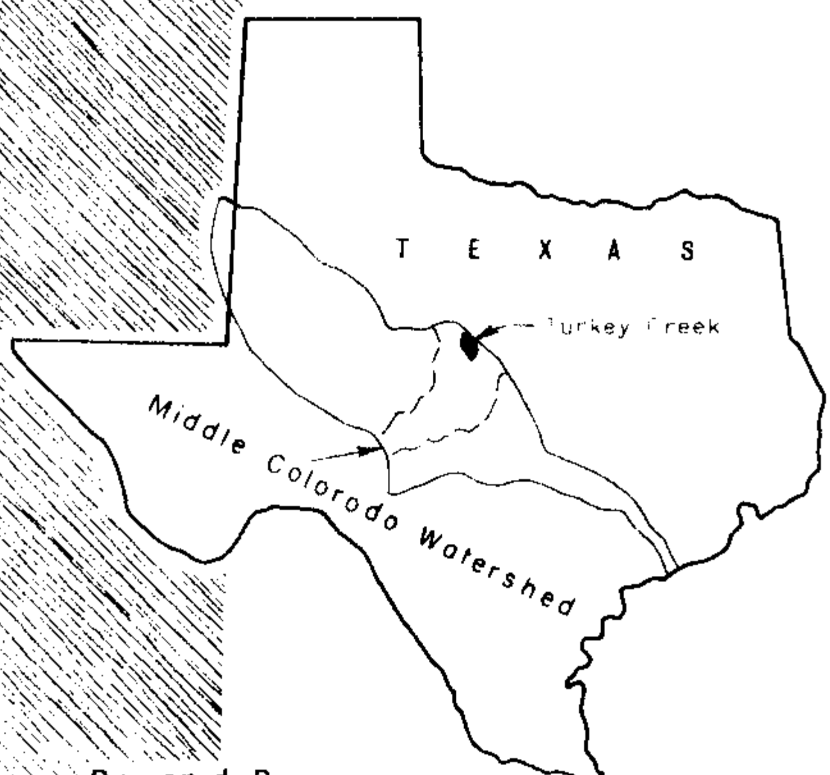
WORK PLAN

TURKEY CREEK WATERSHED

OF THE MIDDLE COLORADO RIVER WATERSHED
CALLAHAN, COLEMAN AND BROWN COUNTIES, TEX.



Prepared By
SOIL CONSERVATION SERVICE
U. S. DEPARTMENT OF AGRICULTURE
Temple, Texas
November 1958

WATERSHED WORK PLAN AGREEMENT

between the

Central Colorado Soil Conservation District
Local Organization
Brown-Mills Soil Conservation District
Local Organization

(Hereinafter referred to as the Districts)

Turkey Creek Conservation District
Local Organization

(Hereinafter referred to as the Water District)

In the State of Texas

and the

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

Whereas, the Districts have 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 Turkey Creek 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 Districts and the Service a mutually satisfactory plan for works of improvement for the Turkey Creek Watershed, State of Texas, hereinafter referred to as the Watershed Work Plan;

Whereas, the Water District will benefit from the carrying out of the plan for works of improvement through the reduction of damages to property, located within the flood plain of the watershed;

It is mutually agreed that in installing and operating and maintaining the Works of Improvement described in the Watershed Work Plan:

1. The Districts and the Water District will acquire without cost to the Federal Government such land, easements, or rights-of-way as will be needed in connection with the Works of Improvement.

2. The Districts will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to State law as may be needed in the installation and operation of the Works of Improvement.

3. The Service will provide all construction costs and installation services applicable to Works of Improvement for flood prevention.

4. The Districts will obtain agreements from owners of not less than 50 percent of the land above each floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.

5. The Districts will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the Watershed Work Plan.

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

7. The Districts Water District 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. No member of or delegate to 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.

Central Colorado Soil Conservation District
Local Organization

By Eldon Knox

Title Chairman

Date August 11, 1959

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

adopted at a meeting held on August 10, 1959

H. W. Milam
(Secretary, Local Organization)

Date August 11, 1959

Brown-Mills Soil Conservation District
Local Organization

By Anson Oden

Title Chairman

Date 8-11-59

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

adopted at a meeting held on 8-11-59

F. S. Lanford
(Secretary, Local Organization)

Date 8-11-59

Turkey Creek Conservation Distict
Local Organization

By [illegible signature]

Title Chairman of Board

DATE Aug 14 1959

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

adopted at a meeting held on Aug 14 - 1959

[illegible signature]
(Secretary, Local Organization)

Date Aug 14 - 1959

County
Local Organization

By

Title

Date

The signing of this agreement was authorized by a resolution of the governing body of the
Local Organization

adopted at a meeting held on

(Secretary, Local Organization)

Date

United States Department of Agriculture
Soil Conservation Service

By H. H. Smith
State Conservationist

Date 11-23-59

M-4-FTW-59

WORK PLAN

TURKEY CREEK WATERSHED
Of the Middle Colorado River Watershed
Callahan, Coleman and Brown Counties, Texas

Plan Prepared and Works of Improvement to be Installed Under the Authority of the Flood Control Act of 1936, as Amended and Supplemented.

Participating Agencies

Central Colorado Soil Conservation District
Brown-Mills Soil Conservation District
Turkey Creek Conservation District

Prepared By:

Soil Conservation Service
U. S. Department of Agriculture
November 1958

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WORK PLAN

TURKEY CREEK WATERSHED
Of the Middle Colorado River Watershed
Brown, Callahan, and Coleman Counties, Texas
November 1958

SUMMARY OF PLAN

Description

Size: 59,200 acres - 92.5 square miles

Land Use:

Cultivation	17,210 acres
Formerly cultivated	3,280 acres
Pasture and range	36,482 acres
Miscellaneous (roads, urban, etc.)	2,228 acres

Flood plain area: 5,188 acres

Soil Conservation Districts: Brown-Mills; Central Colorado

No Federal lands involved.

Flood Frequency:

Total of 79 floods during 20-year period of study (1923 through 1942), of which 29 inundated more than half the flood plain area.

Land Treatment:

Practice	Unit	Applied to Date	Remaining to be Done
Contour Farming	Acre	4,105	1,297
Cover Cropping	Acre	3,229	2,616
Rotation Hay and Pasture	Acre	517	840
Crop Residue Utilization	Acre	6,728	2,625
Proper Use	Acre	21,342	6,849
Deferred Grazing	Acre	2,765	3,547
Range Seeding	Acre	456	325
Brush Control	Acre	6,896	4,900
Terracing	Mile	191	85
Diversion Construction	Mile	14.8	10
Waterway Development	Acre	10	20
Pond Construction	No.	103	31
Pasture Planting	Acre	0	40
Fertilizing	Acre	1,881	2,500

Structural Measures:

Twelve floodwater retarding structures.

Project Cost:

Item	Federal (dollars)	Non-Federal (dollars)	Total (dollars)
Land Treatment	10,860	67,911	78,771
Structural Measures	829,364	64,025	893,389
Work Plan Preparation	19,823	-	19,823
Total	860,047	131,937	991,983

Damages and Benefits:

Item	Without Project (dollars)	With Project (dollars)	Average Annual Monetary Benefits - Structures (dollars)
Floodwater Damage	41,701	8,546	30,520
Sediment Damage	460	175	202
Erosion Damage	1,734	409	1,170
Indirect Damage	4,390	913	3,189
Total	48,285	10,043	35,081
Benefit Outside Project Area			3,539
Changed Land Use			3,409
			42,029

Benefit-Cost Ratio - Structural Measures:

Average Annual Cost - Structures	$33,566
Average Annual Benefit - Structures	42,029
Benefit-Cost Ratio	1.3:1

Operation and Maintenance:

Land Treatment Measures: Central Colorado Soil Conservation District and Brown-Mills Soil Conservation District

Structural Measures: Central Colorado and Brown-Mills Soil Conservation Districts, and Turkey Creek Conservation District.

Annual Cost - $1,834

DESCRIPTION OF WATERSHED

Physical Data

Turkey Creek originates in the southeastern corner of Callahan County, approximately 11.5 miles northwest of Cross Plains, Texas, and flows in a southeasterly direction through Callahan and Brown Counties for about 23 miles. It flows into Pecan Bayou about 4.5 miles south of the town of Cross Cut, Texas. The largest tributaries are Cottonwood and East Turkey Creeks. The watershed ranges from 3 to 6 miles in width. The watershed has an area of 59,200 acres (92.5 square miles), nearly all of which is in farms and ranches.

The topography of the watershed ranges from steep escarpments to a gently rolling plain. The watershed divide is defined by a prominent flat-topped plateau remnant with steep, bluff-like margins incised by the tributaries and headwaters of Turkey Creek. This escarped plateau, which is a part of the Cretaceous outlier extending westward and commonly known as the Callahan Divide, is capped by hard limestone formations of the Fredericksburg group. Sands of the Trinity group lying below the plateau and extending across the central part of the watershed make up a gently to moderately rolling plain. This area is well drained by streams with relatively wide flood plains. The average width of the mainstem flood plain is 1,500 to 2,500 feet in this reach. The portion of the watershed below Cross Plains is made up of several gently rolling minor plains separated by small escarpments formed from erosion resistant limestones and sandstones over thick shales of the Wichita (Permian age) and Cisco (Pennsylvanian age) groups. This area is deeply incised by the tributaries and mainstem of Turkey Creek. The flood plain is confined to a gorge section less than 800 feet wide in the upper and central part of this area and gradually widens out to more than 2,500 feet in the lower reaches. Elevations above mean sea level range from 1,180 feet on the common Turkey Creek - Pecan Bayou flood plain to over 2,100 feet on the upper watershed divide.

Approximately 10 percent of the watershed lies in the Edwards Plateau Land Resource Area. These soils are mostly very shallow, dark colored, fine textured and stony on steep slopes and are used exclusively for rangeland. The sandy soils of the West Cross Timbers Land Resource Area comprise 61 percent of the watershed. These light colored, neutral to slightly acid soils range in surface texture from fine sandy loams to fine sands. Permeability of the subsoils range from slowly permeable to permeable except for small areas of freely permeable deep sands. The dominant soil series are Windthorst, Stephenville and Nimrod. Extensive areas of these soils have suffered severe sheet, wind and gully erosion. The lower 29 percent of the watershed is located in the North Central Prairie Land Resource Area. This area of interbedded shales, limestones and sandstones exhibit an intricate pattern of soil development. Deep, dark colored clay soils developed from the shales predominate. Smaller areas of sandy soils, resembling the West Cross Timbers soils, and stony limestone soils on escarpments have developed on the sandstone and limestone outcrops. The dominant land use is range with some cultivation, principally small grains, on the deeper clay soils.

The soils are generally in fair condition. Legumes, mostly vetch, are interplanted with a high percentage of the small grains grown in the watershed. Crop residue utilization is practiced with varying degrees of effectiveness. Cover crops on cropland used for peanut production lag behind other conservation measures. Unfavorable fall moisture conditions during past years have contributed to this condition.

The watershed lies within the mixed prairie plant group. Range cover is mostly in fair condition with some poor areas in the eroded and formerly cultivated areas in the West Cross Timbers Land Resource Area. Natural recovery on these areas has been slow due to the loss of topsoil and part of the subsoil. There are six range sites in the watershed; Mixed Land site, Rolling Hills site, Deep Hardland site, Sandy site, Sandy Loam site and Bottomland site. The predominant vegetation at the present time consists of sideoats grama, Texas wintergrass, buffalograss, curly mesquite, post oak, mesquite and annual weeds and grasses. The range condition classes of the watershed are as follows: 1 percent, excellent; 6 percent, good, 75 percent, fair; and 18 percent, poor.

The overall land use for the entire watershed is as follows:

Land Use	Acres	Percent
Cultivation	17,210	29
Formerly Cultivated 1/	3,280	5
Pasture and Range	36,482	62
Miscellaneous 2/	2,228	4
Total	59,200	100

1/ Includes cropland retired within the last five years.
2/ Includes roads, highways, towns, etc.

