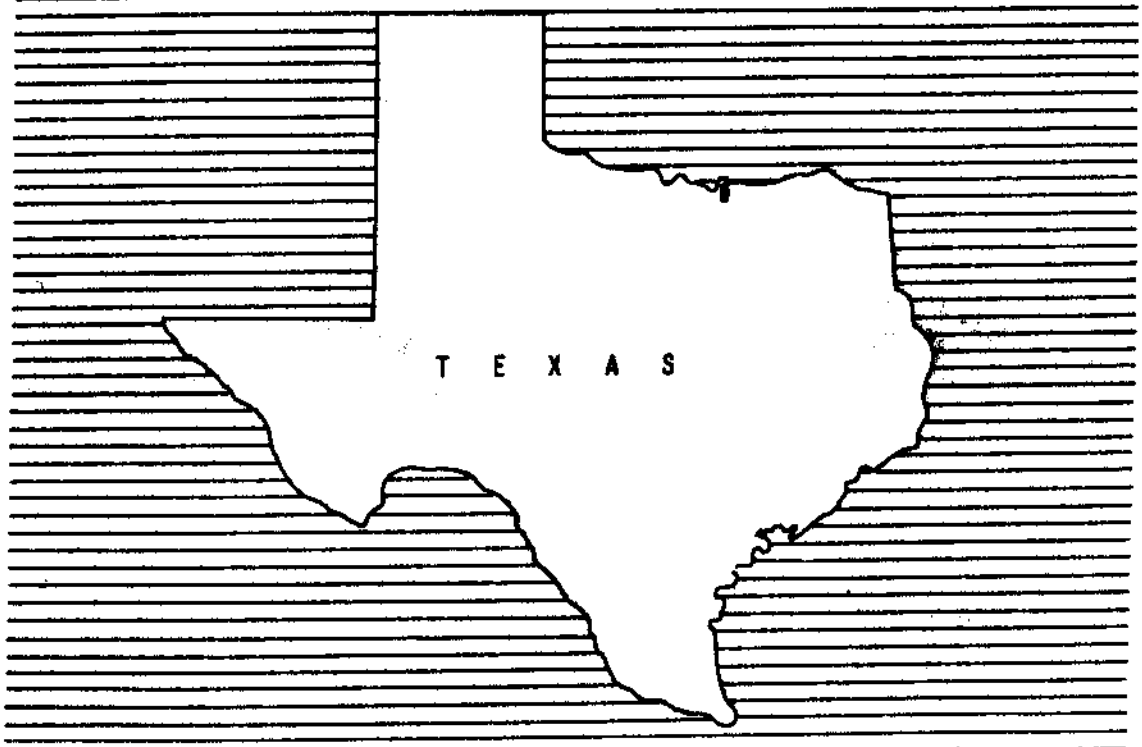
WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

FARMERS CREEK WATERSHED

MONTAGUE COUNTY, TEXAS



March 1966

4-82919 12-66

USDA SCS FORT WORTH TEX 7558

TABLE OF CONTENTS

WATERSHED WORK PLAN AGREEMENT

between the

Upper Elm-Red Soil and Water Conservation District
Local Organization

Farmers Creek Watershed Authority
Local Organization

Montague County Commissioners Court
Local Organization

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 Farmers 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; 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 Farmers 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 can be installed in about 5 years.

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

1. The 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 $ 97,823.)

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 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	723,800
62,340 lineal feet of Stream Channel Improvement	0	100	91,740
22 Debris Basins	0	100	271,700

4. The percentages of the cost for installation services to be borne by the Sponsoring Local Organization and the Service are as follows:

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Installation Service Cost (dollars)
10 Floodwater Retarding Structures	0	100	172,038
62,340 lineal feet of Stream Channel Improvement	0	100	24,805
22 Debris Basins	0	100	66,356

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 8,200 .)

6. The Sponsoring Local Organization will obtain agreements from owners of not less than 50% of the land above each reservoir and 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 **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.

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

Upper Elm-Red Soil and Water Conservation District
Local Organization

By Harold Skaggs
HAROLD SKAGGS

Title Chairman

Date 11-8-1966

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

adopted at a meeting held on 11-8-66

Chas H. Howard
(Secretary, Local Organization)
CHARLES H. HOWARD

Date 11-8-66

Farmers Creek Watershed Authority
Local Organization

By L. L. Newland
L. L. NEWLAND

Title President

Date Nov 8 1966

The signing of this agreement was authorized by a resolution of the governing body of the Farmers Creek Watershed Authority
Local Organization

adopted at a meeting held on 11-8-66

Zola Milner
(Secretary, Local Organization)
ZOLA MILNER

Date Nov 8, 1966

Montague County Commissioners Court
Local Organization

By J. E. Cooksey
J. E. COOKSEY

Title Acting Judge

Date 11-14-66

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

adopted at a meeting held on 11-14-66

Glen Pribble
GLEN PRIBBLE - (Secretary, Local Organization)
Ex Officio Clerk, Commissioners Court,
Montague County, Texas

Date Nov. 14, 1966

- -

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

Date

WATERSHED WORK PLAN

FARMERS CREEK WATERSHED
Montague County, Texas
March 1966

PREFACE

The work plan for watershed protection and flood prevention in the Farmers Creek watershed, Texas, was prepared by the Farmers Creek Watershed Authority, the Upper Elm-Red Soil and Water Conservation District, and the Montague County Commissioners Court, the local sponsoring organizations. Technical assistance was provided by the Soil Conservation Service of the U. S. Department of Agriculture. The Bureau of Sport Fisheries and Wildlife of the U. S. Department of Interior collaborated with the Texas Parks and Wildlife Department in the preparation of a reconnaissance report of the fish and wildlife aspects of the watershed. Financial assistance in developing the work plan was provided by the North Montague County Water Supply District and the Soil Conservation Service of the U. S. Department of Agriculture.

4-21918 11-66

WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

FARMERS CREEK WATERSHED
Montague County, 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 Elm-Red Soil and Water Conservation District

Farmers Creek Watershed Authority

Montague County Commissioners Court

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
March 1966

4-21918 6-66

WATERSHED WORK PLAN

FARMERS CREEK WATERSHED
Montague County, Texas
March 1966

SUMMARY OF PLAN

Farmers Creek watershed comprises an area of 102.4 square miles and is located in the northeast portion of Montague County, Texas. About 10 percent of the project area is cropland, 84 percent is grassland, and 6 is miscellaneous such as farmsteads, roads, the community of Bonita, and Lake Nocona. Extensive sediment damage from severely eroding gullies over a large portion of the upland constitutes the primary problem of the watershed. This sediment causes three major types of damage. The reduction of productive capacity of the flood-plain soil is the largest single damage. Sediment damage to highways, a railroad, and bridges is of major proportions. Sediment accumulation in Lake Nocona, Texas, is reducing the dependable yield of this limited resource at a rapid rate. Total sediment, floodwater, erosion, and indirect damages are estimated to be $92,221 annually.

The work plan proposes the application of land treatment measures on 470 acres of cropland and 20,648 acres of grassland at an accelerated rate during a 5-year installation period. These measures will improve the hydrologic condition of the cropland and grassland with the resultant reduction in sediment deposition to structures and the flood plain below. The installation cost of these measures is estimated to be $507,614. Of this amount, $36,339 will be borne by Public Law 566 funds to accelerate the planning and application of needed land treatment measures.

Structural measures to be installed during the installation period include 10 floodwater retarding structures, 11.80 miles of stream channel improvement, and 22 debris basins. The estimated cost of the structural measures is $1,456,462. The Public Law 566 share of the cost is $1,350,439. Local interests will provide all land, easements, rights-of-way, legal services, and contract administration at an estimated value of $106,023. All of the structural measures will be installed during a 5-year period.

With the project installed, damages will be reduced to $30,766 annually. Total benefits will be $79,662 annually. The ratio of the average annual benefits accruing to structural measures ($74,897) to the average annual cost of these measures ($53,587) is 1.4 to 1.0. Agricultural land totaling 8,880 acres will be benefited by the structural measures. The land treatment measures will be maintained by the owners and operators of the land upon which the measures are applied under agreements with the Upper Elm-Red Soil and Water Conservation District and in accordance with contracts under the Great Plains Conservation Program for those measures applied under that program.

4-21918 10-66

The structural measures will be operated by the Farmers Creek Watershed Authority and maintained by the Montague County Commissioners Court. The average annual value of the cost of operation and maintenance is estimated to be $5,873.

DESCRIPTION OF THE WATERSHED

Physical Data

Farmers Creek, a tributary of the Red River, heads between the towns of Montague and Saint Jo in northeastern Montague County, Texas. It flows into the Red River near the village of Old Spanish Fort. The major tributaries include Greenbrier, West Farmers, Deep Draw and Redbud Creeks. These streams flow into Farmers Creek downstream of the village of Bonita in the central part of the watershed. The total drainage area is 65,536 acres or 102.4 square miles. Of this, 58,995 acres or 92.18 square miles drains into Lake Nocona, which is located in the lower reaches of the watershed. Lake Nocona, with a surface area of 1,478 acres, was constructed as a water supply reservoir for the town of Nocona, which lies two miles west, outside the watershed.

The watershed lies within the Redbed Plains and West Cross Timbers physiographic areas. The Redbed Plains, located in the northern part of the watershed, is a gently rolling plain with moderately deep valleys and flood plains of varying widths. This area is underlain by Paleozoic age shales, redbeds, and hard sandstones of the Cisco and Wichita series. The West Cross Timbers in the southern part of the watershed is a moderately rolling plain with steeply escarped mesas and prominent drainage divides. This area is underlain by Cretaceous age formations of the Trinity group. The mesas are capped by limestones of the Fredericksburg group.

Elevations above mean sea level range from 1,318 feet on Blue Mound near the southern divide to 730 feet in Farmers Creek channel near the Red River.

The easily eroded sandy soils of the Cross Timbers land Resource Area cover approximately 70 percent of the southern parts of the watershed. Soils of the Stephenville, Windthorst, and Nimrod series predominate. These soils have developed on the soft sandstone bedrock under a postoak savannah type vegetation. These soils were intensively cultivated in the past but are now used mainly as grassland. The bluestems and other tall grasses make up the major vegetation on the better managed lands. Threeawns, red gramma, and other low quality vegetation predominate in those areas where poor management prevails.

Soils of the Central Rolling Red Prairies Land Resource Area cover the northern 30 percent of the watershed. These soils, which have developed on shales, redbed materials, and sandstones, are mostly medium textured and slowly permeable. They have developed under the tall and midgrasses with a scattered overstory of postoak and blackjack trees. Rangeland is the dominant land use although crops are grown on some of the deeper soils.

The alluvial flood-plain soils are of the Zavala and Gowen series. These soils have been greatly affected by modern overbank deposition. The clay loam, clay, and fine sandy loam textural classes predominated in the original soils. The dominant textural classes at present are loamy sands and fine sandy loams. The original soils were intensively cultivated, but the present use is mainly for grassland. Land use for the entire flood plain is 20 percent cropland, 75 percent grassland, and 5 percent miscellaneous.

The land use for the entire watershed is as follows:

Land Use	Acres	Percent
Cropland	6,540	10
Grassland	55,156	84
Miscellaneous 1/	3,840	6
	65,536	100

1/ Includes roads, railroad, farmsteads, lake, and village.

The mean annual rainfall of 31 inches is fairly well distributed throughout the year. The larger monthly amounts occur in April, May, and October. Mean temperatures range from 44.0 degrees Fahrenheit in January to 84 degrees in July. The average date of the last killing frost is March 24 and that of the first killing frost is November 8, providing a normal frost free period of 229 days.

Economic Data

Farmers Creek watershed is located in a county which is dependent upon agriculture and the petroleum industry for the bulk of its income. Over 90 percent of the agricultural income of $5,219,703 for 1960 was derived from livestock, primarily beef cattle. In 1960, the county produced 5,459,201 barrels of oil. About one-third of the population of Montague County lives in urban areas; and the trend, as in most of the nation, has been a gradual shift from the farm to the city.

Farms in the watershed, as in Montague County as a whole, are steadily becoming smaller in number and larger in size. Between 1954 and 1959 the number of farms decreased from 1,520 to 1,121 in Montague County. However, the average sized farm increased from 338 to 454 acres. Land values for the county as a whole increased from $42.11 to $59.14 per acre.

Approximately 75 percent of the farms in the watershed are family type. Very little hired labor is used in farming operations. Farm income is less than $3,000 per year for most family type farms. Approximately 63 percent of the landowners supplement their income through off-the-farm employment. About 50 percent have full-time jobs. Nocona, one of the largest leather products manufacturing centers in the state, provides jobs for many. Others work for oil companies or businesses in surrounding towns.

Beef production is the major agricultural enterprise. Common crops grown throughout the watershed consist of sorghums and oats utilized for hay and grazing and alfalfa for hay. Pecan and fruit orchards and small vegetable gardens also are located throughout the watershed.

Crushed rock for highway construction is being quarried from hard limestone beds near the southern watershed divide. These beds are members of the Fredericksburg group. Localized terrace deposits on Farmers Creek and some of the major tributaries supply limestone gravels for surfacing county and farm roads.

Excellent transportation facilities are available in the form of one railroad and 155 miles of paved or all-weather highways and roads serving the watershed and surrounding territory.

Land Treatment Data

The watershed is served by the Soil Conservation Service Work Unit at Nocona, which assists the Upper Elm-Red Soil and Water Conservation District.

There are 200 operating units in the watershed. Basic conservation plans have been developed on 119, or 60 percent of these, representing 64 percent of the watershed. Cooperators with the Soil and Water Conservation District have applied approximately 60 percent of the planned practices. About 50 percent of the cropland and 45 percent of the grassland have been adequately treated. Table 1A lists the practices which have been applied. The total cost of applying these practices is estimated at $677,771.

The high cost of treatment of eroding areas has forestalled application of conservation practices needed to control erosion; however, the inclusion of this area in the Great Plains Conservation Program should accelerate the treatment of these problem areas.

A high percentage of the upland was intensively cultivated in the past. Most intensive use was from World War I through the early 1940's. The deterioration of these soils resulted in their abandonment. At least 20,000 acres of abandoned fields have only a sparse cover of annual weeds and invading grasses with little value for grazing or soil stabilization. About 5 percent of the upland remains in cultivation, primarily on class II and III soils, with a small amount on class IV soils. Erosion, ranging from rills to severe gullies, is active on many of these old fields. Gullies, ranging from medium to large, comprise as much as 30 percent of the total land area of some farms. This has resulted in severe sediment deposition on the flood plain. About 30,000 acres are infested to some degree with invading brush and associated species. About 10,000 of these acres have had some method of brush control applied during the past 15 years, but poor maintenance has resulted in regrowth on about 7,000 acres. This regrowth is often more difficult to control than the original growth.

WATERSHED PROBLEMS

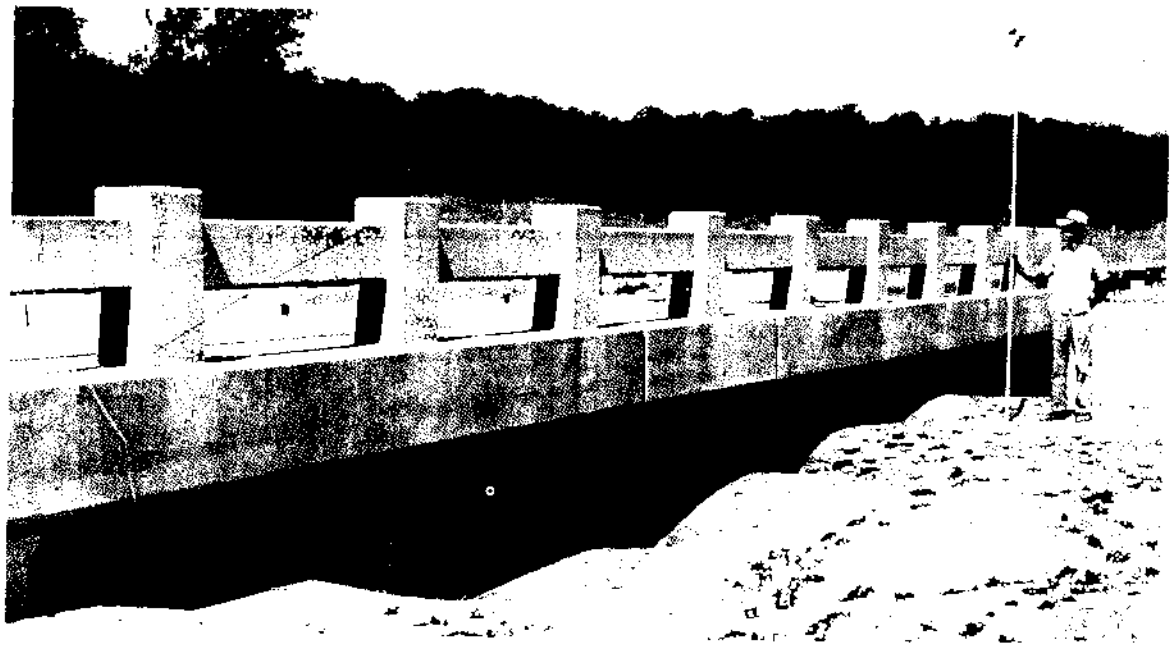
Sedimentation Damage

Sediment damages caused by seriously eroding gullies in the upland constitute the primary problem in the watershed. This is causing severe damage to 2,419 acres of flood plain, Lake Nocona reservoir, transportation facilities, stream channels, fences, other agricultural improvements, and fish and wildlife habitat (figure 6). Infertile sands have accumulated in depths ranging from 8 feet near Lake Nocona to more than 12 feet in the valley reaches near U. S. Highway 82. Most of this deposition has occurred during the past 50 to 60 years. The highest rates probably occurred during the 1930's and 1940's when upland cover was at its poorest and gully erosion had become well entrenched. Sheet erosion is not as severe as in former years as a result of natural revegetation of formerly cultivated lands. However, sediment production from deep gullies is expected to continue at or near the present rate.

