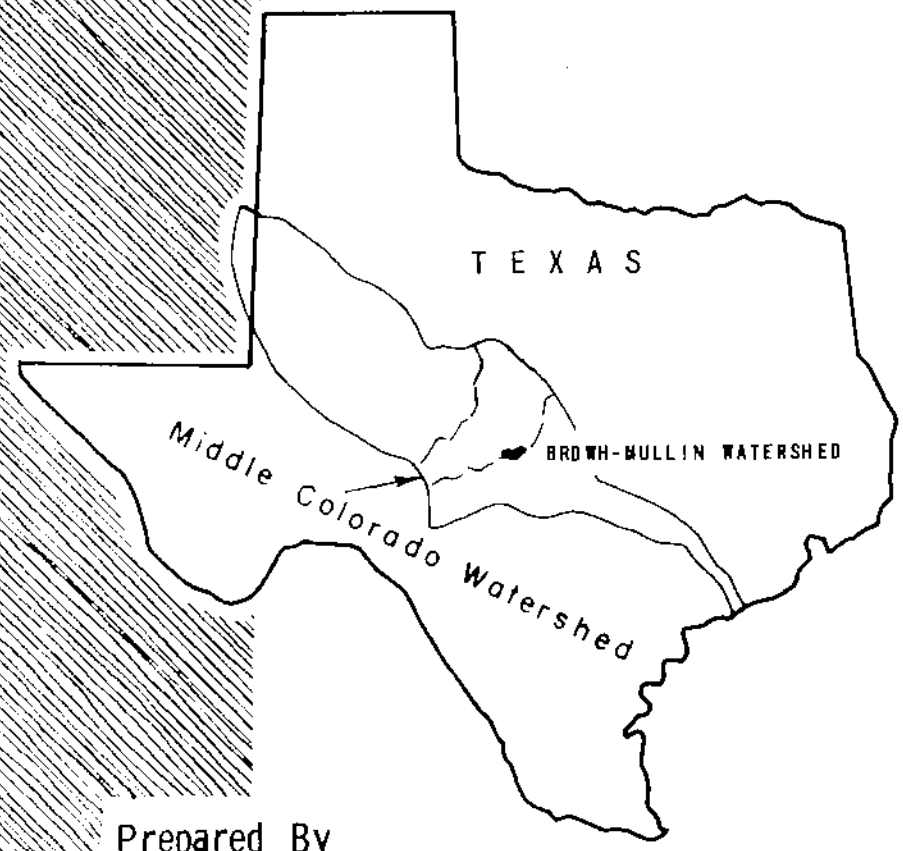
WORK PLAN

BROWN-MULLIN WATERSHED

OF THE MIDDLE COLORADO RIVER WATERSHED
MILLS COUNTY, TEXAS



Prepared By
SOIL CONSERVATION SERVICE
U. S. DEPARTMENT OF AGRICULTURE
Temple, Texas
December 1965

TABLE OF CONTENTS

WATERSHED WORK PLAN AGREEMENT

between the

Brown-Mills Soil and Water Conservation District
Local Organization

(Hereinafter referred to as the District)

Mills County Commissioners Court
Local Organization

(Hereinafter referred to as the County)

In the State of Texas

and the

United States Department of Agriculture
Soil Conservation Service
(Hereinafter referred to as the Service)

Whereas, the District has heretofore entered into a Flood Control Supplemental Memorandum of Understanding with the Soil Conservation Service for assistance in constructing Works of Improvement for the prevention of floods in the Brown-Mullin Watershed, State of Texas, under the authority of the Flood Control Act of 1944 (58 Stat. 887).

Whereas, the responsibility for carrying out all or a portion of the work of the Department on the Watershed has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the District and the Service a mutually satisfactory plan for Works of Improvement for the Brown-Mullin Watershed, State of Texas, hereinafter referred to as the Watershed Work Plan;

Whereas, the County will benefit from the carrying out of the plan for Works of Improvement through the reduction of damages to property, including County Roads and bridges in the County that are located within the flood plain of the watershed;

Now, therefore, in view of the foregoing considerations, the District and the County and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about 10 years.

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

1. The District and the County will acquire all land, easements, and rights-of-way needed for installation of structural works of improvement (estimated at $64,284).

Works of Improvement	District and County (percent)	Service (percent)	Estimated Land, Easements and Rights-of-Way Cost (dollars)
Floodwater Retarding Structures	100	0	64,284 1/

1/ Includes legal fees ($5,845).

2. The Service will provide all construction costs.

Works of Improvement	District and County (percent)	Service (percent)	Estimated Construction Cost (dollars)
Floodwater Retarding Structures	0	100	447,148

3. The Service will provide all costs for installation services.

Works of Improvement	District and County (percent)	Service (percent)	Estimated Installation Service Cost (dollars)
Floodwater Retarding Structures	0	100	112,197

4. The District will obtain agreements from owners of not less than 65 percent of the land above each floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.

5. The District will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.

6. The District will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.

7. The District and the County will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with an Operation and Maintenance Agreement which is to be entered into.

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

9. The program conducted will be in compliance with all requirements respecting non-discrimination as contained in the Civil Rights Act of 1964, and the regulations of the Secretary of Agriculture (7C.F.R. Sec. 15.1 - 15.13), which provide that no person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to, discrimination under any activity receiving Federal financial assistance.

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

Brown-Mills Soil and Water Conservation District
Local Organization

By F. Scott Lanford
F. Scott Lanford

Title Chairman

Date February 15, 1966

The signing of this agreement was authorized by a resolution of the governing body of the Brown-Mills Soil and Water Conservation District
Local Organization

adopted at a meeting held on February 15, 1966

Walter Fry
Secretary, Local Organization
Walter Fry

Date February 15, 1966

Mills County Commissioners Court
Local Organization

By Cecil Egger
Cecil Egger

Title County Judge

Date February 15, 1966

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

adopted at a meeting held on February 15, 1966.

Walter A. Bryant
(Secretary, Local Organization)
Walter A. Bryant

Date February 15, 1966

Soil Conservation Service
United States Department of Agriculture

By _____

Date _____

WORK PLAN

BROWN-MULLIN WATERSHED
of the Middle Colorado River Watershed
Mills County, Texas

Plan Prepared and Works of Improvement
to be Installed Under the Authority
of the Flood Control Act of 1944
as Amended and Supplemented

Participating Agencies:

Brown-Mills Soil Conservation District

Mills County Commissioners Court

Prepared By:

Soil Conservation Service

U. S. Department of Agriculture

December 1965

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WATERSHED WORK PLAN

BROWN-MULLIN WATERSHED
Of the Middle Colorado River Watershed
Mills County, Texas
December 1965

SUMMARY OF PLAN

General Summary

The work plan for watershed protection and flood prevention for Brown-Mullin Watershed was prepared by the Soil Conservation Service in cooperation with the Brown-Mills Soil Conservation District and the Mills County Commissioners Court.

The primary objectives of the project are to provide flood protection to the agricultural lands subject to flood damages from Brown and Mullin Creeks, and proper land use and treatment in the interest of soil and water conservation. Upon completion and continued maintenance of the measures set forth in this plan, a material contribution will be made toward increasing agricultural production to the maximum level consistent with the capabilities of the land.

The sponsoring local organizations determined that no organized group was interested in including additional water storage or other works of improvement for agricultural or nonagricultural water management purposes.

The Brown-Mullin Watershed, a part of the Middle Colorado River Basin, is that part of the Pecan Bayou drainage area located in Mills County, below the confluence of Blanket Creek. The watershed comprises an area of 134 square miles, or 85,760 acres. Approximately 85 percent of the watershed is rangeland, 13 percent cropland, and 2 percent is in miscellaneous uses such as roads, highways, railroads, towns and stream channels.

There are no Federal lands in the watershed.

The work plan proposes installing in a 10-year period a project for protection and development of the watershed. The cost of installing these measures, excluding work plan preparation costs, is estimated to be $1,056,689. Of this amount, $484,344 will be borne by local interests, and $572,345 by flood prevention funds. In addition, local interests will bear the entire cost of operation and maintenance.

Land Treatment Measures

Landowners and operators will establish land treatment measures which will help accomplish the project objectives. Primarily, this treatment will consist of measures, or a combination of measures, which contribute directly to watershed protection, flood prevention, and sediment control.

Costs of land treatment measures, exclusive of expected reimbursement from Agricultural Conservation Program Service or other Federal funds, is $420,060. In addition, prior to work plan preparation, landowners and operators have established land treatment measures at an estimated non-Federal cost of $513,990. Also, prior to work plan preparation, $6,500 of flood prevention funds were used by the Soil Conservation Service to accelerate technical assistance to landowners and operators. Acceleration of technical assistance will continue during the period of installation at a cost of $13,000. The work plan includes land treatment measures that will be installed during the 10-year installation period and those management and recurring-type practices that are necessary for the project to be successful. Remaining land treatment measures will be installed under the going programs.

Structural Measures

The structural measures included in this plan consist of seven floodwater retarding structures, having a total sediment storage and floodwater detention capacity of 6,494 acre-feet. The total estimated installation cost of structural measures is $623,629. Of this amount, $64,284 will be borne by local interests, and $559,345 by flood prevention funds. All structural measures will be installed during the 10-year installation period.

Damages and Benefits

The reduction in floodwater, sediment, flood plain erosion, and indirect damages will directly benefit approximately 50 owners of agricultural lands in the 2,919 acres of flood plain in addition to owners of nonagricultural facilities within the watershed. Flood plain owners and operators below the project area also will benefit from reduced flooding. Processors of agricultural commodities and other businesses in the area will benefit from the project.

The estimated average annual floodwater, sediment, flood plain erosion, and indirect damages without this project total $31,748, at long-term price levels. With the proposed land treatment and structural measures installed, average annual damages from these sources are estimated to be $11,312, a reduction of approximately 64 percent.

The average annual primary benefits accruing to structural measures total $24,822, and are distributed as follows:

Floodwater damage reduction	$16,419
Sediment damage reduction	335
Erosion damage reduction	711
Indirect damage reduction	1,519
Incidental benefits	3,097
Changed land use benefits	1,855
Benefits outside project area	886

Benefits that are incidental to the project purpose amount to $3,097 annually. They are: recreation, $2,600, and livestock water, $497. No addi-

tional project installation costs or extra storage are required to produce these benefits.

Net secondary benefits will average $2,593 annually.

The total benefits of land treatment measures were not evaluated in monetary terms since experience has shown that these soil and water conservation measures produce benefits in excess of their costs.

The ratio of the total average annual benefits accruing to structural measures ($27,415) to the average annual cost of these measures ($21,312) is 1.3 to 1.

Provisions for Financing Local Share of Installation Costs

Funds for the local share of the project costs will come from revenue presently being collected by Mills County. These funds will be adequate and available for financing the local share of the costs for structural works of improvement.

Operation and Maintenance

Land treatment measures for watershed protection will be operated and maintained by landowners and operators of the farms and ranches on which the measures will be installed under agreements with the Brown-Mills Soil Conservation District.

Structural measures will be maintained jointly by the Brown-Mills Soil Conservation District and the Mills County Commissioners Court. The value of the average annual cost of operating and maintaining the structural measures is estimated to be $882, at long-term price levels.

DESCRIPTION OF WATERSHED

Physical Data

The Brown-Mullin Watershed is part of the Middle Colorado River Basin located in Mills County, Texas, and comprises that drainage which enters Pecan Bayou below the mouth of Blanket Creek. The principal tributaries are Brown and Mullin Creeks, which flow in a southwesterly direction into Pecan Bayou about eight miles west of Goldthwaite, Texas. Several other small tributaries which originate on either side of the Bayou are included in the watershed (figure 2).

The Brown-Mullin Watershed has an area of 85,760 acres (134 square miles), nearly all of which are in farms and ranches.

Pecan Bayou above this watershed has a drainage area of 2,036 square miles. Watershed protection and flood prevention work plans have been developed for five separate watersheds which make up a total drainage area of Pecan Bayou above this watershed.

The topography of the watershed is that of a moderately to gently rolling plain, although areas of rather pronounced relief occur along the eastern margin. Most of the watershed is underlain by shales, marls, impure limestones, and a few soft sandstones and siltstones of the Trinity group of Lower Cretaceous (Comanchean) age. The Fredericksburg group, also of Comanchean age, is exposed along the eastern margin of the watershed. The Fredericksburg formations include the Walnut clay and shell conglomerates, Comanche Peak limestone, and Edwards limestone. These Cretaceous rocks are underlain by strata of the Strawn group of Pennsylvanian age. The Strawn is represented by sandstones and shales which are exposed in belts one to three miles wide paralleling Pecan Bayou and the lower reaches of its main tributaries. Deep clayey and sandy alluvium of Quaternary age is present in a narrow belt along Pecan Bayou.

The alluvial valleys of the major tributaries range in width from about 350 feet to about 1,500 feet, averaging 800 feet. Valley widths on the Pecan Bayou flood plain range from around 700 feet to about 3,000 feet. The average valley width on the main stem is about 1,300 feet. Elevations above mean sea level on the flood plain range from 1,510 feet in the upper reaches of Brown Creek, to 1,210 feet at the mouth of Pecan Bayou. Upland elevations in the watershed are about 1,760 feet on the northeast portion.

Brown-Mullin Watershed is in two land resource areas. The Central Rolling Red Prairie comprises approximately 25 percent of the watershed and is located near Pecan Bayou and the lower reaches of its main tributaries. The soils in this area consist of Darnell-Owens fine sandy loams and stony clays and Frio clay loams and clays. The remaining 75 percent of the watershed is within the Grand Prairie Land Resource Area. The soils of the Grand Prairie consist of Denton-Tarrant stony clays, Crawford-Tarrant stony clays, Unnamed-Windthorst clay loams and fine sandy loams, and Unnamed stony loams and fine sandy loams.

The soils generally are in fair condition. Much small grain and many high residue producing crops are grown and help prevent rapid deterioration of the soil. Adequate conservation treatment is being applied effectively on about 40 percent of the cropland.