The flood plain, 5,188 acres, is the area that will be inundated by the runoff, 3.60 inches, that can be expected to occur on an average of once in 25 years from s single storm event. At the present time about 44 percent of the flood plain is in cultivation, 54 percent in pasture and 2 percent in miscellaneous uses.

The largest storm that occurred in the 20-year period studied was a 5.49-inch rain that extended over three days and produced 2.29 inches of runoff. This runoff inundated 87 percent of the flood plain.

The mean annual weighted rainfall for the watershed is 27.28 inches. It is well distributed, with the wettest months being May, June, September, and

October. Individual rains causing serious erosion and flood damage may occur in any season, but are most frequent in the spring and fall months. The minimum recorded annual rainfall was 19.36 inches, the maximum 38.64 inches.

Average temperatures range from 84 degrees Fahrenheit in the summer to 46 degrees in the winter. The normal frost-free season of 234 days extends from March 24 to November 13.

Water for livestock and domestic use in the watershed area is obtained from shallow wells and small farm ponds. These wells and ponds provide an adequate water supply. The town of Cross Plains obtains its water supply from shallow wells. These are adequate for present needs but will not support significant expansion.

Economic Data

The economy of the watershed is basically agricultural. The Brown County portion of the watershed is characterized by a predominance of livestock farming. In this area oats and wheat, which are grazed during the winter months and harvested for grain in June, are the predominant crops. The Callahan County part of the watershed is more diversified. Cash cropping, mostly in the form of peanuts, and livestock production, including sheep, cattle and swine, are the most important agricultural enterprises in this area. Feed crops grown in this area include oats, grain sorghums and corn.

Crude oil production is important to the economy of the watershed. Oil leases and royalties have furnished income to supplement that from agriculture and many local residents are employed by oil companies operating in the area.

The average size farm in the watershed in 1950 was 258 acres and has increased presently to 275 acres. Although this acreage is sufficient for an economical unit there are many small uneconomical units located within the Callahan County portion of the watershed. The average value of land and buildings per farm is $15,260 (1954 agricultural census). The most common form of land tenure is the part-owner type -- that is, most of the farmers own a portion of the land that they operate and rent the other part. This type of tenure makes establishment of land treatment measures difficult on the rented land.

Cross Plains, with a population of 1,305, is the largest town in the watershed. It is the initial marketing point for most of the locally produced peanuts and is the center of considerable oil field activity. Cottonwood, population 60, is located in the upper portion of the watershed and contains a post office, a general merchandise store and two churches.

Most of the livestock is marketed in Brownwood, 32 miles south of Cross Plains, and in Abilene, 43 miles northwest of Cross Plains.

The watershed is adequately served by approximately 95 miles of roads, of which 24 miles are paved (State Highways 36, 206, 279 and Farm Road 880). There is one major bridge at Cross Plains on State Highway 36 and nine lesser bridges on the 71 miles of county roads in the watershed. Floods frequently make most of the county roads impassable. The detours thus occasioned cause delay and extra travel distance to and from markets. Adequate rail facilities are available at Abilene and Brownwood.

Status of Conservation Work in the Watershed

The watershed is served by Soil Conservation Service work units at Baird, Coleman and Rising Star, which are assisting the Brown-Mills and Central Colorado Soil Conservation Districts. These work units have assisted farmers and ranchers in preparing 101 soil and water conservation plans on 27,765 acres (49 percent of the agricultural land) within the watershed and in giving technical guidance in establishing and maintaining planned measures. Forty percent of the needed land treatment measures in the watershed have been applied. Where land treatment measures have been applied and maintained as long as three years, average crop and pasture yields have increased by about one-fifth.

WATERSHED PROBLEMS

Floodwater Damage

Floods occur frequently on Turkey Creek and cause severe damage (figure 1). Major floods (floods covering more than one-half of the flood plain) have occurred on an average of more than once a year, the latest one being in October 1957. During the 20-year period 1923-1942, there were 29 major floods and 50 minor floods. Fifty-six percent of the floods occurred in the spring, causing severe damage to growing crops and delaying the unplanted crops until after the optimum planting dates. The largest storm in the flood series occurred on October 12-14, 1930. This flood covered about 4,477 acres of the flood plain.

The town of Cross Plains is partially located in the flood plain of Turkey Creek. In October 1957, seven city blocks were flooded. Floodwater entered three homes and one business house, causing extensive damage to furniture, floors and foundations. Boats were used to evacuate people from their homes.

The estimated direct floodwater damages for the October 1957 flood are as follows:

1. Crop and Pasture	$ 10,469
2. Other Agricultural	23,095
3. Nonagricultural (roads, bridges, urban)	11,093
Total	$ 44,657

Figure 1
PROBLEM LOCATION MAP
TURKEY CREEK WATERSHED
SUB-WATERSHED OF THE MIDDLE COLORADO RIVER
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

REFERENCE
CARTOGRAPHIC APPROVAL TECHNICAL APPROVAL
COMPILED TRACED CHECKED DATE

Feb 9, 1959 4-R-13088

For the floods experienced during the 20-year period studied, the total direct agricultural and nonagricultural floodwater damages under present conditions were estimated to average $41,701 annually at long-term price levels, of which $21,554 is crop and pasture damage, $14,233 is other agricultural damage, and $5,914 is nonagricultural such as damage to roads, bridges and urban property. Indirect damages such as interruption of travel, extra travel over re-routed school bus and mail routes, losses sustained by dealers and industries in the area, and similar losses are estimated to average $4,390. The average annual monetary flood damages are summarized in table 5.

Erosion Damage

Upland erosion rates in this watershed are moderate. About 62 percent of the area is in rangeland, 29 percent is cultivated land, and 5 percent is formerly cultivated land that has been idle for less than 5 years. The rangeland is generally in fair condition except for small areas of poor cover on severely eroded lands. The cropland has had approximately 45 percent of the needed conservation measures applied. The use of small grain and small grain and vetch plantings on 48 percent of the cropland has reduced erosion rates considerably. Cover on the formerly cultivated lands consists mostly of annual weeds. Of the total estimated sediment production under present conditions, 96 percent is derived from sheet erosion, 1 percent from gully erosion and 3 percent from channel enlargement.

Floodwater and erosion damages are severe in the Turkey Creek Watershed.

Damages of this type amount to about $14,000 annually.

State Highway 36 at Cross Plains following the October, 1957 flood.

Flood plain scour damages an average of 308 acres annually, with damages ranging from 15 to 90 percent of the productive capacity of the soil. The average annual amount of this damage is estimated to be $1,734 under present conditions. Total land damage from channel erosion is small and consists mostly of small isolated areas located throughout the watershed.

Sediment Damage

Sediment damage in this watershed consists primarily of deposition on the flood plain and the contribution of sediment to Lake Brownwood on Pecan Bayou.

Approximately 11 percent of the flood plain has been damaged by sediment. Fine sandy loam and loamy sand deposits up to 4 feet deep have affected a total of 578 acres as follows: 418 acres, damaged 10 percent; 111 acres, damaged 20 percent; and 49 acres, damaged 40 percent. These deposits are low in organic matter and fertility. However, productivity of these areas can be restored through intensive treatment in a short period of time or through natural recovery over a longer period if flooding is eliminated or greatly reduced. The amount of these damages is estimated to be $460 annually under present conditions. Deposition in the channels in the upper and central parts of the watershed has greatly reduced channel capacities and increased flooding and flood damage.

Of the total sediment produced in the Turkey Creek drainage area under present conditions it is estimated that 35 acre-feet will be delivered annually to Lake Brownwood, which impounds water to within 9 miles of the mouth of the watershed. This sediment damage to the reservoir is estimated to be $1,686 annually.

Other damages, such as recreational losses from sediment damage, are recognized. Silt and muddy waters destroy the spawning grounds of fish and adversely affect game fish population more than the less desirable rough fish. Monetary evaluations of these damages were not used for project justification.

Problems Relating to Water Management

There is very little activity relative to drainage or irrigation in the watershed. There is no interest in providing additional storage in any of the floodwater retarding structures for irrigation, municipal water supply or recreation. Needs for water management for fish and wildlife resources and pollution abatement are minor and do not warrant a study at this time.

EXISTING OR PROPOSED WORKS OF IMPROVEMENT

Efforts to prevent or to control flooding on agricultural lands in the watershed have been minor. Some attempts at enlarging, straightening and leveeing of stream channels have been made on an individual basis, with very little effect on the reduction of flood damages.

A reservoir was built in 1932 by the city of Cross Plains on a tributary of Turkey Creek approximately 5 miles north of town. This structure has a drainage area of 704 acres and a capacity of 325 acre feet, or 5.54 inches, of storage capacity between its normal pool level and spillway elevation. The spillway has never functioned since completion of this structure. Therefore, in the development of this work plan the area above this structure was considered as non-contributing.

Lake Brownwood, located on Pecan Bayou with the upper extremity about 9 miles below the mouth of Turkey Creek, was constructed in 1932. Damages to it by deposition of sediment originating from the Turkey Creek drainage area have been calculated under present and future conditions and the benefits accruing to the project have been considered in project justification.

The Central Colorado and Brown-Mills Soil Conservation Districts have been very active in establishing land treatment measures and in initisting flood prevention work. Through these efforts, a high degree of participation in this program by the farmers, ranchers, and other interested parties in the watershed has been achieved. Land treatment measures installed before the development of this flood prevention work plan are listed in table 1A.

WORKS OF IMPROVEMENT TO BE INSTALLED

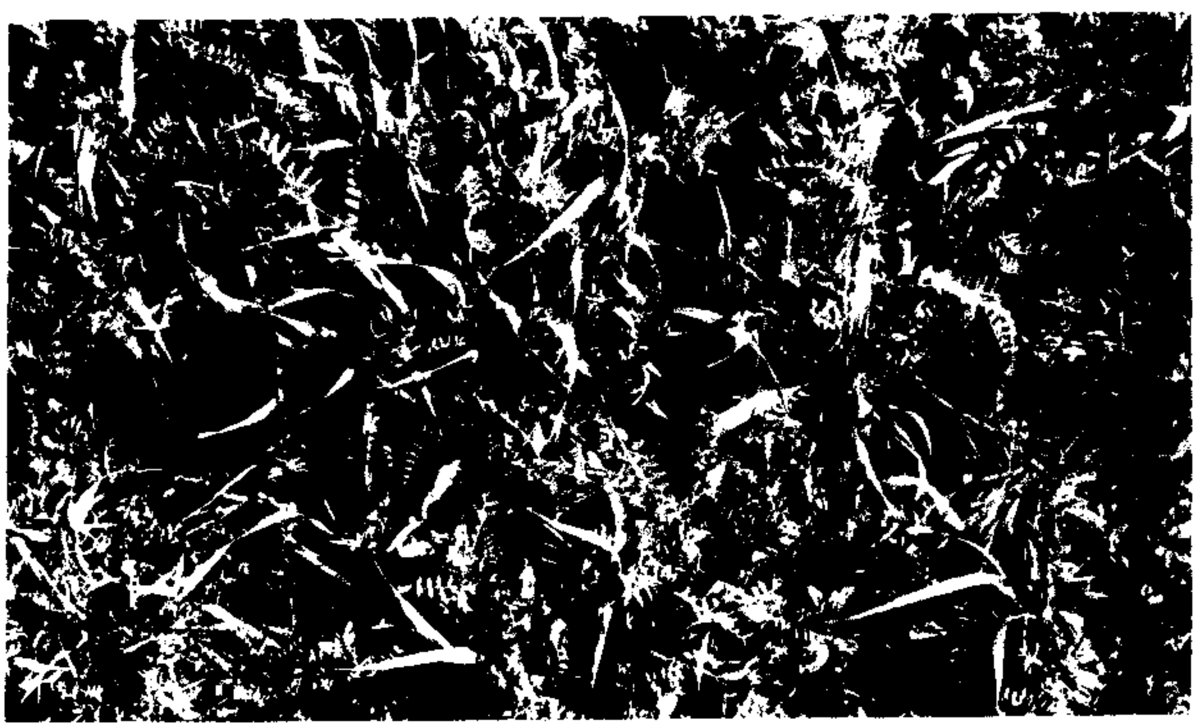
Land Treatment Measures

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 Central Colorado and Brown-Mills Soil Conservation Districts, is necessary for a sound flood prevention program on the watershed. Basic to reaching this objective is the establishment and maintenance of all applicable soil and water conservation and plant management practices essential to proper land use. Emphasis will be placed on accelerating the establishment of those land treatment practices which have a measurable effect on the reduction of floodwater and sediment damages.

