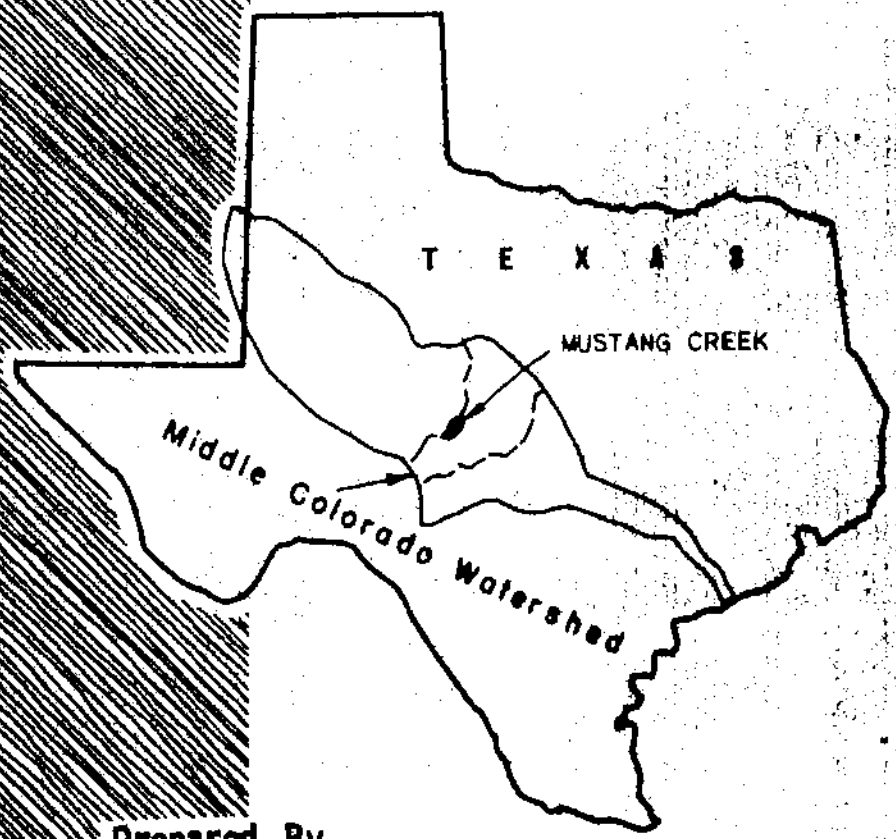
WORK PLAN

MUSTANG CREEK WATERSHED

OF THE MIDDLE COLORADO RIVER WATERSHED
CONCHO COUNTY, TEXAS



Prepared By
SOIL CONSERVATION SERVICE
U. S. DEPARTMENT OF AGRICULTURE
Temple, Texas
June 1959

WATERSHED WORK PLAN AGREEMENT

between the

Concho Soil Conservation District
Local Organization

(Hereinafter referred to as the District)

Concho County Water Control and Improvement District No. 2
Local Organization

(Hereinafter referred to as the WCID)

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 Mustang 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 District and the Service a mutually satisfactory plan for works of improvement for the Mustang Creek 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;

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

1. The District 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 District 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 District 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 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 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.

Concho Soil Conservation District
Local Organization

By James Finlay

Title Chairman

Date September 14, 1959

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

adopted at a meeting held on March 7, 1959 at Brady, Texas

(Secretary, Local Organization)
Ben O. Sims

Date September 14, 1959

Concho County Water Control and Improvement District No. 2
Local Organization

By C. L. Stevens

Title Chairman

Date September 14, 1959

The signing of this agreement was authorized by a resolution of the governing body of the Concho County Water Control and Improvement District No. 2
Local Organization

adopted at a meeting held on February 24, 1959 at Eden, Texas

(Secretary, Local Organization)
F. T. Stansberry

Date September 15, 1959

United States Department of Agriculture
Soil Conservation Service

By H. R. Smith
State Conservationist

Date 9-21-59

WORK PLAN

MUSTANG CREEK WATERSHED
Of the Middle Colorado River Watershed
Concho County, 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

Concho Soil Conservation District
Concho County Water Control and Improvement District No. 2

Prepared By:

Soil Conservation Service
U. S. Department of Agriculture
June, 1959

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

List of Tables and Figures

SECTION I

WORK PLAN

MUSTANG CREEK WATERSHED
Of the Middle Colorado River Watershed
Concho County, Texas
June 1959

SUMMARY OF PLAN

Description

Size: 97,280 acres - 152 square miles

Land Use:

Cultivation	19,835 acres
Pasture and Range	76,835 acres
Miscellaneous (roads, urban, etc.)	610 acres

Flood plain area: 7,197 acres

Soil Conservation District: Concho

No Federal lands involved.

Flood Frequency:

Total of 67 floods during 20-year period of study (1923 through 1942), of which 6 inundated more than half the flood plain area.

Land Treatment:

Practice	Unit	Applied to Date	To Be Applied During Installation Period
Contour Farming	Acre	12,914	4,605
Cover Cropping	Acre	718	5,150
Rotation Hay and Pasture	Acre	1,701	2,487
Crop Residue Utilization	Acre	9,500	3,034
Conservation Crop Rotation	Acre	-	4,500
Fertilizing	Acre	-.	4,500
Deferred Grazing	Acre	20,564	41,351
Proper Use	Acre	28,506	33,282
Brush Control	Acre	7,030	8,096
Range Seeding	Acre	128	1,233
Terracing	Mile	350	279
Diversion Construction	Mile	16	10
Waterway Development	Acre	4	83
Pond Construction	No.	113	50

Structural Measures:

Ten floodwater retarding structures.

Cost During Installation Period:

Item	Federal (dollars)	Non-Federal (dollars)	Total (dollars)
Land Treatment	12,500	175,477	187,977
Structural Measures	750,789	52,471	803,260
Work Plan Preparation	25,633	-	25,633
Total	788,922	227,948	1,016,870

Damages and Benefits:

Item	Without Project (dollars)	With Project (dollars)	Average Annual Monetary Benefits Structures (dollars)
Floodwater Damage	39,130	8,318	29,397
Erosion Damage	1,818	371	1,288
Indirect Damage	3,647	869	2,620
Total	44,595	9,558	33,305
Changed Land Use			1,035
Total			34,340

Benefit-Cost Ratio - Structural Measures

Average Annual Cost - Structures	$30,029
Average Annual Benefits - Structures	34,340
Benefit-Cost Ratio	1.1:1

Operation and Maintenance

Land Treatment Measures: Landowners or operators under agreements with the Concho Soil Conservation District

Structural Measures: Concho Soil Conservation District and Concho County Water Control and Improvement District No. 2

Annual Cost - $1,517

DESCRIPTION OF WATERSHED

Physical Data

Mustang Creek originates in central Concho County, approximately 5 miles north of Eden, Texas, and flows in a northeasterly direction through Concho County for a distance of approximately 19.5 miles. It flows into the Colorado River about 8 5 miles northeast of Millersview, Texas. The largest tributaries are East Mustang and West Mustang Creeks. This watershed also includes several short laterals to the north that drain directly into the Colorado River. The combined drainage area of these laterals is approximately 6,400 acres. The watershed ranges from 4 to 12 miles in width. It has an area of 97,280 acres (152.0 square miles), nearly all of which is in farms and ranches.

The topography of the watershed ranges from a steep escarpment in the headwaters to a gently rolling plain over the remainder of the watershed. The northern margin of the prominently escarped and almost flat-topped Edwards Plateau forms the south boundary of the watershed and stands 100 feet or more above the plain to the north. The rocks consist mostly of resistant crystalline limestones, chiefly the Edwards limestone formation of Cretaceous age. The gently rolling plain below the escarpment is well drained by a dendritic stream pattern which has not been significantly affected by the underlying gently westward dipping beds of the Wichita group (Permian age). These rocks consist of thin alternating beds of limestones and shales, with the limestones predominating. The flood plain in the upper and central reaches of the watershed is located in broad, flat valleys without any noticeable change occurring between the flood plain and the upland soils.

In the lower reaches, however, the flood plain is confined between progressively steeper upland slopes which become very steep at and near the Colorado River. Flood plain widths on the mainstem and larger tributaries range from 900 feet near the mouth of Mustang Creek to 2,200 feet in the widest parts of the central and upper reaches. Elevations range from 1,435 feet in the channel near the mouth of Mustang Creek to more than 2,100 feet above mean sea level on the escarpment.

Approximately six percent of the watershed lies within the Edwards Plateau land resource area. The soils consist of stony, very shallow clays on steep slopes. They are used exclusively for rangeland. The Rolling Plains land resource area, which comprises 94 percent of the watershed area, is characterized by shallow, somewhat stony, fine textured soils on the hills and ridges and deep, silty clay soils in the broad valleys. The dominant soil series are Valera and Abilene. Crop production in the watershed is confined mostly to the productive deeper soils of the watershed which account for about 20 percent of the total land area. The remainder of the watershed is used for rangeland.

The soils are generally in fair physical condition. Considerable amounts of small grains and high-residue grain sorghum crops are grown on the cropland and help prevent rapid deterioration of the soil. The application of agronomic practice is lagging in comparison with the mechanical treatment of cropland, undoubtedly due to the poor success experienced in getting response from applied practices during the recent prolonged drought.

The watershed lies within the mixed prairie plant group. Range cover is mostly in fair condition with a sizable area being classified as in poor range condition. Rangeland areas generally have made considerable improvement in cover especially of the less valuable annual and perennial vegetation with the improvement of rainfall and moisture conditions during the last two growing seasons.

There are three range sites in the watershed: Shallow Upland site, Deep Upland site, and Low stony Hills site. The predominant vegetation consists of the threeawn grasses, Texas wintergrass, buffalograss, mesquite, and annual weeds and grasses. The range condition classes of the watershed are as follows: 1 percent, excellent; 10 percent, good; 54 percent, fair; and 35 percent, poor.