Hydrologic cover conditions of the rangeland varies from poor to good. Range sites in the watershed are as follows:

Sandy	Rolling Prairie
Bottomland	Sandy Loam
Rocky Upland	Redland
Deep Upland	Adobe
Pink Sandstone	

The natural vegetation consists of the mixed prairie plant group. It is composed of Texas wintergrass, buffalograss, curly mesquite, sideoats grama, little bluestem, silver bluestem, and liveoak trees. Invading plants and plants which have increased with overuse of rangeland include threeawn, Texas grama, mesquite, and post oak. The range condition classes of the watershed are as follows: two percent, excellent; 12 percent, good; 31 percent, fair; 55 percent, poor.

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population 219, also serves as a limited marketing and trading center for farm products. From census data, it was estimated that the rural population of the watershed in 1960 was 1,200. This is a decrease of about 900 since 1940. This decrease in population has been the trend for the last 40 years. For example, the population of Mills County in 1920, 1940, and 1960, was 9,019, 7,951, and 4,467, respectively.

The changes in farm operation and farm enterprises in Mills County are typical of those which have occurred in the watershed.

Listed below is come census data for Mills County that indicates the magnitude of these changes:

Item	Year 1934	Year 1959
Average size farm, Acres	270	553
Cropland, harvested Acres	79,201	32,108
Cattle and calves, Number	19,537	21,557
Sheep and lambs, Number	80,857	108,922
Corn, Acres	15,967	1,687
Oats, Acres	17,102	12,326
Wheat, Acres	2,612	1,967
Grain Sorghum, Acres	2,602	4,272

In 1936, 3,799 bales of cotton were ginned in Mills County, but in 1959, only 831 bales were ginned.

For the watershed, the change from a general type of farming to livestock farming is almost complete. In the future, it is expected that more emphasis will be placed on hay and grain production.

Oats and other small grains are well adapted to the soils and climate and are important to supplement range when native grasses are dormant. These crops will continue to be planted in the alluvial valleys and on the deeper upland soils. The size of operating units will continue to expand with a gradual decrease in the number of farm units. Urban population should remain about the same. The watershed is not an economically depressed area.

The average size farm in the watershed is about 600 acres, and the current markst price of land is $75 to $100 per acre. Flood plain lands range from $100 to $125 per acre. Agricultural land is largely owner-operated, with about 25 percent being leased or rented. Usually the leased or rented land is operated by a neighboring landowner.

The watershed has a good system of roads and highways. U. S. Highways 84 and 183, and State highway 16, and Farm-to-Market roads 573, 574, and 1029, serve the watershed. These highways and other county roads provide all-weather travel within the watershed.

The Gulf, Colorado and Santa Fe Railway has excellent loading facilities at Goldthwaite and Brownwood.

Land Treatment Data

The Brown-Mills Soil Conservation District has been very active in establishing land treatment measures and in initiating flood prevention work. It has obtained a high degree of participation in this program from farmers, ranchers, and other interested parties in the watershed.

The watershed is served by the Soil Conservation Service work unit at Goldthwaite, which is assisting the Brown-Mills Soil Conservation District. This work unit has assisted farmers and ranchers in preparing 165 soil and water conservation plans on 69,365 acres (81 percent of the total agricultural land) within the watershed. Of those, 143 are basic conservation plans.

Technical guidance has been furnished in establishing and maintaining planned land treatment measures. There are 112 conservation plans in need of current revisions. About 40 percent of the needed measures have been applied. Where these measures have been applied and maintained for as long as three years, average crop and pasture yields have increased about one-fifth.

Satisfactory soil surveys have been completed on 41,456 acres. Another 27,142 acres needing additional soil surveys will be completed during the installation period. Surveys needed on the remaining agricultural land will be accomplished under the going district program after the project installation period.

Land treatment measures installed before the development of this flood prevention work plan are shown in table 1a.

WATERSHED PROBLEMS

Floodwater Damage

The flood plain of Brown-Mullin Watershed consists of 2,919 acres, excluding 433 acres in stream channels (figure 2). Of this amount, 2,724 acres comprise the area that will be inundated by runoff from the largest storm considered in the 42-year evaluation series. The runoff from this storm approximates a four percent chance of occurrence storm.

At the present time, about 35 percent of the flood plain is in cultivation; 64 percent is in pasture or range; and one percent is in miscellaneous uses.

Some farmers and ranchers, on an individual basis, have attempted to enlarge, straighten, and levee some streams with very little reduction of flood damage. The adverse economic and physical effect of flooding has been felt throughout the entire watershed and will prompt local participation in the alleviation of the flood problem.

Flooding along Brown and Mullin Creeks and that part of Pecan Bayou below the mouth of Brown Creek occurs frequently, covering an average of 2,136

Crop destroyed by spring flood. Note tha land damage and soil loss caused by scour and sediment and fence damaged by debris.

Fence completely destroyed by floodwater. Other agricultural damages such as fence and livestock losses due to floods are moderate to heavy.

acres annually, including areas flooded more than once a year. This causes severe damage to growing crops and to other agricultural and nonagricultural properties. Small overflows occur at least once or twice annually, causing limited damage to crops, livestock, fences, roads, and bridges. In addition, severe erosion takes place, especially on recently plowsd land. Productivity has been reduced, causing some cropland to be converted from cash crops to pasture.

The largest recent damaging flood occurred on October 3-5, 1959, when approximately 2,644 acres were flooded in the main stem evaluation reaches of the Brown-Mullin Watershed. Information obtained from farmers and ranchers showed damages in these reaches to be in excess of $46,300. Damage to crops and pasture was approximately $18,510, and livestock losses and damage to fences were estimated to be $25,845. Nonagricultural damages to roads and bridges were estimated at $1,978.

Spring floods damage seedbeds, growing row crops, and maturing small grains, and, conversely, fall floods damage maturing grain sorghums, and growing small grain. Other agricultural damages are high in this watershed. Some fenoes have to be completely reconstructed as often as once every five years. Interviews with farmers and ranchers indicate that livestock losses of cattle and sheep are heavy from the larger floods.

For floods expected to occur during the evaluation period, the total direct average annual floodwater damage is estimated to be $26,032, at long-term price levels (table 5). This includes crop and pasture damages ($14,494), and other agricultural damages ($10,313), and nonagricultural damages to roads and bridges ($1,225).

Indirect damages, such as interruption of travel to and from school and work, and interruption of community activities, are estimated to average $2,886, annually.

Sediment Damage

Deposits of silty sand ars sparsely scattered on the flood plain in the lower reaches of the watershed. The average annual value of this damage is $834.

In addition to the sediment deposited on the flood plain of this watershed, an estimated 61,700 tons of sediment is delivered by Brown and Mullin Creeks to the mouth of the watershed each year. The delivery of part of this sediment to the Colorado River and thence to Lake Buchanan decreases the storage capacity of the reservoir by an estimated 40 acre-feet per year. The average annual monetary value of this damage is estimated to be $1,180, at long-term price levels.

Also, it is estimated that 4.8 acre-feet of sediment is delivered each year to Lake Merrit on upper Brown Creek. This represents a monetary damage for capacity loss of $329 annually, at long-term price levels.

Erosion Damages

Erosion rates in this watershed are low. This is due to a combination of factors, including gentle slopes, a high percentage of rangeland, and extensive land treatment practices such as contour farming, terracing, and crop residue use on the cultivated areas.

Flood plain scour accounts for average annual damage to 330 acres, with damages ranging from 10 to 50 percent in terms of reduced productivity of the soil. The average annual monetary value of this damage is estimated to be $1,667 at long-term price levels. Total land damage from streambank erosion is minor.

PROJECTS OF OTHER AGENCIES

Lake Merrit, located six miles north of Goldthwaite, Texas, on the upper end of Brown Creek, was built in 1917 by the Gulf, Colorado and Santa Fe Railway Company. The original capacity of the lake was 962 acre-feet, with a surface area of 98.1 acres. Based on a 1940 sedimentation survey by the Soil Conservation Service, the present storage capacity is estimated to be 729 acre-feet. The lake, formed by an earth fill dam and concrete spillway, has a drainage area of 11.43 square miles. Since conservation storage is at spillway crest, there is no provision for flood storage in the lake. The lake is now operated as a private recreation area by the Mills County Sportsman's Club.

In evaluating this plan, consideration was given to the Fox Crossing Reservoir, located just downstream from the mouth of Pecan Bayou on the Colorado River, proposed by the U. S. Corps of Engineers, and recommended by the U. S. Study Commission in their report of March 1962. While no Federal funds have been authorized for advance planning or construction of the reservoir, benefits to the Brown-Mullin project reflect the facility in place by 2010. No benefits from reduction in the Fox Crossing Reservoir sediment storage requirements were assigned to the upstream project.

The works of improvement included in this and similar plans in the Colorado River Basin will have significant effect, none of which are detrimental, on existing downstream works of improvement or those proposed in the water resource development plan for this basin.

The flood prevention program will result in minor reduction in average annual runoff from the watershed. Reduction in average annual runoff at the floodwater retarding structure sites is eight percent. This is an equivalent reduction of two percent over the watershed.

BASIS FOR PROJECT FORMULATION

After a reconnaissance of the watershed was made by specialists of the watershed planning party, meetings were held with the local sponsoring organizations to discuss existing problems and to formulate objectives for a watershed protection and flood prevention program. This watershed de-

pends almost entirely on agricultural enterprises for its income. Livestock farming is the major type of operation. Moderate-to-severe flooding causes extensive damage to flood plain lands, crops, pastures, and other agricultural properties.

It is recognized by the local sponsoring organizations and planning personnel that development of a sound watershed protection and flood prevention project will present many problems due to the wide variation of soil types and treatment needs and the topography and structure site locations. It is also recognized that flood protection for the main stem of Pecan Bayou (Reach 1) will depend primarily on flood control measures previously planned for the Pecan Bayou drainage above this watershed.

Work plans for watershed protection and flood prevention have been developed for the five watersheds covering the 2,036 square miles of Pecan Bayou drainage area above this watershed.

The following table indicates the present status of each of these watersheds:

Watershed	Drainage Area (Square Miles)	Present Status
Jim Ned Creek	746.0	Under Construction
Turkey Creek	92.5	Under Construction
Blanket Creek	196.0	Under Construction
Brownwood Laterals	305.0	Authorized for Construction
Upper Pecan Bayou	696.5	Authorized for Construction
Total	2,036.0	

Existing, authorized and proposed works of improvement of other agencies, both within and outside this watershed area, were examined and studied to determine how they would affect, or be affected, by this project. Consideration was given to the effects of the authorized work plans for the Pecan Bayou drainage area above this watershed. All of the possibilities for development were discussed with the local sponsors.

The opportunities for including storage capacities for purposes other than flood prevention were explained, as were the local responsibilities in connection with completing a project. The local sponsoring organizations considered the possibility of providing storage for agricultural and non-agricultural water management, and fish and wildlife development which might be included in the project. The sponsors determined that a project for watershed protection and flood prevention would most nearly meet their needs and that no group or individual was interested in additional storage capacities for other purposes.

In addition to expressing the desire for the establishment of a complete program for soil and water conservation on the watershed, the following specific objectives were named by the local interests:

1. Establish the remaining land treatment measures which contribute directly to watershed protection and flood prevention, based on current needs.

2. Attain a 65-to-70 percent overall reduction in average annual flood damages so as to insure sustained agricultural production on flood plain lands and maintain the economy of the watershed.

The Soil Conservation Service agreed that the desired level of flood protection and watershed improvement was reasonable. Although reduction in flooding would result from application of needed 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 by the local people. It was recognized that a complete watershed program would result in a reduction of land devoted to crop production and in acreages of crops now in surplus supply.

Structural measures for watershed protection and flood prevention which would be feasible to install to meet the objectives of the local sponsoring organizations were then determined.

In selecting the sites for floodwater retarding structures, consideration was given to locations which would provide the desired level of protection to the areas subject to flood damage. The size, number, design, and cost of the structures was influenced by the location of the damaged areas, the complex topography, and the geologic conditions of the watershed, together with the availability of embankment fill material.

The recommended system of structures most nearly meets the project objectives in providing the desired level of protection for agricultural enterprises and satisfying the needs of the watershed at the least cost.

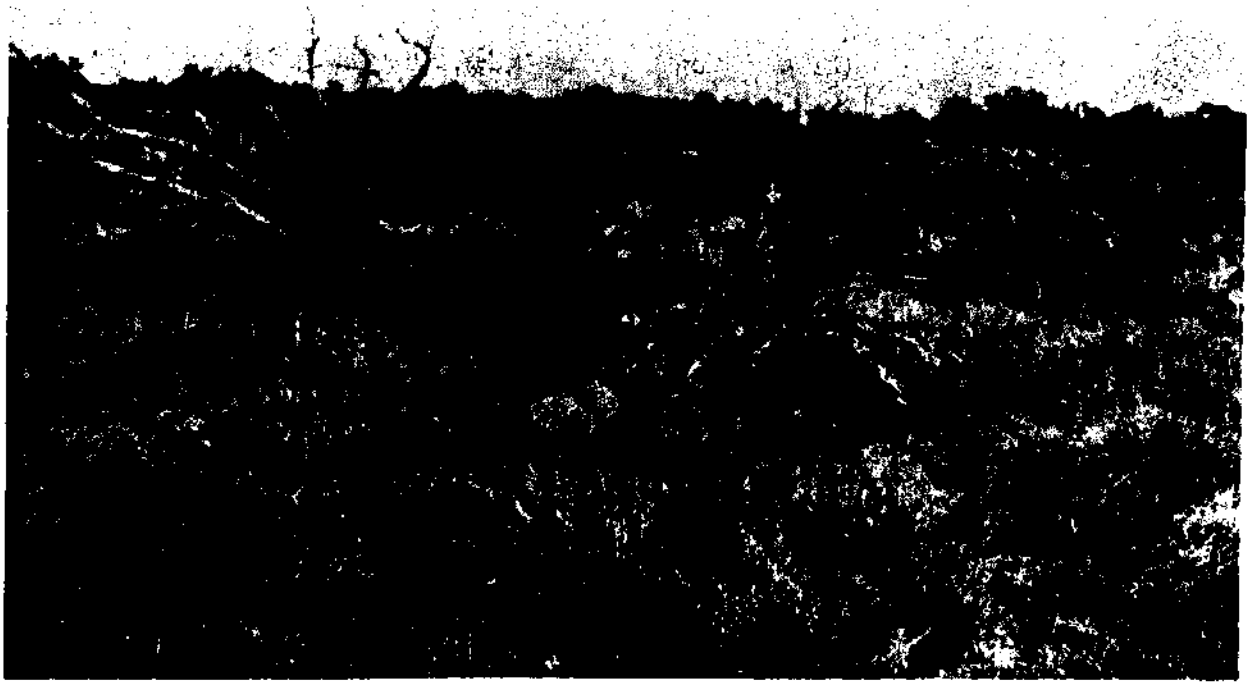
WORKS OF IMPROVEMENT TO BE INSTALLED

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 Brown-Mills Soil Conservation District, is essential for a sound flood prevention program on the watershed. The establishment and maintenance of all applicable soil and water conservation and management practices necessary to proper land use is basic to this objective. Acceleration of the establishment of land treatment measures which have a measurable effect on reducing floodwater damages will be emphasized.

