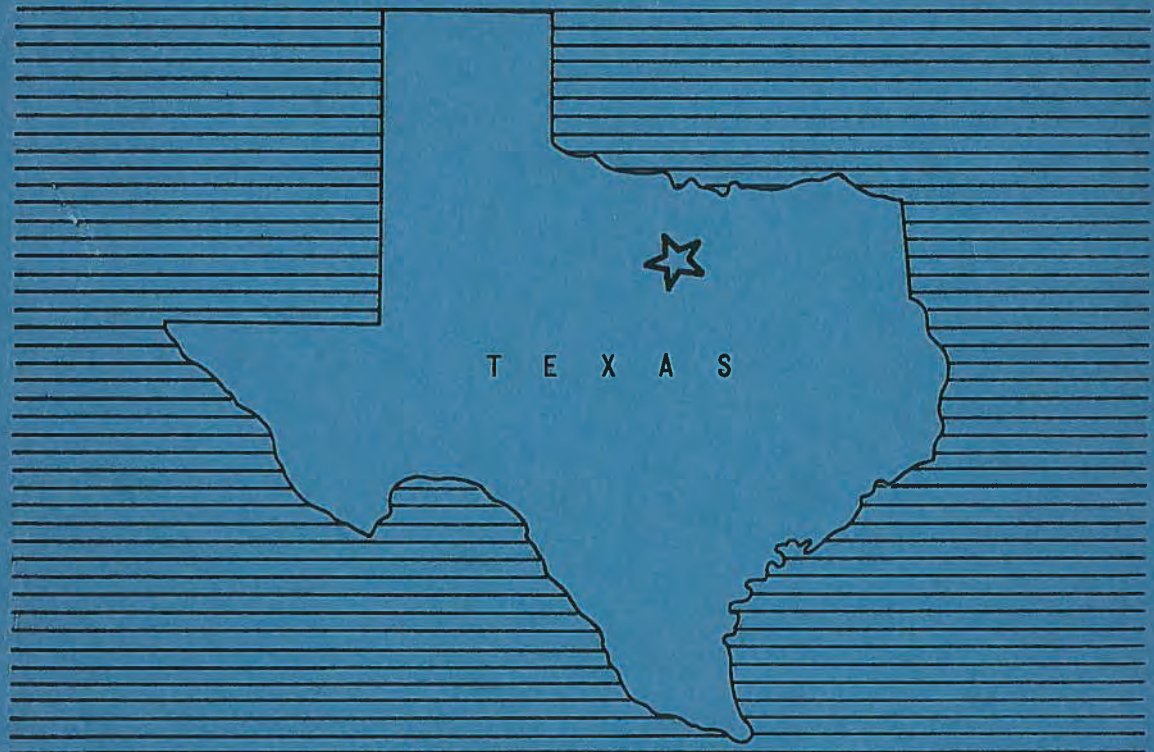
WORK PLAN

FOR WATERSHED PROTECTION
AND FLOOD PREVENTION

EAST KEECHI CREEK WATERSHED

JACK, PALO PINTO, AND PARKER COUNTIES, TEXAS



November 1959

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WATERSHED WORK PLAN AGREEMENT

between the

Upper West Fork Soil Conservation District
Local Organization

Palo Pinto Soil Conservation District
Local Organization

Hood-Parker Soil Conservation District
Local Organization

East Keechi Creek Water Control and Improvement District No. 1
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 East Keechi Creek Watershed, State of Texas 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); 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 East Keechi Creek 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 $ 81,480 .)

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:

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Construction Cost (dollars)
10 **Floodwater Retarding Structures**	0	100	638,526

The Sponsoring Local Organization will pay all of the costs allocated to purposes other than flood prevention, and irrigation, drainage, and other agricultural water management.

4. The Service will bear the cost of all installation services applicable to works of improvement for flood prevention. (Estimated cost $ 164,663 .)

   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 $_____.)

   The Sponsoring Local Organization will bear the cost of all installation services applicable to works of improvement for nonagricultural water management. (Estimated cost $_____.)

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 5,000 .)

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

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.

Upper West Fork Soil Conservation District
Local Organization

By Rollano Hill

Title Chairman

Date March 23, 1960

The signing of this agreement was authorized by a resolution of the governing body of the **Upper West Fork Soil Conservation District**
Local Organization

adopted at a meeting held on March 3, 1960

Geo Clemmons
(Secretary, Local Organization)

Date March 23, 1960

Palo Pinto Soil Conservation District
Local Organization

By A. L. Crawford

Title Chairman

Date March 22, 1960

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

adopted at a meeting held on March 21, 1960.

Wm Sandus
(Secretary, Local Organization)

Date March 22, 1960

Hood-Parker Soil Conservation District
Local Organization

By Jr C Bennett

Title Vice-Chairman

Date March 22, 1960

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

adopted at a meeting held on March 10, 1960

Albert Barker
(Secretary, Local Organization)

Date March 22, 1960

East Keechi Creek Water Control and Improvement District No. 1
Local Organization

By G. F. Wimberly

Title Chairman

Date March 22, 1960

The signing of this agreement was authorized by a resolution of the governing body of the East Keechi Creek Water Control and Improvement District No. 1
Local Organization

adopted at a meeting held on March 22, 1960

G. E. Sendder
(Secretary, Local Organization)

Date March 22, 1960

_____
Local Organization

By _____

Title _____

Date _____

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

adopted at a meeting held on _____

_____
(Secretary, Local Organization)

Date _____

Soil Conservation Service
United States Department of Agriculture

By _____
Administrator

Date _____

WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

EAST KEECHI CREEK WATERSHED
Jack, Palo Pinto, and Parker Counties, Texas

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act, (Public Law 566, 83rd Congress, 68 Stat. 666), as amended.

Prepared By: Upper West Fork Soil Conservation District
(Cosponsor)

Palo Pinto Soil Conservation District
(Cosponsor)

Hood-Parker Soil Conservation District
(Cosponsor)

East Keechi Creek Water Control and Improvement District No. 1
(Cosponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service

November 1959

WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

EAST KEECHI CREEK WATERSHED
Jack, Palo Pinto, and Parker Counties, Texas

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Palo Pinto Soil Conservation District
(Cosponsor)

Hood-Parker Soil Conservation District
(Cosponsor)

East Keechi Creek Water Control and Improvement District No. 1
(Cosponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
November 1959

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WATERSHED WORK PLAN

EAST KEECHI CREEK WATERSHED
Palo Pinto, Jack and Parker Counties, Texas
November 1959

SUMMARY OF PLAN

General Summary

The work plan for watershed protection and flood prevention for the East Keechi Creek watershed was prepared by the Palo Pinto, Upper West Fork, and Hood-Parker Soil Conservation Districts and the East Keechi Creek Water Control and Improvement District No. 1 as cosponsoring local organizations. Technical assistance was provided by the Soil Conservation Service of the United States Department of Agriculture.

The watershed covers an area of 99.64 square miles, or 63,770 acres, in Palo Pinto, Jack and Parker Counties, Texas. Approximately 20 percent of the watershed is cropland, 78 percent is pasture and rangeland, and 2 percent is in miscellaneous uses, such as towns, industrial areas, roads, stream channels, 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 a total estimated installation cost of $1,336,661. The share of this cost to be borne by Public Law 566 funds is $829,589. The share to be borne by other than Public Law 566 funds is $507,072. In addition, the local interests will bear the entire cost of operation and maintenance.

Land Treatment Measures

The cost for land treatment measures is estimated to be $446,992, of which the other than Public Law 566 share is $420,592, including expected reimbursements from ACPS, and $19,760 to be spent by the Soil Conservation Service under its going program for technical assistance during the project period. The Public Law 566 share, consisting entirely of accelerated technical assistance, is $26,400. The work plan includes only the land treatment that will be installed during the 5-year project period.

Structural Measures

The structural measures included in the plan consist of 10 floodwater retarding structures having a total sediment storage and floodwater detention capacity of 13,496 acre-feet. The total cost of structural measures

is $889,669, of which the local share is $86,480 and the Public Law 566 share is $803,189. The local share of the costs of structural measures includes land, easements, and rights-of-way, 94.2 percent, and administering contracts, 5.8 percent. The 10 floodwater retarding structures will be installed during a 3-year period.

Damages and Benefits

The estimated average annual floodwater, sediment, flood plain erosion, and indirect damage without the project is $44,728 at long-term price levels. The estimated average annual floodwater, sediment, flood plain erosion, and indirect damage with the project installed, including land treatment and structural measures is $9,300, a reduction of approximately 79 percent.

The average annual primary benefits accruing to structural measures are $36,674, which are distributed as follows:

Floodwater damage reduction	$26,198
Sediment damage reduction	2,015
Flood plain erosion damage reduction	1,569
Indirect damage reduction	2,977
Benefits from changed land use	3,534
Benefits outside project area (Reduction of damages on mainstem Keechi Creek flood plain)	381

The ratio of the average annual benefits ($36,674) to the average annual cost of structural measures ($32,888) is 1.1 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 East Keechi Creek Water Control and Improvement District No. 1 has powers of taxation and eminent domain under applicable State laws. A special district tax for the purpose of flood control is presently being collected. This revenue is adequate and will be available for financing the local share of the structural costs.

Operation and Maintenance

Land treatment measures for watershed protection will be operated and maintained by the landowners or operators of the farms and ranches on which the measures will be installed under agreements with the Palo Pinto, Upper West Fork and Hood-Parker Soil Conservation Districts.

The East Keechi Creek Water Control and Improvement District No. 1 will be responsible for the operation and maintenance of the 10 floodwater retarding structures. Revenue from the special district tax is available and adequate for this purpose. The estimated average annual cost of operation and maintenance of all structural measures is $1,520.

DESCRIPTION OF WATERSHED

Physical Data

East Keechi Creek (figure 1) heads approximately 6 miles northwest of Perrin, Jack County, Texas, and flows in a southwesterly direction to its confluence with Keechi Creek approximately 2 miles east of Graford, Palo Pinto County, Texas. A major tributary, having many branches flowing from the east and southeast, heads approximately 4 miles north of Perrin and flows in a southwesterly direction to join East Keechi Creek approximately 3½ miles southwest of Perrin. The drainage area of the watershed is 99.64 square miles (63,770 acres).

The topography ranges from nearly level along the alluvial valley to steeply sloping in the north and west fringes, with most of the watershed area being gently rolling. Elevations range from near 1,300 feet to 899 feet above mean sea level.

All of the watershed except the extreme eastern portion lies within the North Central Prairie Land Resource Area and is underlain by shales, limestones, and sandstones of the Graford and Brad formations which belong to the Canyon group of the Pennsylvanian system. The regional dip of this strata is northwest and ranges from 30 to 50 feet per mile. The estreme eastern portion lies within the West Cross Timbers Land Resource Area and is underlain by multicolored conglomerates, unconsolidated white pack sands, sandy clays, and isolated limestone outliers of the Trinity Basement Sands of the Cretaceous system (Comanche series).

The major soil series found in the watershed are Renfro, Darnell, Kirkland, Crawford, Owens, Denton, Gowen, Stephenville, and Windhorst.

The over-all land use for the watershed is as follows:

Land Use	Acres	Percent
Cropland	12,477	19.6
Pasture and Rangeland	49,825	78.1
Miscellaneous 1/	1,468	2.3
Total	63,770	100.0

1/ Includes roads, highways, urban areas, etc.