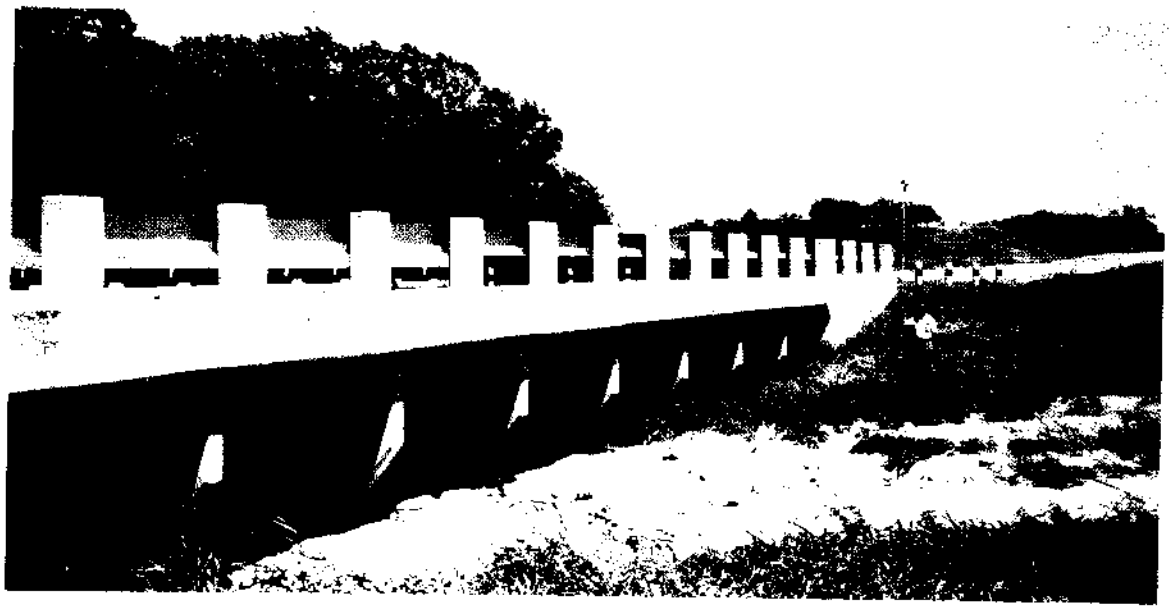
It is expected that the area being damaged by overbank deposition will increase to 2,660 acres in the future as sediment continues to accumulate in the valleys. The damaging nature of this material will also increase as the percentage of infertile sands from the deep gullies increases over the diminishing volume of more fertile sediment derived from sheet erosion. Highly damaging fine sand and loamy sand deposits with profile depths in excess of 6 feet have damaged 1,145 acres of flood plain, reducing productivity of the soils an estimated 75 percent. Another 754 acres have had their productivity reduced 50 percent by sandy loam sediments. Less damaging clay and clay loam sediments have damaged 416 acres by an estimated 25 percent in reduced productivity. The clay and clay loam sediments contain no organic matter and are low in fertility. The sands are almost sterile and very drouthy. The estimated annual damage from overbank deposition is $26,639.

Swamping and poor surface drainage that was caused by overbank deposition and channel filling is affecting 104 acres of grassland. These areas are being damaged 50 percent or more of productive capacity due to drowning out of vegetation by high water tables and long periods of surface impoundment. The estimated annual damage from swamping is $661.

Sediment accumulation in Lake Nocona is depleting the storage capacity by an estimated 48,877,500 gallons (150 acre-feet) per year. Most of this sediment is clay and silt carried in suspension by floodwaters. A smaller volume of sand is delivered by streams as bedload. The annual rate of sediment deposition in this reservoir is estimated to be 1.63 acre-feet per square mile under 1965 conditions. With the present rate of depletion and the anticipated future increased water needs by Nocona, this reservoir can be expected to yield a dependable water supply for only the next 50 to 60 years. The annual sediment damage to Lake Nocona is estimated to be $8,435.



This bridge on U. S. Highway 82 across Farmers Creek had 8 feet of clearance when constructed in 1935. Photo was taken in 1942. Sediment accumulations were cleaned out time after time, but by 1946 it became necessary to build another bridge on top of this one.



This new bridge across Farmers Creek on U. S. Highway 82 was built in 1946 on top of the first bridge shown. The new bridge had 9 feet of clearance. By 1960, despite constant sediment removal operations, sediment had encroached upon it to the extent shown above.

Sediment and debris damage to M.K.T. Railroad bridge. Seven years before photo was made there was clearance enough for a man to ride a horse under the bridge. Railroad bridge and track have been raised 2 feet 4 inches along the "Bonita Bottom" area of Farmers Creek.

Infertile sediment deposition on cropland. Damage of this type amounts to $26,639 annually on cropland and pastureland. Note fence damage in foreground.

4-21418 4-66

The accumulation of excessive volumes of sediment in the valleys is causing problems with existing bridges on highways, railroad, and county roads as well as to the road surfaces and tracks (figure 6). These facilities were originally built at elevations of 8 to 12 feet above the valley floor. Accumulations of sediment have built up the present valley surfaces to the point where they are as high or higher than the roadbeds and tracks. This has necessitated raising and rebuilding the U. S. Highway 82 bridge on Deep Draw Creek. The original bridge was built in 1935 with openings 8 feet high. The second bridge, with openings 9 feet high, was built on top of the first bridge in 1946, after it had become useless. The second bridge now has only 4 of the original 9 feet of clearance remaining. Several miles of this highway are now at or near flood-plain elevations. One segment of highway is at least a foot lower. Other bridges and culverts on this highway, as well as on other roads, are also threatened (figure 6).

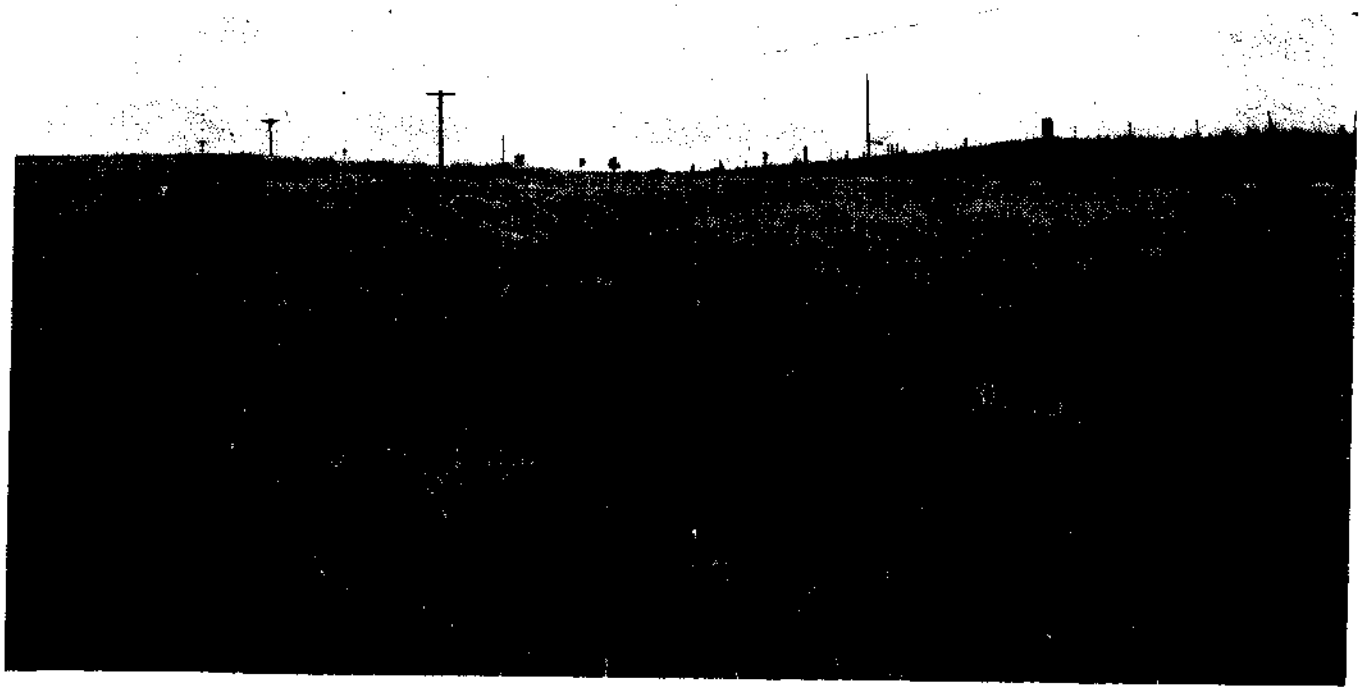
The M.K.T. Railroad bridge and approximately two miles of roadbed had to be raised 2 feet 4 inches during the middle 1940's. Several miles of track, including the above segment, are now at flood-plain elevation and are being covered by sediment during every flood. Smaller bridges and culverts in the vicinity of Bonita have lost most or all of their original capacity. Periodic raising of the roadbed and bridges and/or relocations of these facilities will be necessary in the future as sediment accumulation continues. Sediment damage to roads and bridges amounts to $10,950 annually.

Erosion Damage

Severe gully erosion has caused extensive damage to approximately 1,020 acres of land and is threatening to destroy an additional 3,000 acres in the watershed. Individual gullies and large gully systems, ranging in depths from 20 to 50 feet, have developed. More than 640 acres of land have been completely destroyed to depths averaging more than 25 feet. The present rate of land voiding by these gullies is estimated to be more than 10 acres per year. Most of the severely gullied land is located in the Cross Timbers Land Resource Area where the topography is relatively steep. These soils are underlain by soft, poorly cemented, fine sand bedrock. Abandonment and retirement of most cropland on these soils and natural revegetation by native grasses has greatly reduced sheet erosion. However, the severe head cutting within the deep gully systems has not been reduced. The gross erosion for the entire watershed is estimated to be 3.90 acre-feet per square mile annually. Of this, 74 percent is produced by gully and streambank erosion and the remaining 26 percent by sheet erosion.

Although dwarfed by overbank sediment deposition, 84 acres of flood-plain lands have had their productive capacity reduced by 10 to 20 percent as a result of flood-plain erosion or scouring. The annual erosion damage by gullies is $5,488 and by scouring is $1,042.

Critical area treatment is a "must" on eroded areas such as this. These areas contribute most of the sediment which devestates the flood plain.



This is an excellent example of critical area treatment. What was once a gully 10 feet deep now provides large quantities of excellent forage.

Floodwater Damage

Damages to crops and pasture as a result of inundation by floodwater are extensive, as is damage to other agricultural property, roads, and bridges as a result of the damaging forces unleashed by angry floodwaters. Frequent damaging floods occur on approximately 4,370 acres of valuable flood-plain land in the watershed and an additional 470 acres outside the project area (figure 6). The area subject to floodwater damage as described herein is that land which would be inundated by the 25-year frequency storm. The severity and frequency of flooding have increased as a result of extensive channel filling by sediment. The channel is completely filled in some reaches of Farmers Creek and its tributaries. Although almost inconceivable, the existing channel is 5 or more feet higher than the flood plain in some reaches. These conditions are illustrated by figure 5. Flooding has been reduced below Lake Nocona by the surcharge storage in the reservoir; however, there is no flood storage as such in the reservoir.

Flooding occurs in some portions of the watershed at any time there is enough rainfall to produce runoff. During the 25-year evaluation period, 1940-1964 inclusive, there were more than 100 storms which produced flooding. Thirty of these storms resulted in floods of major proportions, inundating more than half of the flood plain above Lake Nocona. Eight of these major floods would have inundated more than half of the flood plain below Lake Nocona if the reservoir had been in place throughout the evaluation period. Recent major floods occurred in 1957, 1959, and 1962. Most of the major floods occur in the spring and fall months, although flooding can occur at any time of the year.

Flood-plain lands, because of the ever present flood threat, are managed in a manner that results in production far below the actual potential of the land. The value of this flood-plain land varies from $50 to $500 per acre depending upon location within the watershed. The value of production varies from $3.67 to $95.55 per acre, depending upon use.

Under non-project conditions, the average annual monetary damage is $92,221. Of this amount, $14,234 is crop and pasture; $10,630, other agricultural; $5,758, road and bridge; $26,639, overbank sediment deposition; $661, swamping; $8,435, deposition to Lake Nocona; $10,950, sediment damage to roads and bridges; $1,042, flood-plain scour; and $5,488, land destruction by gullies. Indirect damage, such as interruption of travel, re-routing of school buses and mail routes, interruption of livestock feeding and management regiment, losses sustained by businessmen of the area, and similar losses, is estimated to average $8,384 annually.

Problems Relating to Water Management

Nocona, with an estimated population of 3,750 in 1960, obtains its water supply from Lake Nocona. The city used 341 acre-feet of water in 1962, 410 acre-feet in 1963, and 371 acre-feet in 1964. Consulting engineers estimated that the city would need 952 acre-feet per year by 1980. Yield

studies indicate that Lake Nocona would have a dependable yield of 2,500 acre-feet per year, if there were no sediment being deposited in the reservoir. However, at the present rate of sediment accumulation, the yield would be reduced to 1,250 acre-feet per year by 2010 and to 580 acre-feet per year by 2060 (figure 4).

This indicates that if the present rate of sedimentation continues and Nocona's water requirements increase as anticipated, an additional source of water will be needed within the next 50 years. Water for other towns and communities within the area is supplied from underground sources. Water for domestic and livestock use is supplied by wells and farm ponds.

Salt water escaping from oil wells has caused some pollution to a few small areas in past years; however, pollution is not a serious problem at the present.

There are no water permits or certified filings of record for irrigation. However, water from wells is being used for supplemental irrigation of a few pastures. Facilities for water-based recreation are available at Lake Nocona.

A reconnaissance survey report prepared by the Bureau of Sport Fisheries and Wildlife of the Fish and Wildlife Service, U. S. Department of the Interior, states: "Lake Nocona is the only fish habitat of importance in the watershed. Principal sport fish are white crappies, largemouth bass, and catfishes. The lake is open to free public fishing and sport fishing is heavy."

PROJECTS OF OTHER AGENCIES

The North Montague County Water Supply District constructed Lake Nocona in 1960. The reservoir, with a surface area of 1,478 acres, and a capacity of 25,389 acre-feet at the spillway crest, has a drainage area of 92.18 square miles. The water district, which furnishes Nocona its water, has a permit for diverting 4,500 acre-feet per year for municipal, industrial, and mining purposes.

Recreation areas are being developed along the shoreline by civic organizations of the city of Nocona.

BASIS FOR PROJECT FORMULATION

A meeting was held with the sponsoring local organization to discuss the problems in the watershed and to determine their objectives and the degree of development desired. The sponsors requested that consideration be given to all measures needed for adequate watershed protection, flood prevention, and protection of Lake Nocona from excessive sediment deposition. They requested that a level of protection which would reduce the average annual damages by 65 to 70 percent be provided to both Lake Nocona and the flood plain of Farmers Creek.

The sponsors are vitally interested in improving the low farm income by increasing farm production through the application of needed land treatment measures. The sponsors will provide the leadership necessary to promote the acceptance and participation of landowners in the Great Plains Conservation Program. Another objective is increased beef production through more intensive management of flood-plain grazing land. This increase in production will result from proper use of fertilizers, control of noxious plants, and a higher level of grazing management.

A system of floodwater retarding structures was selected to control as much of the runoff from the hill land as possible. In selecting sites for floodwater retarding structures, consideration was given to locations which would provide maximum protection to the areas subject to flood damage. The size, number, design, and cost of these structures was influenced by physical, topographic, and geologic conditions.

A system of debris basins was selected to store sediment until such time as critical area planting of the severely eroded areas becomes effective. The number and location of these was influenced by the amount of sediment being produced, proximity to the area being damaged by sediment deposition, the potential for further voiding of agricultural land, the capability of individual or groups of landowners to install control measures, and cost. The effectiveness of the system to reduce erosion to an acceptable level will depend upon the success the sponsors have in getting landowners to establish vegetation under the ACP and/or Great Plains Conservation Program.

Because of the sandy material in which part of an improved channel would have to be constructed, it was agreed to limit the size of the channel to the capacity required to carry the principal spillway releases with one foot of freeboard.

Several of the floodwater retarding structures offer opportunities for development of additional capacity for the storage of water for agricultural and non-agricultural uses. This was discussed with the sponsors. After due consideration, it was agreed that there was not sufficient interest at this time for multiple-purpose development of floodwater retarding structures. However, an objective of the sponsors is to encourage individual landowners to avail themselves of the opportunities offered by sediment pools of floodwater retarding structures for developing income producing recreation as either primary or supplemental farm enterprises.