There are 18,176 acres above the planned floodwater retarding structures. Land treatment is especially important on these watershed lands to protect the structural measures. On the remaining 64,665 acres of upland, land treatment measures are all important since they constitute the only

Proper range use and deferred grazing increase cover and species of better grasses by allowing ranges to seed. Note the seed crop of little bluestem and Indiangrass and the good cover being provided.



Brush control on rangeland allows better species of forage grasses to increase thereby improving cover conditions of the ranges.

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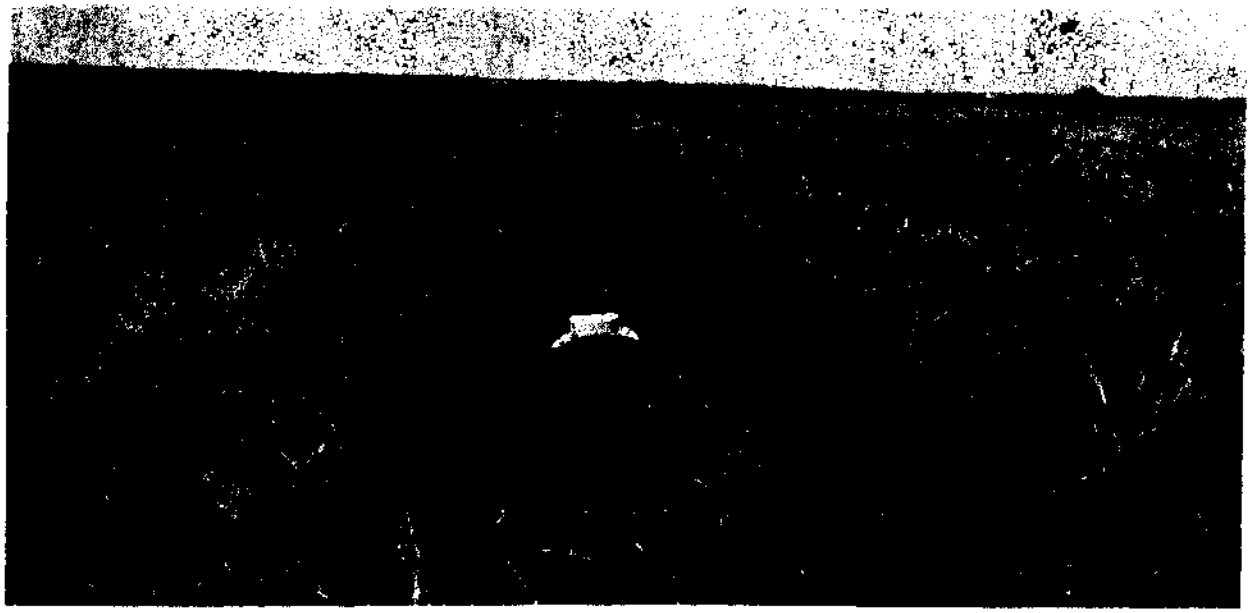
Planting small grain on the contour. Terracing and contour farming help conserve runoff and decrease erosion on cropland.



Crop residue management helps prevent erosion and decrease runoff by helping more water to penetrate the soil.

planned measures for watershed protection. A conservation program on the 2,919 acres of agricultural flood plain is also important in reducing floodwater and erosion damages.

The acreage in each major land use and the estimated cost of establishing, on each, the needed major land treatment measures that will be installed by landowners and operators during the 10-year installation period are shown in table 1. The local people will continue to install and maintain land treatment measures needed in the watershed after the 10-year installation period. Standard soil surveys will be completed on 27,142 acres under the going program during the project installation period. Surveys needed on remaining agricultural land will be accomplished under the going program following the project installation period.

There is a trend toward conversion of small fields of rolling, eroded cropland, to hay or pasture usage. Most of the cropland in the watershed has a high productive capability, and in recent years, the trend has been toward better management and fertilization to increase cover and residues. Also, the use of small grains is increasing considerably.

Most of the land treatment measures will function principally to decrease erosion damage to crop and pasture lands by improving soil-cover conditions. These include conservation cropping systems and crop residue use for the cropland, and range seeding to establish good cover on grassland. They also include brush control to allow grass stands to improve and replace the poor brush cover on grassland; construction of farm ponds to provide adequate watering places to prevent cover-destroying concentrations of livestock; and proper use and deferred grazing of rangeland to provide improvement, protection, and maintenance of grass stands. These measures also effectively improve soil conditions which allow rainfall to soak into the soil at a more rapid rate.

Other beneficial land treatment measures include contour farming, terracing, diversions and irrigation and water management practices, all of which have a measurable effect in reducing peak discharge by slowing runoff. These measures also reduce erosion damage and sediment production.

Structural Measures

A system of seven floodwater retarding structures will most nearly afford the degree of flood prevention desired, and mutually agreed on by the local people. This flood protection cannot be provided by land treatment measures alone. Additional structures were evaluated to determine if a greater reduction in average annual damages could be obtained. The evaluation showed that the additional structural measures considered could not be justified economically, and that the system of seven floodwater retarding structures would produce the highest net benefit per dollar of cost.

Flood detention storage in the structures will range from 3.30 to 5.50 inches of runoff, depending on local conditions.

The following tabulation reflects the degree of control, detention storage in acre-feet and inches, and the equivalent detention storage for Brown and Mullin Creeks and the Pecan Bayou Basin:

Watershed	Drainage Area of Watershed	Drainage Area Controlled by Structures	Drainage Area Controlled by Structures	Detention Storage	Capacity Equivalent Area Controlled	Capacity Equivalent Watershed Area
	(Sq.Mi.)	(Sq.Mi.)	(Percent)	(Ac.Ft.)	(Inch)	(Inch)
Upper Pecan Bayou	696.50	343.00	49.20	57,405	3.14	1.55
Turkey Creek	92.50	52.80	55.00	10,360	3.67	2.10
Jim Ned Creek	838.50	377.25	50.57	96,679	4.83	2.42
Brownwood Laterals	305.00	96.64	31.69	23,548	4.56	1.45
Blanket Creek	196.00	81.75	41.71	16,158	3.70	1.54
Brown-Mullin Creek	134.00	28.40	21.19	5,598	3.85	0.82
Total Program	2,170.00	979.84	45.15	209,748	4.01	1.81

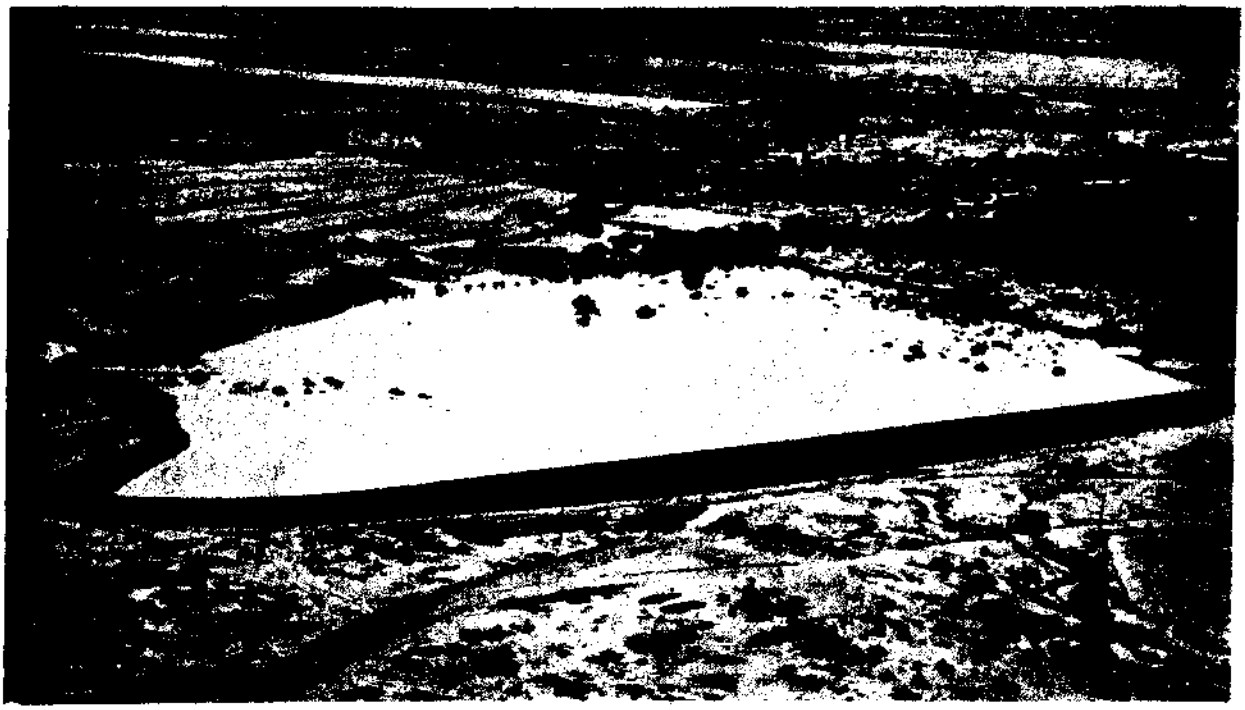
Capacity was provided in the floodwater retarding structures to store the 100-year accumulation of sediment. However, the principal spillway of all sites will be set at the 50-year sediment volume elevation.

Figure 1 shows a section of a typical floodwater retarding structure. Plans of a floodwater retarding structure typical of those planned for this watershed are illustrated by figures 3 and 3a. The locations of the structural measures are shown on the Project Map (figure 4).

There are seven lowwater crossings on county roads and numerous private intrafarm lowwater crossings on Brown and Mullin Creeks that will be affected by the release flow from the principal spillway of floodwater retarding structures. Under present conditions, water flows over these crossings for relatively short periods following rains. After the structures are installed, the flow will be reduced in peak, but will be greatly prolonged. One county road located in the vicinity of Structure Site 5 will be relocated (figure 4).

The total area of the sediment pools, including reserve, is 147 acres, and none of these are flood plain lands. The detention pools will temporarily inundate an additional 433 acres and none of these are flood plain lands.

Sufficient detention storage can be developed at all structure sites to make possible the use of natural rock or vegetative emergency spillways, thereby effecting a substantial reduction in cost over a concrete or similar type spillway.



Runoff from heavy rains being controlled by floodwater retarding structures in a nearby watershed.

Floodwater retarding structures releasing water slowly through the principal spillway following heavy rains.

All applicable State water laws will be complied with in the design and construction of the planned structural measures.

The details on quantities, costs, and design features of the floodwater retarding structures are shown in tables 2 and 3.

EXPLANATION OF INSTALLATION COSTS

The estimated cost of planning and installing land treatment measures, exclusive of Federal funds, is $420,060, based on current program criteria (table 1). In addition, prior to work plan preparation, landowners and operators have established land treatment measures at an estimated non-Federal cost of $513,990 (table 1a).

Prior to work plan preparation, $6,500 of flood prevention funds were used by the Soil Conservation Service for the acceleration of technical assistance to landowners and operators. This technical assistance will be continued during the period of installation at a cost of $13,000. Land treatment costs are based on present prices being paid to landowners or operators to establish the individual measures in the area.

The land treatment measures to be applied and the unit cost of each measure were estimated by the Brown-Mills Soil Conservation District.

The estimated cost of installing the seven floodwater retarding structures is $623,629. Of this amount, $64,284 will be borne by local interests, and $559,345 by flood prevention funds, of which $447,148 is construction costs $112,197 is installation services.

Land, easements, and rights-of-way, and relocation of roads, bridges, utilities, and other improvements for the floodwater retarding structures will be provided by local interests at no cost to the Federal government. The value of these is estimated to be $58,439, based on current market value estimated by local organizations. An additional $5,845 of non-Federal funds will be expended for legal and other services required in obtaining land, easements, and rights-of-way.

Construction costs include both the engineers' estimates and the contingencies. The engineers' estimates were based on the unit costs of floodwater retarding structures in similar areas, modified by special conditions peculiar to each individual site location. They include such items as rock excavation, permeable foundation conditions, and site preparation. Ten percent of the engineers' estimates was added as a contingency to provide for unpredictable costs.

Installation services include engineering and administrative costs. These estimates were based on an analysis of previous work in this area.

The tentative schedule of obligations for the complete 10-year project installation period, including installation of both land treatment and structural measures, is as follows:

SCHEDULE OF OBLIGATIONS

Fiscal Year	Measures	Federal Funds	Non-Federal Funds	Totals
		(dollars)	(dollars)	(dollars)
First	Land Treatment	1/ 1,300	33,605	34,905
Second	Land Treatment	1/ 1,300	37,805	39,105
	Structure Nos. 1,2,3	1/ 249,450	31,488	280,938
Third	Land Treatment	1/ 1,300	42,000	43,300
	Structure Nos. 4,5,6,7	1/ 309,895	32,796	342,691
Fourth	Land Treatment	1/ 1,300	50,407	51,707
Fifth	Land Treatment	1/ 1,300	58,808	60,108
Sixth	Land Treatment	1/ 1,300	50,407	51,707
Seventh	Land Treatment	1/ 1,300	46,207	47,507
Eighth	Land Treatment	1/ 1,300	37,805	39,105
Ninth	Land Treatment	1/ 1,300	33,605	34,905
Tenth	Land Treatment	1/ 1,300	29,411	30,711
TOTAL		572,345	484,344	1,056,689

1/ Includes only accelerated technical assistance.

