marl is similar to the upper marly portion of the Austin formation. The bedrock consists of marls, marly shales, and some shaly limestone. Soils are derived from the marly bedrocks, and are chiefly heavy blackland clays with varying amounts of limestone gravel.

The Kamp clay is quite similar to the Taylor marl. The contact is very hard to distinguish because of the gradual transition. Bedrock consists of marls, marly shales and limestones. The soils are heavy blackland clays and are only slightly lighter in color and sandier than the Taylor marls.

The Kincaid formation consists of glauconitic sands, soft gypsiferous clays and hard indurated limestone lentils. The clays are calcareous and weather to produce rich black or olive-yellow soils. The color depends on the amount of iron present.

The rangeland in the watershed is largely in poor and fair condition. Originally the cover was predominantly mid and tall grasses, consisting

mainly of Little bluestem, Indiangrass, Big bluestem, Sideoats grama and Texas winter grass. In areas of shallow soils the poor condition is caused by the invasion of woody vegetation, principally cedar, and the forage species are suppressed due to the competition for moisture. The range on deep and medium depth soil sites is generally in fair condition, but even in poor condition the vegetation produces considerably more forage and cover than on the shallow soils. In most areas the climax grasses are present in sufficient quantity to permit recovery. The control of woody vegetation on the shallow soils and grazing management throughout the watershed are essential to the recovery and protection of the rangeland.

Mean temperatures range from 83 degrees Fahrenheit in summer to 49 degrees in winter. The extreme recorded temperatures are 5 degrees below zero and 110 degrees above zero. The average date of the last killing frost is February 28 and that of the first killing frost is November 25, a normal frost-free period of 266 days.

The mean annual precipitation is 33.68 inches, according to the 20-year rainfall series used for evaluation purposes. It is well distributed, with the larger average monthly rainfall occurring in April, May and October. Individual rains of excessive amounts, which may occur at any season, cause erosion and serious flood damage. Although these storms may occur during any season the majority have occurred in the spring months. The minimum recorded annual rainfall was 22.86 inches; the maximum was 52.34 inches.

Water for livestock and domestic uses in the Blackland Prairie is supplied largely by shallow wells and small farm ponds. These shallow wells do not provide a dependable water supply. Farm and ranch units in the Grand Prairie largely depend on deeper wells. The towns of Leander, Georgetown, Round Rock, Hutto and Taylor obtain their water from deep wells, while Coupland gets its water from shallow wells.

The Upper Brushy Creek subwatershed is served by Soil Conservation Service work units at Georgetown, Round Rock, and Taylor, which are assisting the Taylor Soil Conservation District. These work units have assisted farmers and ranchers in preparing 559 conservation plans on 103,700 acres within the watershed. Where land treatment measures have been applied and maintained for as long as three to five years, crop yields have increased 30 to 40 percent.

Economic Data

Types of farming in the watershed vary considerably. Livestock production of beef cattle, sheep and goats predominates in the western half of the watershed. Because of the predominance of livestock enterprises, 95 percent of the cropland in this area is used for production of feed crops such as corn, oats, hay, sudan and grain sorghums. Cash crop

farming predominates in the eastern half of the watershed. Approximately 95 percent of the cultivated land in this part of the watershed is devoted to cotton, corn and grain sorghums and 5 percent is used for small grains. There are several dairies within this watershed, which sell milk to Austin processors and distributors. A poultry processing plant in Taylor has encouraged broiler and turkey production.

There are approximately 1,060 farms in the watershed with an average size of 177 acres. Tenancy is not a problem since most farms are owner-operated. Ordinarily the farms have remained in the family, being handed down from father to son. Land values are usually high because little land is for sale.

Taylor, the largest town in the watershed, is located on the northeastern edge. Other towns are Leander in the extreme western end, Georgetown on the north-central edge, Round Rock in the south-central portion, Hutto in the central, and Coupland in the southeastern part of the watershed.

The principal towns and their populations are:

Town	Population
Taylor	9,083
Georgetown	4,943
Round Rock	1,440
Hutto	530

Southwestern University is located at Georgetown.

The principal industries in the area are associated with agriculture and include cotton oil mills, poultry packing plants, and clothing and mattress factories. In addition, a large lime kiln is located at Round Rock and several Austin stone quarries are located in the watershed.

The drainage area is served by approximately 277 miles of roads, of which 102 miles are paved (U. S. Highways 79, 81 and 183, Texas State Highway 95, and FM-620,685, 973, 1325, and 1328, and 27 miles of County highways). There are 112 bridges on these roads, 18 of which span the larger streams. Floods occasionally make some of the roads impassable. The detours thus occasioned cause delay and extra travel distance to and from places of employment and markets in Taylor and Georgetown. The Missouri, Kansas and Texas Railroad, Missouri Pacific Railroad, and the Southern Pacific Railroad provide adequate rail service for carload lot shipments.

WATERSHED PROBLEMS

Floodwater Damage

The flood plain of the Upper Brushy Creek subwatershed floods frequently and causes high annual damage. Large floods have occurred on an average

of once a year, the latest one being December 1, 2 and 3, 1953. During the 20-year period, 1923 to 1942, inclusive, there were 22 floods which covered more than 50 percent of the flood plain, and 57 smaller floods. Eleven of the larger floods and 25 smaller floods occurred during the growing season, causing considerable damage to growing crops.

For the floods experienced during the 20-year period studied the total direct floodwater and sediment damages were estimated to average $110,785 annually under present conditions, of which $73,893 is crop and pasture damage. Excluding the area of the flood plain which would be inundated by the proposed floodwater retarding structures these damages would be $110,195 and $73,303 respectively. In addition, there are numerous indirect damages such as the interruption of travel, initial losses sustained by dealers and industries in the area, and similar items. The total annual value of these indirect damages is estimated to be $11,020. The average annual monetary flood damages are summarized in Table 4.

At one time nearly all of the flood plain on Mustang Creek, one of the large tributaries, was in cultivation, with cotton as the most important crop. Frequent severe floods have caused many operators of flood plain lands to shift a large proportion of their lands to Johnsongrass meadow and other less intensive uses.

Sediment Damage

A large area of the flood plain in Upper Brushy Creek subwatershed has received substantial amounts of modern sediment deposition, but only 5 percent of the total flood plain is considered damaged by this process. Practically all the damaging sediment has been deposited below the locations of the proposed floodwater retarding structures. Crop production on 405 acres of flood plain is being reduced about 10 percent by sediment deposition.

Most of the damaging sediment deposits consist of silt and clay produced from accelerated erosion of the upland subsoil. It is low in organic matter and tends to seal the surface of the flood plain soils. 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 from the reduction in sedimentation damages effected by land treatment measures and floodwater retarding structures were limited to the flood plain area below the proposed structure sites 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 the flood plain, will be reduced 23 percent by the floodwater retarding structures and 67 percent by the entire program.

Many short tributaries with high gradients emerge on the flood plain of the main stem in the lower reaches of the watershed. This has caused the formation, in modern times, of numerous small alluvial fans at the outer edge of the flood plain. They range in area from 1 to 5 acres and from 0.5 to 2.0 feet in thickness. The texture of the sediment is usually coarser than the flood plain soils, and a reduction in productivity results. The total area of these fans is 35 acres. For evaluation purposes, this acreage was included with that damaged by infertile overwash.

No large reservoirs exist in the watershed. Farm ponds, in general, have suffered moderate to high losses in storage capacity from sedimentation.

Erosion Damage

Erosion rates are high since 55 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. Ninety percent of the total gross erosion in the watershed results from this process. Gully and streambank erosion produce two percent of the total, and flood plain scour accounts for the remaining eight percent. The percentage of sediment yield from these sources at the mouth of the watershed may differ from the above gross erosion percentages due to different delivery rates.

The channels of Brushy Creek and its tributaries which lie in this watershed are enlarging slightly over most of their lengths. Channel 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 0.1 to 5.0 feet annually. The average annual land loss from this process is slightly over two acres. It is estimated that bank erosion contributes approximately four percent of the total sediment yield at the mouth of the watershed.

Frequent flooding has caused considerable scour damage to the cultivated land. Fifteen percent (1,192 acres) of the flood plain has been scoured by floodwater, with resulting damages ranging from 10 to 80 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 major floods. The damage due to flood plain scour is estimated as follows: 370 acres, damaged 10 percent; 362 acres, damaged 20 percent; 238 acres,damaged 40 percent; 157 acres, damaged 60 percent; and 65 acres, damaged 80 percent.

It is estimated that scour damage occurs in about a 10-year cycle, from the original damage to recovery, and that damage and recovery are approximately in equilibrium. Flood plain scour produces an estimated 17 percent of the total annual sediment yield at the mouth of the watershed. This relatively high percent of the total annual yield at the mouth of the watershed is due primarily to the location of the producing areas which causes high delivery rates.

Problems Relating to Methods now used in the Conservation, Development, Utilization and Disposal of Water.

Problems relating to methods now used in the conservation, development, utilization and disposal of water are of a minor nature in this watershed and do not warrant a study at this time. The planned works of improvement will produce no detrimental effects on any program which may be developed in the future.

INVESTIGATION AND ANALYSES

Program Determination

Determination was made first of the land treatment measures which contribute directly to flood prevention and remain to be done in the watershed, based on range condition classes and land capability classes developed from soil surveys. The hydraulic, hydrologic, sedimentation and economic investigations provided data on the effects of these measures in terms of the reduction of flood damages resulting from such treatment. Although significant benefits would result from installation of these land treatment measures, it was apparent that other flood prevention measures would be required to attain the degree of watershed protection and flood damage reduction desired.

Determination was made secondly of structural measures for flood prevention which would be feasible to install. The study made and the procedures used in that determination were as follows:

1. 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-inch 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 surveyed 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 map was prepared of the flood plain on which land use, cross section locations and other pertinent data were delineated.

2. 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.

3. 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 the size of the pools were determined by the storage volume needed to detain temporarily the runoff from the design storm and to provide the 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. Structure data tables were developed to show for each structure the drainage area, the storage capacity needed for detention and for sediment storage in acre-feet and in inches of runoff from the drainage areas, the release rate of the outlet tube, and the acres of flood plain inundated by the sediment and detention pools, the volume of fill in the dams and the estimated cost of the structures (Tables 6 and 6B).