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

Land Use	Acres	Percent
Cultivation	19,835	20
Range	76,835	79
Miscellaneous 1/	610	1
Total	97,280	100

1/ Includes roads, highways, towns, etc.

The flood plain consists of 7,197 acres, and is the area that will be inundated by a runoff of 3.50 inches which can be expected to occur on an average of once in 25 years from a single storm event. At the present time about 41 percent of the flood plain is in cultivation, 58 percent in pasture, and one percent in miscellaneous uses.

The largest storm that occurred in the 20-year period studied was a 11.18-inch rain that extended over three days and produced 3.28 inches of runoff. This runoff inundated 97 percent of the flood plain.

The mean annual weighted rainfall for the watershed is 24.42 inches. It is well distributed, with the wettest months being April, May, June, September and October. Individual excessive 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 12.63 inches, the maximum 39.95 inches.

Average temperatures range from 83 degrees Fahrenheit in the summer to 45 degrees in the winter. The normal frost-free season of 230 days extends from March 26 to November 11.

Water for livestock and domestic use in the watershed area is obtained from shallow wells and small farm ponds. These wells and ponds do not provide an adequate water supply during periods of drought. The town of Millersview obtains its water supply from individual wells. These are adequate except during periods of extreme drought.

Economic Data

The economy of the watershed depends largely upon its farms and ranches. Livestock enterprises, including beef cattle and sheep, predominate. Winter feeding and pasturing of lambs has become a major practice. About 90 percent of the cropland is used for the production of feed crops, such as grain sorghum, oats, barley and other crops that produce winter grazing.

Crude oil and natural gas production in the watershed is minor. Oil and gas leases have furnished some income to supplement that from livestock.

The average size of the farms in the watershed is 881 acres. This acreage is sufficient for an economical unit. The average value of land and buildings per farm is $44,543 (1954 agricultural census) The most common form of land tenure is the part-owner type--that is, most of the farmers and ranchers own a portion of the land they operate and rent or lease the other part. This type of tenure makes establishment of land treatment difficult on the rented land.

Millersview, with a population of 175, is the only town in the watershed. It is located near the center of the watershed and contains a post office, three retail stores, a school and two churches. Eden, population 1,993, is located about 5 miles south of the upper end of the watershed and is a retail and shipping point for the surrounding farm and ranch area. Most of the wool and livestock is marketed in San Angelo, 40 miles west of Millersview and in Fort Worth, about 200 miles northeast of Millersview.

The watershed is adequately served by approximately 90 miles of roads, of which 20 miles are paved (U. S. Highway 83 and State Farm Roads 765 and 2134). Most of the crossings are of the "low-water" type and floods make many of these crossings impassable for several days. The detours thus occasioned cause delay and extra travel distance to and from markets. Adequate rail facilities are available at Eden.

Status of Conservation Work in Watershed

The watershed is served by a Soil Conservation Service work unit at Eden, which is assisting the Concho Soil Conservation District. This work unit has assisted farmers and ranchers in preparing 69 soil and water conservation plans on 69,094 acres (71 percent of the agricultural land) within the watershed and in giving technical guidance in eatablishing and maintaining planned measures. Fifty 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. Land treatment measures installed before the development of this flood prevention work plan are listed in table 1A.

WATERSHED PROBLEMS

Floodwater Damage

Floods occur frequently on Mustang Creek and cause severe damage (figure 1).

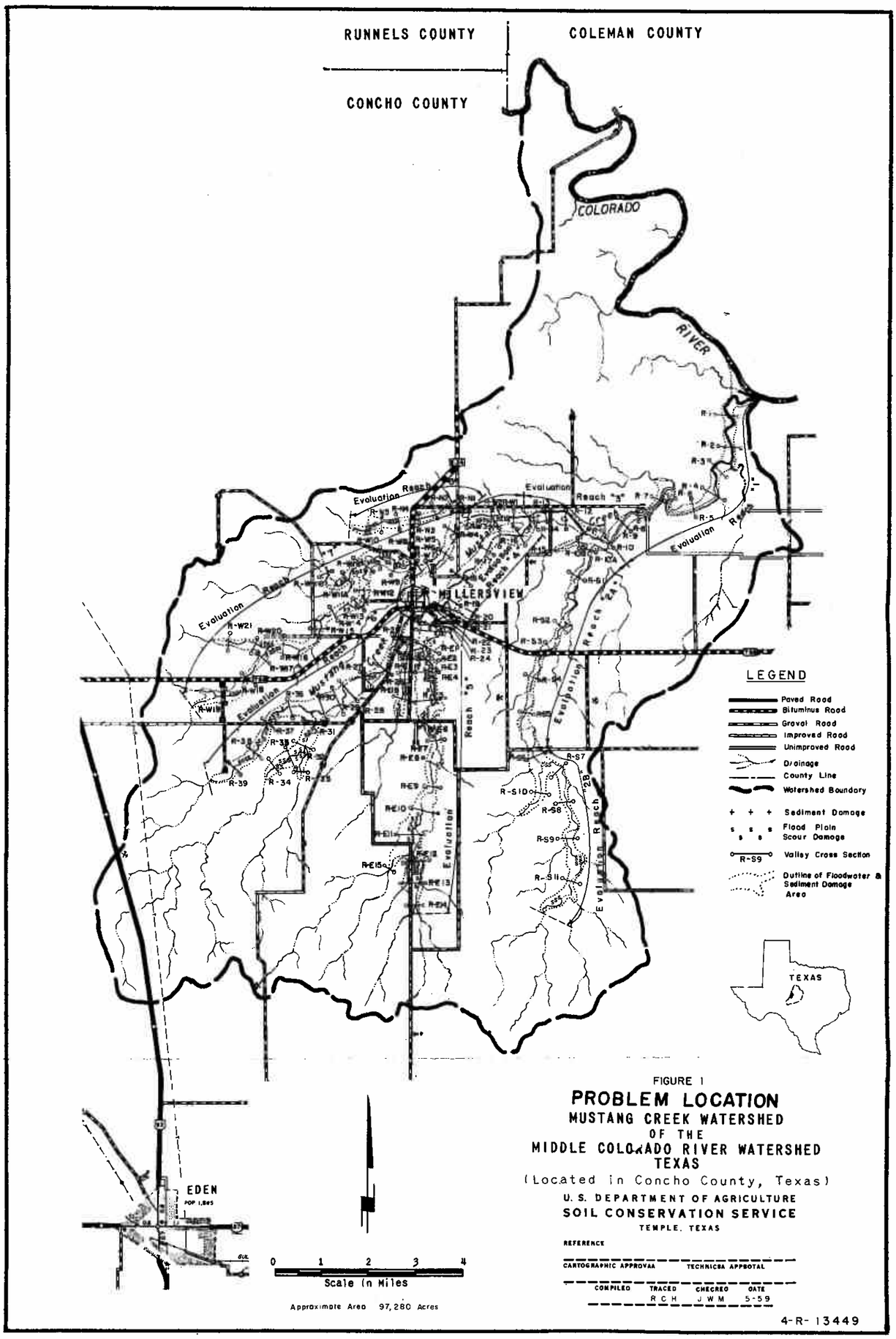


FIGURE 1

PROBLEM LOCATION

MUSTANG CREEK WATERSHED OF THE MIDDLE COLORADO RIVER WATERSHED TEXAS

(Located in Concho County, Texas)

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

REFERENCE

CARTOGRAPHIC APPROVAL		TECHNICAL APPROVAL	
COMPILED	TRACED	CHECKED	DATE
	R C H	J W M	5-59

4-R-13449

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U.S. Department of Agriculture, Soil Conservation Service, Fort Worth, Texas

Revised 5-26-59

Major floods (floods covering more than one-half of the flood plain) have occurred on an average of about once every three years, the latest being in May 1955. During the 20-year period 1923-1942, there were 6 major floods and 61 minor floods. Thirty-one of the floods occurred in the spring, causing severe damage to growing row crops and to maturing small grain crops. Sixteen of the floods occurred in September and October causing severe damage to growing small grain and to maturing row crops. The largest storm in the flood series occurred in July 22-24, 1938 and inundated 6,996 acres of flood plain.

The May 1955 flood occurred during the 1950-1957 drought period. Due to the drought there were no crops to be damaged. If this flood had happened during a normal year the estimated direct floodwater damage would have been as follows:

1. Crop and Pasture	$46,700
2. Other Agricultural	68,300
3. Nonagricultural (roads and bridges)	9,000
Total	$124,000

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 $39,130 annually at long-term price levels, of which $19,868 is crop and pasture damage, $17,209 is other agricultural damage, and $2,053 is nonagricultural damage such as damage to roads and bridges. 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 $3,647. The average annual monetary flood damages are summarized in table 5.

Erosion Damage

Upland erosion rates in this watershed are low. About 79 percent of the area is in rangeland and 20 percent is cultivated. The rangeland generally has a fair to good effective cover for reducing sheet erosion rates in this area. The cropland has had approximately 50 percent of the needed conservation practices applied. The use of considerable amounts of small grains further helps to reduce erosion from the cropland areas. Of the total estimated annual gross erosion under present conditions, 98 percent is derived from sheet erosion and 2 percent from channel enlargement.

Flood plain scour causes an annual loss of production on 565 acres. This loss ranges from 10 to 80 percent of the original productive capacity of the soil. The average annual amount of this damage is estimated to be $1,818 under present conditions. Land damage from channel erosion is minor and consists only of small isolated areas.

Sediment Damage

Sediment damage to the flood plain is minor. Only 1.5 acres have been damaged by deposition of gravel and cobbles up to 2 feet in depth. Damages in terms of reduced soil productivity are estimated to range from 20 to 40 percent.