Approximately 32,538 acres of the total watershed area of 59,200 acres lie above planned floodwater retarding structures. Land treatment is especially important for protection of these watershed lands tc support and supplement the structural measures. There are another 21,474 acres of upland in the waterahed for which no structural control has been planned and for which establishment of land treatment constitute the only planned measures in this plan. Land treatment measures on the 5,188 acres of flood plain are also important in reducing floodwater and flood plain scour damages.

The amounts and estimated cost of establishing the needed measures that will be installed by landowners and operators are shown in table 1. The estimated cost of planning and installing these measures, exclusive of

Range seeding and proper use makes old fields productive again.



Vetch and oats make an excellent winter cover crop.

expected reimbursement from ACPS or other Federal funds, is $67,911, based on current program criteria. In addition, prior to work plan preparation, landowners and operators have established land treatment measures at an estimated non-Federal cost of $111,267 (table 1A). Also prior to work plan preparation, $3,600 of Federal funds were used for the acceleration of technical assistance by the Soil Conservation Service to landowners and operators. This acceleration of technical assistance will be continued during the period of installation at a cost of $10,860.

The total estimated conservation needs of the watershed is shown in table 1B.

Most of the land treatment measures will function principally to decrease erosion damage to fields and pastures by providing improved soil-cover conditions. These measures include cover cropping, use of rotation hay and pasture, crop residue utilization for croplands and proper use and deferred grazing to provide improvement, protection and good maintenance of grass stands on the rangelands. They also include brush eradication to allow grass stands to improve for replacement of the poor cover afforded by brushy pastures; the construction of farm ponds to provide adequate numbers and locations of watering places to prevent cover-destroying, seasonal concentrations of livestock; and range seeding to establish good cover on grassland. These measures, especially the cropland measures and range seeding and pasture planting, also effectively improve soil conditions which allow larger amounts of rainfall to soak into the soil.

In addition to the above soil improvement and cover measures, land treatment includes contour farming, terracing, fertilizing, diversion construction and waterway development to serve these measures, all of which have a measurable effect in reducing peak discharge by reducing the velocity of runoff water from fields. These measures also help the soil improvement and cover measures to reduce erosion damage and sediment yield.

Structural Measures

A system of 12 floodwater retarding structures will be installed in the watershed to afford the needed protection to flood plain lands that cannot be provided by land treatment measures alone. The structures will temporarily detain the runoff from 50.84 square miles of drainage area, or 55 percent of the watershed, from a storm that can be expected to occur on an average of once in 25 years. Storage in individual sites will range from 3.50 to 4.00 inches of runoff from their watersheds. The total of 10,360 acre feet of detention capacity provided by the 12 structures is sufficient to detain 3.82 inches of runoff from the area above structures, or the equivalent of 2.10 inches from the entire watershed.

Due to the relatively flat terrain at site 6 limiting the amount of storage that could be developed, it was necessary to locate sites 4 and 5 above site 6 in order to reduce the amount of storage required and still maintain the desired level of protection.

Figure 2 shows a section of a typical floodwater retarding structure.

Land, easements and rights-of-way for the floodwater retarding structures will be provided by local interests at no cost to the Federal Government.

The value of these sites, together with the cost of relocating roads, pipe lines and utilities, is estimated to be $64,025, based on current market values furnished by the local organizations. The total area of the sediment pools is 295 acres, of which 39 acres are flood plain lands.

There are four low water crossings in the watershed that will be affected by the release flow from the principal spillways of the floodwater retarding structures. Under present conditions water flows through 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. The Commissioners Courts of Brown and Callahan Counties will install culverts or other improvements needed to keep the crossings passable during periods of floodwater release at no cost to the Federal Government.

The locations of the floodwater retarding structures are shown on the Planned Structural Measures map, figure 3. The total estimated cost of establishing these works of improvement is $893,389, of which $64,025 will be borne by local interests and $829,364 by Flood Prevention funds.

Floodwater retarding structures release water slowly following heavy rains.

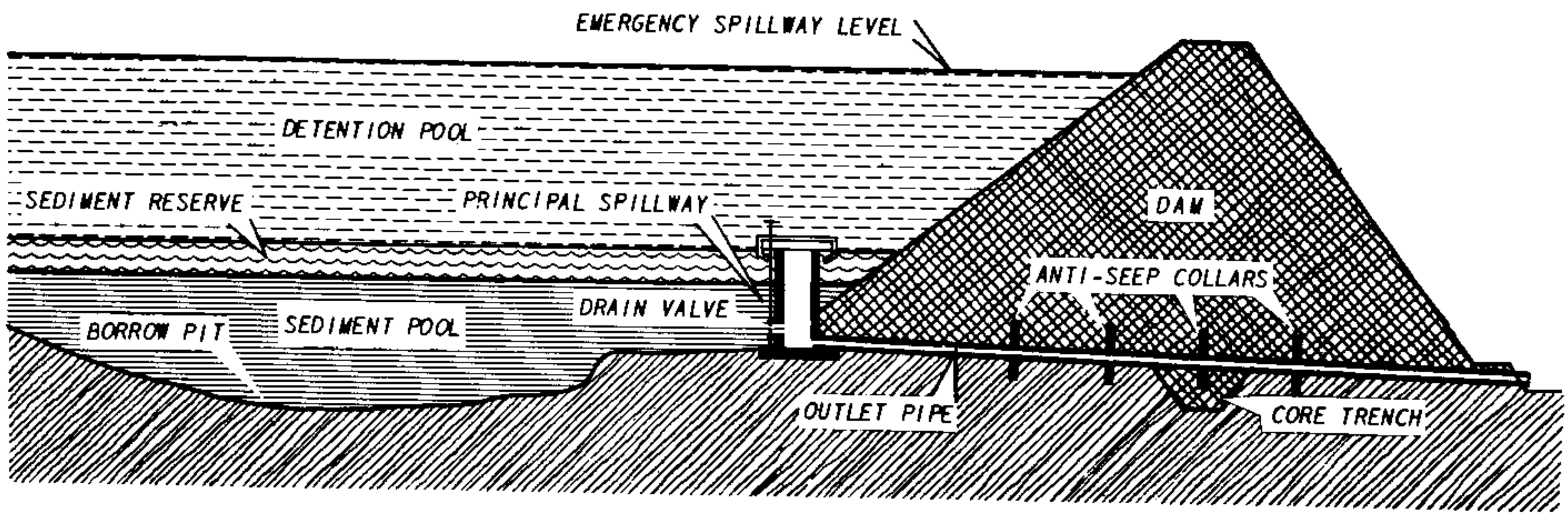


Figure 2
SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

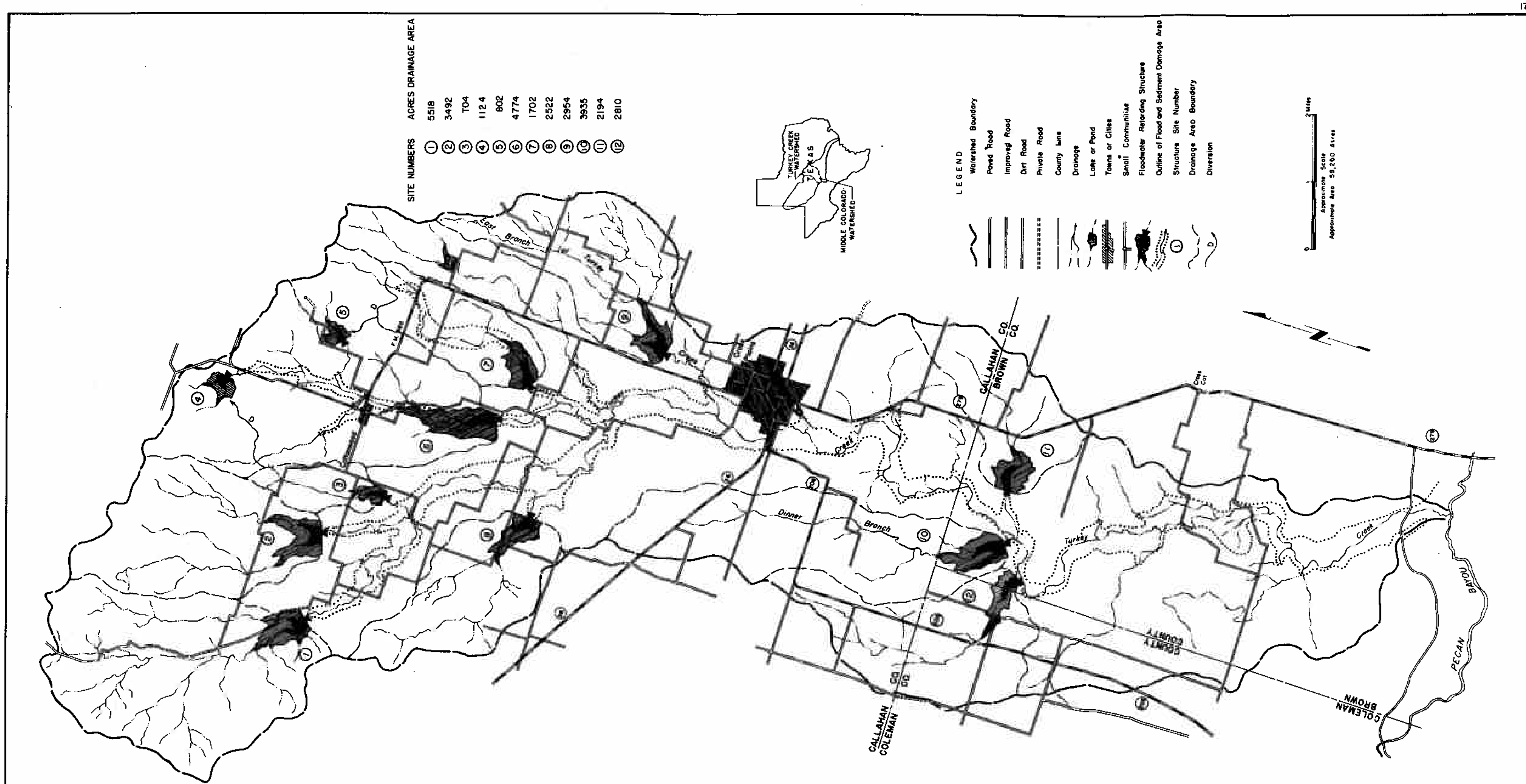


Figure 3
PLANNED STRUCTURAL MEASURES MAP
TURKEY CREEK WATERSHED
SUB-WATERSHED OF THE MIDDLE COLORADO RIVER
U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE TEXAS

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BENEFITS FROM WORKS OF IMPROVEMENT

The general location of the benefits from the combined program of land treatment and structural measures is presented in the following table:

	Evaluation Reach (figure 1)				
	1	2	3	4	Total
Average Annual Area Flooded					
Without Project - Acres	1,932	3,462	433	164	5,991
With Project - Acres	691	1,081	234	106	2,112
Percent Reduction	64.23	68.78	45.96	35.37	64.75
Area Flooded by Largest Storm					
Without Project - Acres	1,480	2,380	352	265	4,477
With Project - Acres	1,160	1,340	276	220	2,996
Percent Reduction	21.62	43.70	21.59	16.98	33.08
Average Annual Damages					
Without Project - Dollars	15,794	29,795	1,219	1,477	48,285
With Project - Dollars	4,036	4,663	459	885	10,043
Percent Reduction	74.45	84.35	62.35	40.08	79.20

The evaluation storm series for the period 1923 through 1942 contained 79 storms which would cause flooding under present conditions at the valley cross section having the least channel capacity. The following table shows a comparison with and without the project for each evaluation reach, the inches of runoff when damage starts, the number of storms in the evaluation series which caused floodwater damage and the number which inundated more than half of the flood plain in each reach:

	Evaluation Reach (figure 1)			
	1	2	3	4
Inches of Runoff When Damage Starts				
Without Project	.09	.02	.02	.06
With Project	.30	.09	.07	.07
Number of Floods in Evaluation Series				
Without Project	63	79	79	68
With Project	32	52	61	61
Number of Major Floods in Evaluation Series				
Without Project	28	29	15	9
With Project	9	5	8	6

The estimated average annual floodwater, erosion, sediment and indirect damage within the watershed would be reduced from $48,285 to $10,043, a 79 percent reduction. Approximately 92 percent, $35,081, of the expected reduction in the average annual damage will result from the system of floodwater retarding structures.