4. Damages resulting from floodwater, sediment and erosion were determined from damage schedules and surveys of sample areas. Reduction in these damages resulting from the proposed works of improvement were estimated on the basis of reduction of area inundated and depth of inundation as determined by flood routings. These flood routings were made using present conditions and future conditions for which it was assumed that the proposed works of improvement had been installed. Benefits so determined were allocated to individual measures or groups of interrelated measures on the basis of the effect of each on reduction of damages. In this manner it was determined that floodwater retarding structures and channel improvement could be economically justified. By further analysis those individual floodwater retarding structures and interrelated structures which had favorable benefit-cost ratios were determined. These were selected to be included in the plan. Those which were unfavorable were dropped from further consideration and, where replacements were found to be necessary to effect needed control, alternate sites were investigated until a system of floodwater retarding structures and channel improvement was developed which would give maximum net benefits.

When the land treatment measures and those structural measures for flood prevention had been determined a table was developed which gave the total cost of each type of measure. The summation of the total costs for all the needed measures represented the estimated cost of the proposed watershed protection and flood prevention project (Table 1). A second cost table was developed to show separately the annual installation cost, annual maintenance cost, and total annual cost of the structural measures (Table 3).

Hydraulic and Hydrologic Investigations

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

1. Basic meterologic and hydrologic data were tabulated and analysed.

2. Engineering surveys were made to collect information on stream reaches, including valley cross sections, channel capacities, and other hydraulic characteristics; and structure location and other data for design purposes.

3. Determination was made of the hydrologic conditions of the watershed, taking into consideration such factors as soils, land use, topography, cover and climate.

4. Determination was made of rainfall-runoff relationship by comparing weighted rainfall with actual gaged runoff. The frequency of meterologic events was determined by plotting accumulative departure from normal annual rainfall as taken from climatological papers. The relationship of precipitation to runoff, flood stage and area inundated was determined.

5. Determination was made of peak discharges under present watershed conditions, as related to area inundated and damages.

6. Determination was made of peak discharges and area inundated under conditions which would 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 channel improvement.

From a graph showing cumulative departures from normal precipitation the rainfall for the period 1923 to 1942, inclusive, was selected as most representative of a normal rainfall period on the Upper Brushy Creek subwatershed.

The largest rain which occurred during the 20-year period was a storm of 6.67 inches. An average rain of this magnitude during the spring season would produce 4.02 inches of runoff. Under present conditions 8,115 acres of flood plain in the Upper Brushy Creek subwatershed would be flooded by runoff from this storm. 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 7,890 acres. With land treatment measures applied and the structural measures for flood prevention in operation only 5,253 acres would be flooded.

A study of the hydraulic and hydrologic characteristics, topography and geology of this watershed as compared to the Lower Brushy Creek subwatershed, which lies between it and the San Gabriel River, indicated that these two subwatersheds would have to be considered as a unit for hydraulic and hydrologic analyses and computations. All flood routings and other hydrologic studies were made for the total Brushy Creek watershed. The results obtained were then allocated to the respective subwatersheds depending upon the effects of the planned measures to be applied in each.

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. An infiltration rate of 0.10 was selected as best suited for the watershed. This analysis indicated a 25-year maximum runoff of 5.4 to 5.7 inches for the design storm. An average of 5.5 inches of runoff was used.

It was found that a rain of 1.00 inch during November to March, 1.19 inches during April to June, or 1.72 inches during July to October, would produce 0.08 inches of runoff on the average. This is the minimum that would cause flooding to a depth of six inches at the smallest channel cross section in the Upper Brushy Creek subwatershed. Therefore no rains producing less than this amount of runoff were considered for flood routing purposes. A runoff of 0.08 inch would produce a discharge of 230 cubic feet per second at the minimum cross section (No. M-10). This same amount of runoff would produce 1,360 cubic feet per second at the reference cross section (No. 6) on the main stem of Brushy Creek. The minimum cross section, No. M-10, is located about one-half mile west of the Texas State Highway No. 95 bridge across Mustang Creek on the south side of Taylor, Texas. The reference cross section, No. 6, is located in the Lower Brushy Creek subwatershed about 4 miles southwest of the confluence of Brushy Creek and the San Gabriel River.

Channel capacity at the reference section is 1,550 cubic feet per second. The peak discharge at this point for a 6.67-inch rain under present conditions is estimated to be 65,120 cubic feet per second. After installation and full functioning of the planned measures in both subwatersheds, the discharge at the same point would be reduced to 36,900 cubic feet per second.

Sedimentation Investigations

The field survey of the sedimentation problems in the Upper Brushy Creek subwatershed was made in accordance with methods prescribed in the "Sedimentation Section of Procedures for Developing Flood Prevention Work Plans" Water-Conservation-6, SCS, Region 4, Revised February 1954. Field studies included reconnaissance surveys of geology and physiography, studies of overbank deposits, flood plain scour, streambank erosion, and the nature of the channels and valley on or near all valley cross sections. Borings were made along all cross sections to determine the nature and thickness of sediment deposits. In the preparation of the report tabular summaries of all the above findings, with explanatory text, were prepared. These were used by the economist as the basis for calculating monetary damages.

Investigations of sediment sources in the drainage areas above 10 proposed floodwater retarding structures in this watershed were made according to standard procedures. Estimates were then made for both present and future sediment yields in the drainage area above each of the remaining structure sites.

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 (such as percent row crop and/or percent small grain).

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.

The amount of sediment derived from gully and streambank erosion was estimated by field studies, comparison of old and recent aerial photographs, and by interviews with landowners 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: 227 acre-feet from sheet erosion, 1 acre-foot from gully erosion, and 2 acre-feet from channel enlargement. The average yield of sediment above structures is 1.8 acre-feet per square mile annually. The principal source of sediment is sheet erosion on cultivated land. It is estimated that 99 percent of the total sediment produced above the proposed structures is derived from sheet erosion, and the remaining 1 percent is derived mostly from channel enlargement, with only an insiginificant amount from active gully erosion.

Effect of Watershed Treatment on Sediment Yields:

Areas damaged by infertile overwash and flood plain scour will be rendered productive again after they have been protected from flooding, and adapted soil-improving crop rotations have been put into effect. In addition, the future rate of damage by these causes will be greatly reduced.

Cultivated land produces most of the sediment in the watershed; however substantial quantities are derived from pasture land. 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. Gully erosion has not been and is not now very active in the watershed. Establishment of adequate terrace outlet systems is expected to reduce the active gullies by approximately 50 percent. An estimated 10 percent reduction in sediment yield from streambank erosion is expected as a result of land treatment measures. The installation of the floodwater retarding structures is expected to reduce the sediment yield at the mouth of the watershed by 25 percent, and the application of planned land treatment measures is estimated to reduce the sediment yield an additional 41 percent.

Foundation and Borrow Investigations

Preliminary geological investigations with core drill equipment were made on 7 sites in the Upper Brushy Creek subwatershed. In addition, reconnaissance geological inspections were made on 13 sites in the central and lower reaches of the watershed. These included brief lithologic, stratigraphic and structural studies of the valley slopes, alluvium, channel banks and exposed rock outcrops. No borings were made at sites inspected by reconnaissance; however, a good cross section of the materials expected to be encountered in the proposed sites were found in exposed road cuts and stream channels. The formations underlying the area are quite similar to formations of other areas where dams are already under construction, and the problems generally should be the same.

Construction costs for some of the sites located in the Edwards limestone (Fredericksburg group) may be higher than average for the following reasons: (1) poor foundation conditions, due to cavities and faults in the limestone that could lead to the formation of solution cavities; (2) water loss from the sediment pools could be excessive because of the high porosity of the limestone and could result in abnormally high release rates from reservoirs unless controlled; (3) preliminary core drill investigations revealed that problems may be encountered in obtaining an adequate amount of embankment materials immediately adjacent to the sites; and (4) hard limestone will be encountered in the abutment and spillway which may result in a large volume of high-cost excavation.

Sites investigated in the Washita group appear to have satisfactory foundation and abutment conditions. The borrow contains a clay high in gravel and will be suitable for construction.

Few serious construction problems are foreseen for sites located in the Eagle Ford shale area. The available fill materials consist chiefly of sandy clay with some light gravel. These materials will be suitable for construction. Excavation for foundations and abutments will be sufficiently deep to reach unweathered material.

Some of the sites located within the Austin Chalk area may have unfavorable foundation conditions due to the faulted nature of this formation. Where such conditions occur, minor adjustments in site location will usually provide satisfactory foundation conditions. Sites will be carefully inspected at the time of detailed investigations with the core drilling equipment to determine the possible existence and nature of faults. Some of the spillways will need to be cut into a hard marly or chalky limestone and probably will be difficult to excavate. In some areas borrow material will be thin and may necessitate extension of excavation into the flood pool area.

Sites located in the Taylor marl formation should have no construction problems from a geological standpoint. Borrow materials will consist chiefly of heavy blackland clays with varying amounts of limestone gravel. These heavy clay soils will probably require heavy rolling to obtain the desired compaction, and careful mixing with available coarser materials to prevent cracking. Few excavation problems are expected in the spillway areas, and further study will probably show little hard bedrock to be excavated.

Most of the sites in the Kemp clay are quite similar to sites in the Taylor marl. The bedrock consists of marls, marly shales and limestones. Few foundation, abutment or spillway problems are expected in this area. Borrow materials consist of blackland clays derived from calcareous sediments and are only slightly lighter in color and sandier than the Taylor marls. These materials are adequate in quantity and should make good construction materials.

Sites in the Kincaid formation should offer few foundation or spillway problems. The dark marly, gravelly, clay soils will make good borrow material. Some of the alluvial deposition, adjacent to the channel areas, indicates a sandy influence on the clay soils. These sands will be excavated for placement of the core wall.

Detailed investigations, including explorations with core drilling equipment, will be made at all sites prior to design and construction. Laboratory tests will be made to determine the stability of foundation strata and the suitability of the available embankment and core-wall materials. Special emphasis will be placed upon investigations of sites located in the Edwards limestone.