Flood damage of this type amounts to about $44,595 annually.

Flood of May, 1955 at Millersview, Texas.

Since this damage is primarily to rangeland, the monetary loss on an annual basis is negligible and was not evaluated. Other damages, such as recreational losses from sediment damages to wildlife and fish, are recognized; but 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 structures for irrigation, municipal water supply or recreation. Needs for water management for fish and wildlife resources for pollution abatement are minor and do not warrant a study at this time.

EXISTING OR PROPOSED WORKS OF IMPROVEMENT

Efforts to prevent or reduce 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.

The Concho Soil Conservation District has been very active in establishing land treatment measures and in initiating flood prevention work. The district has exerted its influence toward a high degree of participation in this program on the part of the farmers, ranchers and other interested parties in the watershed.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

An effective conservation program based upon the use of each acre of agricultural land within its capabilities and its treatment in accordance with its needs, such as is now being carried out by the Concho Soil Conservation District, 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.

Land treatment measures are the only planned measures in the 6,400 acres comprising the watersheds of the direct Colorado River laterals included in this work plan.

Approximately 35,462 acres of the Mustang Creek watershed area of 90,880 acres lie above planned floodwater retarding structures. Land treatment is especially important for protection of these watershed lands to support and supplement the structural measures. There are another 48,987 acres of upland in the watershed 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 7,197 acres of flood plain, 766 acres of which are

above floodwater retarding structures, 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 during the 5-year installation period are shown in table 1. The estimated cost of planning and installing these measures, exclusive of expected reimbursement from ACPS or other Federal funds, is $175,477, 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 $144,132 (table 1A). Also prior to work plan preparation, $2,500 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 $12,500.

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, 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, 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.

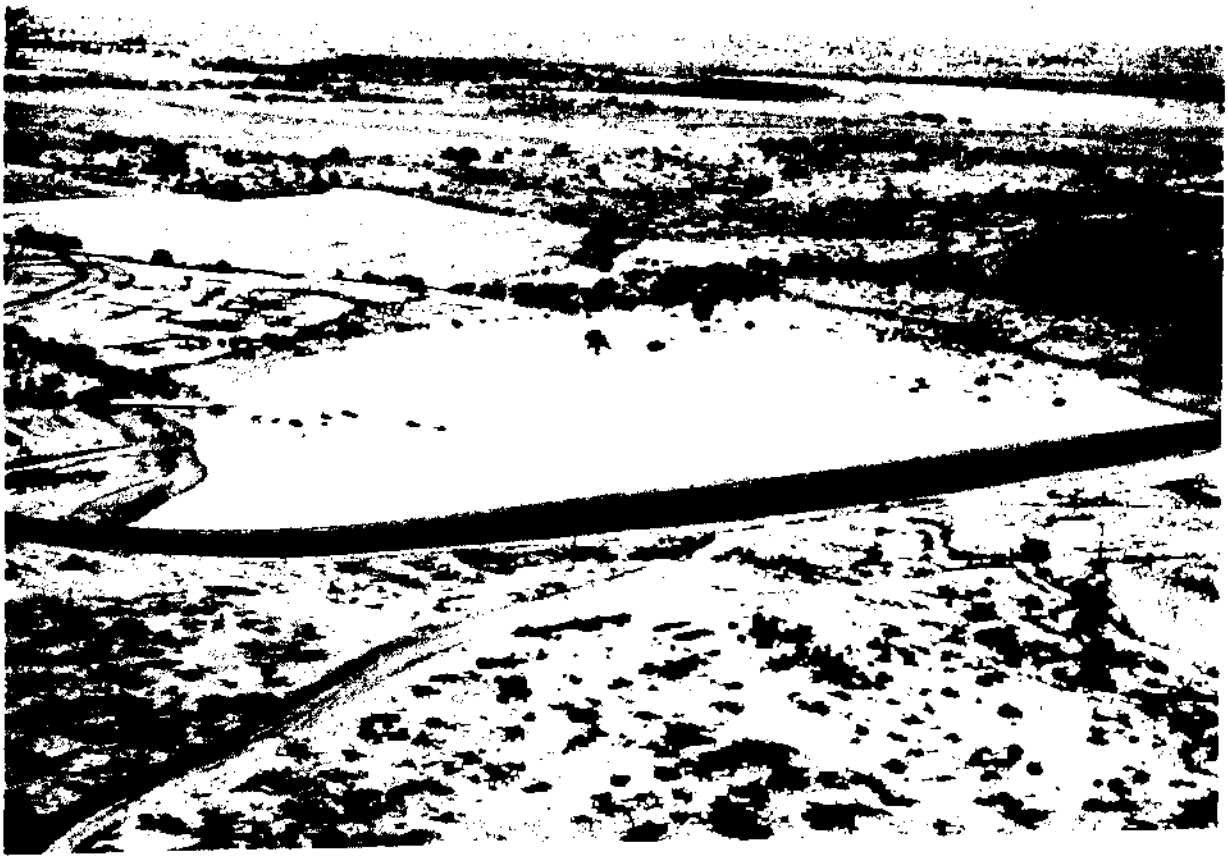
Structural Measures

A system of 10 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 55.41 square miles, or 42 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 4.77 inches of runoff from their watersheds, depending on local conditions. The total of 12,331 acre-feet of detention capacity provided by the 10 structures is sufficient to detain 4.23 inches of runoff from the area above structures, or the equivalent of 1.65 inches from the entire watershed.

To obtain the desired degree of protection for the watershed, structures were necessary at Sites 3 and 8. In order to develop the required storage for Site 3 it was necessary to locate Site 2 above Site 3. This will give protection to the flood plain lands between these two sites. Site 7 was located above Site 8 to give protection to the intervening flood plain lands.

Proper use and deferred grazing maintains stands of good grass on rangelands.

Austrian winter peas make an excellent winter cover crop.



Runoff from heavy rains being controlled by floodwater retarding structures.

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

Figure 2 shows a section of a typical floodwater retarding structure. The location of the structural measures is shown on figure 3, Planned Structural Measures.

There are 22 low-water crossings on Mustang Creek and its tributaries that will be affected by the release flow from the principal spillways of the floodwater retarding structures. Under present conditions water flows over these crossings for relative short periods following rains. After the structures are installed, the flow will be reduced in peak but flow will be greatly prolonged. Eighteen of these crossings are on county roads and 4 on farm to market road FM-765. The Concho County Commissioners Court will install culverts or other improvements needed to keep the crossings on county roads passable during periods of floodwater release at no cost to the Federal Government. The Concho Soil Conservation District and the Concho County Water Control and Improvement District Number 2, in cooperation with the State Highway Department, will make necessary arrangements to keep the crossings passable on the farm to market road FM-765.

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 and utilities, is estimated to be $47,700, based on current market values furnished by the local organizations. It is estimated that an additional $4,771 of non-Federal funds will be expended for legal services required in the securing of easements. The total area of the sediment pools is 287 acres, of which 36 acres are flood plain lands. In addition, the detention pools will temporarily inundate 1,381 acres, of which 128 acres is flood plain.

The total estimated cost of establishing these works of improvement is $803,260, of which $52,471 will be borne by local interests and $750,789 by flood prevention funds.

The estimated annual equivalent cost of installation, $28,512, with an estimated annual operation and maintenance cost of $1,517, makes a total annual cost of $30,029.

Sufficient detention storage can be developed at all structure sites to make possible the use of vegetative spillways, thereby effecting a substantial reduction in cost over concrete or similar type of spillway. All applicable State water laws will be complied with in the design and construction of the floodwater retarding structures.

BENEFITS FROM WORKS OF IMPROVEMENT

The evaluation storm series for the period 1923 through 1942 contained 67 storms which would cause flooding under present conditions at the valley cross section where flooding begins.

The estimated average annual floodwater, erosion and indirect damage within the watershed would be reduced from $44,595 to $9,558, a 79 percent reduction. Approximately 95 percent, $33,305, of the expected reduction in the average annual damage will result from the system of floodwater retarding structures.

