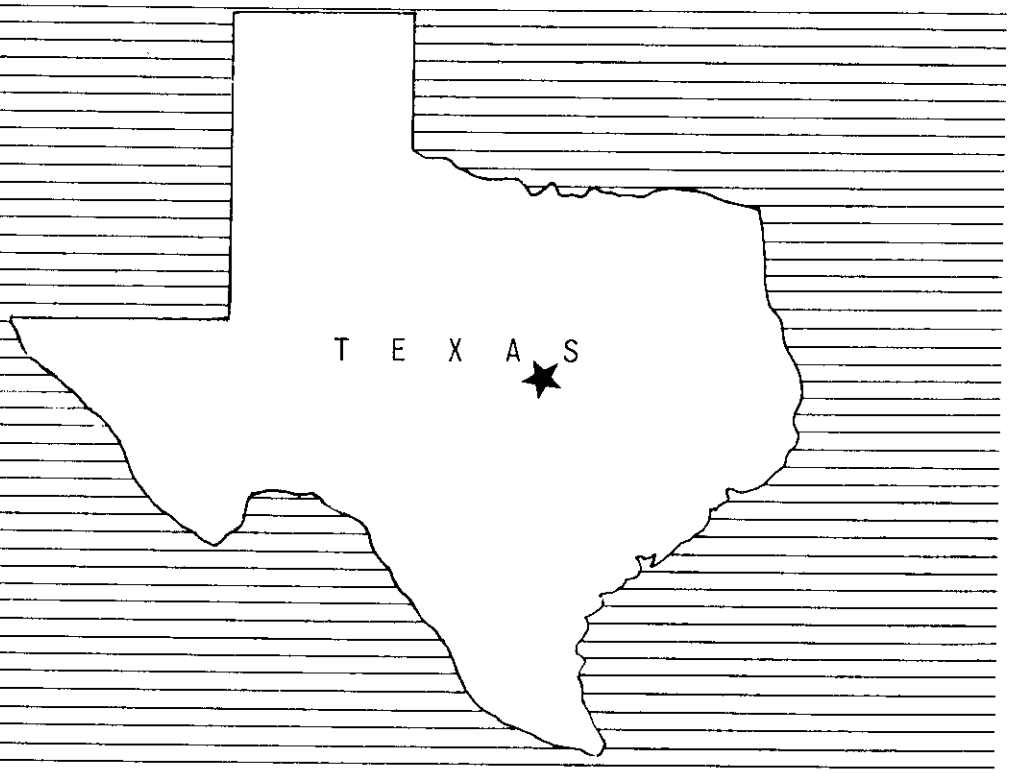
WATERSHED WORK PLAN

FOR WATERSHED PROTECTION AND FLOOD PREVENTION

HOG CREEK WATERSHED

BOSQUE, CORYELL, HAMILTON
AND McLENNAN COUNTIES, TEXAS



January 1968

4-27231 5-69
USDA-SCS-FORT WORTH, TEX 1969

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WATERSHED WORK PLAN AGREEMENT

between the

Bosque Soil and Water Conservation District
Local Organization

Hamilton-Coryell Soil and Water Conservation District
Local Organization

McLennan County Soil and Water Conservation District
Local Organization

Bosque County Commissioners Court
Local Organization

Coryell County Commissioners Court
Local Organization

McLennan County Commissioners Court
Local Organization

Hog Creek Watershed Association
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 Hog 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 Hog 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;

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. 15.1 - 15.12), 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.

Bosque Soil and Water Conservation District
Local Organization

By J. W. Hardcastle
J. W. Hardcastle
Title Chairman

Date March 5, 1969

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

adopted at a meeting held on Feb. 13, 1969

(Secretary, Local Organization)
J. F. Wade
Date March 5, 1969

Hamilton-Coryell Soil and Water Conservation District
Local Organization

By O. C. King
O. C. King
Title Chairman

Date March 5, 1969

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

adopted at a meeting held on Feb. 11, 1969

(Secretary, Local Organization)
Paul Hinson
Date March 5, 1969

McLennan County Soil and Water Conservation District
Local Organization

By Dave Simons
Dave Simons

Title Chairman

Date March 5, 1969

The signing of this agreement was authorized by a resolution of the governing body of the McLennan County Soil and Water Conservation District
Local Organization

adopted at a meeting held on 21 February 1969

Harry F. Holland, Jr.
(Secretary, Local Organization)
Harry F. Holland Jr.

Date March 5, 1969

Bosque County Commissioners Court
Local Organization

By E. W. McGee
E. W. McGee

Title County Judge

Date March 5, 1969

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

adopted at a meeting held on February 10, 1969

Jimmie B. Gill
(Secretary, Local Organization)
Jimmie B. Gill

Date March 5, 1969

Coryell County Commissioners Court
Local Organization

By Norman C. Storm
Norman C. Storm
Title Coryell Co. Judge

Date 4-14-1969

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

adopted at a meeting held on 4-14-69

Rebel J. Henson
(Secretary, Local Organization)
Coryell Co. Clerk
Rebel J. Henson

Date 4-14-1969

McLennan County Commissioners Court
Local Organization

By Raymond L. Mossman

Title COUNTY JUDGE

Date April 22, 1969

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

adopted at a meeting held on April 22, 1969

FRANK DENNY, County Clerk
(Secretary, Local Organization)
By Marianne J. Berkeley deputy
Date April 22, 1969

Hog Creek Watershed Association
Local Organization

By Evans Ficklin
Evans Ficklin

Title Chairman

Date March 5, 1969

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

adopted at a meeting held on March 5, 1969

Vernon Smith
(Secretary, Local Organization)
Vernon Smith

Date March 5, 1969

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

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

HOG CREEK WATERSHED
Bosque, Coryell, Hamilton, and McLennan Counties, Texas

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

Prepared By:

Bosque Soil and Water Conservation District

Hamilton-Coryell Soil and Water Conservation District

McLennan County Soil and Water Conservation District

Bosque County Commissioners Court

Coryell County Commissioners Court

McLennan County Commissioners Court

Hog Creek Watershed Association

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
January 1968

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WATERSHED WORK PLAN

HOG CREEK WATERSHED
Bosque, Coryell, Hamilton and McLennan Counties, Texas

ADDENDUM

Since the preparation of this watershed work plan, the Federal interest rate for benefit and cost evaluations has been increased from 3.25 percent to 4.875 percent.

As a result, annual equivalent costs for the installation of these structural measures will increase from $21,759 to $31,580. The total average annual cost of structural measures (amortized total installation cost, plus operation and maintenance costs) will be increased to $33,110. Average annual benefits, excluding secondary benefits, accruing to structural measures will change to $36,094, resulting in a benefit-cost ratio of 1.1 to 1.0.

Total average annual project benefits, including secondary benefits, will change to $40,033, resulting in a benefit-cost ratio of 1.2 to 1.0.

WATERSHED WORK PLAN

HOG CREEK WATERSHED
Bosque, Coryell, Hamilton, and McLennan Counties, Texas

SUMMARY OF PLAN

General Summary

This work plan for watershed protection and flood prevention for the Hog Creek watershed was prepared by the Bosque, the Hamilton-Coryell, and the McLennan County Soil and Water Conservation Districts, the Commissioners Courts of Bosque, Coryell, and McLennan Counties, and the Hog Creek Watershed Association, 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 the 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 for the development of the work plan was provided by the Texas State Soil and Water Conservation Board and the Soil Conservation Service.

Hog Creek watershed, comprising an area of 91.34 square miles (58,460 acres), is located in Central Texas and lies to the west of the city of Waco. It heads in southwestern Hamilton County and flows across northeastern Coryell, southwestern Bosque, and western McLennan Counties, and empties into Lake Waco.