Economic Investigations

Determination of Annual Benefit from Reduction in Damage:

Damage schedules covering 80 percent of the flood plain area of Brushy Creek and its major tributaries above the lower limits of this watershed were obtained from landowners or operators. These schedules covered land use and crop distribution, yields, and historical data on flooding and flood damages. Analysis of the information contained therein formed the basis for determining damage rates for various depths and seasons of flooding. In calculation of crop and pasture damage, expenses saved, such as costs of harvesting, were deducted from the gross value of the damage. The proper rates of damage were applied flood-by-flood, to the floods during the historical series and an adjustment was made to take into account the effect of recurrent flooding, several floods occurring within one crop year. The flood plain land use was mapped in the field. Normal yields were based on data obtained from the schedules, supplemented by information obtained from soils men and other agricultural workers in the area. It was found that differences in land use, yields and flood frequencies were significant. Therefore, to facilitate accurate appraisal the flood plain was divided into two evaluation reaches, each with its own damageable value and flood history. These were Mustang Creek and the main stem of Brushy together with its other tributaries.

The monetary value of the physical damage to the flood plain from scour and from deposition of sediment was based on the value of the production lost, taking into account the lag in recovery of productivity and/or the costs of farm operations to speed recovery.

Damage to other agricultural property such as fences, livestock, and farm equipment was obtained from analysis of schedules and correlated with sizes of floods. The major item of nonagricultural damage was that sustained by roads and bridges. Estimates of these damages were based on information supplied by County Commissioners, supplemented by that from local farmers.

As Upper Brushy Creek subwatershed is almost entirely an agricultural area, indirect damages primarily involve extra farming expense, additional travel time to market, extra costs of purchasing additional feed for livestock and the like. Information regarding damages of this type was obtained from local residents. Upon analysis it appeared that indirect damages were rather small, amounting to only about 10 percent of the direct damage.

Floodwater, scour 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 project. 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 and flood plain scour resulted from the combined effects of reduction in area inundated and reduced depth of inundation. Benefits from reduction of valley sediment damages derived from each class of measure were determined on the basis of estimated reductions in sediment yield and in acreage flooded after installation of each class of measure.

Damages on the main stem of Brushy Creek below the Upper Brushy Creek subwatershed were calculated after routing the flood series through these reaches, and benefits from the reduction of these damages were apportioned back to the subject watershed and the structures therein in proportion to the reduction in flooding resulting from them. Data from the Little River Watershed Survey Report were analyzed and benefits accruing to Upper Brushy Creek subwatershed from San Gabriel below the mouth of Brushy Creek and Little River below the mouth of San Gabriel were determined on the basis of the reduction in flooding due to structural measures in the subject watershed. No evaluation was made of benefits accruing on the main stem of Brazos River.

Areas that will be inundated by the sediment and detention pools of floodwater retarding structures were excluded from the damage calculations. However, an estimate was made of the value of production lost in these areas after installation of the program. In this appraisal it was considered that there would be no production in the sediment pools. The land covered by the detention pools was assumed to be converted to grassland under project conditions.

Determination of Annual Benefit from Changed Land Use in the Flood Plain:

Farmers were asked to state the changes made in the use of their flood plain lands as a result of past flooding. These estimates provided the basis for separating benefits from changed land use into classes 1 and 2. Benefits from restoration of productive use, described above, were considered as class 1 benefits.

Operators of flood plain lands were also asked what changes they would make in their use of the flood plain if flooding were halved. Analysis of these responses provided the basis for estimating benefits from more intensive use of the flood plain. Additional factors considered in this analysis were: the size and location of the areas affected, land capability, existence of available markets, management skills of the operators, reductions in frequency of flooding, and similar factors. The difference between the total benefit from changed land use and the benefit from restoration to productive use assigned as described in the preceding paragraph to class 1 benefits, constituted the class 2 benefit. All benefits from change in flood plain land use were discounted over a 5-year build-up period to allow for a lag in installation.

Benefits from changed land use, including restoration of productive use, accruing to operators of flood plain lands on the main stem of Brushy Creek below Upper Brushy Creek subwatershed were apportioned between the subject watershed and the Lower Brushy Creek subwatershed in the proportion that structural measures in each watershed contributed to reductions in flooding.

Details of Methodology:

Details of the procedures used in the investigation are described in the Economic Section of Water Conservation-6, Revised, Procedures for Developing Flood Prevention Work Plans, SCS, Region 4, March 26, 1952.

EXISTING OR PROPOSED WORKS OF IMPROVEMENT

Efforts to prevent or to control floods in the Upper Brushy Creek subwatershed have been minor. Since the early 1930's some farmers have been trying to enlarge, straighten and levee stream channels in this watershed on an individual and widely scattered basis, but these efforts have had little effect on flooding. During the past 10 years small neighbor groups of farmers and ranchers, cooperating with the Taylor Soil Conservation District, started preparing their soil and water conservation plans on a community and watershed basis in an attempt to alleviate flooding. The Brushy Creek Watershed Association has set up a committee of the leaders in the various communities within the watershed to assist the supervisors in getting soil and water conservation measures established. The Taylor and Round Rock Chambers of Commerce, along with the Taylor Soil Conservation District Supervisors, have been very active in soil and water conservation as related to flood prevention work. They have exerted their influence toward a high degree of participation in this program on the part of the farmers, ranchers and other interested parties in the watershed.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

An effective conservation program based upon the use of each acre of agricultural land within its capabilities and its treatment in accordance with its needs, such as is now being carried out by the Taylor Soil Conservation District, is essential in a sound and continuing flood prevention program on the watershed. Basic to the attainment of this objective is the establishment and maintenance of all applicable soil, water and plant management practices essential to proper land use. Emphasis will be placed on accelerating the establishment of those land treatment practices which have a measurable effect on the reduction of floodwater and sediment damages.

An important phase of work is the seeding or overseeding of adapted grasses on 7,768 acres. This includes land formerly cultivated, some class VII land which is still in cultivation, and range and pasture which have been so overgrazed that reseeding is necessary to establish adequate cover to reduce erosion and sediment yield.

Three thousand six hundred and twenty-two miles of terraces will be built on 45,450 acres of cultivated land, and 121 miles of diversion terraces will be constructed to protect lower lying fields. Two thousand six hundred and eleven acres of protected outlets will be established to carry the runoff from these terraces and diversions.

Deep-rooted legumes such as sweet clover, will be grown in the crop rotation to break up the plow pan, improve percolation rates and reduce runoff. Soil tests indicate that these crops will need the application of commerical fertilizers if desired results are to be obtained. These crops will be grown on 51,825 acres of cultivated land.

Other needed land treatment measures which have a direct effect on flood prevention and which will be applied include stock ponds, contour farming, crop residue management, rotation hay and pasture, brush eradication and proper use of pasture and range lands. Six hundred and sixty-five additional stock ponds will be constructed to assure adequate distribution of grazing on the grasslands. This density provides approximately one farm pond per average size unit. Contour farming will be practiced on 25,702 acres, crop residue management will be practiced on 67,367 acres and rotation hay and pasture will be established on 6,400 acres to improve the water-holding capacity of the soils, improve infiltration rates, and reduce erosion on cultivated lands. Brush will be eradicated on 18,930 acres, and proper use of 22,332 acres of pasture and 48,430 acres of range land will be practiced to improve and maintain an effective vegetative cover on these lands.

Under the guidance and with the assistance of the Taylor Soil Conservation District, landowners and operators will apply other needed land treatment measures such as farm drainage, land clearing, fish pond management and wildlife area improvement. These practices are needed in a complete soil, plant and water conservation program, but they either do not contribute directly to flood prevention, or their contribution is minor due to characteristics of the practice or small areas affected.

The estimated total cost of planning and installing these measures over and above the going program is $1,678,097, as shown in Table 1.

Structural Measures for Flood Prevention

The floodwater retarding structures (Figure 1) and channel improvement needed to provide flood protection for flood plain lands, highways and urban improvements are listed with their costs in Table 1.

A system of 33 floodwater retarding structures and 6.42 miles of channel improvement is to be installed to protect the flood plain lands in the Upper Brushy Creek aubwatershed. The locations of the structures and channel improvement are shown on the structure location map, Figure 2. Data concerning these waterflow control structures are summarized in Tables 6, 6A and 6B.

The system of floodwater retarding structures will detain the runoff from 43 percent of the Upper Brushy Creek subwatershed. 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 type spillways. Approximately 43 acres of flood plain in the watershed will lie within the sediment pools of the proposed structures and 19 additional acres within the detention pools.

Sitea for the floodwater retarding structures will be provided by local interests. The value of these sites is estimated to be $366,005, based on market values as furnished by real estate dealers and other local people. 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 value of the structure sites exceeds the average annual value of the loas of production within the sites at long-term price levels. Therefore, in accordance with sound procedures, the larger figure was used in determining the economic evaluation of the program. The estimated value of additional land required for channel improvement is $21,979. The total estimated cost of installing these works of improvement is $3,243,413. The annual equivalent cost, including installation and maintenance, is $94,657, based on long-term price levels.

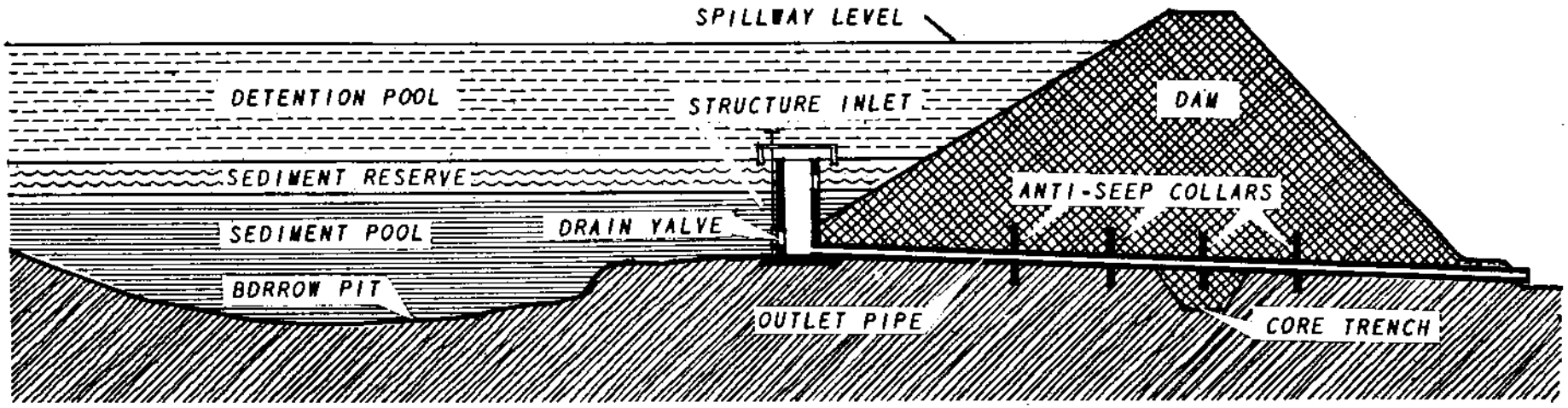

Figure 1

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

Effect of Works of Imrpovement on Damages and Benefits

The combined program of land treatment and waterflow control measures described above would prevent flood plain damage from 16 of the 79 floods such as occurred in this watershed in the period of 1923 to 1942 inclusive. Of the 22 major floods, 20 would be reduced to minor floods. Average annual flooding throughout the watershed would be reduced from 10,055 acres to approximately 2,755.

