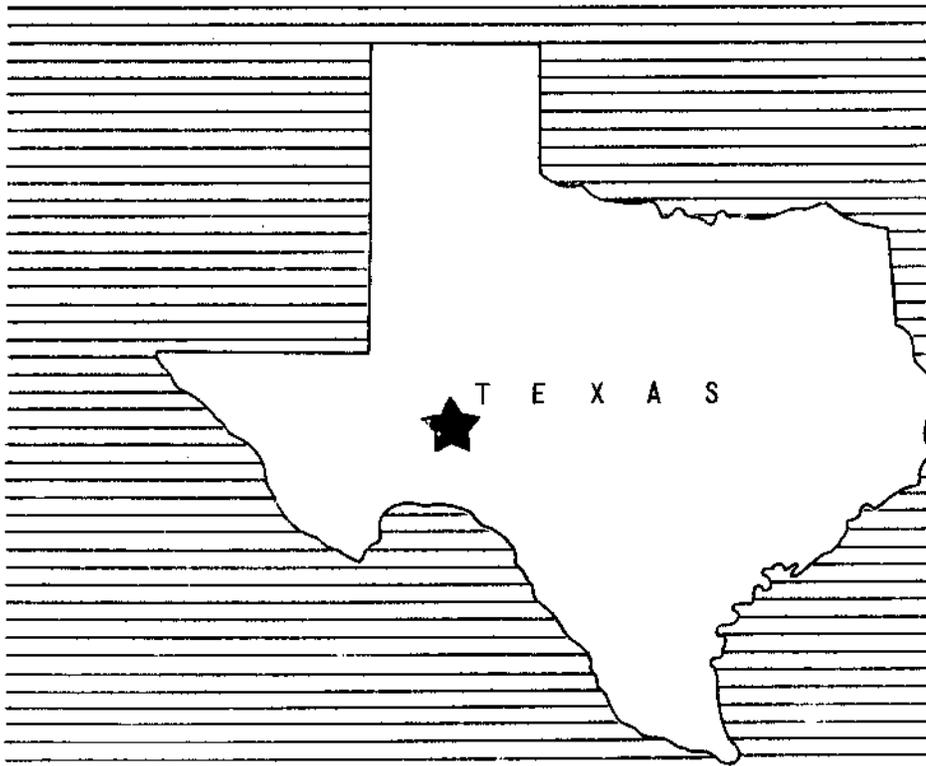


WORK PLAN FOR WATERSHED PROTECTION  
AND FLOOD PREVENTION

# DRY DEVILS RIVER AND LOWREY DRAW WATERSHED

SCHLEICHER AND SUTTON COUNTIES, TEXAS



FEBRUARY, 1958

TX-914b  
4/58

U. S. DEPARTMENT OF AGRICULTURE - SOIL CONSERVATION SERVICE  
WATERSHED WORK PLAN AGREEMENT

between the

Edwards Plateau Soil Conservation District  
Local Organization

Eldorado Divide Soil Conservation District  
Local Organization

Sutton County Commissioners Court  
Local Organization

Schleicher County Commissioners Court  
Local Organization

City of Sonora  
Local Organization

In the State of Texas  
(hereinafter referred to as the Sponsoring Local Organization)

and the

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

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the Dry Devils River and Lowrey Draw Watershed, State of Texas, under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666), as amended by the Act of August 7, 1956 (Public Law 1018, 84th Congress; 70 Stat. 1088); and

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

Whereas, there has been developed through the cooperative efforts of the sponsoring Local Organization and the Service a mutually satisfactory plan for works of improvement for the Dry Devils River and Lowrey Draw Watershed, State of Texas, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan will be installed, within 5 years, and operated and maintained substantially in accordance with the terms, conditions, and stipulations provided for therein.

It is mutually agreed that in installing and operating and maintaining the works of improvement described in the watershed work plan:

1. The Sponsoring Local Organization 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. (Estimated cost \$ 180,445 .)
2. The Sponsoring Local Organization 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 percentages of construction costs of structural measures and land treatment measures for flood prevention to be paid by the Sponsoring Local Organization and by the Service are as follows:

<u>Works of Improvement</u>	<u>Sponsoring Local Organization (Percent)</u>	<u>Service (Percent)</u>	<u>Estimated Construction Cost (Dollars)</u>
13	0	100	1,278,731

4. The Service will bear the cost of all installation services applicable to works of improvement for flood prevention. (Estimated cost \$ 383,618 .)

The Service will bear      percent of the cost of installation services applicable to works of improvement for agricultural water management and the Sponsoring Local Organization will

bear \_\_\_\_\_ percent of the cost of such services. (Estimated cost \$ None .)

The Sponsoring Local Organization will bear the cost of all installation services applicable to works of improvement for non-agricultural water management. (Estimated cost \$ None .)

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost \$ 6,500 .)
6. The Sponsoring Local Organization will obtain agreements from owners of not less than 50% of the land above each floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.
7. The Sponsoring Local Organization will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.
8. The Sponsoring Local Organization will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.
9. The Sponsoring Local Organization 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 agreements to be entered into prior to issuing invitations to bid for construction work.
10. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred in the installation of works of improvement will be used.
11. This agreement does not constitute a financial document to serve as a basis for the obligation of Federal funds, and financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the appropriation of funds for this purpose.

Where there is a Federal contribution to the construction cost of works of improvement, a separate agreement in connection with each construction contract will be entered into between the Service and the Sponsoring Local Organization prior to the issuance of the invitation to bid. Such agreement will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

12. 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.
13. 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.

Edwards Plateau Soil Conservation District  
Local Organization

By Joe B. Ross  
Title Chairman

Date April 9, 1958

The signing of this agreement was authorized by a resolution of the governing body of the Edwards Plateau Soil Conservation District  
Local Organization  
adopted at a meeting held on April 9, 1958

Edwin E. Sawyer  
(Secretary, Local Organization)

Date April 9, 1958

Schleicher County Commissioners Court

Local Organization

By

Title

Date

The signing of this agreement was authorized by a resolution of the governing body of the Schleicher County Commissioners Court

Local Organization

adopted at a meeting held on April 9, 1958

(Secretary, Local Organization)

Date

City of Sonora

Local Organization

By

Title

Date

The signing of this agreement was authorized by a resolution of the governing body of the City of Sonora

Local Organization

adopted at a meeting held on April 9, 1958

(Secretary, Local Organization)

Date

Soil Conservation Service  
United States Department of Agriculture

By

Administrator

Date

Eldorado Divide Soil Conservation District  
Local Organization

By J. Forrest Kunge

Title Chairman

Date April 9, 1958

The signing of this agreement was authorized by a resolution of the governing body of the Eldorado Divide Soil Conservation District Local Organization adopted at a meeting held on 2/10, 58.

B. E. Moore  
acting (Secretary, Local Organization)

Date April 9 - 1958

Sutton County Commissioners Court  
Local Organization

By George Wynn

Title County Judge

Date April 9, 1958

The signing of this agreement was authorized by a resolution of the governing body of the Sutton County Commissioners Court Local Organization adopted at a meeting held on April 9, 1958.

J. L. McKinney  
(Secretary, Local Organization)

Date April 9, 1958

WORK PLAN  
FOR  
WATERSHED PROTECTION AND FLOOD PREVENTION  
DRY DEVILS RIVER AND LOWREY DRAW WATERSHED  
Sutton and Schleicher Counties, Texas

Prepared Under the Authority of the Watershed  
Protection and Flood Prevention Act (Public  
Law 566, 83rd Congress, 68 Stat. 666) as Amend-  
ed by the Act of August 7, 1956 (Public Law  
1018, 84th Congress, 70 Stat. 1088).

Prepared by: Edwards Plateau Soil Conservation District  
(Cosponsor)  
Eldorado Divide Soil Conservation District  
(Cosponsor)  
Sutton County Commissioners Court  
(Cosponsor)  
Schleicher County Commissioners Court  
(Cosponsor)  
City of Sonora  
(Cosponsor)

With Assistance by:

U. S. Department of Agriculture  
Soil Conservation Service

February 1958

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## SECTION 1

### WATERSHED WORK PLAN

DRY DEVILS RIVER AND LOWREY DRAW WATERSHED  
Sutton and Schleicher Counties, Texas  
February 1958

#### SUMMARY OF PLAN

##### General Summary

The work plan for watershed protection and flood prevention for the Dry Devils River and Lowrey Draw watershed, Texas was prepared by the Edwards Plateau Soil Conservation District, Eldorado Divide Soil Conservation District, Sutton County Commissioners Court, Schleicher County Commissioners Court and the city of Sonora as the cosponsoring local organizations. Technical assistance was provided by the United States Department of Agriculture.

The watershed work plan covers an area of approximately 233 square miles, or 149,120 acres, in Sutton and Schleicher Counties, Texas. Approximately 6 percent of the watershed is cropland, 91 percent is grassland and 3 percent is in miscellaneous uses, such as stream channels, urban areas, roads and railroads.

There are no Federal lands in the watershed.

The work plan proposes installing, in a 5-year period, a project for the protection and development of the watershed at an estimated cost of \$2,148,327. Of this project cost \$1,662,349 will be paid for from Public Law 566 funds and the remaining \$485,978 will be borne by other interests. In addition, local interests will bear the entire cost of operation and maintenance, with a capitalized value of \$85,711.

##### Land Treatment Measures

The cost of land treatment measures is estimated at \$299,033, all of which will be paid for by funds other than those provided under Public Law 566, as amended.

##### Structural Measures

The structural measures included in this plan consist of 13 floodwater retarding structures having an aggregate capacity of 37,778 acre-feet. The total cost of these measures, including the capitalized value of operation and maintenance, is \$1,935,005 of which local interests will bear \$272,656. The remaining \$1,662,349 is to be provided from Public Law 566 funds. The local interests share of the total cost of

structural measures includes: land, easements and rights-of-way, 66.2 percent; operation and maintenance, 31.4 percent; and administering contracts, 2.4 percent.

#### Damages and Benefits

The estimated average annual floodwater, sediment and erosion damage without the project is \$161,554. The estimated average annual damage with the project installed, including land treatment and structural measures, is \$6,042. The average annual primary benefits accruing to structural measures are \$136,967, which are distributed as follows:

Floodwater damage reduction	\$117,783
Sediment damage reduction	24
Erosion damage reduction (flood plain)	6
Indirect damage reduction	17,672
Benefits from changed land use	1,251
Benefits from outside project area	231

The ratio of the average annual benefits (\$136,967) to the average annual cost of structural measures (\$68,224) is 2.0 to 1.

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

#### Provisions for Financing Construction

The Sutton County Commissioners Court, which has taxing power, will contract for the construction of the floodwater retarding structures listed in the plan. Funds for the local share of the project will be financed by assessment of local taxes.

#### Operation and Maintenance

Land treatment measures will be installed, operated and maintained by the landowners or operators of the ranches on which the measures are installed, under agreements with the Edwards Plateau and the Eldorado Divide Soil Conservation Districts. The 13 floodwater retarding structures will be operated and maintained by the Sutton County Commissioners Court, which has legal authority to raise funds. This includes two floodwater retarding structures located in Schleicher County. The estimated average annual cost of operations and maintenance of the structures is \$3,022.

## DESCRIPTION OF WATERSHED

### Physical Data

Dry Devils River originates in the south-central part of Schleicher County, approximately 8 miles northwest of Eldorado, Texas, flows south through Schleicher and Sutton Counties for about 46 miles, and discharges into the Devils River about 26 miles southwest of Sonora, Texas. The Dry Devils River and Lowrey Draw watershed, as designated in this plan, consists of that portion of the drainage area of Dry Devils River which lies north of a point on the stream channel one mile south of Sonora. This watershed lies in Schleicher and Sutton Counties and is approximately 21 miles in length. Lowrey Draw, which enters the Dry Devils River in the town of Sonora, is the major tributary and is approximately 11 miles in length. The watershed has an area of 149,120 acres (233 square miles), nearly all of which is in farms and ranches. Of this area, 19,840 acres (31 square miles) were determined to be non-contributing to the runoff from the watershed.