This schedule will be adjusted from 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.

EFFECTS OF WORKS OF IMPROVEMENT

After installation of the combined programs of land treatment and structural measures described above, average annual flooding will be reduced from 2,136 acres to 943 acres. This project will benefit directly approximately 50 owners of agricultural flood plain lands. Reduction in area inundated varies with respect to location within the watershed. The effect of the project in each area is shown in the following tabulation:

Average Annual Area Inundated

Evaluation Reach (figure 2)	Without Project	With Project	Reduction
	(acres)	(acres)	(percent)
1	94	37	61
2	292	191	35
3	1,750	715	59
Total	2,136	943	56

The following presentation shows, by reaches, the area flooded by the 3-year, 10-year, and 25-year frequency floods, and reductions expected from the installed project:

Area Inundated

Evaluation Reach (figure 2)	Average Recurrence Interval					
	3-year		10-year		25-year	
	Without Project (acres)	With Project (acres)	Without Project (acres)	With Project (acres)	Without Project (acres)	With Project (acres)
1	118	53	168	103	184	130
2	200	156	425	338	500	426
3	1,200	590	1,790	1,020	2,040	1,310
Total	1,518	799	2,283	1,461	2,724	1,866

Owners and operators of flood plain lands reported they would restore 83 acres now in low-yield pastures to production of higher value crops when adequate flood protection is provided. This land was formerly cultivated, but is now used only for grazing. It will be used to produce hay, grain sorghum, and small grains other than wheat. It was determined that no increase in allotted crops would result in this changeover. Some small grains and grain sorghums now grown on upland soils would be shifted to more productive bottomlands.

It was determined from discussion with farmers and other agricultural workers that about 327 acres of flood plain lands would be farmed more intensively with flooding reduced. The timeliness of farm operations and a more secure feeling with the project installed will result in the application of better farming techniques. More fertilizer will be used, more insecticides applied, and the use of certified and treated seed will be more common.

Shifts in upland use will reduce the total acreage of cropland in the watershed during the project installation period. Allotment crops of cotton and wheat will be reduced to some extent. Decreases in cropland will result from the conversions of cropland to grassland and grassed waterways as a result of the planned accelerated land treatment program.

Some loss of wildlife habitat will result from the clearing of sediment pools at a few of the structure sites, but these losses will be offset by fish production and habitat for wild fowl. Wildlife habitat in the flood plain areas will be improved by reduction of frequency, depth, and duration of flooding.

Incidental benefits will result from use of the sediment pools of floodwater retarding structures. It is estimated that these seven structures, with a combined total of 104 surface-acres in sediment pools, will be open to the general public for recreation with permission of the landowners. Recreation, such as camping, picnicking, fishing and hunting will be available to local people throughout the year. Based on the use of existing structures, it is expected that the project will have an average use of approximately 5,200 visitor days annually. Recreational use of sediment pools will cease after about 38 years because of depletion in capacity by sediment deposition.

Sediment pools of the seven floodwater retarding structures will provide a more dependable water supply for livestock.

Benefits will accrue to the project from some reduction in floodwater and sediment damages outside the project area. These benefits will occur on the Colorado River mainstem below the mouth of Pecan Bayou. Secondary benefits, including increased net income in local business activities will be realized after installation of the complete project. The increased farm production will provide an outlet for sale of products used in agricultural production. These will include farm equipment, fertilizers, seed, feed, and insecticides. It will provide added income to farm families, and improve their standard of living. It will also stimulate local business establishments in the sale of sporting goods, boats, motors, and other goods and services associated with recreation.

Land treatment measures will reduce the present average annual sediment yield to the seven floodwater retarding structure sites from 0.34 to 0.31 acre-feet per square mile of drainage area, a reduction of 9 percent. Similar reductions are expected in other portions of the watershed.

The annual flood plain scour damage is expected to be reduced about 60 percent. Five percent will be attributable to land treatment and 55 percent to the structural measures.

The annual sediment yield to the mouth of the watershed is expected to be reduced from 61,700 tons to 40,800 tons, with the project installed.

The complete program will result in a reduction of 13 acre-feet of annual capacity loss to Lake Buchanan and 2.2 acre-feet annually to Lake Merrit.

PROJECT BENEFITS

It is estimated that the average annual monetary floodwater, sediment, erosion, and indirect damages within the watershed will be reduced from $31,748 to $11,312, by the project (table 5). This is a reduction of 64 percent. Approximately 94 percent of this reduction in the average annual damage will result from the system of floodwater retarding structures. In addition, average annual damage reductions of $886 will accrue on the Colorado River mainstem and to Lake Buchanan.

The following presentation shows, by evaluation reaches, the effect the program of land treatment and structural works of improvement will have in the reduction of monetary damages caused by the 3-year, 10-year, and 25-year frequency floods:

Direct Monetary Floodwater Damage

Evaluation Reach (figure 2)	Average Recurrence Interval					
	3-year		10-year		25-year	
	Without Project	With Project	Without Project	With Project	Without Project	With Project
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1	744	322	1,365	630	1,739	808
2	1,059	785	2,478	1,909	3,050	2,505
3	18,320	6,054	36,295	14,262	40,424	20,586
Total	20,123	7,161	40,138	16,801	45,213	23,899

The average annual damage reduction by evaluation reaches is as follows:

Evaluation Reach (figure 2)	Average Annual Damage 1/		
	Without Project 2/	With Project 2/	Reduction
	(dollars)	(dollars)	(percent)
1	5.117	3,652	29
2	1,258	693	45
3	23,485	6,967	70
Total	29,860	11,312	62

1/ Excludes values of restoration of former productivity.

2/ Based on long-term prices, September 1957 projections.

Benefits due to sediment reduction to Lake Merrit are estimated to be $178 annually.

The estimated net increase in farm income due to restoration of former productivity will amount to $1,716 annually, at long-term price levels. This loss from the original production has been included as a crop and pasture damage and its restoration a benefit in table 5.

The net increase in income due to more intensive use of flood plain lands will amount to $1,855 annually.

No increase in allotted crops is expected to result from the project.

Benefits from reduction of floodwater and sediment damages outside the project area are estimated to average $886 annually. These reductions will occur along the Colorado River mainstem below the mouth of Pecan Bayou and to Lake Buchanan.

Recreation benefits incidental to the project will amount to $2,600 annually. An economic analysis was made of existing recreation facilities.

Based on studies completed in the area, supplemented by data from projects installed on nearby watersheds, it was estimated that approximately 5,200 people would use the sediment pools for recreation annually. After deduction of associated costs, a value of $0.50 per visitor day was used in calculating incidental recreation benefits. Peak use, estimated at 250 persons, will occur on holidays and weekends through the spring and fall.

Incidental benefits resulting from the use of sediment pools for livestock water were estimated at $497 annually.

Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation. The project will, however, provide a higher level of imcome to farmers and stimulate business in towns and marketing centers in and adjacent to the watershed. The monetary value of secondary benefits is estimated to be $2,593 annually.

Consideration was given to decreased production in pool areas resulting from project installation. The amortized value of land in pool areas ($1,652) exceeded the net loss in pool area production plus associated secondary losses ($592) and no further calculations were made.

The total average annual benefits from structural works of improvement are estimated to be $27,415.

Since Mills County has not been designated as eligible for assistance under the Area Redevelopment Act, no redevelopment benefits were estimated as a result of project installation.

In addition to monetary benefits, other benefits will accrue to the project, such as an incresed sense of security, better living conditions, and improved habitat for wildlife. None of these benefits were given a monetary value and used for project justification.

COMPARISON OF BENEFITS AND COSTS

Average annual primary benefits of $24,822 will accrue from $21,312 annual equivalent costs. This represents a primary benefit of about $1.20 for each dollar of cost.

The average annual cost of structural measures (amortized total installation costs plus operation and maintenance) is estimated to be $21,312. The ratio of the total average annual project benefits ($27,415) to the average annual cost of structural measures ($21,312) is $1.30 for each dollar of cost (table 6).

PROJECT INSTALLATION

Land Treatment Measures

The land treatment measures needed to protect both the cropland and rangeland as shown in table 1 will be established by farmers and ranchers in cooperation with the Brown-Mills Soil Conservation District during the

10-year installation period. The district is giving assistance in the planning and application of these measures under its going programs. These going programs will be accelerated with flood prevention funds to assure application of the planned measures within the 10-year installation period.

In reaching the goal for establishing land treatment measures during the installation period, it is expected that accomplishments will progress about as follows:

Land Use	FISCAL YEAR				
	1st	2nd	3rd	4th	5th
	(acres)	(acres)	(acres)	(acres)	(acres)
Cropland	398	448	498	597	697
Rangeland	2,441	2,746	3,051	3,662	4,272
Total	2,839	3,194	3,549	4,259	4,969

Land Use	FISCAL YEAR (Continued)					
	6th	7th	8th	9th	10th	TOTAL
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Cropland	597	547	448	398	347	4,975
Rangeland	3,662	3,356	2,746	2,441	2,136	30,513
Total	4,259	3,903	3,194	2,839	2,483	35,488

The governing body of the soil conservation district will arrange for meetings in accordance with definite schedules. By this means, and by individual contacts, they will encourage the landowners and operators within the watershed to adopt and carry out soil and water conservation plans on their farms. District-owned equipment will be made available to the landowners in accordance with existing arrangements for equipment usage in the district.

Ths Soil Conservation Service work unit will assist landowners and operators cooperating with the district in accelerating the preparation of soil and water conservation plans and in the application of conservation practices.

The soil and water conservation loan program of the Farmers Home Administration is available to all eligible individual farmers and ranchers or organized groups in the area. Educational meetings will be held in cooperation with other agencies to outline the services available and eligibility requirements. Present FHA clients will be encouraged to cooperate in the project.

The county Agrioultural Stabilization and Conservation committee will cooperate with the governing body of the soil conservation district by selecting and recommending financial assistance for those ACPS practices that will accomplish the conservation objectives in the shortest possible time.

The Extension Service will assist with the educational phase of the program by conducting general information and local farm meetings, preparing radio, television and press releases, and using other methods of getting information to landowners and operators in the watershed. This activity will help get the land treatment practices and structural measures for flood prevention established.

Structural Measures

The Soil Conservation Service will contract for the construotion of the seven floodwater retarding structures. It also will provide technical specialists to prepare plans and specificatione, supervise construction, prepare contract payment estimates, make contract payments, make final inspections, certify completion, and perform related duties for the installation of the structural measuree.

The Mills County Commissioners Court, in cooperation with the Brown-Mills Soil Conservation District, will furnish the land, easements, and rights-of-way and arrange for road, utility, and improvement changes for all structural measures. They will install culverts or make other needed improvements to keep crossings on public roade passable, while the floodwater retarding structures are operating. Local interests will be responsible for the improvement of individually-owned crossings. The cost of these improvements is included in the estimated cost of land, easements, and rights-of-way.

There are no construction units in this watershed, therefore, structures will be constructed after all necessary land, easements and rights-of-way have been obtained for all planned structural measures. The seven floodwater retarding structures will be constructed during the 10-year installation period in the general sequence of Sites 1, 2, 3, 4, 5, 6, and 7.

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

FINANCING PROJECT INSTALLATION

Federal assistance in carrying out the works of improvement as described in this plan will be provided under the Flood Control Act of 1944, as amended and supplemented.

The cost of establishing land treatment 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 Service, Great Plains Conservation Program, or other Federal programs. The amount of reimbursement to be ex-

pected has been estimated, based on current program criteria, and this amount has not been included in the total estimated non-Federal cost for land treatment listed in table 1.

Flood prevention funds will be used to accelerate technical assistance by the Soil Conservation Service to landowners and operators in the application of land treatment measures.

Based on experience in this area, the local sponsors have estimated that more than 90 percent of the needed land, easements, and rights-of-way for the floodwater retarding structures will be donated. Sufficient funds will be made available from taxes now being collected to meet all local obligations in completing this project.

Federal aseistance will be made available pursuant to the following conditions:

1. The required land treatment in the drainage area above structures has been installed or is in the process of being installed.

2. All required land, easements, and rights-of-way have been obtained.

3. The project agreements have been executed.

4. Operation and maintenance agreements have been executed.

5. Flood prevention funds are available.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be operated and maintained by the owners and operators of the farms and ranches on which the measures are installed under agreements with the Brown-Mills Soil Conservation District. Representatives of this district will make periodic inspections of the land treatment measures to determine maintenance needs and to encourage landowners and operators to perform maintenance. District-owned equipment will be made available for this purpose in accordance with existing arrangements for equipment usage.

Structural Measures

All seven of the proposed floodwater retarding structures will be operated and maintained jointly by the Mills County Commissioners Court and the Brown-Mills Soil Conservation District.

The estimated average annual operation and maintenance cost is $882, based on long-term prices. The necessary maintenance work will be accomplished through the use of contributed labor and equipment, by contract, by force

account, or a combination of these methods. Funds for this work will be provided by the Mills County Commissioners Court.

All floodwater retarding structures will be inspected by representatives of the local sponsoring organizations after each heavy rain, or at least annually. A Soil Conservation Service representative will participate in these inspections at least annually, for a period of at least three years. Items for inspection for the floodwater retarding structures will include, but will not be limited to, the condition of the principal spillway and its appurtenances, the emergency spillway, the earth fill, the vegetative cover of the earth fill and the emergency spillway, and fences and gates installed as part of the structures. The items of inspection are those most likely to require maintenance.

The sponsoring local organizations will maintain a record of the inspections and maintenance work performed and have it available for review by Soil Conservation Service personnel.

Provisions will be made for free access of representatives of the sponsoring organizations and the Federal government to inspect the floodwater retarding structures and their appurtenances at any time.