The estimated average annual floodwater and erosion damage, based on floods experienced in the 20-year period of study, would be reduced from $108,277 to $23,991, or a reduction of 78 percent. Approximately 80 percent of the expected reduction in average annual damages caused by the storms in the 20-year period studied would result from the system of floodwater retarding structures and channel improvement. The annual value of this reduction is estimated to be $75,430 out of the total of $94,129 from all measures, as shown in Table 4.

Owners and operators of flood plain lands say that, if adequate flood protection is provided, they will restore land now in pasture to the production of high value crops such as cotton, corn and maize. Most, if not all, of this pasture land was in cultivation at one time, but was turned to pasture because of the flood hazard. It is estimated that increased net income from such restoration will amount to $9,013 (long-term prices) annually.

Benefits from reduction of damage on the main stem of Brushy Creek in the Lower Brushy Creek subwatershed accrue to land treatment measures applied in Upper Brushy Creek subwatershed in the amount of $53,328 annually. Floodwater retarding structures included in the plan will effect a further benefit on the lower main stem of Brushy Creek of $138,397 annually. Additional benefits of $12,642 annually will accrue to the floodwater retarding structures in the Upper Brushy Creek subwatershed from reduction of damage on the main stem of the San Gabriel and Little Rivers below the mouth of Brushy Creek. The total flood prevention benefits, including both the reduction in flood damages and the benefits from restoration of use of flood plain lands are estimated to be $307,509 annually, of which $235,482 is the result of structural measures.

The installation of the proposed watershed protection and flood prevention program in Upper Brushy Creek subwatershed and the expansion of this program to the other tributaries of Brushy Creek, San Gabriel River, Little River and Brazos River will give added protection to flood plain lands along these rivers and greatly reduce the sediment load carried by these streams. This proposed program will have no known detrimental effect on any downstream projects that might be constructed in the future.

COMPARISON OF COST AND BENEFIT

When the structural measures for flood prevention are installed and operating at full effectiveness the ratio of the average annual benefit, $235,482, to the average annual cost of the measures, $94,657, is about 2.49:1, based on long-term price levels for costs and benefits. Community benefits will be created through opportunity for a more complete utilization of existing resources and greater opportunities for employment. Although these benefits are estimated to equal at least $3,429 annually, they have not been included in the economic justification of the program. 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, and sense of security, which have not been evaluated.

ACCOMPLISHING THE PLAN

The Extension Service will carry out the educational phase of the program by conducting general information and local farm meetings, the preparation of radio and press releases and the use of other forms of disseminating information to reach the landowners and operators in Upper Brushy Creek subwatershed to help achieve understanding and stimulate participation in the entire plan to be carried out, including the land treatment practices and the structural measures for flood prevention.

Land Treatment Measures

Land treatment measures itemized in Table 1 will be established on the land by farmers in cooperation with the Taylor Soil Conservation District. The cost of applying these measures will be borne by the owners and operators of the land. It is expected that the owners and operators will be reimbursed for a portion of this cost through the existing Agricultural Conservation Program. The amount of reimbursement to be expected has been estimated, based on the current program, and has not been included in the total estimated non-Federal cost for land treatment as listed in Table 1. The soil conservation district is giving assistance in the planning and application of these measures under its going program. This assistance will be accelerated to assure application of the planned measures within the 10-year installation period of the project.

The governing body of the Taylor Soil Conservation District with the assistance of the Brushy Creek Watershed Association, will arrange for meetings according to a definite schedule and by individual contacts encourage the landowners and operators within the Upper Brushy Creek subwatershed 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 body will make periodic inspections of the completed conservation measures within the district and follow through to see that needed maintenance is performed.

The Soil Conservation Service will assign additional technicians and aids to the Taylor Soil Conservation District to assist landowners and operators cooperating with the district in accelerating the preparation and application of soil, plant and water conservation plans.

The Farmers Home Administration soil and water conservation loan program, will be made available to all eligible individual farmers and ranchers in the area. Educational meetings will be held in cooperation with other agencies outlining the services available and eligibility requirements. Present FHA clients will be encouraged to cooperate in the program.

The County ASC Committee will cooperate with the governing body of the soil conservation district by selecting and providing financial assistance for those ACPS practices which will accomplish the conservation objectives in the shortest possible time.

Structural Measures for Flood Prevention

The landowners in the watershed plan to form a special purpose water control and improvement district, which will have the powers of taxation and eminent domain under the state laws of Texas. This district will include within its boundaries both the Upper Brushy Creek subwatershed and Lower Brushy Creek subwatershed.

The special purpose water control and improvement district will contract for the construction of all floodwater retarding structures and channel improvement listed in the plan. Funds for the local share of the construction costs will be raised through a bond issue financed by a district-wide ad valorem tax. The bond issue will be voted as soon as the project is approved. Land easements for the sites for the floodwater retarding structures and the reservoirs created by them will be obtained insofar as possible by private donation. In those instances where such donations would create excessive hardship, easements will be purchased. Construction of the structural measures will be started as soon as the local organization is equipped to handle its responsibilities and Federal funds are available. Floodwater retarding structures and the planned channel improvement will be scheduled for construction so as to complete the project within the 10-year period.

Technical specialists will be provided by the Soil Conservation Service to assist in the planning, design, preparation of specifications, supervision of construction, preparation of contract payment estimates, making final inspection, executive of certificates of completion and to perform related duties for the establishment of the planned structural measures for flood prevention.

Table 1 indicates 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 to 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 OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be operated and maintained by the landowners or operators of the farms on which the measures are installed under agreements with the Taylor Soil Conservation District. Representatives of the soil conservation district will make periodic inspections of the land treatment measures to determine maintenance needs, encourage landowners and operators to perform maintenance and make district-owned equipment available for this purpose.

Structural Measures for Flood Prevention

The 33 floodwater retarding structures and the 6.42 miles of channel improvement will be operated and maintained by the Taylor Soil Conservation District with assistance from the proposed special purpose district which will have legal authority to raise funds.

All floodwater retarding structures will be inspected at least annually and after each heavy rain or streamflow. Items of inspection will include but not be limited to the conditions of the principal spillway and its appurtenances, the emergency spillway, the earth fill, the vegetative cover of the earth fill and emergency spillway, fences and gates installed as a part of the floodwater retarding structures. The improved channel will be inspected at least annually to determine the need for control of vegetation to prevent the reduction of channel capacity and accumulation of sediment. The sponsoring local organization will maintain a record of all maintenance inspections.

The estimated annual operation and maintenance cost is $4,731, based on long-term price levels. The necessary maintenance work will be

accomplished through the use of contributed labor and equipment, by contract or by force account, or a combination of these methods. Funds for accomplishing the maintenance work will be obtained from revenue derived through the sale of bonds of the special purpose district.

Provisions will be made for free access of District and Federal representatives to inspect the 33 floodwater retarding structures and their appurtenances and channel improvements at any time.

COST-SHARING

The Federal government expects to provide technical assistance in the amount of $69,564 during the 10-year installation period to accelerate the installation of land treatment measures included in the plan for reduction of erosion and peak rates of runoff. Private interests will install these measures at an estimated cost of $1,608,533 (Table A).

Tables B through G show the allocation of costs of the structural works of improvement between local interests and the Federal government on the basis of benefits received. The required non-Federal costs, consisting of the value of land easements and right-of-way, the capitalized value of operation and maintenance of works of improvements (capitalized at 3 percent interest), and the cost of administering contracts are estimated at $576,391. The value of installation services to be provided by the Federal government is estimated to be $635,481.

Construction costs were allocated in Table C on the basis of the benefits received. Benefits were divided into two major classes for this analysis. Those benefits resulting from reduction of flood or other damage were placed in class 1 and those represented by the greater income derived from land enhancement were placed in class 2. Each class was further subdivided into subclasses A and B. Subclass B benefits were those where the principal beneficiaries were located outside the project area or were otherwise unidentifiable, or the magnitude of the benefit was not significantly large. Benefits, significant in amount, received by identifiable beneficiaries were assigned to subclass A.

In the cost-sharing analysis for the Upper Brushy Creek subwatershed, the benefits from changed land use were considered to accrue to identifiable beneficiaries and were assigned to class 1A or 2A, depending on whether they were derived from restoration of previous levels of production or from enhancement, as described in the section "Economic Investigations." However, it appeared improbable that production would be lifted above levels which had existed previously in any part of the flood plain in this watershed. Consequently all benefits of this type in the watershed were placed in the 1A classification.

Benefits from reduction of road and bridge damage were assigned to class 1B because these benefits would accrue to taxpayers and those using the roads, many of whom are located far from the watershed. Reductions to be expected in the severity of flooding were analyzed for representative

cross sections along Brushy Creek and its major tributaries. As a result of this analysis it was found that reductions in flooding would be sufficiently large to effect significant reductions in flooding in all areas in this watershed. Benefits accruing outside the watershed, for example, in the San Gabriel River flood plain, were classified as 1B. Likewise, benefits from reduction of indirect damage were assigned to class 1B.

Allocation of construction costs on the above basis, Table C, shows 30.83 percent, $663,853, to be paid by local interests and 69.17 percent, $1,489,416, payable by the Federal government.

PROPOSED COST-SHARING ADJUSTMENT

A combination of watershed characteristics, land treatment costs and other factors establish $217,500 as the maximum sum, over and above the rquired non-Federal costs of the structural measures, which the local sponsors believe they can contribute to the construction cost of the floodwater retarding structures and channel improvement and still insure their ability to participate in the project. It is, therefore, proposed that $446,353 of the allocated non-Federal cost be borne by the Federal government. The share of the total project cost to be borne by the local people after such an adjustment would be $2,402,424, or 48 percent. Including land treatment practices already established, the local costs would be $3,206,184 or 55 percent.