Upland erosion rates are moderate. The most severe sediment source area is located in the eastern portion of the watershed. In the past, severe gullies have been carved into the white packsands, sandy clays, and shales of the Trinity Basement Sands. Most of these gullies are healing rapidly and the headward migration has ceased, but there are several headcuts and overfalls ranging from a few feet to 15 feet in depth, which are still active. It is estimated that these overfalls and headcuts are now

advancing upstream at an average rate of not more than 5 feet per year, which is much slower than the past rate. At the present time this area is under excellent management and under very limited use for grazing. These factors have had marked effect on the degree of active erosion and the delivery of damaging sediment to the lower areas of the watershed.

About 4,735 acres, not including stream channels, of the watershed is flood plain. The flood plain as described herein is the area inundated by the 32-year frequency storm runoff. Land use in the flood plain is 40 percent cropland, 57 percent pasture and rangeland, and 3 percent miscellaneous.

The average annual rainfall is 28 inches as recorded at U. S. Weather Bureau gage at Graham, Texas. The monthly average ranges from 4.24 inches in May to 1.44 inches in February.

Normal temperatures range from 43.7 degrees in January to 83.5 degrees in July. The normal frost-free period of 226 days extends from March 25 through November 8.

Water for livestock and rural domestic use is obtained from stock ponds and shallow wells.

Economic Data

The economy of the watershed is based almost entirely on agricultural production and the area has long been considered one of the most productive in Palo Pinto and Jack Counties. During the past decade the size of farm units has increased slightly, and at present the average size is approximately 290 acres, which is sufficient for an economic unit.

Small grains, corn, cotton and feed crops are the most important crops grown. Also, beef cattle production is an important source of income in the watershed.

Perrin, population approximately 400, and Oran, population approximately 100, are the only towns located within the watershed. Perrin is the cotton ginning center for the entire area. Mineral Wells, population 12,500, and Jacksboro, population 4,000, are both within 15 miles of the watershed. Fort Worth, one of the largest livestock and grain marketing centers in the southwest is within 60 miles of the watershed. These cities provide the needed marketing, educational, recreational and medical facilities for the inhabitants of the area. The watershed is adequately served by 93 miles of Federal, State and County roads, of which 24 miles are hard surfaced. Rail service is provided at both Jacksboro and Mineral Wells.

WATERSHED PROBLEMS

Floodwater Damage

Flooding occurs frequently in the watershed and causes severe damage. During the 32-year period studied, 1926 through 1957, a period considered

to be representative of normal rainfall in the area, there were 23 major floods that inundated more than half of the flood plain (figure 1) as well as 52 minor floods that inundated less than half the flood plain.

For the floods experienced during the period studied, the total direct floodwater damages were estimated to average $35,105 annually, at long-term price levels, of which $22,384 is crop and pasture damage, $9,065 is other agricultural damage, and $3,656 is nonagricultural damage, primarily to roads and bridges. Also, there are numerous indirect damages, such as interruption of travel, re-routing of school bus and mail routes, losses sustained by businesses in the area, and similar losses, all of which are estimated to average $4,067 per year.

Sediment Damage

Approximately 45 percent of the flood plain has been damaged by sediment. Erosion in the upland areas has resulted in the deposition of fine and medium grained sand with lesser amounts of silt and clay. These deposits of damaging material range in depth from approximately 2 to 6 inches. The productive capacity has been reduced on an estimated 1,725 acres (figure 1) of which 889 acres have been damaged 10 percent and 836 acres 20 percent. This amounts to an average annual monetary damage of $3,225 at long-term price levels.

Erosion Damage

Erosion rates in the upland areas of the watershed are moderate. Sheet erosion accounts for 80 percent of the annual gross erosion, gully erosion 12 percent and streambank erosion 8 percent. The average annual rate of upland gross erosion under present conditions is 1.89 acre-feet per square mile.

Flood plain scour damage is moderate in extent. It is estimated that the productive capacity of 446 acres has been reduced by this process as follows: 126 acres damaged 10 percent; 294 acres damaged 20 percent; 20 acres damaged 30 percent; and 6 acres damaged 40 percent. This represents an average annual monetary damage of $2,331 at long-term price levels.

Problems Relating to Water Management

There is no activity relative to drainage or irrigation in the watershed. No individual landowner or group of landowners has indicated an interest in including measures for agricultural water management. Officials of the town of Graford, located 2 miles west of the mouth of the watershed, indicated interest in providing storage for municipal water supply as a project purpose. At the present time Graford obtains its water from two low-water dams, one located on Keechi Creek just below the confluence of East Keechi Creek and the other on East Keechi Creek just above this confluence. During periods of prolonged drought the supply afforded by this source is not adequate. Representatives of Graford and the cosponsors

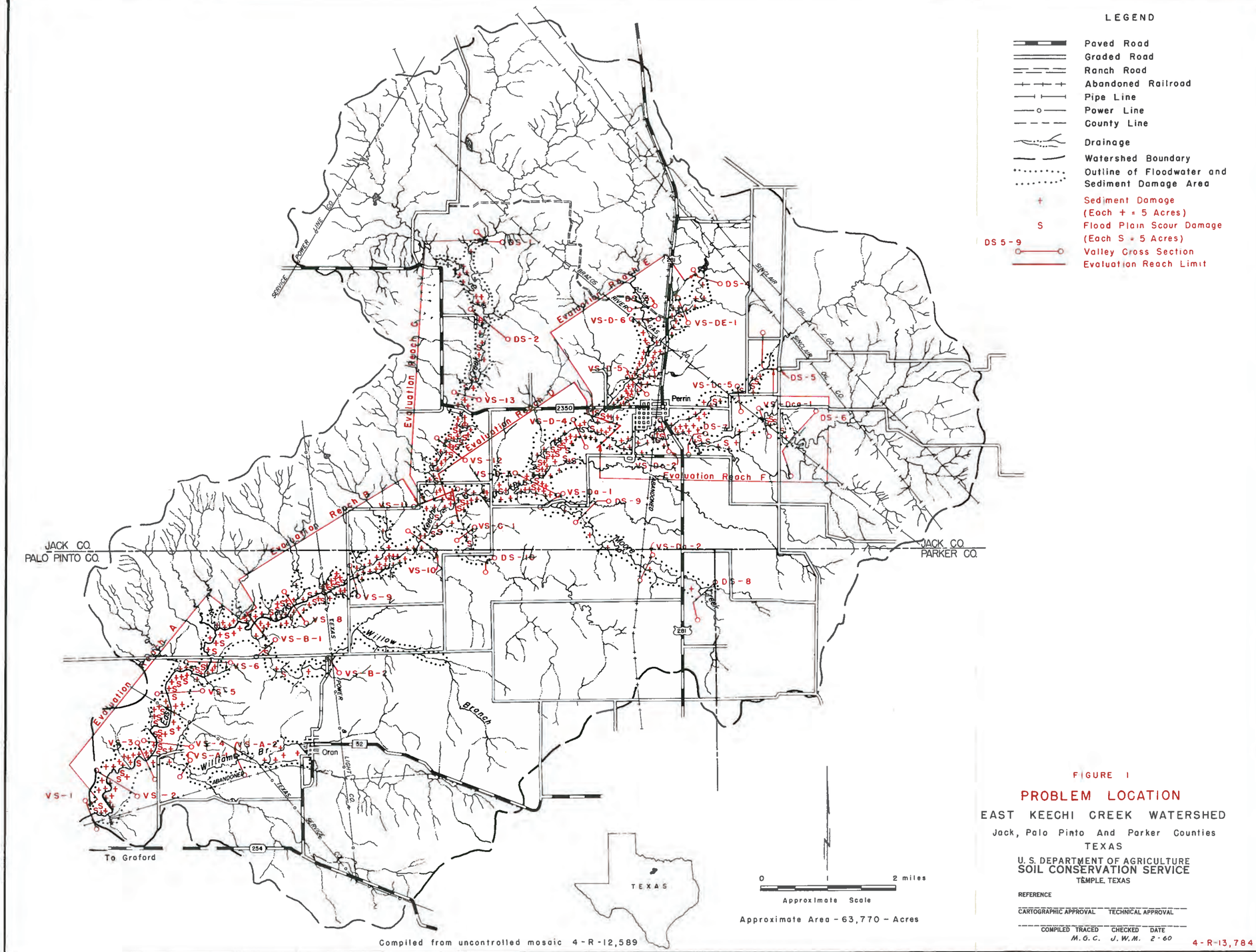

FIGURE 1

PROBLEM LOCATION

EAST KEECHI CREEK WATERSHED

Jack, Palo Pinto And Parker Counties

TEXAS

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

REFERENCE

CARTOGRAPHIC APPROVAL | TECHNICAL APPROVAL

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considered the possibility of including a multiple-purpose structure in the plan to supplement the existing water supply. The local interests investigated the possible locations and the probable water yields and determined that supplemental water from this source would be inadequate during periods of prolonged drought. Consequently, they asked that the inclusion of municipal water storage be dropped as a project purpose.

EXISTING OR PROPOSED WORKS OF IMPROVEMENT

The watershed is served by the Soil Conservation Service work units at Mineral Wells, Jacksboro, and Weatherford. These work units have assisted farmers and ranchers in preparing 175 soil and water conservation plans on 54,498 acres (87 percent of the agricultural land) within the watershed and have given technical assistance in establishing and maintaining planned measures. Approximately 77 percent of the planned measures have been applied.

Efforts to control or prevent flooding of agricultural lands in the watershed have been minor. Some individual attempts have been made to enlarge or straighten stream channels and construct levees, but these efforts have had little effect on the reduction of flood damage.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures 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 Palo Pinto, Upper West Fork and Hood-Parker Soil Conservation Districts, is necessary for a sound watershed protection and flood prevention program on the watershed. Basic to reaching this objective is the establishment and maintenance of all applicable soil and water conservation and plant management practices essential to proper land use. Emphasis will be placed on accelerating the establishment of land treatment practices which have a measurable effect on the reduction of floodwater, sediment and erosion damages.

Of the total watershed area of 63,770 acres, 29,748 acres lie above planned floodwater retarding structures. Land treatment is especially important for protection of these watershed lands to support and supplement the structural measures. Land treatment constitutes the only planned measures for the remaining upland area. Land treatment measures on the 4,400 acres of flood plain that will not be inundated by the pools of the planned floodwater retarding structures are also important in reducing floodwater, sediment, and erosion damage.