Owners and operators of flood plain lands say that if adequate flood protection is provided, they will restore land now in Johnsongrass meadow, idle or poor pasture to cultivation. All of this land was in cultivation at one time but is now used chiefly for hay or pasture because of the frequency of flooding. Landowners further indicated that if flooding is reduced they will be able to increase yields through better production practices and more extensive use of fertilizers. It is estimated that the average net income from such restoration will amount to $5,724 (long-term price levels) annually. This loss from the original production has been considered a crop and pasture damage and its restoration a benefit in table 5.

It is also expected that landowners will convert some pastureland to cropland, which will result in an additional $3,409 increase in net average annual income.

Average annual benefits of $2,700 will accrue to the planned structural measures in the watershed from reduction of damages on the mainstem of Pecan Bayou below the mouth of Turkey Creek. Benefits in the amount of $839 annually will be derived from the reduction of sediment damage to the Brownwood reservoir.

The total flood prevention benefits, as a result of structural measures, are estimated to be $42,029 annually.

COMPARISON OF BENEFITS AND COST

The annual equivalent cost of structural measures (converted from total installation cost) plus the annual operation and maintenance cost is estimated to be $33,566. When the project is completely installed, it is expected to produce average annual benefits of $42,029. The project, therefore, will produce $1.25 for each dollar of cost. Other substantial values will accrue from the project, such as increased opportunity for recreation, improved wildlife habitat and a sense of security, which have not been used for project justification.

ACCOMPLISHING THE PLAN

Federal assistance for carrying out the works of improvement, as described in this work plan, will be provided under the Soil Conservation Act of 1935 (Public Law No. 46, 74th Congress), the Flood Control Act of June 22, 1936 (Public Law No. 738, 74th Congress) and the Flood Control Act of December 22, 1944 (Public Law No. 534, 78th Congress, 2nd Session).

Land Treatment Measures

Land treatment measures itemized in table 1 will be established by farmers in cooperation with the Central Colorado and Brown-Mills Soil Conservation Districts during the 5-year project installation period. The cost of applying these measures will be borne by the owners and operators of the land. It is expected that the owners and operators will be reimbursed for a portion of this cost through the existing Agricultural Conservation Program or other Federal programs. The amount of reimbursement to be expected 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. The soil conservation districts are giving assistance in the planning and application of these measures under its going program. This assistance will be continued to assure application of the planned measures within the 5-year installation period of the project.

The governing bodies of the two soil conservation districts will arrange for meetings according to a definite schedule. 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 the existing arrangements for equipment usage in the districts. The district governing bodies will make periodic inspections of the completed conservation measures within the districts and follow through to see that needed maintenance is performed.

The Soil Conservation Service work units at Baird, Coleman and Rising Star will assist landowners and operators cooperating with the districts in accelerating the preparation of soil and water conservation plans and the application of conservation practices.

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

The soil and water conservation loan program of the Farmers Home Administration will be made available to all eligible individual farmers and ranchers 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 ASC Committees will cooperate with the governing bodies of the soil conservation districts by selecting and recommending financial assistance for those ACPS practices which will accomplish the conservation objectives in the shortest possible time.

Structural Measures for Flood Prevention

The Soil Conservation Service will contract for the construction of the 12 floodwater retarding structures. It will also provide technical specialists to plan, design, prepare specifications, supervise construction, prepare contract payment estimates, make contract payments, make final inspections, certify completion, and perform related duties for the installation of these structural measures.

The Central Colorado and Brown-Mills Soil Conservation Districts in cooperation with the Callahan County Water Control and Improvement District No. 2 and the Turkey Creek Conservation District will furnish the land, easements, rights-of-way and arrange for road and utility changes for all the structural measures at no cost to the Federal Government.

Since the entire watershed is one hydrologic unit and all structures are needed to secure the desired reduction in damages no attempt was made to separate the watershed into construction units. This will necessitate securing all necessary easements and rights-of-way prior to the expenditure of Federal funds for construction in the watershed.

The cooperating parties have agreed on a 3-year installation period for the structural measures. The estimated schedule of obligation for the complete 5-year project installation period, including installation of both land treatment and structural measures, is as follows:

Fiscal Year	Structure Numbers	Federal Funds	Non-Federal Funds	Total
		(dollars)	(dollars)	(dollars)
1st	1, 2, 3, 4, & 5	377,252	33,812	411,064
2nd	10,11, & 12,	188,830	29,032	217,862
3rd	6, 7, 8, & 9	269,798	41,928	311,726
4th		3,258	20,373	23,631
5th		1,086	6,791	7,877
Total		840,224	131,936	972,160

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 the light of appropriations and accomplishments actually made.

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

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be maintained by the landowners or operators of the farms and ranches on which the measures are installed under agreements with the Central Colorado and Brown-Mills Soil Conservation Districts. Representatives of the soil conservation districts will make periodic inspections of the land treatment measures to determine management and maintenance needs and to encourage landowners and operators to perform the management practices and maintenance needs. They will make district-owned equipment available for this purpose.

Structural Measures

The 12 floodwater retarding structures will be operated and maintained jointly by the Central Colorado and Brown-Mills Soil Conservation Districts, and the Turkey Creek Conservation District. The Central Colorado Soil Conservation District will be responsible for the operation of the 9 structures in Callahan County, and the Brown-Mills Soil Conservation District will have the responsibility of the operation of the three in Brown County. Maintenance of the 12 structures in the Turkey Creek watershed will be the responsibility of the Turkey Creek Conservation District.

All floodwater retarding structures will be inspected by representatives of all cosponsoring organizations at least annually and after each heavy rain or stream flow. A Soil Conservation Service representative will participate in these inspections at least annually. Items of inspection will include, but not be limited to, the conditions of the principal spillway and its appurtenances, the emergency spillway, the earthfill, the vegetative cover of the earthfill and emergency spillway and fences and gates installed as a part of the floodwater retarding structures. The sponsoring local organizations will maintain a record of the inspection and maintenance work performed and have it available for review by Soil Conservation Service personnel.

Maintenance work generally will be performed by contract or force account. Funds for this work will be provided by the Turkey Creek Conservation District, which has legal authority to raise funds, as set forth in maintenance agreements executed prior to the letting of contracts for construction of the structural works of improvement. The estimated operation and maintenance cost is $1,834 (based on long-term price levels). Provisions will be made for free access of representatives of the cosponsoring organizations and the Federal Government to inspect the 12 floodwater retarding structures and their appurtenances at any time.

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

CONFORMANCE OF PLAN TO FEDERAL LAWS AND REGULATIONS

The installation of the watershed protection and flood prevention project on the Turkey Creek watershed will make a substantial contribution to the over-all development of Pecan Bayou.

This project plan conforms to all Federal laws and regulations and will have no known detrimental effects on existing downstream projects or any that might be constructed in the future.

SECTION 2

INVESTIGATIONS, ANALYSES, AND SUPPORTING TABLES

INVESTIGATIONS AND ANALYSES

Land Treatment

Soil Conditions, Land Use and Treatment Needs

Soil Conditions and land use on the upland were determined by expanding a 20 percent random sample of the watershed to the entire upland area. The land use of the flood plain was determined by planimetering the flood plain strip map which was developed during the economic investigations.

The current conservation needs were secured from the records of the Central Colorado and Brown-Mills Soil Conservation Districts.

Cover Conditions and Range Sites

Cover conditions and range sites were determined from information secured by a 20 percent random sampling of the watershed and from available range surveys.

Program Determination

Determination was made, first, of the needed land treatment measures which contribute directly to flood prevention remaining to be done in the watershed, based on range condition classes and land capability classes developed from soil surveys. The hydraulic, hydrologic, geologic and economic investigations provided data on the effects of these measures as related to reduce sediment and flood damages resulting from such treatment. Although significant benefits would result from application of these 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.

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

1. A base map of the watershed was prepared showing the watershed boundary, drainage pattern, system of roads and railroads, and other pertinent information. A stereoscopic study of 4-inch consecutive aerial photographs located all probable floodwater retarding structure sites, the limits and the area of the flood plain, and points where valley cross sections should be taken for the determination of hydraulic

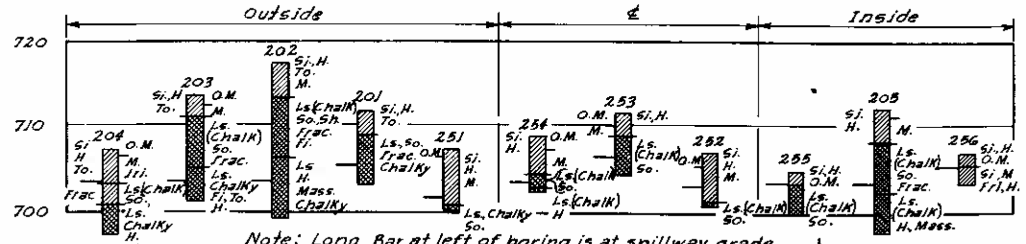
characteristics and for flood routing purposes. This information was placed on the watershed base map for use in field surveys.

2. 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. 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.

3. A field examination was 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 relocating could not be economically justified, were dropped from further consideration. From the remaining sites a system of floodwater retarding structures 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 4 and 4A.

4. A topographic map was made of the pool area of each of the proposed sites in order to determine the storage capacity of the sites, the estimated cost of the dam and the areas of flood plain and upland that would be inundated by the sediment and flood pools. Sediment storage requirements were determined for each site through a study of the physical and vegetative conditions of the drainage area above that site. Spillway widths, depths of flow, embankment yardage, and volumes of rock excavation in spillways were computed for each structure starting with the storage volume needed to detain temporarily a minimum of 3.50 inches of runoff and to provide the additional capacity needed for sediment. The inches of runoff to be stored was then increased by increments to determine the amount of storage that would result in the most economical structure. The minimum storage was determined from criteria as set forth in Soil Conservation Service, Washington Engineering Memorandum No. 27, and Section 2404, Texas State Manual.