The sponsoring local organizations fully understand their obligations for maintenance and will execute specific maintenance agreements prior to the issuance of any invitation to bid.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST 1/

Brown-Mullin Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1964

Installation Cost Item	Unit	Number	Installation Period: Estimated Cost 2/ Federal (dollars)	Non-Federal (dollars)	Total (dollars)
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acre	4,975	-	102,710	102,710
Grassland	Acre	30,513	-	317,350	317,350
Technical Assistance (Accel.)			13,000	-	13,000
SCS Subtotal			13,000	420,060	433,060
TOTAL LAND TREATMENT			13,000	420,060	433,060
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	7	447,148	-	447,148
Subtotal - Construction			447,148	-	447,148
Installation Services					
Soil Conservation Service					
Engineering Services			70,763	-	70,763
Other			41,434	-	41,434
SCS Subtotal			112,197	-	112,197
Subtotal - Installation Services			112,197	-	112,197
Other Costs					
Land, Easements and Rights-of-Way			-	58,439	58,439
Legal Fees			-	5,845	5,845
Subtotal - Other			-	64,284	64,284
TOTAL STRUCTURAL MEASURES			559,345	64,284	623,629
WORK PLAN PREPARATION			30,000	-	30,000
TOTAL PROJECT			602,345	484,344	1,086,689
SUMMARY					
Subtotal - SCS			602,345	484,344	1,086,689
TOTAL PROJECT			602,345	484,344	1,086,689

1/ Does not include prior expenditures of flood prevention funds or accomplishments resulting therefrom (see table 1a).

2/ Excludes costs that will be reimbursed from other Federal funds.

4-20987 12-65

TABLE 1a - STATUS OF WATERSHED WORKS OF IMPROVEMENT 1/

Brown-Mullin Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1964

Prior to December 1965

Installation Cost Item	Unit	Number	Estimated Cost		
			Federal 2/	Non-Federal 3/	Total
			(dollars)	(dollars)	(dollars)
LAND TREATMENT					
Soil Conservation Service					
Contour Farming	Acre	4/ 3,748	-	37,480	37,480
Crop Residue Use	Acre	4/ 4,672	-	46,720	46,720
Conservation Cropping System	Acre	4/ 4,541	-	68,120	68,120
Proper Range Use	Acre	4/ 29,191	-	72,980	72,980
Deferred Grazing	Acre	4/ 21,926	-	87,700	87,700
Range Seeding	Acre	1,875	-	18,750	18,750
Brush Control	Acre	15,812	-	79,060	79,060
Terraces, Graded	Foot	485,000	-	16,980	16,980
Diversions	Foot	187,000	-	18,700	18,700
Farm Ponds	No.	270	-	67,500	67,500
Technical Assistance (Accel.)			6,500	-	6,500
SCS Subtotal			6,500	513,990	520,490
TOTAL LAND TREATMENT			6,500	513,990	520,490
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.		-	-	-
Subtotal - Construction			-	-	-
Installation Services					
Soil Conservation Service					
Engineering Services			-	-	-
Other			-	-	-
Subtotal - Installation Services			-	-	-
Other Costs					
Land, Easements and Rights-of-Way			-	-	-
Legal Fees			-	-	-
Subtotal - Other			-	-	-
TOTAL STRUCTURAL MEASURES			-	-	-
WORK PLAN PREPARATION			-	-	-
TOTAL PROJECT			6,500	513,990	520,490
SUMMARY					
Subtotal - SCS			6,500	513,990	520,490
TOTAL PROJECT			6,500	513,990	520,490

1/ At time of work plan preparation.
2/ Flood Prevention funds only.
3/ Excludes costs that were reimbursed from other Federal funds.
4/ The level of application of the management and recurring-type practices reached at the time of work plan preparation and are not cumulative.

NOTE: There are no Federal lands in the watershed.

December 1965

4-20487 12-65

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION
Brown-Mullin Watershed, Texas
Middle Colorado River Watershed
(dollars) 1/

Structure: Site Number or: Name	Federal Installation Cost				Non-Federal Installation Cost			Total Installation Cost
	Construction	Installation Services: Engineering	Installation Services: Other	Total Federal	Easements and Rights-of-Way	Legal Fees and Other	Total Non-Federal	
1	44,790	8,062	4,228	57,080	6,750	675	7,425	64,505
2	108,525	14,108	9,811	132,444	17,563	1,756	19,319	151,763
3	47,023	8,464	4,439	59,926	4,313	431	4,744	64,670
4	60,581	9,087	5,573	75,241	7,688	769	8,457	83,698
5	82,625	12,394	7,603	102,622	14,875	1,488	16,363	118,985
6	55,568	10,018	5,254	70,930	4,125	413	4,538	75,468
7	47,946	8,630	4,526	61,102	3,125	313	3,438	64,540
Total	447,148	70,763	41,434	559,345	58,439	5,845	64,284	623,629

1/ Price Base: 1964

4-20487
12-65

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Brown-Mullin Watershed, Texas
Middle Colorado River Watershed

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	Total
Drainage Area	Sq.Mi.	2.10	12.05	1.75	2.63	4.98	2.78	2.11	28.40
Storage Capacity									
Sediment Pool (50-yr.or 200 Ac.Ft.)	Ac.Ft.	38	174	48	62	90	50	42	504
Sediment Pool (Above Riser)	Ac.Ft.	22	96	37	48	54	30	21	308
Sediment in Detention Pool	Ac.Ft.	6	32	5	7	17	10	7	84
Floodwater Detention	Ac.Ft.	392	2,291	355	770	920	488	382	5,598
Total	Ac.Ft.	458	2,593	445	887	1,081	578	452	6,494
Surface Area									
Sediment Pool (50-yr.or 200 Ac.Ft.)	Acre	10	35	9	15	18	10	7	104
Sediment Reserve Pool (100-yr.)	Acre	15	45	15	22	26	14	10	147
Floodwater Detention Pool	Acre	58	207	47	90	95	47	36	580
Volume of Fill	Cu.Yds.	84,000	232,000	92,000	131,000	177,000	114,000	88,500	918,500
Elevation Top of Dam	Foot	1,495.3	1,498.0	1,508.6	1,451.0	1,451.9	1,517.2	1,533.6	xxx
Maximum Height of Dam	Foot	30	45	33	32	42	40	45	xxx
Emergency Spillway									
Crest Elevation	Foot	1,490.0	1,492.0	1,503.3	1,445.5	1,546.0	1,511.5	1,528.1	xxx
Bottom Width	Foot	60	300	50	150	120	90	80	xxx
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use 1/		4.0	3.1	4.0	2.0	4.0	4.0	4.0	xxx
Average Curve No. - Condition II		80	80	83	83	80	80	80	xxx
Emergency Spillway Hydrograph									
Storm Rainfall (6-hour)	Inch	6.7	6.5	6.5	9.5	6.5	6.5	6.7	xxx
Storm Runoff	Inch	4.5	4.3	4.5	7.2	4.2	4.2	4.4	xxx
Velocity of Flow (Vc) 2/	Ft./Sec.	3.5	3.8	2.8	4.1	3.6	4.4	4.2	xxx
Discharge Rate 2/	C.F.S.	79	540	33	324	180	237	179	xxx
Maximum Water Surface Elevation 2/	Foot	1,491.0	1,493.2	1,504.0	1,446.7	1,547.0	1,512.8	1,529.3	xxx
Freeboard Hydrograph									
Storm Rainfall (6-hour)	Inch	13.7	13.4	13.5	20.8	13.5	13.6	13.8	xxx
Storm Runoff	Inch	11.4	10.9	11.4	18.5	10.9	11.0	11.2	xxx
Velocity of Flow (Vc) 2/	Ft./Sec.	10.0	10.8	10.2	10.2	10.8	10.5	10.2	xxx
Discharge Rate 2/	C.F.S.	1,929	11,640	1,643	5,064	4,645	3,242	2,769	xxx
Maximum Water Surface Elevation 2/	Foot	1,495.3	1,498.0	1,508.6	1,451.0	1,451.9	1,517.2	1,533.6	xxx
Principal Spillway									
Capacity	C.F.S.	21	120	17	26	50	28	21	xxx
Capacity Equivalents									
Sediment Volume	Inch	0.59	0.47	0.96	0.83	0.60	0.60	0.63	xxx
Detention Volume	Inch	3.51	3.57	3.81	5.50	3.47	3.30	3.39	xxx
Spillway Storage	Inch	3.50	2.31	3.12	4.00	2.38	2.02	1.84	xxx
Class of Structure		A	A	A	B	A	A	A	

1/ Based on frequency analysis of stream gage records.
2/ Maximum during passage of hydrograph.

TABLE 4 - ANNUAL COSTS 1/
Brown-Mullin Watershed, Texas
Middle Colorado River Watershed
(Dollars)

Evaluation Unit	Amortization of Installation Costs 2/	Operation and Maintenance Costs 3/	Total
All Floodwater Retarding Structures	20,430	882	21,312
Total	20,430	882	21,312

1/ Does not include work plan preparation cost.

2/ 1964 prices amortized for 100 years at 3-1/8 percent.

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

4-20467 12-65

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS
Brown-Mullin Watershed, Texas
Middle Colorado River Watershed

Price Base: Long-term 1/

Item	Estimated Average Annual Damage		Damage Reduction Benefit
	Without Project (dollars)	With Project (dollars)	(dollars)
Floodwater			
Crop and Pasture	14,494	5,008	9,486
Other Agricultural	10,313	3,057	7,256
Roads and Bridges	1,225	558	667
Subtotal	26,032	8,623	17,409
Sediment			
Overbank Deposition	834	624	210
Reservoir	329	151	178
Subtotal	1,163	775	388
Erosion			
Flood Plain Scour	1,667	886	781
Indirect	2,886	1,028	1,858
Total	31,748	11,312	20,436

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

4-20487 12-65

4-20-67 12-65

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES
Brown-Mullin Watershed, Texas
Middle Colorado River Watershed

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/						Average Annual Cost	Benefit-Cost Ratio
	Flood Prevention							
	Damage Reduction	Changed Land Use Intensification	Incidental 2/	Secondary	Outside Watershed 3/	Total		
All Floodwater Retarding Structures	18,984	1,855	3,097	2,593	886	27,415	21,312	1.3:1
GRAND TOTAL	4/ 18,984	1,855	3,097	2,593	886	27,415	21,312	1.3:1

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

2/ Includes $497 benefits from livsstock water and $2,600 benefits from recreation.

3/ Includes $503 benefits from reduction of flood damage to the mainstem of the Colorado River, and $383 benefits for reduction of sediment damage to Lake Buchanan.

4/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $1,452, annually.

INVESTIGATIONS AND ANALYSES

Land Use and Treatment

Soil conditions and land use on the upland were determined by expanding a 25 percent sample of the watershed to the entire upland area. The current land use of the flood plain was determined by field investigations.

Cover conditions and range sites were determined from available range surveys and other cover information obtained from records of the soil conservation district and expanded, with assistance from personnel of the Soil Conservation Service work unit to the entire watershed.

The status of land treatment measures and practices effectively applied and the current conservation needs, based on range conditions and land capability classes developed from soil surveys, were secured from rscords of the Brown-Mills Soil Conservation District. From this information, with assistance of personnel from the Soil Conservation Service work unit at Goldthwaite, estimates were made of the various practices contributing directly to flood prevention which will be applied on the watershed during the 10-year installation period. The hydraulic, hydrologic, sedimentation and economic investigations provided data on the effect land treatment measures would have on reduction of flood damages.

Although measurable benefits would result from application of the 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 by the local people.

Engineering Investigations

The study made and the procedures used in planning structural measures were as follows:

1. A base map of the watershed was prepared showing the watershed boundary, drainage pattern, system of roads, and other pertinent information. A stereoscopic study of consecutive 4-inch aerial photographs was used to locate all probable floodwater retarding structure sites, the limits and the area of the flood plain, and other points 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.

2. Field examinations were made of all probable floodwater retarding structure sites previously located stereoscopically. Sites which did not show good storage possibilities or which would inundate highways or improvements for which the cost of relocation

could not be economically justified, were dropped from further consideration. From the remaining sites, a system of floodwater retarding structure sites was selected, based on the degree of control desired, for further consideration and detailed survey. Plans of a floodwater retarding structure typical of those planned for this watershed are illustrated by figures 3 and 3a.

3. The cross-sections of the flood plain, previously located stereoscopically, were examined in the field, adjusted to give the best representation of hydraulic characteristics and surveyed at the selected locations (figure 2). Data developed from these cross-sections permitted the computation of peak discharge-stage-damage relationships for various flood flows. A map was prepared of the flood plain on which land use, cross-section locations, and other pertinent information were recorded.

4. A topographic map with 4-foot contour intervals was made of the pool area of each of the proposed sites to determine the storage capacity of the site, the estimated cost of the structure, and the areas of the flood plain and upland that would be inundated by the sediment and detention pools. Maps of the structure sites were developed by use of the stereoplotter and other standard survey procedures. Topographic maps with one-foot contour intervals and a scale of one inch equals 50 feet were developed for each emergency spillway to determine spillway design. Sediment storage requirements were determined for each site through the study of the physical and vegetative conditions of the drainage area above the site. Spillway widths, depths of flow, embankment yardage, and volume of excavation in spillways were computed for each structure, starting with the storage volume needed to temporarily detail the minimum runoff as determined from criteria set forth in Soil Conservation Service Engineering Memorandum SCS-27, and Section 2441, Texas State Manual. The runoff to be stored was then increased by increments to determine the amount of storage that would result in the most economical structure.

5. The limits of the detention and sediment pools of all satisfactory sites, and the flood plain of the streams were drawn to scale on a copy of the base map. Structure data tables were developed to show for each structure the drainage area, floodwater detention and sediment storage in acre-feet and in inches of runoff from the drainage area, the release rate of the principal spillway, emergency spillway width and depth of flow, maximum height of dam, area inundated by the sediment

and detention pools, the volume of fill in the dam, and the estimated cost of the structure (tables 2 and 3).

6. Damages resulting from floodwater, sediment, and erosion were determined from damage schedules and a survey made of sample areas. Reductions in these damages resulting from the proposed works of improvement were estimated on the basis of reduction of peak discharges, stages, and volume of runoff in inches for various frequency storms, as determined by flood routings. These flood routings were made for conditions without the project, with land treatment, and for conditions with all works of improvement installed. Benefits so determined were allocated to groups of interrelated measures including existing works of improvement on the basis of the effect of each on reduction of damages. In this manner, it was determined that floodwater retarding structures could be economically justified.

When the structural measures for flood prevention had been determined, a table was developed to show the cost distribution of structural measures (table 2). The summation of the total costs of all needed land treatment and structural measures represented the estimated cost of the planned 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 4).