Approximately 40 percent of the watershed is cropland, 58 percent is grassland, and 2 percent is in miscellaneous uses.

The only Federal lands in the watershed are located in Lake Waco.

The principal problem in the watershed is frequent flooding on about 4,872 acres of bottomland along Hog Creek and its tributaries.

Average annual direct damages to agricultural properties amount to $36,399. This includes damages to crops and pastures and to other agricultural properties such as fences and livestock, and loss in productivity by flood plain soils as the result of erosion and deposition of infertile sediment. Nonagricultural damage averages $7,348 annually. This is the result of sediment deposition to Lake Waco and floodwater damages to roads and bridges. Indirect damages are estimated to average $4,375 annually.

The work plan proposes installing, during a 5-year period, a project for the protection and development of the watershed at a total estimated installation cost of $1,553,635. The share of this cost to be borne by Public Law 566 funds is $570,410. The share to be borne by other than

Public Law 566 funds is $983,225. In addition, the sponsors will bear the entire cost of operation and maintenance.

Land Treatment Measures

Needed land treatment measures will be applied at an accelerated rate on 8,050 acres of cropland and 22,499 acres of grassland in addition to the maintenance of those already applied. These measures will improve the hydrologic condition of both cropland and grassland. This improvement in soil condition and cover will reduce sediment to floodwater retarding structures below and will effect some reduction in flooding.

The installation cost of these land treatment measures is estimated to be $911,381, of which $880,812 will be from funds other than Public Law 566. Public Law 566 funds will provide $30,569 in order to accelerate technical assistance needed for the application and maintenance of these measures.

Structural Measures

The structural measures included in the plan are 2 floodwater retarding structures, and 44,700 feet of stream channel improvement.

The estimated total cost of structural measures is $642,254, of which the local share is $102,413, and the Public Law 566 share is $539,841. The local share of the cost consists of land rights and project administration (table 1).

Benefits

The reduction in floodwater, sediment, and erosion will directly benefit the owners and operators of about 100 farms and ranches in the watershed, as well as all the residents of the city of Waco, who depend on Lake Waco for a water supply. About 3,670 acres of the 4,872 acres of flood plain will benefit from the structural measures. Damages after project installation will be reduced from $48,122 to $14,083 annually, or 71 percent. The average annual primary benefits accruing to structural measures are estimated to be $36,323, of which $31,317 are damage reduction benefits, $2,942 are benefits resulting from more intensive land use, and $2,064 are incidental benefits. Secondary benefits will amount to $3,962 annually in the immediate locale.

The ratio of the total annual benefits ($40,285) resulting from the installation of the structural measures to the annual cost ($23,289) is 1.7 to 1.0.

Benefits from land treatment measures are estimated to amount to $2,722 annually.

Provisions for Financing Local Share of Installation Cost

The Commissioners Courts of Bosque and Coryell Counties have the power of taxation and eminent domain under applicable State laws. Funds for the local share of installing the structural measures will be provided by these counties from taxes now being levied.

Operation and Maintenance

Land treatment measures for watershed protection will be operated and maintained by landowners or operators of the farms and ranches upon which the measures will be installed under agreement with the Bosque, the Hamilton-Coryell, and the McLennan County Soil and Water Conservation Districts.

The Hog Creek Watershed Association will have coordination responsibility for the operation, maintenance, and inspection for all structural measures, but the operation, maintenance, inspection, and financing will be the responsibility of the commissioners court of the county in which the various structures are located.

The estimated average annual value of operation and maintenance is $1,530.

DESCRIPTION OF THE WATERSHED

Physical Data

Hog Creek watershed is located in Central Texas immediately west of the city of Waco. Hog Creek, a tributary of the Bosque River, is part of the Brazos River Basin. It heads in southeastern Hamilton County, flows across northeastern Coryell County, southwestern Bosque County, and western McLennan County and empties into Lake Waco. The drainage is long and narrow, having a total length of approximately 36 miles and an average width of 2½ miles. The major tributaries include South Fork, Hurst Branch, and Live Oak Creek, all of which flow into Hog Creek in the upper part of the watershed. The total drainage area is 58,460 acres or 91.34 square miles.

The watershed lies within the Lampasas Cut Plain physiographic area. The streams are deeply incised into a gently rolling, southeasterly sloping plain. A moderately wide flood plain of up to 2,500 feet occurs in the lower reach. A narrow flood plain of less than 400 feet in width and confined between steep walls of hard limestone occurs in the central reach. Relatively wide flood plains of up to 1,000 feet occur upstream from the incised reach on the mainstem and South Fork of Hog Creek, and on Live Oak Creek and Hurst Branch. The beds of most streams are on limestone bedrock in all reaches except in the headwaters area. Elevations above mean sea level range from 455 feet at Lake Waco to 1,220 feet on the upper watershed divide.

The watershed is underlain by rocks of Lower Cretaceous age. Formations of the Washita group predominate. Outcrops of the Edwards limestone and

the Comanche Peak limestone of the Fredericksburg group are confined to exposures along the valleys and streambeds in the central and upper reaches. Small areas of Quaternary age deposits occur as alluvium along the valleys and terrace deposits in the lower part near Lake Waco.

The porous Edwards limestone is an important shallow ground-water bearing formation. Permanent spring flow from this formation feeds Hog Creek and some of the major tributaries in the upper and central reaches. Hurst Springs on Hurst Branch, located about 5 miles northeast of Turnersville in Coryell County, is a well-known permanent spring. Volumes of flow from most of the springs vary with the seasons and the rainfall.

Mineral resources of economic value in and near the watershed include the alluvial and terrace limestone gravel deposits, limestone from the Edwards formation, and oil from the Paluxy formation. Terrace gravel deposits occur along the north side of the flood plain from the central reach downstream to the extensive gravel deposits of the Bosque River system around Lake Waco. These Bosque gravels are noted for their outstanding properties as road building material and are utilized in the metropolitan area of Waco as well as for county roads in the watershed. The almost pure limestone of the Edwards formation is mined for lime production in the vicinity of the watershed. Minor oil production from shallow wells in the South Bosque field occurs in the lower portion of the watershed.

Soils of the watershed are predominantly of the Grand Prairie Land Resource Area. They consist of deep to shallow and slowly to moderately permeable dark-colored clays which developed from marl and limestone bedrock under a tall grass prairie. Deep soils of the San Saba and Crawford series on the flatter uplands and the Houston Black series on the terrace deposits are extensively cultivated. Shallow and very shallow stony soils of the Tarrant and Denton series on the rolling uplands and along the steeply incised valleys are used for rangeland. The alluvial soils of the flood plain consist mainly of the Frio and Frio-like series. These fertile clayey soils are used mainly for cultivation and large areas have been severely damaged by scour.

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

Land Use	Acres	Percent
Cropland	23,367	40
Grassland	34,039	58
Miscellaneous[1/]	1,054	2
Total	58,460	100

1/ Roads, railroads, villages, and farmsteads.

Average annual rainfall is 32 inches. The months of April and May normally receive the greatest amounts; however, rainfall is fairly well distributed throughout the year. The average January temperature is 38° Fahrenheit and

the July average is 95° Fahrenheit. The average date of the last killing frost in the spring is March 10 and that of the first killing frost in the fall is November 15, resulting in an average growing season of 250 days.