The amounts and estimated costs of the measures that will be installed by the landowners and operators are shown in table 1. The estimated total cost of planning and installing these measures is $446,992 including $26,400 from Public Law 566 funds during the 5-year installation period for technical assistance to landowners and operators to accelerate the planning

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST 1/

East Keechi Creek Watershed, Texas
Price Base: 1959

Installation Cost Item	Unit	No. to be Applied Non-Federal Land	Estimated Cost Public Law 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
LAND TREATMENT FOR					
Watershed Protection					
Soil Conservation Service					
Contour Farming	Acre	1,830	-	1,372	1,372
Cover Cropping	Acre	8,200	-	82,000	82,000
Rotation Hay and Pasture	Acre	1,170	-	11,700	11,700
Crop Residue Utilization	Acre	8,250	-	16,500	16,500
Proper Use	Acre	35,000	-	35,000	35,000
Range Seeding	Acre	1,001	-	12,012	12,012
Fertilization	Acre	4,320	-	25,920	25,920
Rotation Grazing	Acre	484	-	242	242
Pasture Planting	Acre	418	-	6,270	6,270
Brush Control	Acre	9,741	-	116,892	116,892
Deferred Grazing	Acre	35,000	-	52,500	52,500
Terracing	Mile	29	-	7,656	7,656
Diversion Construction	Mile	6.9	-	4,368	4,368
Waterway Development	Acre	85	-	3,400	3,400
Pond Construction	Each	50	-	25,000	25,000
Technical Assistance			26,400	19,760	46,160
SCS Subtotal			26,400	420,592	446,992
TOTAL LAND TREATMENT			26,400	420,592	446,992
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	10	638,526	-	638,526
SCS Subtotal			638,526	-	638,526
Subtotal - Construction			638,526	-	638,526
Installation Services					
Soil Conservation Service					
Engineering Services			114,935	-	114,935
Other			49,728	-	49,728
SCS Subtotal			164,663	-	164,663
Subtotal - Installation Services			164,663	-	164,663
Other Costs					
Land, Easements, and R/W			-	81,480	81,480
Administration of Contracts			-	5,000	5,000
Subtotal - Other			-	86,480	86,480
TOTAL STRUCTURAL MEASURES			803,189	86,480	889,669
TOTAL PROJECT			829,589	507,072	1,336,661
SUMMARY					
Subtotal SCS			829,589	507,072	1,336,661
TOTAL PROJECT			829,589	507,072	1,336,661

1/ No Federal land in watershed.

and application of conservation practices. The share to be borne by other than Public Law 566 funds, $420,592, includes expected reimbursements from ACPS, based on current program criteria, and $19,760 to be spent by the Soil Conservation Service in providing technical assistance under its going program to the districts during the project installation period. Landowners and operators will maintain these measures in accordance with provisions of the farmer-district cooperative agreements with the Palo Pinto, Upper West Fork and Hood-Parker Soil Conservation Districts.

Land treatment measures will decrease erosion damage and sediment production from fields and pastures by providing improved soil-cover conditions. These measures include conservation cropping systems, cover cropping, use of rotation hay and pasture, crop residue utilization for cropland, and pasture planting to establish good cover on grassland and formerly cultivated lands. They also include range seeding and brush control to allow grass stands to replace the poor brushy cover; construction of farm ponds to provide adequate watering places for livestock and uniform distribution of grazing; and proper use and rotation grazing of grasslands to provide improvement, protection, and maintenance of grass stands. These measures also effectively improve soil conditions which allow rainfall to soak into the soil at a more rapid rate.

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

Structural Measures

A system of 10 floodwater retarding structures will be installed to afford the needed protection to flood plain lands which cannot be provided by land treatment measures alone.

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

The locations of the structural measures are shown on Planned Structural Measures, figure 3.

This system of structures will temporarily detain runoff from approximately 47 percent of the entire watershed. The 10 floodwater retarding structures will have a total floodwater detention capacity of 11,163 acre-feet and will temporarily detain an average of 4.50 inches of runoff from the watershed area above them. This is the equivalent of 2.10 inches of runoff from the entire 63,770-acre watershed.

The total estimated cost of establishing these works of improvement is $889,669 of which $86,480 will be borne by local interest and $803,189 by P. L. 566 funds (table 1). The average annual equivalent cost is estimated

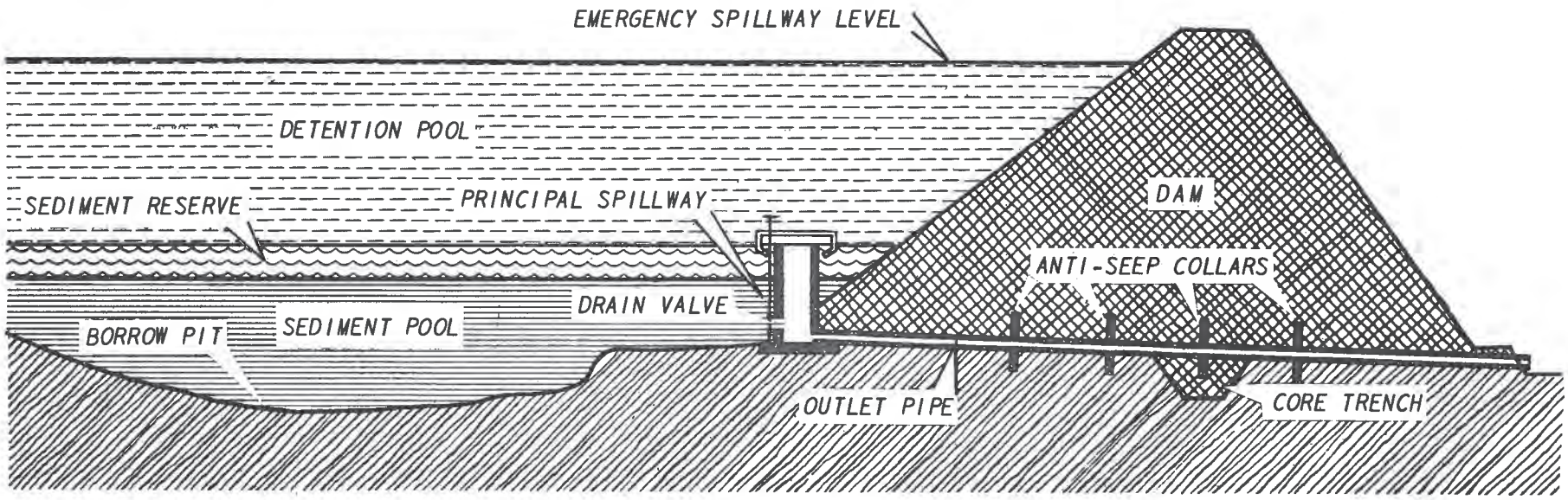
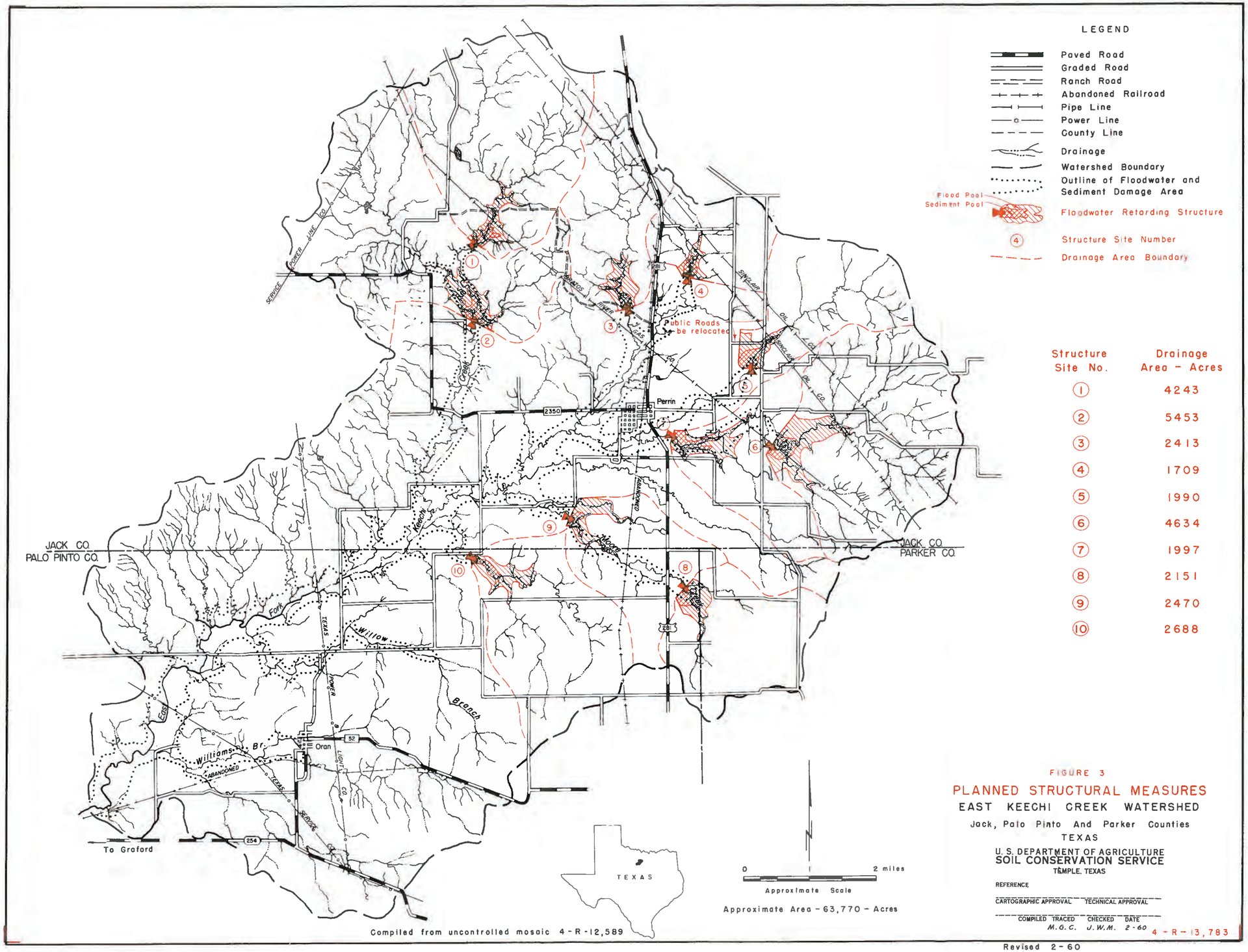


Figure 2

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE



Structure Site No.	Drainage Area - Acres
1	4243
2	5453
3	2413
4	1709
5	1990
6	4634
7	1997
8	2151
9	2470
10	2688

FIGURE 3

PLANNED STRUCTURAL MEASURES

EAST KEECHI CREEK WATERSHED

Jack, Palo Pinto And Parker Counties

TEXAS

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

REFERENCE

CARTOGRAPHIC APPROVAL — TECHNICAL APPROVAL

COMPILED	TRACED	CHECKED	DATE
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to be $31,368 for installation and $1,520 for operation and maintenance, making a total annual cost of $32,888.

Sufficient detention storage can be developed in all structures to make possible the use of vegetative spillways, thereby effecting a substantial reduction in cost over concrete or similar types of spillways.

All applicable State water laws will be complied with in design and construction of the floodwater retarding structures.

BENEFITS FROM WORKS OF IMPROVEMENT

The combined program of land treatment and structural measures described above would prevent flood damage from 25 of the 75 floods, such as occurred in the watershed from 1926 through 1957. Of the 23 major floods that inundated more than half of the flood plain, 17 would be reduced to minor floods, inundating less than half of the flood plain. Average annual flooding would be reduced from 3,620 acres to 1,368 acres, including the area inundated on the flood plains of Willow Branch and Williams Branch for which no structural measures are planned.

The largest and most damaging flood to occur during recent years was caused by the storm of April 29-30, 1957. This storm inundated 4,358 acres of flood plain and caused an estimated $64,775 direct floodwater damage. If the complete program for watershed protection and flood prevention had been installed, 2,673 acres would have been inundated and floodwater damage would have been reduced to an estimated $21,572.

The area on which sediment damage from overbank deposition will occur annually is expected to be reduced from 1,725 to 327 acres, a reduction of 81 percent. About 23 percent of the expected reduction will result from land treatment and 77 percent from the structural measures.