Hydraulic and Hydrologic Investigations

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

1. Basic meteorological and hydrologic data were tabulated from Climatological Bulletins, United States Weather Bureau and Water Supply Papers, United States Geological Survey and local records. These data were analyzed to determine average precipitation, depth-duration relationships, seasonal distributions of precipitation, the frequency of occurrence of meteorological events, the historical flood series, rainfall-runoff peak discharge relationships, and the relationship of geology, soils and climate to runoff depth for single storm events.

2. Engineering surveys were made to collect information on selected stream reaches, including valley cross-sections, channel capacities, highwater elevations of selected storms, bridge capacities, and other hydraulic characteristics, and on proposed structure sites to collect data used in design. Cross-sections and evalu-

tion reaches were selected on the ground in collaboration with the economist and geologist.

3. Present hydrologic conditions of the watershed were determined, taking into consideration such factors as soils, land use, topography, cover, and climate. Future hydrologic conditions were determined by obtaining from work unit conservationists and local landowners estimates of the changes in land use and cover conditions that could be expected during the installation period of the project. Runoff curve numbers were computed from soil-cover complex data obtained from the drainage area of representative structure sites and a 10 percent random sample of the uncontrolled drainage area (about 25 percent of the drainage area of the watershed) and used with figures 3.10-1, Soil Conservation Service, National Engineering Handbook, Section 4, Supplement A, to determine depth of runoff from individual storms in the evaluation series and the design storms.

4. Rainfall-runoff relationships were determined and compared with nearby gaged runoff on similar watersheds. The percent chance of occurrence of meteorological events was determined by computing the plotting of values taken from Climatological Papers and Water Supply Bulletins, and plotting rainfall, runoff, and peak discharges against their respective plotting positions on Hazen probability paper. The relationships of runoff, peak discharges, and damages were determined for various frequencies (3-10-1-24, NEH, Section 4, Supplement A).

5. Rating curves for the cross-sections were computed by Mannings formula (4.2-1-9, NEH, Section 4, Supplement A). Stage-area inundated curves were developed for each cross-section. From these, composite runoff-area inundated curves were developed for each evaluation reach.

6. Determination was made of peak discharges, area inundated, and damages caused by the various amounts of runoff which would exist due to:

    a. Present conditions of the watershed.

    b. Effect of land treatment measures.

    c. Effect of land treatment measures and floodwater retarding structures.

    d. Consideration of alternative and various combinations of measures.

7. Floodwater retarding structures were classified on the basis of potential downstream damages in accordance with Engineering Memorandum SCS-27, and Section 2441, Texas State Manual.

8. Emergency spillway design storm inflow hydrographs were developed for all structure sites. Spillway widths and depths of flow were determined by the Goodrich-Wisler graphical routing method in accordance with procedures set forth in Engineering Memorandum SCS-27; NEH, Section 4, Hydrology, Supplement A; NEH, Section 5, Hydraulics; Technical Release No. 2, and Section 2441, Texas State Manual.

The rainfall for the period 1922 to 1963, inclusive, was selected for evaluating damages in this watershed. Rainfall information for the historical evaluation series used in these studies was obtained by applying the Thiessen polygon method of weighting to the rainfall data tabulated for the Goldthwaite and Mullin stations.

The 6-hour design storm rainfall and the emergency spillway and freeboard hydrographs were computed for each site in accordance with Section 2441, Texas State Manual. The dimensions of the emergency spillways were determined by graphically routing the freeboard hydrographs. The criteria and procedures used are set forth in Engineering Memorandum SCS-27; Technical Release No. 2; NEH, Section 4, Hydrology, Supplement A; NEH, Section 5, Hydraulics, and Section 2441, Texas State Manual.

Frequency of use of emergency spillways was based on regional analysis of gaged runoff from this amd similar watersheds. Detention storage, embankment yardage, rock excavation, and spillway depth, width, and alignment were balanced to give the most economical structure, which was included in the watershed plan.

Sedimentation Investigations

Sedimentation investigations were made in accordance with procedures in Watershed Memorandum WS-TX-25, "Sedimentation Investigations in Work Plan Development", dated August 21, 1959.

Sediment Source Studies

Sediment source studies to determine the 100-year sediment storage requirements were made in the drainage areas of the seven planned floodwater retarding structures.

1. Detailed investigations were made in the drainage areas of two of the planned floodwater retarding structures. These investigations included: mapping soil units by slope in percent; slope length; present land use; present land treatment on cultivated land; present cover condition classes on rangeland

and pasture; land capability classes; lengths, widths, and depths of all stream channels and scour channels and sheet scour effected by erosion; and the estimated annual lateral erosion of stream channels.

2. Office computations included summarizing erosion by sources (sheet erosion, flood plain scour, and streambank erosion) in order to fit these data into the Musgrave equation for computation of gross annual erosion in tons.

3. Sediment delivery ratios of 36 to 51 percent, depending on the size of the drainage areas, were applied to the gross annual erosion above each floodwater retarding structure to determine the actual amount of sediment delivered to the sites. A delivery ratio of 85 percent was used to determine the amount of sediment delivered to Lake Buchanan from the mouth of the watershed.

4. Field surveys and office computations to determine sediment volumes under present conditions for the remaining five structures not surveyed in detail consisted of mapping the land use and arranging the sites into homogeneous groups. Sediment source summary sheets were prepared, based on similar sites which were surveyed in detail. The combined sediment source studied both detailed and otherwise represent 28 percent of the watershed area.

5. The sediment rates were then adjusted to reflect the effect of expected land treatment on the drainage areas of the seven planned floodwater retarding structures. The computed sediment storage requirements for each site is based on a gradual improvement of watershed conditions due to installation of needed land treatment measures expected to be installed during the first 10 years and maintained at 60 to 70 percent effectiveness during the next 90 years.

6. The volume of sediment storage allocated to the different pools in the planned structures is based on a volume weight of 59.0-63.0 pounds per cubic foot for submerged sediment, and 83.5-85.5 pounds per cubic foot for aerated sediment.

7. The allocation of sediment to the structure pools was based on a range of 52 to 55 percent deposition in the detention pool area and 45 to 48 percent deposition in the sediment pool. This allocation was determined on the basis of topography and texture of sediment after allowing for 5 to 20 percent of the sediment being carried in suspension through the outlet structure.

The sediment source studies indicated that the erosion rates in the watershed were low. A summation found the annual sediment yields above the eeven planned floodwater retarding structures to be 9.48 acre-feet, or an average of 0.34 acre-feet per square mile.

Flood Plain Sedimentation and Scour

The following sedimentation and scour damage investigations were made to evaluate the nature and extent of phyeical damage to flood plain lands, giving due consideration to agronomic and other land treatment practices, eoils, crop yields, and land capabilities:

1. Field examinations and aerial photograph studiee were made along representative valley cross-sections (figure 2) making note of the depth and width of scour channels and eheet scour areas, stream channel aggradation or degradation, and other important factors.

2. Estimates of past physical flood plain damages were obtained through interviews with the landowners and operators and by comparison of damages with non-damaged areas.

3. A damage table was developed to show percent damage by texture and depth increment for deposition and percent damage by depth and width of scour.

4. The sediment and scour damages were summarized by evaluation reaches for the entire flood plain and adjusted for recoverability of productive capacity. Estimates for recoverability were developed from field studies and interviews with farmers.

5. Ueing the average annual erosion rates as a baeis, the average annual sediment yields to selected reaches of the flood plain were estimated for present conditions, with land treatment, and with etructural measures installed. The reeults were compared to show the average annual reduction of sediment load contributing to overbank deposition. The reduction of overbank deposition is based on this reduction of sediment load and reduction of area inundated by floodwater. The reduction of scour damages due to the installation of the complete project is based on a reduction of depth of flooding and area inundated.

Geologic Investigations

Preliminary geologic dam site investigations were made at each of the seven planned floodwater retarding structure sites in accordance with "Guide to Geologic Site Investigations", Fort Worth Engineering and Water-

shed Planning Unit area, dated October 1963, and Section 8, Engineering Geology, National Engineering Handbook. The following procedures were used:

1. Available pertinent geologic maps and literature were gathered and studied.

2. Stereoscopic studies were made of aerial photographs to determine the location of rock outcrops and to help trace the strata through the site areas.

3. A field investigation was made of each site, and notes were made of the following:

    a. Lithology, thickness, structure, and sequence of rock strata.

    b. The nature and thickness of the soil mantle in the foundation, borrow, and spillway areas as determined from exposures and from hand auger borings.

    c. General topography.

    d. Stream channel dimensions, type of bedload, and stability of bed and banks.

    e. Springs, open bedding planes, erodible areas, water tables, faults, caverns, and any other geologic characteristics that might have a bearing on the design and construction of a dam.

4. The field notes, along with information pertaining to spillway excavation volumes, embankment dimensions and volumes, physiographic descriptions, etc., were used to complete form SCS-375, "Preliminary Geologic Investigations of Dam Sites".

Descriptions of Problems

All of the planned floodwater retarding structures are located on the Glen Rose formation of the Trinity group of lower Cretaceous series.

The Glen Rose in this area consists primarily of thick layers of soft marl interbedded with thin, hard, impure limestone strata. The marl and limestone are overlain by moderate thicknesses of sandy clays, clayey sands, and clayey gravels. These soils are CL, SC, and GC, according to the Unified Soil Classification System.

The structure sites should provide sound foundations at moderate depths, ample building materials near the sites, and little, if any, rock excavation. Erodible emergency spillway areas are present and will need a protective cover of grass.

Detailed investigations, including explorations with core drill equipment, will be made at all floodwater retarding etructure sites prior to construction. Laboratory tests will be made to help determine precise treatment of soil materials in the foundation and embankments.

Economic Investigations

Selection of Reaches

The flood plain was divided into three evaluation reaches (figure 2) due to the difference in damageable values and flood plain characteristics. This break simplified the evaluation of the effects that various components of the overall program and combination of structural measures would have on the reduction of damages.

Determination of Damages

Urban damages in the watershed are minor.

Agricultural damage estimates were based on historical data contained in approximately 34 flood damage schedules taken in the field and covering about 68 percent of flood plain ownership or approximately 75 percent of the total flood plain area. Historical data obtained included flood damages to crops, fences, livestock, farm equipment, and roads and bridges. Cropping systems, average flood-free yields, production costs, land values, and land use were collected from farmers, ranchers, local bankers, and agricultural specialists in the field. This data was used as a basis for determining the damageable values and damage rates at various depths and seasons of flooding.

The applicable rates of damage were applied to each flood occurring in the flood series for the period 1922 through 1963. Adjustments were made on each reach to account for the effect of recurrent flooding when several floods occurred within one year.

Estimates of damages to other agricultural properties such as fences, livestock and farm equipment were made from information in flood damage schedules and correlated with size of flood. Estimates of damages to roads and bridges were obtained from county commissioners, State highway officials and local farmers.

On the calculation of crop and pasture damages, expenses saved, such as costs of harvesting and production inputs, were deducted from the gross value of the damage. Current flood plain land use was mapped in the field.

Estimates of flood-free yields obtained from owners and operators of farms and agricultural workers in the area were adjusted to allow for increased technology and the assumption was made that production practices now used by the better farmers would be in general use over the life of the project.

Monetary values of physical damage to flood plain lands from scour and sediment were based on the net value of production lost, taking into account the time for recovery, and discounted.

Indirect damage from floods included re-routing of school busses, isolation of farmers from some fields due to farm road damage, delays and extra travel in rural mail delivery, additional travel time for farmers, and extra feed for livestock following floods. Based on information obtained from watersheds previously analyzed, it is estimated that these indirect damages will approximate 10 percent of all direct damages.

Benefits from Reduction of Damages

Average annual damages within the waterehed were calculated for conditions without a project, with land treatment installed, and after installation of the complete project. The difference between the damage at the time of the initiation of each project increment and that expected after its installation constituted the benefits brought about by that increment through reduction in damages.

After determination that primary benefits from structural measures exceeded their annual equivalent cost, the estimated land treatment benefits accruing in areas controlled by structures were assigned to these structural measures.

Reduction in monetary value of sediment to Lake Merrit was included as a project benefit. Based on the engineers' estimates, the current replacement value of Lake Merrit Dam would amount to about $68.50 per acre-foot. This cost per acre-foot was used in computing the monetary value of sediment reduction to Lake Merrit.

Installation of this project will provide flood reduction benefits on the Colorado River below the mouth of Pecan Bayou. These benefits were evaluated and included as a project benefit in this watershed.

Restoration of Former Productivity and More Intensive Land Use Benefits

Farmers in the watershed were asked what changes in cropping systems and land use had been made as a result of frequent flooding and what changes in land use and cropping practices might be expected in the future with these floods reduced in extent and frequency. Using their predictions as a guide, it was estimated that approximately 83 acres of formerly cultivated land now in low-yielding pasture would be returned to more productive cash crops. It was determined from this analysis that the average annual benefits from restoration of former crop use would amount to $1,716.

Added damage to higher damageable values from the remaining floods was calculated and subtracted.

Field studies indicated that 327 acres of flood plain would be farmed more intensively with flooding reduced. The timeliness of farm operations with flooding reduced will result in the use of better farming techniques. More fertilizers will be applied and wider use will be made of insecticides and weed control measures. The use of certified and treated seeds is expected to become more common. The benefits from more intensive use of flood plain lands were estimated to be $1,855, annually.

Incidental Benefits

Approximately 104 surface-acres of sediment pools at seven structural sites will be available to the public for recreation. Based on studies made of similar watersheds, it is estimated that use of these facilities will approximate 5,200 visitor days. Since basic facilities would be limited to access roads and campsites, a gross value of $0.70 per visitor day was used in the evaluation. After deducting associated costs and operation and maintenance, and discounting for the 2-year lag in accrual, a net benefit of $0.50 per visitor day was obtained. Due to the limited basic facilities, the value of $0.50 per visitor day was used in the evaluation of incidental recreational benefits.

The analysis was based on the assumption that the sediment pools would be available for a period of 38 years, and decline to zero at the end of 40 years. The recreation benefits were discounted to allow for a 2-year lag in accrual and the gradual decrease in sediment capacity.

Benefits accruing from use of sediment pools for livestock water were based on a flat rate of $71 per site, as established on the Green Creek study, or a total of $497.