Economic Data

Hog Creek watershed is located in portions of four Central Texas counties. A small acreage in the upper reaches is in Hamilton County. The balance of the watershed is in Coryell, Bosque, and McLennan Counties. Hamilton and Bosque Counties depend heavily upon agriculture for their incomes. Livestock and associated products account for about 70 percent of the agricultural income for these two counties. Coryell County, formerly an agricultural county much like the aforementioned, was influenced tremendously during World War II by the creation of Fort Hood, a massive military installation and one of the primary training centers of this country. The immediate postwar period saw a decline in both population and income in Coryell County; however, both have increased by about 50 percent since the 1960 census. Agriculture is an important segment of the economy of this county. About two-thirds of the agricultural income is derived from livestock and poultry. Although McLennan County is one of the leading agricultural counties in the State, it composes the Waco metropolitan area and as such, its agricultural income is overshadowed by the vast industrial complexes located in the city of Waco and the surrounding area. About half of the agricultural income is derived from livestock and its associated products and the balance from crops, primarily cotton and grain sorghum.

The watershed lies in an area famed locally for its natural beauty. This beauty has resulted in portions of the watershed being included on the tour of 1 of the 10 "Texas Travel Trails" recently proclaimed by the Governor of the State. Hog Creek, fed by springs from the Edwards limestone formation, affords many visitor-days of recreation for people of the surrounding area. The recreation is primarily in the form of fishing, swimming, and picnicking. The deer population of this area has increased tremendously during the past few years, and this has resulted in an additional source of income for landowners in the form of hunting leases, either on a day or season basis. Revenue from dove and quail hunting also contributes to the landowners' incomes in some cases.

The flood plain lands are used as follows: sorghum for hay and grazing, 24 percent; corn, 7 percent; grain sorghum, 6 percent; oats, 4 percent; cotton, 1 percent; pasture, 57 percent; and miscellaneous uses, 1 percent. During the 1930's and through the World War II era, a higher percentage of the flood plain was used for crops requiring intensive management. Spiraling labor, equipment, and supply costs, however, have forced farm operators to manage these lands less intensively.

There are approximately 273 farms, most of which are owner operated, averaging 210 acres in size, with an average value of $31,500. Approximately 250 of these are family-type operations. A relatively small

percentage of these farms are low income producing units; however, 50 percent or more of these farm families have at least one member employed on an off-farm job, either full or part-time. At the present about 100 of these farms, most of which are of the family type, suffer flood damages.

The communities of Mosheim and Ocee are located within the watershed; however, most of the needed supplies and services for the local populace are obtained in the towns of Valley Mills, Clifton, McGregor, Gatesville, or the city of Waco, all of which are located within a few miles of the watershed. Good highways and railroads link these cities with other population and marketing centers in all directions.

Approximately 214 miles of paved roads and 244 miles of unpaved roads serve the watershed.

Land Treatment Data

Soil Conservation Service Work Units at Meridian, Hamilton, Gatesville, and Waco serve the Bosque, the Hamilton-Coryell, and the McLennan County Soil and Water Conservation Districts.

These districts pioneered the movement of soil and water conservation in the State of Texas, and many fine examples of the quality of the planning, application, and maintenance of needed conservation measures are in evidence today.

Leaders of these soil and water conservation districts have long recognized the need for and have advocated the use of each acre of land within its capabilities and its treatment in accordance with its needs. They have worked long and diligently toward their goal of proper use and treatment of all land within their districts.

There are 273 operating units in the watershed. Basic soil and water conservation plans have been developed on 180, or 66 percent, of these, representing 78 percent of the agricultural land in the watershed. Cooperators with the soil and water conservation districts have applied about 58 percent of the needed conservation measures on cropland and about 35 percent of the needed measures on grassland. Table 1A lists the practices which have been applied. The total cost of applying these practices is estimated at $346,609.

Fish and Wildlife Resource Data

The fish and wildlife habitat populations in the watershed are described by the Bureau of Sport Fisheries and Wildlife as follows:

> The soils in the watershed are calcareous, crumbly, granular clay. They range from very shallow to deep, and are moderately to slowly permeable. Vegetation consists mainly of buffalo, grama, little bluestem, and Indian grasses, and other short,

mid, and tall grasses. The stony and shallow soils support growths of oaks and juniper trees. Scattered mesquite and hackberry trees occur on the deeper soils. The dominant bottomland trees are elm, hackberry, pecan, and cottonwood.

. . . . . .

Fish habitat in the watershed is found in Hog Creek, farm ponds, and that portion of Waco Reservoir which inundates the lower reach of Hog Creek. Principal fish species in the watershed are largemouth bass, white crappie, bluegill, channel catfish, flathead catfish, black bullhead, smallmouth buffalo, and carp.

Stream and farm pond fishing for largemouth bass, white crappie, and bluegill is heavy even though landowners permission is needed for access. Waco Reservoir supports heavy fishing for largemouth bass, white crappie, channel catfish, flathead catfish, black bullhead, and bluegill.

There is no commercial fishing in streams and farm ponds in the watershed, and none is expected to develop in the future. Waco Reservoir supports a commercial fishery for smallmouth buffalo and carp.

. . . . . .

Principal wildlife species in the watershed are white-tailed deer, bobwhite, mourning dove, fox squirrel, cottontail, waterfowl, raccoon, ring-tailed cat, and gray fox.

Deer populations are gradually increasing in the watershed and hunting for them is moderate. Bobwhites are plentiful on suitable habitat, but nesting cover is scarce because of intensive cultivation. Bobwhite hunting also is moderate. The most intensive hunting is for mourning doves which are found throughout the project area. Hunting for fox squirrels, cottontails, and gray foxes is insignificant.

The small portion of the watershed inundated by Waco Reservoir receives moderate waterfowl use during migration seasons. Waterfowl hunting in the watershed is not heavy.

Raccoons and ringtails are abundant in the watershed but support only moderate sport hunting and light fur trapping.

About one-half of the hunting in the watershed is by leasing. The remaining is by landowners permission.

WATERSHED PROBLEMS

Floodwater Damage

Damage to 4,872 acres of agricultural land as a result of flooding is extensive, as is damage to other agricultural property, roads, bridges, and low-water crossings. The bulk of this damage occurs on 2,757 acres of agricultural land below the confluence of Live Oak Creek with Hog Creek. The flood plain is broad and intensively managed below the juncture of these streams. The upper reaches of Hog Creek suffer insignificant damage when compared to the lower reach because the flood plain is narrow and the land is used less intensively. Crop and pasture damage on Hurst Branch is extensive due to the high percentage of cropland involved although the acreage flooded is relatively small. Damage to crops and pasture and to other agricultural properties is significant on Live Oak Creek. Normal delivery of mail to the community of Mosheim is frequently interrupted by inundation of a low-water crossing on Live Oak Creek.

Major floods inundating more than half of the flood plain occur on an average of once every two years. Extremely serious flooding has occurred during the years 1926, 1931, 1936, 1937, 1942, 1949, 1950, 1953, 1955, 1957, 1959, 1962, 1964, and 1965. The flood of October 1959, having a 4 percent chance of occurrence, produced a peak discharge of 15,400 c.f.s. at the stream gage on Hog Creek near Crawford, Texas, and inundated an estimated 4,072 acres of flood plain. The maximum flood of record, which occurred in September 1936, produced a peak discharge of 22,500 c.f.s. at the stream gage location, flooded 4,872 acres, and had a 1 percent chance of occurrence.