The area on which flood plain scour damage will occur is expected to be reduced from 446 to 121 acres, a reduction of 73 percent.

With the planned land treatment measures installed, it is estimated that the annual gross erosion in the watershed will be reduced from 194 to 140 acre-feet.

The estimated average annual monetary floodwater, sediment, flood plain erosion and indirect damages within the watershed will be reduced from $44,728 to $9,300, a 79 percent reduction. About 92 percent of the expected reduction will result from the system of floodwater retarding structures.

The general locations of the benefits from reduction in flooding from the combined program of land treatment and structural measures are presented in the following tables:

Average Annual Area Inundated

Evaluation Reach 1/	Without Project	With Project	Reduction
	(acres)	(acres)	(percent)
A	1,211 2/	831 2/	31.4
B	513	120	76.6
C	315	0	100.0
D	619	159	74.3
E	343	95	72.3
F	619	163	73.7
Total	3,620	1,368	62.2

Average Annual Damages

Evaluation Reach 1/	Without Project	With Project	Reduction
	(dollars)	(dollars)	(percent)
A	10,854 3/	4,742 3/	56.3
B	7,832	1,012	87.1
C	3,340	56	98.3
D	12,901	2,090	83.8
E	1,123	226	79.9
F	8,678	1,174	86.5
Total	44,728	9,300	79.2

1/ See Figure 1 for location of evaluation reaches.
2/ Includes area subject to overflow on Williams Branch and Willow Branch for which no structural control is planned.
3/ Includes damages on Williams Branch and Willow Branch for which no structural control is planned.

Operators of flood plain land say that if adequate flood protection is provided, they will restore land now idle or in low value crops to production of high value crops such as corn, oats, wheat, feed crops and alfalfa. It is estimated that 341 acres will be restored to production of higher value crops. All of this land was in production of cultivated crops until recent years, but is now either idle or in production of low value crops because of excessive flood damages. It is estimated that the net increase in income from such restoration of productivity will amount to $5,556 (long-term price levels) annually. This loss from the original production has been included in the crop and pasture damage and its restoration a benefit in table 7. It is expected, in addition, that landowners will convert an estimated 218 acres of land, that is at present uneconomical for crop production because of frequent flooding, to production of high value crops. This changed land use will result in an additional $3,534 (at long-term price levels) annually. Consideration was given to the effect of acreage allotment restrictions in the analysis of benefits from restoration and changed land use. The calculations exclude increases in the acreage of these crops above present restrictions.

The total flood prevention benefits, as a result of structural measures, are estimated to be $36,674 annually. Of this amount $381 represents benefits resulting from reduction of floodwater damages on the mainstem flood plain of Keechi Creek below its confluence with East Keechi Creek.

COMPARISON OF BENEFITS AND COSTS

The average annual cost of the structural measures (converted from total installation cost, plus operations and maintenance) is estimated to be $32,888. The structural measures are expected to produce average annual benefits of $36,674, or $1.12 for each dollar of cost. In addition to the direct monetary benefits, there are other substantial values which will accrue from the project, such as an increased opportunity for recreation, improved wildlife conditions, better living conditions and an increased sense of economic security, none of which has been used for project justification.

The 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.

ACCOMPLISHING THE PLAN

Federal assistance for carrying out the works of improvement on non-Federal land, as described in this work plan, will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666), as amended.

Land Treatment Measures

The land treatment measures itemized in table 1 will be established by farmers and ranchers over a 5-year period in cooperation with the Palo Pinto, Upper West Fork and Hood-Parker Soil Conservation Districts, which are giving technical assistance in the planning and application of these measures under their going program. This assistance will be accelerated with Public Law 566 funds to assure application of the planned measures within the 5-year project installation period.

The governing bodies of the Palo Pinto, Upper West Fork and Hood-Parker Soil Conservation Districts with the assistance of the East Keechi Creek Water Control and Improvement District No. 1 will assume aggressive leadership in getting an accelerated land treatment program underway. The landowners within the watershed will be encouraged to adopt and carry out soil and water conservation plans on their farms. District-owned equipment will be made available to the landowners in accordance with existing arrangements for equipment usage in the districts. The Soil Conservation Service will provide additional technical assistance to the soil conservation districts to assist landowners and operators cooperating with the districts in accelerating the preparation and application of soil, plant, and water conservation plans.

The soil and water conservation loan program of the Farmers Home Administration is available to all eligible 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.

Each County ASC Committee will cooperate with the governing bodies 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.

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

Structural Measures for Flood Prevention

The East Keechi Creek Water Control and Improvement District No. 1 has the right of eminent domain under applicable State laws and will obtain the necessary land, easements, and rights-of-way, including the relocation of utilities and improvements; will provide necessary legal, administrative, and clerical personnel, facilities, supplies and equipment to advertise, award and administer contracts; and will determine the legal adequacy of easements and permits for construction of the 10 floodwater retarding structures. Funds for the local share of the project cost, including land, easements, rights-of-way, and administration of contracts, are available from the existing special district tax and are adequate for these purposes.

The easements will be dedicated jointly to the East Keechi Creek Water Control and Improvement District No. 1, and the appropriate soil conservation district. The East Keechi Creek Water Control and Improvement District No. 1 will provide for the necessary improvement of low water crossings on private roads to make them passable during prolonged release flow from the structures or obtain permission to inundate road crossings where equal alternate routes are designated for use during periods of inundation and will provide for the relocation of the public road affected by the pools of Floodwater Retarding Structure 5.

The 10 floodwater retarding structures constitute a single construction unit, and all land, easements, and rights-of-way will be obtained before Public Law 566 funds are made available.

The estimated schedule of obligation for the complete 5-year installation period, covering installation of both land treatment and structural measures, is as follows:

Schedule of Obligation

Fiscal Year	Measure	P. L. 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
1st	Sites 1, 3, 8, and 10	250,131	24,740	274,871
	Land Treatment	5,280	84,118	89,398
2nd	Sites 2, 4, and 9	247,030	24,220	271,250
	Land Treatment	5,280	84,118	89,398
3rd	Sites 5, 6, and 7	306,028	37,520	343,548
	Land Treatment	5,280	84,118	89,398
4th	Land Treatment	5,280	84,119	89,399
5th	Land Treatment	5,280	84,119	89,399
	Total	829,589	507,072	1,336,661

This schedule will be adjusted year to year on the basis of any significant changes in the plan found to be mutually desired, and in the light of appropriations and accomplishments actually made.

The structural measures will be constructed during a 3-year installation period pursuant to the following conditions:

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

2. The necessary land, easements, rights-of-way, and permits have been obtained.

3. Provisions have been made for improving low water crossings on private roads or permission obtained to temporarily inundate the low water crossings and roads, provided equal alternate routes are available for use by all people concerned, during periods when these crossings are impassable due to prolonged flow from the principal spillways of the floodwater retarding structures. If equal alternate routes are not available, the provisions will specify that necessary improvements will be made, at no cost to the Federal Government, to make the crossings passable during prolonged periods of release flows from the structures.

4. Arrangements are completed for relocating County road at Site 5.

5. The contracting agency is prepared to discharge its responsibilities.

6. Operation and maintenance agreements have been executed.

7. Public Law 566 funds are available.

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

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 landowners and operators of the farms on which the measures are applied, under agreements with the Palo Pinto, Upper West Fork and Hood-Parker Soil Conservation Districts. Representatives of these soil conservation districts will make periodic inspections of the land treatment measures to determine maintenance needs and encourage landowners and operators to perform management practices and maintenance. They will make district-owned equipment available for this purpose.

Structural Measures for Flood Prevention

The 10 floodwater retarding structures will be operated and maintained by the East Keechi Creek Water Control and Improvement District No. 1. Funds for this purpose will come from the special district tax which is available and adequate for this purpose. The District will establish a permanent reserve fund for this purpose in the following manner and amounts: As the structural works of improvement are completed $200 per year per floodwater retarding structure will be placed in a fund for operation and maintenance. The portion of this fund not needed for current operation and maintenance will be placed in a reserve fund until the sum of $1,000 per floodwater retarding structure is established. This will amount to $10,000 when all structures are completed. This reserve fund will be kept available for abnormally costly maintenance activities that may result from excessive storms or other causes. When it becomes necessary to use any of the reserve fund for maintenance expenditures, the District will take appropriate action to replenish the fund in the shortest feasible time.

All structural measures will be inspected at least annually and after each heavy rain by representatives of the East Keechi Creek Water Control and Improvement District No. 1 and Upper West Fork and Palo Pinto Soil Conservation Districts. A Soil Conservation Service representative will participate in these inspections at least annually. For the floodwater retarding structures, items of inspection will include, but will not be limited to,

the conditions of the principal spillway and its appurtenances, the emergency spillway, the earth fill, the vegetative cover of the earth fill and the emergency spillway, and fences and gates installed as part of the floodwater retarding structures.

The Soil Conservation Service, through the Upper West Fork and Palo Pinto Soil Conservation Districts, will participate in operation and maintenance activities only to the extent of furnishing technical assistance.

Provisions will be made for free access of representatives of the cosponsoring organizations and Federal agencies to inspect and provide maintenance for all structural measures and their appurtenance at any time.

The cosponsoring local organizations will maintain a record of all maintenance inspections made and maintenance performed and have it available for inspection by Soil Conservation Service personnel.

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

The estimated average annual operation and maintenance cost of all structural measures is $1,520 based on long-term prices. The necessary maintenance work will be accomplished either by contract, force account, or equipment owned by the East Keechi Creek Water Control and Improvement District No. 1.

COST-SHARING

Public Law 566 funds will provide technical assistance in the amount of $26,400 during the 5-year installation period to accelerate the installation of land treatment measures included in the plan for watershed protection. These measures will be installed through funds other than P. L. 566 at an estimated cost of $420,592 (table 1). This cost includes ACPS payments based on present program criteria and technical assistance under the going district program. The required local costs for structural measures consisting of the value of land, easements and rights-of-way, ($81,480), and the cost of administering contracts ($5,000), are estimated at $86,480.

The entire construction cost for structural measures, amounting to $638,526 will be borne by Public Law 566 funds. In addition, the installation services cost of $164,663 will be a Public Law 566 expense. This is a total Public Law 566 cost of $803,189 for the installation of structural measures.

The total project cost of $1,336,661 will be shared 62.1 percent ($829,589) by Public Law 566 funds and 37.9 percent ($507,072) by other than Public Law 566 funds.

CONFORMANCE OF PLAN TO FEDERAL LAWS AND REGULATIONS

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

SECTION 2

INVESTIGATIONS, ANALYSES, AND SUPPORTING TABLES

INVESTIGATIONS AND ANALYSES

Project Formulation

Project Objectives

Flood problems and project objectives were reviewed with representatives of the Palo Pinto, Upper West Fork, and Hood-Parker Soil Conservation Districts, and the East Keechi Creek Water Control and Improvement District No. 1. The desired objectives of the project, as expressed by the local cosponsoring organizations, were to provide a degree of flood protection that would result in a reduction of existing damages of at least 70 percent; allow the flood plain lands that are now either idle or in low value production to be restored to their former productivity, and to investigate the possibility of non-agricultural water management in the form of municipal water supply for the town of Graford.