The topography of the watershed ranges from steep to very gently rolling. The Edwards Plateau is well dissected by the dendritic stream pattern of Dry Devils River and Lowrey Draw. Incised, but relatively wide stream valleys are bordered by steep hills of moderate relief. The relief of the hills diminishes rapidly upstream to the top of the plateau in the vicinity of Eldorado. Elevations above mean sea level are 2,102 feet in the bottom of the channel below Sonora, 2,291 feet in the channel at floodwater retarding structure site 2, and 2,410 feet on the plateau. The main alluvial flood plain ranges from 3,200 feet wide below Sonora to less than 150 feet wide in the headwaters. The top of the plateau is extremely flat and is marked by the existence of numerous large, circular sink holes. These sink holes, caused by the collapse of caverns in the underlying limestone beds, exist in profusion on extensive areas of the watershed and are scattered singly in other areas. This general area is identified also by the term "karst plain". The larger sink holes with fractured and cavernous bottoms were considered as non-contributing in the production of sediment and runoff.

The watershed lies entirely within the Edwards Plateau Land Resource Area. The soils which have developed from the weathering of limestones and marls are dark colored, fine textured and well aggregated. Over 75 percent of the soils are shallow to very shallow and stony, on moderate to steep slopes. The deeper soils are confined to the alluvial flood plain and the top of the plateau. The shallow to very shallow soils are of the Tarrant series, the deeper soils on top of plateau of the Toboso and Ozona series, and the deep alluvial soils are of the Frio series.

The dominant land use is range, with only a limited amount of cultivation of the deeper soils.



General view of section of non-contributing area  
in the vicinity of Eldorado, Texas.



A typical opening in bottom of sink area  
draining several hundred acres.

The overall land use for the watershed is as follows:

<u>Land Use</u>	<u>Acres</u>	<u>Percent</u>
Cropland	8,760	6
Rangeland	135,096	91
Miscellaneous <u>1/</u>	<u>5,264</u>	<u>3</u>
Total	149,120 <u>2/</u>	100

1/ Includes roads, highways, railroads, airports, towns, etc.

2/ Includes 19,840 acres of non-contributing area.

The agricultural alluvial land subject to overflow consists of 3,510 acres, of which 2,279 acres are flood plain and 1,231 acres are stream channels. Under present conditions of the watershed, the entire flood plain would be flooded by the runoff from the maximum storm to be expected once in 100 years. At the present time, about 7 percent of the agricultural flood plain is in cultivation and 93 percent in range.

The range in the watershed is primarily in fair and poor condition due to the extreme and prolonged drought of 1950 through 1956. However, sufficient base grasses remain that quick recovery of the vegetative cover can be expected under normal moisture conditions.

Average temperatures range from 81 degrees Fahrenheit in the summer to 48 degrees in the winter. The normal frost-free season of 240 days extends from March 23 to November 18.

The mean annual rainfall for the watershed is 22.08 inches. Computed from records at Texas Agricultural Experiment Sub-station No. 14 located near Sonora, Texas. The minimum recorded annual rainfall was 7.82 inches, the maximum was 41.51 inches. The rainfall is well distributed, with the wettest months being April, May, June, September and October. Individual storms producing excessive rainfall of sufficient amount to cause serious erosion and flood damage may occur in any season, however, these occur more frequently in the spring and fall months.

Water for livestock and domestic uses is supplied by deep wells. These wells provide an adequate and dependable water supply, however, due to the high cost of drilling, they are too few in number to provide proper distribution of grazing.

The town of Sonora obtains its water from deep wells, which are adequate and dependable at this time.

#### Economic Data

Ranching is the principal agricultural enterprise in this watershed. During the wolf-proof fencing boom of 1910-1915, sheep and goat numbers

increased rapidly. They were temporarily reduced in 1917-1918 due to extreme drought, but sheep, particularly, made rapid gains until the peak was reached in 1937. The rapid decline of sheep numbers following 1937 is largely attributed to a serious deterioration in range conditions, together with the spread of poisonous bitterweed and the recent extreme drought. It is estimated that of the total livestock currently in the watershed 90 percent are sheep and 10 percent are cattle.

Livestock in the area are, in general, of very high quality. Most of the ranchmen have for many years used purebred sires, together with rigid culling. Several breeders of registered sheep and cattle are located within the watershed.

The principal livestock markets for this area are Fort Worth, San Antonio, Kansas City and San Angelo, to which ranchers ship direct; however, most of the livestock are marketed as feeder lambs and calves and are shipped through local representatives to northern buyers. Most of the marketing is done in the fall.

Practically all of the wool and mohair produced in the area is marketed through the Sonora Wool and Mohair Company. This company, one of the four largest in the United States, is capable of marketing the high-grade wool in large quantities thereby obtaining premium prices.

Only about 6 percent of the watershed is in cultivation. Principal crops are grain sorghums, cotton and tame pasture grasses, which are used to supplement native pastures.

The average size of ranches in, or partly in, the Dry Devils River and Lowrey Draw watershed is 5,713 acres. This acreage is sufficient for an economical unit. The average value of land and buildings per ranch is \$200,274 (1954 agricultural census). Approximately 62 percent of the ranches are owner operated and the other 38 percent are leased on a short time basis. There is usually very little soil and water conservation practices established on the ranches operated under short term leases.

Even though farm and ranch income has been relatively high the past decade, the recent drought situation has created a temporary "strained" financial condition. The present high price of feed and slump in livestock prices have forced many ranchers to carry heavy livestock and land loans.

Crude oil and natural gas production is important to the economy of Sutton and Schleicher Counties. Oil production within the watershed is relatively minor, however, a major gas company is presently constructing a collecting and processing system in order to utilize the production of numerous gas wells located within the drainage area. Oil and gas leases have furnished some income to supplement that from livestock. The average lease has sold for about \$4.00 or \$5.00 per acre. Most of the

ranchers get \$0.50 per acre rental annually for five or ten-year leases.

Sonora, with a population of 2,633, is the Sutton County seat and the only town in the Dry Devils River and Lowrey Draw watershed, as well as in the county. Most of the ranchers in the county have homes in Sonora. It is known for its annual wool and mohair show, an outstanding exhibit in the Nation. Eldorado, population 1,663, is the Schleicher County seat and is located just north of the watershed boundary. It is the market center and shipping point for the county and has one of Texas' few wool-processing mills.

The watershed is served by approximately 65 miles of roads, of which 45 miles are paved (U. S. Highway 290, U. S. Highway 277, and Farm Roads 33 and 864). There are five major bridges on these roads. There are no bridges on the 20 miles of county roads in the watershed. Many miles of private roads lead from the paved highways and county roads to ranch headquarters and through various pastures. Floods occasionally make some of the roads impassable. The detours thus occasioned cause delay and extra travel distance to and from markets. The Panhandle and Santa Fe Railroad provides ample loading facilities at both Sonora and Eldorado for carload lot shipments of livestock.

#### Status of Conservation Work in the Watershed

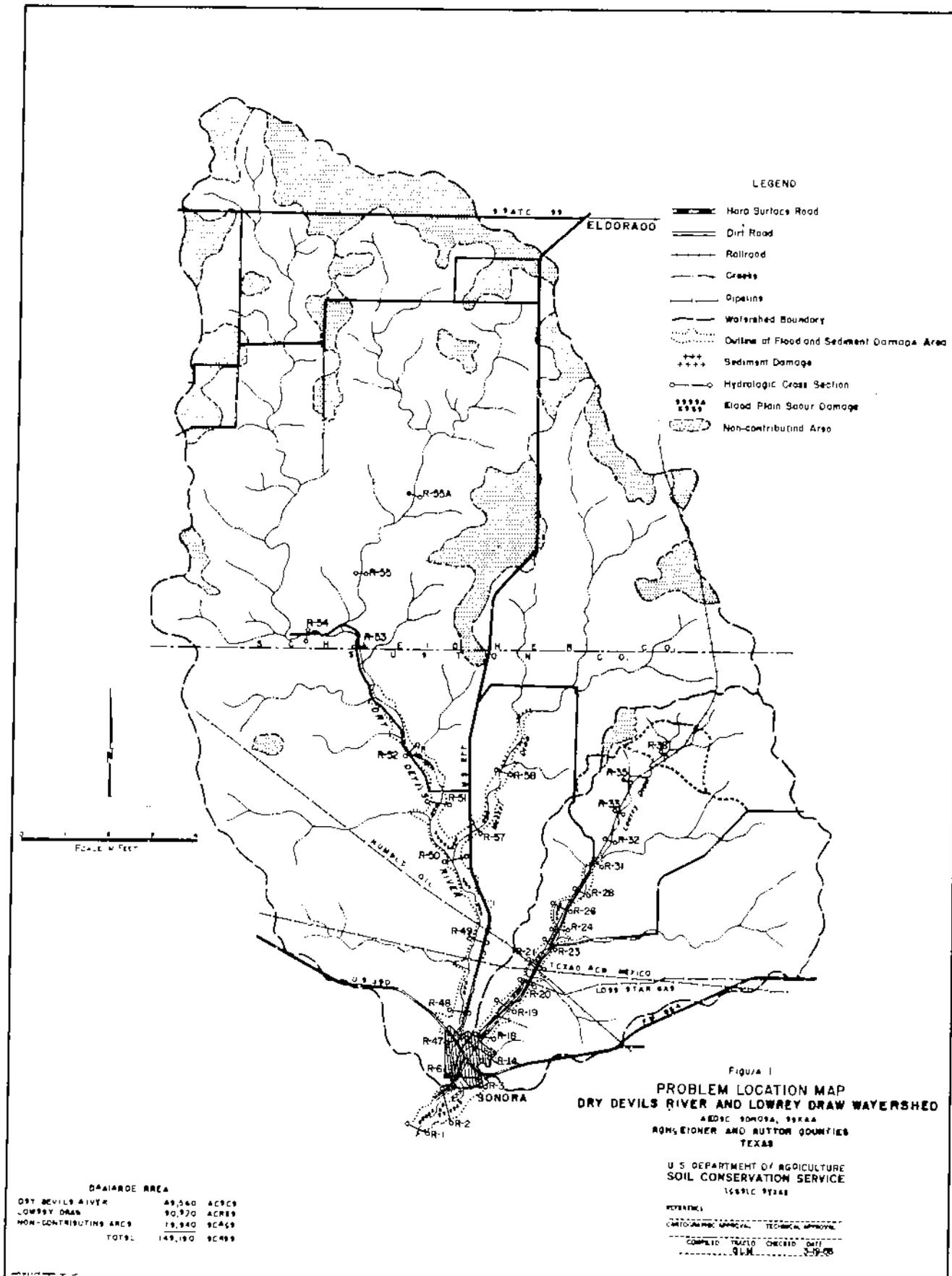
The Dry Devils River and Lowrey Draw watershed is served by Soil Conservation Service work units at Sonora and Eldorado, which are assisting the Edwards Plateau and Eldorado Divide Soil Conservation Districts. These work units have assisted farmers and ranchers in preparing 84 soil and water conservation plans on 91,652 acres (64 percent of the agricultural land) within the watershed and in giving technical guidance in establishing and maintaining planned measures. Thirty 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 to five years, average crop and pasture yields have increased by about one-fourth.

### WATERSHED PROBLEMS

#### Floodwater Damage

Sonora, founded in 1888, is located at the confluence of Dry Devils River and Lowrey Draw. Due to the scarcity of building sites, approximately 75 percent of the town has been built within the flood plain of Dry Devils River and Lowrey Draw. Approximately 98 percent of the average annual flood damage in the watershed occurs within the town (figure 1).

Urban property subject to flood damage consists of residential and business properties, utilities, churches, schools, and city and county property. The current value of urban property subject to flood damage is estimated to be \$11,839,000.