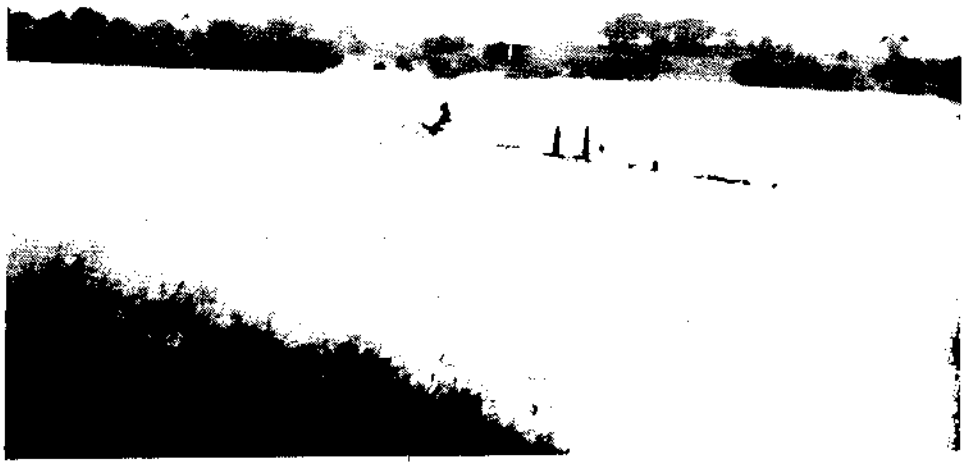
Because of the ever-present flood threat and the resulting flood plain scour, flood plain lands are managed in a manner that results in production well below the actual potential of the land. The value of this land varies from $100 to $300 per acre and the net value of production varies from $4.50 to $41 per acre.

Under nonproject conditions the estimated average annual direct monetary damage by floodwater is $29,494. Of this amount, $19,789 is crop and pasture; $6,991, other agricultural; and $2,714, road and bridge. Indirect damage, such as interruption of travel, re-routing of school buses and mail routes, interruption of livestock feeding and management regimen, losses sustained by business establishments of the area, and similar losses, is estimated at $4,375 annually.

Erosion Damage

Severe flood plain scour damage is a major problem in the watershed. Depth of the fertile clay and clay loam topsoil on the flood plain varies from less than 3 feet to more than 6 feet over gravelly materials and calcite cemented gravels. Removal of the topsoil by scouring is destroying the

The flood of October 1959 inundated 4,072 acres of flood plain. Note the water well surrounded by floodwater.



Hog Creek on a rampage during May 1965.

Floodwaters surround vacation cabin during flood of May 1965. The cabin is about 7 feet above the ground.

Floodwater isolated the barns from the residence during flood of May 1965. Estimated damages to crops and pastures, other agricultural properties, flood plain soils, and nonagricultural property average $29,494 annually.

The flood of January 1965 caused extensive erosion damage to this cultivated field adjacent to Live Oak Creek.

The flood of May 1965 inundated this county road. Average annual damages to roads and bridges exceeds $2,700.

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productive capacity of these soils. Approximately 647 acres have been damaged from 10 to 80 percent by this process. Continued scouring is increasing the severity of damage on soils already damaged. More than 80 percent of the topsoil has been lost on 70 acres; 60 percent has been lost on 115 acres; 40 percent has been lost on 191 acres; and 20 percent has been lost on 271 acres. Approximately 108 acres of once productive cropland has been abandoned in the past 15 to 25 years because of damage. It is now in low-grade pasture. An additional 260 acres are destined to be abandoned within the next 15 to 25 years at the present rate of damage. The average annual damage from scour is $9,619.

Sheet erosion rates in the upland are moderate. The estimated average annual gross erosion rate in the watershed is 2,270 tons per square mile. Of this total volume, 79 percent is produced by upland sheet erosion, 20 percent by flood plain scour, and 1 percent by channel erosion.

Sediment Damage

Sediment deposited in Lake Waco from the watershed is a serious problem. This watershed represents only 5.5 percent of the Lake Waco drainage area, but sediment from Hog Creek is carried directly into the lake. The original lake was built in 1930 for municipal water for the city of Waco. New Lake Waco, which completely covers the old dam and reservoir, was completed in 1964 as a multiple-purpose reservoir. A detailed sedimentation survey of the old lake in 1947 showed that more than 44 percent of the original capacity had been lost during the first 17.7 years of life. The application of needed land treatment measures throughout the watershed has reduced the rate of upland erosion significantly. In spite of this reduced rate of upland erosion, it is estimated that an average of 68 acre-feet of sediment from this watershed is being deposited in Lake Waco annually.

The average annual damage from this loss of capacity is estimated at $4,634.

Other sediment damages in the watershed are minor. Overbank deposition of gravels derived from stream bedload were observed in isolated areas. Most of these gravels, however, are deposited on the inside bends of the channels and not on the productive alluvial soils.

Problems Relating to Water Management

The small communities in the area obtain their water from underground sources. Water for rural domestic and livestock is obtained from wells, farm ponds, and streams. Some of the communities and rural residents of the watershed have organized and developed a water system with a loan from Farmers Home Administration.

Opportunities for water-based recreation are available at Lake Waco and Lake Whitney. Hog Creek offers many opportunities for fishing and swimming during years of normal rainfall.

There is no evidence of stream pollution.

PROJECTS OF OTHER AGENCIES

Hog Creek empties into Lake Waco, a multiple-purpose reservoir located on the Bosque River. This reservoir provides a water supply for the metropolitan area of Waco and flood protection to the Bosque River and Brazos River flood plains. The original Lake Waco lost most of its storage capacity in a very few years because of sedimentation. This reservoir will be benefited by the project as a result of the reduction of sediment being deposited in it.

BASIS FOR PROJECT FORMULATION

A reconnaissance and preliminary investigation of the watershed was made by representatives of the Soil Conservation Service and the Hog Creek Watershed Association to determine the location and severity of watershed problems. A map was prepared to show the location of the land being damaged by floodwater, erosion, and sediment.

Meetings were held with the sponsors to discuss their problems, possible solutions, watershed resource development needs, and the formulation of project objectives. Initially the sponsors listed the following objectives:

1. Immediate establishment and maintenance of land treatment measures which contribute directly to watershed protection.

2. Reduction in flood damages by 70 to 75 percent.

3. Development of a multiple-purpose structure to include water storage for recreational use or to augment the flow of Hog Creek during the dry season.

It was agreed that the following steps be taken in order that these objectives be reached:

1. The establishment and maintenance of at least 80 percent of needed land treatment measures by the end of the installation period.

2. The installation of those structural measures needed for detention, orderly release, and disposal of floodwaters.

The location, number, design, and cost of structural measures were determined by the physical, topographic, and geologic conditions in the watershed.

Other influencing factors were improvements, land use, and the location of damage areas.

The topography of the upper and lower portion of the watershed is generally gently rolling and unsuitable for floodwater retarding structures. The topography of the middle portion of the watershed is steep and is suitable for installation of floodwater retarding structures. This necessitated the planning of the floodwater retarding structures in the middle portion of the watershed. Stream channel improvement was planned on Live Oak Creek and Hurst Branch because there are no feasible sites for the installation of floodwater retarding structures. The project will meet the flood prevention objectives of the sponsors where structural measures have been planned. Investigations indicated that it was not feasible to plan structural measures to reduce flooding on the upper mainstem and South Fork of Hog Creek. This flood plain area is predominantly rangeland and suffers very minor monetary flood damages.

The watershed association, after considerable study, decided not to develop a structure to include a recreational development. It was felt that the cost was not justified because of the extensive recreational development at nearby Lake Waco and Lake Whitney.