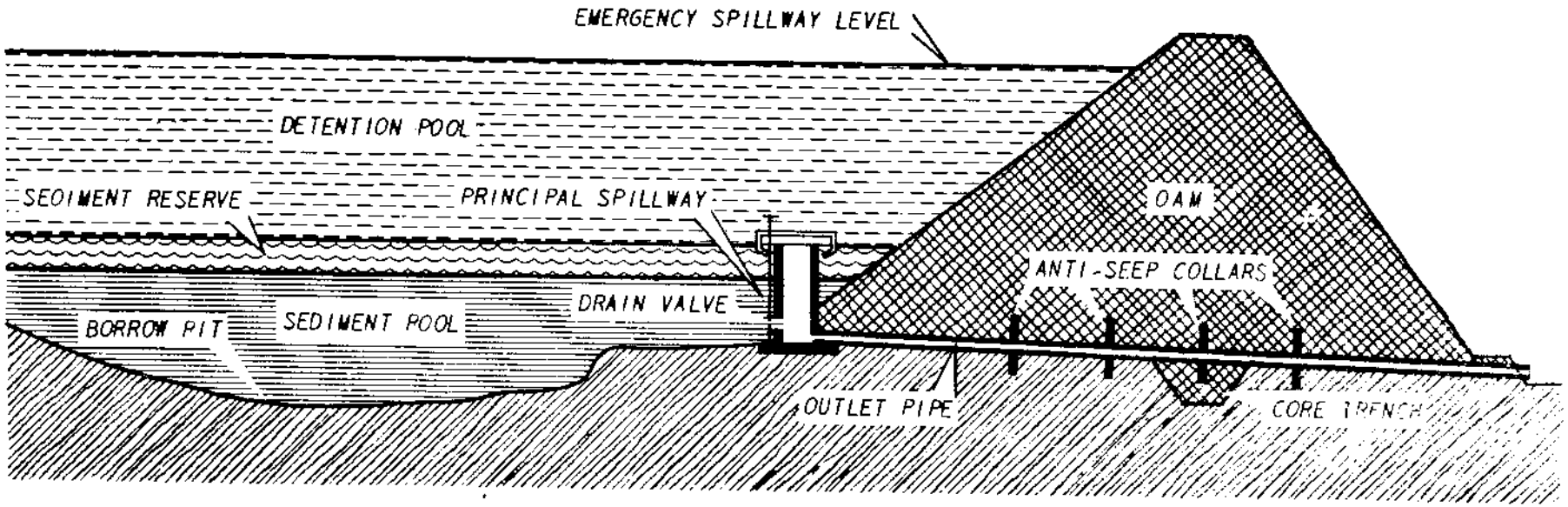


Figure 2

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

Revised 10-24-57 4-L-10,071

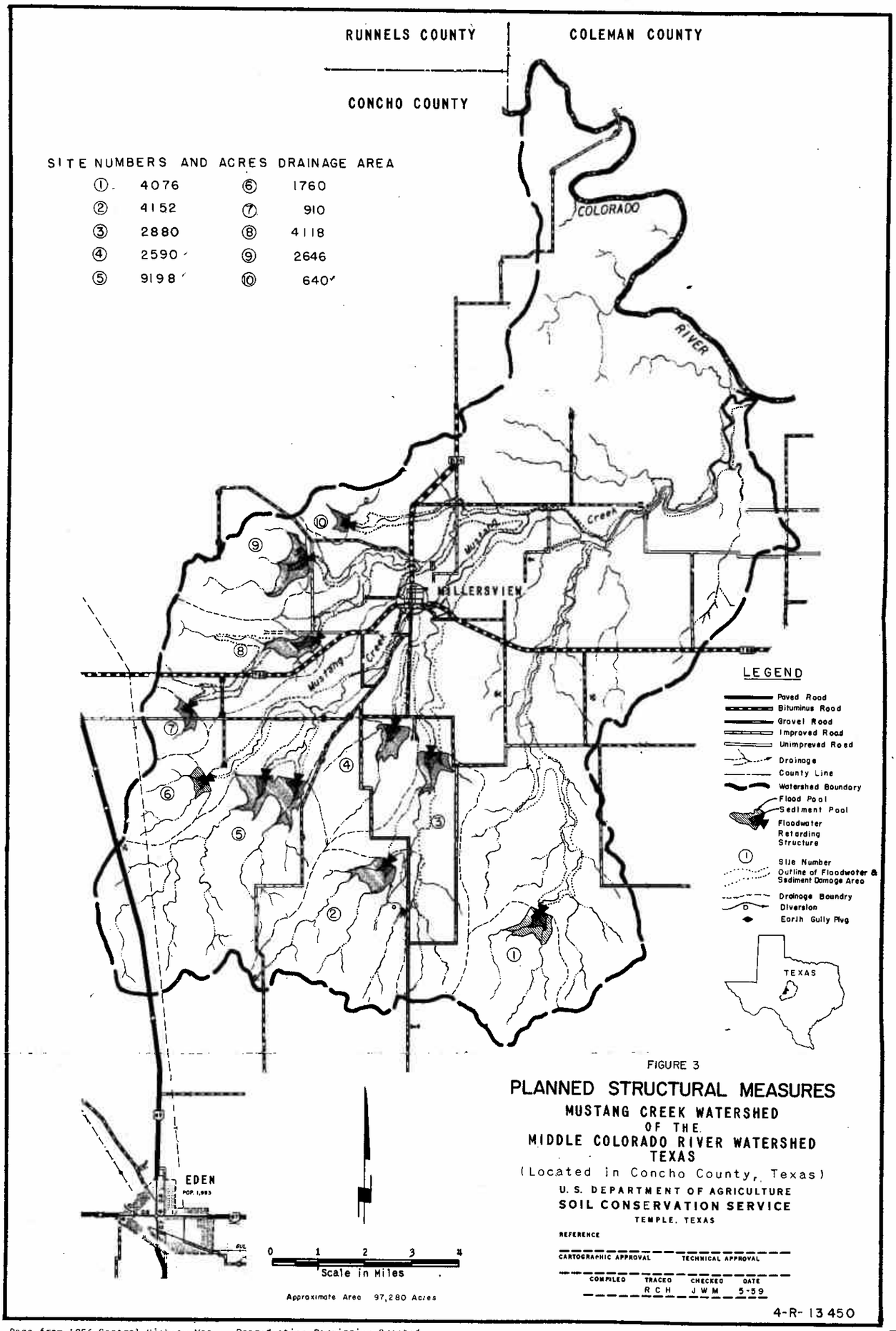


FIGURE 3

PLANNED STRUCTURAL MEASURES

MUSTANG CREEK WATERSHED
OF THE
MIDDLE COLORADO RIVER WATERSHED
TEXAS

(Located in Concho County, Texas)

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

REFERENCE

CARTOGRAPHIC APPROVAL	TECHNICAL APPROVAL		
COMPILED	TRACED	CHECKED	DATE
	R C H	J W M	5-59

4-R-13450

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Revised 5-26-59

The general location of the benefits from the combined program of land treatment and structural measures is presented in table A. The highest level of protection is provided in Reaches 2B through 8 where 95 percent of the existing damages occur.

Owners and operators of flood plain lands say that if adequate flood protection is provided, they will restore land now in idle or poor pasture to cultivation. All of this land was in cultivation at one time but is now used chiefly for pasture because of the frequency of flooding. It is estimated that average net income from such restoration will amount to $4,482 (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 $1,035 increase in net average annual income.

The total flood prevention benefits, as a result of structural measures, are estimated to be $34,340.

COMPARISON OF BENEFITS AND COSTS

The annual equivalent cost of structural measures (converted from total installation cost) plus the annual operation and maintenance cost is estimated to be $30,029. When the project is completely installed, it is expected to produce average annual benefits of $34,340. The project, therefore, will produce $1.14 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, none of which has 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 Flood Control Act of 1936, as amended snd supplemented.

Land Treatment Measures

Land treatment measures itemized in table 1 will be established by farmers in cooperation with the Concho Soil Conservation District 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 district is 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.

TABLE A - GENERAL LOCATION OF BENEFITS

	Evaluation Reach (Figure 1)									
	1	2A	2B	3	4	5	6	7	8	Total
Average Annual Acres Flooded										
Without Project - Acres	271	249	347	264	212	948	651	1,088	149	4,179
With Project - Acres	140	162	154	136	56	195	135	488	79	1,545
Percent Reduction	48	35	56	48	74	79	79	55	47	63
Area Flooded by Largest Storm										
Without Project - Acres	690	470	650	390	358	1,470	1,430	1,390	148	6,996
With Project - Acres	540	390	500	245	204	660	360	830	108	3,837
Percent Reduction	22	17	23	37	43	55	75	40	27	45
Average Annual Damages										
Without Project - Dollars	569	1,025	3,636	2,365	1,876	12,564	8,041	12,610	1,909	44,595
With Project - Dollars	213	587	1,061	724	311	1,301	1,064	3,738	559	9,558
Percent Reduction	63	43	71	69	83	90	87	70	71	79
Number of Major Floods in Evaluation Series										
Without Project	5	6	7	6	9	7	4	9	6	
With Project	2	4	3	1	1	0	0	1	4	

June 1959

The governing body of the soil conservation district 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 district. The district governing body will make periodic inspections of the completed conservation measures within the district and follow through to see that needed maintenance is performed.

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

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. Any present FHA clients will be encouraged to cooperate in the project.

The county ASC committees will cooperate with the governing body of the soil conservation district by selecting and recommending financial assistance for those ACPS practices which 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 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.

Structural Measures for Flood Prevention

The Soil Conservation Service will contract for the construction of the 10 floodwater retarding structures. It also will provide technical specialists to prepare plans and 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 Concho County Water Control and Improvement District Number 2, in cooperation with the Concho Soil 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 (dollars)	Non-Federal Funds (dollars)	Total (dollars)
1st	7, 8, 9 and 10	187,513	41,031	228,544
2nd	4, 5 and 6	288,575	56,501	345,076
3rd	1, 2 and 3	282,076	58,314	340,390
4th		2,750	38,535	41,285
5th		2,375	33,567	35,942
Total		763,289	227,948	991,237

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 structural measures will be constructed 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 land, easements and rights-of-way have been secured.

3. Operation and maintenance agreements have been executed.

4. Flood prevention funds are available.

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 Concho Soil Conservation District. Representatives of the soil conservation district 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 ten floodwater retarding structures will be operated and maintained jointly

by the Concho Soil Conservation District and the Concho County Water Control and Improvement District Number 2. The estimated operation and maintenance cost is $1,517 annually, based on long-term price levels. 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 Concho County Water Control and Improvement District Number 2, which has legal authority to raise funds. A maintenance fund of $1,000 per structure or $10,000 will be established. This will be raised by taxation at the rate of $1,517 per year. When it becomes necessary to use any of this money for maintenance expenditures, it will be replenished in the shortest feasible time.

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.

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

The cosponsoring local organizations fully understand their obligations for maintenance and will executive 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 Mustang Creek watershed will make a substantial contribution to the objectives of the overall Middle Colorado River development program.

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

Project Objectives

Flood problems, needed land treatment measures, and the desired degree of protection were discussed with the local sponsoring organizations and the following project objectives reached:

1. That more land treatment measures which contribute directly to flood prevention, based on current needs, are required.

2. That a 75 percent reduction in average annual floodwater damage will be required to maintain the economy of the watershed.