LEGENO

- Hard Surface Road
- Dirt Road
- Railroad
- Creeks
- Pipeline
- Watershed Boundary
- Outline of Flood and Sediment Damage Area
- +++ Sediment Damage
- Hydrologic Cross Section
- Flood Plain Scour Damage
- Non-contributing Area

Figure 1  
**PROBLEM LOCATION MAP**  
 DRY DEVILS RIVER AND LOWREY DRAW WATERSHED  
 AEDDC SONORA, 59XAA  
 AGNES ETCHER AND BUTTON COUNTIES  
 TEXAS

U.S. DEPARTMENT OF AGRICULTURE  
 SOIL CONSERVATION SERVICE  
 15691C 97248

PREPARED BY  
 CAROL ANN MCKEE APPROVAL TECHNICAL APPROVAL  
 COMPILED TERRY GIBBS DATE  
 8-1-58

**DRAINAGE AREA**

DRY DEVILS RIVER	49,560	ACRES
LOWREY DRAW	90,970	ACRES
NON-CONTRIBUTING AREAS	19,940	ACRES
<b>TOTAL</b>	<b>149,190</b>	<b>ACRES</b>

Floods on Dry Devils River and Lowrey Draw caused extensive damage to fences, roads, bridges, railroads, and urban property in 1892, 1932, 1936, 1938 and 1957. High-intensity storms, with rainfall ranging from 6 to 15 inches, have occurred recently on adjoining watersheds. Had the June 1954 rainfall which fell on Granger Draw, located ten miles west of Sonora, fallen on the Dry Devils River and Lowrey Draw watershed, the city of Sonora would have suffered floodwater and sedimentation damages comparable to the damages at Ozona from the flood of Johnsons Draw. It was at Ozona, located 36 miles west of Sonora, where 17 lives were lost and several million dollars in damage resulted from a severe flood in 1954.

In 1892 two persons were drowned in the flooding of Dry Devils River at Sonora. In 1928 a ranch employee was drowned while attempting to cross the Devils River at flood stage. There are many tales of people barely escaping death from the rapidly rising waters of either Dry Devils River or Lowrey Draw. The 1936 flood caused considerable damage to property in the city of Sonora, and about 100 families were temporarily made homeless. It is estimated that the 1936 storm, which was approximately of the magnitude that could be expected to occur on an average of once in 25 years, caused damage which under present conditions and values would be approximately \$1,655,000.

The greatest concentration of damage can be expected to occur at the Sonora Wool and Mohair Company warehouse. About two million pounds of wool and mohair are stored in this warehouse each year until it can be sold. Local ranchers say that if the bottom sacks stored in the warehouse get water around them, the entire clip would be lost due to the "wick" effect of the sacks and their contents. There are no scouring plants in Texas large enough to process this quantity of wool in time to prevent spoilage. The loss of a clip of wool and mohair would have a disastrous effect on the economy of the town of Sonora and Sutton County.

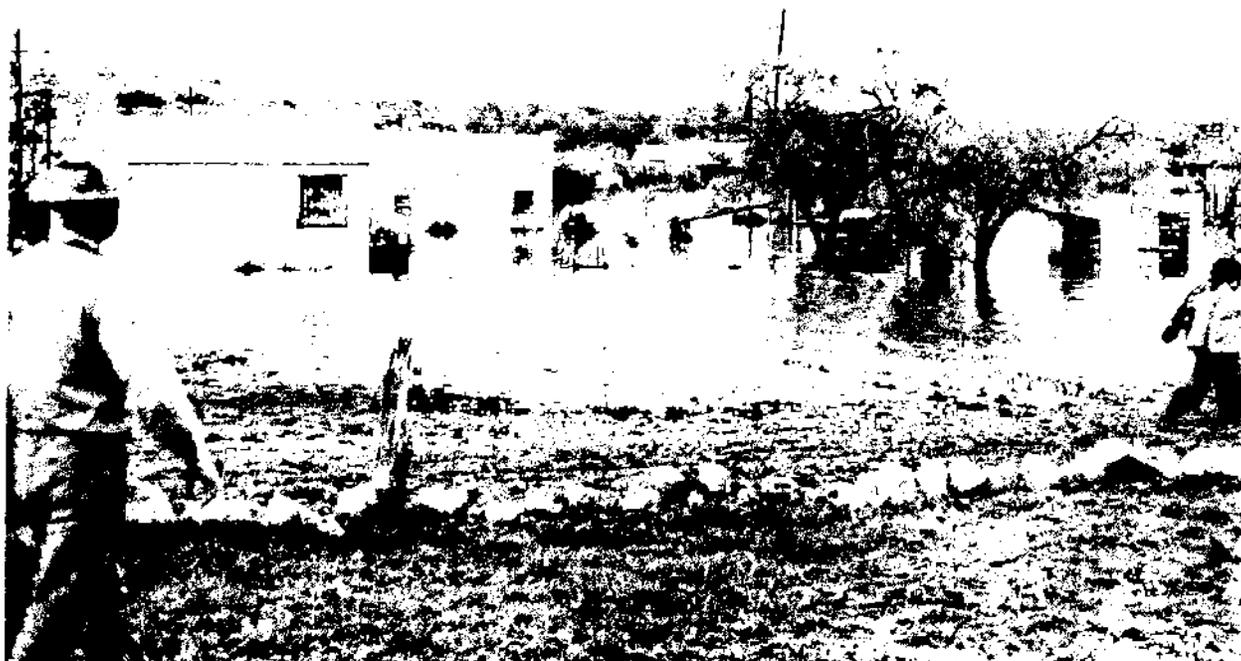
Small floods occur on Dry Devils River and Lowrey Draw on an average of once in 5 years. They cause some livestock loss, fence damage and spreading of noxious plants such as bitterweed.

Based on the frequency study of floods during a normal 100-year period, the total direct floodwater, sediment, and erosion damages that can be expected were estimated to average \$140,482 annually at long-term price levels. Annual floodwater damages were estimated to average \$140,442 under present conditions, of which \$27 is crop damage, \$454 is other agricultural damage, and \$139,961 is nonagricultural damage, such as damage to roads, bridges, public utilities, wool houses, railroads, pipelines, retail and wholesale business establishments, and to residences.

Indirect damages such as interruption of travel, loss of business, breakdown of utility service and the like are unusually heavy in this watershed due to the concentration of urban property having high damageable values in the flood plain. The total annual value of these indirect



Sonora residents anxiously watch rising flood waters of Dry Devils River and Lowrey Draw inundate their homes. May 1957.



Dry Devils River and Lowrey Draw shown entering 25 Sonora homes from 3.5 inch rain on May 12, 1957.

damages is estimated to be \$21,072. The average annual monetary flood damages are summarized in table 7.

#### Sediment Damage

Sediment damage from overbank deposition on the agricultural lands of the flood plain is minor.

Only about 2 percent, 52 acres, of the flood plain has been damaged by deposition. Sand and gravel deposits up to 2 feet deep have damaged 42 acres an estimated 25 percent and 10 acres an estimated 50 percent in terms of reduced productivity. Deposits of highly aggregated clay and clay loam sediment were not deep enough to be considered as damaging. Sediment damage in the city of Sonora was not evaluated separately from floodwater damages.

There are no large reservoirs in the watershed.

#### Erosion Damage

Upland erosion rates are low, as only 6 percent of the watershed is in cultivation. Level terraces have been constructed on more than 60 percent of the cropland and approximately 67 percent of the rangeland is in fair to good cover condition. Sheet erosion accounts for approximately 94 percent of the sediment produced in the watershed.

About 232 acres in the flood plain have been scoured by floodwater. Removal of soil to depths ranging from 6 to 12 inches has damaged 208 acres an estimated 10 percent and 24 acres an estimated 20 percent in terms of reduced productivity.

Streambank and channel erosion is minor and consists mostly of scouring in the bottoms of the wide, grassed-over channels. Gravel produced by this scouring action makes up the stream bedload and is deposited on the flood plain by floodwaters.

#### 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 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 Dry Devils River and Lowrey Draw watershed have been minor. However, following the 1932 flood considerable work was done in Sonora to prevent damage from floodwater. A rock wall was built on the north bank of

Lowrey Draw and a levee was built on the south bank. This levee extended up Murphy Draw in an effort to prevent water from following an old slough south of the railroad tracks. In addition, some channel improvement was done on Dry Devils River. These measures, estimated to have cost \$30,000 in 1934, are still effective in preventing damage by the runoff from small rains, but are inadequate for controlling major floods. The effectiveness of these measures was given consideration in the development of the watershed work plan. They must be maintained at present size and capacity in order to obtain the full protection and benefits as outlined in the plan.

The Edwards Plateau and the Eldorado Divide Soil Conservation Districts have been very active in initiating flood prevention work and have exerted their influence toward a high degree of participation in this program on the part of the ranchers and other interested parties in the watershed.

There are no existing or proposed works of improvement of any other agency which would affect or be affected by the measures included in this plan.

#### WORKS OF IMPROVEMENT TO BE INSTALLED

##### Land Treatment for Watershed Protection

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 Edwards Plateau and Eldorado Divide 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 the establishment of those land treatment practices which have a measurable effect on the reduction of floodwater and sediment damages.

The amounts and estimated costs of the measures that will be installed by the landowners are shown in table 1. The estimated total cost of these measures, including the expected reimbursement from ACPS or other Federal funds, is \$299,033. It is not expected that any additional technical assistance will be necessary to keep land treatment in balance with structural development during the 5-year installation period. Landowners and operators will maintain these land treatment measures in accordance with provisions of farmer-district cooperative agreements.

Land treatment measures will decrease erosion damage and sediment production from fields and pastures by improving soil-cover conditions. Most of the land treatment measures will not only function to decrease erosion damage and sediment production from fields and pastures but also will effectively improve soil conditions and allow larger amounts of rainfall to soak into the soil at more rapid rates. These measures include deferred grazing and proper use of rangeland to provide improvement,

**TABLE 1 - ESTIMATED PROJECT INSTALLATION COST 1/  
Dry Devils River and Lowrey Draw Watershed, Texas**

Installation Cost Item	Unit	Number to be Applied	Total Project		
			Estimated Cost <sup>2/</sup> :		Total
			P.L.566 Funds	Other Funds	
<b>LAND TREATMENT FOR</b>					
<b>Watershed Protection</b>					
<b>Soil Conservation Service</b>					
Contour Farming	Acre	829	-	2,072	2,072
Cover Cropping	Acre	4,785	-	28,710	28,710
Crop Residue Utilization	Acre	4,785	-	8,374	8,374
Strip Cropping	Acre	348	-	696	696
Rotation Hay and Pasture	Acre	319	-	2,712	2,712
Brush Control	Acre	11,102	-	78,765	78,765
Deferred Grazing	Acre	56,418	-	49,418	49,418
Pasture Planting	Acre	128	-	1,280	1,280
Pitting	Acre	4,262	-	9,786	9,786
Proper Use	Acre	76,230	-	62,707	62,707
Range Seeding	Acre	9,102	-	49,202	49,202
Diversion Construction	Mile	2.2	-	2,091	2,091
Terracing	Mile	16	-	2,720	2,720
Wire Diversion	Feet	2,500	-	500	500
Technical Assistance(Accel.)	-	-	-	-	-
<b>SCS Subtotal</b>			-	<b>299,033</b>	<b>299,033</b>
<b>TOTAL LAND TREATMENT</b>			-	<b>299,033</b>	<b>299,033</b>
<b>STRUCTURAL MEASURES</b>					
<b>Soil Conservation Service</b>					
Floodwater Retarding Structures No.		13	1,278,731	-	1,278,731
<b>SCS Subtotal</b>			<b>1,278,731</b>	-	<b>1,278,731</b>
<b>Subtotal - Construction</b>			<b>1,278,731</b>	-	<b>1,278,731</b>
<b>Installation Services</b>					
<b>Soil Conservation Service</b>					
Engineering Services			232,495	-	232,495
Other			151,123	-	151,123
<b>SCS Subtotal</b>			<b>383,618</b>	-	<b>383,618</b>
<b>Subtotal - Installation Services</b>			<b>383,618</b>	-	<b>383,618</b>
<b>Other Costs</b>					
Land, Easements & R/W			-	180,445	180,445
Administration of Contracts			-	6,500	6,500
<b>Subtotal - Other</b>			-	<b>186,945</b>	<b>186,945</b>
<b>TOTAL STRUCTURAL MEASURES</b>			<b>1,662,349</b>	<b>186,945</b>	<b>1,849,294</b>
<b>TOTAL PROJECT</b>			<b>1,662,349</b>	<b>485,978</b>	<b>2,148,327</b>
<b>SUMMARY</b>					
<b>Subtotal SCS</b>			<b>1,662,349</b>	<b>485,978</b>	<b>2,148,327</b>
<b>TOTAL PROJECT</b>			<b>1,662,349</b>	<b>485,978</b>	<b>2,148,327</b>

1/ No Federal lands are involved.