No irrigation or other agricultural water management benefits were evaluated.

Secondary Benefits

The value of local secondary benefits induced by or stemming from the project were estimated to be equal to 10 percent of the direct primary benefits plus 10 percent of the cost of the additional agricultural production and associated costs incurred in obtaining the increased production. This excludes all indirect benefits from the computation of secondary benefits.

Appraisal of Land Easement Values

The value of easements was determined through local appraisal, giving full credit to the current real estate market values. Areas inundated by sediment pools of the floodwater retarding structures were excluded from the damage calculations. An estimate was made of the value of production lost in the pool areas after installation of the project. The average annual loss in value of production within pool areas, plus secondary costs there-

from, were compared with the amortized value of easements. The easement value was greater, therefore, easement values were used in economic justification to assure a more conservative appraisal.

Details of Methodology

The historical storm series for the period 1922 through 1963 was used on reaches 2 and 3, and the synthetic storm series was used on reach 1.

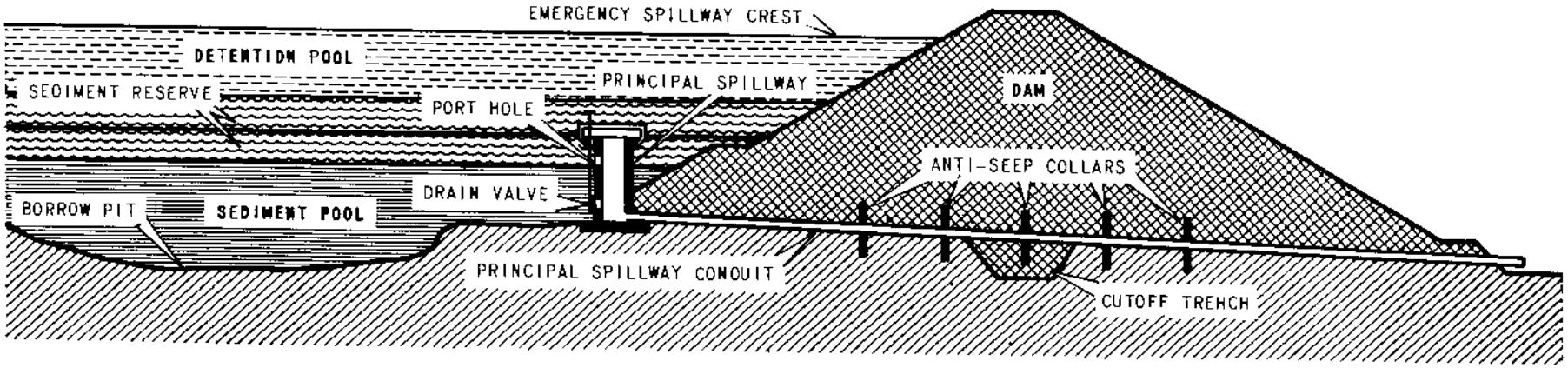


Figure 1

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Rev. 3-65 4-1-10,071

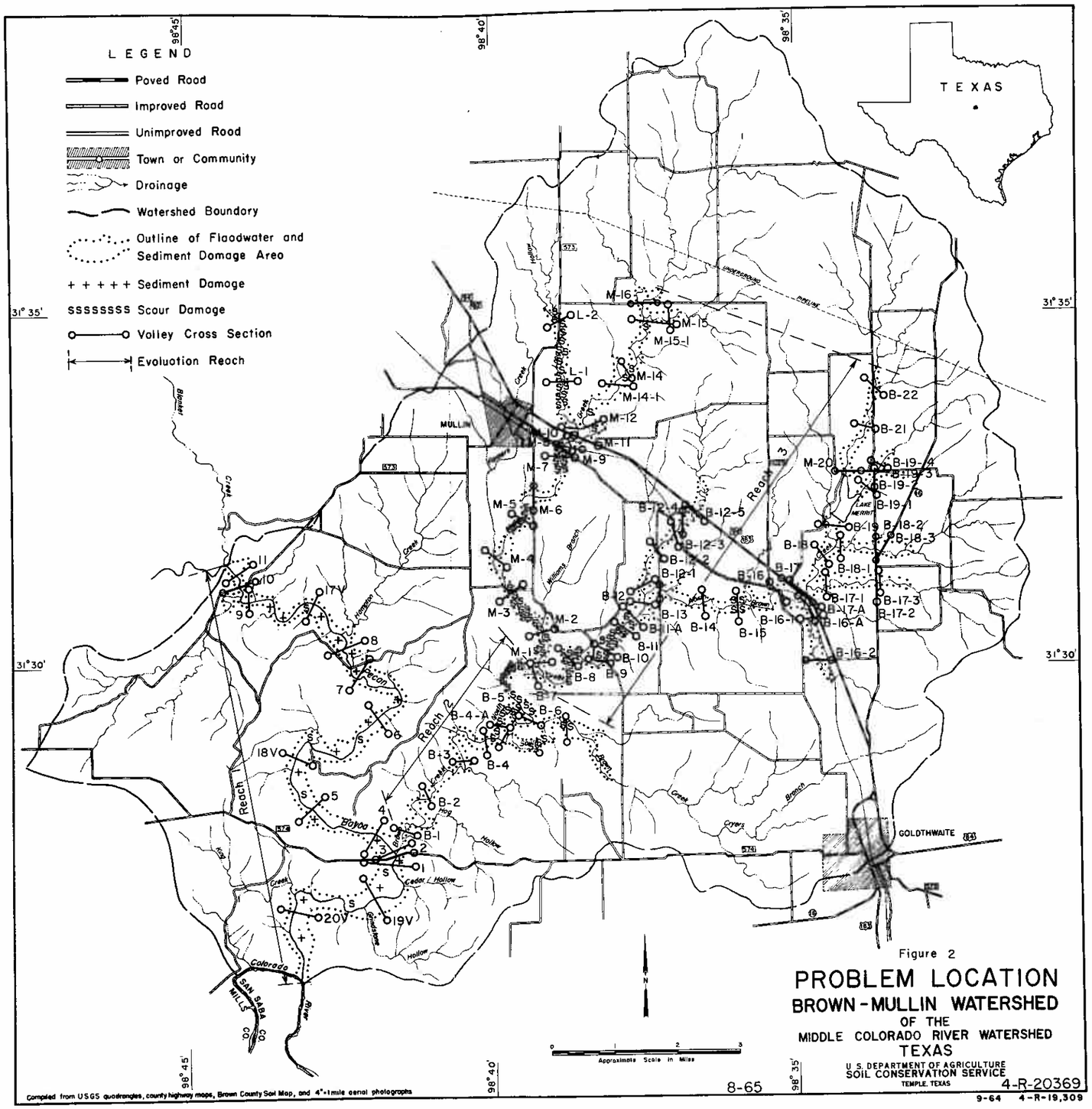


Figure 2

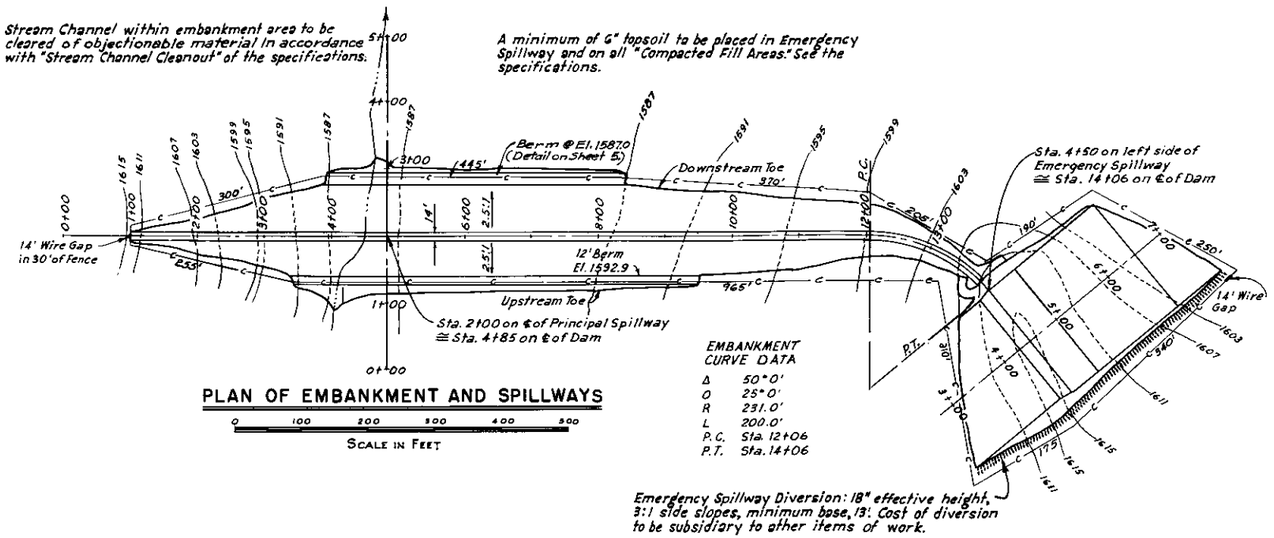
PROBLEM LOCATION
BROWN-MULLIN WATERSHED
OF THE
MIDDLE COLORADO RIVER WATERSHED
TEXAS

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

4-R-20369

9-64 4-R-19,309

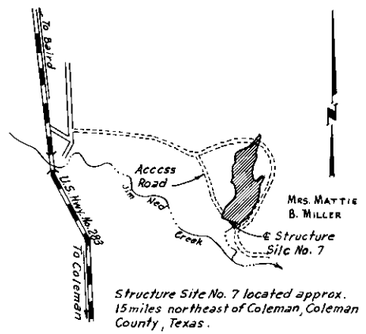
USDA-SCS ROAD WORK TEX 1965



PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 300 400 500

SCALE IN FEET

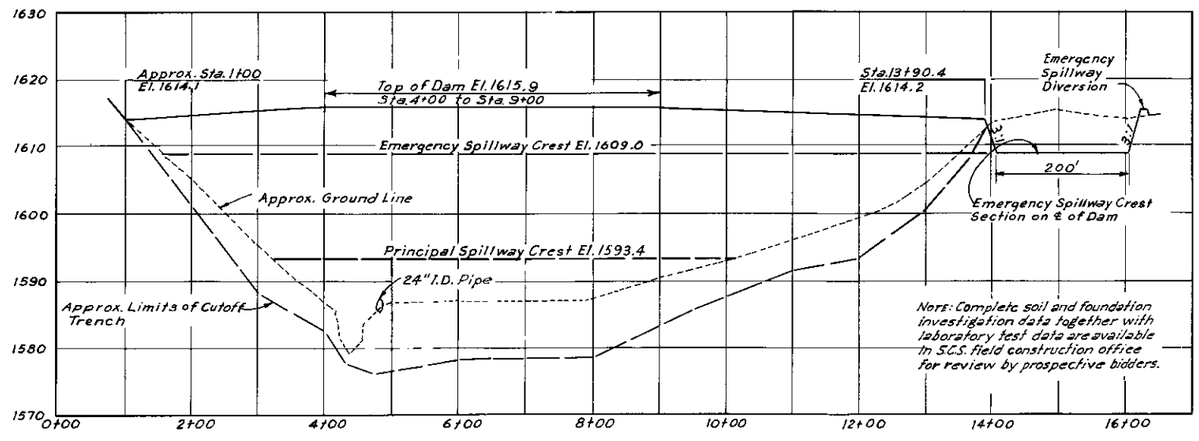


Structure Site No. 7 located approx. 15 miles northeast of Coleman, Coleman County, Texas.