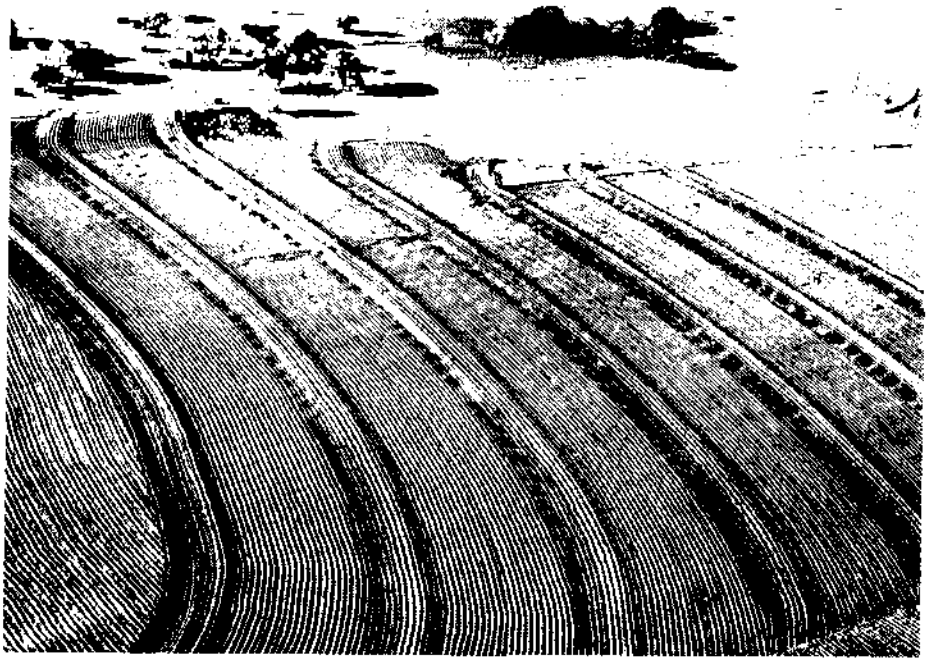
WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

The use of each acre of land within its capabilities and its treatment in accordance with its needs has long been accepted as one of the foundations for the building of a strong and free community, state, or nation. Sponsors of this project are keenly aware of this concept and deem the installation and maintenance of needed land treatment measures as essential.

Soil surveys have been completed on 86 percent of the watershed. The remaining surveys will be made during the first 2 years of the 5-year installation period in order that planning and application of needed conservation measures can be achieved without interruption and on schedule.

In addition to effectively maintaining those land treatment measures already established (table 1A), additional soil and water conservation measures, or combinations of measures, to be applied on cropland include conservation cropping system, contour farming, crop residue use, cover and green manure crops, grassed waterways, terraces, and diversions. Conservation measures which will be applied on grassland include control of invading brush, range seeding where the native seed source is deemed inadequate to permit natural revegetation within a reasonable period, and deferred grazing in order that the better species of grass may become well established. Ponds will be constructed in order to permit more uniform distribution of grazing by livestock. The aforementioned measures, when combined with proper grazing use, will result in the production of large quantities of good quality grasses on a sustained yield basis. Marginal cropland will be converted to pasture by sodding or seeding adapted grasses, and will be managed so as to achieve high production.



This system of parallel terraces helps to control erosion and conserves valuable moisture for crop production. Landowners and operators plan to install 327,692 feet of parallel terraces during the project installation period in addition to what has already been applied.

Properly managed crop residues improve soil structure and fertility, and enable the soil to absorb rainfall at a more rapid rate.

4-27221 15-64

Mechanical control of invading brush, when coupled with sound range management practices, results in good yields and high quality livestock forage, and provides excellent protection to the watershed.

Submarginal cropland being converted to permanent pasture. A mixture of Blackwell switchgrass, sideoats grama, and other good native grasses was planted in May 1959. This picture was taken in May 1960.

4-27231 10-68

Structural Measures

A system of 2 floodwater retarding structures and approximately 44,700 feet of stream channel improvement will be installed to provide protection to those flood plain lands having a significant flood problem and for which protection by structural measures is feasible. The location of the planned structural measures is shown on the project map (figure 3).

Runoff from 46 percent of the watershed will be detained by the floodwater retarding structures. The storage capacity of the floodwater retarding structures is 11,155 acre-feet, of which 2,167 acre-feet are sediment storage and 8,988 acre-feet are floodwater detention storage. These structures will detain an average of 4.01 inches of runoff from the drainage area above them. In addition, an average of 0.97 inch of storage has been allocated for the expected 100-year accumulation of sediment. The principal spillway crest elevation for each structure will be set at the 50-year sediment capacity. The principal spillway of each structure will be ported at the 200 acre-feet capacity.

The emergency spillways will be vegetated. The principal spillways will be the drop inlet type with a cantilever outlet. A combination of principal spillway capacity and retarding storage will assure that the vegetated emergency spillways of floodwater retarding structures will have a maximum of 3.2 percent chance of use at the end of their design life.

The installation of floodwater retarding structure No. 1 will necessitate modifying one pole of a power line crossing the detention pool of the structure.

All of the structure sites are located on hard limestones and soft marls of Lower Cretaceous age. The attitude of these beds is simple with dip to the southeast at about 50 feet per mile. The streambed and lower abutments are on the hard to moderately hard limestones of the Edwards and Comanche peak formations. The upper abutments and emergency spillways are on soft marls, shales, and thin to medium bedded hard limestones of the Washita group.

The alluvial materials in the relatively narrow valleys at both sites consist of silty and gravelly clays (CL and CH) overlying clayey and silty gravels (GC and GM), and poorly graded gravels (GP). These materials are more plentiful at Site 1 than at Site 2. Depths range from 12 to 15 feet at Site 1 and from 6 to 10 feet at Site 2. The sediment pool borrow area will not provide sufficient material for the embankment of floodwater retarding structure No. 2. Additional material will be obtained outside the sediment pool area.

Seasonal streamflow occurs at both sites, with permanent spring flow from the Edwards limestone occurring slightly upstream from Site 2.

The improved stream channels will have the capacity to carry the peak flow of the 1-year frequency flood, which is the capacity required to meet the project objectives.

The beds of the stream channels to be improved are on hard limestone bedrock except in localized areas where clayey sediments and bedload gravels have covered the bedrock. The stream channel banks consist of cohesive, highly plastic clays (CH) and silty clays (CL). The dimensions of the improved channel were proportioned to avoid rock excavation. No channel stability problems are expected. Installation of the Live Oak Creek stream channel improvement will require the modification of two county road bridges in Bosque County.

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

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

EXPLANATION OF INSTALLATION COSTS

Land treatment measures listed in table 1 will be applied by local interests at an estimated cost of $911,381. This includes funds for Public Law 46 and Public Law 566 technical assistance to be provided by the Soil Conservation Service and cost sharing in the establishment of approved conservation measures under the Agricultural Conservation Program as administered by the Agricultural Stabilization and Conservation Service. Included in the above sum is $30,569 of Public Law 566 funds to accelerate technical assistance in order that planning and application of the above land treatment measures may be completed by the end of the 5-year installation period. The estimated cost for application of the various measures is based on present prices being paid by landowners and operators in the area.

The total installation cost of the structural measures is estimated to be $642,254, of which $539,841 is Public Law 566 cost and $102,413 is local cost. Table 2 provides a detailed distribution of costs.

The construction cost includes the engineer's estimate and contingencies. The engineer's estimate is based on the unit cost of construction items planned for each structural measure. The unit cost is 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 costs. The construction cost estimate includes funds for rock excavation in the core trench and emergency spillway of structures Nos. 1 and 2 and for the additional expense of hauling embankment material for structure No. 2.

Engineering and project administration costs are based on Service experience in similar watersheds. The engineering portion of this cost consists of, but is not limited to, detailed surveys, geological investigations, laboratory reports, designs, and cartographic services.

The sponsors' cost for land rights is based on the appraised value of the land, the number of easements required, and the estimated cost of county road and utility modifications. The local cost of project administration is based on experience in other watersheds.