2/ Price Base 1957

February 1958



Practically bare rangeland pitted and seeded to sideoats grama, KR bluestem, buffelgrass and blue panicum.



The results as obtained by the conservation practices applied in the above picture.



Brush control and proper use give good results  
in Sutton and Schleicher Counties.

protection and good maintenance of grass stands. They also include: brush control, to allow grass stands to improve and replace the poor soil cover afforded by brush; range seeding to establish good cover on the grassland, and cover cropping and crop residue utilization to provide cover to the cultivated land.

In addition to the above soil improvement and cover measures, land treatment includes contour farming, strip cropping, rotation hay and pasture, pasture planting, pitting, diversion construction and terracing, all of which have a measurable effect in reducing peak discharge by slowing runoff water from fields and rangelands. These measures also help the soil improvement and cover measures to reduce erosion damage and downstream sediment yields.

#### Structural Measures

A system of 13 floodwater retarding structures will be installed in the Dry Devils River and Lowrey Draw watershed to afford the needed protection to flood plain lands that cannot be provided by land treatment measures alone. Figure 2 shows a section of a typical floodwater retarding structure. The structures will detain temporarily the runoff from 76.8 percent of the

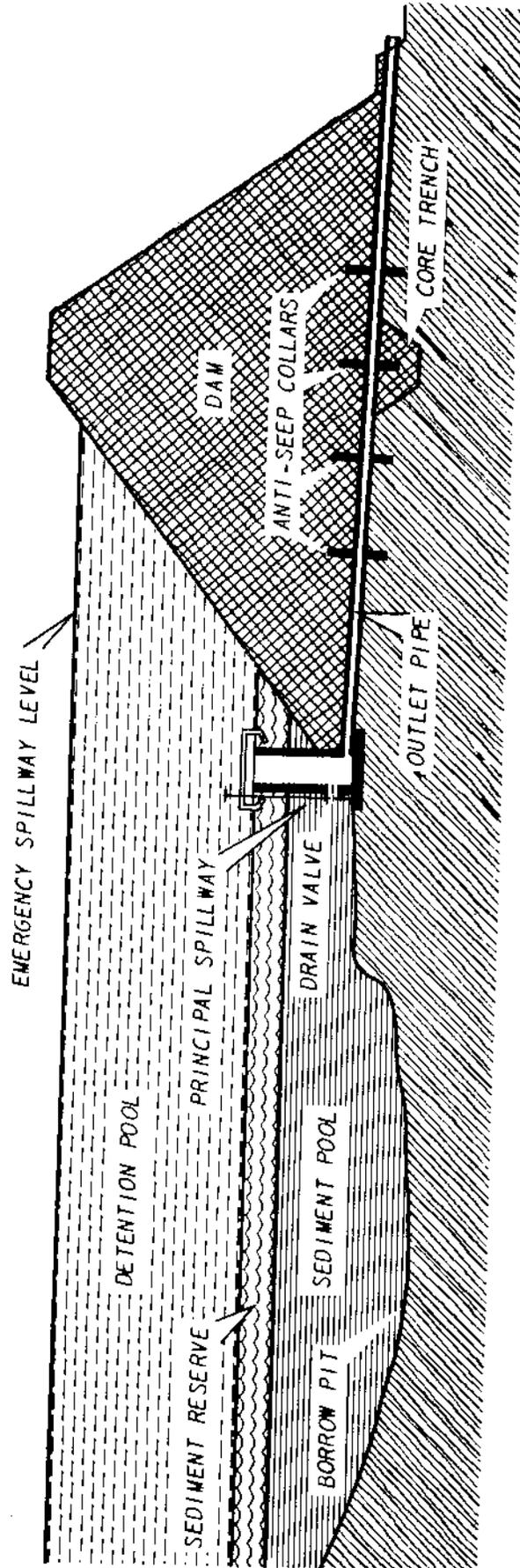


Figure 2  
SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE



Floodwater retarding structures release water slowly following heavy rains.

contributing portion of the watershed from a storm that can be expected to occur no more often than once in 100 years. Storage in individual sites will vary from 3.64 to 5.56 inches of runoff from their watersheds. The total of 35,303 acre-feet of detention capacity provided by the 13 structures is sufficient to detain 4.3 inches of runoff for the area above structures or the equivalent of 3.3 inches from the entire contributing area of the watershed.

Due to the limited number of site locations in the watershed and the need for a high percentage of control to give the desired degree of protection to Sonora, a structure was necessary at the location of site number 3. The terrain is relatively flat at this point limiting the amount of storage that could be developed at this site, consequently, it was necessary to locate sites 1 and 2 above site number 3 in order to reduce the amount of storage required.

It was determined that a structure across the mainstem of Lowrey Draw could not be economically justified due to the cost of relocating the railroad.

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, pipelines and utilities is estimated to be \$180,445, based on current market values furnished by bankers and other local people. The total area of the sediment pools is 420 acres, none of which is in the flood plain.

There are five low-water crossings on Dry Devils River and four on Lowrey Draw that will be effected by the release flow from the principal outlets of the floodwater retarding structures. Under present conditions water flows through these crossings for relative short periods following rains. After the structures are constructed the flow will be reduced in peak but flow will be greatly prolonged. The Sutton County Commissioners Court has agreed to install the culverts, or other improvements, needed to keep these crossings passable during periods of floodwater release.

The location 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 \$1,849,294, of which \$186,945 will be borne by local interests and \$1,662,349 by Public Law 566 funds.

#### BENEFITS FROM WORKS OF IMPROVEMENT

The combined program of land treatment and structural measures described above will eliminate all urban damage from floods of the magnitude equal to that experienced in September, 1936 (figure 4). The estimated damage from the 100-year frequency storm will be reduced from \$5,025,000 to \$522,000, a 90 percent reduction. Damages from the 50-year frequency storm will be reduced from \$3,102,000 to \$103,000, a 97 percent reduction. Urban damages from this frequency storm will be confined to lawns, streets and foundations of a few buildings. In planning future development it should be kept in mind that the area southwest of Mesquite Street and the low lying areas on both sides of U. S. Highway 290 west of Dry Devils River will experience moderate to severe flooding from the 100-year frequency storm after the program has been installed. This area is also shown on figure 4.

The estimated average annual flood, erosion and sediment damage within the watershed would be reduced from \$161,554 to \$6,042, a 96 percent reduction. About 87 percent of the expected reduction in the average annual damage would result from the system of floodwater retarding structures.

It is not expected that any changes will take place in flood plain crop distribution due to installation of the project.

The planned project will reduce flooding in the watershed enough to greatly diminish the hazard to human life.

Owners of urban property in areas subject to flooding along Dry Devils River and Lowrey Draw indicate that property values will increase when

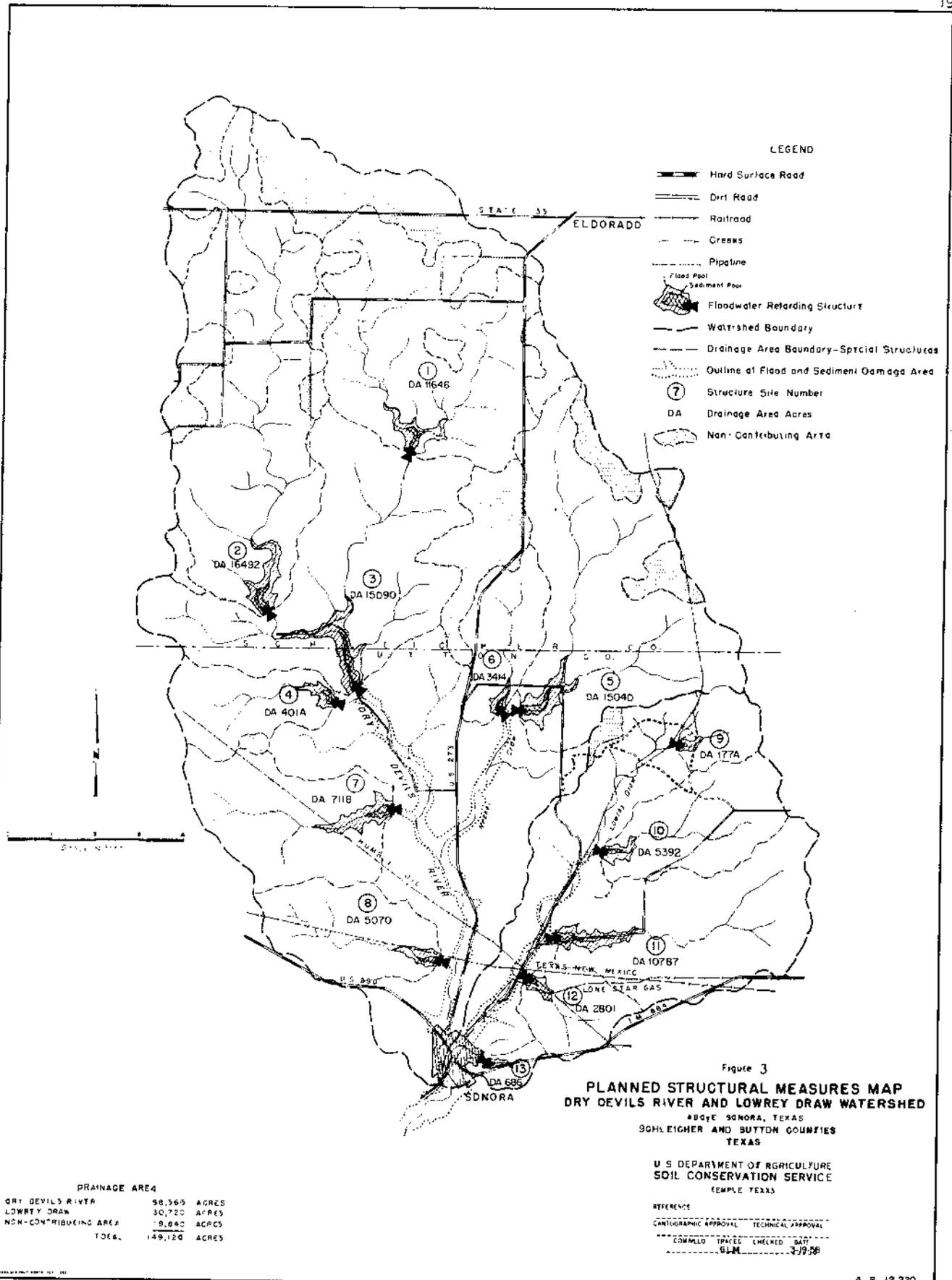


Figure 4

EXTENT OF FLOODING  
CITY OF SONORA, TEXAS

- ..... 1936 Flood
- 100 Year Frequency Design  
Storm - Present Conditions
- 100 Year Frequency Design  
Storm - With Program



the hazard of flooding is reduced. There are about 150 lots which have been subdivided but, due to the flood threat, have remained undeveloped. When the flood hazard is removed and when the gas companies begin to fully exploit the local gas fields, it is expected that many of these lots will be utilized for both industrial and residential locations. The annual benefit of the additional income from increased values of property is estimated to be \$1,251.