3. That a structural program will be necessary.

Land Treatment

Soil Conditions, Land Use and Treatment Needs

Soil conditions and land use on the upland were determined by expanding a 10 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 status of land treatment measures and practices effectively applied and the current conservation needs were secured from the records of the Concho Soil Conservation District. This information was expanded, with assistance from personnel of the Soil Conservation Service Work Unit at Eden to estimate the amounts of various practices that will be applied during the 5-year installation period for the entire watershed.

Cover Conditions and Range Sites

Cover conditions and range sites were determined from information secured by a 10 percent random sampling of the watershed and from available range surveys.

Project Formulation

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, sedimentation and economic investigations provided data on the effect these measures would have on the reduction of sediment and flood damages. 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 so as to meet the objectives of the sponsoring local organizations. The study made and the procedures used in that determination were as follows:

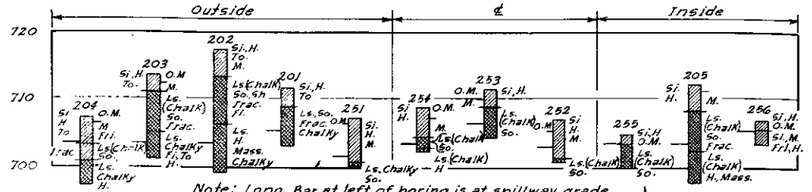
1. A base map of the watershed was prepared showing the watershed boundary, drainage pattern, system of roads, and other pertinent information. A stereoscopic study of 4-inch consecutive aerial photographs located all probable floodwater retarding structure sites, the limits and the area of the flood 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 steroscopically, 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. To obtain the desired degree of protection needed, give adequate protection to all flood plain lands, and develop the storage necessary for this protection, it was necessary to locate Site 2 in series with Site 3 and Site 7 in series with Site 8 (figure 3).

5. A topographic map with 4-foot contour intervals was made of the pool area of each of the proposed sites in order to determine the storage capacity of the site, the estimated cost of the dam and the areas of flood plain and upland that would be inundated by the sediment and flood pools. 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 temporarily detain a minimum of 3.50 inches of runoff and to provide the additional storage needed for sediment. The inches of runoff to be stored were 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,



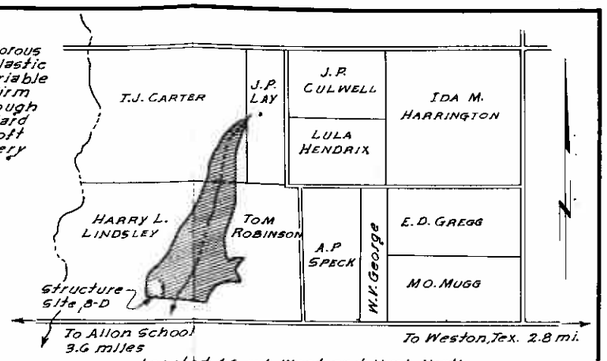
LOG OF SPILLWAY BORINGS

SEE PLAN OF EMBANKMENT AND SPILLWAY

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	

LEGEND OF BORINGS

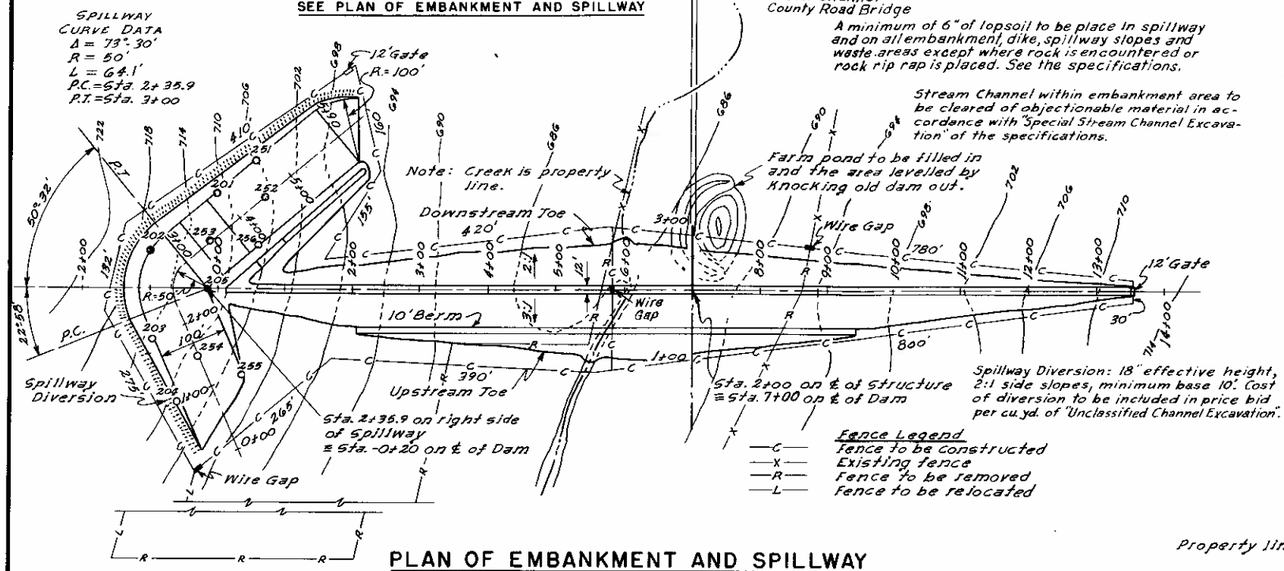


Located 4.6 mi. West and 11 mi. North of McKinney, Collin County, Texas

VICINITY MAP

0 1/4 1/2 1

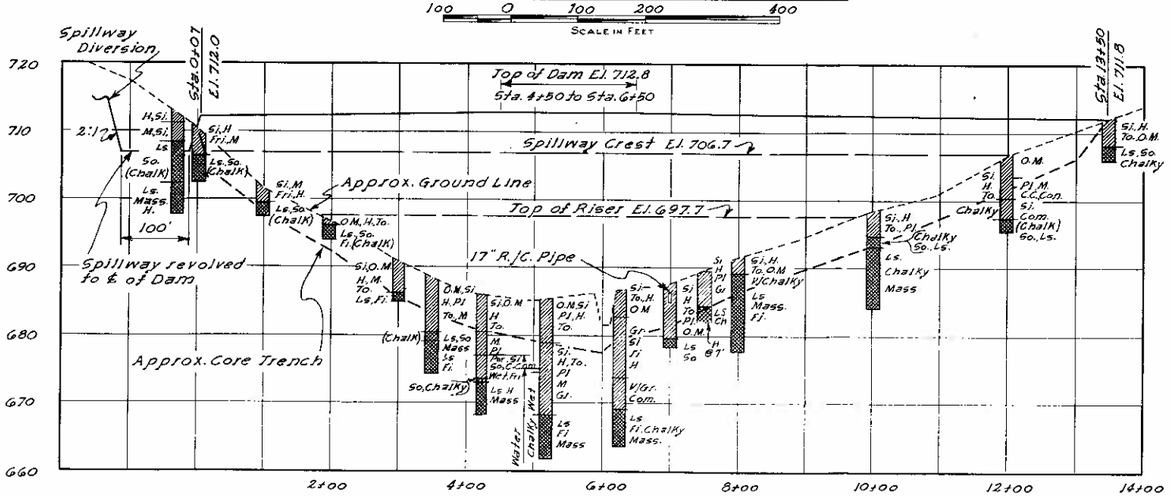
SCALE IN MILES



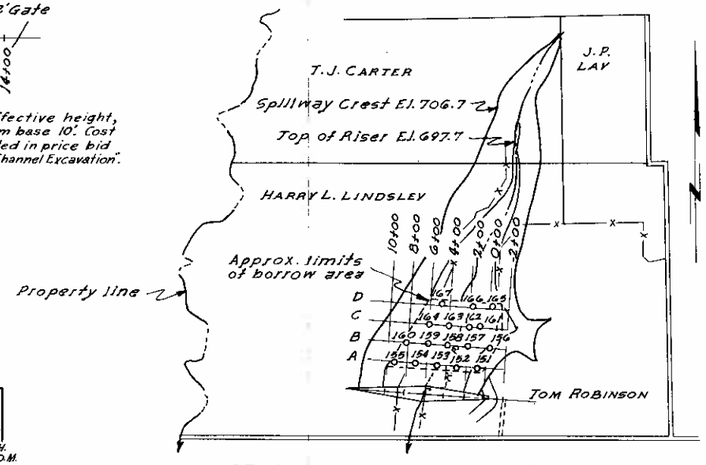
PLAN OF EMBANKMENT AND SPILLWAY

100 0 100 200 400

SCALE IN FEET



PROFILE ON ℄ OF DAM



GENERAL PLAN OF RESERVOIR

660 0 660 1980

SCALE IN FEET

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.	692.3
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