Several of the factors which prompted this proposal were:

1. Remaining land treatment costs will be high, amounting to an estimated $1,608,533. Landowners and operators have already established land treatment measures on approximately one-third of the land within the watershed at an estimated expenditure of $803,760. Establishment of all the planned land treatment measures will represent an expenditure by local people of $2,412,293. This estimated expenditure is over and above any financial assistance received or which might be forthcoming from other going agricultural programs.

2. Due to the drought conditions which have existed in this area for the past few years, the income of the local landowners in the watershed has been decreased to such an extent that they do not have the financial ability needed to carry the full share of the cost as indicated by the ratio of local benefits to total benefits.

3. While the average acres per farm unit in the watershed is 177, approximately 60 percent of the area consists of farm units which are smaller, averaging from 100 to 120 acres. These farm units frequently support two families, father and son. These units do not produce enough financial returns over and above the immediate needs of the operators to permit large contributions to this project.

4. The costs associated with procurement of land, easements and rights-of-way are high, $444,163. It is expected that some of the easements will have to be bought since the pool areas concerned will materiallly reduce the production area of some farm units. Many of the other easements which may be donated will represent a large contribution by the landowner or owners affected. The removal of obstacles to construction and the obtaining and recording of easements will require the expenditure of local funds.

5. A regular expenditure of local funds will be required for operation and maintenance of the installed structural measures as well as for the operation of the special purpose district which accepts the responsibility for these structures.

6. In accordance with Budget Bureau Circular A-47, local beneficiaries of the Navarro-Mills flood control reservoir authorized on Richland Creek will be expected to contribute 11 percent of the construction cost. The proposal made herein by the sponsoring agencies will amount to a local contribution of approximately 30 percent of the total construction cost. It is the feeling of the sponsoring agencies that this proposal is compatible with the intent of the Congress in accordance with the requirements for local contribution on other projects of local and public interest.

Table A - Land Treatment Costs

Type of Cost	Federal Cost (dollars)	Non-Federal Cost (dollars)	Total Cost (dollars)
Non-Federal Lands			
1. Technical Assistance	69,564	-	69,564
2. Installation Costs 1/	-	1,608,533	1,608,533
3. Total	69,564	1,608,533	1,678,097

1/ This cost is exclusive of any reimbursement from ACP or other Federal funds.

Date: August, 1955

Table B - Distribution of Average Annual Benefits and Allocation of Construction Costs by Purposes and by Classes of Benefits

Step A — Distribution of Average Annual Benefits

Class of Benefits	Purpose: Flood Prevention (dollars)	Purpose: Flood Prevention (percent)	Total (dollars)
Class 1A Benefits	73,663	30.83	73,663
Class 1B Benefits	165,248	69.17	165,248
Class 2A Benefits	-	-	-
Class 2B Benefits	-	-	-
Total	238,911	100	238,911

Step B — Allocation of Construction Costs

Class of Benefits	Purpose: Flood Prevention (percent)	Purpose: Flood Prevention (dollars)	Total (dollars)
Class 1A Benefits	30.83	663,853	663,853
Class 1B Benefits	69.17	1,489,416	1,489,416
Class 2A Benefits	-	-	-
Class 2B Benefits	-	-	-
Total	100.00	2,153,269	2,153,269

August, 1955

Table C - Benefits and Allocated Construction Costs

Class of Benefits	Benefits		Allocated Construction Costs	
	(dollars	(percent)	(dollars)	(percent)
1. Class 1A	73,663	30.83	663,853	30.83
2. Class 1B	165,248	69.17	1,489,416	69.17
3. Subtotal - Class 1	238,911	100.00	2,153,269	100.00
4. Class 2A	-	-	-	-
5. Class 2B	-	-	-	-
6. Subtotal - Class 2	-	-	-	-
7. Total	238,911	100.00	2,153,269	100.00

Table D - Required Non-Federal Costs

Type of Cost	Cost or Appraised Value
	(dollars)
1. Land, easements and rights-of-way	444,163
2. Water rights	-
3. Capacity and facilities for its use on or at the structure for purposes other than flood prevention and features related thereto	-
4. Capitalized value of operation and maintenance during expected life of improvements	121,728
5. Cost of administering contracts	10,500
6. Total	576,391

August, 1955

Table E - Installation Services

Agency	Cost	Total
	(dollars)	(dollars)
Soil Conservation Service	635,481	635,481
Total	635,481	635,481

Table F - Proposed Adjustment in Federal and Non-Federal Costs

Reason for Adjustment	Transfer from Federal to Non-Federal	Transfer from Non-Federal to Federal
	(dollars)	(dollars)
Watershed characteristics and highland treatment costs	None	446,353
Total	-	446,353

August, 1955

Table G - Proposed Cost-Sharing

Type of Costs	Federal Cost (dollars)	Non-Federal Cost (dollars)	Total Cost (dollars)
COSTS FOR STRUCTURAL MEASURES			
1. Required non-Federal costs	-	576,391	576,391
2. Installation Services	635,481	-	635,481
3. Subtotal (Items 1 plus 2)	635,481	576,391	1,211,872
Allocation of Construction Costs			
4. Costs allocated to Class 1A benefits	-	663,853	663,853
5. Costs allocated to Class 1B benefits	1,489,416	-	1,489,416
6. Costs allocated to Class 2 benefits	-	-	-
7. Subtotal (Items 4 plus 5 plus 6)	1,489,416	663,853	2,153,269
Recommended Adjustments of Construction Costs			
8. Increase of Federal Cost	446,353	-	-
9. Decrease of non-Federal Cost	-	446,353	-
10. Subtotal (Items 8 plus 9)	+ 446,353	- 446,353	-
11. Total Cost Sharing for Structural Measures (Items 3 plus 7, plus or minus 10)	2,571,250	793,891	3,365,141
COSTS FOR LAND TREATMENT MEASURES			
12. Non-Federal Lands	69,564	1,608,533	1,678,097
13. Federal Lands	-	-	-
14. Subtotal (Item 12 plus 13)	69,564	1,608,533	1,678,097
15. Grand Total Project Cost-Sharing (Item 11 plus 14)	2,640,814	2,402,424	5,043,238

Date: August, 1955

TABLE 1 - ESTIMATED INSTALLATION COSTS
(Based on 1953 Price Levels)

Upper Brushy Creek Subwatershed, Texas — For: First Year

Items	Unit	No. to be Applied Non-Federal Land	Estimated Cost Non-Federal Land: Federal (dollars)	Non-Federal (dollars)	Total (dollars)
LAND TREATMENT					
Soil Conservation Service					
Land Treatment Measures					
Contour Farming	Acre	2,570	-	5,140	5,140
Cover Cropping	Acre	1,357	-	11,364	11,364
Crop Residue Management	Acre	6,737	-	13,474	13,474
Rotation Hay and Pasture	Acre	640	-	4,466	4,466
Brush Eradication	Acre	1,893	-	9,248	9,248
Proper Use Pasture	Acre	2,232	-	5,580	5,580
Proper Use Range	Acre	4,842	-	7,263	7,263
Pasture Seeding	Acre	312	-	6,240	6,240
Range Seeding	Acre	464	-	5,800	5,800
Terracing	Mile	262	-	27,427	27,427
Diversion Construction	Mile	12	-	1,993	1,993
Waterwsy Development	Acre	261	-	6,375	6,375
Pond Construction	No.	40	-	8,375	8,375
Technical Assistance (Accl.)					
SCS Subtotal					
TOTAL LAND TREATMENT				112,745	112,745
				112,745	112,745
STRUCTURAL MEASURES					
FLOOD PREVENTION					
Soil Conservation Service					
Waterflow Control					
Floodwater Retarding Structures	Each				
Channel Improvement	Mile				
SCS Subtotal					
TOTAL FLOOD PREVENTION					
TOTAL CONSTRUCTION COSTS					
INSTALLATION SERVICES					
Total SCS					
TOTAL INSTALLATION SERVICES					
OTHER COSTS					
TOTAL STRUCTURAL MEASURES					
GRAND TOTAL				112,745	112,745
SUMMARY					
Total SCS				112,745	112,745
TOTAL				112,745	112,745

Date: August, 1955

TABLE 1 - ESTIMATED INSTALLATION COSTS
(Based on 1953 Price Levels)

Upper Brushy Creek Subwatershed, Texas — For: Second Year

Items	Unit	No. to be Applied Non-Federal Land	Estimated Cost Non-Federal Land: Federal (dollars)	Non-Federal (dollars)	Total (dollars)
LAND TREATMENT					
Soil Conservation Service					
Land Treatment Measures					
Contour Farming	Acre	2,570	-	5,140	5,140
Cover Cropping	Acre	1,357	-	11,364	11,364
Crop Residue Management	Acre	6,737	-	13,474	13,474
Rotation Hay and Pasture	Acre	640	-	4,466	4,466
Brush Eradication	Acre	1,893	-	9,248	9,248
Proper Use Pasture	Acre	2,232	-	5,580	5,580
Proper Use Range	Acre	4,842	-	7,263	7,263
Fasture Seeding	Acre	312	-	6,240	6,240
Range Seeding	Acre	464	-	5,800	5,800
Terracing	Mile	382	-	39,989	39,989
Diversion Construction	Mile	12	-	1,993	1,993
Waterway Development	Acre	311	-	7,597	7,597
Pond Construction	No.	72	-	15,075	15,075
Technical Assistance (Accl.)			4,092	-	4,092
SCS Subtotal			4,092	133,229	137,321
TOTAL LAND TREATMENT			4,092	133,229	137,321
STRUCTURAL MEASURES					
FLOOD PREVENTION					
Soil Conservetion Service					
Waterflow Control					
Floodwster Retarding Structures	Each	1,2,3,& 4	392,781	44,132	436,913
Channel Improvement	Mile				
SCS Subtotal			392,781	44,132	436,913
TOTAL FLOOD PREVENTION			392,781	44,132	436,913
TOTAL CONSTRUCTION COSTS			392,781	44,132	436,913
INSTALLATION SERVICES					
Total SCS			129,874	1,200	131,074
TOTAL INSTALLATION SERVICES			129,874	1,200	131,074
OTHER COSTS				46,310	46,310
TOTAL STRUCTURAL MEASURES			522,655	91,642	614,297
GRAND TOTAL			526,747	224,871	751,618
SUMMARY					
Total SCS			526,747	224,871	751,618
TOTAL			526,747	224,871	751,618