Land Treatment Measures

The needed land treatment measures for the watershed was developed by the soil conservation districts assisted by personnel from the Soil Conservation Service at Mineral Wells, Jacksboro and Weatherford. These were based on conservation needs data compiled from existing conservation plans within the watershed expanded to represent the conservation needs of the entire watershed. The quantity of each land treatment practice which contributes directly to flood prevention that will be applied during the 5-year installation period was estimated (table 1). The hydraulic, hydrologic, sedimentation and economic investigations provided data as to the effects of these land treatment measures in terms of the reduction of flood damages. Although significant benefits would result from application of these needed land treatment measures, it was apparent that other flood prevention measures would be required to attain the degree of watershed protection and flood damage reduction desired by the local people.

Structural Measures

Structural measures for flood prevention needed to attain the project objectives that could not be accomplished by land treatment measures alone were then determined. The studies and procedures used in that determination were as follows:

1. A base map of the watershed was prepared showing watershed boundary, drainage pattern, system of roads, and other pertinent information. A stereoscopic study of 4-inch consecutive aerial photographs was used to locate all

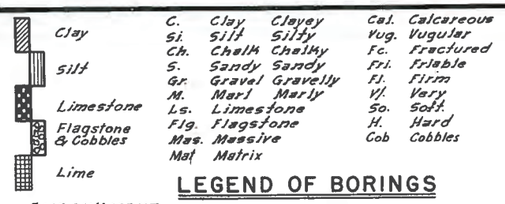
probable floodwater retarding structure sites, the limits of the flood plain, and the points at which valley cross sections should be surveyed to develop data for the determination of hydraulic characteristics and for flood-routing purposes. This information was placed on the watershed base map for use in field surveys. Cross sections of the stream channels and flood plain were surveyed at the selected locations. Data developed from these cross sections permitted the computation of peak discharge-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.

2. A field examination was made of all probable floodwater retarding structure sites previously located stereoscopically. Sites which did not have sufficient storage capacities or could not be economically justified were dropped from further consideration. From the remaining sites, a system of floodwater retarding structures was selected for further consideration and detailed survey. Site 1 is in series with Site 2; Site 6 in is in series with Site 7; and Site 8 is in series with Site 9. These series of sites are necessary because of the limited storage at Sites 2, 7, and 9, and alternate sites with adequate storage are not available to provide the needed degree of control to effect the desired level of damage reduction. Plans of a floodwater retarding structure, typical of those planned for the watershed, are illustrated by figures 4 and 4A.

3. A topographic map was made of the pool, dam, and spillway areas of each of the proposed sites to determine the storage capacity of the site, the estimated cost of the dam including spillway, the limits of the pool areas, and the area involved in the dam and spillway. The height of the dams and the size of the pools were determined by the criteria outlined in Washington Engineering Memorandum, SCS-27, and Texas State Manual Supplement 2441. The limits of the flood and sediment pools of the proposed floodwater retarding structures 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 capacity needed for floodwater detention and for sediment storage in acre-feet and in inches of runoff from the drainage area, the release rate of the principal spillway, the acres of flood plain and upland inundated by the sediment and detention pools, the volume of fill in the dams, the estimated cost of the structures, and other pertinent data (tables 2, 3, and 5).

4. A detailed investigation was made of State, County, and farm roads having low-water crossings on the streams below the

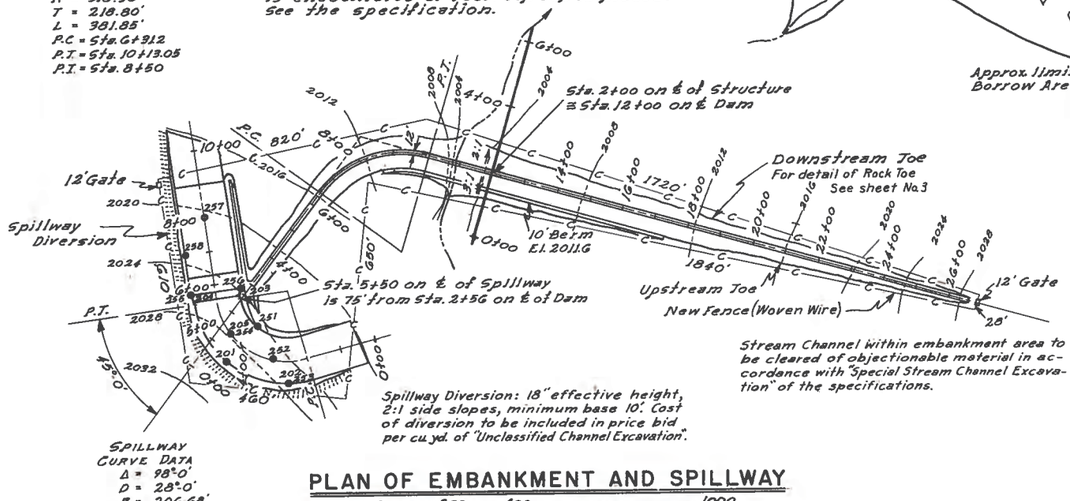


C.	Clay	Clayey	Cal.	Calcareous
Si.	Silt	Silty	Vug.	Vuguler
Ch.	Chalk	Chalky	Fc.	Fractured
S.	Sandy	Sandy	Fri.	Friable
Gr.	Gravel	Gravelly	Fi.	Firm
M.	Marl	Marly	Vl.	Very
Ls.	Limestone		So.	Soft.
Flg.	Flagstone		H.	Hard
Mas.	Massive		Cob	Cobbles
Mat	Matrix			

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+93.2
P.I. = Sta. 10+19.05
P.I. = Sta. 8+50

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.

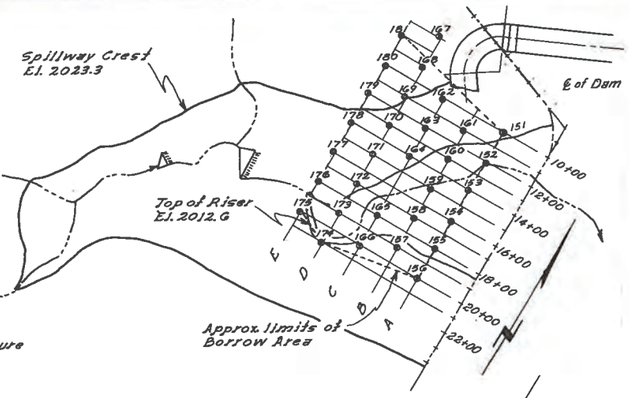


Stream Channel within embankment area to be cleared of objectionable material in accordance with "Special Stream Channel Excavation" of the specifications.

SPILLWAY CURVE DATA
Δ = 98°-0'
D = 28°-0'
R = 206.68'
L = 350.0'
P.C. = Sta. 2+00
P.T. = Sta. 5+50

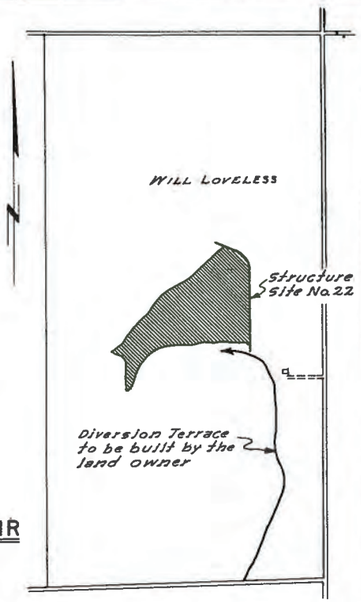
PLAN OF EMBANKMENT AND SPILLWAY

0 200 400 1000
SCALE IN FEET



GENERAL PLAN OF RESERVOIR

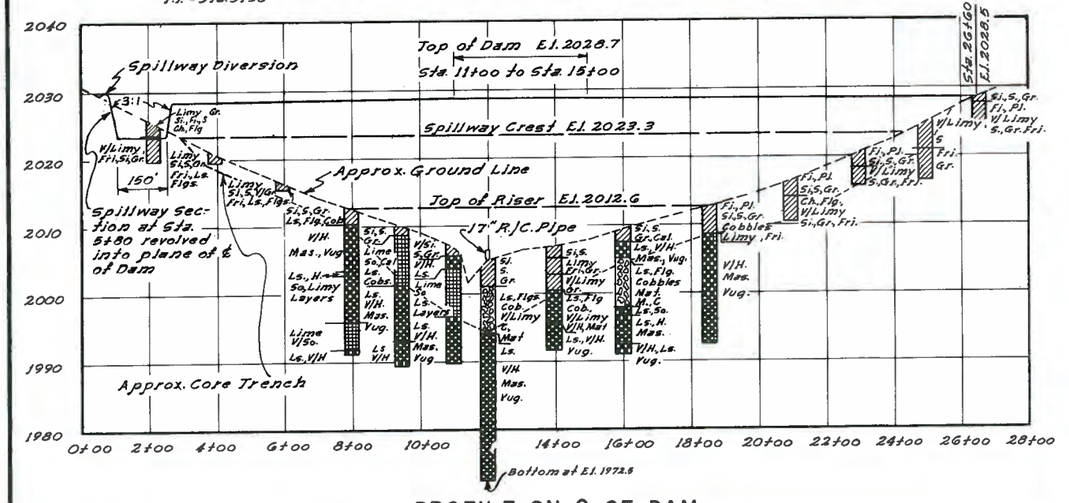
0 400 800 1600
SCALE IN FEET



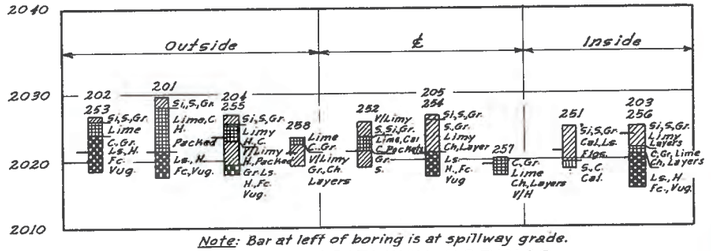
Located 5½ mi. East and 4 mi. South of Eden, Concho County, Texas

VICINITY MAP

0 ¼ ½ 1
SCALE IN MILES



PROFILE ON ℄ OF DAM



Note: Bar at left of boring is at spillway grade.