The system of 10 floodwater retarding structures, 22 debris basins, and 11.80 miles of stream channel improvement represents the least costly system of structural and land treatment measures that will meet the objectives of the sponsors.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

Landowners and operators cooperating with the Upper Elm-Red Soil and Water Conservation District have applied many of the needed conservation practices on their land. An effective conservation program based upon the use of each acre of land within its capabilities and upon its treatment in accordance with its needs for utilization, protection, and improvement is the key to a sound watershed protection and flood prevention program. 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 utilization.

The treatment of the watershed area lying above planned floodwater retarding structures is paramount in the reduction of the rate of deterioration in the uplands and in the prevention of excessive sediment accumulation in the sediment pools of the structures and in Lake Nocona. The land treatment measures will reduce soil erosion, sediment production, and storm runoff by improving the soil-water relationship.

Table 1 shows the acreages of agricultural land which will receive accelerated land treatment during the project installation period. These measures will be applied and maintained by the landowners and operators in cooperation with the district program. Measures previously applied will be properly maintained as well. Trends are toward a reduction in cultivated land and more intensive use of grassland.

In accordance with Section 1110.6 of the Watershed Protection Handbook, not less than 75 percent of the effective land treatment measures must be installed, or their installation provided for, in the drainage areas of structures 5, 6, 7, 8, and 9. Basic conservation plans must be prepared prior to the execution of a project agreement for construction of these structures. These plans must schedule the installation of the required land treatment measures either before or concurrently with the installation of the structural measures covered by each project agreement.

Critical area planting on 75 percent of the severely gullied land is needed to reduce sediment delivered to these structures to an acceptable level and to prevent depletion of the designed sediment storage during the project life.

Structural Measures

Ten floodwater retarding structures and 11.8 miles of stream channel improvement will be installed to provide flood protection to the floodplain lands of Farmers Creek and its tributaries. In addition, 22 debris basins will be installed to supplement vegetative measures to be established on 22 critical sediment source areas to reduce sediment production to an acceptable level. The location of the planned structural measures is shown

on the project map (figure 7). The storage capacity of the 10 floodwater retarding structures is 11,670 acre-feet. Of this, 2,731 acre-feet is sediment storage and 8,939 acre-feet is detention storage. Runoff from 34 percent of the watershed will be retarded. This is an average of 4.82 inches of runoff from the area upstream from the floodwater retarding structures. The sediment storage provided in the floodwater retarding structures is for the sediment accumulation for a 100-year period. Also 100-year sediment storage is provided in debris basin No. 115 to be consistent with other structures designed using Engineering Memorandum-27. The sediment storage provided in the other debris basins is for the sediment accumulation for a 25-year period; however, the life expectancy of these structures is 50 years. Structure replacement or restoration of sediment storage beyond the life expectancy of the debris basins is not deemed necessary since the vegetative measures will have corrected the sediment source areas. The total sediment storage in the 22 debris basins is 1,067 acre-feet.

The improved channels are designed to carry the maximum release flows from the floodwater retarding structures with a minimum of about one foot of freeboard. The improved channels were located in cohesive materials and in the low points in the flood plain where possible. The channels will have a trapezoidal cross section with 4:1 side slopes to encourage natural vegetation of the channel and to allow mowing. The spoil from the improved channels will be placed within the right-of-way area in accordance with Service criteria outlined in Texas State Manual Supplement 2441.8.

A power line in the reservoir area of Site No. 1 will be relocated. Three small oil pipelines will be relocated prior to the construction of the embankment of Debris Basin No. 113. It will be necessary to relocate a bridge on the county road south of the railroad in order to achieve more satisfactory channel alignment. The county road within the reservoir area of Site No. 3 will be raised.

The total cost of all structural measures is $1,456,462. This includes $960,436 for floodwater retarding structures, $352,081 for debris basins, and $143,945 for stream channel improvement.

Figures 1, 2, 2A, and 3 show structures which are typical of those planned for this watershed. Tables 3, 3A, and 3B show details on quantities and design features.

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

EXPLANATION OF INSTALLATION COSTS

Land Treatment

Land treatment measures to be applied by local interests during the 5-year installation period are estimated to cost $507,614 (table 1). This includes Public Law 46 technical assistance cost from the Soil Conservation Service and Agricultural Conservation Program cost sharing as administered by the Agricultural Stabilization and Conservation Service. Costs were based on 1965 prices that were paid by local farmers to establish these land treatment measures. To speed up the application of land treatment measures, $36,339 of Public Law 566 funds (table 1) will be used to meet increased demands for technical assistance during the 5-year installation period. This amount includes $2,229 for the completion of soil surveys in the first two years.

Floodwater Retarding Structures

The total cost of the 10 floodwater retarding structures is estimated to be $960,436. This includes $895,838 for Public Law 566 cost and $64,598 for local sponsors' cost. The Public Law 566 cost consists of $723,800 for construction and $172,038 for providing installation services.

The local share of the cost of floodwater retarding structures is estimated to be $64,598. This includes $59,598, or value in kind, for land, easements, and rights-of-way and $5,000 for the administration of the construction contracts. The estimated cost of land, easements, and rights-of-way includes the cost of relocating or modifying roads, utilities, and improvements and $800 for legal fees.

Debris Basins

The estimated cost of the 22 debris basins is $352,081, of which $338,056 will be borne by Public Law 566 funds and $14,025 will be borne by local funds. The Public Law 566 cost consists of $271,700 for construction and $66,356 for installation services. The local sponsors' cost, $14,025, consists of $9,925 for land values, $750 for relocations, $750 for legal fees and $2,600 for contract administration.

4-21918 11-66

Stream Channel Improvement

The total cost for stream channel improvement is $143,945, of which $116,545 will be borne by Public Law 566 funds and $27,400 will be borne by local sponsors. The Public Law 566 cost consists of $91,740 for construction and $24,805 for the cost of installation services. The local sponsors' cost will be $26,800 for land, easements, rights-of-way, relocations, and legal fees and $600 for contract administration. The cost of land, easements, and rights-of-way includes $1,000 for legal fees.

Summary of Costs of Structural Measures

The total installation cost of all structural measures is estimated to be $1,456,462. Of this total, $1,087,240 is for construction and $263,199 is for installation services, which will be borne by Public Law 566 funds. The local share of the cost is $97,823 for land, easements, rights-of-way, relocations and legal fees and $8,200 for contract administration. (Table 2).

The construction cost includes the engineer's estimate and contingencies. The engineer's estimate was based on the unit cost of construction items planned for each structural measure. The unit cost was based on actual cost of structural measures in similar areas modified to conditions found in this watershed. Ten percent of the engineer's estimate was added as a contingency to provide funds for unpredictable construction cost.

Installation services consist of engineering and administrative cost and are based on analysis of previous work in similar areas. The engineering portion of this cost consists of, but is not limited to, detailed surveys, geological investigations, laboratory reports, designs, cartographic services, and inspection services.

Cost of land, easements, and rights-of-way was estimated by representatives of the local sponsors and concurred in by the Soil Conservation Service. The estimated cost for altering or re-routing roads, utility and pipelines was furnished by the County Commissioners Court and the utility and pipeline companies, respectively.

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

Schedule of Obligations

Fiscal Year	Measure	Public Law 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
1st	Sites 6, 7; Debris Basins 110, 111, 115, 116, 117; and Land Treatment	282,424	115,320	397,744
2nd	Sites 8, 9; Debris Basins 112, 113, 114, 118, 119, 120, 121, 122; and Land Treatment	284,052	111,088	395,140
3rd	Sites 3, 4, 5; Debris Basins 106, 107, 108, 109; and Land Treatment	312,235	110,738	422,973
4th	Sites 1, 2, 10; and Land Treatment	309,511	115,622	425,133
5th	Stream Channel Improvement; Debris Basins 101, 102, 103, 104, 105; and Land Treatment	198,556	124,530	323,086
Total		1,386,778	577,298	1,964,076

EFFECTS OF WORKS OF IMPROVEMENT

The project will directly benefit the owners and operators of approximately 100 farms and ranches in the watershed. Approximately 8,880 acres of agricultural land will benefit from installation of the structural measures. Residents of the city of Nocona, dependent upon Lake Nocona for municipal water, will also benefit because of the greatly extended life of Lake Nocona due to the sharp reduction in sediment deposition resulting from project installation. It is expected that well in excess of 25,000 people will benefit from this project during its life.

The annual volume of sediment delivered downstream and causing damage to Lake Nocona reservoir, the flood-plain soils, transportation facilities, and other agricultural improvements will be drastically reduced after installation of combined land treatment and structural measures. Deposition in Lake Nocona will be reduced by 70 percent, amounting to approximately 34,000,000 gallons of storage capacity saved from destruction each year. Sediment accumulation in the valleys in the vicinity of affected transportation facilities will be reduced by more than 80 percent and thus provide stable conditions for these facilities in the future. Similar conditions

will prevail for agricultural improvements. Overbank deposition damage to the flood-plain soil profile will be reduced by 90 percent. Land treatment measures will effect about 5 percent of the monetary reduction in sediment damages.

The installation of the project will prolong the useful life of Lake Nocona by reducing the sediment accumulation in the reservoir from 150 acre-feet to 46 acre-feet per year. After 50 years, the dependable yield will be 1,630 acre-feet per year under with project conditions compared to 1,080 acre-feet per year without the project. This represents a comfortable margin of safety of 630 acre-feet annually as compared to the slim margin of 80 acre-feet annually under without project conditions.

Immediately after their completion, evaporation losses in the sediment pools of the floodwater retarding structures will cause a reduction of inflow to Lake Nocona. This reduction of inflow will reduce the dependable yield by 200 acre-feet per year. As sediment accumulates in the sediment pools, the inflow will again approach pre-PL 566 project conditions. As illustrated by the time-yield curve, figure 4, the net effect of the PL 566 project will be to assure the future water supply of the city of Nocona by prolonging the useful life of its source.

The project will provide flood protection to 3,636 acres of flood-plain land below floodwater retarding structures and approximately 470 acres outside the project area on the common flood plain of the Red River and Farmers, Village, and Cottonwood Creeks. About 274 acres of flood plain below debris basins will also benefit from incidental flood storage in the structures while they are effective. Had the project been in place during the evaluation period, 1940-1964, 15 of the 30 major floods that occurred above Lake Nocona would have been reduced to minor floods inundating less than half of the flood plain. All but 2 of the 8 major floods would have been reduced to minor proportions in the reach below Lake Nocona.

Owners and operators of flood-plain land will be able to manage pastures more intensively as a result of flood reduction. More intensive management will consist primarily of fertilization, noxious plant control, and planned grazing for maximum grass production. It is not expected that any flood-plain land will be shifted from pasture to cropland, nor is it expected that the project will result in any increase in acreage of crops in surplus supply.

Excellent opportunities for the development of on-farm income producing recreation facilities will become available at and in the vicinity of sediment pools.

The sediment pools of those floodwater retarding structures open to the general public will provide needed water-based recreation activities such as fishing, hunting, picnicking, and camping. Such waters are used to a great extent by youth organizations, such as Boy Scouts, Girl Scouts,

church organizations, etc. These facilities will furnish approximately 5,810 visitor-days of recreation annually. Most of the usage will occur from May through September, but it is expected that these facilities will be used to some extent during all seasons.

Secondary benefits will accrue to the trade area as a result of increased business to those who furnish farm equipment, petroleum products, fertilizers, farm supplies, and the various services associated with a farming and ranching community.

PROJECT BENEFITS

The estimated average annual monetary damages (table 5) within the watershed will be reduced from $92,221 to $30,766, a reduction of 67 percent. Crop and pasture damages will be reduced from $14,234 to $6,346, or 55 percent. Other agricultural damages, such as losses of fences, farm equipment, etc., will be reduced from $10,630 to $3,036, or 71 percent. Of the $61,455 damage reduction benefits attributable to the project, $56,690 or 92 percent is the result of structural measures, with the remaining 8 percent the result of land treatment.

Flood-plain scour damages occurring in the watershed will be reduced from $1,042 to $248, a reduction of 76 percent. Damage from land destruction by gullies in the upland is expected to be reduced from $5,488 under non-project conditions to $1,614 after project installation, or 71 percent.

Damages from overbank deposition of infertile sediment upon formerly fertile land amount to $26,639 under without project conditions. This will be reduced to $12,075 after project installation, or 55 percent. Damages from swamping will be reduced from $661 to $104, or 84 percent. Damages from sediment deposition to Lake Nocona will be reduced from $8,435 under non-project conditions to $1,138 after project installation, or 87 percent.

Benefits from intensification of land use by fertilization, noxious plant control, and proper management, with the resultant increase in production, are estimated at $7,628 annually. Incidental recreation benefits from those pools open to the public will be $3,504 annually.

Secondary benefits are not considered pertinent from a national viewpoint, but are expected to average $7,075 annually in the immediate locale. This amount, which excludes indirect benefits in any form, results from $5,879 in benefits stemming from the project and $1,196 induced by the project.

Other substantial benefits will accrue to the project, such as an increased sense of security, a more satisfying and healthful environment in which to live and rear a family, and the knowledge that one is living in a more

wholesome community. These benefits, although of growing importance,with the passing of each day, have not been evaluated in monetary terms, nor have they been used for project justification.

COMPARISON OF BENEFITS AND COSTS

The total average annual cost of structural measures (amortized total installation cost, plus operation and maintenance) is $53,587. These measures are expected to produce average annual primary benefits of $67,822. The benefit-cost ratio without secondary benefits is 1.3 to 1.0. The ratio of total average annual project benefits ($74,897) to the average annual cost of structural measures ($53,587) is 1.4 to 1.0 (table 6).

PROJECT INSTALLATION

Farmers will be encouraged to establish the remaining needed land treatment measures in cooperation with the Upper Elm-Red Soil and Water Conservation District during a 5-year installation period. The governing body of the soil and water conservation district will assume aggressive leadership in accelerating the land treatment program now being applied. Landowners and operators will be encouraged to participate in the Great Plains Conservation Program. It is expected that most of the critical sediment source area treatment will be accomplished under this cost-sharing program.

The Soil Conservation Service will provide any additional technical assistance needed to the soil and water conservation district to accelerate the planning and application of soil, plant, and water conservation measures. The Montague County ASCS County Committee will cooperate with the governing body of the soil and water conservation district and the Farmers Creek Watershed Authority in selecting for financial assistance those practices which will accomplish the conservation objectives in the shortest possible time. The Extension Service will assist in the educational phase of the program by holding local farm meetings, preparing press, radio and televison releases, and using other methods of getting information to landowners and operators in the watershed. Soil and water conservation loans available through the Farmers Home Administration will be given special emphasis. Present FHA clients in the watershed will be encouraged to cooperate in the program. The goal of the application of 80 percent of the needed land treatment practices by or before the end of the installation period is expected to be accomplished as follows:

Land Use	FISCAL YEAR 1st (acres)	2nd (acres)	3rd (acres)	4th (acres)	5th (acres)	Total (acres)
Cropland	94	94	94	94	94	470
Grassland	4,130	4,130	4,130	4,129	4,129	20,648
Total	4,224	4,224	4,224	4,223	4,223	21,118

The structural measures will be installed during a 5-year installation period. All of the debris basins that are located within the drainage area of a floodwater retarding structure must be constructed prior to or concurrently with the construction of the floodwater retarding structure. All of the floodwater retarding structures and all of the debris basins must be in place before the improved channel is constructed. This sequence of construction may result in prolonged flooding until the improved channel is in place in those areas where there is no channel or where the existing channel is too small to carry release flows from structures.

The Farmers Creek Watershed Authority will act as the contracting local organization to administer the contracts for the construction of all planned structural measures. The Watershed Authority will make arrangements for necessary legal, administrative, and clerical personnel, facilities, supplies and equipment to advertise, award, and administer the contracts. The Watershed Authority will select and appoint a contracting officer. His letter of appointment will include a listing of duties, responsibilities, and authorities. The individual appointed as contracting officer shall be available at all times to carry out his duties. He should be selected on the basis of his administrative ability. Legal, accounting, and/or engineering background would be helpful assets. He will be provided with clerk-typist assistance, available to him at all times. He will also be provided with office space at a recognized location easily accessible to the public and construction contractors. Arrangements will be made by the contracting officer to handle formal construction contract bid openings, publicly conducted, and attended by approximately 20 persons. The contracting officer will be provided with transportation facilities so that he will be able to make inspection trips to the locations of apparent low bidders' equipment plants and to all construction sites as necessary to perform his duties.

Land, easements, and rights-of-way, including utility, pipe line, road and improvement changes, will be acquired for all of the planned structural measures by the Farmers Creek Watershed Authority and/or the Montague County Commissioners Court. These sponsors have entered into an agreement whereby the county will assume prime responsibility for acquisition of such land, easements, or rights-of-way as will be needed upon specific request of the Watershed Authority in given cases.

The Montague County Commissioners Court has the authority under applicable State law to exercise the right of eminent domain, if necessary, to acquire such land, easements, or rights-of-way, including utility, pipe line, road and improvement changes, as will be needed in connection with the works of improvement to be installed with Federal assistance. The legal adequacy of easements, permits, etc., for the construction of the planned structural measures will be determined by the Farmers Creek Watershed Authority.

The structural measures will be installed during a 5-year installation period pursuant to the following conditions:

1. The requirements for land treatment in the drainage area above the floodwater retarding structures have been met.

2. All land, easements, rights-of-way, and permits have been obtained for all structural measures or written statements have been furnished by the Farmers Creek Watershed Authority and the Montague County Commissioners Court, giving a schedule for remaining non-cleared sites, by site number, and the exact date by which all land rights therefor will be obtained or the right of eminent domain of the county will be used to secure any remaining land, easements, or rights-of-way and that sufficient funds are available for purchasing those easements and rights-of-way and for condemnation proceedings and awards.