Date: August, 1955

TABLE 1 - ESTIMATED INSTALLATION COSTS
(Based on 1953 Price Levels)

Upper Brushy Creek Subwatershed, Texas — For: Third Year

Items	Unit	No. to be Applied Non-Federal Land	Estimated Cost Non-Federal Land: Federal (dollars)	Non-Federal (dollars)	Total (dollars)
LAND TREATMENT					
Soil Conservation Service					
Land Treatment Measures					
Contour Farming	Acre	3,084	-	6,168	6,168
Cover Cropping	Acre	1,629	-	13,642	13,642
Crop Residue Management	Acre	8,084	-	16,168	16,168
Rotation Hay and Pasture	Acre	768	-	5,360	5,360
Brush Eradication	Acre	2,272	-	11,099	11,099
Proper Use Pasture	Acre	2,680	-	6,700	6,700
Proper Use Range	Acre	5,812	-	8,718	8,718
Pasture Seeding	Acre	374	-	7,480	7,480
Range Seeding	Acre	558	-	6,975	6,975
Terracing	Mile	455	-	47,631	47,631
Diversion Construction	Mile	15	-	2,492	2,492
Waterway Development	Acre	363	-	8,867	8,867
Pond Construction	No.	85	-	17,796	17,796
Technical Assistance (Accl.)			8,184	-	8,184
SCS Subtotal			8,184	159,096	167,280
TOTAL LAND TREATMENT			8,184	159,096	167,280
STRUCTURAL MEASURES					
FLOOD PREVENTION					
Soil Conservation Service					
Waterflow Control					
Floodwater Retarding Structures	Each	5,6,7,8,9	330,251	37,106	367,357
Channel Improvement	Mile		-	-	-
SCS Subtotal			330,251	37,106	367,357
TOTAL FLOOD PREVENTION			330,251	37,106	367,357
TOTAL CONSTRUCTION COSTS			330,251	37,106	367,357
INSTALLATION SERVICES					
Total SCS			108,707	1,500	110,207
TOTAL INSTALLATION SERVICES			108,707	1,500	110,207
OTHER COSTS				59,675	59,675
TOTAL STRUCTURAL MEASURES			438,958	98,281	537,239
GRAND TOTAL			447,142	257,377	704,519
SUMMARY					
Total SCS			447,142	257,377	704,519
TOTAL			447,142	257,377	704,519

Date: August, 1955

TABLE 1 - ESTIMATED INSTALLATION COSTS
(Based on 1953 Price Levels)

Upper Brushy Creek Subwatershed, Texas — For: Remaining to be Done

Items	Unit	No. to be Applied: Non-Federal Land	Estimated Cost: Non-Federal Land: Federal (dollars)	Non-Federal (dollars)	Total (dollars)
LAND TREATMENT					
Soil Conservation Service					
Land Treatment Measures					
Contour Farming	Acre	17,478	-	34,956	34,956
Cover Cropping	Acre	47,482	-	397,649	397,649
Crop Residue Management	Acre	45,809	-	91,618	91,618
Rotation Hay and Pasture	Acre	4,352	-	30,373	30,373
Brush Eradication	Acre	12,872	-	62,884	62,884
Proper Use Pasture	Acre	15,188	-	37,970	37,970
Proper Use Range	Acre	32,934	-	49,401	49,401
Pasture Seeding	Acre	2,120	-	42,400	42,400
Range Seeding	Acre	3,164	-	39,550	39,550
Terracing	Mile	2,523	-	264,119	264,119
Diversion Construction	Mile	82	-	13,620	13,620
Waterway Development	Acre	1,676	-	40,938	40,938
Pond Construction	No.	468	-	97,985	97,985
Technical Assistance (Accl.)			57,288	-	57,288
SCS Subtotal			57,288	1,203,463	1,260,751
TOTAL LAND TREATMENT			57,288	1,203,463	1,260,751
STRUCTURAL MEASURES					
FLOOD PREVENTION					
Soil Conservation Service					
Waterflow Control					
Floodwater Retarding Structures	Each	10 to 33 Incl.	1,143,249	128,455	1,271,704
Channel Improvement	Mile	6.42	69,488	7,807	77,295
SCS Subtotal			1,212,737	136,262	1,348,999
TOTAL FLOOD PREVENTION			1,212,737	136,262	1,348,999
TOTAL CONSTRUCTION COSTS			1,212,737	136,262	1,348,999
INSTALLATION SERVICES					
Total SCS			396,900	7,800	404,700
TOTAL INSTALLATION SERVICES			396,900	7,800	404,700
OTHER COSTS				338,178	338,178
TOTAL STRUCTURAL MEASURES			1,609,637	482,240	2,091,877
GRAND TOTAL			1,666,925	1,685,703	3,352,628
SUMMARY					
Total SCS			1,666,925	1,685,703	3,352,628
TOTAL			1,666,925	1,685,703	3,352,628

Date: August, 1955

TABLE 1 - ESTIMATED INSTALLATION COSTS
(Based on 1953 Price Levels)

Upper Brushy Creek Subwatershed, Texas — For: Total Project

Items	Unit	No. to be Applied Non-Federal Land	Estimated Cost Non-Federal Land: Federal (dollars)	Non-Federal (dollars)	Total (dollars)
LAND TREATMENT					
Soil Conservation Service					
Land Treatment Measures					
Contour Farming	Acre	25,702	-	51,404	51,404
Cover Cropping	Acre	51,825	-	434,019	434,019
Crop Residue Management	Acre	67,367	-	134,734	134,734
Rotation Hay and Pasture	Acre	6,400	-	44,665	44,665
Brush Eradication	Acre	18,930	-	92,479	92,479
Proper Use Pasture	Acre	22,332	-	55,830	55,830
Proper Use Range	Acre	48,430	-	72,645	72,645
Pasture Seeding	Acre	3,118	-	62,360	62,360
Range Seeding	Acre	4,650	-	58,125	58,125
Terracing	Mile	3,622	-	379,166	379,166
Diversion Construction	Mile	121	-	20,098	20,098
Waterway Development	Acre	2,611	-	63,777	63,777
Pond Construction	No.	665	-	139,231	139,231
Technical Assistance (Accl.)			69,564	-	69,564
SCS Subtotal			69,564	1,608,533	1,678,097
TOTAL LAND TREATMENT			69,564	1,608,533	1,678,097
STRUCTURAL MEASURES					
FLOOD PREVENTION					
Soil Conservation Service					
Waterflow Control					
Floodwater Retarding Structures	Each	33	1,866,281	209,693	2,075,974
Channel Improvement	Mile	6.42	69,488	7,807	77,295
SCS Subtotal			1,935,769	217,500	2,153,269
TOTAL FLOOD PREVENTION			1,935,769	217,500	2,153,269
TOTAL CONSTRUCTION COSTS			1,935,769	217,500	2,153,269
INSTALLATION SERVICES					
Total SCS			635,481	10,500	645,981
TOTAL INSTALLATION SERVICES			635,481	10,500	645,981
OTHER COSTS				444,163	444,163
TOTAL STRUCTURAL MEASURES			2,571,250	672,163	3,243,413
GRAND TOTAL			2,640,814	2,280,696	4,921,510
SUMMARY					
Total SCS			2,640,814	2,280,696	4,921,510
TOTAL			2,640,814	2,280,696	4,921,510

Date: August, 1955

TABLE 2 - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(Based on 1953 Price Levels)
June 30, 1955
Upper Brushy Creek Subwatershed, Texas

Measures	Unit	Applied to Date	Total Non-Federal Cost (dollars)
LAND TREATMENT			
Contour Farming	Acre	34,333	68,666
Cover Cropping	Acre	40,940	343,896
Crop Residue Management	Acre	25,398	50,796
Rotation Hay and Pasture	Acre	7,219	50,533
Brush Eradication	Acre	7,898	38,700
Proper Use Pasture	Acre	3,221	8,052
Proper Use Range	Acre	6,444	9,666
Pasture Seeding	Acre	2,270	31,780
Range Seeding	Acre	992	8,680
Terracing	Mile	1,160	121,800
Diversion Construction	Mile	24	3,998
Waterway Development	Acre	934	22,883
Pond Construction	Number	211	44,310
Subtotal		-	803,760
STRUCTURAL MEASURES FOR FLOOD PREVENTION			
Floodwater Retarding Structures	Each	0	0
Channel Improvement	Miles	0	0
Subtotal		0	0
TOTAL			803,760

Date: August, 1955

TABLE 3 - ANNUAL COSTS

(Based on Long-Term Price Levels)

Upper Brushy Creek Subwatershed, Texas

Measures	AMORTIZATION OF INSTALLATION COSTS			OPERATION AND MAINTENANCE COSTS			Total
	Federal (dollars)	Non-Federal (dollars)	Total (dollars)	Federal (dollars)	Non-Federal (dollars)	Total (dollars)	(dollars)
STRUCTURAL MEASURES FOR FLOOD PREVENTION							
Waterflow Control							
1. Floodwater Retarding Structure No. 1	3,609	776	4,385	154	154	4,539	
2. Floodwater Retarding Structure No. 2	2,704	486	3,190	116	116	3,306	
3. Floodwater Retarding Structure No. 3	4,959	912	5,871	154	154	6,025	
4. Floodwater Retarding Structure No. 4	2,917	569	3,486	154	154	3,640	
5. Floodwater Retarding Structure No. 5	1,039	180	1,219	77	77	1,296	
6. Floodwater Retarding Structures No. 6 and 7	5,927	1,395	7,322	270	270	7,592	
7. Floodwater Retarding Structure No. 8	2,605	765	3,370	116	116	3,486	
8. Floodwater Retarding Structure No. 9	2,346	601	2,947	116	116	3,063	
9. Floodwater Retarding Structures No. 10 and 11	5,632	1,499	7,131	270	270	7,401	
10. Floodwater Retarding Structure No.12	2,878	555	3,433	154	154	3,587	
11. Floodwater Retarding Structure No.13	3,250	539	3,789	154	154	3,943	
12. Floodwater Retarding Structure No.14	1,049	678	1,727	77	77	1,804	
13. Floodwater Retarding Structure No.16	2,562	1,036	3,598	116	116	3,714	
14. Floodwater Retarding Structure No.18	1,640	478	2,118	116	116	2,234	
15. Floodwater Retarding Structure No.23	1,957	1,364	3,321	116	116	3,437	
16. Floodwater Retarding Structure No.24	3,095	1,003	4,098	154	154	4,252	
17. Floodwater Retarding Structure No.25	2,612	704	3,316	116	116	3,432	
18. Floodwater Retarding Structure No.26	1,010	238	1,248	77	77	1,325	
19. Floodwater Retarding Structure No.27	1,380	852	2,232	116	116	2,348	
20. Floodwater Retarding Structure No.28	1,557	653	2,210	116	116	2,326	