LOG OF SPILLWAY BORINGS

SEE PLAN OF EMBANKMENT AND SPILLWAY

Elevation	Surface Acres	Storage Acre Ft.	Storage 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	1242.0
Sediment Storage, Ac. Ft.	51.7
Floodwater Storage, Ac. Ft.	464.0

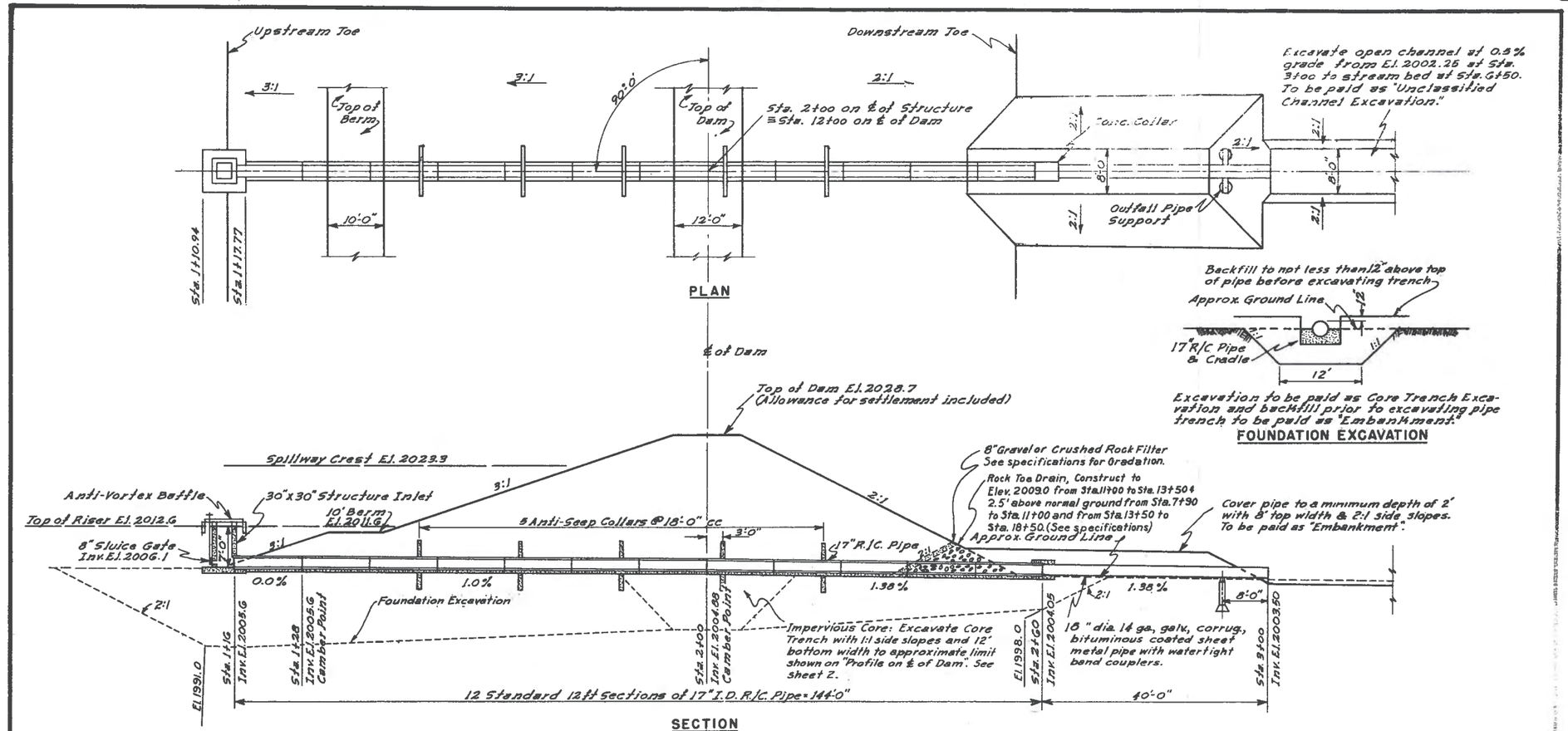
Figure 11
TYPICAL
FLOODWATER RETARDING STRUCTURE
PLAN AND PROFILE

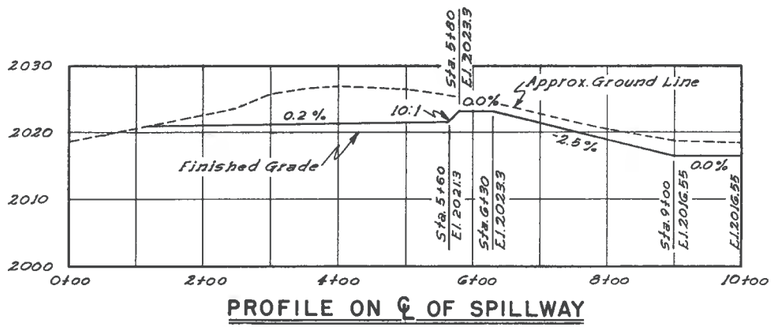
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed H.C.N. Date 8-56
Drawn H.C.N. & G.R. 8-56
Traced G.R. 8-56
Checked H.C.N. & H.H.L. 9/56

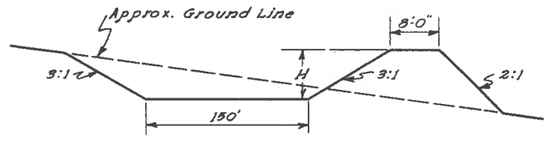
Approved by [signature]
AREA ENGINEERING & WATERSHED PLANNING UNIT, FORT WORTH, TEXAS
STATE CONSERVATION ENGINEER, S.C.S., TEMPLE, TEXAS

Sheet No. 2 of 7
Drawing No. 4-E-10,760





PROFILE ON ℄ OF SPILLWAY



Top of Dike, El. 2028.55 from Sta. 3+00 to Sta. 6+30 12 ft. top width with 10:1 end slope. Transition from El. 2028.55 at Sta. 6+30 to 4 ft. height at Sta. 7+00, top width 8 ft. H = 4 ft. from Sta. 7+00 to Sta. 9+00, top width 8 ft. with 10:1 end slope.

TYPICAL SPILLWAY SECTION

Figure 4A
TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed H.C.N.	8-56	Approved by	
Drawn H.C.N. & G.R.	8-56	AREA ENGINEERING & WATERSHED PLANNING UNIT, POST, TEXAS	
Traced G.R.	8-56	STATE CONSERVATION ENGINEER, S.C.S. TEMPLE, TEXAS	
Checked H.C.N. & H.H.L.	9/56	Sheet No 3 of 7	Drawing No. 4-E-10,760

floodwater retarding structures. Where there are no equal alternate routes, the improvements required to provide passage during periods of prolonged floodwater release from structures were determined.

5. Representatives of Graford investigated the feasibility of obtaining a supplemental water supply by incorporating water storage in one of the planned structures and transporting the water in the stream channel to their existing surface reservoirs near Graford. The local interests investigated the locations of possible multiple-purpose structures, the probable water yields, and the transportation losses that would be incurred and determined that supplemental water from this source would not be adequate during periods of prolonged drought. At the request of the local interests, the storage of municipal water was dropped as a project objective.

6. Damages resulting from floodwater and sediment were determined from damage schedules, surveys of sample areas, and flood routings under present conditions. Reductions in these damages resulting from the proposed works of improvement were estimated on the basis of reduction in sediment yields and reduction of peak discharges as determined by flood routings under future conditions for which it was assumed that the proposed works of improvement had been installed. Benefits so determined were allocated to individual measures or groups of interrelated measures, on the basis of the effects of each on reduction of damages. In this manner it was determined that a system of floodwater retarding structures could be economically justified. By further analyses those individual and interdependent floodwater retarding structures which had favorable benefit to cost ratios were determined. Those which were unfavorable were dropped from further consideration and alternate sites were investigated until the most economical system of floodwater retarding structures was developed which would provide the degree of protection desired by the sponsoring local organizations. This system consisted of 10 interdependent floodwater retarding structures.

When the structural measures for flood prevention had been determined, a table was developed to show the cost of each type of measure. The summation of the total costs for all works of improvement 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 part of the hydrologic investigations and determinations:

1. Basic meteorologic and hydrologic data were tabulated from Climatological Bulletins, U. S. Weather Bureau and Water Supply Papers, and U. S. Geological Survey. These data were analyzed to determine average precipitation depth-duration relationships, seasonal distribution of precipitation, the historical flood series to be used in the evaluation of the project, rainfall-runoff relationships, runoff-peak discharge relationship of geology, soils and climates to runoff depth-frequency for single storm events.

2. Engineering surveys were made of channel and valley cross-sections selected to represent adequately the stream channel and flood plain area. Preliminary locations for cross sections were made by stereoscopic examination of aerial photographs of the flood plain. The final locations were selected on the ground, giving due consideration to the needs of the economist and sedimentation specialists. The evaluation reaches were delineated in conference with the economist and sedimentation specialist..

3. Hydrologic conditions of the watershed were determined by considering such factors as climate, geology, topography, soils, land use and cover. From this, soil-cover complex data were assembled and rainfall-runoff relationships computed for use in determining depth of runoff from individual storm events, using monthly soil moisture indices. These data were compared to the best available gaged runoff data.

4. Cross section rating curves were developed from field survey data collected in 2, above, by solving water surface profiles for various discharges. Water surface profiles were computed by the Doubt method described on pages 3.14-7-13, Soil Conservation Service National Engineering Handbook, Section 4, Supplement A.

5. The theory of concordant flow was used to determine the relationship of peak discharge to the volume of runoff at selected points in the watershed. The exponent of the concordant flow equation was established from the relationship between reliable highwater marks left by recent floods and the volume of runoff computed from rainfall records of each flood studied.

6. State-area inundation curves were developed from field survey data for each portion of the valley represented by a cross section. Composite runoff-area inundation curves, by incremental depths of flooding, were developed for each evaluation reach by routing incremental volumes of runoff downstream using the peak discharge-volume relationship determined by the concordant flow curve as developed above and summating the area flooded for each portion of the valley represented by a cross section in the evaluation reach. Similarly, a family

of runoff-area inundation curves were developed to reflect the effect of the proposed system of floodwater retarding structures.

7. The period 1926 through 1957 was selected as the most representative of normal precipitation of the watershed, and is the period from which the historical flood series for evaluation was developed.

8. The area, by depth increments, that would have been inundated by each storm in the evaluation series was determined for:

   a. Present conditions.

   b. With land treatment measures applied.

   c. With land treatment measures applied and floodwater retarding structures completed.

   d. With alternative systems of structures.

9. The largest rain which occurred during the 32-year period studied was a storm of 6.12 inches on September 16-17, 1936. If soil moisture condition II is assumed, the computed runoff from a storm of this size is 3.69 inches. The runoff frequency line developed by means of the computed runoff from 32 years of record indicated a frequency of approximately 32 years for this storm runoff. The runoff from this storm would inundate 4,735 acres under present conditions. This is the flood plain area.

10. The appropriate design storm and storm pattern was selected from figures 3.21-1 and 3.21-4, NEH Section 4, Supplement A, in accordance with criteria contained in Washington Engineering Memorandum SCS-27, and Texas State Mannual Supplement 2441.

11. Spillway design storm hydrographs were developed for each of the floodwater retarding structures by the distribution graph method. The combination of emergency spillway width, depth, and elevation for the most economical structure design was obtained by the Goodrich flood-routing method described on page 5.8-12 NEH, Section 5 and using Hydrology Memorandum EWP-4, dated March 19, 1959 for flood routing of structures in series.

12. Emergency spillway capacities were designed in accordance with Washington Engineering Memorandum SCS-31 (Rev.), Technical Release No. 2 (Tentative) Washington Design Section, dated October 1, 1956; Supplement A to Tentative

Technical Release No. 2, dated May 13, 1957; Section 3.21, NEH Section 4, Supplement A; and Texas State Manual Supplement 2441.

13. Maximum release rates for the principal spillways of the floodwater retarding structures were determined by a detailed study of the stream channel, and the effect of release rates on the design of structures and emergency spillways. The maximum release rates will be 10 c.s.m. for Sites 1 and 2. All other sites will have 7 c.s.m. release rate.