3. Court orders have been obtained from the Montague County Commissioners Court that the county roads affected by the floodwater retarding structures will be relocated or raised 2 feet above emergency spillway crest elevation at no expense to the Federal government, or closed, or permission granted to temporarily inundate the road, provided equal alternate routes can be provided.

4. Court orders have been obtained from the Montague County Commissioners Court stating that all county and private road bridges that are affected by stream channel improvement will be modified or replaced, if needed, concurrently with or prior to the construction of the improved stream channel.

5. The contracting agencies are prepared to discharge their responsibilities.

6. Project, land rights, and operation and maintenance agreements have been executed.

7. Flowage rights have been obtained from affected landowners to save the sponsors harmless from the effects of prolonged flooding caused by release flows from floodwater retarding structures and debris basins until such time as the improved channel is completed.

8. Public Law 566 funds are available.

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out the works of improvement 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.

The cost of installing the needed land treatment measures during the 5-year installation period will be borne by the landowners and operators of the land on which these measures are installed. The Agricultural Stabilization and Conservation Service will provide financial assistance for the installation of those land treatment measures which are eligible for this assistance, as will the Soil Conservation Service through the Great Plains Conservation Program. The Farmers Home Administration, local banks, and other lending institutions can arrange financing for the landowners and operators' share of the cost. The Soil Conservation Service will provide funds in the amount of $65,369 to finance the cost of technical assistance in planning and application of the land treatment measures. This consists of $36,339 of Public Law 566 funds and $29,030 to be provided from Public Law 46 funds (table 1).

Funds for the local share of the cost of installing the structural measures will be provided by the Farmers Creek Watershed Authority. The Authority is collecting an annual tax of 15 cents on each $100 of assessed property valuation. Approximately $2,300 per year is being collected. These funds can be used for any purpose except to pay off a bond issue or a loan from the Federal government. These funds may be used for that purpose only upon approval by a vote of the qualified voters. The Upper Elm-Red Soil and Water Conservation District and the Farmers Creek Watershed Authority have entered into an agreement with the Montague County Commissioners Court whereby the County will exercise its right of eminent domain to acquire such land, easements, or rights-of-way as will be needed in specific cases when requested by the Farmers Creek Watershed Authority.

It is anticipated that 80 percent of the easements to be acquired by the Watershed Authority and/or the County will be donated. Out-of-pocket costs are expected to be $18,000. This consists of the cost of acquiring those land easements and rights-of-way that are not donated, the cost of modification or relocation of roads, pipe lines and utilities, and contract administration.

Financial and other assistance to be furnished by the Service is contingent on the appropriation of funds for this purpose. In addition, all prerequisite conditions will be met before Federal funds will be made available for the installation of the structural measures.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land treatment measures will be maintained by the landowners and operators of farms on which the measures are installed under agreements with the Upper Elm-Red Soil and Water Conservation District. Representatives of the district will make periodic inspections of the completed land treatment measures to determine maintenance needs. The landowners and operators will be encouraged to perform needed maintenance and management practices. District owned equipment will be made available for this purpose in accordance with existing working arrangements.

The structural measures will be operated by the Farmers Creek Watershed Authority and maintained by the Montague County Commissioners Court. An operations and maintenance agreement will be executed by the parties hereto, prior to the issuance of invitation to bid on construction of the structural measures. The agreement will set forth specific details on procedure in line with recognized assignments of responsibility.

The estimated annual operation, maintenance, and replacement cost is $5,873, based on long-term prices. This consists of $1,340 for the floodwater retarding structures; $2,475 for the stream channel improvement; and $2,058 for debris basins.

The Farmers Creek Watershed Authority will have maintenance inspection and coordinating responsibility for all of the structural measures, but accomplishment and financing will be the responsibility of the Montague County Commissioners Court.

The Farmers Creek Watershed Authority, the Upper Elm-Red Soil and Water Conservation District, and the Montague County Commissioners Court will be represented on each joint inspection group making scheduled inspections of works of improvement. Inspections will be made in accordance with procedural details of the Operation and Maintenance Agreement.

The Service and the sponsors will make a joint inspection annually, or after unusually severe floods, or in the event of other unusual conditions that may adversely affect the works of improvement, for three years following installation of each structure. Inspection after the third year will be made annually by the sponsors. The Service will participate in annual inspections as often as it elects to do so after the third year. Inspection items are those items which may need maintenance. These include, but will not be limited to, the condition of the principal spillways, earth fills or embankments, vegetative cover of the earth fills and emergency spillways; the need for removal of woody vegetation, sediment bars and debris from improved channels; the need for corrective measures to prevent bank cutting in the improved channel; and the condition of fences, gates, and other appurtenances installed as a part of the structural measures.

Maintenance needs for all structural measures noted by the representative of the Farmers Creek Watershed Authority, or those called to his attention by others and confirmed by him, will be referred to the Montague County Commissioners Court. The representative of the watershed authority will prepare a report of all maintenance inspections. A copy of the report will be submitted to the Service representative. The authority representative will keep summary control records in support of proper maintenance having been performed on these works of improvement for the entire watershed.

The Soil Conservation Service, through the Upper Elm-Red Soil and Water Conservation District, will participate in operation and maintenance by furnishing technical assistance to aid in inspections and technical guidance and information necessary for the operation and maintenance program.

Provisions will be made to provide for free access of representatives of the Farmers Creek Watershed Authority, the Montague County Commissioners Court, and Federal representatives to inspect and provide for maintenance for all structural measures and their appurtenances at any time.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Farmers Creek Watershed, Texas

Installation Cost Item	Unit	Number to Be Applied	Estimated Cost (Dollars) 1/ Public Law: 566 Funds	Other	Total
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acre	470	-	15,913	15,913
Grassland	Acre	20,648	-	426,332	426,332
Technical Assistance			36,339	29,030	65,369
SCS Subtotal			36,339	471,275	507,614
TOTAL LAND TREATMENT			36,339	471,275	507,614
STRUCTURAL MEASURES					
Soil Conservation Service					
Floodwater Retarding Structures	No.	10	723,800	-	723,800
Stream Channel Improvement	Feet	62,340	91,740	-	91,740
Debris Basins	No.	22	271,700	-	271,700
SCS Subtotal			1,087,240	-	1,087,240
Subtotal - Construction			1,087,240	-	1,087,240
Installation Services					
Soil Conservation Service					
Engineering Services			167,526	-	167,526
Other			95,673	-	95,673
SCS Subtotal			263,199	-	263,199
Subtotal Installation Services			263,199	-	263,199
Other Costs					
Land, Easements and Rights-of-Way			-	97,823	97,823
Administration of Contracts			-	8,200	8,200
Subtotal - Other Costs				106,023	106,023
TOTAL STRUCTURAL MEASURES			1,350,439	106,023	1,456,462
TOTAL PROJECT			1,386,778	577,298	1,964,076
SUMMARY					
Subtotal SCS			1,386,778	577,298	1,964,076
TOTAL PROJECT			1,386,778	577,298	1,964,076

1/ Price Base: 1966

March 1966

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT

Farmers Creek Watershed, Texas

Measures	Unit	Applied to Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Cropland			
Conservation Cropping System	Acre	3,410	3,410
Contour Farming	Acre	2,540	2,540
Cover and Green Manure Crop	Acre	4,300	54,825
Crop Residue Use	Acre	4,510	18,040
Grasses and Legumes in Rotation	Acre	455	8,873
Diversion	Foot	18,480	2,218
Grassed Waterway	Acre	15	1,800
Terrace, Gradient	Foot	189,108	9,455
Grassland			
Land Clearing	Acre	820	32,800
Pasture and Hayland Planting	Acre	6,080	194,560
Pasture and Hayland Management	Acre	6,080	912
Range Deferred Grazing	Acre	31,100	4,665
Range Proper Use	Acre	46,355	5,563
Brush Control	Acre	12,000	180,000
Critical Area Planting	Acre	100	12,500
Farm Pond	No.	104	52,000
Grade Stabilization Structure	No.	1	2,500
Range Seeding	Acre	6,074	91,110
TOTAL LAND TREATMENT			677,771

1/ Price Base: 1966

March 1966

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Farmers Creek Watershed, Texas

(Dollars) 1/

Structure Site Number or Name	Installation Cost - Public Law 566 Funds				Installation Cost - Other Funds			Total Installation Cost
	Construction	Installation Services		Total Public Law 566	Other			
		Engineering	Other		Adm. of Contracts	Easements and R/W	Total Other	
Floodwater Retarding Structures								
1	75,900	11,385	6,655	93,940	500	6,928	7,428	101,368
2	80,300	12,045	7,041	99,386	500	5,332	5,832	105,218
3	57,200	8,580	5,016	70,796	500	3,960	4,460	75,256
4	61,600	9,240	5,402	76,242	500	2,562	3,062	79,304
5	96,800	14,520	8,488	119,808	500	6,361	6,861	126,669
6	58,300	8,745	5,112	72,157	500	5,094	5,594	77,751
7	62,700	9,405	5,498	77,603	500	10,296	10,796	88,399
8	75,900	11,385	6,655	93,940	500	6,952	7,452	101,392
9	67,100	10,065	5,884	83,049	500	4,506	5,006	88,055
10	88,000	13,200	7,717	108,917	500	7,607	8,107	117,024
Subtotal	723,800	108,570	63,468	895,838	5,000	59,598	64,598	960,436
Channel Improvement								
Farmers Creek	75,350	11,303	6,607	93,260	200	22,400	22,600	115,860
D Trib.	13,310	4,259	1,340	18,909	200	3,550	3,750	22,659
F Trib.	3,080	986	310	4,376	200	850	1,050	5,426
Subtotal	91,740	16,548	8,257	116,545	600	26,800	27,400	143,945
Debris Basins								
101	11,660	1,749	1,022	14,431	100	375	475	14,906
102	12,980	1,947	1,138	16,065	100	575	675	16,740
103	5,830	875	511	7,216	100	275	375	7,591
104	20,350	3,053	1,784	25,187	100	625	725	25,912
105	9,570	1,436	839	11,845	100	525	625	12,470

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION - Continued
Farmers Creek Watershed, Texas
(Dollars) 1/

Structure Site Number or Name	Installation Cost - Public Law 566 Funds				Installation Cost - Other Funds			Total Installation Cost
	Construction	Installation Services		Total Public Law 566	Other			
		Engineering	Other		Adm. of Contracts	Easements and R/W	Total Other	
Debris Basins - Continued								
106	5,940	891	521	7,352	100	325	425	7,777
107	8,580	1,287	752	10,619	100	375	475	11,094
108	7,480	1,122	656	9,258	100	325	425	9,683
109	8,800	1,320	772	10,892	100	675	775	11,667
110	13,200	1,980	1,157	16,337	100	675	775	17,112
111	9,350	1,403	820	11,573	100	400	500	12,073
112	7,260	1,089	636	8,985	100	400	500	9,485
113	5,170	776	453	6,399	100	1,000	1,100	7,499
114	5,280	792	463	6,535	100	175	275	6,810
115	55,000	9,900	4,949	69,849	500	1,725	2,225	72,074
116	11,110	1,666	974	13,750	100	450	550	14,300
117	11,220	1,683	984	13,837	100	525	625	14,512
118	11,770	1,766	1,032	14,568	100	275	375	14,943
119	14,960	2,244	1,312	18,516	100	475	575	19,091
120	13,200	1,980	1,157	16,337	100	350	450	16,787
121	15,730	2,360	1,380	19,470	100	450	550	20,020
122	7,260	1,089	636	8,985	100	450	550	9,535
Subtotal	271,700	42,408	23,948	338,056	2,600	11,425	14,025	352,081
TOTAL PROJECT	1,087,240	167,526	95,673	1,350,439	8,200	97,823	106,023	1,456,462

1/ Price Base: 1966

March 1966

4-21918
6-66

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

Farmers Creek Watershed, Texas

Item	Unit	STRUCTURE NUMBER 1	2	3	4	5	6	7
Drainage Area	Sq. Mi.	2.23	1.57	2.05	1.12	4.88	3.97	5.94
Storage Capacity								
Sediment Pool (50-year or 200 acre-feet)	Ac. Ft.	59	75	87	72	198	106	200
Sediment Reserve (Below riser - 50-year)	Ac. Ft.	-	-	-	-	-	-	53
Sediment in Detention Pool	Ac. Ft.	71	76	98	72	244	148	329
Floodwater Pool	Ac. Ft.	515	511	487	262	1,317	995	1,088
Total	Ac. Ft.	645	662	672	406	1,759	1,249	1,670
Surface Area								
Sediment Pool (50-year or 200 acre-feet)	Acre	15	15	18	12	25	27	43
Sediment Reserve (Below riser)	Acre	-	-	-	-	-	-	47
Floodwater Pool	Acre	55	56	56	38	114	109	156
Volume of Fill	Cu. Yd.	132,000	134,000	91,000	98,000	184,000	82,000	90,000
Elevation Top of Dam 1/	Foot	1031.3	1086.5	1059.3	1065.9	996.1	1003.0	957.4
Maximum Height of Dam 2/	Foot	37	63	51	55	53	33	36
Emergency Spillway								
Crest Elevation	Foot	1027.5	1082.0	1056.0	1062.5	992.0	999.0	953.0
Bottom Width	Foot	80	100	100	50	120	100	140
Type		Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 3/		2.8	1.2	2.8	2.9	1.9	2.1	3.7
Average Curve No. - Condition II		73	73	73	73	73	72	72
Emergency Spillway Hydrograph								
Storm Rainfall (6-hour) 4/	Inch	6.5	9.4	6.5	6.5	6.5	6.5	6.5
Storm Runoff	Inch	3.5	6.1	3.5	3.5	3.5	3.4	3.4
Velocity of Flow (V_c)	Ft./Sec.	0	0	0	0	0	0	0
Discharge Rate	C.F.S.	0	0	0	0	0	0	0
Maximum Water Surface Elevation	Foot	-	-	-	-	-	-	-
Freeboard Hydrograph								
Storm Rainfall (6-hour) 4/	Inch	13.4	20.2	13.4	13.4	13.4	13.4	13.4
Storm Runoff	Inch	9.8	16.4	9.8	9.8	9.8	9.7	9.7
Velocity of Flow (V_c) 5/	Ft./Sec.	8.3	9.1	7.6	7.8	8.6	8.5	8.9
Discharge Rate 1/	C.F.S.	1,414	2,374	1,370	755	2,424	1,902	3,051
Maximum Water Surface Elevation 1/	Foot	1031.3	1086.5	1059.3	1065.9	996.1	1003.0	957.4
Principal Spillway								
Capacity (Maximum)	C.F.S.	22	19	16	9	49	40	59
Capacity Equivalents								
Sediment Volume	Inch	0.50	0.90	0.80	1.20	0.76	0.50	0.63
Sediment Reserve Volume (Below riser)	Inch	-	-	-	-	-	-	0.17
Sediment in Detention Pool	Inch	0.60	0.90	0.90	1.20	0.94	0.70	1.04
Detention Volume	Inch	4.33	6.10	4.45	4.40	5.06	4.70	3.43
Spillway Storage	Inch	1.97	3.37	1.89	2.38	1.98	2.30	2.43
Class of Structure		A	B	A	A	A	A	A

(See footnotes last page table 3.)

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued
Farmers Creek Watershed, Texas

Item	Unit	STRUCTURE NUMBER 8	9	10	Total
Drainage Area	Sq. Mi.	5.76	2.16	5.08	34.76
Storage Capacity					
Sediment Pool (50-year or 200 acre-feet)	Ac. Ft.	184	46	135	1,162
Sediment Reserve (Below riser - 50-year)	Ac. Ft.	-	-	-	53
Sediment in Detention Pool	Ac. Ft.	246	69	163	1,516
Floodwater Pool	Ac. Ft.	1,677	784	1,303	8,939
Total	Ac. Ft.	2,107	899	1,601	11,670
Surface Area					
Sediment Pool (50-year or 200 acre-feet)	Acre	38	13	31	237
Sediment Reserve (Below riser)	Acre	-	-	-	47
Floodwater Pool	Acre	166	82	134	966
Volume of Fill	Cu. Yd.	132,000	128,000	154,000	1,225,000
Elevation Top of Dam 1/	Foot	956.9	955.5	930.9	xxx
Maximum Height of Dam 2/	Foot	38	37	45	xxx
Emergency Spillway					
Crest Elevation	Foot	953.0	951.5	927.0	xxx
Bottom Width	Foot	100	150	150	xxx
Type		Veg.	Veg.	Veg.	xxx
Percent Chance of Use 3/		1.4	0.9	2.3	xxx
Average Curve No. - Condition II		72	74	74	xxx
Emergency Spillway Hydrograph					
Storm Rainfall (6-hour) 4/	Inch	6.5	9.4	6.5	xxx
Storm Runoff	Inch	3.4	6.2	3.6	xxx
Velocity of Flow (V_c)	Ft./Sec.	0	0	0	xxx
Discharge Rate	C.F.S.	0	0	0	xxx
Maximum Water Surface Elevation	Foot	-	-	-	xxx
Freeboard Hydrograph					
Storm Rainfall (6-hour) 4/	Inch	13.4	20.2	13.4	xxx
Storm Runoff	Inch	9.7	16.5	10.0	xxx
Velocity of Flow (V_c) 5/	Ft./Sec.	8.5	8.5	8.3	xxx
Discharge Rate 1/	C.F.S.	1,899	2,835	2,707	xxx
Maximum Water Surface Elevation 1/	Foot	956.9	955.5	930.9	xxx
Principal Spillway					
Capacity (Maximum)	C.F.S.	58	32	51	xxx
Capacity Equivalents					
Sediment Volume	Inch	0.60	0.40	0.50	xxx
Sediment Reserve Volume (Below riser)	Inch	-	-	-	xxx
Sediment in Detention Pool	Inch	0.80	0.60	0.60	xxx
Detention Volume	Inch	5.46	6.81	4.81	xxx
Spillway Storage	Inch	2.32	3.28	2.19	xxx
Class of Structure		A	B	A	xxx

1/ Values obtained from routing.