The increased recharge of groundwater, as a result of this project, will be of benefit to people whose water supply comes from the Edwards limestone aquifer. However, these benefits will be so widely dispersed that it is beyond the scope of this investigation to determine who would be benefited, and the value of these benefits.

The total flood prevention benefits, as a result of the structural measures are estimated to be \$136,967. Of this amount, \$231 represents downstream benefits to the flood plain of Dry Devils River below the project area.

#### COMPARISON OF BENEFITS AND COSTS

The average annual cost of the structural measures (converted from total installation cost plus operation and maintenance) is estimated to be \$68,224. When the project is completely installed, it is expected to produce average annual benefits of \$136,967. The project, therefore, will produce benefits of two dollars for each dollar of cost. In addition to the monetary benefits, there are other substantial intangible values which will accrue to the program, such as increased opportunity for recreation, better living conditions, sense of economic security, protection of public health, and the safeguarding of human life.

#### ACCOMPLISHING THE PLAN

Federal assistance for carrying out the works of improvement as described in this work plan will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as amended by the Act of August 7, 1956, (Public Law 1018, 84th Congress, 70 Stat. 1088).

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

#### Land Treatment Measures

Land treatment measures itemized in table 1 will be established by farmers and ranchers in cooperation with the Edwards Plateau and Eldorado Divide Soil Conservation Districts. The cost of applying these measures will

be borne by the owners and operators of the land, with some reimbursement from the Agricultural Conservation Program. The soil conservation districts are giving assistance in the planning and application of these measures under its going program. The assistance will be intensified to assure application of the planned measures within the 5-year installation period for the project.

The governing bodies of the Edwards Plateau and Eldorado Divide Soil Conservation Districts will assume aggressive leadership in advancing the land treatment program, with the assistance of the Commissioners Court of Sutton and Schleicher Counties and the city of Sonora, by arranging for meetings according to a definite schedule. By this means and by individual contacts they will encourage the landowners and operators within the Dry Devils River and Lowrey Draw 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 to the existing arrangements for equipment usage in the district. The soil conservation district governing bodies will make, or cause to be made, periodic inspections of the completed conservation measures within the district and make necessary arrangements for maintenance work to be done upon receipt of maintenance inspection reports.

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 program.

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

#### Structural Measures

The Sutton County Commissioners Court, which has taxing power, will let and service all contracts for the construction of all floodwater retarding structures listed in the plan. The Court also will furnish all land, easements and rights-of-way for all structural measures at no cost to the Federal Government. Funds for the local share of project costs, including land, easements and rights-of-way and administering contracts, will be financed by local taxes. Construction of the structural measures will be started as soon as the local organization is equipped to handle its responsibilities, Public Law 566 funds are available, the necessary easements are obtained and maintenance agreements are executed. Floodwater retarding structures will be scheduled for construction so as to complete the project within a 5-year period.

The following is a grouping of structures for construction purposes, each

of which has a favorable benefit-cost ratio, based on those benefits obtained within the boundary of each construction unit:

Construction Unit No. 1 - Sites 9, 10, 11, 12 and 13.

Construction Unit No. 2 - Sites 1, 2, 3, 4, 5, 6, 7 and 8.

All necessary land, easements, and rights-of-way will be obtained for each construction unit before Federal financial assistance is made available for installation of any part of that construction unit.

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

The cooperating parties have agreed on a 5-year installation period. The tentative schedule for construction is outlined in the following table:

Fiscal Year	Structure Numbers	P. L. 566 Funds	Other Funds	Total
1st	9, 10, 11	432,088	46,140	478,228
2nd	12, 13, 1	304,808	39,005	343,813
3rd	2, 3, 4	408,215	51,050	459,265
4th	5, 6	289,758	16,675	306,433
5th	7, 8	227,480	34,075	261,555
Total		1,662,349	186,945	1,849,294

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 applied, under agreements with the Edwards Plateau and Eldorado Divide 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 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 13 floodwater retarding structures will be operated and maintained by the Sutton County Commissioners Court which has legal authority to raise and use funds for this purpose.

All floodwater retarding structures will be inspected by representatives of all cosponsoring organizations and the Soil Conservation Service at least annually and after each heavy rain or streamflow. Items of inspection will include, but not be limited to the conditions of the principal spillway and its appurtenances, the emergency spillway, the earthfill, the vegetative cover of the earthfill and emergency spillway, and fences and gates installed as a part of the floodwater retarding structures. The cosponsoring local organizations will maintain records of all maintenance inspections and all maintenance performed.

The Sutton County Commissioners Court will establish a maintenance fund consisting of \$1,000 per structure for the first 10 structures and \$750 each for the remaining 3 structures and will replenish this fund as used. The necessary maintenance work will be accomplished as far as possible through the use of county labor and equipment. Major items of maintenance will be accomplished either by contract or force account. The estimated annual operation and maintenance cost is \$3,022, 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 13 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.

### COST-SHARING

With the aid of such cost-sharing assistance as will be available under other Federal programs, private interests will install land treatment measures at an estimated cost of \$299,033 (table 1).

The required local costs for structural measures, consisting of the value of land, easements and rights-of-way, (\$180,445), the capitalized value of operation and maintenance of works of improvement (\$85,711), and the cost of administering contracts (\$6,500), are estimated at \$272,656.

The entire cost of constructing the structural measures, amounting to \$1,278,731, will be provided from Public Law 566 funds. In addition, the installation services cost of \$383,618 will be borne by the Public Law 566 funds. This represents a total Public Law 566 structure installation cost of \$1,662,349.

The total project cost of \$2,234,038, including operation and maintenance, will be shared 74.4 percent (\$1,662,349) by the Federal Government under the authority of Public Law 566 and 25.6 percent (\$571,689) by other interests.

CONFORMANCE OF PLAN TO FEDERAL LAWS AND REGULATIONS

The installation of the watershed protection and flood prevention project on the Dry Devils River and Lowrey Draw watershed will make a substantial contribution to the overall development of Devils River.

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

## SECTION 2

## INVESTIGATIONS, ANALYSES, AND SUPPORTING TABLES

INVESTIGATIONS AND ANALYSESLand TreatmentSoil Conditions

The soils of Dry Devils River and Lowrey Draw watershed are generally in fair condition, with small areas in poor condition. Effective agronomic rotations on the cropland are hard to maintain due to the uncertain rainfall in this area. Winter legume cover crops are only successful occasionally. The use and return to the soil of the residue from high residue producing crops and the use of grasses in hay-pasture rotations is the most effective method of maintaining soil condition. The range soils are generally in fair to good condition, but some of the non-stony shallow and very shallow soils are in very poor condition. Natural recovery of native grasses is expected to be very slow on many of these areas.

Cover Conditions and Range Sites

The vegetative cover of the rangeland in the Dry Devils River and Lowrey Draw watershed is primarily in fair and poor condition, with small isolated areas of the deep soils in good condition. The watershed lies within the mixed prairie plant group, and original vegetation consisted of a luxuriant cover of grammas, bluestems, and other good grasses. Range sites found in the watershed include the Deep Soil site, Shallow Upland site and Low Stony Hills site. These are described as follows:

The Deep Soil site includes valleys and divides having deep productive soils that take water moderately fast. The principal climax grasses adapted to this site are sideoats grama, feathery bluestem, Texas wintergrass, vine mesquite and cottontop. The deep soil sites are characterized at present by a predominance of curly mesquite, an increaser, and by invading weeds and mesquite trees.

The Shallow Upland site is characterized by soils ranging from 10 to 20 inches deep that take water moderately fast. These sites will support feathery bluestem, sideoats and hairy grama, green sprangletop, curly mesquite and other grasses. Most of this site is presently in poor condition with a sparse cover of red grama, hairy tridens and weeds. Catclaw, agarito and mesquite are common woody invaders.

The Low Stony Hills site has very shallow soils that are less than ten inches in depth. It is characterized by rolling rocky hills and ridges with many ledges and rock outcrops. Although the soils on this site are very shallow, rainfall infiltrates readily due to the fractured condition of the rock surface. The better grasses adapted to this site are bluestems, grammas, green sprangletop, cupgrass and Texas wintergrass. Common invading plants include red grama, hairy tridens, oak and cedar.

The range condition of these areas is shown on the following table:

<u>Range Site and Condition Class</u>		
<u>Condition Class</u>	<u>Acres</u>	<u>Percent For Site</u>
<u>Deep Soil Site</u>		
Good	5,200	13
Fair	17,201	43
Poor	17,601	44
Total	40,002	100
<u>Shallow Upland Site</u>		
Good	0	0
Fair	8,292	30
Poor	19,348	70
Total	27,640	100
<u>Low Stony Hills Site</u>		
Good	2,623	4
Fair	44,510	66
Poor	20,321	30
Total	67,454	100
<u>All Sites</u>		
Good	7,823	6
Fair	70,003	52
Poor	57,270	42
Total	135,096	100

#### Land Use and Treatment Needs

The land use on the upland was obtained by actual measurement of each land use from aerial photographs. The land use of the flood plain was planimetered from the flood plain strip map that was developed during the economic investigation.

The current conservation needs of the Edwards Plateau and Eldorado Divide Soil Conservation Districts were used as the basis for arriving at the land treatment needs for the watershed.

#### 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, sedimentation and economic investigations provided data on the effects of these measures as related to 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.

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, the non-contributing areas, 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 5 and 5A.

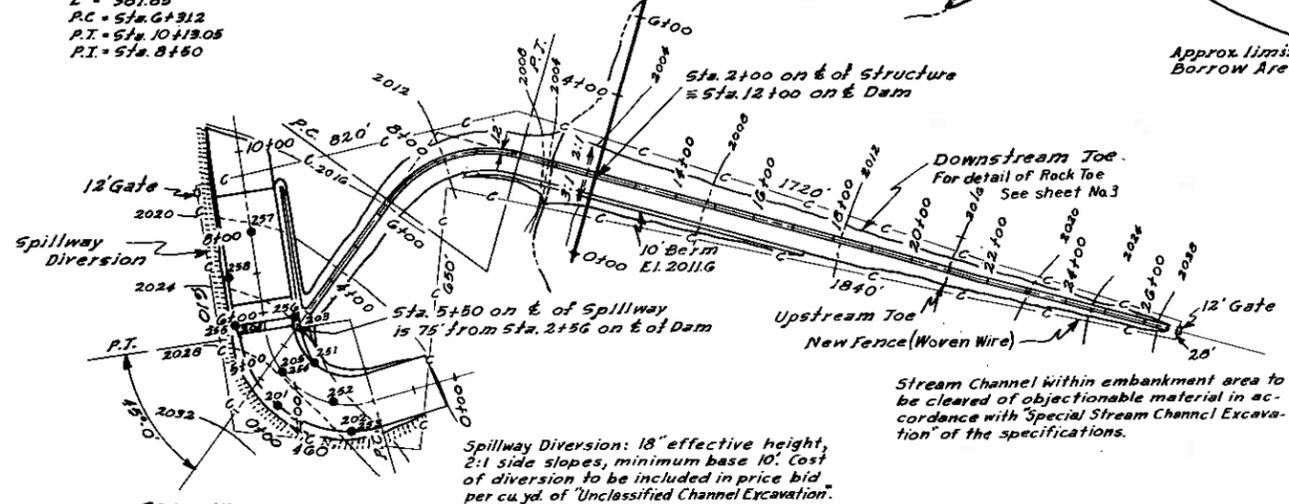
4. A topographic map was made of the pool area of each of the proposed sites in order to determine the storage capacity of the site, the estimated cost of the dam and the areas of flood plain and upland that would be inundated by the sediment and flood pools. Sediment storage requirements were determined 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 3.20 inches of runoff and to provide the additional storage needed for sediment and increasing the inches of runoff stored until the amount of storage that would result in the most economical structure was determined. The minimum storage was determined from criteria as set forth in Soil Conservation Service, Washington Engineering Memorandum No. 3, Revised. 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 spillways, 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 and for future conditions, assuming that the proposed works of improvement had been installed. Benefits so determined were allocated to individual measures or groups of interrelated measures on the basis of the effect of each on reduction of damages. In this manner it was determined that floodwater retarding structures 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