   The limits of the flood pools and sediment pools of all satisfactory sites and the flood plain of the stream were drawn to scale on a copy of the base map. Structure



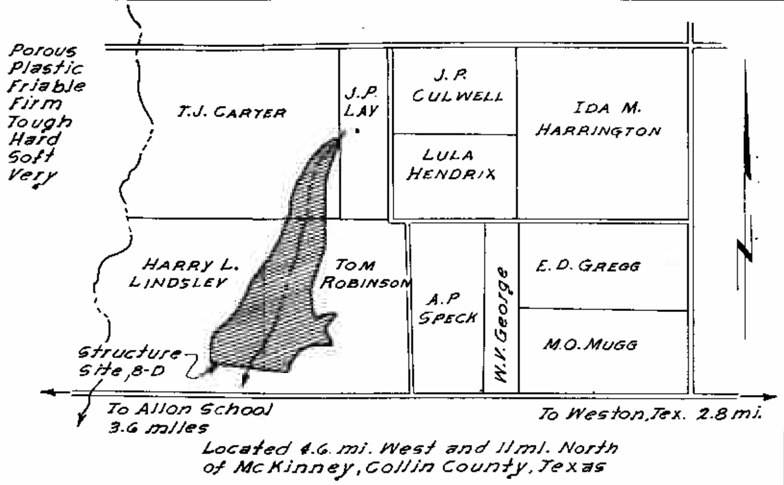
LOG OF SPILLWAY BORINGS

SEE PLAN OF EMBANKMENT AND SPILLWAY

LEGEND OF BORINGS

Clay
Stone

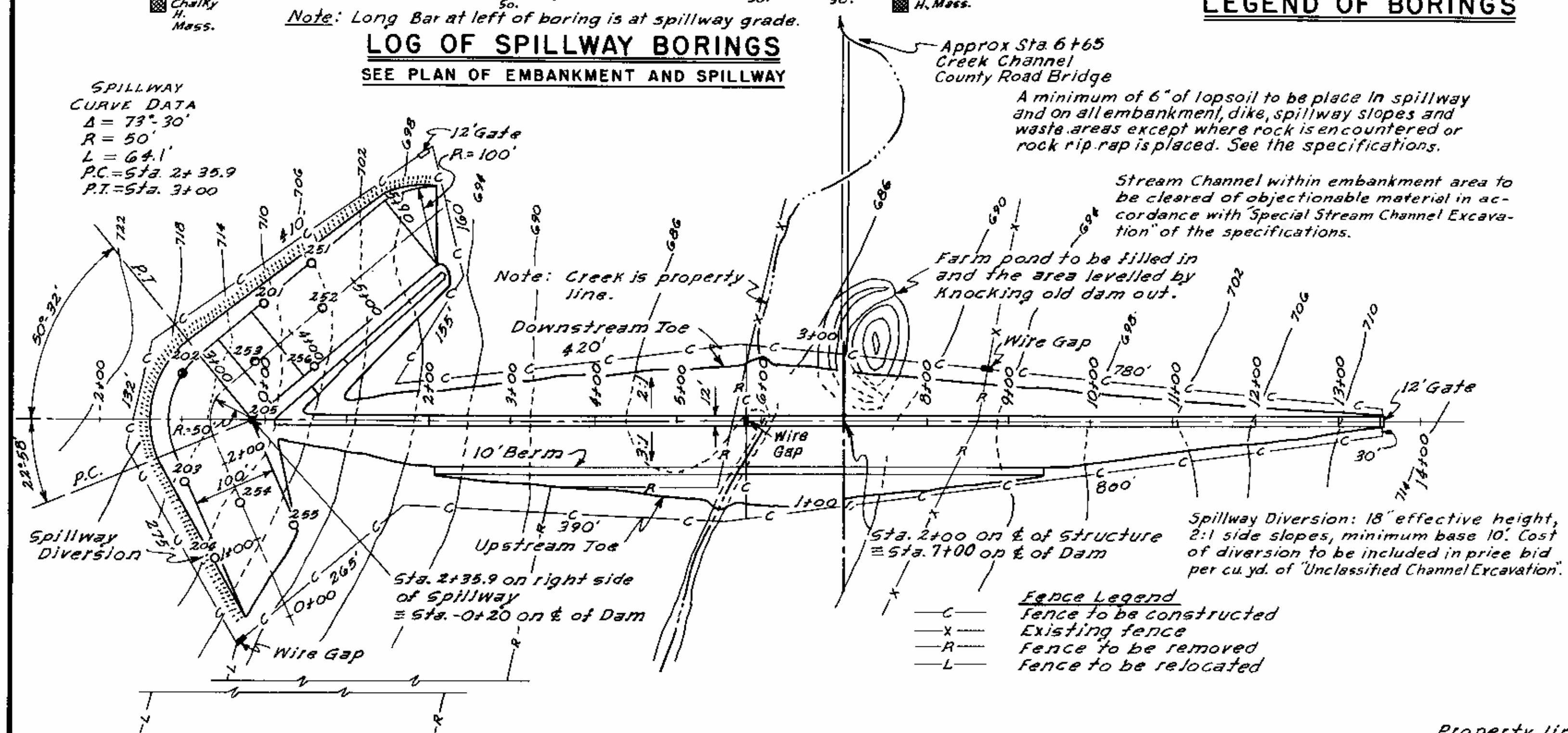
Ch.	Chalk	Chalky
Si.	Silt	Silty
Gr.	Gravel	Gravelly
M.	Marl	Marly
O.M.	Organic Matter	
C.C.	Calcium Carbonate	
Com.	Compact	
Ls.	Limestone	
Mass.	Massive	
Con	Concretions	
Por.	Porous	
Pl.	Plastic	
Fri.	Friable	
Fi.	Firm	
To.	Tough	
H.	Hard	
So.	Soft	
V.	Very	



Located 4.6 mi. West and 1 mi. North of McKinney, Collin County, Texas

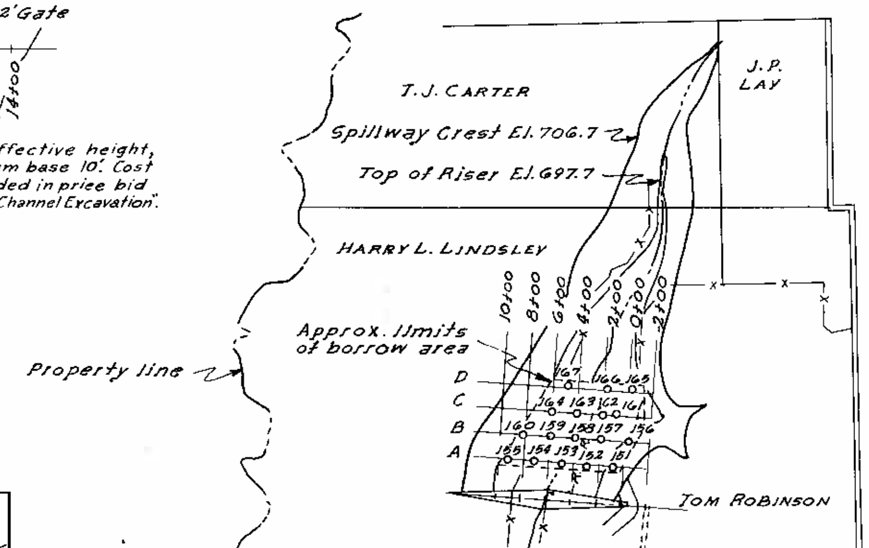
VICINITY MAP

0 1/4 1/2 1
SCALE IN MILES



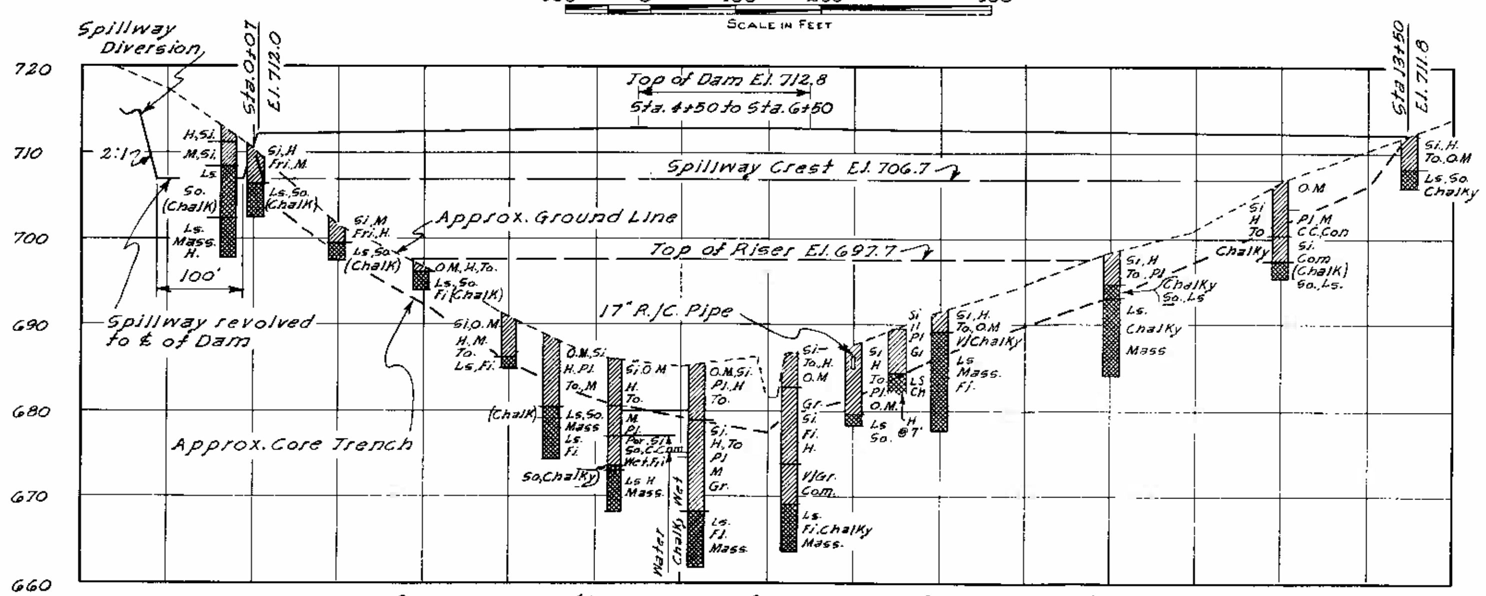
PLAN OF EMBANKMENT AND SPILLWAY

100 0 100 200 400
SCALE IN FEET



GENERAL PLAN OF RESERVOIR

660 0 660 1980
SCALE IN FEET



PROFILE ON ℄ OF DAM

Elevation	Surface Acres	Storage Acre Ft.	Storage Inches
694.0	18.0	64.0	.82
697.7	30	154.0	1.98
698.0	31.0	162	2.08
698.3	35.6	172	2.20
702.	45	314	4.03
706	63	530	6.79
706.7	67	576	7.38
710	85	826	10.59

Top of Dam (Effective) Elev.	711.8
Spillway Crest Elev.	706.7
Top of Riser Elev.	697.7
Sediment Pool Elev.	698.3
Drainage Area, Acres	936.0
Sediment Storage, Ac. Ft.	172.0
Floodwater Storage, Ac. Ft.	422.0

NOTICE

CHANGES MADE DURING CONSTRUCTION ARE NOT SHOWN ON THESE DRAWINGS.
FOR "AS BUILT" CHANGES, SEE PRINTS ON FILE IN CARTOGRAPHIC UNIT, FORT WORTH, TEXAS.

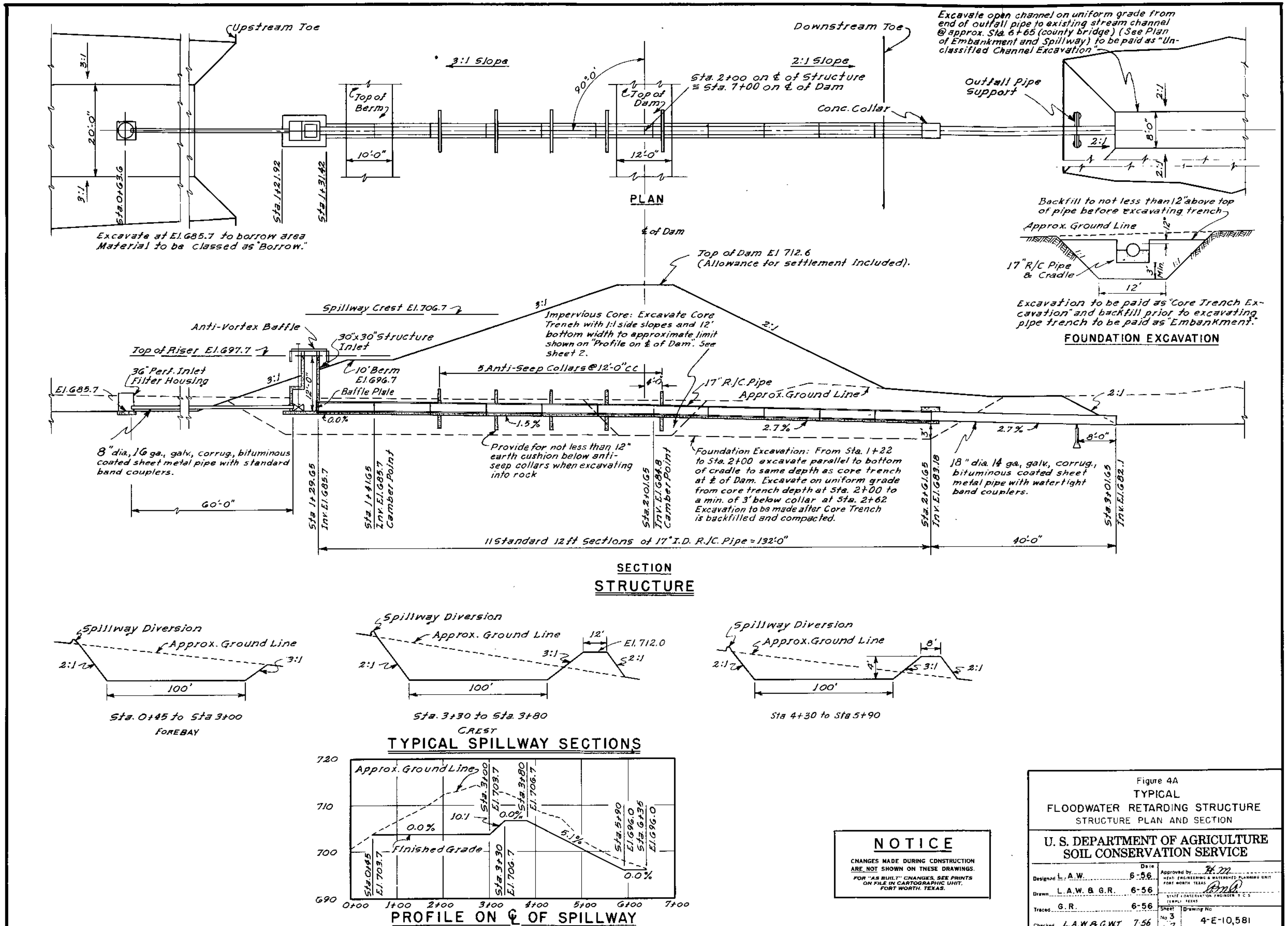
Figure 4
TYPICAL
FLOODWATER RETARDING STRUCTURE
PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	L.A.W.	6-56
Drawn	L.A.W. & G.R.	6-56
Traced	G.R.	6-56
Checked	L.A.W. & G.W.T.	7-56