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

Schedule of Obligations

Fiscal Year	Measure	PL 566 Funds (dollars)	Other Funds (dollars)	Total (dollars)
1st	Land Treatment	6,100	170,000	176,100
2nd	Land Treatment	6,100	180,000	186,100
	Structure No. 1	203,352	54,088	257,440
3rd	Land Treatment	6,100	180,000	186,100
	Structure No. 2	281,598	31,175	312,773
4th	Land Treatment	6,200	180,000	186,200
	Live Oak Creek and Hurst Branch Stream Channel Improvement	54,891	17,150	72,041
5th	Land Treatment	6,069	170,812	176,881
TOTAL		570,410	983,225	1,553,635

EFFECTS OF WORKS OF IMPROVEMENT

The installation of all measures will benefit all of the farms and ranches in the watershed. About 100 farms, primarily family-type operations, will benefit directly from reduced flooding as the result of installation of structural measures. Approximately 3,670 acres of valuable flood plain land will receive flood protection benefits from structural measures. About 3,012 acres will be protected by floodwater retarding structures and 658 acres by stream channel improvement. About 182 acres of flood plain, now predominantly low quality pasture, are located in the sediment and detention pools of floodwater retarding structures.

Reduction in average annual flooding varies with respect to location within the watershed. The general locations of the areas benefited from reduction in flooding from the combined program of land treatment and structural measures are presented in the following table:

Evaluation Reach	Location	Average Annual Area Inundated 1/ Without Project (acres)	With Project (acres)	Reduction (percent)
A	Hog Creek - Bottom of Watershed to Live Oak Creek (Cross Sections H-10 through H-18B)	1,000	278	72
B	Hog Creek - From Live Oak Creek to Floodwater Retarding Structure No. 1 (Cross Sections H-6 through H-9)	74	3	96
C	Hurst Branch (Cross Sections HB-1 through HB-1C)	256	48	81
D	Live Oak Creek (Cross Sections LO-1A through LO-4)	378	65	83
	Subtotal	1,708	394	77
X	Hog Creek (Sections H-1A3 through H-2A) and South Fork of Hog Creek (Sections S-1 through S-1B) 2/	933	886	5
TOTAL		2,641	1,280	52

1/ Exclusive of area of flood plain inundated by floodwater retarding structure pools.
2/ Includes area subject to overflow for which no structural control is planned.

Average annual flooding for the entire watershed will be reduced from 2,641 acres under without project conditions to 1,280 acres after project installation, or a reduction of 52 percent.

Average annual flooding on that portion of the flood plain for which protection by structural measures is feasible will be reduced from 1,708 acres to 394 acres, or 77 percent.

The following tabulation, by evaluation reaches, shows the acreages expected to be inundated by floods having 1, 4, and 33 percent chances of occurrence:

Evaluation Reach	Flooded by 1 Percent Chance of Occurrence: Without Project (acres)	Flooded by 1 Percent Chance of Occurrence: With Project (acres)	Flooded by 4 Percent Chance of Occurrence: Without Project (acres)	Flooded by 4 Percent Chance of Occurrence: With Project (acres)	Flooded by 33 Percent Chance of Occurrence: Without Project (acres)	Flooded by 33 Percent Chance of Occurrence: With Project (acres)
A	2,757	1,988	2,447	1,287	841	208
B	255	44	195	22	86	0
C	263	245	207	180	130	72
D	395	354	340	288	233	50
Subtotal	3,670	2,631	3,189	1,777	1,290	330
X 1/	1,202	1,202	883	883	555	555
TOTAL	4,872	3,833	4,072	2,660	1,845	885

1/ Reach X includes flood plain in sediment and detention pools of floodwater retarding structures and that portion of the flood plain in which it is infeasible to install structural measures.

The application of needed land treatment measures is expected to reduce upland sheet erosion rates by 24 percent. Flood plain scour will be reduced by 77 percent. Land now being damaged is expected, in most cases, to recover its former productivity. Damage to Lake Waco as the result of sediment deposition will be reduced by 70 percent.

The effect of the proposed floodwater retarding structures on yield to Lake Waco will be less than 1 percent reduction in average annual runoff. This reduction in inflow to Lake Waco will become less as the sediment pools of the floodwater retarding structures are filled with sediment. This will result in preserving the capacity of Lake Waco by reducing the sediment contribution to the lake from this watershed.

It is expected that about 300 acres of pastureland, now producing little in the way of palatable livestock forage, will be managed more intensively. Proper fertilization, weed control, and livestock management will result in increased income of a stable nature to farm operators. It is not expected that any flood plain land will be shifted from pasture to cropland, nor is it expected that the project will cause an increase in the acreage of crops in surplus supply.

Excellent opportunities for the development of on-farm income producing recreation will become available at and in the vicinity of the 2 floodwater retarding structures. These pools, expected to be open to the general public on either a free or fee basis, will provide water-based recreation such as fishing, hunting, picnicking, and camping. Such facilities are used extensively by youth organizations such as Boy Scouts, Girl Scouts, church groups, etc. These facilities are expected to furnish 3,450 visitor-days of recreation annually. Most of the usage will occur from April through September, but use will be made of these facilities to a limited extent throughout the balance of the year.

Landowners and other private interests have assured the sponsors that they will develop some recreational facilities, including sanitary facilities meeting State and local health agencies' requirements, prior to making the sites available to the general public for recreational uses.

The effects of works of improvement on fish and wildlife habitat are described by the Bureau of Sport Fisheries and Wildlife as follows:

> With the project, the construction of two floodwater retarding structures would benefit fishery resources and increase sport fishing opportunities. The structures would be on private lands and public access would be by landowners permission. The impoundments, in combination with the land treatment measures, would reduce the amount of silt deposited in Waco Reservoir thereby improving fish habitat and prolonging the life of the reservoir. Stream channel improvements would be done in the upper reaches of the watershed and would cause no significant change in fish habitat.
>
> No commercial fishing would be expected to develop under with-the-project conditions, except for that which already exists in Waco Reservoir.
>
> . . . . . .
>
> With the project, flood protection below floodwater retarding structures would improve wildlife habitat for ground nesting species. The floodwater retarding structures would provide watering places for wildlife and resting areas for migrating waterfowl. Stream channel improvements would not significantly affect wildlife because they would occur in areas which are mostly in agriculture and require little clearing.
>
> Conservation cropping systems, contour farming, cover crops, critical area planting, crop residue use, range deferred grazing, farm ponds, grassed waterways, pasture management, pasture and hayland planting, range proper use, range seeding, and adequate protection of cropland, rangeland, and pasture-land would benefit some upland wildlife, such as cottontails. However, conversion of croplands to grasslands would not favor such species as mourning dove and bobwhite. Brush control and

clearing of floodwater structure sites would destroy some valuable upland-game habitat.

There are certain measures that could be included in the project plan that would improve fish habitat and reduce loss of wildlife habitat.

Excellent opportunities exist in the Hog Creek Watershed to develop good quality fish habitat. The addition of a conservation storage pool to any of the proposed floodwater retarding reservoirs would create high quality fish habitat at nominal cost. Similarly, the construction of low water channel dams in Hog Creek would form "water holes" which also would provide high quality fish habitat. Greater use would be made of these facilities if public access were provided to them.

These benefits from damage reduction in the watershed will result in improved living standards for watershed residents. This improvement will be reflected in local support of schools and churches, both so essential to the well-being of present and future generations.

In addition to the aforementioned benefits, there are intangible benefits which will accrue. Residents will feel more secure knowing that the fruits of their labors and investments are not so likely to be washed away at the whim of Mother Nature. They will also appreciate the fact that here is an excellent environment in which to rear their families, in direct contrast with the problems facing a large segment of our population in this country today. These benefits, although real, have not been evaluated, nor have they been used for project justification in any way.

Secondary benefits will accrue to the trade area as a result of increased purchases from those supplying farm equipment, petroleum products, seeds, feeds, fertilizers, and the various services associated with a farming and ranching community.

PROJECT BENEFITS

The estimated average annual monetary damage (table 5) will be reduced from $48,122 to $14,083, or 71 percent. Crop and pasture damage will be reducedd from $19,789 to $6,136, or 69 percent. Other agricultural damage, such as loss of fences, farm equipment, livestock, and other property, will be reduced from $6,991 to $2,345, or 67 percent. Road and bridge damage will be reduced from $2,714 to $690, or 75 percent. Flood plain scour damage, now occurring at the rate of $9,619 annually, will be reduced to $2,256, or 77 percent. Sediment deposition damages to Lake Waco will be reduced from $4,634 to $1,376, or 70 percent.