The structure classification, minimum floodwater storage required and actual floodwater storage planned for all structures are shown in the following table:

Site No.	Structure Classification	Minimum Floodwater Detention Required 1/	Actual Floodwater Detention Planned
		(inches)	(inches)
1	A	3.30	4.97
2	A	3.25	3.25
3	A	3.52	3.52
4	A	3.85	3.85
5	A	3.56	3.56
6	B	5.08	6.25
7	B	5.59	5.59
8	A	3.90	3.90
9	A	4.00	4.79
10	A	3.90	4.70

1/ For Class A Structures: 25-year frequency, based on regional analysis of gaged runoff.
For Class B Structures: 50-year frequency, based on regional analysis of gaged runoff.

Detention volumes in excess of the minimum established by the criteria in Texas State Manual Supplement 2441 were used for Sites 1, 6, 9, and 10 to obtain more economical or desirable emergency spillway location or structure design.

Sedimentation Investigations

Sediment Source Studies

Investigations of sediment sources to determine the sediment storage requirements for a 50-year period were made in the drainage areas of the 10 planned floodwater retarding structures according to the following procedures:

1. Detailed investigations were made in the drainage areas

above 5 of the planned floodwater retarding structures. Estimates of sediment rates were made for the remaining 5 sites based on similarity of these drainage areas to areas which had been surveyed in detail.

2. Field surveys included:

   (a) Mapping soil units by slope in percent, slope length, present land use, present land treatment on cultivated land, present cover condition classes on pasture and rangeland, and land capability classes.

   (b) Determining the lengths, widths, depths, and estimating the annual lateral erosion of all gullies and all stream channels affected by erosion.

   (c) Determining the widths, depths, and estimating the annual headward erosion of all headcuts and overfalls.

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

The following formula was used for computing sheet erosion:

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

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

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

The following formula was used for computing headcut and overfall erosion:

E = H x W x HE ÷ 43,560, where

E = Erosion rate in acre-feet per year
H = Height of overfall or headcut in feet
W = Width of overfall or headcut in feet
HE = Estimated annual headward erosion in feet

4. Field surveys to determine the estimated sediment rates for the remaining 5 planned structures under present conditions consisted of mapping the land use and arranging the sites to be estimated into homogeneous groups.

5. Office computations to determine the estimated sediment rates under present conditions for the drainage areas not investigated in detail consisted of preparation of sediment source summary sheets based on the homogeneous grouping of the sites and the detailed investigations.

6. The sediment rates were then adjusted to reflect the effect of expected land treatment on the drainage areas of the planned floodwater retarding structures. The computed sediment storage requirement for each site is based on a gradual improvement of watershed conditions as a result of the installation of 80 percent of all needed land treatment measures during the first 10 years and maintaining these measures at 75 percent effectiveness during the next 40 years.

7. The ratio of sediment storage volume in the sediment pool to soil in place was estimated to be 1.3 for all structures in the watershed.

8. The allocation of sediment to the structure pools was based on 20 percent deposition in the detention pools and 80 percent deposition in the sediment pools for all sites except Sites 6 and 10. The allocation of sediment for Site 6 was based on 30 percent deposition in the detention pool and 70 percent in the sediment pool because of the slightly coarser textured sediment and very gently sloping pool area. Allocation for Site 10 was based on 15 percent deposition in the detention pool and 85 percent in the sediment pool, mainly because of the steeply sloping pool area and slightly finer textured sediment.

The total estimated annual sediment yield above the 10 planned floodwater retarding structures is 41.95 acre-feet.

The estimated average annual rate of sediment deposition in the floodwater retarding structures is 1.05 acre-feet per square mile of watershed area.

Flood Plain Sedimentation and Scour Damages

The following sedimentation and scour damage investigations were made to evaluate the nature and extent of physical damage to flood plain land:

1. Sample areas between valley cross sections were selected for field studies and mapping of sedimentation and scour damages.

2. Hand auger borings were made to determine the depth, texture, and extent of deposits. Scour channels and sheet scour areas were located and mapped. Other pertinent factors contributing to flood plain damage, such as stream channel degradation or aggradation, were studied.

3. A damage table was developed to show percent damage by texture and depth increment for deposition and percent damage by depth and width for scour. Due consideration was given to agronomic and other land treatment practices, soils, crop yields, and land capabilities in assigning damage categories based on percent loss of productivity.

4. The depth and area of modern alluvial deposits and scour areas were measured and tabulated.

5. Damages found within sample areas were expanded to represent the entire flood plain in each evaluation reach.

6. Using average annual erosion rates as a basis, the average annual sediment yields at selected valley sections along the flood plain were estimated for present conditions, with land treatment applied and with structural measures installed. The results were compared to show the average reduction of sediment load contributing to overbank deposition. The reduction of overbank deposition is based on this reduction of sediment load and reduction of area inundated by floodwater. The reduction of scour damage due to installation of the complete project is based on reduction of depth and area inundated by floodwater.

The reduction of approximately 16 percent in sediment production from the upland areas was determined by considering the expected application of 80 percent of the needed land treatment measures applied and maintained at 75 percent effectiveness.

Geologic Investigations

Preliminary geologic investigations were made at all of the planned floodwater retarding structure sites. These investigations included lithologic and stratigraphic studies of the valley slopes, alluvium, channel banks, and exposed geologic formations. Hand auger borings were made in the channel beds and representative areas of the spillway, borrow, and foundation of the dam sites to determine the nature and extent of embankment material, emergency spillway excavation, and other possible problems that might be encountered in construction.

Description of Problems

Sites 1, 2, 3, 4, 7, 9, and 10 are located entirely within the Graford formation. The estimated percent of rock excavation in the emergency spillways is as follows: Site 1, 75 percent; Sites 2 and 3, 15 percent; Site 9, 20 percent; and Site 10, 40 percent. No rock will be encountered in the spillways of Sites 4 and 7. Except for dispersed soils present at Site 2, borrow soils will be good embankment material, consisting of sandy and silty clays and clayey sands. The soils, as classified by the Unified Soil Classification System, are generally CL, CL-ML, and SC.

Sites 5 and 8 are located partially within the Trinity and Graford formations and have emergency spillways in the highly erosive sandy clays and shales of the Trinity Basement Sands. Although Site 6 is located entirely within the Trinity, the shallow cut in the emergency spillway will not reach the highly erodible material. No rock will be encountered in emergency spillway excavation of Sites 5, 6, and 8. The soils for embankment purposes are primarily CL and SC and are of good quality.

The formations in the watershed, especially the Trinity Basement Sands, are very susceptible to erosion when stripped of vegetative cover. Embankments and emergency spillways will be vegetated as soon as possible after construction.

Prior to construction, detailed investigations, including exploration with core drilling equipment, will be made at all floodwater retarding structure sites. Laboratory tests will be made to determine the stability of foundation strata and the suitability and methods of handling the materials to be used in the embankment.

Economic Investigations

Determination of Annual Benefits from Reduction in Damage

Agricultural damage estimates were based on schedules obtained in the field covering approximately 70 percent of the flood plain of East Keechi Creek and its tributaries. These schedules covered land use and crop distribution, yields and historical data on flooding and flood damages. Most of the flood damage information obtained was for floods which occurred in 1957 and 1958. Analysis of this information formed the basis for determining damage rates for various depths and seasons of flooding. In the calculation of crop and pasture damages, expenses saved, such as costs of harvesting and other production inputs, were deducted from the gross value of the damage. Information on other agricultural damages was also obtained on the damage schedules and correlated with sizes of floods. The major item of nonagricultural damage was that sustained by roads and bridges. Estimates of these damages were based on information supplied by county and State highway officials, supplemented by that from local farmers.

The proper rates of damage were applied, flood by flood, to the floods

covering the period 1926 through 1957, and adjustments were made to take into account the effects of recurrent flooding when more than one flood occurred within the same year. The flood plain land use was mapped in the field. Normal flood-free yields were based on data obtained from schedules supplemented by information obtained from other agricultural workers in the area.

In analyzing flood plain land use, yields, and frequency of flooding it was found that significant variations existed with respect to location within the watershed. Therefore, the flood plain was divided into six evaluation reaches, each with its own damageable value.

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

Evaluation Reach A - From bottom of watershed upstream to a point approximately halfway between valley cross sections 6 and 8, including the flood plain of Willow and Williams Branches.

Evaluation Reach B - From a point approximately halfway between valley cross sections 6 and 8 to a point halfway between valley cross sections 10 and 12.

Evaluation Reach C - From a point approximately halfway between valley cross sections 10 and 12 to valley cross section DS-1.

Evaluation Reach D - From a point approximately halfway between valley cross sections 10 and D-3 to a point approximately halfway between valley cross sections D-4 and D-5.

Evaluation Reach E - From a point approximately halfway between valley cross sections D-4 and D-5 to valley cross sections DS-3 and DS-4.

Evaluation Reach F - From a point approximately halfway between valley cross sections D-4 and D-2 to valley cross sections DS-5 and DS-6.

The monetary value of the physical damage to the flood plain from erosion and from deposition of sediment was based on the net value of the production lost, taking into account the time lag for recovery and/or the cost of operations necessary to speed recovery.

Indirect damages in this watershed primarily involve additional travel time for farmers, school bus transportation and mail deliveries and costs for extra feed for livestock during and following floods. Upon analysis, it appears that these damages are about 10 percent of the direct damage.

Farmers in the flood plain were asked to state changes made in land use as a result of past flooding. Operators were also asked what changes they would make in their use of flood plain lands if flooding were reduced. Analysis of these responses indicated that benefits from restoration of lands to their former use and changed land use would result from the anticipated reduction in flooding. Factors considered in this analysis were the size and location of the areas affected, land capability, reduction in frequency of flooding, and similar factors. Consideration was given to increased damage after restoration of production and changed land use, and all benefits are net benefits remaining after production, harvesting, and all other allied costs were considered. Benefits from restoration of production are included as crop and pasture benefits and discounted for an expected 5-year lag in conversion. Benefits from land use change were discounted for an expected 10-year lag in conversion. Consideration was given to the effects of acreage allotment restrictions in the analyses of benefits from restoration of production and changed land use and it was determined that benefits are not dependent upon production increases in restricted crops.

Areas that will be inundated by the sediment and detention pools of floodwater retarding structures were excluded from damage calculations. An estimate was made however, of the value of production lost in those areas after installation of the program. In this appraisal it was considered that there would be no production in the sediment pools. The land covered by the detention pools was assumed to be converted to grassland, under project conditions. The costs of land, easements, and rights-of-way for the 10 floodwater retarding structures were determined by individual appraisal in conjunction with representatives of the sponsoring organizations. Floodwater retarding structure site costs were based on appraisals of the value of the easements with consideration of the values that will remain after the land is devoted to project purposes. The average annual net loss in production, based on long-term prices, within the sites was calculated and this value compared with the amortized cost of the structure sites. The larger amount was used in the economic evaluation of the project to assure a conservative appraisal.

Determination of Annual Benefits Outside Watershed Resulting from Project

Benefits from outside the watershed will result from a reduction in flooding on the flood plain of Keechi Creek below its confluence with East Keechi Creek. These benefits, amounting to $381 annually, were estimated from data collected from operators of flood plain lands in conjunction with estimates of reductions in peak flows resulting from the system of floodwater retarding structures to be installed in East Keechi Creek watershed.

Details of Methodology

Details of the procedures used in the investigations are described in the Soil Conservation Service Economics Guide for Watershed Protection and Flood Prevention, December 1958.