Approved by
HEAD ENGINEERING & WATERSHED PLANNING UNIT FORT WORTH TEXAS
STATE CONSERVATION ENGINEER F.C.S. TEMPLE TEXAS

Sheet No 2 of 7
Drawing No 4-E-10,581



Upstream Toe
3:1 Slope
2:1 Slope
Downstream Toe
Excavate open channel on uniform grade from end of outfall pipe to existing stream channel @ approx. Sta. 6+65 (county bridge) (See Plan of Embankment and Spillway) to be paid as "Unclassified Channel Excavation".
Top of Berm
Top of Dam
Sta. 2+00 on ℄ of Structure = Sta. 7+00 on ℄ of Dam
Conc. Collar
Outfall Pipe Support
20'-0"
10'-0"
12'-0"
8'-0"
Sta. 0+63.6
Sta. 1+21.92
Sta. 1+31.42
Excavate at El. 685.7 to borrow area Material to be classed as "Borrow."
PLAN
℄ of Dam
Backfill to not less than 12" above top of pipe before excavating trench
Approx. Ground Line
17" R/C Pipe & Cradle
Excavation to be paid as "Core Trench Excavation" and backfill prior to excavating pipe trench to be paid as "Embankment."
FOUNDATION EXCAVATION
Top of Dam El. 712.6 (Allowance for settlement included).
Spillway Crest El. 706.7
Impervious Core: Excavate Core Trench with 1:1 side slopes and 12' bottom width to approximate limit shown on "Profile on ℄ of Dam". See Sheet 2.
Anti-Vortex Baffle
30"x30" Structure Inlet
Top of Riser El. 697.7
36" Perf. Inlet Filter Housing
El. 685.7
10' Berm El. 696.7
Baffle Plate
5 Anti-Seep Collars @ 12'-0" c.c.
17" R/C Pipe
Approx. Ground Line
8" dia., 16 ga., galv., corrug., bituminous coated sheet metal pipe with standard band couplers.
Provide for not less than 12" earth cushion below anti-seep collars when excavating into rock
Foundation Excavation: From Sta. 1+22 to Sta. 2+00 excavate parallel to bottom of cradle to same depth as core trench at ℄ of Dam. Excavate on uniform grade from core trench depth at Sta. 2+00 to a min. of 3' below collar at Sta. 2+62. Excavation to be made after Core Trench is backfilled and compacted.
18" dia. 14 ga., galv., corrug., bituminous coated sheet metal pipe with watertight band couplers.
60'-0"
Sta. 1+29.65 Inv. El. 685.7
Sta. 1+41.65 Inv. El. 685.7 Camber Point
Sta. 2+01.65 Inv. El. 684.8 Camber Point
Sta. 2+61.65 Inv. El. 683.18
Sta. 3+01.65 Inv. El. 682.1
11 Standard 12 ft Sections of 17" I.D. R/C Pipe = 132'-0"
40'-0"
SECTION
STRUCTURE
Spillway Diversion
Approx. Ground Line
100'
Sta. 0+45 to Sta. 3+00 FOREBAY
El. 712.0
Sta. 3+30 to Sta. 3+80 CREST
Sta. 4+30 to Sta. 5+90
TYPICAL SPILLWAY SECTIONS
Approx. Ground Line
Finished Grade
10:1
0.0%
5.1%
Sta. 0+45 El. 703.7
Sta. 3+00 El. 703.7
Sta. 3+30 El. 706.7
Sta. 3+80 El. 706.7
Sta. 5+90 El. 696.0
Sta. 6+36 El. 696.0
PROFILE ON ℄ OF SPILLWAY
NOTICE
CHANGES MADE DURING CONSTRUCTION ARE NOT SHOWN ON THESE DRAWINGS.
FOR "AS BUILT" CHANGES, SEE PRINTS ON FILE IN CARTOGRAPHIC UNIT, FORT WORTH, TEXAS.
Figure 4A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed L.A.W. 6-56
Drawn L.A.W. & G.R. 6-56
Traced G.R. 6-56
Checked L.A.W. & G.W.T. 7-56
Sheet No. 3 of 7
Drawing No. 4-E-10,581

data tables were developed to show, for each structure, the drainage area, the storage capacity needed for floodwater detention and sediment, storage in acre-feet and in inches of runoff from the drainage areas, the release rate of the principal spillway, the emergency spillway widths and depths of flow, maximum height of dams, the acres inundated by the sediment and detention pools, the volume of fill in the dams, and the estimated cost of the structures (tables 2 and 3).

5. Damages resulting from floodwater, sediment and erosion were determined from damage schedules and surveys of sample areas. Reduction in these damages resulting from the proposed works of improvements were estimated on the basis of reduction of peak discharges, stages, and volumes 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 future conditions assuming that all proposed works of improvement had been installed. Benefits so determined were allocated to individual measures or groups of interrelated measures on the basis of the effect of each on reduction of damages. In this manner it was determined that floodwater retarding structures could be economically justified. By further analysis those individual floodwater retarding structures and interrelated structures which had favorable benefit-cost ratios were determined. Those which were unfavorable were dropped from further consideration and, where replacements were found to be necessary to effect needed control, alternate sites were investigated until a system of floodwater retarding structures was developed which would give maximum net benefits and the degree of control needed. These works were included in the plan.

When the land treatment measures and the structural measures for flood prevention had been determined, a table was developed to show the total cost of each type of measure. The summation of the total costs of all needed 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 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 meteorologic and hydrologic data were tabulated from Climatological Bulletins, United States Weather Bureau and Water Supply Papers, United States Geological Survey, and locally recorded records and

analyzed to determine average precipitation depth-duration relationships, seasonal distribution of precipitation, the frequency of occurrence of meteorological events to be used in the evaluation of the project, rainfall-runoff relationships, runoff-peak discharge relationships, and the relationship of geology, soils and climate to runoff depth frequency for single storm events.

2. Engineering surveys were made to collect information on selected stream reaches, including valley cross sections, channel capacities, high water elevations of selected storms, bridge capacities, and other hydraulic characteristics, and on proposed floodwater retarding structure sites to collect data used in design. These cross sections and evaluation reaches were selected on the ground in conference with the economist and sedimentation specialist.

3. Determination was made of the present hydrologic conditions of the watershed, taking into consideration such features as soils, land use, topography, cover and climate. Future hydrologic conditions were determined by obtaining from the Work Unit Conservationist 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 this soil-cover complex data and used with figure 310-1, Soil Conservation Service, National Engineering Handbook, Section 4, Supplement A, to determine depth of runoff from individual storms.

4. Determination was made of the rainfall-runoff relationship. This was then compared to actual gaged runoff from nearby similar watersheds. The frequency of meteorologic events was determined by computing the plotting positions of historical series 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. (Pages 3.18-1-24, NEH, Section 4, Supplement A).

5. Rating curves for the cross sections were computed by solving water surface profiles for various selected discharges. (Doubt method, Pages 3.14-7-13, NEH, Section 4, Supplement A and NEH, Section 5, Supplement A).

   Stage-area inundated curves were developed for each cross section.

6. Determination was made of peak discharges under present conditions, as related to area inundated and damages caused by various amounts of runoff.

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

   a. Effect of land treatment measures.

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

   c. Consideration of alternative programs and measures.

8. Structure classifications were determined and emergency spillway design storm inflow hydrographs were developed for all structure sites. Spillway widths and depths of flow were determined by the Goodrich graphical routing method. (Washington Engineering Memorandum No. 27; NEH, Section 4, Hydrology, Supplement A; NEH, Section 5, Hydraulics; Section 2404, Texas State Manual).

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

The largest rain which occurred during the 20-year period was a storm of 5.49 inches. An average rain of this magnitude would produce the equivalent of 2.29 inches of runoff at section (T-0), after adjustment for transmission loss. Under present conditions, 4,477 acres of flood plain would be flooded by runoff from this storm. If such a rain were to occur after land treatment practices and measures had been applied, it is estimated that the area inundated would be reduced to 4,404 acres. With land treatment measures applied and the structural measures for flood prevention in operation, only 2,996 acres would be flooded.

It was determined that 0.02 inch of runoff was the minimum volume that would cause flooding to a depth of six inches at the smallest channel cross-section. Therefore, no storms producing less than 0.02 inch of runoff were considered for flood-routing purposes. This amount of runoff would be produced by 1.75 inches of rainfall under Moisture Condition I, 0.85 inch under Moisture Condition II, and 0.30 inch under Moisture Condition III. Runoff of 0.02 inch would produce a discharge of 75 cubic feet per second at the minimum cross section (T-28A) and 200 cubic feet per second at the reference section (T-0). The minimum cross section is located about 5.0 miles northwest of Cross Plains, Texas. The reference cross section is located approximately 0.45 mile north of the confluence of Turkey Creek and Pecan Bayou (figure 1).

The channel capacity at the reference section is 1,825 cubic feet per second. The peak discharge at this point for a 5.49-inch rain under present conditions is estimated to be 23,020 cubic feet per second. After installation and full functioning of all the planned measures on the Turkey Creek watershed, the discharge at the same point would be reduced to 9,850 cubic feet per second.

The runoff produced by a 13.50-inch point rainfall in a period of six hours as determined from the Moisture Condition Curve No. II was used to develop the inflow hydrographs for emergency spillway design. The width and depth of the emergency spillway was determined by graphically routing these hydrographs through each structure.

Sedimentation Investigations

The field surveys of the sedimentation problems in the watershed were made in accordance with methods prescribed in the "Sedimentation Section of Procedures for Developing Flood Prevention Work Plans", Water Conservation-6, SCS, Region 4, Revised February, 1954. Field studies to locate areas of damaging overbank deposits and damaging scour on the flood plain and to determine extent of streambank erosion were made at many points along the length of the channels. Since this watershed lies above Lake Brownwood, a prediction of the annual sediment yield from the watershed under both present and future conditions was made. Data from detailed erosion studies made on watersheds above five planned floodwater retarding structure sites were expanded to the total watershed area to compute total annual gross erosion.