The general locations of damage reduction benefits attributable to the combined program of land treatment and structural measures are presented in the following tabulation:

Evaluation Reach	Location	Average Annual Damage: Without Project 1/ (dollars)	With Project 1/ (dollars)	Reduction (percent)
A	Hog Creek - Bottom of Watershed to Live Oak Creek (Cross Sections H-10 through H-18B)	35,518	9,513	73
B	Hog Creek - From Live Oak Creek to Floodwater Retarding Structure No. 1 (Cross Sections H-6 through H-9)	1,112	31	97
C	Hurst Branch (Cross Sections HB-1 through HB-1C)	5,756	1,461	75
D	Live Oak Creek (Cross Sections LO-1A through LO-4)	3,178	649	80
	Subtotal	45,564	11,654	74
X	Hog Creek (Sections H-1A3 through H-2A) and South Fork of Hog Creek (Sections S-1 through S-1B) 2/	2,558	2,429	5
TOTAL		48,122	14,083	71

1/ Adjusted Normalized Prices, April 1966
2/ Includes damages on Hog Creek and South Fork of Hog Creek where no structural control is planned

Benefits from the intensification of land use, primarily by fertilization, weed control and proper pastureland management, are expected to accrue at the rate of $2,942 annually. These benefits were discounted to reflect an expected 5-year lag in accrual of full level benefits. The use of the sediment pools of floodwater retarding structures open to the general public is expected to produce incidental recreation benefits of $2,064 annually after deduction of associated costs for cleanup, repair, and replacement of recreation and sanitary facilities, and liability insurance. A gross value of $1 per visitor-day was used for evaluation. Benefits, expected to accrue at full level for the first 40 years of the project, diminish to zero by the end of the 50th year, and to be nonexistent for the balance of the 100-year evaluation period, are discounted accordingly.

Although not considered pertinent from a national viewpoint, secondary benefits will amount to $3,962 annually in the immediate locale. This amount, excluding indirect benefits in any form, results from $3,393 in benefits stemming from the project and $569 in benefits induced by the project.

None of the counties in which the watershed is located have been designated as eligible for assistance under the Economic Development Act. Consequently, no redevelopment benefits were considered.

Other substantial benefits will accrue to the project, such as an increased sense of security, a more satisfying environment in which to work and rear a family, and a deeper sense of well-being, secure in the knowledge that at least some of the hazards involved in wresting a livelihood from the land have been alleviated. These benefits, although extremely important, 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 $23,289. These measures are expected to produce average annual primary benefits of $36,323. The benefit-cost ratio without secondary benefits is 1.6 to 1.0. The ratio of total annual project benefits accruing to structural measures, $40,285, to the average annual cost of structural measures, $23,289, is 1.7 to 1.0 (table 6).

PROJECT INSTALLATION

The project installation period will be 5 years. The general sequence of installation is shown in the tabulation under the schedule of obligations, "EXPLANATION OF INSTALLATION COSTS."

Planned land treatment (table 1) will be accomplished by farm and ranch operators in cooperation with the Bosque, the Hamilton-Coryell, and the McLennan County Soil and Water Conservation Districts during the 5-year installation period. The goal is the adequate treatment of 16,261 acres of cropland and 30,979 acres of grassland by the end of the installation period. To reach this goal, the application of needed land treatment, in addition to what is applied at present, will be achieved as follows:

Land Use	Fiscal Year 1st (acres)	2nd (acres)	3rd (acres)	4th (acres)	5th (acres)	Total (acres)
Cropland	1,610	1,610	1,610	1,610	1,610	8,050
Grassland	4,500	4,500	4,500	4,500	4,499	22,499
Total	6,110	6,110	6,110	6,110	6,109	30,549

The governing bodies of the soil and water conservation districts will assume aggressive leadership in accelerating the land treatment program now being applied.

The Soil Conservation Service will provide additional technical assistance to the soil and water conservation districts to accelerate the planning and application of soil, plant, and water conservation measures. The Agricultural Stabilization and Conservation Service will provide financial assistance for the application of those measures 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 television 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.

Technical assistance needed to install the structural measures will be provided by the Soil Conservation Service.

The Hog Creek Watershed Association will obtain all land rights needed for construction in the name of the county in which the structural measure is located.

The Bosque County Commissioners Court will:

1. Act as the contracting agency for all structural measures. The court will appoint a contracting officer and will provide necessary legal, administrative, and clerical personnel and facilities, supplies, and equipment to advertise, award, and administer the contracts.

2. Determine the legal adequacy of land rights and use its power of eminent domain to obtain all land rights not donated for floodwater retarding structure No. 2, the dam and emergency spillway, and portions of the reservoir area of floodwater retarding structure No. 1, and portions of the Live Oak Creek stream channel improvement.

3. Modify or replace the county road crossings that are affected by the Live Oak Creek stream channel improvement concurrently with or prior to start of construction.

The Coryell County Commissioners Court will:

1. Determine the legal adequacy of land rights and use its power of eminent domain to obtain all land rights not donated for Hurst Branch stream channel improvement, portions of the Live Oak Creek stream channel improvement, and portions of the reservoir area of floodwater retarding structure No. 1.

2. Provide a court order stating that the county road affected by floodwater retarding structure No. 1 will be relocated, or raised 2 feet above the emergency spillway crest elevation at no expense to the Federal government, or closed, or permission granted for temporary inundation, provided equal alternate routes are available.

The McLennan County Commissioners Court will provide court orders stating that the low-water crossings in McLennan County on county roads affected by the release flows from the floodwater retarding structures will be modified, or replaced if necessary, or permission granted for temporary inundation provided equal alternate routes are available.

The structural measures will be installed 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 rights have been obtained for all structural measures or the respective commissioners courts have furnished written statements to the effect that they have the means of securing land rights and the exact date by which all land rights will have been obtained. Following is a schedule, by 6-month periods, for obtaining land rights:

1st 6-month period	Floodwater retarding structures Nos. 1 and 2
2nd 6-month period	Live Oak Creek and Hurst Branch stream channel improvement

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

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

5. 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. 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 $57,034 to finance the cost of technical assistance in planning and application of land treatment measures. This consists of $30,569 of Public Law 566 funds and $26,465 to be provided from Public Law 46 funds (table 1).

It is anticipated that 95 percent of the easements to be acquired will be donated. Out-of-pocket costs for land rights and project administration are expected to be $8,200.

Funds for the local share of the cost of installing the structural measures will be provided by the commissioners court of the county in which the structural measure is located. The structural measures for which each commissioners court is responsible are itemized under "PROJECT INSTALLATION."

Financial and other assistance to be furnished by the Soil Conservation 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 and ranches on which the measures are installed under agreements with the Bosque, the Hamilton-Coryell, and the McLennan County Soil and Water Conservation Districts. Representatives of the districts will make periodic inspections of the completed land treatment measures to determine maintenance needs.

The operation, maintenance, inspection, and coordination of all structural measures will be the responsibility of the commissioners court of the county in which the structural measure is located. The Bosque County Commissioners Court will be responsible for floodwater retarding structures Nos. 1 and 2, and that portion of the Live Oak Creek stream channel improvement located in Bosque County. The Coryell County Commissioners

Court will be responsible for the Hurst Branch stream channel improvement and that portion of the Live Oak Creek stream channel improvement located in Coryell County.