2/ Difference in elevation between the top of the settled dam and the bottom of the stream channel.

3/ Is the average number of times the emergency spillway will be expected to function in 100 years based on regional analysis of gaged runoff.

4/ Based on Engineering-Hydrology Memorandum TX-1, "Design Storm Inflow Hydrograph Development Methods," October 15, 1963.

5/ Obtained from curves drawn from figure 4-R-11472 revised March 1959 and ES-98 dated April 27, 1955, based on flows obtained from routing of the Freeboard Hydrograph.

4-219/9 10-66

TABLE 3A - STRUCTURE DATA
CHANNELS

Farmers Creek Watershed, Texas

Channel Designation	Station Numbering for Reach: Station (feet)	Station (feet)	Watershed Area 1/ (sq. mi.)	Planned Channel Capacity (c.f.s.)	Average Bottom Width (feet)	Average Side Slope	Design Depth 2/ (feet)	Average Grade (ft./ft.)	Average Velocity in Channel (ft./sec.)	Volume of Excavation (1000 cu.yds.)
Farmers Creek	315+00	340+00	6.88	105	10	4:1	1.9	.00500	3.1	-
	340+00	342+00		Transition Section						
	342+00	371+35	7.38	116	16	4:1	1.9	.00300	2.6	-
	371+35	400+00	8.21	116	18	4:1	1.9	.00250	2.4	-
	400+00	448+85		No Channel Work Planned						
	448+85	485+65	12.33	135	10	4:1	2.3	.00300	3.1	-
	485+65	498+00	17.04	150	10	4:1	2.5	.00261	3.0	-
	498+00	536+50	24.50	268	10	4:1	3.3	.00261	3.5	-
	536+50	538+50		Transition Section						
	538+50	732+00	34.24	508	22	4:1	3.8	.00190	3.6	-
	732+00	836+25	37.15	603	22	4:1	4.2	.00190	3.7	295.4
D Tributary	382+00	445+50	3.82	110	10	4:1	2.0	.00412	3.1	-
	445+50	502+80	4.64	126	10	4:1	2.2	.00400	3.0	53.5
F Tributary	428+00	458+00	0.41	122	10	4:1	2.0	.00540	3.4	12.7
								Total Excavation		361.6

1/ Excluding the area from which runoff is controlled by floodwater retarding structures.

2/ Depth of channel will be greater where elevation of hydraulic gradient of design flow is at a lower elevation than that of normal ground.

March 1966

TABLE 10 - STRUCTURE DATA - DEBRIS BASINS

Farmers Creek Watershed, Texas

Structure Number	Drainage Area (Acre)	Storage Capacity: Sediment: Inches	Storage Capacity: Sediment: Acre-Feet	Storage Capacity: Principal Spillway: Inches	Storage Capacity: Principal Spillway: Acre-Feet	Elevation: Principal Spillway (M.S.L.)	Elevation: Emergency Spillway (M.S.L.)	Elevation: Top of Dam (M.S.L.)	Principal Spillway Capacity (Maximum) (C.F.S.)	Volume of Fill (Cu.Yd.)
101	70	5.7	33	.76	4	1072.0	1074.8	1076.8	23	30,000
102	371	2.0	62	1.18	36	998.2	1003.6	1005.6	80	30,000
103	58	3.0	14	.60	3	1010.2	1012.5	1014.5	24	9,200
104	346	2.9	84	.68	19	981.2	985.2	987.2	127	55,000
105	154	4.7	60	1.55	20	962.2	966.1	968.1	20	23,000
106	45	6.3	23	.48	2	971.0	972.8	974.8	23	11,000
107	122	2.3	23	.67	7	1106.2	1108.9	1110.9	46	15,400
108	51	5.6	24	.54	2	1113.6	1115.5	1117.5	23	15,200
109	102	7.3	62	1.13	10	1061.4	1063.8	1065.8	22	18,500
110	269	2.3	52	1.24	28	1122.2	1126.2	1128.2	51	30,000
111	115	2.3	22	1.25	12	1103.2	1107.0	1109.0	22	22,500
112	243	1.3	26	.91	19	973.5	977.2	979.2	65	12,000
113	38	4.7	15	.40	1	963.2	965.2	967.2	22	9,200
114	70	1.7	10	.87	5	964.5	967.8	969.8	20	9,500
115	442	6.8	250	4.40	163	1100.3	1117.0	1119.6	28	94,000
116	243	2.2	45	.78	15	1119.0	1123.2	1125.2	78	22,200
117	186	3.7	57	.83	13	1091.8	1095.5	1097.5	134	17,300
118	282	1.8	42	.80	19	1107.1	1115.9	1117.9	89	23,000
119	282	2.6	61	.70	16	1059.5	1064.4	1066.4	190	23,000
120	282	1.4	33	.81	19	1122.5	1130.2	1132.2	87	27,000
121	397	1.4	46	.80	26	1080.3	1088.4	1090.4	193	26,000
122	102	2.7	23	1.00	8	1012.3	1014.8	1016.8	25	15,800

March 1966

TABLE 4 - ANNUAL COST

Farmers Creek Watershed, Texas

(Dollars) 1/

Evaluation Unit	Amortization of Installation Cost	Operation and Maintenance Cost 2/	Total
Floodwater Retarding Structures 1 through 10; 62,340 feet of Stream Channel Improvement; and Debris Basins 101 through 122	3/47,714	5,873	53,587
TOTAL	3/47,714	5,873	53,587

1/ Price Base: 1966

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

3/ Amortized at 3.125 percent for 100 years.

March 1966

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Farmers Creek Watershed, Texas

(Dollars) 1/

Item	Estimated Average Annual Damage		Damage Reduction Benefits
	Without Project	With Project	
Floodwater			
Crop and Pasture	14,234	6,346	7,888
Other Agricultural	10,630	3,036	7,594
Non-agricultural			
Road and Bridge	5,758	1,000	4,758
Subtotal	30,622	10,382	20,240
Sediment			
Overbank Deposition	26,639	12,075	14,564
Swamping	661	104	557
Deposition to Lake Nocona	8,435	1,138	7,297
Road and Bridge	10,950	2,408	8,542
Subtotal	46,685	15,725	30,960
Erosion			
Flood Plain Scour	1,042	248	794
Land Destruction by Gullies	5,488	1,614	3,874
Subtotal	6,530	1,862	4,668
Indirect	8,384	2,797	5,587
TOTAL	92,221	30,766	61,455

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

March 1966

4-21818 8-68

4-2191S 10-66

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Farmers Creek Watershed, Texas

(Dollars) 1/

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/					Average Annual Cost 2/	Benefit Cost Ratio
	Flood Prevention						
	Damage Reduction	Incidental Recreation	More Intensive Land Use	Secondary	Total		
10 Floodwater Retarding Structures; 62,340 feet of Stream Channel Improvement; and 22 Debris Basins 3/	56,690	3,504	7,628	7,075	74,897	53,587	1.4:1
GRAND TOTAL 4/	56,690	3,504	7,628	7,075	74,897	53,587	1.4:1

1/ Price Base: Long-term prices as projected by ARS, September 1957.
2/ From table 4.
3/ Interrelated measures.
4/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $4,765 annually.

March 1966

INVESTIGATIONS AND ANALYSES

Land Use and Treatment

The status of land treatment for the watershed was developed by supervisors of the Upper Elm-Red Soil and Water Conservation District, with assistance from personnel of the Soil Conservation Service Work Unit at Nocona, Texas. A 40 percent sample of current conservation plans was used to develop conservation needs data for the entire watershed. Acres to be treated by land use during the 5-year project installation period were based upon total conservation needs and the priority of planning and servicing set by the Soil and Water Conservation District. Technical assistance needs were based on the amount of time now required for soil surveys, development and preparation of basic conservation plans, and application of conservation measures. The difference between funds that are available under the going program and those required to assure application and maintenance of all planned land treatment practices prior to the end of the 5-year installation period is the amount of technical assistance funds that will be made available from PL 566 funds.

Engineering Investigations

The procedures used to determine the most feasible plan of structural measures to meet the objectives of the sponsoring local organizations that could not be accomplished by land treatment measures were as follows:

1. A base map of the watershed was prepared showing watershed boundary, drainage pattern, systems of roads and railroads, utility lines, and other pertinent information.

2. A study of photographs, supplemented by field examination, indicated the limits of flood plain subject to flood damage and critical sediment producing areas.

3. Floodwater retarding structure and debris basin sites were selected by stereoscopic photo and topographic map studies supplemented by field examination. Investigations also indicated a need for stream channel improvement in some reaches of the watershed.

4. A system of 11 floodwater retarding structures, 11.8 miles of stream channel improvement, and 22 debris basins was recommended to the sponsoring local organizations for further consideration and detailed survey. The ownership and property lines for each structure and for channel improvement were located and drawn on the photographs by the local sponsors prior to the start of engineering surveys.

5. Surveys - Engineering surveys were made after agreement was reached with the sponsoring local organizations on the location of structural measures to be studied.

   a. Horizontal Control - Scales of aerial photographs were determined by chaining between identifiable points.

   b. Vertical Control - Existing U. S. Coast and Geodetic Survey and U. S. Geodetic Survey bench marks were supplemented with temporary bench marks set at strategic locations for use in making structural surveys.

   c. Floodwater Retarding Structures - Field surveys were made in two stages. First, topographic maps were made of the reservoir areas. Surveys were made of roads, pipe lines, and utility lines located within the reservoir areas. Second, after preliminary plans were reviewed and accepted by the local sponsors, detailed topographic maps with a contour interval of 2 feet and a scale of 1 inch to 100 feet were made of emergency spillway areas. A profile survey was made of the centerline of each structure. Contour lines of water elevations at the lesser of the 50-year sediment pool or 200 acre-feet level, at the top of the riser, the emergency spillway crest, and 2 feet above the emergency spillway crest were located on the ground and recorded on the photo map. These surveys provided the data necessary to determine if required sediment and floodwater detention storage capacities could be obtained, to determine the most economical design for each structure, to estimate the installation cost and to make land rights maps. Surveys were made in accordance with procedures outlined in Watersheds Memorandum TX-2.

   d. Channel Improvement - Channel improvement surveys were made in accordance with procedures outlined in Watersheds Memorandum TX-1. Surveys consisted of 58 additional cross sections to supplement valley cross section surveys. Topographic maps were prepared for some reaches of the flood plain for use in determining the alignment of the improved channel.

   e. Debris Basins - These structures were surveyed in accordance with procedures outlined in Texas Engineering Handbook, Section 17, except No. 115, which was surveyed the same as the floodwater retarding structures.

6. Designs - Designs of structural measures were initiated as survey data for individual or related groups of structures were completed.

   a. Floodwater Retarding Structures - Criteria outlined in Engineering Memorandum-27 and Texas State Manual Supplement 2441 were used

to determine the sediment and floodwater detention storage requirements, structure classification, and principal and emergency spillway design. As the topography was determined for each floodwater retarding structure site, storage tables and curves were developed. Preliminary layouts of pools, centerlines of dams, and emergency spillways were prepared and then reviewed on the ground with the sponsors. These preliminary layouts showed the approximate area of the dam, emergency spillway, and the sediment and detention pools affecting each landowner. After any adjustments found desirable and feasible were made, the final pool elevations were determined, release rates for the principal spillways were established, and emergency spillways were designed. The elevations of the sediment pools were determined in accordance with Engineering Memorandum-16 and Section 3107, Watershed Protection Handbook. The lower sediment pool elevation was set, using the lesser of the capacities required for 50 years or 200 acre-feet. Storage of permanent water is limited by State law to 200 acre-feet unless a special permit is obtained. Detention volumes exceed the minimum criteria set forth in Engineering Memorandum-27 and Texas State Manual Supplement 2441.

b. Stream Channel Improvement - The design of the improved stream channel was based on the procedures outlined in USDA Technical Release No. 25, Planning and Design of Open Channels, December 15, 1964. Maps and profiles were developed from engineering survey data. The improved channels were located in the low point of the flood plain and in cohesive soils where possible. The channels were designed to carry the maximum release flows from the floodwater retarding structures with about one foot of freeboard.

c. Debris Basins - The debris basins were designed in accordance with Standards and Specifications for Sediment Control Structures for West Cross Timbers and North Central Prairies Land Resource Areas - Texas, except No. 115, where the product of the storage times the height of the dam is greater than 3,000. For this site, Engineering Memorandum-27 criteria was used. These structures were proportioned so the 25-year frequency storm flood would not produce flow in the emergency spillway. The elevation for the top of the dams was determined by routing the 100-year frequency flood through the site, using a storage indication method of flood routing. An emergency spillway no less than 30 feet wide and 2 feet deep was provided at all sites. For those structures where, at the minimum top of dam elevation, the detention storage plus emergency spillway storage exceeded the storage required to contain the 100-year flood, no routing was made.

7. Cost Estimates - Construction costs were based on unit prices being expended at similar sites, Soil Conservation Service experience, and values furnished by local organizations and companies. Alternate dam site locations were analyzed to determine the least costly combination of emergency spillways and embankments. The average annual cost of maintaining structural measures was converted to long-term prices.

Hydraulic and Hydrologic Investigations

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

1. Basic meteorologic and hydrologic data were tabulated from U. S. Weather Bureau Bulletins for the gages at Bonita and Gainesville, Texas, U. S. Geological Survey Water Supply Papers, and Texas Board of Water Engineers' Bulletins. Precipitation records were also tabulated for the rain gage at the Soil Conservation Service office at Nocona, Texas.

   A tabulation of cumulative departure from normal precipitation for the gages shows the period 1940 through 1964 to be representative of normal. Storms that occurred during this period were used to evaluate flood damages. Each storm during this period was analyzed to determine the antecedent moisture condition, using the procedure outlined in National Engineering Handbook, Section 4, Supplement A, Section 3.4. The depth of runoff from individual storms was estimated, using runoff curves, Figure 3.10-1, NEH, Section 4, Supplement A, Section 3.4. The runoff from each storm was adjusted to reflect future hydrologic conditions of the watershed.

2. The present hydrologic conditions were determined from a 10 percent sampling of soil and cover conditions. The future condition was determined by considering the effect of changes in land use and treatment that could be expected during the installation period. The following is a summary of curve numbers by land resource areas:

Land Resource Area	Present Conditions	Future Conditions
Cross Timbers	73	72
Central Rolling Red Prairies	80	79
Watershed Average	75	74

3. The area subject to damage from flooding was determined by stereoscopic photo study, supplemented with information obtained from residents of the watershed and field investigations. A flood damage area strip map was developed from this data.

4. A base map of the watershed was developed showing the drainage divides of the floodwater retarding structures and valley cross sections. Drainage divides were determined by stereoscopic photo study, supplemented by field investigations. Drainage areas for evaluation purposes were measured on the drainage area map.

5. Engineering surveys were made of 44 valley cross sections to represent the stream hydraulics and flood-plain area. Stream and flood-plain lengths were measured from the flood-plain strip map and profiles of the streams were developed and plotted.

6. Stage-discharge relationships were developed for the valley cross sections by use of Manning's formula.

7. The peak discharge runoff relationship was developed at each proposed floodwater retarding structure site and at each valley cross section by use of the IBM 7090/7094 computer program outlined in USDA Technical Release No. 20, "Project Formulation Program - Hydrology," June 8, 1965. Various combinations of floodwater retarding structures were analyzed to determine the system of structures which would accomplish the project objectives most efficiently.

8. Stage-area inundated curves were developed for each portion of the flood plain represented by a single cross section. Acres inundated by 0-1, 1-3, and 3 feet plus depth increments were determined for selected floods. Composite runoff-area inundated curves were developed for without project conditions and to reflect the effect of the planned works of improvement for each evaluation reach.

9. Determinations were made of the area that would be flooded by each storm in the evaluation series under each of the following conditions:

   a. The 1965 condition of the watershed remaining static.

   b. The application of land treatment.

   c. The application of land treatment and installation of floodwater retarding structures and channel improvement.

10. Reservoir operation studies were made to determine the dependable yield from Lake Nocona. Runoff records indicated that the period 1950 through 1957 was the most critical drought period in recent times. Separate studies included the following watershed and reservoir conditions:

    a. Present condition inflow and original area capacity curve.

    b. Present (1965) condition inflow and area capacity curve adjusted by the area increment method for 7,361 and 16,323 acre-feet of sediment accumulation.

    c. Present condition inflow with 4,591, 6055, and 7,655 acre-feet of sediment in the bottom of the reservoir.

    d. Present condtion (1965) inflow, but with 34.76 square miles controlled by floodwater retarding structures and the area capacity curve adjusted by the area increment method for 1,736 acre-feet of sediment accumulation. This is the sediment accumulation expected in Lake Nocona at the time the PL 566 project is completed.