Existing delivery rate curves were used in estimating sediment yield to the mouth of the watershed. Data from the detailed sedimentation survey of Lake Brownwood in 1940 by the Soil Conservation Service was used to estimate the amount of sediment that would be delivered to the reservoir. Consideration was given to the general relationship of this watershed to the total drainage area above Lake Brownwood. In preparation of the work plan, tabular summaries of all the above findings, with explanatory text, were prepared and were used by the economist as a basis for calculating monetary damages.

Sediment Source Areas

Estimates of sediment storage requirements in the planned floodwater retarding structures were based on detailed sediment source surveys above representative floodwater retarding structures in the watershed. The sediment production rates thus determined were then applied to the other sites and adjusted for drainage area size. The sediment production derived from sheet erosion was estimated by the use of the method shown in "Suggested Criteria for Estimating Gross Sheet Erosion and Sediment Delivery Rates for the Blackland Prairies Problem Area in Soil Conservation", SCS, Region 4, February, 1953. The amount of sediment derived from gully and streambank erosion was estimated by field studies, use of aerial photographs, and by interviews with local people who were able to furnish important information to the survey. Estimates of rates of sediment production were made for the areas above and below structures to estimate the present and future sediment yield at the mouth of the watershed. Based on these studies the total annual sediment yields above the 12 planned floodwater retarding structures were estimated to be 30.3 acre-feet from sheet and gully erosion and 0.8 acre-foot from channel enlargement. The estimated average annual production of sediment above structures is 0.68 acre-foot per square mile.

Effect of Watershed Treatment on Sediment Yields

Cultivated land and poor rangeland of the West Cross Timbers Land Resource Area produce most of the sediment in the watershed. The application of land treatment measures planned for installation during the next 5-year application period will be effective in reducing the annual rate of sediment production by an estimated 18 percent. The application of all needed land treatment measures would effect a reduction of 47 percent in the annual rate of sediment production.

The installation of planned structural measures and land treatment measures will protect the areas now being damaged by scour and overbank deposition and greatly reduce future rates of damage.

Geological Investigations

Preliminary geologic dam site investigations were made at each of the 12 planned floodwater retarding structure sites. These studies included inspections of valley slopes, alluvium, channel banks, and exposed geologic formations. Borings with a hand auger were made to determine the nature and extent of fill material that might be encountered in construction.

Description of Problems

Sites 1 through 9 are located in the Paluxy sand formation, which represents the Trinity group of the Cretaceous period in this watershed. This formation consists of sand, sandstone and thin seams of sandy limestone. Complete cutoff trenches to prevent leakage under the embankments probably will not be practicable and may necessitate foundation drains or placement of coarser materials in the downstream toe of the dam. Spillway excavation volumes will generally be small and volume of rock excavation, if encountered, will be small. Removal of vegetation and topsoil in spillways will expose very erodible material; however, the re-establishment of protective vegetation will not be difficult. Borrow materials for embankment are ample but will be varied and will require selection, placement and mixing for embankment use.

Sites 10, 11 and 12 are located in the limestone, shale, and sandstone formations of the Moran and Pueblo groups of Permian age. Sites 10 and 12 are not expected to have any major problems in construction. However, since the embankment of site 12 will be subject to backwater from floods on the mainstem, a rock fill on the back slope will be necessary for the safety of the dam. The embankment of site 11 extends across relatively steep escarpments of hard, irregularly bedded limestone that will require some shaping and sloping. Rock excavation is also expected in the spillway of this site, but the total volume will be small. Satisfactory embankment material will be available above all sites.

Detailed investigations, including exploration with core-drilling equipment, will be made at all floodwater retarding structure sites prior to their construction. Laboratory tests will be made to determine the suitability of the available embankment and cutoff wall material.

Economic Investigations

Basic methods used in the economic investigation and analysis are outlined in the Interim Economics Guide issued May 14, 1956.

Determination of Annual Benefits from Reduction in Damages

Agricultural damage estimates were based upon schedules obtained in the field covering approximately 65 percent of the flood plain of Turkey Creek and its tributaries. These schedules covered land use, crop distribution under normal conditions, crop yields and historical data on flooding and flood damage.

Most of the flood damage information obtained was for floods which occurred in 1957.

Analysis of this information formed the basis for determining damage rates for various depths and seasons of flooding. In calculating crop and pasture damage, expenses saved, such as costs of harvesting, were deducted from the gross value of the damage.

The proper rates of damages were applied, flood by flood, to the floods covering the historical period 1923 to 1942, and an adjustment was made to take into account the effect of recurrent flooding when several floods occurred within one year. The flood plain land use was mapped in the field. Normal yields were based on data obtained from the schedules supplemented by information obtained from agricultural workers in the area.

It was found that significant differences in land use, yields, frequency of flooding and degree of future use are sufficient to divide the flood plain into four evaluation reaches. A different damageable value was used for each reach.

The locations of the evaluation reaches are (figure 1):

Reach 1 - from confluence of Turkey Creek and Pecan Bayou to valley cross section 14A.

Reach 2 - from valley cross section 14A to structure site Nos. 1, 2, 3, 6, 7, 8 and 9.

Reach 3 - from structure site No. 6 to structure site Nos. 4 and 5.

Reach 4 - from site 7 to where damage begins below the diversion to site 5.

Estimates of damages to other agricultural property such as fences, livestock, and farm equipment were made from analysis of flood damage schedules.

The monetary value of the physical damage to the flood plain from erosion and from deposition of sediment was based on the value of the production lost, taking into account the lag in recovery of productivity and for the cost of farm operations to speed recovery. Damage from erosion was related to depth of flooding, giving greater weight to deeper flows.

Estimates of damages to roads and bridges in the flood plain were obtained from county commissioners and from the state highway district maintenance engineers. These estimates were supplemented by information obtained from local farmers.

Indirect damages in this watershed primarily involve extra farming expense, such as additional travel time for farmers and costs for extra feed; re-routing school bus transportation and mail delivery; and interruption of utility service. Upon analysis, it appeared that these damages are about 10 percent of the direct damage for all evaluation reaches.

Farmers in the flood plain were asked to state changes made in land use as a result of past flooding. This information, together with landowners and operators estimates of future changes in land use and crop distribution as a result of reduction in flood extent and frequency was the basis for estimating benefits from changed land use and restoration of productivity. These estimated benefits were divided between intensification and restoration of productivity based upon farm by farm analysis. Benefita from restoration of productivity are included as crop and pasture benefits. They involve changes in crop distribution, increased yields due to earlier dates of planting, wider use of fertilizers and lower cost of tillage. Consideration waa given to increased damage after restoration of productivity and the added damage was deducted. Among the factors considered in this analysis were the size and location of the areas affected, land capability, acreage allotment restrictions, existence of available markets and reduction in frequency of flooding. It is not expected that acreages of crops subject to acreage allotments will be increased as a result of the project.

All benefits from flood plain land use changes and restoration of productivity are net benefits remaining after production and harvest costs, additional costs for taxes and overhead, and clearing costs where applicable.

All benefits from changed flood plain land use were discounted to provide for either a five-or ten-year lag in accomplishment.

Benefits in Reach 1 were allocated by drainage area controlled and by proximity of the structures to valley cross section 0. Benefits in Reach 2 were distributed to all floodwater retarding structures above Reach 1 on the basis of drainage area controlled by each structure. Benefits occurring in Reach 3 were allocated to structures four and five on the basis of drainage area controlled and all benefits accruing in Reach 4 were allotted to structure No. 5.

Flood plain areas which will be inundated by the aediment and detention pools were excluded from the damage and benefit calculations. An estimate was made, however, of the value of the production lost in these areas after installation of the program. In this appraisal it was considered that there would be no production in the sediment pools, and that the land covered by the detention pools would continue to be used as pasture after installation of the program.

The cost of land, easements and rights-of-way for the 12 floodwater retarding structures was determined by individual appraisal. This evaluation was based on full value for the sediment pools and half value for the detention pools, since the latter will remain in use as pasture.

The average annual loss in production within the structure sites was compared with amortized value of easements. The easement value was found to be the greater and therefore was used in economic justification to assure a conservative benefit-cost analysis.

Determination of Benefits Outside of the Watershed

Benefits from the reduction of damage on the mainstem of Pecan Bayou were estimated from benefits in watersheds having similar flood plain land use. Analysis of these data indicated that benefits of about $0.261 would accrue for each acre foot of detention storage. The straight-line depreciation method was used in evaluating the benefits that are derived from reduction of sediment damage to the Brownwood reservoir.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Turkey Creek Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1957

Project 1/

Item	Unit	Number to be Applied	Estimated Cost 2/ Federal (dollars)	Non-Federal (dollars)	Total (dollars)
LAND TREATMENT FOR:					
Watershed Protection					
Soil Conservation Service					
Contour Farming	Acre	1,297	-	1,621	1,621
Cover Cropping	Acre	2,616	-	10,340	10,340
Rotation Hay and Pasture	Acre	840	-	2,520	2,520
Crop Residue Utilization	Acre	2,625	-	2,625	2,625
Proper Use	Acre	6,849	-	3,300	3,300
Deferred Grazing	Acre	3,547	-	870	870
Range Seeding	Acre	325	-	1,625	1,625
Brush Control	Acre	4,900	-	24,500	24,500
Terracing	Mile	85	-	6,800	6,800
Diversion Construction	Mile	10	-	1,510	1,510
Waterway Development	Acre	20	-	300	300
Pond Construction	No.	31	-	7,800	7,800
Pasture Planting	Acre	40	-	100	100
Fertilizing	Acre	2,500	-	4,000	4,000
Technical Assistance(Accel.)			10,860	-	10,860
SCS Subtotal			10,860	67,911	78,771
TOTAL LAND TREATMENT			10,860	67,911	78,771
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Struc.	No.	12	637,973	-	637,973
Subtotal - Construction			637,973	-	637,973
Installation Services					
Soil Conservation Service					
Engineering Services			115,994	-	115,994
Other			75,397	-	75,397
Subtotal - Installation Services			191,391	-	191,391
Other Costs					
Land, Easements, and R/W			-	57,625	57,625
Legal Fees			-	6,400	6,400
Subtotal - Other			-	64,025	64,025
TOTAL STRUCTURAL MEASURES			829,364	64,025	893,389
WORK PLAN PREPARATION COST			19,823	-	19,823
TOTAL PROJECT			860,047	131,936	991,983
SUMMARY					
Total SCS			860,047	131,936	991,983
TOTAL PROJECT			860,047	131,936	991,983

1/ At time of work plan preparation; does not include prior expenditures of flood prevention funds or accomplishments resulting therefrom (see table 1A).
2/ Excludes cost that will be reimbursed from other Federal funds.
NOTE: There are no Federal lands in this watershed.

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TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
Turkey Creek Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1957

Prior to November 1958

Item	Unit	Number Applied	Estimated Cost Federal 1/ (dollars)	Estimated Cost Non Federal 2/ (dollars)	Total (dollars)
LAND TREATMENT FOR:					
Watershed Protection					
Soil Conservation Service					
Contour Farming	Acre	4,105	-	5,131	5,131
Cover Cropping	Acre	3,229	-	14,320	14,320
Rotation Hay and Pasture	Acre	517	-	1,551	1,551
Crop Residue Utilization	Acre	6,728	-	6,728	6,728
Proper Use	Acre	21,342	-	10,163	10,163
Deferred Grazing	Acre	2,765	-	1,554	1,554
Range Seeding	Acre	456	-	2,280	2,280
Brush Control	Acre	6,896	-	27,584	27,584
Terracing	Mile	191	-	15,280	15,280
Diversion Construction	Mile	14.8	-	1,916	1,916
Waterway Development	Acre	10	-	150	150
Pond Construction	No.	103	-	21,600	21,600
Pasture Planting	Acre	0	-	0	0
Fertilizing	Acre	1,881	-	3,010	3,010
Technical Assistance (Accel.)			3,600	-	3,600
SCS Subtotal			3,600	111,267	114,867
TOTAL LAND TREATMENT			3,600	111,267	114,867
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 R/W			-	-	-
Legal Fees			-	-	-
Subtotal - Other			-	-	-
TOTAL STRUCTURAL MEASURES			-	-	-
WORK PLAN PREPARATION COST			-	-	-
TOTAL PROJECT			3,600	111,267	114,867
SUMMARY					
Total SCS			3,600	111,267	114,867
TOTAL PROJECT			3,600	111,267	114,867

1/ Flood Prevention funds, including accelerated funds.
2/ Excludes costs that will be reimbursed from other Federal funds.