VICINITY MAP

0 1 2 3 4

SCALE IN MILES

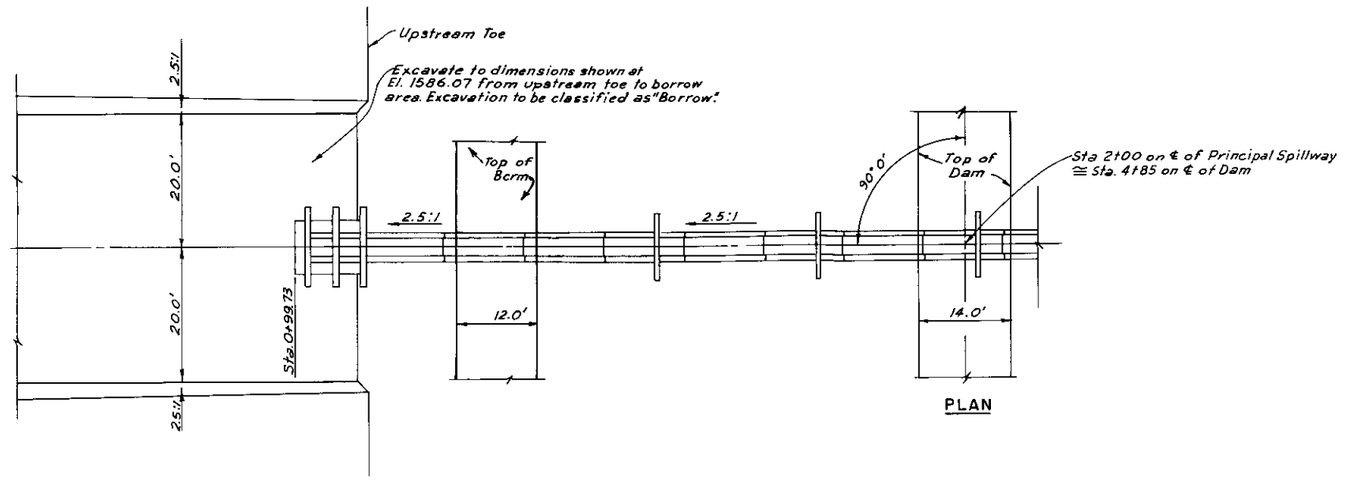


PROFILE ON ℄ OF DAM

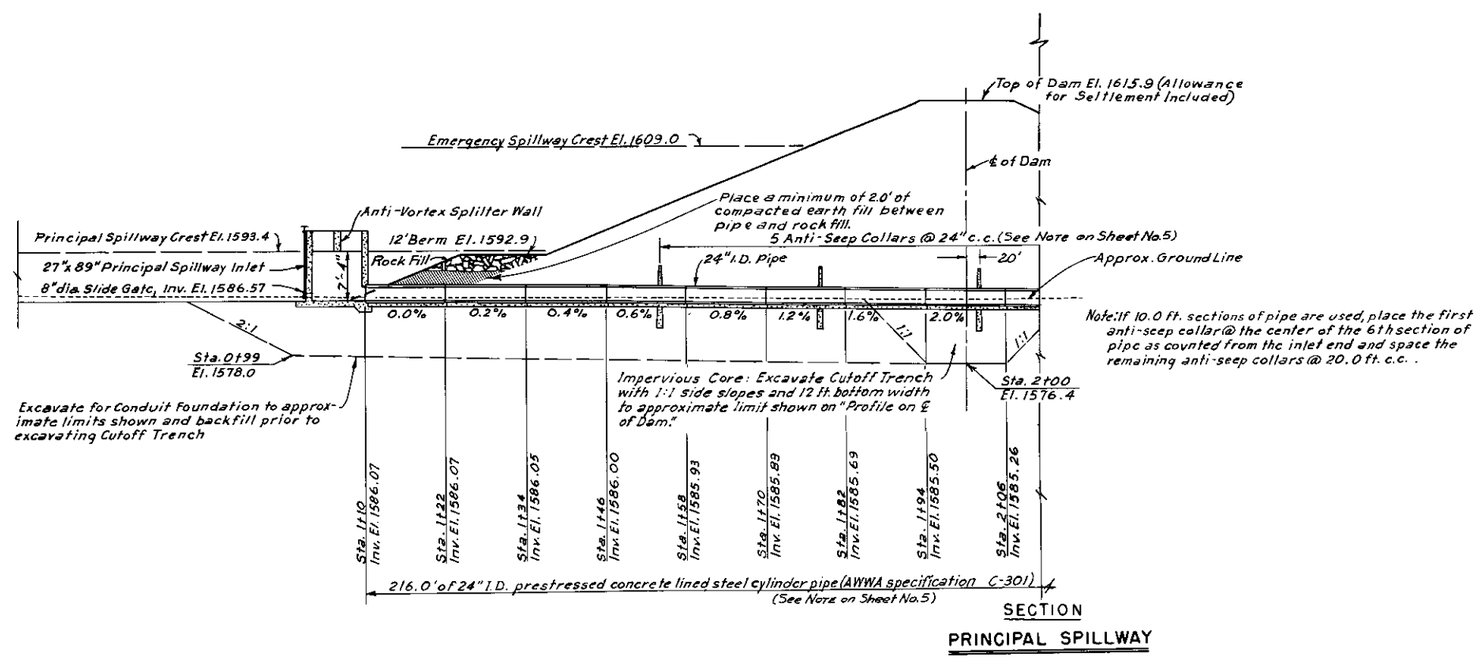
Figure 3
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed M.O.K.	3-61	Approved by	
Drawn M.O.K. & M.G.C.	3-61		
Traced M.G.C.	3-61	Sheet	Drawing No.
Checked M.D.K. & G.W.T.	4-61	No 2 of 10	4-E-15,400



PLAN



SECTION

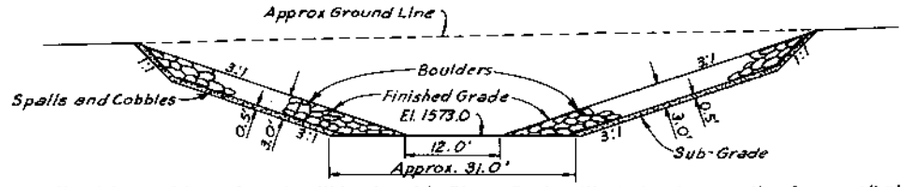
PRINCIPAL SPILLWAY

Figure 3A

TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

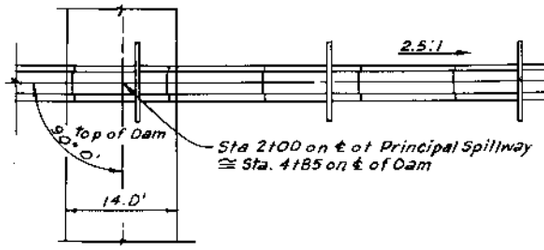
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed M.D.K.	3-61	Approved by: HEAD, ENGINEERING & WATERSHED PLANNING UNIT, FORT WORTH, TEXAS	
Drawn M.D.K. & M.G.C.	3-61	STATE CONSERVATION ENGINEER, S. C. S.	
Traced M.G.C.	3-61	TEMPLE, TEXAS	
Checked M.D.K. & G.W.T.	4-61	Sheet No. 4 of 10	Drawing No. 4-E-15,400

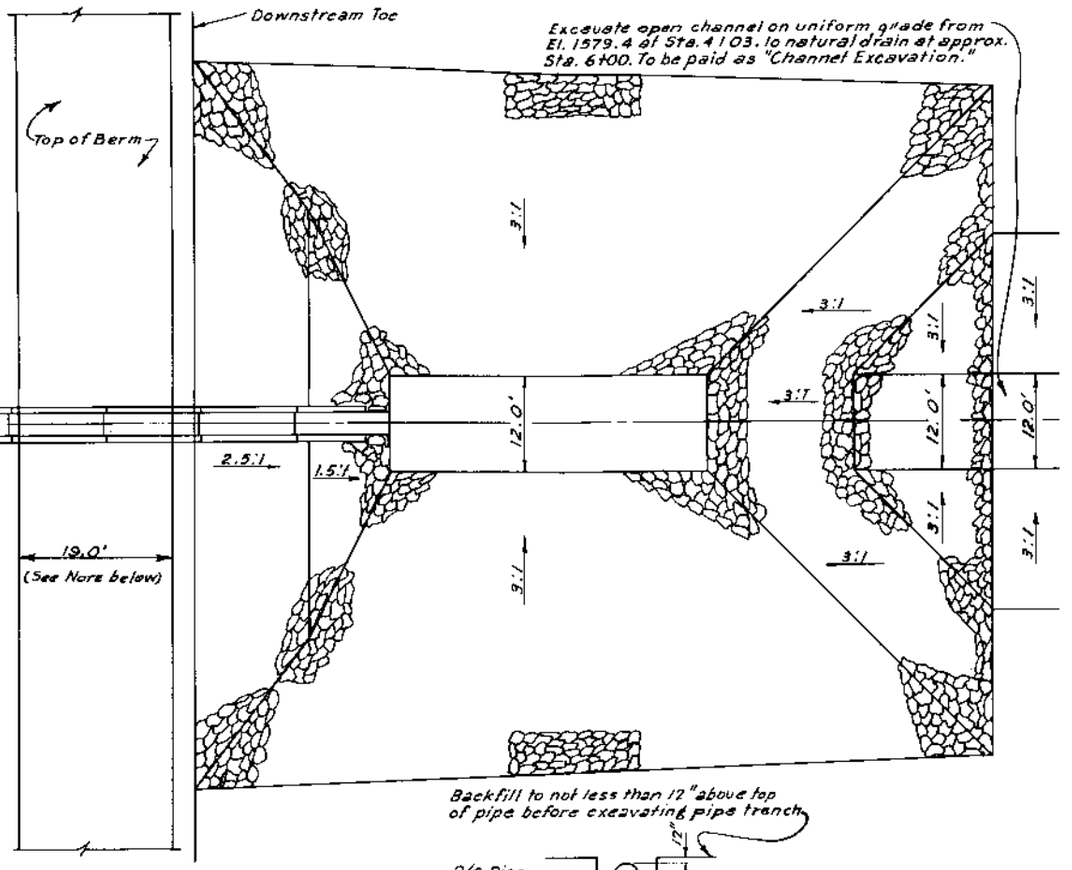


The 2.5 ft. thickness of dumped rock will be placed in Plunge Basin with rock sizes grading from small at sub-grade to large at finished grade. Placement of spalls and cobbles will precede dumping and placement of boulders. Boulders will be placed to reasonable neat lines of the finished grades, as shown on drawings. Cost of excavating and preparing Plunge Basin for placement of rock will be paid as "Channel Excavation". Rock against Principal Spillway will be hand placed to avoid damage to pipe or other structural works. Any damage to pipe or other structural works caused by the Contractor during construction of the Plunge Basin shall be repaired by the Contractor without compensation. Source of rock will be from the Emergency Spillway Excavation. Rock shall be quarry-run size. Placement of the rock in the Plunge Basin is not a direct pay item; such cost is to be considered subsidiary to other items of work. Approximately 560 cu.yd. of rock will be required to construct the Plunge Basin.

TYPICAL SECTION – PLUNGE BASIN

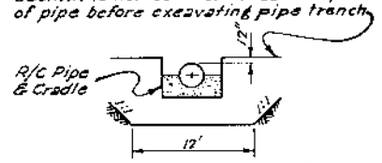


PLAN



Excavate open channel on uniform grade from El. 1579.4 at Sta. 4+03. to natural drain at approx. Sta. 6+00. To be paid as "Channel Excavation."

Backfill to not less than 12" above top of pipe before excavating pipe trench.



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

TYPICAL FOUNDATION EXCAVATION

Impervious Core: Excavate Cutoff Trench with 1:1 side slopes and 12 ft. bottom width to approximate limit shown on "Profile on ℄ of Dam."

Excavate for Conduit Foundation to approximate limits shown and backfill prior to excavating Cutoff Trench

Note: If 10.0 ft. sections of pipe are used, place the first anti-seep collar at the center of the 6th section of pipe as counted from the inlet end and space the remaining anti-seep collars @ 20.0 ft. c.c.

Plunge Basin shall bottom on rock at approx. El. 1573.0 Excavate for plunge so that overall length, width and finished slopes will be as shown on the drawing.

Note: Add 4/1. to all Station points shown for plunge basin if 10.0 ft. sections of pipe are used.

Note: The detail above is planned for 12.0 ft. sections of pipe. Section lengths of 10.0 ft. may be used with inrerl of joints set on grade line as established above, utilizing 220.0 ft. of pipe, ending at station 3+30. Section lengths in excess of 12.0 ft. will not be permited.

SECTION
PRINCIPAL SPILLWAY

Figure 3A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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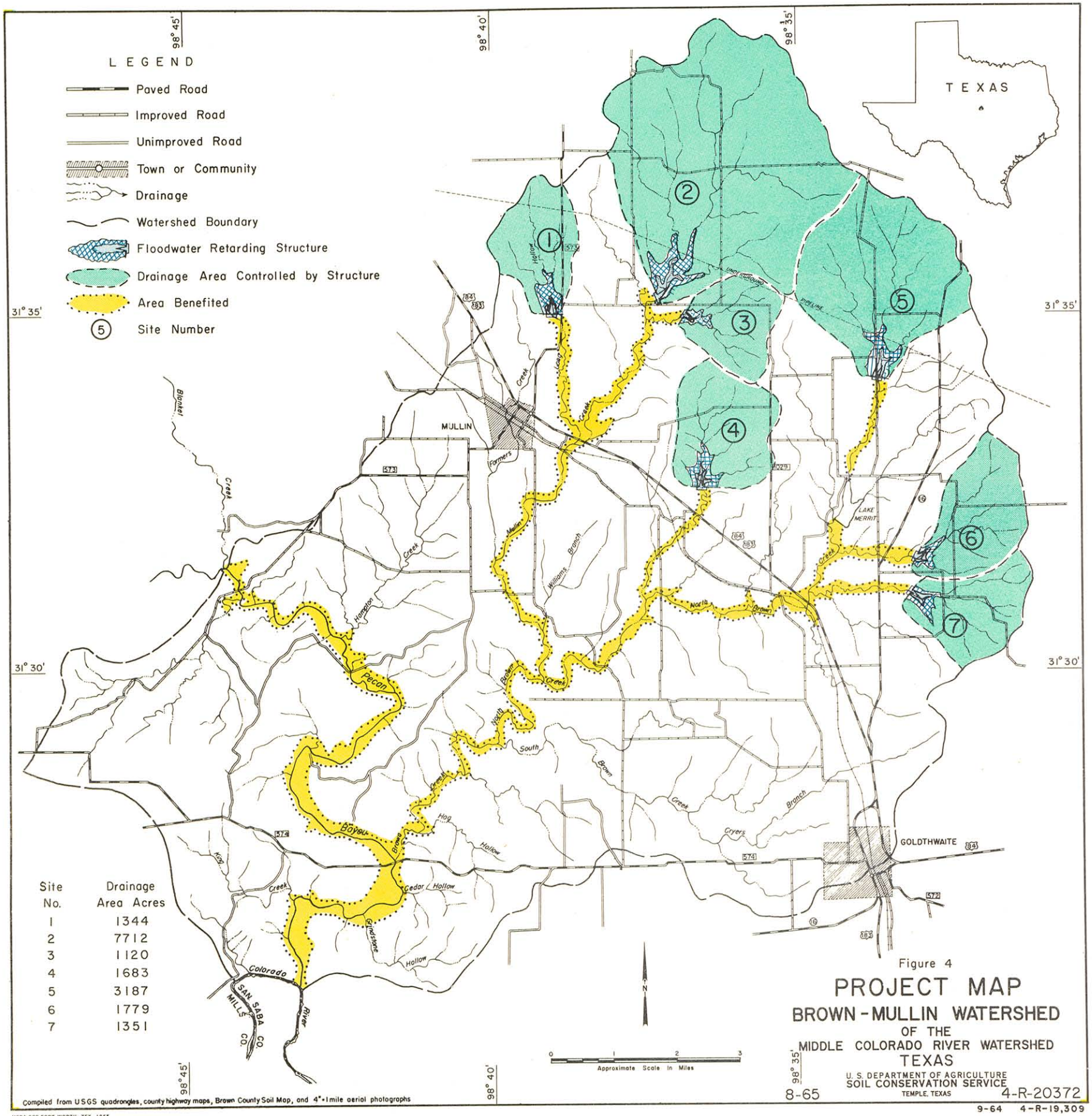

Figure 4

PROJECT MAP

BROWN - MULLIN WATERSHED

OF THE

MIDDLE COLORADO RIVER WATERSHED

TEXAS

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

TEMPLE, TEXAS

8-65 4-R-20372

9-64 4-R-19,309