    The procedure for making these studies is contained in Texas Engineering Handbook, Section 4, Hydrology, Chapter 2, Reservoir evaporation rates were obtained from the Texas Board of Water Engineers, Bulletin 6006, Monthly Reservoir Evaporations for Texas. The inflow to the reservoir was based on stream flow records for Big Sandy Creek near Bridgeport, Texas. Rainfall records for the U.S.W.B. gage at Bonita were used in the studies.

11. Detention volumes for floodwater retarding structures were determined in accordance with Texas State Manual Supplement 2441 criteria. Volumes used exceed these criteria at all sites to obtain a more economical or desirable emergency spillway or structure design. The percent chance of use of the emergency spillway was determined by adding to the actual detention storage the volume which would be released by the principal spillway during a 2-day period.

12. The principal spillway release rates for the floodwater retarding structures vary from 8 csm to 15 csm. The average release rate for the watershed for the area controlled is 10 csm. Release rates were determined by studying the effect of release rates on design of the structures and on downstream channels.

13. The emergency spillway and freeboard design storms were selected from Engineering-Hydrology Memorandum TX-1. The values exceed those shown on standard drawing ES-1020. The distribution graph

method was used to develop inflow hydrographs for each site in the watershed. The elevation of the top of the dams was determined by routing the freeboard hydrograph, using the Monrobot Computer for all floodwater retarding structures except No. 7 and debris basin No. 115. The top of dam elevations for these two structures were determined by graphically routing the freeboard hydrographs. The routing method described on page 5.8-12, NEH, Section 5, was used.

14. Rainfall amounts contained in U. S. Department of Commerce Weather Bureau Technical Paper No. 40, "Rainfall Frequency Atlas of the United States," were used with hydrologic soil cover complex curve No. 72 to develop mass inflow hydrographs for the 25-year and 100-year frequency floods. These hydrographs were used to determine the emergency spillway crest and top of dam elevations for the debris basins. Design procedures presented in Texas Engineering Handbook, Section 17, were used.

Sedimentation Investigations

Sedimentation investigations were made in accordance with procedures outlined in Technical Release No. 12, "Procedures for Computing Sediment Requirements for Retarding Reservoirs," September 1959, USDA, SCS; Watersheds Memorandum TX-25, "Sedimentation Investigations," August 1959, USDA, SCS; and "Guide to Sedimentation Investigations," South Regional Technical Service Area, March 1965, USDA, SCS.

Sediment Source Studies

The following steps were used to determine the required 100-year sediment storage requirements for the planned floodwater retarding structures:

1. Representative samples covering about 10 percent of the watershed drainage area were selected on aerial photographs.

2. Soils and slope data from unpublished soil survey field sheets were utilized for all samples.

3. Land use, cover conditions, land treatment, and slope lengths in sample areas were mapped in the field.

4. Field investigations of gullies and stream channels above all structures were made to determine lengths, depths, and estimated rates of erosion.

5. Soils by slope in percent, slope length, land use, and cover conditions were tabulated for each land resource area.

6. The Musgrave soil loss equation for computing sheet erosion was used to adjust present erosion rates to reflect the effect of land treatment to be applied.

7. Sheet erosion rates were expanded by land use for each land resource area in the drainage area of each planned structure.

8. Applicable delivery ratios were applied to the gross erosion rates obtained in steps 4 and 7 to determine the sediment delivered to the reservoir.

9. The sediment delivered to the reservoir was adjusted for estimated trap efficiency.

10. Allowances for differences in density between soil in place and sediment were made for the required sediment storage volumes. These densities were based on the following textural classes:

Texture	Soil in Place (lbs./cu.ft.)	Submerged Sediment (lbs./cu. ft.)
Clay and clay loam	82	45
Loam and sandy loam	88	68
Sand and loamy sand	95	95

11. Allocation of sediment to the floodwater retarding structure and debris basin pools was made on textural classes as follows:

Period of Deposition	Structure Pool	Condition of Sediment	Allocation (Percent)
	Floodwater Retarding Structures		
First 50 Yearss	Detention	Aerated	30
	Sediment	Submerged	70
Last 50 Years	Detention	Aerated	100
	Debris Basin Structures		
25 Years	Above riser	Aerated	30
	Below riser	Submerged	70

Erosion Damage

Land destruction by valley trenching was determined by comparing the positions of headcuts shown on aerial photographs taken in 1950 and 1963.

Acreage computations reflect ultimate total width of the gully after widening due to aging and length of time expected for destruction to occur based on adjusted future rate of advancement.

Flood Plain Sedimentation and Scour Damages

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

1. Observations were made along each of the valley cross sections, making note of the depth and texture of sediment deposits, soil conditions, sheet and channel scoured areas, stream channel aggradation or degradation, and other factors contributing to flood-plain damages.

2. The approximate elevation of the original flood plain before modern deposition or erosion began was determined for each valley section.

3. Information on past physical damages was obtained through interviews with landowners and operators.

4. Damage tables were developed to show percent damage to productive capacity of the flood-plain soil, by depths for scour and by texture and depth for deposition. Adjustments for recoverability of productive capacity for each damage category were made on the basis of information obtained from landowners and operators and from field studies.

5. The damage areas were measured and data tabulated for each valley segment, and summarized for each evaluation reach.

6. Using the average annual erosion rates as a basis, the average annual volume of sediment produced above the area damaged was estimated for without project conditions, with land treatment applied, and with structural measures installed. These volumes were used as a basis for estimating the average reduction of overbank deposition in the watershed. Scour damage reductions are based on reductions of depth and area inundated for with project conditions.

Lake Nocona Reservoir Sedimentation

Physical damage to Lake Nocona due to sedimentation was determined by using the sediment source data developed for estimating sediment accumulation in floodwater retarding structures. A detailed sedimentation survey of the reservoir was not made during these investigations since it is almost impossible to obtain reliable rates of sedimentation from such relatively new reservoirs.

Sediment Damages to Transportation Facilities

Damages to transportation facilities were based on past history of sedimentation and the dates, amounts, and costs of repairs and/or reconstruction of facilities required as a result of sediment accumulation. Present rates of accumulation along with field studies of affected facilities were made and compared with the past damages to arrive at present and future damages.

Channel Stability Studies

Channel investigations for stability studies were made in accordance with suggested procedures outlined in Technical Release No. 25, "Planning and Design of Open Channels," December 15, 1964, USDA, SCS. A power soils auger was used in making necessary field studies. A laboratory analysis was made of representative samples of soil selected in the field.

Description of Problems

The mainstem valley of Farmers Creek is located in cohesive residual and bedrock materials of the Cisco and Wichita series, with the upper reaches of the mainstem and most major tributaries being located on non-cohesive sands of the Trinity group. The original alluvium consisted mainly of cohesive sandy clays (CL) and clayey sands (SC). Modern alluvium consisting mainly of silty sand (SM) materials has accumulated in depths ranging from 8 to 12 feet in all of the major valleys and on the mainstem upstream of Lake Nocona. Modern lenticular clays and clayey deposits occur in the depressions formed between the prominent natural levees of the stream channel and the valley margin.

Most of the stream channels are unstable. Conditions range from severe degradation to aggradation (figure 6). This condition is best illustrated at VS-7 upstream of Lake Nocona where the channel has degraded through 6 feet of modern sandy alluvium and approximately 10 feet of original clayey alluvium and into cohesive bedrock materials. Immediately upstream at VS-8 the channel is completely filled. West Farmers Creek channel is degrading in its lower reaches, stable or relatively stable in the central reaches, and aggrading in the upper reaches. Similar conditions are found on the other channels.

The improved channel is located on alluvial and residual clays which occur in and under the natural depressions on the outer margins of the flood plain. All of the mainstem downstream of its confluence with West Farmers Creek is located on cohesive materials except where the alignment required crossing the silty sand. These cohesive soils have a plasticity index of 20 or higher and non-scouring velocities of 5.5 feet per second. Weak cohesive and non-cohesive sandy alluvium and bedrock materials are encountered on all improved segments upstream of the West Farmers Creek confluence.

The D_{50} grain size of these materials is 0.2 millimeters, with a non-scouring velocity of 1.7 feet per second.

The Schoklitsch bedload transport equation indicates that some degree of instability might occur in certain segments of both improved and unimproved channels. Degradation is indicated in the following segments: immediately downstream of Site 1 to vicinity of VS-21, downstream of F.M. Road 1815 bridge to vicinity of VS-17, downstream of Site 5 to vicinity of VS-D-2, and the lower reach of Redbud Creek. Aggradation is indicated in improved segments of the channel downstream from the degrading segments. The bedload transport equation indicates that sediment may accumulate at a rate of 10 acre-feet annually. All of the improved channels will be located in Bermudagrass pastures. Side slopes of 4 to 1 were planned to encourage the rapid re-establishment of vegetation. The ensuing protection afforded by this vegetative lining is expected to reduce degradation, which in turn will reduce aggradation.

It is expected that the existing overfalls immediately upstream from Lake Nocona will become inactive after the reservoir has filled to its expected capacity; therefore, there should be no adverse effect upon the improved channel from stream bank degradation.

Geologic Investigations

Preliminary geologic investigations were made at each structure site. These investigations included studies of exposed geologic formations and structure, valley slopes, alluvium, and channel banks. Reports of the investigation were made as outlined in Chapter 6 of National Engineering Handbook, Section 8, "Engineering Geology," USDA, SCS, and Chapter 6 of "Guide to Geologic Site Investigations," South Regional Technical Service Area, EWPU, USDA, SCS, July 1965.

Geologic Problems

Sites 9 and 10 are located on sandstone and redbed shales of the Cisco series. Materials classified as CL, CH, and SC predominate. Modern silty sand (SM) alluvium derived from sands of the Trinity group upstream of the sites occur to depths of 5 or 6 feet in the valleys. The original alluvium is dominantly clayey with some basal gravel deposits noted at Site 10. Moderately hard sandstone occurs in the emergency spillway of Site 9.

Sites 1 through 8 are located in sandstones of the Trinity group. This sandstone is soft to moderately soft, poorly cemented, fine grained, and massive bedded. Occasional thin beds and lenses of clay occur. The valleys at Sites 2, 3, and 4 have been deeply entrenched. Clayey alluvium (CL and SC) with beds of silty sand (SM) is exposed in depths of more than 30 feet. Shaping of banks will be required at these sites. Sites 1, 5, 6, 7, and 8 are located in severely aggraded valleys. High water tables

are expected at these sites. Drainage measures will be required. Materials classified as SM, SC, CL, and ML occur in the borrow areas of these sites.

Economic Investigations

Basic methods used in the economic investigations and analyses are outlined in the "Economics Guide for Watershed Protection and Flood Prevention," USDA, SCS, March 1964. The flood plain, because of the diversity of damageable values and flood-plain characteristics, was divided into two agricultural reaches, one above and one below Lake Nocona.

Agricultural damage estimates were based upon information obtained by interviewing landowners and operators of approximately 25 percent of the acreage of the flood plain. This sample was considered adequate and representative for the economic evaluation. Schedules covered past, present, and intended future use, crop distribution under normal conditions, planting dates, yields, historical data on flooding and resultant damages to crop and pasture, as well as other agricultural damages such as loss of fences, farming equipment and livestock. Supplemental information pertaining to crop yields, as well as trends in crop production and farming operations, was obtained from agricultural workers in the area. The present land use of all the land in the flood plain was obtained by field mapping. Analyses of this information formed the basis for determining the damageable value and damage rates for various depth increments and seasons of flooding in the historical series, 1940-1964, inclusive. An adjustment was made to take into account the effect of recurrent flooding when several floods occurred during the same crop year.

The monetary value of the physical damage from erosion and from deposition of infertile sediment upon formerly fertile bottomland was based upon the value of production lost, and the value of recovery from this damage was discounted in accordance with length of time required for complete recovery.

Indirect damages, involving such items as additional travel time for farmers and others; re-routing of general traffic, school buses, and mail deliveries; and interruption of transportation schedules and the regimen of both farm and city dweller alike, were estimated to approximate 10 percent of the direct damage.

Average annual damages within the watershed were calculated for conditions without a project, with planned land treatment only applied, and after installation of the complete project.

The difference between the damage after the installation of a phase of a project and that before its installation constituted the benefit from reduction of damage creditable to that phase.

Owners and operators, when interviewed, were asked if they would make any changes in their operations if protection from flooding were provided. They indicated that they would manage approximately 1,380 acres of pasture-land more intensively, primarily by proper fertilization and noxious plant control. Acreage of crops subject to acreage allotment is not expected to increase as a result of the project.

Damage calculations for both with and without project conditions were based upon studies made of the effect of sediment accumulation upon the dependable yield of required amounts of municipal water by Lake Nocona. Benefit to the project represents the difference in the annual amount which need be placed in a sinking fund in order to accumulate sufficient capital to replace that storage capacity lost to sediment under without and with project conditions.

Calculations of damages to roads and bridges for both with and without project conditions were based upon the remaining useful life of these facilities expected under both conditions. The benefit represents the difference between annual maintenance and replacement cost under those conditions.

Incidental recreation benefits were evaluated for sediment pools of flood-water retarding structures. In accordance with Watersheds Memorandum-57. October 3, 1962, a value of 85 cents per visitor-day was used for evaluation purposes since it is expected that basic facilities available will be between the undeveloped and partially developed categories.

Benefits were calculated allowing for full level of use and attractiveness for 40 years, with a gradual diminishing of usefulness for the next 10 years to zero, and then no benefits for the duration of the evaluation period.

All project benefits, other than those which occur immediately following project installation, such as reduced damages from flooding, were discounted for lag in accrual.

Values of secondary benefits of a local nature only were calculated in accordance with interim procedures outlined in Watersheds Memorandum-57, October 3, 1962. These benefits were considered as either (1) stemming from the project, or (2) induced by the project. Benefits stemming from the project were estimated to be at least 10 percent of the direct primary benefits accruing to the structural measures included in this plan. Secondary benefits induced by the project were estimated to be 10 percent of the additional cost expended to achieve increased production as a result of the project.

The value of easements was determined by local appraisal, giving full consideration to current real estate market values. The value of production lost in the pool areas as a result of the project was calculated.

It was considered that sediment pools would yield no agricultural production. Land needed for detention pools was expected to be used for intermittent grazing after program installation. This average annual loss of production, plus secondary losses therefrom, was compared with the amortized value of easements. The easement value was found to be greater and therefore was used in economic evaluation, in the interest of a conservative analysis.

Fish and Wildlife Investigations

The following is reproduced from the reconnaissance survey report for the Farmers Creek watershed prepared by the Bureau of Sport Fisheries and Wildlife of the Fish and Wildlife Service, U. S. Department of Interior:

> "Lake Nocona is the only fish habitat of importance in the watershed. Principal sport fish are white crappies, largemouth bass, and catfishes. The lake is open to free public fishing and sport fishing is heavy. These conditions are expected to prevail in the future without the project.
>
> "There is no commercial fishing in the watershed nor is any expected in the future.
>
> "With the project, farm ponds and floodwater retarding reservoirs will reduce the amount of sediment deposited in Lake Nocona thereby improving the fish habitat and prolonging the life of that lake. The ponds and reservoirs also will create more good fish habitat in the watershed.
>
> "Wildlife of importance in the watershed are bobwhites, mourning doves, fox squirrels, cottontails, jackrabbits, raccoons, and bobcats.
>
> "Bobwhites and mourning doves are hunted heavily. Fox squirrels and rabbits also provide a substantial amount of hunting. Hunting for raccoons and bobcats with dogs is especially popular. Most of the hunting is done by landowners and their friends. Without the project, the above conditions are expected to prevail in the future with few significant changes.
>
> "There is no trapping of fur animals in the watershed and none is expected in the future.
>
> "With the project, land treatment measures such as range and pasture proper use, range deferred grazing, critical area planting, and pasture planting will improve habitat for most species of upland game. Farm ponds, floodwater retarding structures, and sediment debris basins will be used as resting habitat by waterfowl during periods of migration.

4-21918 10-66

"Brush and weed control and clearing for farm ponds, floodwater retarding structures, sediment debris basins, and channel improvement will destroy wildlife habitat.

"An opportunity exists in the watershed to develop a good quality fishery, improve wildlife habitat in some areas, and minimize losses of wildlife habitat in other areas.

"During the construction of farm ponds, floodwater retarding structures, and sediment debris basins, and the enlargement of the stream channel, clearing of timber should be kept to an absolute minimum. To promote fertility and reduce turbidity, the basins of ponds and floodwater retarding reservoirs should be disked and planted to small grains adaptable to the area upon completion and prior to the storage of water. When practicable, the farm ponds and floodwater retarding structures should be fenced to prevent damage to the dam and muddying of the water by livestock. A watering device, if required, should be installed below the dam and outside of the enclosure.

"Lands adjacent to the periphery of farm ponds and floodwater retarding structures should be sowed in grass to prevent soil erosion and deposition of silt into the basins of these impoundments.

"The farm ponds and floodwater retarding reservoirs should be stocked only with fish species recommended by the Texas Parks and Wildlife Department. Subsequent stocking of fish should be undertaken only when recommended by that Department.