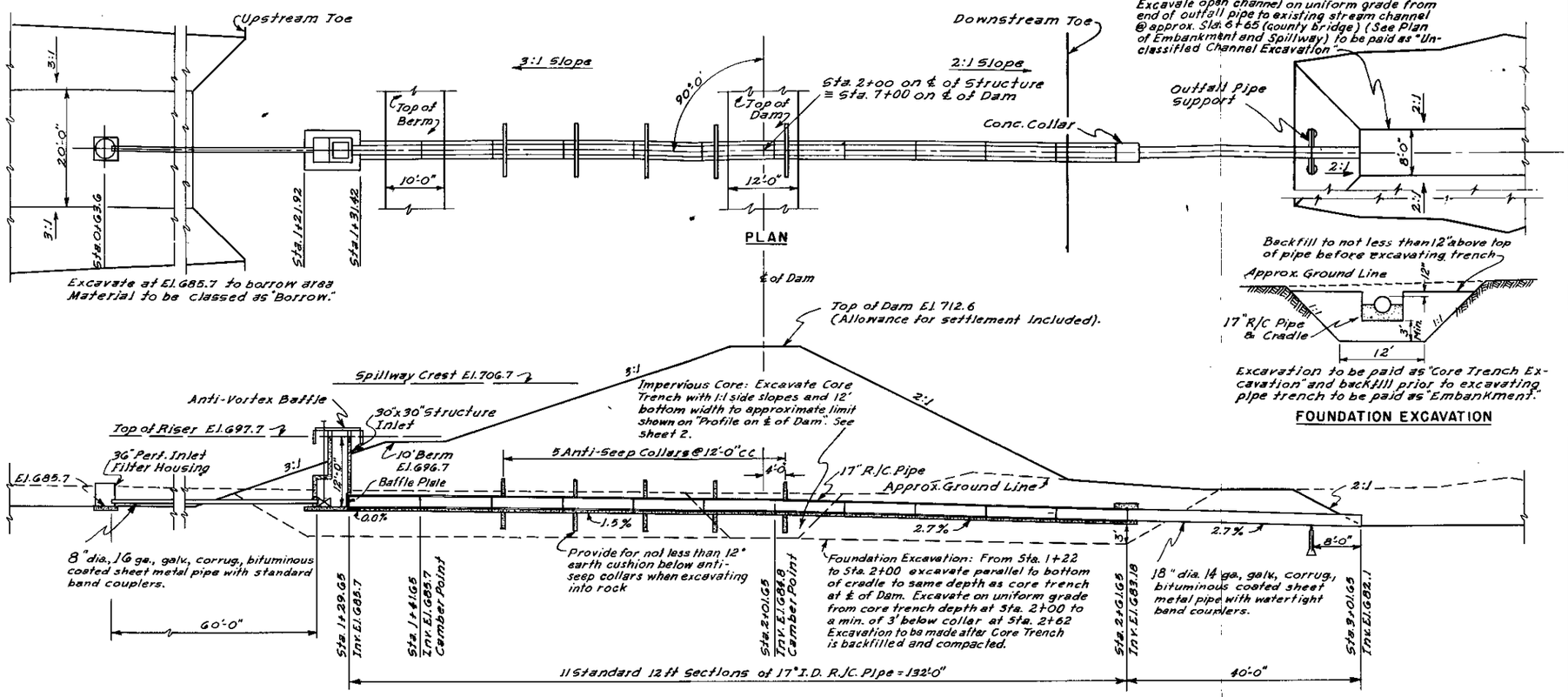
TYPICAL

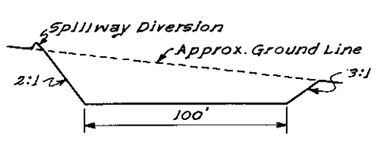
FLOODWATER RETARDING STRUCTURE

PLAN AND PROFILE

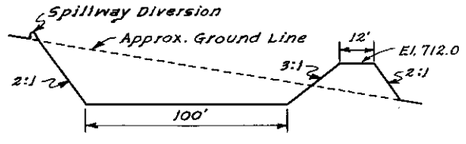
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	L.A.W.	6-56	Approved by ___
Drawn	L.A.W. & G.R.	6-56	STATE CONSERVATION ENGINEER, S.C.S. TEMPLE, TEXAS
Traced	G.R.	6-56	Sheet No. 2 of 7
Checked	L.A.W. & G.W.T.	7-56	Drawing No. 4-E-10,581

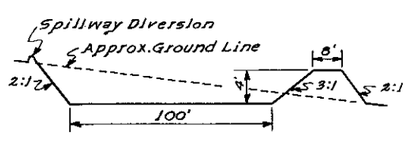




Sta. 0+45 to Sta. 3+00
FOREBAY

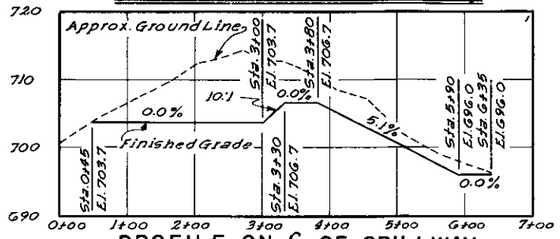


Sta. 3+30 to Sta. 3+80
CREST



Sta 4+30 to Sta 5+90

TYPICAL SPILLWAY SECTIONS



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.	Date 6-56	Approved by	HEAD ENGINEERING & WATERSHED PLANNING UNIT FORT WORTH, TEXAS
Drawn L. A.W. & G.R.	6-56		STATE CONSERVATION ENGINEER R.C.S. TEMPLE, TEXAS
Traced G.R.	6-56	Sheet No. 3 of 7	Drawing No. 4-E-10,581
Checked L. A.W. & G.W.T.	7-56		

Washington Engineering Memorandum No. 27, Hydrology Memorandum EWP-2 (Revised), Technical Release No. 2, and Section 2404, Texas State Mannual.

6. The limits of the flood pools and sediment pools of all satisfactory sites and the flood plain of the stream were drawn to scale on a copy of the base map. Structure data tables were developed to show, for each structure, the drainage area, the storage capacity needed for 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).

7. 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 for 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 measures. 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 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 meteorologic and hydrologic data were tabulated from Climatological Bulletins, United States Weather Bureau and Water

Supply Papers, United States Geological Survey, and local records and analyzed to determine average precipitation depth-duration relationships, seasonal distribution of precipitation, the frequency of occurrence of meteorological events and the historical flood series 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 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 3.10-1, 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 nearby actual gaged runoff on 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 Mannings formula and concordant flow (Pages 4.2-1-9, NEH, Section 4, Supplement A), and were checked at selected sections by 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, and from these, composite runoff-area inundation curves for each evaluation reach were developed.

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

   a. Present conditions.

b. Effect of land treatment measures.

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

d. Consideration of alternative programs and measures.

7. 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 in accordance with procedures set forth in Washington Engineering Memorandum No. 27; NEH, Section 4, Hydrology, Supplement A; NEH, Section 5, Hydraulics; Technical Release No. 2; Hydrology Memorandum EWP-2 (Revised); 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 11.18 inches. An average rain of this magnitude would produce the equivalent of 3.28 inches of runoff at section No. 1, after adjustment for transmission loss. Under present conditions, 6,996 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 6,953 acres. With land treatment measures applied and the structural measures for flood prevention in operation, only 3,837 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 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 1.65 inches of rainfall under Moisture Condition I, 0.82 inch under Moisture Condition II, and 0.30 inch under Moisture Condition III. Runoff of 0.02 inch would produce a discharge of 150 cubic feet per second at the minimum cross section (No. 16) and 380 cubic feet per second at the reference section (No. 1). The minimum cross section is located about 2.3 miles northeast of Millersview, Texas. The reference cross section is located approximately 0.80 mile southwest of the confluence of Mustang Creek and the Colorado River (figure 1).

The channel capacity at the reference section is 16,500 cubic feet per second. The peak discharge at this point for a 11.18-inch rain under present conditions is estimated to be 42,640 cubic feet per second. After installation and full functioning of all the planned measures on the Mustang Creek watershed, the discharge at the same point would be reduced to 25,200 cubic feet per second.

The 6-hour design storm rainfall was taken from figure 3.21-1, NEH 4-A. The emergency spillway and freeboard hydrographs were computed using 0.50 P and 1.00 P, respectively, adjusted to the drainage area of each site. Routing

the emergency spillway hydrographs resulted in no flow through the emergency spillways. Therefore, the dimensions of the emergency spillways were determined by graphically routing the freeboard hydrographs and adding one foot of dry freeboard Composite hydrographs were developed for those sites in series using the storage indication method to flood route between the structures. The criteria and procedures used are set forth in Washington Engineering Memorandum SCS No. 27, Technical Release No. 2; Hydrology Memoranda EWP-1, EWP-2, and EWP-4; NEH, Section 4, Supplement A; NEH, Section 5 and Section 2404, Texas State Mannual.

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

Sedimentation Investigations

Sediment Source Studies

Sediment source studies to determine the 50-year sediment storage requirements were made in the drainage areas of the 10 planned floodwater retarding structures according to the following procedures:

1. Detailed investigations were made in the drainage areas above 4 of the planned floodwater retarding structures. These investigations included: mapping soil units by slope in percent; slope length in feet; present land use; present land treatment on cultivated land; present cover condition classes on pasture and woodland; land capability classes; lengths, widths, and depths of all gullies; lengths, widths, and depths of all stream channels affected by erosion; and the estimated annual lateral erosion of gullies and stream channels in feet.

2. Office computations included summarizing erosion by sources (sheet erosion, gully erosion, and streambank erosion) in order to fit these data into formulas for computation of gross annual erosion in acre-feet

   The following formula was used for computing sheet erosion:

   E = A x F x SF x CF x RF, where
   E - Sheet erosion in acre-feet per year
   A - Area in acres
   F - Basic erosion rate of soil unit in feet per year
   SF - Slope factor, based on percent and length of slope
   CF - Cover factor, based on present cover and land treatment
   RF - Rainfall factor, based on maximum two-year 30-minute rainfall intensity

   The following formula was used for computing gully and streambank erosion:

E = N x L x P x H x LE ÷ 43,560, where
E - Erosion in acre-feet per year
N - Number of banks affected
L - Length of gully or streambank in feet
P - Percent of gully or streambank affected by erosion
H - Average height of bank in feet
LE - Estimated annual lateral erosion in feet

3. Field surveys and office computations to determine the estimated sediment rates for the remaining six structures under present conditions consisted of mapping the land use and arranging the sites into homogeneous groups and the preparation of sediment source summary sheets based on the homogeneous grouping of the sites and the detailed investigations.

4. The sediment rates were then adjusted to reflect the effect of expected land treatment on the drainage areas of the planned floodwater retarding structures. The computed sediment storage requirement for each site is based on a gradual improvement of watershed conditions as a result of the installation of needed land treatment measures expected to be installed during the first ten years and maintaining these measures at 75 percent effectiveness during the next 40 years.