Clay	C.	Clay	Clayey	Cal.	Calcareous
Silt	Si	Silt	Silty	Vug.	Vugular
Limestone	Ls.	Chalk	Chalky	Fc.	Fractured
Flagstone & Gobbles	Flg.	Sandy	Sandy	Frl.	Frable
Lime	Mat	Marl	Marly	Ff.	Firm
		Ls.	Limestone	Vf.	Very
		Flg.	Flagstone	So.	Soft
		Mas.	Massive	H.	Hard
		Mat	Matrix	Cob	Cobbles

**LEGEND OF BORINGS**

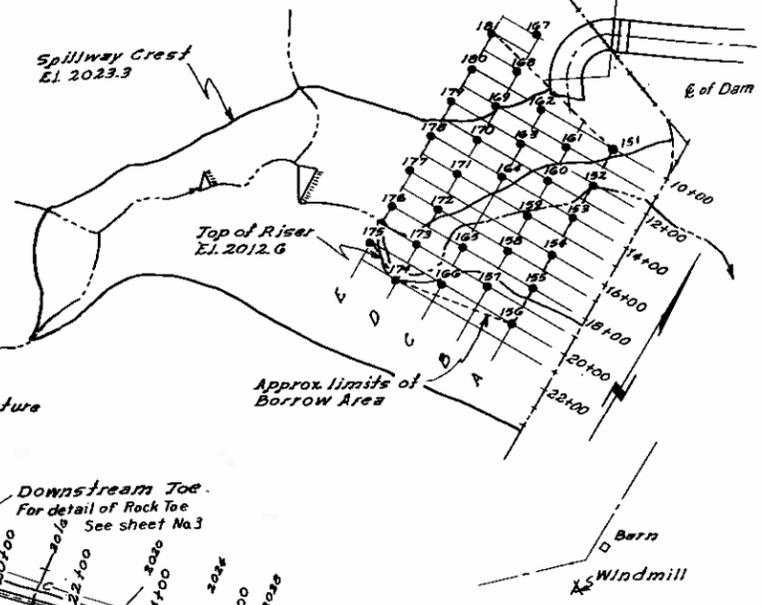
**EMBANKMENT CURVE DATA**  
 Δ = 69°-0'  
 D = 18°-04.3'  
 R = 318.36'  
 T = 218.80'  
 L = 381.85'  
 P.C. = Sta. 6+312  
 P.T. = Sta. 10+130.5  
 P.I. = Sta. 8+60

A minimum of 6" of topsoil to be placed in spillway and on all embankment, dike, spillway slopes and waste area except where rock is encountered or rock rip rap is placed. See the specification.

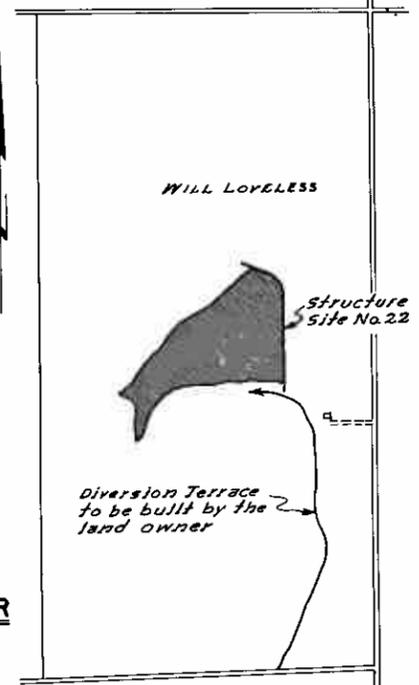


**PLAN OF EMBANKMENT AND SPILLWAY**

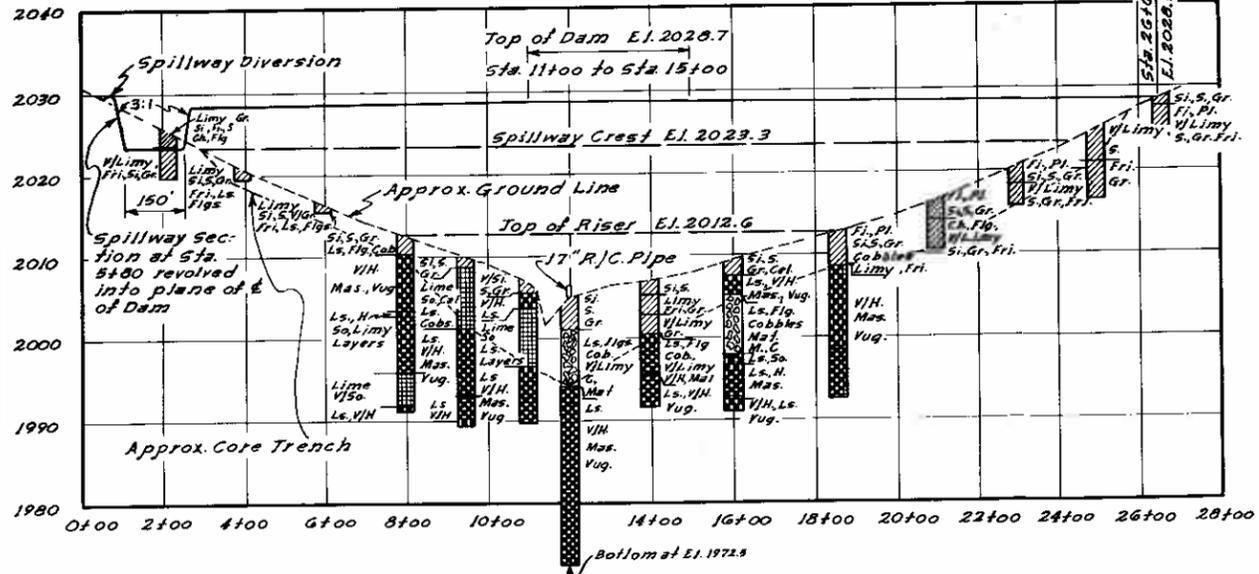
**SPILLWAY CURVE DATA**  
 Δ = 98°-0'  
 D = 28°-0'  
 R = 206.68'  
 L = 390.0'  
 P.C. = Sta. 2+00  
 P.T. = Sta. 5+50



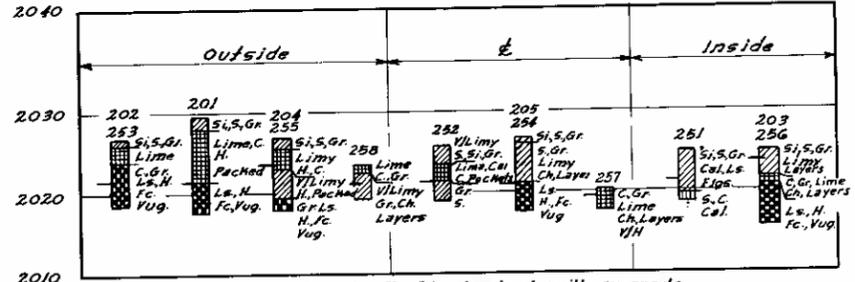
**GENERAL PLAN OF RESERVOIR**



**VICINITY MAP**



**PROFILE ON C OF DAM**



**LOG OF SPILLWAY BORINGS**

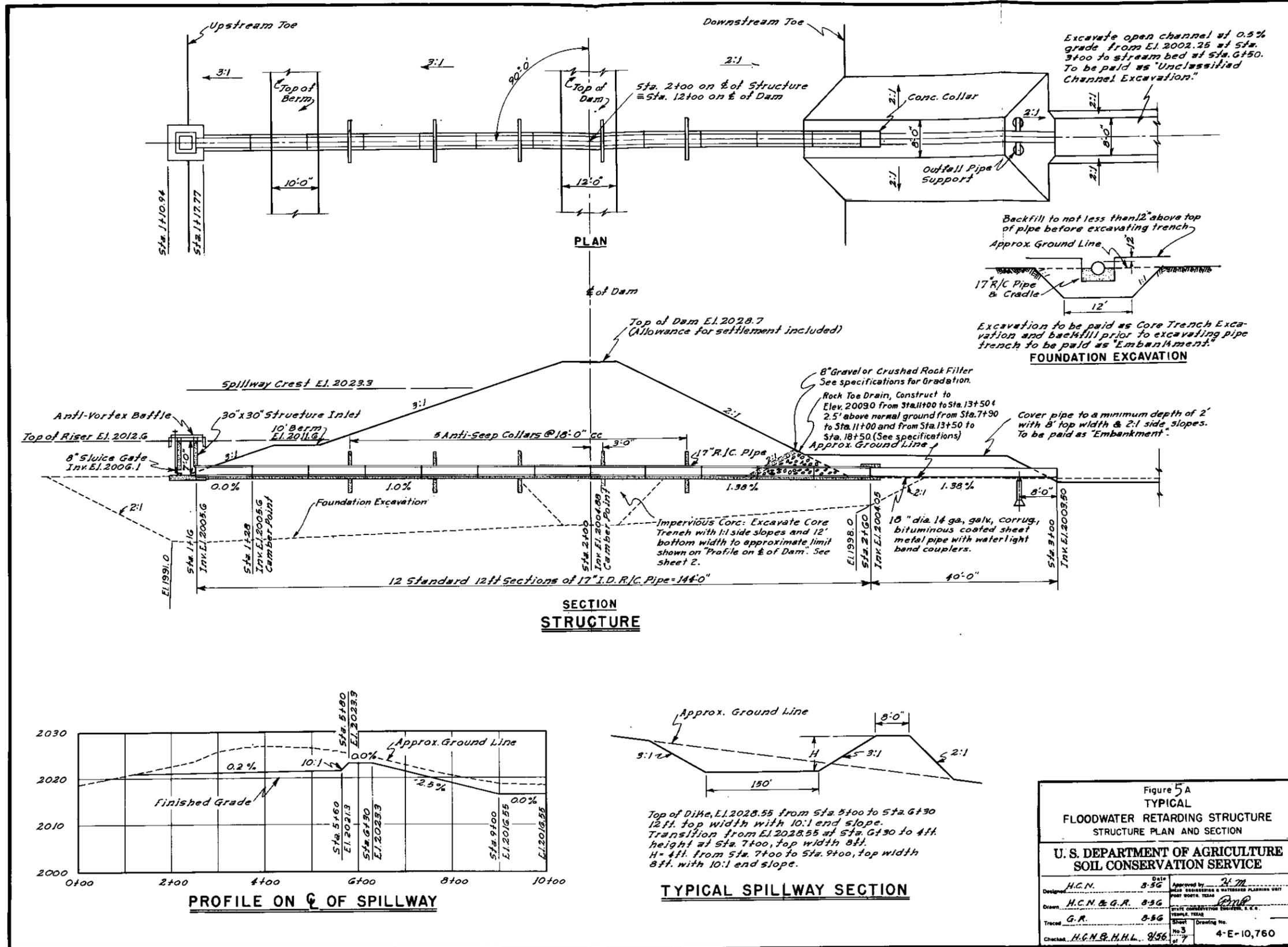
Note: Bar at left of boring is at spillway grade.  
 SEE PLAN OF EMBANKMENT AND SPILLWAY

ELEVATION	SURFACE		STORAGE	
	ACRES	ACRE FT.	INCHES	
2012.6	16.84	51.70	0.50	
2016.0	30.76	132.66	1.28	
2020.0	54.21	302.60	2.92	
2023.3	74.94	515.68	5.00	
2024.0	79.33	569.68	5.50	
2028.0	108.17	944.68	9.13	

Top of Dam (Effective) Elev.:	2028.5
Spillway Crest Elev.:	2023.3
Top of Riser Elev.:	2012.6
Sediment Pool Elev.:	2012.6
Drainage Area, Acres:	1243.0
Sediment Storage, Ac. Ft.:	51.7
Floodwater Storage, Ac. Ft.:	464.0

Figure 5  
 TYPICAL  
 FLOODWATER RETARDING STRUCTURE  
 PLAN AND PROFILE  
 U. S. DEPARTMENT OF AGRICULTURE  
 SOIL CONSERVATION SERVICE

Designed by	H.C.N.	Date	8-56	Approved by	H.M.
Drawn by	H.C.N. & G.R.	Scale	8-56	Checked by	H.M.
Traced by	G.R.	Sheet	8-56	Drawing No.	4-E-10,760
Checked by	H.C.N. & H.H.	of	7		



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 for 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 6).