"Further improvement of wildlife habitat could be achieved by the planting of wildlife food and cover plants on eroded areas, gullies, steep banks, and in strips along fencerows and driveways. Such plantings would provide food and cover for wildlife and additionally serve as windbreaks, prevent erosion, and beautify the landscape.

"It is recommended:

"1. That clearing of timber be kept at a minimum during construction of the farm ponds, floodwater retarding structures, and sediment debris basins.

"2. That the stream improvement plans allow for the retention of as much woody vegetation as possible along the stream banks.

"3. That the basins of farm ponds and floodwater retarding structures be disked and planted to small grains adaptable to the area upon completion and prior to storage of water.

"4. That, when practicable, the floodwater retarding structures and farm ponds be fenced and, if necessary for livestock watering, a watering device be installed below the dam and outside of the fenced enclosure.

"5. That lands adjacent to the periphery of farm ponds and floodwater retarding structures be planted into grass to prevent soil erosion and runoff of silt into the basins of these impoundments.

"6. That farm ponds and other structures be stocked with fish upon the advice of the Texas Parks and Wildlife Department.

7. That eroded areas, gullies, steep banks, and strips along fencerows and driveways be planted with plants that are of value to wildlife for food and cover and which also will prevent soil erosion, provide windbreaks, and beautify the landscape."

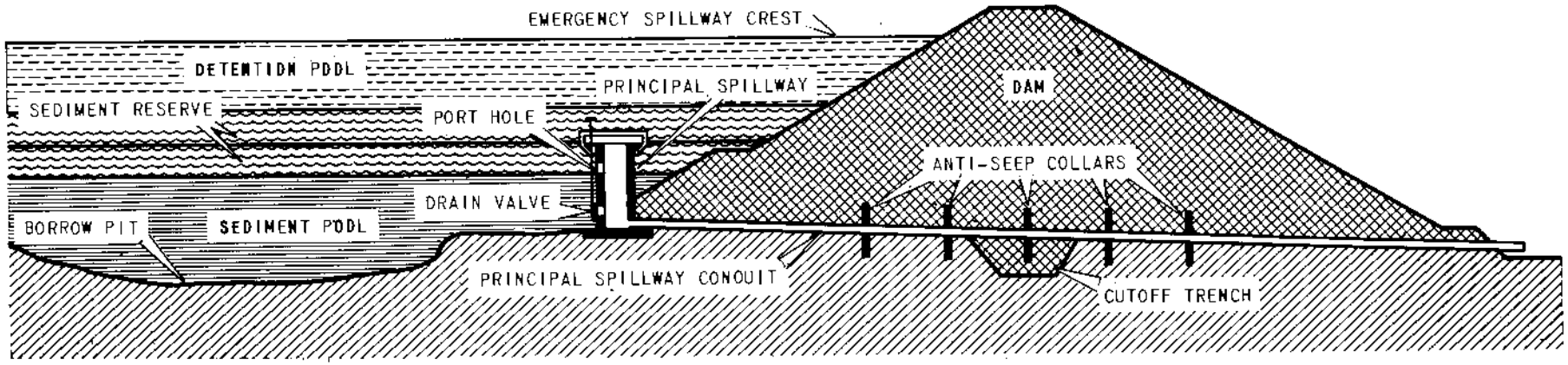


Figure 1

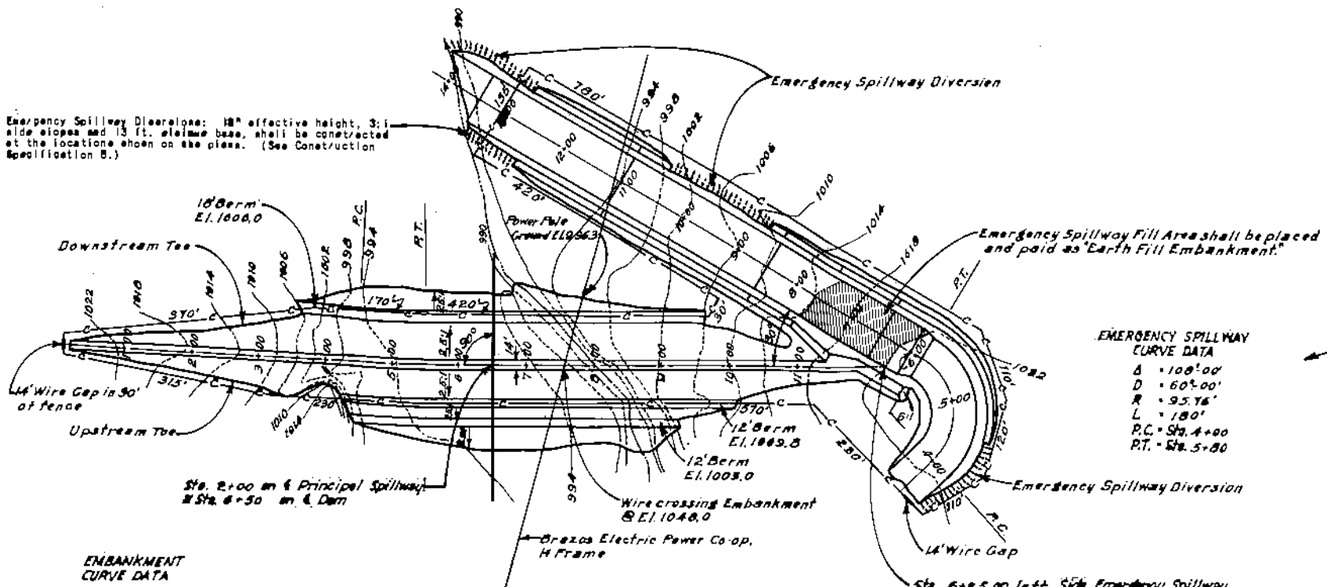
SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

A stripping of 6" topsoil shall be placed in Emergency Spillway and on all Earth Fill Areas. (See Construction Specification 20C.)

Emergency Spillway Discharge: 18" effective height, 3:1 side slopes and 13 ft. minimum base, shall be constructed at the locations shown on the plans. (See Construction Specification 8.)

FENCE LEGEND

—— C —— C ——New fence to be constructed under this contract.

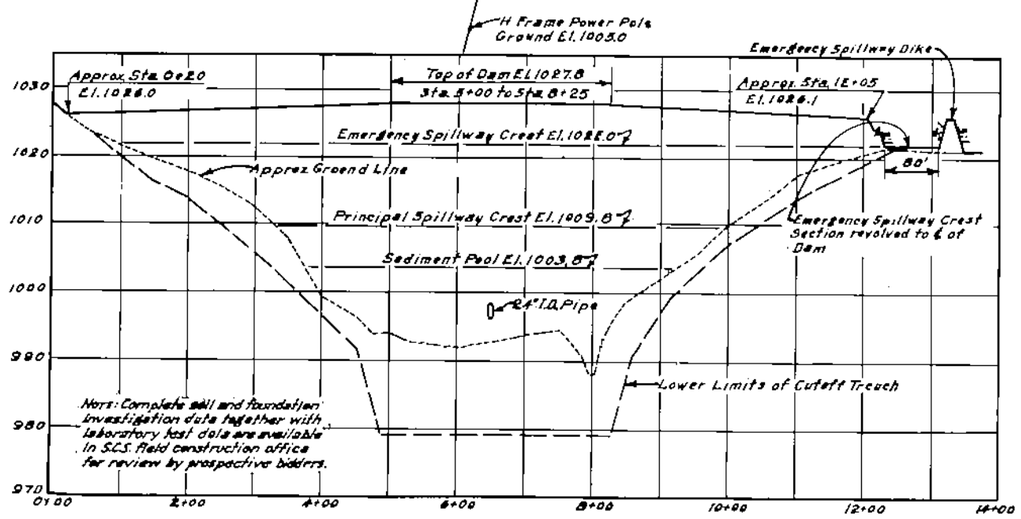


EMBANKMENT CURVE DATA
Δ = 4° 48'
D = 4° 48'
R = 1193.89'
L = 100.0'
P.C. = Sta. 4+50
P.T. = Sta. 5+50

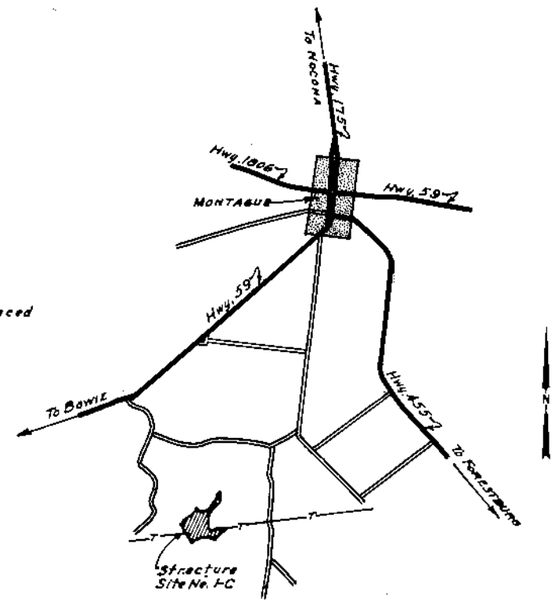
EMERGENCY SPILLWAY CURVE DATA
Δ = 108° 00'
D = 60° 00'
R = 95.76'
L = 180'
P.C. = Sta. 4+00
P.T. = Sta. 5+80

PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 300 400 500
SCALE IN FEET



PROFILE ON ℄ OF DAM



Structure site is located 5.0 miles south and 2.0 miles west of Montague, Montague County, Texas.

VICINITY MAP

1 0 1 2 3 4
SCALE IN MILES

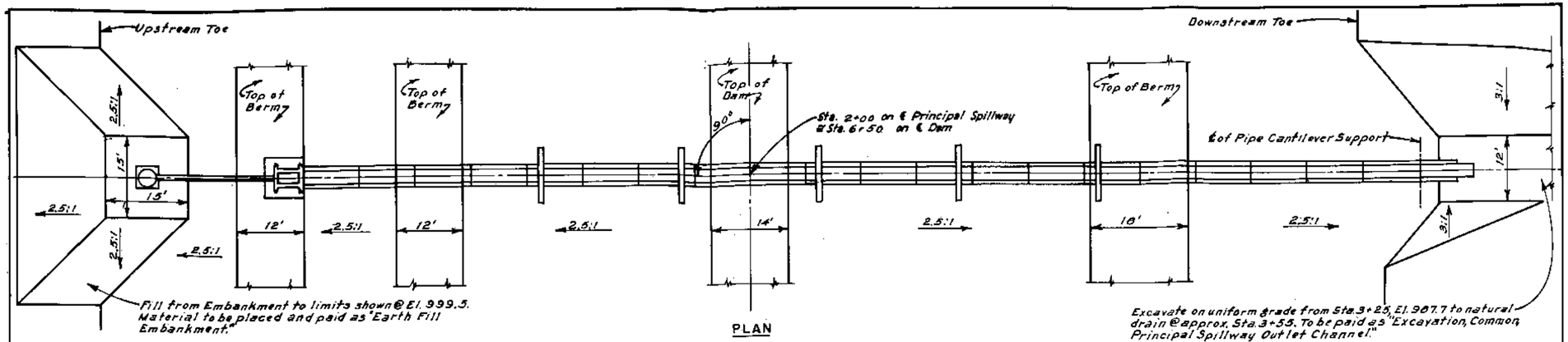
Dozer pits excavated during Soil and Foundation Investigation and not recovered by earthen construction operations, shall be filled, levelled and graded by the contractor. (See Construction Specification 8).

Brazos Electric Power Co-op Line to remain in place.

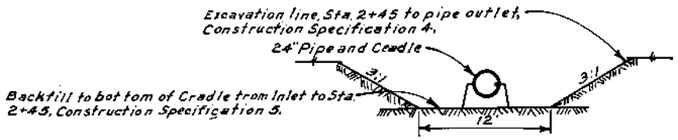
Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	R.V.S. & J.A.B.	11-65	Approved by: [illegible]
Drawn	B.W.P. & J.A.B.	11-65	
Traced	T.F.R.	11-65	
Checked	R.V.S. & B.W.T.	11-65	Drawing No. 4-E-20,756



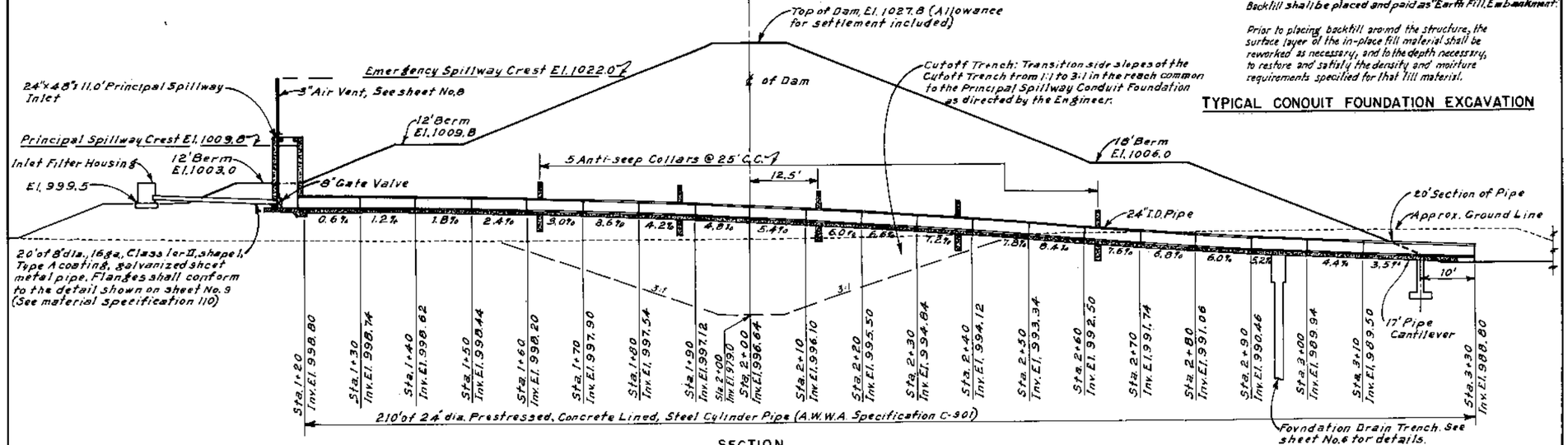
PLAN



Excavation shall be paid as "Excavation Common Foundation" Backfill shall be placed and paid as "Earth Fill, Embankment."

Prior to placing backfill around the structure, the surface layer of the in-place fill material shall be reworked as necessary, and to the depth necessary, to restore and satisfy the density and moisture requirements specified for that fill material.

TYPICAL CONDUIT FOUNDATION EXCAVATION



SECTION

PRINCIPAL SPILLWAY

Figure 2a

TYPICAL FLOODWATER RETARDING STRUCTURE

STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	R.V.S.	Date 10-65	Approved by: ...
Drawn	R.V.S.	10-65	
Traced	T.F.R.	11-65	
Checked	R.V.S. & G.W.T.	11-65	Sheet No. 4 of 14

Drawing No. 4-E-20,756

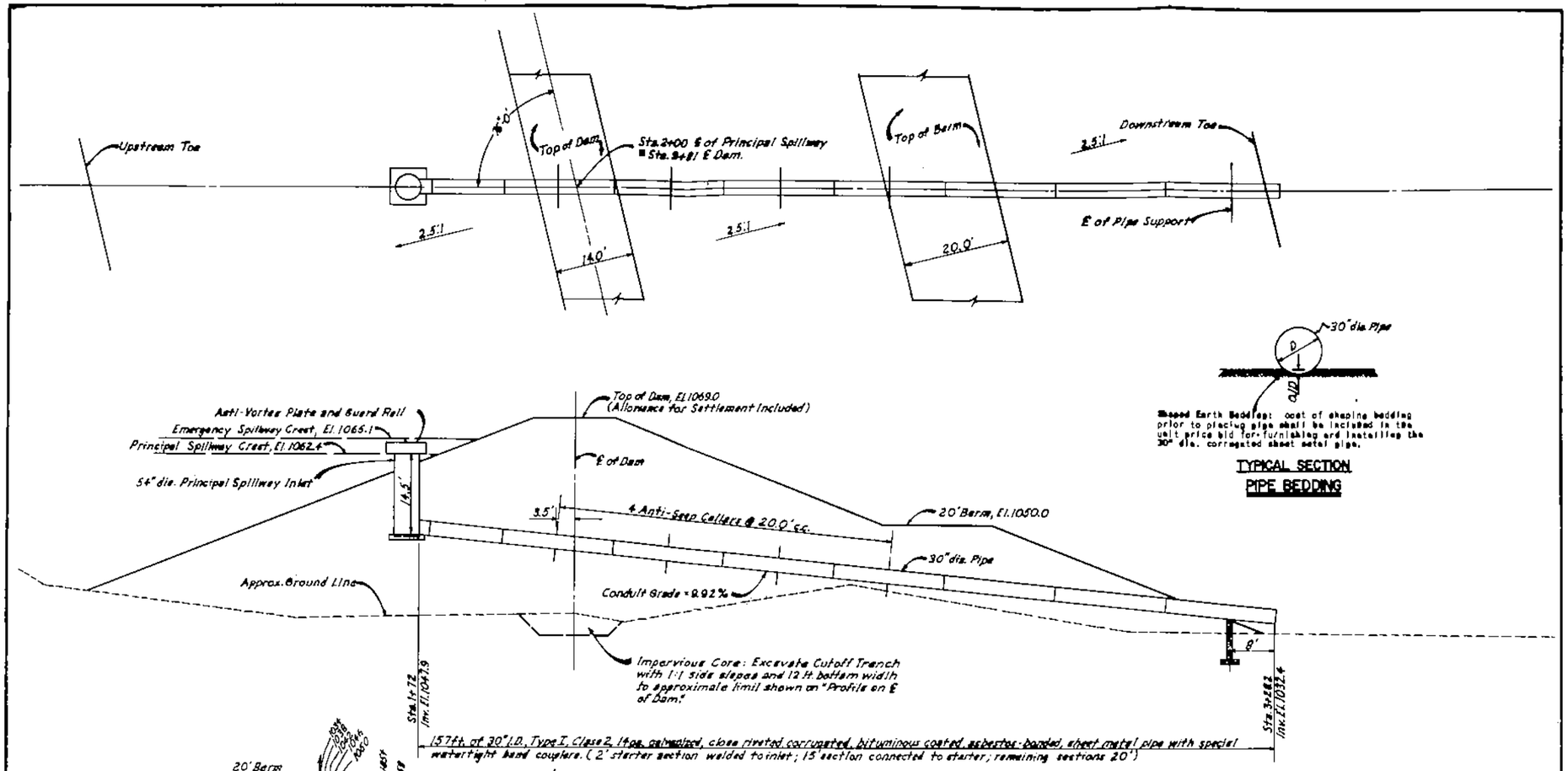


Figure 3

TYPICAL DEBRIS BASIN

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	M.D.K.	4-65
Drawn	M.D.K.	6-65
Traced	K.R.H.	5-65
Checked	M.D.K. & G.H.T.	5-65