TABLE 3 - ANNUAL COSTS (Continued)

(Based on Long-Term Price Levels)
Upper Brushy Creek Subwatershed, Texas

Measures	AMORTIZATION OF INSTALLATION COSTS			OPERATION AND MAINTENANCE COSTS			Total
	Federal (dollars)	Non-Federal (dollars)	Total (dollars)	Federal (dollars)	Non-Federal (dollars)	Total (dollars)	(dollars)
STRUCTURAL MEASURES FOR FLOOD PREVENTION							
Waterflow Control							
21. Floodwater Retarding Structures No. 29, 30, and 31	4,888	1,823	6,711	309	309	7,020	
22. Floodwater Retarding Structure No.32	702	307	1,009	77	77	1,086	
23. Floodwater Retarding Structure No.33	714	212	926	77	77	1,003	
24. Stream channel improvement in combination with floodwater retarding structures No. 15,17,19,20,21, & 22	8,774	2,495	11,269	1,529	1,529	12,798	
Subtotal	69,806	20,120	89,926	4,731	4,731	94,657	
TOTAL STRUCTURAL MEASURES FOR FLOOD PREVENTION	69,806	20,120	89,926	4,731	4,731	94,657	
GRAND TOTAL	69,806	20,120	89,926	4,731	4,731	94,657	

Date: August, 1955

TABLE 4 - SUMMARY OF BENEFITS
(Based on Long-Term Price Levels)
Upper Brushy Creek Subwatershed, Texas

Item	Estimated Average Annual Damage Without Project	Estimated Average Annual Damage Without Structural Measures	Estimated Average Annual Damage With Project	Benefits From Structural Measures	Classes of Benefits	
					1	2
					A	B
	(dollars)	(dollars)	(dollars)	(dollars)	- - - (dollars) - - -	
BENEFITS IN PROJECT AREA						
Floodwater	94,884	81,096	21,876	59,220	55,298	3,922
Sediment	1,918	1,074	633	441	441	
Erosion	13,393	11,026	2,115	8,911	8,911	
Indirect	11,020	9,320	2,462	6,858		6,858
SUBTOTAL	121,215	102,516	27,086	75,430	64,650	10,780
Benefits from changed use of land	xxx	xxx	xxx	9,013	9,013	
TOTAL BENEFITS IN PROJECT AREA	xxx	xxx	xxx	84,443	73,663	10,780
BENEFITS OUTSIDE OF PROJECT AREAS						
Benefits from San Gabriel and Little River	xxx	xxx	xxx	12,642		12,642
Benefits from Main Stem Brushy Creek Below Project Area	xxx	xxx	xxx	138,397		138,397
TOTAL BENEFITS OUTSIDE OF PROJECT AREA				151,039		151,039
TOTAL FLOOD PREVENTION BENEFITS				235,482	73,663	161,819
GRAND TOTAL ALL BENEFITS	235,482					

Date: August, 1955

TABLE 5 - BENEFIT-COST ANALYSIS
(Based on Long-Term Price Levels)
Upper Brushy Creek Subwatershed, Texas

Measures	AVERAGE ANNUAL BENEFITS							Average Annual Cost (dollars)	Benefit-Cost Ratio
	Floodwater (dollars)	Sediment (dollars)	Erosion (dollars)	Indirect (dollars)	Changed Use of Land (dollars)	Outside of Project Area (dollars)	Total (dollars)		
STRUCTURAL MEASURES FOR FLOOD PREVENTION									
Waterflow Control									
1. Floodwater Retarding Structure No. 1	2,013	18	361	239	-	6,417	9,048	4,539	1.99:1
2. Floodwater Retarding Structure No. 2	1,179	11	211	140	-	3,760	5,301	3,306	1.60:1
3. Floodwater Retarding Structure No. 3	3,133	29	562	372	-	10,193	14,289	6,025	2.37:1
4. Floodwater Retardiog Structure No. 4	2,120	19	379	252	-	6,757	9,527	3,640	2.62:1
5. Floodwater Retarding Structure No. 5	485	4	87	58	-	1,967	2,601	1,296	2.01:1
6. Floodwater Retarding Structures No. 6 and 7	5,356	48	960	636	-	16,861	23,861	7,592	3.14:1
7. Floodwater Retarding Structure No. 8	2,939	26	527	349	-	9,492	13,333	3,486	3.82:1
8. Floodwater Retarding Structure No. 9	2,075	19	372	247	-	6,617	9,330	3,063	3.05:1
9. Floodwater Retarding Structures No. 10 and 11	5,238	47	940	622	-	16,914	23,761	7,401	3.21:1
10. Floodwater Retarding Structure No.12	1,455	13	260	173	-	4,638	6,539	3,587	1.82:1
11. Floodwater Retarding Structure No.13	1,918	17	343	228	-	6,113	8,619	3,943	2.19:1
12. Floodwater Retarding Structure No.14	907	8	163	108	-	2,896	4,082	1,804	2.26:1
13. Floodwater Retarding Structure No.16	1,925	17	345	229	-	6,146	8,662	3,714	2.33:1
14. Floodwater Retarding Structure No.18	849	8	151	101	-	2,710	3,819	2,234	1.71:1
15. Floodwater Retarding Structure No.23	3,534	28	370	393	2,577	8,199	15,101	3,437	4.39:1
16. Floodwater Retarding Structure No.24	2,773	22	289	308	2,022	6,413	11,827	4,252	2.78:1
17. Floodwater Retarding Structure No.25	1,716	14	179	191	1,252	3,971	7,323	3,432	2.13:1
18. Floodwater Retarding Structure No.26	564	4	59	63	411	1,304	2,405	1,325	1.82:1
19. Floodwater Retarding Structure No.27	1,508	12	157	168	1,100	3,489	6,434	2,348	2.74:1
20. Floodwater Retarding Structure No.28	1,859	15	193	207	1,355	4,299	7,928	2,326	3.41:1
21. Floodwater Retarding Structures No. 29, 30, and 31	3,647	32	656	433	-	11,667	16,435	7,020	2.34:1
22. Floodwater Retsrding Structure No.32	444	4	80	53	-	1,421	2,002	1,086	1.84:1
23. Floodwater Retarding Structure No.33	406	3	43	45	296	940	1,733	1,003	1.73:1
24. Stream channel improvement in combination with floodwater retarding structures No. 15,17,19,20,21,& 22	11,177	23	1,224	1,243	-	7,855	21,522	12,798	1.68:1
Subtotal	59,220	441	8,911	6,858	9,013	151,039	235,482	94,657	2.49:1
TOTAL STRUCTURAL MEASURES FOR FLOOD PREVENTION	59,220	441	8,911	6,858	9,013	151,039	235,482	94,657	2.49:1
GRAND TOTAL	59,220	441	8,911	6,858	9,013	151,039	235,482	94,657	2.49:1

Date: August, 1955

TABLE 6 - STRUCTURE DATA
Preliminary Estimates for Floodwater Retarding Structures
Upper Brushy Creek Subwatershed, Texas

Site No.	Drainage Area	STORAGE CAPACITY								SURFACE AREA			FLOOD PLAIN AREA INUNDATED				PRINCIPAL SPILLWAY		
		Sed. Pool	Sed. Reserve	Det. Pool	Total	Sed. Pool	Sed. Reserve	Det. Pool	Total	Top Sed. Pool 1/	Top Det. Pool	Max. Ht. of Dam	Onder Sed. Pool 1/	Under Det. Pool	Total	Volume of Fill	Size	Max. Disc. Cap.
	sq. mi	acre-feet				inches				acres		ft.	acres			cu. yd.	sq.ft.	cfs
1	5.48	200	96	1,575	1,871	0.70	0.30	5.4	6.4	55	195	34	0	0	0	262,665	1.86	28
2	3.21	171	0	924	1,095	1.00	0	5.4	6.4	28	101	39	0	0	0	196,959	1.07	16
3	8.53	200	118	3,094	3,412	0.40	0.30	6.8	7.5	40	228	58	0	0	0	360,665	2.87	43
4	5.77	200	15	1,660	1,875	0.60	0.10	5.4	6.1	31	144	54	0	0	0	212,418	1.93	29
5	1.32	35	0	380	415	0.50	0	5.4	5.9	8	35	37	0	0	0	76,002	0.47	7
6	5.92	200	21	1,705	1,926	0.60	0.10	5.4	6.1	38	157	55	0	0	0	159,767	2.00	30
7 2/	8.66	200	123	3,142	3,465	0.40	0.30	6.8	7.5	54	235	56	0	0	0	247,119	4.86	73
8	8.00	200	56	2,688	2,944	0.40	0.10	6.3	6.8	42	267	47	0	0	0	189,755	2.66	40
9	5.65	182	0	1,626	1,808	0.60	0	5.4	6.0	40	187	40	0	0	0	170,949	1.86	28
10	8.65	185	0	3,136	3,321	0.40	0	6.8	7.2	30	283	50	0	0	0	215,269	2.87	43
11 2/	5.61	200	100	1,645	1,945	0.70	0.30	5.5	6.5	58	219	39	0	0	0	177,174	4.73	71
12	3.96	126	0	1,140	1,266	0.60	0	5.4	6.0	24	145	35	0	0	0	209,563	1.33	20
13	5.22	139	0	1,503	1,642	0.50	0	5.4	5.9	18	120	58	0	0	0	236,578	1.73	26
14	2.47	200	24	724	948	1.50	0.20	5.5	7.2	62	156	29	0	0	0	76,742	0.80	12
15	1.38	132	0	403	535	1.80	0	5.5	7.3	26	69	31	0	0	0	102,595	0.47	7
16	5.24	200	386	1,537	2,123	0.70	1.40	5.5	7.6	92	227	47	0	0	0	186,610	1.73	26
17	1.00	118	0	297	415	2.20	0	5.5	7.7	18	42	44	0	0	0	67,622	0.33	5
18	2.31	197	0	679	876	1.60	0	5.5	7.1	34	94	40	0	0	0	119,690	0.80	12
19	1.69	135	0	495	630	1.50	0	5.5	7.0	21	51	39	0	0	0	113,184	0.53	8
20	0.92	88	0	270	358	1.80	0	5.5	7.3	14	39	36	0	0	0	64,702	0.33	5
21	0.87	79	0	255	334	1.70	0	5.5	7.2	10	32	51	0	0	0	58,032	0.26	4
22	0.84	98	0	240	338	2.20	0	5.5	7.7	19	39	34	0	0	0	53,038	0.26	4
23	6.96	200	357	2,153	2,710	0.50	1.00	5.8	7.3	96	260	36	0	0	0	225,371	2.33	35
24	5.46	200	237	1,630	2,067	0.70	0.80	5.6	7.1	62	173	47	0	0	0	142,672	1.80	27
25	3.38	200	88	1,012	1,300	1.00	0.60	5.6	7.2	52	115	39	0	0	0	190,237	1.13	17
26	1.11	100	0	334	434	1.70	0	5.6	7.3	15	38	41	0	0	0	73,903	0.40	6
27	2.97	205	0	888	1,093	1.30	0	5.6	6.9	42	154	32	0	0	0	100,813	1.00	15
28	3.66	200	230	1,094	1,524	1.00	1.20	5.6	7.8	68	139	38	0	0	0	113,646	1.27	19
29	2.50	200	40	747	987	1.50	0.30	5.6	7.4	39	104	43	0	0	0	130,341	0.87	13
30	0.92	108	0	275	383	2.20	0	5.6	7.8	18	39	33	0	0	0	41,179	0.33	5
31 2/	6.51	200	416	1,954	2,570	0.60	1.20	5.6	7.4	90	235	47	43	19	62	168,381	3.33	50
32	1.21	149	0	362	511	2.30	0	5.6	7.9	31	63	26	0	0	0	51,535	0.40	6
33	0.80	102	0	238	340	2.40	0	5.6	8.0	15	40	40	0	0	0	52,427	0.26	4
TOTAL	128.18	5,349	2,307	39,805	47,461					1,290	4,425		43	19	62	4,847,603		