#### 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 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 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 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 discharge under present conditions as related to damages caused by various peak discharge frequencies.
7. Determination was made of peak discharges and damages caused by various peak discharge frequencies 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. 3, Revised; NEH, Section 4, Hydrology, Supplement A; NEH, Section 5, Hydraulics).

Due to the scarcity of available meteorologic data and the high intensity thunderstorm patterns of this area, and after a study of the hydraulic and hydrologic characteristics, topography and geology of this watershed, and the types of damages occurring, it was determined that the annual flood frequency method should be used for analysis in this watershed.

The largest rain studied for damage determination was the 100-year-frequency storm. It was determined that this storm would produce a

peak discharge of 118,000 cubic feet per second at cross section number 3, which is the reference section (figure 1). This section is located about 0.3 mile south of the confluence of Dry Devils River and Lowrey Draw at the southern edge of the city limits of Sonora, Texas.

It was found that urban damages would begin at a discharge of 9,200 cubic feet per second and crop and pasture damage at 3,940 cubic feet per second at the reference section. Therefore, no storms producing peak discharges less than 3,940 cubic feet per second were used in flood routing.

The channel capacity at the reference section is 7,100 cubic feet per second. The peak discharge of 118,000 cubic feet per second for the 100-year-frequency storm would be reduced to only 26,000 cubic feet per second after installation and full functioning of the project.

#### 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. 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.

Estimates of sediment storage requirements in the planned floodwater retarding structures were based on detailed sediment source studies in the watersheds above representative floodwater retarding structures. These rates, adjusted for drainage area size, were then applied to the other sites.

Based on these studies, the total annual sediment yields above the planned floodwater retarding structures were estimated to be 41.40 acre-feet from sheet erosion and 0.34 acre-feet from channel erosion. The estimated average annual production of sediment above structures is 0.27 acre-feet per square mile. The principal source of sediment is sheet erosion from poor rangeland and from untreated cropland.

#### Effect of Watershed Treatment on Sediment Yields

Rangeland in poor condition produces most of the sediment in the watershed but cultivated land also is an important contributor. Application of needed land treatment and range improvement measures will reduce the annual rate of sheet erosion by an estimated 16 percent.

Areas damaged by flood plain scour and overbank deposition will be rendered productive again after they have been protected from

flooding and needed land treatment measures have been put into effect. Future rates of damage caused by these erosive processes will be greatly reduced.

### Geologic Investigations

Reconnaissance dam site investigations were made on all 13 proposed flood-water retarding structure sites.

Investigations with a hand auger and general observations indicate that suitable quantities of material for the embankments are available above all sites except 6, 9 and 10. Sites 6 and 10 will probably require additional fill from borrow areas immediately below the dam. Suitable fill material for site 9 is available approximately one-half mile above the dam in the drainage area of the site. Rock from the excavation of the emergency spillways can be used as a blanket and riprap. Over 95 percent of the total spillway excavation will be in hard rock.

The foundations of all sites will be on the hard Edwards limestone which is slightly fractured and moderately segmented. A minimum keyway in the abutments will require hard rock excavation. The cutoff trenches in the alluvial flood plain area will require excavation through several feet of clay and gravelly soils and keying into the underlying hard limestone. Seepage through the bottom of the sediment pools into the underlying Edwards aquifer will probably keep the sediment pools dry.

Water needed in construction is scarce. The closest reliable supplies are located at Sonora and Eldorado. There are some strong wells on ranches in the watershed that could supply construction needs.

### Ground-water Recharge into the Edwards Underground Reservoir

A limited recharge of the Edwards limestone is expected to occur from the proposed works of improvement. Since the local people are not interested in adding additional measures for recharge only at this time, no attempt was made to include such measures in the plan.

### Economic Investigations

#### Determination of Annual Benefits from Reduction in Damages

Agricultural damage estimates were based upon schedules obtained in the field covering 70 percent of the agricultural flood plain area of Dry Devils River and Lowrey Draw. These schedules covered land use, crop distribution under normal conditions, yields, and historical data on flooding and flood damages. Estimates of urban and nonagricultural damage were obtained from newspaper files, residents, highway and railroad officials and city and county officials. Highwater marks, depths and some of the damage by depths were also furnished by the local people. These interviews, together with the small amount of rainfall

data available proved that a high percentage of the flood damage was caused to residential, business and other nonagricultural property. Since the season during which flooding occurs has little effect on this type of damage, it was decided to use the frequency method instead of the historical method of analysis.

A contour map of the townsite of Sonora was prepared. Highwater lines for the 1936 storm were delineated on the map (figure 4). After values of different type and style residences and average personal property values were furnished by local contractors and residents, a house-to-house, block-by-block evaluation was made of the residential area subject to floodwater damage. Local businessmen were contacted individually for evaluation of their property. Using information obtained from local residents, the 1954 flood at Ozona, Texas, and the 1957 flood at Lampasas, Texas, a relationship between damage and value by depth was obtained. The value of the area inundated by incremental depths of flooding was obtained for each storm in the frequency series and the proper damage factor applied. The monetary damage thus arrived at was used as the basis for the economic evaluation.

After analyzing the agricultural flood damage schedules, it was concluded that there was no appreciable range and pasture damage. In the calculation of crop damage all expenses saved, such as costs of harvesting, were deducted from the gross value of the damage. The calculated rates of damage were applied to the frequency series.

Damage to other agricultural property, such as fences, livestock and farm equipment, was obtained from analysis of schedules and correlated with size of floods.

Since a very large portion of the damages in this watershed is nonagricultural, indirect damages are higher than usually sustained in a watershed which is primarily agricultural in character. Nonagricultural indirect damages include delayed deliveries, interrupted travel, loss of business and damages sustained by urban residents as a result of interruption of utility services, dislocation and loss of employment. Indirect damage to agricultural enterprises include extra travel time to market, spread of bitterweed and other noxious plants, extra feed costs for livestock, and the like. Information regarding damage of this type was obtained from local ranchers, local residents, owners of business establishments, and from files of the local newspaper. Upon analysis, it appeared that indirect damage amounted to at least 15 percent of the direct damages.

Floodwater, erosion, and sediment damages on the flood plain were calculated under present conditions, under those which will prevail after installation of land treatment measures, and under conditions after installation of both land treatment and structural measures included in the proposed project. The difference between average annual damages with only land treatment measures established and those expected after

full project installation constitutes the benefit brought about by structural measures of the planned project.

The history of the development of Sonora was analyzed carefully and it was concluded that the damageable value at the end of 50 years, even though no project is installed, will be at least 15 percent higher than at present. A 15 percent increase occurring at a uniform rate and discounted over a 50-year period at 4 percent is equivalent to a 5.34 percent increase; therefore, all estimates of urban damages and benefits were increased by 5.34 percent in the determination of economic justification.

After careful study and analysis of property values in the flood plain and the economy of the area, both past and present, and checking with local leaders, it was concluded that benefits from enhancement will accrue due to the protection afforded by the project. These were converted to an annual equivalent value by assuming a uniform increase of income and discounting at a 4 percent interest rate over the life of the project. No enhancement benefits were calculated for the agricultural reaches, because landowners and operators indicated that they will continue to be engaged in livestock enterprises.

An estimate was made of the value of the production lost in areas after installation of the program. In this appraisal it was considered that there would be no production in the sediment pools. The land covered by the detention pools is in grass, and estimates of production were based on continued use of these areas as grassland. As the annual value of the production lost was less than the annual equivalent of the appraised value of the easements, the latter value was used in economic justification.

#### Determination of Annual Benefits Outside of Watershed

Similar investigations were made on the mainstem of Dry Devils River from the lower boundary of Dry Devils River and Lowrey Draw watershed to where U. S. Highway 277 last crosses the river, which is approximately 10 miles downstream. Annual flood damages were calculated and benefits claimed from the reduction of these damages by the project.

#### Details of Methodology

Details of the procedure used in the investigations are described in the Soil Conservation Service, Interim Economics Guide for Watershed Protection and Flood Prevention, Revised April 1, 1956.

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Dry Devils River and Lowrey Draw Watershed, Texas

Price Base: 1957

Structure Site Number	Public Law 566 Installation Costs										Other Installation Costs			Estimated Total Cost (dollars)
	Engineers Estimate (dollars)	Construction Engineers Estimate (dollars)	Continuing Engineers Estimate (dollars)	Other (dollars)	P.L. 566 (dollars)	Total (dollars)	Adm. of Contract & R/W (dollars)	Easements (dollars)	Other (dollars)	Total (dollars)	Estimated Total Cost (dollars)			
1	119,004	11,900	23,801	15,470	170,175	500	14,175			14,675	184,850			
2	121,407	12,141	24,281	15,783	173,612	500	13,375			13,875	187,487			
3	110,199	11,020	22,040	14,326	157,585	500	30,900			31,400	188,985			
4	53,858	5,386	10,772	7,002	77,018	500	5,275			5,775	82,793			
5	146,883	14,688	29,377	19,095	210,043	500	12,675			13,175	223,218			
6	55,745	5,574	11,149	7,247	79,715	500	3,000			3,500	83,215			
7	86,700	8,670	17,340	11,271	123,981	500	7,850			8,350	132,331			
8	72,377	7,238	14,475	9,409	103,499	500	25,225			25,725	129,224			
9	43,761	4,376	8,752	5,689	62,578	500	3,690			4,190	66,768			
10	95,491	9,549	19,098	12,414	136,552	500	5,340			5,840	142,392			
11	162,908	16,291	32,581	21,178	232,958	500	35,610			36,110	269,068			
12	57,787	5,779	11,557	7,512	82,635	500	18,630			19,130	101,765			
13	36,363	3,636	7,272	4,727	51,998	500	4,700			5,200	57,198			
<b>GRAND TOTAL</b>	<b>1,162,483</b>	<b>116,248</b>	<b>232,495</b>	<b>151,123</b>	<b>1,662,349</b>	<b>6,500</b>	<b>180,445</b>			<b>186,945</b>	<b>1,849,294</b>			

Floodwater Retarding Structures

February 1958

TABLE 3 - STRUCTURE DATA  
FLOODWATER RETARDING STRUCTURES

Dry Devils River and Lowrey Draw Watershed, Texas

Item	Unit	STRUCTURE NUMBER						
		1	2	3	4	5	6	7
Drainage Area	sq.mi.	18.20	25.77	23.58	6.27	23.50	5.33	11.12
Storage Capacity								
Sediment Pool	ac.ft.	200	200	200	127	200	108	200
Sediment reserve below riser	ac.ft.	182	86	84	-	160	-	29
Sediment in detention pool	ac.ft.	31	23	23	-	29	-	19
Floodwater detention	ac.ft.	4,866	5,000	5,000	1,338	4,961	1,046	2,379
Total	ac.ft.	5,279	5,309	5,307	1,465	5,350	1,154	2,627
Surface Area								
Sediment pool	acre	41	45	51	30	41	23	47
Sediment reserve pool	acre	60	54	74	-	65	-	51
Floodwater detention pool	acre	252	397	553	146	396	97	259
Maximum Height of Dam	foot	52	49	40	43	50	37	37
Volume of Fill	cu.yd.	227,699	200,986	176,980	107,467	244,735	113,966	158,863
Emergency Spillway								
Type		Rock	Rock	Rock	Rock	Rock	Rock	Rock
Frequency of use <u>1/</u>	year	190	140	170	185	158	150	148
Design storm rainfall								
Duration	hour	6	6	6	6	6	6	6
Total	inch	11.23	10.17	10.35	11.47	10.40	11.58	11.05
Bottom width	foot	300	400	400	150	400	150	200
Design depth	foot	5.3	5.6	4.6	5.0	5.5	5.5	5.1
Design capacity	c.f.s.	10,600	15,600	11,300	4,800	15,000	5,650	6,700
Freeboard	foot	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Total capacity	c.f.s.	17,400	24,900	20,200	8,200	24,400	9,000	10,900
Principal Spillway								
Capacity	c.f.s.	182	258	675	63	235	53	110
Capacity Equivalent								
Sediment volume	inch	.43	.23	.25	.38	.32	.38	.43
Detention volume <u>2/</u>	inch	5.00	3.64	3.95	4.00	3.95	3.68	4.00
Spillway storage	inch	3.24	2.53	3.70	3.62	2.87	2.56	3.81
Class of Structure		B	B	B	B	B	B	B

1/ Based on Yarnell's 6-hour storm, II Moisture Condition.