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

East Keechi Creek Watershed, Texas
Price Base: 1959

Structure Number	Installation Cost - Public Law 566 Funds					Installation Cost-Other Funds			Total Installation Cost
	Construction		Installation Services		Total Public Law 566	Adm. of Contracts	Easements and R/W	Total Other	
	Engineer's Estimate (dollars)	Contingencies (dollars)	Engineering (dollars)	Other (dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1	69,955	6,996	13,851	5,993	96,795	500	7,720	8,220	105,015
2	82,349	8,235	16,305	7,055	113,944	500	10,490	10,990	124,934
3	25,103	2,510	4,970	2,150	34,733	500	5,210	5,710	40,443
4	33,464	3,346	6,626	2,867	46,303	500	6,410	6,910	53,213
5	49,224	4,922	9,746	4,217	68,109	500	6,740	7,240	75,349
6	127,648	12,765	25,274	10,935	176,622	500	18,410	18,910	195,532
7	44,300	4,430	8,772	3,795	61,297	500	10,870	11,370	72,667
8	67,636	6,764	13,392	5,794	93,586	500	4,950	5,450	99,036
9	62,719	6,272	12,419	5,373	86,783	500	5,820	6,320	93,103
10	18,080	1,808	3,580	1,549	25,017	500	4,860	5,360	30,377
TOTAL	580,478	58,048	114,935	49,728	803,189	5,000	81,480	86,480	889,669

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TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

East Keechi Creek Watershed, Texas

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7	8	9	10	Total
Drainage Area	sq. mi.	6.63	8.52 1/	3.77	2.67	3.11	7.24	3.12 1/	3.36	3.86 1/	4.20	46.48
Storage Capacity												
Sediment Pool	ac. ft.	200	200	95	125	184	200	178	167	142	139	1,630
Sediment Reserve Below Riser	ac. ft.	0	95	0	0	0	194	0	0	0	0	289
Sediment in Detention Pool	ac. ft.	44	55	17	24	35	127	35	32	27	18	414
Floodwater Detention	ac. ft.	1,757	1,477	708	549	590	2,414	930	699	986	1,053	11,163
Total	ac. ft.	2,001	1,827	820	698	809	2,935	1,143	898	1,155	1,210	13,496
Surface Area												
Sediment Pool (top of riser)	acre	41	83	32	26	45	67	56	45	33	30	458
Floodwater Detention Pool	acre	173	240	115	101	98	270	163	110	151	122	1,543
Volume of Fill	cu. yd.	132,910	166,300	61,770	83,660	123,060	319,120	110,750	169,090	147,160	33,620	1,347,440
Elevation Top of Dam	foot	1,091.5	1,048.6	1,068.8	1,078.4	1,095.9	1,104.0	1,058.6	1,110.6	1,044.7	1,033.7	xxx
Maximum Height of Dam	foot	32	28	24	23	24	37	22	23	26	33	xxx
Emergency Spillway												
Crest Elevation	foot	1087.5	1044.8	1064.9	1074.5	1092.4	1099.0	1054.0	1106.7	1041.5	1030.0	xxx
Bottom Width	foot	230	450	200	140	215	340	400	250	400	240	xxx
Type	xxx	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use 2/	xxx	1.6	4.0	4.0	4.0	4.0	1.1	1.7	4.0	3.4	2.6	xxx
Ave. Curve No.-Cond. II	xxx	74	74	74	76	74	75	77	78	79	78	xxx
Emergency Spillway Hydrograph												
Storm Rainfall (6 hr.)	inch	6.03	5.91	6.24	6.30	6.24	8.75	9.37	6.24	6.00	6.17	xxx
Storm Runoff	inch	3.22	3.11	3.40	3.64	3.40	5.72	6.54	3.80	3.68	3.73	xxx
Velocity of Flow (Vc) 3/	ft./sec.	0	0	0	0	0	0	3.30	0	0	0	xxx
Discharge rate 3/	c.f.s.	0	0	0	0	0	0	427	0	0	0	xxx
Maximum Water Surface Elev.3/	foot	xxx	xxx	xxx	xxx	xxx	xxx	1,054.89	xxx	xxx	xxx	xxx
Freeboard Hydrograph												
Storm Rainfall (6 hr.) 4/	inch	14.11	13.83	14.59	14.74	14.59	19.47	19.49	14.59	14.03	14.43	xxx
Storm Runoff	inch	10.63	10.37	11.09	11.53	11.09	15.97	16.31	11.68	11.28	11.53	xxx
Velocity of Flow (Vc) 3/	ft./sec.	8.5	8.2	8.4	8.4	8.1	9.6	9.2	8.2	7.5	8.2	xxx
Discharge rate 3/	c.f.s.	4,354	7,998	3,754	2,576	3,598	9,470	10,037	4,246	5,260	4,091	xxx
Maximum Water Surface Elev.3/	foot	1,091.5	1,048.6	1,068.8	1,078.4	1,095.9	1,104.0	1,058.6	1,110.6	1,044.7	1,033.7	xxx
Principal Spillway												
Capacity Low Stage	c.f.s	66	152	26	19	22	51	73	24	50	29	xxx
Capacity Equivalents												
Sediment Volume	inch	0.69	0.77	0.56	1.05	1.32	1.35	1.28	1.11	0.82	0.70	xxx
Detention Volume	inch	4.97	3.25	3.52	3.85	3.56	6.25	5.59	3.90	4.79	4.70	xxx
Spillway Storage	inch	2.31	2.36	2.62	3.50	2.39	4.07	5.38	2.64	3.14	2.45	xxx
Class of Structure	xxx	A	A	A	A	A	B	B	A	A	A	xxx

1/ Exclusive of any area controlled by other structures.
2/ Based on regional analysis of gaged runoff.
3/ Maximum during passage of hydrograph.
4/ For Class A structures 1.17 x P and for Class B structures 1.67 x P of the 6-hour rainfall shown by figure 3.21-1, N.E.H. - 4 Supplement A.

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TABLE 4 - SUMMARY OF PHYSICAL DATA

East Keechi Creek Watershed, Texas

Item	Unit	Quantity Without Project	Quantity With Project
Watershed Area	sq.mi.	99.64	-
Watershed Area	Acre	63,770	-
Area of Cropland	Acre	12,477	12,416
Area of Pasture and Rangeland	Acre	49,825	49,428
Area of Miscellaneous Use	Acre	1,468	1,926
Overflow Area Subject to Damage 1/	Acre	2/ 4,400	2/ 2,775
Overflow Area Damaged Annually by:			
Sediment	Acre	3/ 1,725	4/ 327
Flood Plain Scour	Acre	3/ 446	4/ 121
Streambank Erosion	Acre	.41	.41
Annual Rate of Erosion:			
Sheet	Ac.Ft.	138.33	113.60
Gully	Ac.Ft.	21.07	17.41
Streambank	Ac.Ft.	3.68	3.68
Scour	Ac.Ft.	30.45	5.35
Average Annual Rainfall	Inch	28	-

1/ Area inundated by the runoff from a 32-year frequency storm.

2/ Excludes 335 acres of flood plain within structure sites.

3/ Acres on which some loss of production is occurring each year.

4/ The area on which production loss will occur each year after all recovery has taken place and equilibrium has been reached. This applies to all flooding up to the area inundated by the largest storm in the 32-year series.

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TABLE 5 - SUMMARY OF PLAN
East Keechi Creek Watershed, Texas

Item	Unit	Quantity
Years to Complete Project	Year	5
Total Installation Cost		
Public Law 566 Funds	Dollar	829,589
Other	Dollar	507,072
Annual O & M Cost		
Public Law 566 Funds	Dollar	0
Other	Dollar	1,520
Average Annual Monetary Benefits 1/	Dollar	36,674
Agricultural	Percent	91
Nonagricultural	Percent	9
Structural Measures		
Floodwater Retarding Structures	Each	10
Area Inundated by Structures		
Flood Plain		
Sediment Pool	Acre	130
Detention Pool	Acre	205
Upland		
Sediment Pool	Acre	328
Detention Pool	Acre	880
Watershed Area Above Structures	Acre	29,748
Reduction of Floodwater Damage	Dollar	27,895
By Land Treatment Measures		
Watershed Protection	Percent	4.8
By Structural Measures	Percent	74.6
Reduction of Sediment Damage	Dollar	2,613
By Land Treatment Measures		
Watershed Protection	Percent	18.5
By Structural Measures	Percent	62.5
Reduction of Erosion Damage	Dollar	1,699
By Land Treatment Measures		
Watershed Protection	Percent	5.6
By Structural Measures	Percent	67.3
Flood Prevention Benefit From Changed Land Use	Dollar	3,534

1/ From Structural Measures

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TABLE 6 - ANNUAL COST

East Keechi Creek Watershed, Texas

Measures	Amortization of Installation Cost 1/	Operation and Maintenance Costs 2/			Total Annual Costs
		Public Law 566	Other	Total	
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
Floodwater Retarding Structures					
3/ 1 through 10	31,368	0	1,520	1,520	32,888
TOTAL	31,368	0	1,520	1,520	32,888

1/ Price Base: 1959 prices amortized for 50 years at 2.5 percent.

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

3/ Interdependent measures.

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TABLE 7 - MONETARY BENEFITS FROM STRUCTURAL MEASURES

East Keechi Creek Watershed, Texas
Price Base: Long-Term 1/

Item	Estimated Average Annual Damage: Without Project	After Land Treatment for W/S Protection	With Project	Average Annual Monetary Benefits
	(dollars)	(dollars)	(dollars)	(dollars)
Floodwater Damage				
Crop and Pasture	22,384	21,501	5,034	16,467
Other Agricultural	9,065	8,503	1,930	6,573
Road and Bridge	3,656	3,404	246	3,158
Subtotal	35,105	33,408	7,210	26,198
Sediment Damage				
Overbank Deposition	3,225	2,627	612	2,015
Subtotal	3,225	2,627	612	2,015
Erosion Damage				
Flood Plain Scour	2,331	2,201	632	1,569
Subtotal	2,331	2,201	632	1,569
Indirect Damage	4,067	3,823	846	2,977
Total, All Damage	44,728	42,059	9,300	32,759
Changed Land Use to Crop Production	xxx	xxx	xxx	3,534
Benefits from Outside Project Area 2/	xxx	xxx	xxx	381
TOTAL FLOOD PREVENTION BENEFITS	xxx	xxx	xxx	36,674
TOTAL PRIMARY BENEFITS	xxx	xxx	xxx	36,674
TOTAL MONETARY BENEFITS	xxx	xxx	xxx	36,674

1/ As projected by ARS, September 1957.
2/ From mainstem Keechi Creek flood plain.

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TABLE 8 - BENEFIT COST ANALYSIS

East Keechi Creek Watershed, Texas

Measures	AVERAGE ANNUAL BENEFITS 1/ Flood Prevention: Flood-water	Sediment	Erosion	Indirect	Changed Land Use	Other 2/	Total	Average Annual Cost 3/	Benefit-Cost Ratio
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	
Floodwater Retarding Structures									
1 through 10 4/	26,198	2,015	1,569	2,977	3,534	381	36,674	32,888	1.1:1
GRAND TOTAL	26,198	2,015	1,569	2,977	3,534	381	36,674	32,888	1.1:1

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

2/ Benefits from reduction in damages to Keechi Creek flood plain.

3/ Derived from installation costs based on 1957 price level, and operation and maintenance cost based on long-term price levels, as projected by ARS, September 1957.

4/ All floodwater retarding structures are interdependent.

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