5. The ratio of sediment storage volume in the pools to soil in place was estimated to be 1.4 for all structures in the watershed.

6. The allocation of sediment to the structure pools was based on 20 percent deposition in the detention pool and 80 percent in the sediment pool.

The sediment source studies indicated that the erosion rates in the watershed are low. A summation of the annual sediment yields above the 10 planned floodwater retarding structures was found to be 18.1 acre-feet.

The average annual rate of sediment production above structures is 0.33 acre-feet per square mile.

Using the detailed sediment source studies as a basis, it was found that approximately 99 percent of the annual sediment production in the upland areas of the watershed results from sheet erosion and 1 percent from gully and streambank erosion. The expected application of 80 percent of the needed land treatment measures, if maintained at 75 percent effectiveness, will reduce sediment production from the upland areas approximately 22 percent.

Flood Plain Sedimentation and Scour

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

1. Field examinations were made along each of the valley cross sections (figure 1) making note of depth and texture of deposits, scour channels, sheet scour areas, stream channel aggradation or degradation and other important factors.

2. Estimates of past physical flood plain damage were obtained through interviews with the landowners and operators.

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

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

5. The present annual damages from overbank deposition in the watershed was found to be negligible in terms of monetary loss and was not further evaluated. The reduction of scour damage due to installation of the complete project is based on reduction of depth and area inundated.

Geological Investigations

Preliminary geologic dam site investigations were made at each of the 10 planned floodwater retarding structure sites. These studies included valley slopes, alluvium, channel banks, and exposed geologic formations. Borings with a hand auger were made to determine nature and extent of fill material that might be encountered in construction.

Description of Problems

All of the proposed sites are underlain by formations of the Wichita group of Permian age. Sites 1 through 4 are located in outcrops of the Belle Plains formation and Sites 5 through 10 in outcrops of the Clyde formation. These formations consist of regular thin beds of moderately hard, blue-gray limestones with alternating beds of shale or marl which are somewhat thicker in the lower beds than the upper beds. The presence of anhydrite and gypsum in the upper part of the Belle Plains formation has caused some minor folding and moderate jointing of the overlying limestone beds which are exposed at Site 3 and in the vicinity of Site 2. No surface outcrops of gypsum were observed. Leakage through the thin-bedded and jointed limestones will probably be a problem in all sites and will require toe drains in the embankment. Rock excavation is expected in the emergency spillways of Sites 2, 3, 4, 5, 8 and 9, but the total volume of this excavation will not be excessively high. Soils suitable for embankment purposes are adequate and are classified as predominantly CL, CH, and GC by the Unified Soil Classification System.

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 and placement of the available embankment materials.

Economic Investigations

Basic methods used in the economic investigation and analysis are outlined in the Economics Guide issued December 8, 1958.

Determinations of Annual Benefits from Reduction in Damages

Agricultural damage estimates were based upon schedules obtained in the field covering approximately 85 percent of the flood plain of Mustang 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 1955.

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 damage were applied, flood by flood, to the floods which occurred during the 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 agricultural workers in the area.

Significant differences in land use, frequency of flooding and degree of future use were sufficient to divide the flood plain into nine evaluation reaches. A different damageable value was used for each reach. The locations of the evaluation reaches are shown in figure 1.

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

The estimated monetary value of the physical damage to the flood plain from erosion 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 the county commissioner and from the state highway district maintenance engineer. 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. An analysis indicates that these damages are slightly less than 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 changed land use and restoration of productivity based upon farm-by-farm analysis. Benefits from restoration are included as crop and pasture benefits. Consideration was 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 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 deducting production and harvest costs, additional costs for taxes and overhead, and clearing costs where applicable. All such benefits were discounted to provide for either a five- or ten-year lag in accomplishment.

Benefits in each evaluation reach were allocated to each evaluation unit on the basis of drainage area controlled. The allocation was made so that no structure or group of structures received benefits from a reach in which that structure or group of structures did not effect a reduction in damage.

Flood plain which will be inundated by the sediment and detention pools was 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 10 floodwater retarding structures was determined by individual appraisal. This evaluation was based on estimates by local interests.

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.

No evaluation was made of benefits accruing on the mainstem of the Colorado River.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST[1/]

Mustang Creek Watershed, Texas
(Middle Colorado River Watershed)
Price Base. 1958

Item	Unit	Number Applied	Installation Period June 1959-June 1964 Estimated Cost 2/. Federal (dollars)	Non-Federal (dollars)	Total (dollars)
LAND TREATMENT FOR.					
Watershed Protection					
Soil Conservation Service					
Contour Farming	Acre	4,605	-	4,605	4,605
Cover Cropping	Acre	5,150	-	20,600	20,600
Rotation Hay and Pasture	Acre	2,487	-	13,461	13,461
Crop Residue Utilization	Acre	3,034	-	3,034	3,034
Conservation Crop Rotation	Acre	4,500	-	7,200	7,200
Fertilizing	Acre	4,500	-	7,200	7,200
Deferred Grazing	Acre	41,351	-	16,540	16,540
Proper Use	Acre	33,282	-	13,312	13,312
Brush Control	Acre	8,096	-	40,470	40,470
Range Seeding	Acre	1,233	-	6,165	6,165
Terracing	Mile	279	-	16,740	16,740
Diversion Construction	Mile	10	-	2,000	2,000
Waterway Development	Acre	83	-	4,150	4,150
Pond Construction	No.	50	-	20,000	20,000
Technical Assistance (Accel.)			12,500	-	12,500
SCS Subtotal			12,500	175,477	187,977
TOTAL LAND TREATMENT			12,500	175,477	187,977
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Struc.	No.	10	577,530	-	577,530
SCS Subtotal			577,530	-	577,530
Subtotal - Construction			577,530	-	577,530
Installation Services					
Soil Conservation Service					
Engineering Services			105,005	-	105,005
Other			68,254	-	68,254
SCS Subtotal			173,259	-	173,259
Subtotal - Installation Services			173,259	-	173,259
Other Costs					
Land, Easements, and R/W			-	47,700	47,700
Legal Fees			-	4,771	4,771
Subtotal - Other			-	52,471	52,471
TOTAL STRUCTURAL MEASURES			750,789	52,471	803,260
WORK PLAN PREPARATION COST			25,633	-	25,633
TOTAL PROJECT			788,922	227,948	1,016,870
SUMMARY					
Subtotal SCS			788,922	227,948	1,016,870
TOTAL PROJECT			788,922	227,948	1,016,870

1/ 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.

June 1959

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT[1/]
Mustang Creek Watershed, Texas
(Middle Colorado River Watershed)
Price Base. 1958

Prior to June 1959

Item	Unit	Number Applied	Estimated Cost Federal[2/] (dollars)	Estimated Cost Non-Federal[3/] (dollars)	Total (dollars)
LAND TREATMENT FOR					
Watershed Protection					
Soil Conservation Service					
Contour Farming	Acre	12,914	-	12,914	12,914
Cover Cropping	Acre	718	-	2,872	2,872
Rotation Hay and Pasture	Acre	1,701	-	5,103	5,103
Crop Residue Utilization	Acre	9,500	-	9,500	9,500
Conservation Crop Rotation	Acre	-	-	-	-
Fertilizing	Acre	-	-	-	-
Deferred Grazing	Acre	20,564	-	8,226	8,226
Proper Use	Acre	28,506	-	11,402	11,402
Brush Control	Acre	7,030	-	35,150	35,150
Range Seeding	Acre	128	-	640	640
Terracing	Mile	350	-	21,000	21,000
Diversion Construction	Mile	16	-	3,200	3,200
Waterway Development	Acre	4	-	225	225
Pond Construction	No.	113	-	33,900	33,900
Technical Assistance (Accel)			2,500	-	2,500
SCS Subtotal			2,500	144,132	146,632
TOTAL LAND TREATMENT			2,500	144,132	146,632
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Struc.	No.	-	-	-	-
SCS Subtotal		-	-	-	-
Subtotal - Construction		-	-	-	-
Installation Services					
Soil Conservation Service					
Engineering Services		-	-	-	-
Other		-	-	-	-
SCS Subtotal		-	-	-	-
Subtotal - Installation Services		-	-	-	-
Other Costs					
Land, Easements, R/W and Legal Fees		-	-	-	-
Subtotal - Other		-	-	-	-
TOTAL STRUCTURAL MEASURES		-	-	-	-
WORK PLAN PREPARATION COST		-	-	-	-
TOTAL PROJECT			2,500	144,132	146,632
SUMMARY					
Subtotal SCS			2,500	144,132	146,632
TOTAL PROJECT			2,500	144,132	146,632

1/ At time of work plan preparation.
2/ Flood Prevention funds, including accelerated funds.
3/ Excludes costs that will be reimbursed from other Federal funds.