Approved by

Sheet No. 1 of 1 Sheets

4-E-21899

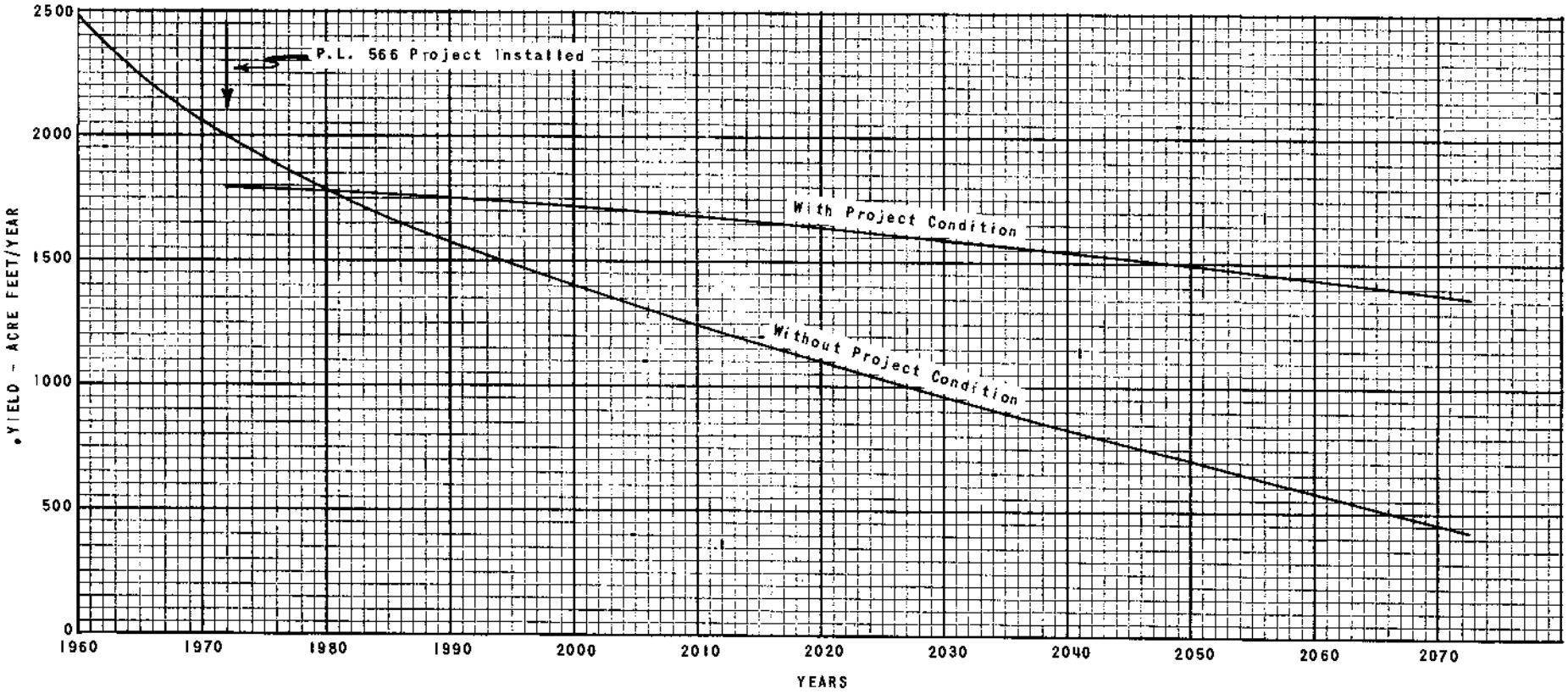


FIGURE 4

TIME YIELD CURVE
FOR
LAKE NOCONA, TEXAS
FARMERS CREEK WATERSHED

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TEMPLE, TEXAS

USDA-SCS-FORT WORTH, TEX 1966

5-66 4-N-21706

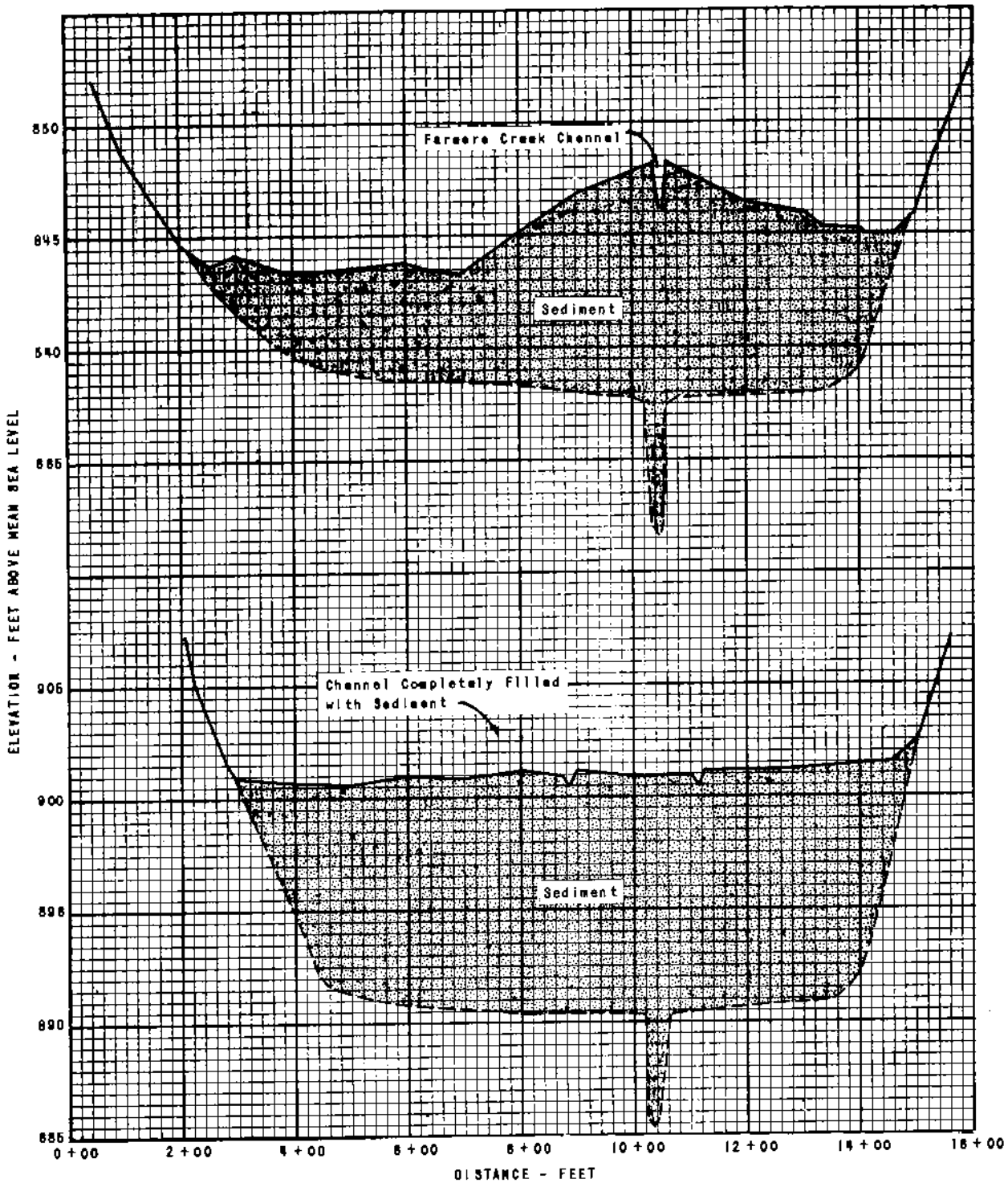


FIGURE 5

TYPICAL VALLEY CROSS SECTIONS
SHOWING
SEVERITY OF SEDIMENT DEPOSITION
FARMERS CREEK WATERSHED

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TEMPLE, TEXAS

5-68 4-N-21707

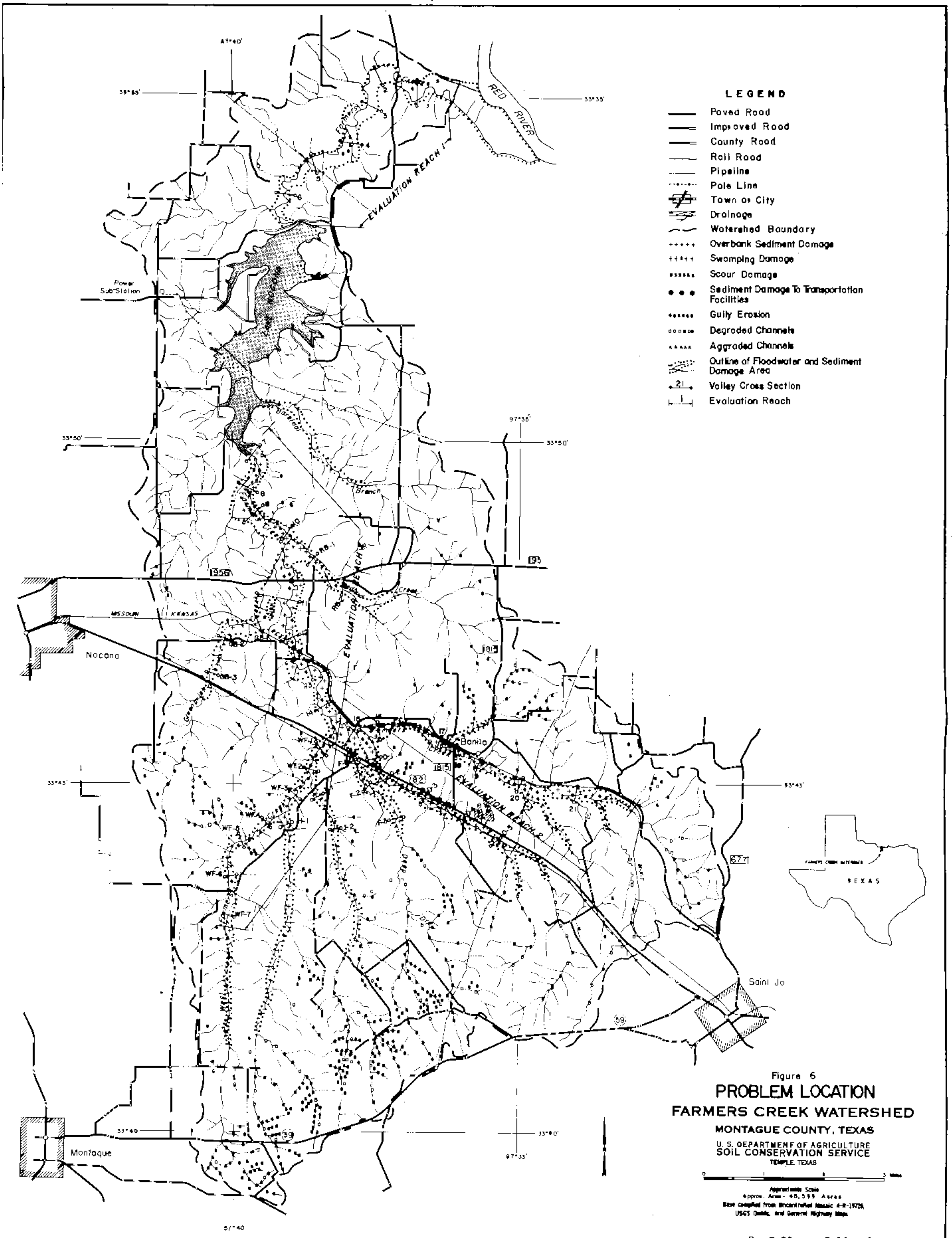


Figure 6

PROBLEM LOCATION

FARMERS CREEK WATERSHED

MONTAGUE COUNTY, TEXAS

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

Rev. 7-66 3-66 4-R-21265

Revised 3-66 4-R-19727

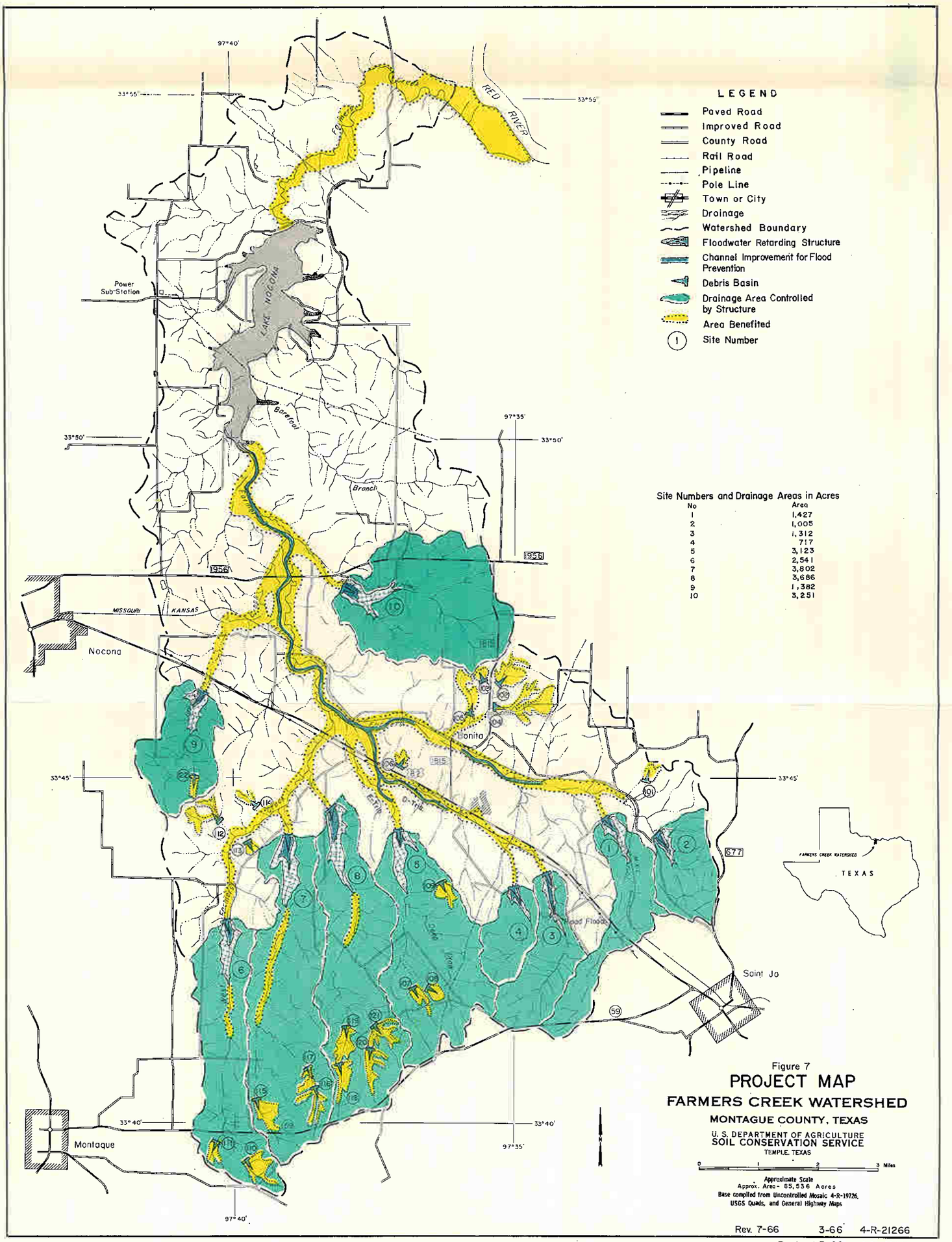


Figure 7

PROJECT MAP

FARMERS CREEK WATERSHED

MONTAGUE COUNTY, TEXAS

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

Rev. 7-66 3-66 4-R-21266

Revised 3-66 4-R-19727