1/ Includes sediment reserve (See Figure 1).
2/ Excluding the area from which runoff is controlled by other floodwater retarding structures in series.

Note: Vegetative emergency spillways provided for all structures.

Date: August, 1955

TABLE 6A - STRUCTURE_DATA

Preliminary Estimates for Channel Improvement

Upper Brushy Creek Subwatershed, Texas

Location	Length (miles)	Excavation (cubic yards)
Main Stem Brushy Creek	6.42	456,747
TOTAL	6.42	456,747

Date: August, 1955

TABLE 6B - STRUCTURE DATA

Estimated Structure Cost Distribution
(Based on 1953 Price Levels)
Upper Brushy Creek Subwatershed, Texas

Structure Site No. or Name	FEDERAL INSTALLATION COST					NON FEDERAL INSTALLATION COST					Estimated Total Cost
	Contract	Installation Services	Contingencies	Adm. and Misc.	Total Federal	Contract	Installation Services	Easements and R/W	Contingencies	Total Non-Federal	
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
FLOODWATER RETARDING STRUCTURES											
1	90,820	20,205	9,082	12,833	132,940	10,205	300	14,410	1,020	25,935	158,875
2	68,101	15,151	6,810	9,548	99,610	7,652	300	7,535	765	16,252	115,862
3	124,706	27,743	12,471	17,733	182,653	14,011	300	14,740	1,401	30,452	213,105
4	73,446	16,340	7,345	10,321	107,452	8,253	300	9,625	825	19,003	126,455
5	26,280	5,846	2,628	3,500	38,254	2,952	300	2,475	295	6,022	44,276
6	55,241	12,290	5,524	7,688	80,743	6,207	300	11,660	621	18,788	99,531
7	93,989	20,910	9,399	13,291	137,589	10,561	300	15,895	1,056	27,812	165,401
8	65,610	14,596	6,561	9,188	95,955	7,372	300	17,160	737	25,569	121,524
9	59,108	13,150	5,911	8,248	86,417	6,641	300	12,485	664	20,090	106,507
10	74,432	16,559	7,443	10,463	108,897	8,363	300	17,215	836	26,714	135,611
11	67,387	14,992	6,739	9,444	98,562	7,571	300	14,740	757	23,368	121,930
12	72,459	16,120	7,246	10,178	106,003	8,142	300	9,295	814	18,551	124,554
13	81,801	18,198	8,180	11,529	119,708	9,191	300	7,590	919	18,000	~~137,708~~
14	26,535	5,903	2,654	3,537	38,629	2,981	300	19,085	298	22,664	61,293
15	35,473	7,892	3,547	4,830	51,742	3,986	300	7,837	399	12,522	64,264
16	64,523	14,355	6,452	9,030	94,360	7,250	300	26,318	725	34,593	128,953
17	23,381	5,202	2,338	3,081	34,002	2,627	300	5,060	263	8,250	42,252
18	41,385	9,207	4,138	5,685	60,415	4,650	300	10,560	465	15,975	76,390
19	39,135	8,706	3,913	5,359	57,113	4,397	300	4,070	440	9,207	66,320
20	22,372	4,977	2,237	2,935	32,521	2,513	300	3,025	251	6,089	38,610
21	20,065	4,464	2,006	2,602	29,137	2,255	300	2,310	226	5,091	34,228
22	18,339	4,080	1,834	2,352	26,605	2,060	300	3,190	206	5,756	32,361

TABLE 6B - STRUCTURE DATA (Continued)

Estimated Structure Cost Distribution
(Based on 1953 Price Levels)
Upper Brushy Creek Subwatershed, Texas

Structure Site No. or Name	FEDERAL INSTALLATION COST					NON-FEDERAL INSTALLATION COST					Estimated Total Cost
	Contract	Installation Services	Contingencies	Adm. and Misc.	Total Federal	Contract	Installation Services	Easements and R/W	Contingencies	Total Non-Federal	
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
FLOODWATER RETARDING STRUCTURES											
23	49,331	10,975	4,933	6,834	72,073	5,543	300	39,160	554	45,557	117,630
24	77,925	17,336	7,792	10,968	114,021	8,756	300	23,567	876	33,499	147,520
25	65,777	14,634	6,578	9,212	96,201	7,390	300	15,076	739	23,505	119,706
26	25,553	5,684	2,555	3,395	37,187	2,871	300	4,482	287	7,940	45,127
27	34,857	7,755	3,486	4,741	50,839	3,917	300	23,870	392	28,479	79,318
28	39,295	8,742	3,930	5,382	57,349	4,415	300	16,665	442	21,822	79,171
29	45,067	10,026	4,507	6,217	65,817	5,064	300	11,908	506	17,778	83,595
30	14,239	3,168	1,424	1,759	20,590	1,599	300	4,702	160	6,761	27,351
31	64,042	14,247	6,404	8,961	93,654	7,196	300	28,133	720	36,349	130,003
32	17,819	3,964	1,782	2,277	25,842	2,002	300	7,755	200	10,257	36,099
33	18,126	4,033	1,813	2,321	26,293	2,037	300	4,538	204	7,079	33,372
TOTAL	1,696,619	377,450	169,662	235,442	2,479,173	190,630	9,900	416,136	19,063	635,729	3,114,902
OTHER											
Channel Improvement	63,171	14,054	6,317	8,535	92,077	7,097	600	28,027	710	36,434	128,511
TOTAL	63,171	14,054	6,317	8,535	92,077	7,097	600	28,027	710	36,434	128,511
GRAND TOTAL	1,759,790	391,504	175,979	243,977	2,571,250	197,727	10,500	444,163	19,773	672,163	3,243,413

Date: August, 1955

TABLE 7 - SUMMARY OF PHYSICAL DATA

Upper Brushy Creek Subwatershed, Texas

Item	Unit	Quantity Without Program	Quantity With Program
Watershed Area	Sq. Mi.	299	229
Watershed Area	Acre	191,360	191,360
Area of Cropland	Acre	105,959	98,164
Area of Grassland	Acre	78,317	86,112
Area of Woodland	Acre	--	--
Overflow Area Subject to Damage by Design Storm	Acre	9,804	6,130
Annual Rate of Erosion			
Sheet	Tons/Yr.	2,707,515	1,425,979
Gully	Tons/Yr.	4,744	2,372
Streambank	Tons/Yr.	56,807	51,126
Scour	Tons/Yr.	249,773	28,674
Area Damaged Annually by			
Sediment	Acre	405	134
Flood Plain Scour	Acre	1,192	167
Swamping	Acre	--	-
Streambank Erosion	Acre	2.2	2.0
Sheet Erosion	Acre	138,642	58,712
Sediment Production 1/	Tons/Ac/Yr.	2.69	0.85
Average Annual Rainfall	Inches	33.68	33.68

1/ Net leaving watershed

Date: August, 1955

TABLE 8 - SUMMARY OF PLAN DATA
Upper Brushy Creek Subwatershed, Texas

Item	Unit	Quantity
Years to Complete Program	Year	10
Total Installation Cost		
Federal	Dollar	2,640,814
Non-Federal	Dollar	2,280,696
Annual O & M Cost		
Federal	Dollar	None
Non-Federal	Dollar	183,611
Annual Benefits	Dollar	235,482
Structural Measures		
Floodwater Retarding Structures	Each	33
Channel Improvement	Mile	6.42
Area Inundated by Structures		
Floodplain		
Detention Pool	Acre	19
Sediment Pool	Acre	43
Upland		
Detention Pool	Acre	3,116
Sediment Pool	Acre	1,247
Watershed Area above Structures	Acre	82,035
Reduction of Floodwater Damage		
Land Treatment Measures	Percent	15
Structural Measures	Percent	62
Reduction of Sediment Damage		
Land Treatment Measures	Percent	44
Structural Measures	Percent	23
Reduction of Erosion Damage		
Land Treatment Measures	Percent	18
Structural Measures	Percent	67
Benefits from more Intensive Use of Land Resulting from Reduction of Flood Hazard	Dollar	9,013

Date: August, 1955