June 1959

TABLE 1B - TOTAL ESTIMATED INSTALLATION COSTS[1/]
Mustang Creek Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1958

Item	Unit	Number	Total Project[1/] Estimated Cost Federal[2/] (dollars)	Non-Federal[3/] (dollars)	Total (dollars)
LAND TREATMENT FOR:					
Watershed Protection					
Soil Conservation Service					
Contour Farming	Acre	17,519	-	17,519	17,519
Cover Cropping	Acre	5,868	-	23,472	23,472
Rotation Hay and Pasture	Acre	4,188	-	18,564	18,564
Crop Residue Utilization	Acre	12,534	-	12,534	12,534
Conservation Crop Rotation	Acre	4,500	-	7,200	7,200
Fertilizing	Acre	4,500	-	7,200	7,200
Deferred Grazing	Acre	61,915	-	24,766	24,766
Proper Use	Acre	61,788	-	24,714	24,714
Brush Control	Acre	15,126	-	75,620	75,620
Range Seeding	Acre	1,361	-	6,805	6,805
Terracing	Mile	629	-	37,740	37,740
Diversion Construction	Mile	26	-	5,200	5,200
Waterway Development	Acre	87	-	4,375	4,375
Pond Construction	No.	163	-	53,900	53,900
Technical Assistance (Accel.)			15,000	-	15,000
SCS Subtotal			15,000	319,609	334,609
TOTAL LAND TREATMENT			15,000	319,609	334,609
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Struc.	No.	10	577,530	-	577,530
SCS Subtotal			577,530	-	577,530
Subtotal - Construction			577,530	-	577,530
Installation Services					
Soil Conservation Service					
Engineering Services			105,005	-	105,005
Other			68,254	-	68,254
SCS Subtotal			173,259	-	173,259
Subtotal - Installation Services			173,259	-	173,259
Other Costs					
Land, Easements and R/W			-	47,700	47,700
Legal Fees			-	4,771	4,771
Subtotal - Other			-	52,471	52,471
TOTAL STRUCTURAL MEASURES			750,789	52,471	803,260
WORK PLAN PREPARATION COST			25,633	-	25,633
TOTAL PROJECT			791,422	372,080	1,163,502
SUMMARY					
Subtotal SCS			791,422	372,080	1,163,502
TOTAL PROJECT			791,422	372,080	1,163,502

1/ Table 1 plus table 1A.
2/ Flood prevention funds, including acceleration funds.
3/ Excludes costs that will be reimbursed from other Federal funds.

June 1959

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Mustang Creek Watershed, Texas
(Middle Colorado River Watershed)
Price Base: 1958

Structure Site No.	Federal Installation Costs					Non-Federal Installation Costs			Total Installation Cost
	Construction		Installation Service			Easements and R/W	Legal Fees and Other	Total Non-Federal	
	Engineer Estimate (dollars)	Contingencies (dollars)	Engineering (dollars)	Other (dollars)	Total Federal (dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1	48,018	4,802	9,604	6,242	68,666	4,850	485	5,335	74,001
2	91,137	9,114	18,227	11,848	130,326	4,625	462	5,087	135,413
3	56,003	5,600	11,201	7,280	80,084	5,325	532	5,857	85,941
4	41,899	4,190	8,380	5,447	59,916	4,175	418	4,593	64,509
5	126,962	12,696	25,392	16,505	181,555	12,425	1,243	13,668	195,223
6	31,192	3,119	6,238	4,055	44,604	2,875	288	3,163	47,767
7	28,120	2,812	5,624	3,656	40,212	2,600	260	2,860	43,072
8	52,381	5,238	10,476	6,810	74,905	5,650	565	6,215	81,120
9	32,458	3,246	6,492	4,220	46,416	3,925	393	4,318	50,734
10	16,857	1,686	3,371	2,191	24,105	1,250	125	1,375	25,480
GRAND TOTAL	525,027	52,503	105,005	68,254	750,789	47,700	4,771	52,471	803,260

June 1959

TABLE 3 - STRUCTURE DATA
FLOODWATER RETARDING STRUCTURES
Mustang Creek Watershed, Texas
(Middle Colorado River Watershed)

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	8	9	10	Total
Drainage Area	sq. mi.	6.37	8.04	6.86[1]	4.05	14.36	2.75	1.42	6.43[1]	4.13	1.0	55.41
Storage Capacity												
Sediment Pool	ac. ft.	95	103	132	67	235	50	28	120	68	20	918
Sediment in Detention Pool	ac. ft.	17	17	22	13	43	9	2	21	11	4	159
Floodwater Detention	ac. ft.	1,188	1,904	1,414	954	3,651	513	281	1,373	850	203	12,331
Total	ac. ft.	1,300	2,024	1,568	1,034	3,929	572	311	1,514	929	227	13,408
Surface Area												
Sediment Pool	acre	30	25	42	24	76	17	10	33	23	7	287
Floodwater Detention Pool	acre	164	188	186	143	465	98	54	193	134	43	1,668
Volume of Fill	cu. yd.	129,778	240,300	147,376	114,860	356,757	86,646	74,000	124,037	77,255	45,267	1,396,276
Elevation Top of Dam	foot	1791.0	1798.3	1718.4	1688.5	1778.4	1798.8	1785.0	1703.8	1787.0	1675.9	
Maximum Height of Dam	foot	28.1	42.6	31.5	29.1	33.1	21.4	24.0	29.1	26.3	20.5	
Emergency Spillway												
Crest Elevation	foot	1786.0	1793.4	1714.1	1684.0	1774.0	1794.0	1780.3	1699.0	1682.0	1672.5	
Bottom Width	foot	200	200	300	100	200	100	50	150	100	50	
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	
Percent Chance of Use[2]		2.7	1.6	2.1	2.0	1.2	2.9	2.8	2.2	2.3	2.8	
Average Curve No. - Cond. II		77	77	77	77	77	77	77	77	77	77	
Emergency Spillway Hydrograph												
Storm Rainfall 6-hour	inch	5.94	5.87	5.92	6.09	5.64	6.19	6.34	5.94	6.09	6.41	
Storm Runoff	inch	3.42	3.38	3.42	3.45	3:10	3.58	3.72	3.43	3.55	3.84	
Velocity of Flow (vc)	f.p.s.	0	0	0	0	0	0	0	0	0	0	
Discharge Rate	c.f.s.	0	0	0	0	0	0	0	0	0	0	
Maximum W. S. Elevation	foot	-	-	-	-	-	-	-	-	-	-	
Freeboard Hydrograph												
Storm Rainfall 6-hour	inch	11.88	11.74	11.84	12.19	11.29	12.39	12.69	11.88	12.19	12.82	
Storm Runoff	inch	8.92	8.60	8.78	9.20	8.40	9.50	9.70	8.90	9.30	9.80	
Velocity of Flow (vc)	f.p.s.	8.6	8.5	7.8	8.2	8.2	8.3	8.2	8.3	8.5	7.8	
Discharge Rate	c.f.s.	3,900	3,570	4,375	1,650	3,500	1,750	860	2,725	1,880	770	
Maximum W. S. Elevation	foot	1790.0	1797.3	1717.4	1687.5	177.7	1797.8	1784.0	1702.8	1786.0	1674.9	
Principal Spillway Capacity Low Stage	c.f.s.	64	80	150	40	144	27	27	94	40	27	
Capacity Equivalents												
Sediment Volume	inch	.28	.24	.36	.31	.31	.34	.37	.35	.31	.38	
Sediment in Detention Pool	inch	.05	.04	.06	.06	.05	.06	.03	.06	.05	.07	
Detention Storage	inch	3.50	4.44	3.86	4.42	4.77	3.50	3.70	4.00	3.85	3.80	
Spillway Storage	inch	3.24	2.47	2.68	3.52	2.25	4.08	4.53	3.47	2.99	4.46	
Class of Structure		A	A	A	A	A	A	A	A	A	A	

June, 1959

1/ Exclusive of watershed from which runoff is controlled by other structures in series.
2/ Based on regional analysis of gaged runoff.

TABLE 4 - ANNUAL COST[1/]
Mustang Creek Watershed, Texas
(Middle Colorado River Watershed)

Measures	Amortization of Installation Costs[2/]			Operation and Maintenance Cost [3/]		Total
	Federal	Non-Federal	Total	Non-Federal	Total	
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
Floodwater Retarding Structures						
1	2,421	207	2,628	142	142	2,770
2, 3, 4, 5, and 6[4/]	17,506	1,258	18,764	948	948	19,712
7, 8, 9, and 10[4/]	6,546	574	7,120	427	427	7,547
TOTAL	26,473	2,039	28,512	1,517	1,517	30,029

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

June 1959

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

Item	Estimated Average Annual Damage			Average Annual Monetary Benefits
	Without Project	After Land Treatment for W/S Protection	With Project	
	(dollars)	(dollars)	(dollars)	(dollars)
Floodwater Damage				
Crop and Pasture	19,868	19,131	5,175	13,956
Other Agricultural	17,209	16,618	2,834	13,784
Nonagricultural				
Roads and Bridges	2,053	1,966	309	1,657
Subtotal	39,130	37,715	8,318	29,397
Erosion Damage				
Flood Plain Scour	1,818	1,659	371	1,288
Subtotal	1,818	1,659	371	1,288
Indirect Damages	3,647	3,489	869	2,620
Total, All Damages	44,595	42,863	9,558	33,305
Changed Land Use				
To Crop Production	xxx	xxx	xxx	1,035
Subtotal	xxx	xxx	xxx	1,035
TOTAL FLOOD PREVENTION BENEFITS	xxx	xxx	xxx	34,340
TOTAL MONETARY BENEFITS	xxx	xxx	xxx	34,340

1/ As projected by ARS, September 1957.

June 1959

TABLE 6 - BENEFIT COST ANALYSIS
Mustang Creek Watershed, Texas
(Middle Colorado River Watershed)

Measures	AVERAGE ANNUAL BENEFITS[1/] Flood Prevention					Average Annual Cost[2/]	Benefit Cost Ratio
	Flood-water	Erosion	Indirect	Change of Land Use	Total		
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	
Floodwater Retarding Structures							
1	2,603	48	212	0	2,863	2,770	1.0:1
3/ 2, 3, 4, 5, and 6	17,684	897	1,643	635	20,859	19,712	1.1:1
3/ 7, 8, 9, and 10	9,110	343	765	400	10,618	7,547	1.4:1
GRAND TOTAL	29,397	1,288	2,620	1,035	34,340	30,029	1.1:1

1/ Long-term price levels, as projected by ARS, September 1957.
2/ Installation cost based on 1958 prices and operation and maintenance on long-term prices as projected by ARS, September 1957.
3/ Interrelated measures.

June 1959