2/ Additional storage provided in all structures to reduce rock excavation in spillways.

TABLE 3 - STRUCTURE DATA -Continued  
FLOODWATER RETARDING STRUCTURES

Dry Devils River and Lowrey Draw Watershed, Texas

Item	Unit	STRUCTURE NUMBER											Total	
		8	9	10	11	12	13							
Drainage Area	sq.mi.	7.92	2.77	8.43	16.85	4.38	1.07							155.19
Storage Capacity														
Sediment pool	ac.ft.	152	46	97	189	68	22							1,809
Sediment reserve below riser	ac.ft.	-	-	-	-	-	-							541
Sediment in detention pool	ac.ft.	-	-	-	-	-	-							125
Floodwater detention	ac.ft.	1,690	591	2,028	5,000	1,089	315							35,303
Total	ac.ft.	1,842	637	2,125	5,189	1,157	337							37,778
Surface Area														
Sediment pool	acre	33	10	21	51	20	7							420
Sediment reserve pool	acre	-	-	-	-	-	-							304
Floodwater detention pool	acre	176	86	155	354	124	40							3,035
Maximum Height of Dam	foot	38	34	45	47	36	31							xxx
Volume of Fill	cu.yd.	146,167	81,038	165,209	294,952	114,637	70,756							2,103,455
Emergency Spillway														
Type		Rock	Rock	Rock	Rock	Rock	Rock							xxx
Frequency of use <sup>1/</sup>	year	142	172	200	250	200	246							xxx
Design storm rainfall														
Duration	hour	6	6	6	6	6	6							xxx
Total	inch	11.30	11.93	11.24	16.00	11.70	18.52							xxx
Bottom width	foot	150	200	170	400	150	100							xxx
Design depth	foot	5.4	3.2	5.5	6.4	4.0	4.3							xxx
Design capacity	c.f.s.	5,550	3,000	6,350	19,200	3,300	2,500							xxx
Freeboard	foot	2.0	2.0	2.0	1.8	2.0	2.0							xxx
Total capacity	c.f.s.	8,950	6,750	10,000	27,600	6,400	4,650							xxx
Principal Spillway														
Capacity	c.f.s.	80	28	84	168	44	10							xxx
Capacity Equivalents														
Sediment volume	inch	.36	.31	.23	.21	.29	.40							xxx
Detention volume <sup>2/</sup>	inch	4.00	4.00	4.50	5.56	4.67	5.50							xxx
Spillway storage	inch	3.81	4.32	3.05	3.81	3.77	5.65							xxx
Class of Structure		B	B	B	C	B	C							xxx

<sup>1/</sup> Based on Yarnell's 6-hour storm, II Moisture Condition.

<sup>2/</sup> Additional storage provided in all structures to reduce rock excavation in spillways.

TABLE 4 - SUMMARY OF PHYSICAL DATA  
 Dry Devils River and Lowrey Draw Watershed, Texas

Item	Unit	Quantity Without Project	Quantity With Project
Watershed area	sq.mi.	233	xxx
Watershed area, contributing	acre	129,280	xxx
Watershed area, non-contributing	acre	19,840	xxx
Watershed area, total	acre	149,120	xxx
Area of cropland	acre	8,760	8,434
Area of grassland	acre	135,096	135,422
Miscellaneous area <u>1/</u>	acre	5,264	5,264
Overflow area subject to damage	acre	2,279	554
Overflow area damaged annually by:			
Sediment	acre	52 <u>2/</u>	8.3 <u>3/</u>
Flood plain scour	acre	232 <u>2/</u>	32.5 <u>3/</u>
Annual rate of erosion			
Sheet	ac.ft./yr.	129.1	108.8
Scour	ac.ft./yr	7.7	1.1
Average annual rainfall	inch	22.08	xxx

1/ Includes urban area.

2/ Acreage on which some production loss occurs each year.

3/ The acreage on which some production loss will occur each year after recovery has taken place. Applies to all flooding up to the area inundated by the largest storm in the 100-year series.

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TABLE 5 - SUMMARY OF PLAN DATA

## Dry Devils River and Lowrey Draw Watershed, Texas

Item	Unit	Quantity
Years to complete project	year	5
Total installation cost		
Public Law 566 funds	dollar	1,662,349
Other funds	dollar	485,978
Annual O & M cost		
Public Law 566 funds	dollar	0
Other funds	dollar	3,022
Average annual monetary benefits	dollar	136,967
Agricultural	percent	0.3
Nonagricultural	percent	99.7
Structural Measures		
Floodwater retarding structures	each	13
Area inundated by structures		
Flood plain		
Sediment pool	acre	0
Detention pool	acre	0
Upland		
Sediment pool	acre	420
Detention pool	acre	2,615
Watershed area above structures	acre	99,324
Reduction of floodwater damage	dollar	135,194
By Land Treatment Measures -		
Watershed Protection	percent	12
By Structural Measures	percent	84
Reduction of sediment damage	dollar	27
By Land Treatment Measures -		
Watershed Protection	percent	9
By Structural Measures	percent	75
Reduction of erosion damage	dollar	7
By Land Treatment Measures -		
Watershed Protection	percent	13
By Structural Measures	percent	75
Flood Prevention Benefit from Changed		
Land Use	dollar	1,251

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TABLE 6 - ANNUAL COSTS

Dry Devils River and Lowrey Draw Watershed, Texas

Measures	Amortization of		Operation and Maintenance Costs		Total
	Installation	Public Law	566	2/	
	Cost 1/			Total	
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
Floodwater Retarding Structures					
3/ 1, 2, 3	19,791	-	842	842	20,633
4	2,919	-	198	198	3,117
5	7,870	-	297	297	8,167
6	2,934	-	198	198	3,132
7	4,666	-	248	248	4,914
8	4,556	-	198	198	4,754
9	2,354	-	149	149	2,503
10	5,020	-	248	248	5,268
11	9,487	-	297	297	9,784
12	3,588	-	198	198	3,786
13	2,017	-	149	149	2,166
TOTAL	65,202	0	3,022	3,022	68,224

1/ 1957 prices amortized for 50 years at 2.5 percent.  
 2/ Long-term prices, as projected by ARS, September, 1957.  
 3/ Sites 1, 2, and 3 are interdependent.

TABLE 7 - MONETARY BENEFITS FROM STRUCTURAL MEASURES

Dry Devils River and Lowrey Draw Watershed, Texas

Price Base: Long-Term 1/

Item	Estimated Average Annual Damage			Average
	Without Project (dollars)	After Land Treatment for W/S Protection (dollars)	With Project (dollars)	Annual Monetary Benefit Structures (dollars)
Floodwater Damage				
Crop and Pasture	27	24	1	23
Other Agricultural Nonagricultural	454	354	3	351
Urban	138,213	120,992	5,244	115,748
Roads, Railroads	1,748	1,661	0	1,661
Subtotal	140,442	123,031	5,248	117,783
Sediment Damage				
Overbank Deposition	32	29	5	24
Subtotal	32	29	5	24
Erosion Damage				
Flood plain scour	8	7	1	6
Subtotal	8	7	1	6
Indirect Damage	21,072	18,460	788	17,672
Total, All Damage	161,554	141,527	6,042	135,485
Changed Land Use				
To Urban Use	-	-	-	1,251
Subtotal	-	-	-	1,251
Benefits Outside Project Area	-	-	-	231
<b>TOTAL PRIMARY BENEFITS</b>				<b>136,967</b>
<b>TOTAL MONETARY BENEFITS</b>				<b>136,967</b>

1/ As projected by ARS, September, 1957.

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TABLE 8 - BENEFIT COST ANALYSIS

Dry Devils River and Lowrey Draw Watershed, Texas

Measures	AVERAGE ANNUAL BENEFITS										Average: Benefit : Annual : Cost
	Floodwater : (dollars)	Sediment : (dollars)	Erosion : (dollars)	Indirect: Use (dollars)	Other : (dollars)	Total : (dollars)	1/ : Total	Changed : Land : Use :	Average: Benefit : Annual : Cost	Ratio	
1, 2, 3	42,629	13	2	6,396	83	49,575		452	20,633	2.4:1	
4	3,955	1	0	593	8	4,599		42	3,117	1.5:1	
5	14,829	5	1	2,225	29	17,247		158	8,167	2.1:1	
6	3,364	1	0	505	7	3,913		36	3,132	1.2:1	
7	7,019	2	0	1,053	14	8,163		75	4,914	1.7:1	
8	4,999	2	0	750	10	5,814		53	4,754	1.2:1	
9	2,349	0	0	352	5	2,731		25	2,503	1.1:1	
10	9,349	0	1	1,403	18	10,870		99	5,268	2.1:1	
11	21,379	0	1	3,208	41	24,856		227	9,784	2.5:1	
12	5,947	0	1	892	12	6,915		63	3,786	1.8:1	
13	1,964	0	0	295	4	2,284		21	2,166	1.1:1	
GRAND TOTAL	117,783	24	6	17,672	231	136,967		1,251	68,224	2.0:1	

Floodwater Retarding Structures

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

2/ Installation costs based on 1957 price level and operation and maintenance costs based on long-term price levels, as projected by ARS, September 1957.

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TABLE 8A - BENEFITS AND COSTS BY CONSTRUCTION UNITS

Dry Devils River and Lowrey Draw Watershed, Texas

Construction Unit and Structures	: Annual : Benefits <u>1/</u> (dollars)	: Annual : Costs <u>2/</u> (dollars)
Construction Unit No. 1 Structures Nos. 9 through 13	47,137	23,507
Construction Unit No. 2 Structures Nos. 1 through 8	88,348	44,717

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

2/ Installation costs based on 1957 price level, and operation and maintenance costs based on long-term price levels, as projected by ARS, September, 1957.

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TABLE 9 - COST-SHARING SUMMARY

Dry Devils River and Lowrey Draw Watershed, Texas  
Price Base: 1957 1/

Type of Cost	: P.L. 566 Funds		: Other Funds		: Total Cost	
	: Dollars	: Percent	: Dollars	: Percent	: Dollars	: Percent
Land Treatment						
Non-Federal Land For Watershed Protection	0	0	299,033	100.0	299,033	13.4
Subtotal	0	0	299,033	100.0	299,033	13.4
Structural Measures						
Installation Flood Prevention	1,662,349	89.9	186,945	10.1	1,849,294	82.8
Subtotal	1,662,349	89.9	186,945	10.1	1,849,294	82.8
Total Installation Cost	1,662,349	77.4	485,978	22.6	2,148,327	96.2
Operation and Maintenance <u>2/</u>	0	0	85,711	100.0	85,711	3.8
Total Structural Cost	1,662,349	85.9	272,656	14.1	1,935,005	86.6
TOTAL PROJECT COST	1,662,349	74.4	571,689	25.6	2,234,038	100.0

1/ Except operation and maintenance which is based on long-term prices, as projected by ARS, September 1957.

2/ Capitalized for 50 years at 2.5 percent.

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