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TABLE 1B - TOTAL ESTIMATED INSTALLATION COST
Turkey Creek Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1957

Total 1/

Item	Unit	Number	Estimated Cost 2/ Federal (dollars)	Estimated Cost Non- 3/ Federal (dollars)	Total (dollars)
LAND TREATMENT FOR:					
Watershed Protection					
Soil Conservation Service					
Contour Farming	Acre	5,402	-	6,752	6,752
Cover Cropping	Acre	5,845	-	24,660	24,660
Rotation Hay and Pasture	Acre	1,357	-	4,071	4,071
Crop Residue Utilization	Acre	9,353	-	9,353	9,353
Proper Use	Acre	28,191	-	13,463	13,463
Deferred Grazing	Acre	6,312	-	2,424	2,424
Range Seeding	Acre	781	-	3,905	3,905
Brush Control	Acre	11,796	-	52,084	52,084
Terracing	Mile	276	-	22,080	22,080
Diversion Construction	Mile	24.8	-	3,426	3,426
Waterway Development	Acre	30	-	450	450
Pond Construction	No.	134	-	29,400	29,400
Pasture Planting	Acre	40	-	100	100
Fertilizing	Acre	4,381	-	7,010	7,010
Technical Assistance (Accel.)			14,460	-	14,460
SCS Subtotal			14,460	179,178	193,638
TOTAL LAND TREATMENT			14,460	179,178	193,638
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	12	637,973	-	637,973
Subtotal - Construction			637,973	-	637,973
Installation Services					
Soil Conservation Service					
Engineering Services			115,994	-	115,994
Other			75,397	-	75,397
Subtotal - Installation Services			191,391	-	191,391
Other Costs					
Land, Easements, and R/W			-	57,625	57,625
Legal Fees			-	6,400	6,400
Subtotal - Other			-	64,025	64,025
TOTAL STRUCTURAL MEASURES			829,364	64,025	893,389
WORK PLAN PREPARATION COST			19,823	-	19,823
TOTAL PROJECT			863,647	243,203	1,106,850
SUMMARY					
Total SCS			863,647	243,203	1,106,850
TOTAL PROJECT			863,647	243,203	1,106,850

1/ Includes total watershed needs (table 1 plus table 1A).
2/ Flood Prevention funds, including acceleration funds.
3/ Excludes costs that will be reimbursed from other Federal funds.

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION
Turkey Creek Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1957

Structure Site Number	Federal Installation Costs					Non-Federal Installation Costs		Estimated Total Cost
	Construction		Installation Service					
	Engineer Estimate	Contin-gencies	Engineer-ing	Other	Total Federal	Easements and R/W	Total Non-Federal	
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1	85,415	8,541	17,083	11,104	122,143	7,500	7,500	129,643
2	62,652	6,265	12,530	8,145	89,592	9,725	9,725	99,317
3	22,607	2,261	4,521	2,939	32,328	2,000	2,000	34,328
4	48,688	4,869	9,738	6,329	69,624	2,650	2,650	72,274
5	43,312	4,331	8,662	5,631	61,936	1,750	1,750	63,686
6	65,490	6,549	13,098	8,514	93,651	11,600	11,600	105,251
7	40,156	4,016	8,031	5,220	57,423	3,750	3,750	61,173
8	36,834	3,683	7,367	4,788	52,672	5,200	5,200	57,872
9	44,292	4,429	8,858	5,758	63,337	4,400	4,400	67,737
10	60,894	6,089	12,179	7,916	87,078	5,500	5,500	92,578
11	25,106	2,511	5,021	3,264	35,902	3,750	3,750	39,652
12	44,530	4,453	8,906	5,789	63,678	6,200	6,200	69,878
GRAND TOTAL	579,976	57,997	115,994	75,397	829,364	64,025	64,025	893,389

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TABLE 3 - STRUCTURE DATA
FLOODWATER RETARDING STRUCTURES
Turkey Creek Watershed
(Middle Colorado River Watershed)

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	Total
Drainage Area	Sq.Mi.	8.62	5.46	1.10	1.76	1.25	1/ 7.46	2.66	3.94	4.62	6.15	3.43	4.39	50.84
Storage Capacity														
Sediment Pool	Ac.Ft.	106	93	45	36	27	183	76	109	133	197	118	200	1,323
Sediment Reserve	Ac.Ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
Sediment in Detention Pool	Ac.Fc.	34	29	13	11	7	56	23	34	39	49	25	53	373
Floodwater Detention	Ac.Ft.	1,724	1,041	207	375	233	1,608	496	736	961	1,311	731	937	10,360
Total	Ac.Ft.	1,864	1,163	265	422	267	1,847	595	879	1,133	1,557	874	1,190	12,056
Surface Area														
Sediment Pool (top of riser)	Acre	32	21	10	11	5	42	20	31	33	38	18	34	295
Floodwater Detention Pool	Acre	159	128	45	57	33	228	88	109	134	147	101	121	1,350
Maximum Height of Dam	Foot	43	39	32	29	30	34	26	32	36	42	39	41	xxx
Volume of Fill	Cu.Yd.	213,540	166,630	56,520	101,720	85,780	163,730	100,390	92,350	110,730	152,240	62,760	111,320	1,417,710
Emergency Spillway														
Type	-	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Frequency of Use 2/	Year	30	25	25	35	25	35	25	25	35	35	35	35	xxx
Design Storm (emergency spillway hydrograph)														
Duration	Hour	6	6	6	6	6	6	6	6	6	6	6	6	xxx
Rainfall 3/	Inch	5.80	6.00	6.38	6.27	6.41	5.60	6.21	6.14	6.05	5.94	6.14	6.07	xxx
Runoff	Inch	3.20	3.30	3.20	3.50	3.60	2.80	3.45	3.30	3.00	3.40	3.65	3.85	xxx
Bottom Width	Foot	300	175	50	100	50	250	100	125	100	150	150	175	xxx
Design Depth	Foot	0	0	0	0	0	0	0	0	0	0	0	0	xxx
Design Capacity	C.F.S.	0	0	0	0	0	0	0	0	0	0	0	0	xxx
Freeboard 4/	Foot	5.1	4.9	3.8	4.2	5.0	4.6	4.2	5.0	4.7	5.0	4.1	4.4	xxx
Total Capacity	C.F.S.	10,000	5,500	1,080	2,400	1,630	7,100	2,420	4,000	2,950	4,860	3,500	4,500	xxx
Principal Spillway														
Capacity	C.F.S.	86	55	10	17	12	135	27	40	46	62	34	44	xxx
Capacity Equivalents														
Sediment Volume	Inch	.23	.32	.76	.38	.40	.46	.54	.52	.54	.60	.65	.85	xxx
Sediment Reserve	Inch	0	0	0	0	0	0	0	0	0	0	0	0	xxx
Sediment in Detention Pool	Inch	.07	.10	.23	.12	.10	.14	.16	.16	.16	.15	.13	.23	xxx
Oetention Storage	Inch	3.75	3.58	3.51	4.00	3.50	4.04	3.50	3.50	3.90	4.00	4.00	4.00	xxx
Spillway Storage 2/	Inch	1.60	1.89	2.35	2.13	2.86	2.34	2.39	2.35	2.96	2.65	1.94	2.00	xxx
Class of Structure	-	A	A	A	A	A	A	A	A	A	A	A	A	xxx

1/ Ooes not include drainage area of Sites 4 and 5.
2/ Based on regional analysis of runoff.
3/ 0.5P from figure 3.21-1, NEH 4-A.
4/ H_p for 1.0P + 1.0'.

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TABLE 4 - ANNUAL COST 1/

Turkey Creek Watershed, Texas
(Middle Colorado River Watershed)

Structure Site Number	Amortization of Installation Costs 2/			Operation and Maintenance Costs 3/		Total
	Federal	Non-Federal	Total	Non-Federal	Total	
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1	4,307	292	4,599	248	248	4,847
2	3,159	378	3,537	198	198	3,735
3	1,140	78	1,218	99	99	1,317
4/ 4, 5, 6	7,940	622	8,562	446	446	9,008
7	2,025	146	2,171	149	149	2,320
8	1,857	202	2,059	99	99	2,158
9	2,233	171	2,404	149	149	2,553
10	3,070	214	3,284	198	198	3,482
11	1,266	146	1,412	99	99	1,511
12	2,245	241	2,486	149	149	2,635
TOTAL	29,242	2,490	31,732	1,834	1,834	33,566

1/ Does not include work plan preparation cost.
2/ Prices amortized for 50 years at 2.5 percent for Federal and 3.0 percent non-Federal.
3/ Long-term prices as projected by ARS, September 1957.
4/ Interdependent structures.

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TABLE 5 - MONETARY BENEFITS FROM STRUCTURAL MEASURES
Turkey Creek Watershed, Texas
(Middle Colorado River Watershed)
Price Base: Long-Term 1/

Item	Estimated Average Annual Damage: Without Project (dollars)	After Land Treatment For W/S Protection (dollars)	With Project (dollars)	Average Annual Monetary Benefits (dollars)
Floodwater Damage				
Crop and Pasture	21,554	20,633	5,417	15,216
Other Agricultural	14,233	13,009	2,311	10,698
Nonagricultural				
Urban, Roads, etc.	5,914	5,424	818	4,606
Subtotal	41,701	39,066	8,546	30,520
Sediment Damage				
Overbank Deposition	460	377	175	202
Subtotal	460	377	175	202
Erosion Damage				
Flood Plain Scour	1,734	1,579	409	1,170
Subtotal	1,734	1,579	409	1,170
Indirect Damage	4,390	4,102	913	3,189
Total, All Damage	48,285	45,124	10,043	35,081
Benefit Outside Project Area 2/	xxx	xxx	xxx	3,539
Subtotal	xxx	xxx	xxx	3,539
Changed Land Use to				
Crop Production	xxx	xxx	xxx	3,409
Subtotal	xxx	xxx	xxx	3,409
TOTAL FLOOD PREVENTION BENEFITS	xxx	xxx	xxx	42,029
TOTAL MONETARY BENEFITS	xxx	xxx	xxx	42,029

1/ As projected by ARS, September 1957.
2/ Includes $2,700 for damage reduction on the Pecan Bayou flood plain below Turkey Creek and $839 for sediment damage reduction to the Brownwood reservoir.

TABLE 6 - BENEFIT COST ANALYSIS

Turkey Creek Watershed, Texas
(Middle Colorado River Watershed)

Measures	AVERAGE ANNUAL BENEFITS 1/							Average Annual Cost 3/	Benefit Cost Ratio
	Flood Prevention								
	Floodwater	Sediment	Erosion	Indirect	Change of Land Use	Other 2/	Total		
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	
Floodwater Retarding Structures									
1	4,832	17	149	499	155	349	6,001	4,847	1.2:1
2	3,223	14	103	333	127	246	4,046	3,735	1.1:1
3	679	7	23	71	500	68	1,348	1,317	1.0:1
4/ 4,5,6	8,200	38	324	857	1,149	582	11,150	9,008	1.2:1
7	1,853	12	65	193	112	159	2,394	2,320	1.0:1
8	2,686	17	93	279	154	228	3,457	2,158	1.6:1
9	3,440	21	124	358	231	296	4,470	2,553	1.8:1
10	2,416	29	125	258	422	639	3,889	3,482	1.1:1
11	1,347	17	70	144	236	358	2,172	1,511	1.4:1
12	1,844	30	94	197	323	614	3,102	2,635	1.2:1
GRAND TOTAL	30,520	202	1,170	3,189	3,409	3,539	42,029	33,566	1.3:1

1/ Long-term price levels, as projected by ARS, September 1957.
2/ Includes benefits occurring outside project area.
3/ Installation costs based on 1957 prices; operation and maintenance on long-term prices as projected by ARS, September 1957.
4/ Interdependent structures.

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