An operation and maintenance agreement will be executed by the parties hereto prior to the signing of the initial project agreement and the issuance of invitations 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 average annual value of operation and maintenance is $1,530, based on adjusted normalized prices. This consists of $683 for the floodwater retarding structures and $847 for the stream channel improvement. The estimated average annual value of operation and maintenance is $1,206 for those structural measures located in Bosque County and $324 for those measures located in Coryell County.

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 stream channels; and the condition of fences, gates, and other appurtenances installed as a part of the structural measures.

The respective commissioners courts will prepare a report of all maintenance inspections. A copy of this report will be submitted to the Service representative. The commissioners courts will keep summary control records in support of proper maintenance having been performed on these works of improvement.

The Soil Conservation Service, through the soil and water conservation districts, 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 sponsoring local organizations and of Federal representatives to inspect and provide for maintenance of all structural measures and their appurtenances at any time.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST
Hog 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	8,050	-	343,727	343,727
Grassland	Acre	22,499	-	510,620	510,620
Technical Assistance			30,569	26,465	57,034
SCS Subtotal			30,569	880,812	911,381
TOTAL LAND TREATMENT			30,569	880,812	911,381
STRUCTURAL MEASURES					
Construction					
Soil Conservation Service					
Floodwater Retarding Structures	No.	2	404,250	-	404,250
Stream Channel Improvement	Feet	44,700	40,590	-	40,590
SCS Subtotal			444,840	-	444,840
Subtotal - Construction			444,840	-	444,840
Engineering Services					
Soil Conservation Service					
Floodwater Retarding Structures	No.	2	20,213	-	20,213
Stream Channel Improvement	Feet	44,700	4,481	-	4,481
Subtotal - Engineering			24,694	-	24,694
Project Administration					
Soil Conservation Service					
Construction Inspection			31,851	-	31,851
Other			38,456	2,000	40,456
Subtotal - Administration			70,307	2,000	72,307
Other Costs					
Land Rights			-	100,413	100,413
Subtotal - Other			-	100,413	100,413
TOTAL STRUCTURAL MEASURES			539,841	102,413	642,254
TOTAL PROJECT			570,410	983,225	1,553,635
SUMMARY					
Subtotal - SCS			570,410	-	570,410
TOTAL PROJECT			570,410	983,225	1,553,635

1/ Price Base: 1967

January 1968

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT

Hog Creek Watershed, Texas

Measure	Unit	Applied to Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Cropland			
Conservation Cropping System	Acre	8,211	8,211
Contour Farming	Acre	6,428	3,214
Cover and Green Manure Crops	Acre	3,078	30,780
Crop Residue Use	Acre	11,369	22,738
Diversion	Foot	10,817	1,298
Terraces	Foot	1,183,232	61,382
Grassed Waterways	Acre	202	20,200
Grassland			
Brush Control	Acre	1,415	26,885
Critical Area Planting	Acre	8	560
Deferred Grazing	Acre	2,914	2,186
Farm Pond	Number	107	42,800
Pasture and Hayland Planting	Acre	2,059	61,770
Pasture and Hayland Management	Acre	2,416	24,160
Proper Grazing Use	Acre	6,065	6,065
Range Seeding	Acre	1,718	34,360
TOTAL			346,609

1/ Price Base: 1967

January 1968

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TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

Hog Creek Watershed, Texas

(Dollars) 1/

Item	Installation Cost - PL 566 Funds			Installation Cost - Other Funds		Total Installation Cost
	Construction	Engineering	Total PL 566	Land Rights	Total Other	
Floodwater Retarding Structures						
No. 1	168,630	8,432	177,062	2/ 53,588	53,588	230,650
No. 2	235,620	11,781	247,401	30,675	30,675	278,076
Live Oak Creek Stream Channel Improvement	30,030	3,003	33,033	3/ 11,500	11,500	44,533
Hurst Branch Stream Channel Improvement	10,560	1,478	12,038	4,650	4,650	16,688
Subtotal	444,840	24,694	469,534	4/ 100,413	100,413	569,947
Project Administration	xxx	xxx	70,307	xxx	2,000	72,307
GRAND TOTAL	444,840	24,694	539,841	100,413	102,413	642,254

1/ Price Base: 1967
2/ Includes $100 for modification of powerline and $100 for county road modification
3/ Includes $1,000 for modification of county road crossing
4/ Includes $1,275 for legal fees

January 1968

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

ITEM	UNIT	STRUCTURE NUMBER 1	STRUCTURE NUMBER 2	TOTAL
Class of Structure		A	A	xxx
Drainage Area	Sq. Mi.	29.32	12.67	41.99
Curve No. (1-day) (AMC II)		81	81	xxx
Tc	Hrs.	5.10	3.42	xxx
Elevation Top of Dam	Ft.	952.2	842.4	xxx
Elevation Crest Emergency Spillway	Ft.	945.5	838.0	xxx
Elevation Crest Principal Spillway	Ft.	913.3	812.0	xxx
Elevation Crest Lowest Ungated Outlet	Ft.	907.5	805.5	xxx
Maximum Height of Dam	Ft.	66	61	xxx
Volume of Fill	Cu. Yds.	267,300	366,600	633,900
Total Capacity	Ac. Ft.	7,506	3,649	11,155
Sediment Submerged 1st 50 years[1/]	Ac. Ft.	610	419	1,029
Sediment Submerged 2nd 50 years	Ac. Ft.	594	405	999
Sediment Aerated	Ac. Ft.	78	61	139
Retarding	Ac. Ft.	6,224	2,764	8,988
Surface Area				
Sediment Pool Lowest Ungated Outlet	Acres	42	27	69
Sediment Pool Principal Spillway Crest	Acres	79	42	121
Retarding Pool	Acres	460	237	697
Principal Spillway				
Rainfall Volume (areal) (1-day)	In.	7.30	7.49	xxx
Rainfall Volume (areal) (10-day)	In.	12.36	12.54	xxx
Runoff Volume (10-day)	In.	6.22	6.69	xxx
Capacity (Maximum)	cfs	433	225	658
Frequency Operation - Emer. Spillway	% Chance	3.6	3.2	xxx
Size of Conduit	In.	48	36	xxx
Emergency Spillway				
Rainfall Volume (ESH) (areal)	In.	6.40	6.90	xxx
Runoff Volume (ESH)	In.	4.25	4.71	xxx
Type		Veg.	Veg.	xxxxx
Bottom Width	Ft.	400	600	xxx
Velocity of Flow (V_e)	Ft./Sec.	0	2.7	xxx
Slope of Exit Channel	Ft./Ft.	0.023	0.027	xxx
Maximum Water Surface Elevation	Ft.	945.5	838.7	xxx
Freeboard				
Rainfall Volume (FH) (areal)	In.	13.16	14.18	xxx
Runoff Volume (FH)	In.	10.69	11.69	xxx
Maximum Water Surface Elevation	Ft.	952.2	842.4	xxx
Capacity Equivalents				
Sediment Volume	In.	0.82	1.31	xxx
Retarding Volume	In.	3.98	4.09	xxx

1/ Principal spillway ported at 200 acre-feet or less

January 1968

TABLE 3A - STRUCTURE DATA
CHANNELS
Hog Creek Watershed, Texas

Channel Name	Station Numbering for Reach: Station (100 ft.)	Station (100 ft.)	Deainage Area (sq.mi.)	Capacity (c.f.s.): Req'd.	Capacity (c.f.s.): Design	Water Surface Elev. (ft.)	Hydraulic Gradient (ft./ft.)	Channel Dimensions: Bottom (ft.)	Depth (ft.)	Side Slopes	"n" Value: Aged	"n" Value: As Built	Velocities: Aged	Velocities: As Built	Excavation (cu.yds)	Type of Improvement 1/
Hurst Branch																
	22+00	25+00					Transition Section									
HB-1	25+00	60+00	1.98	450	470	1028.2	.00500	24	3.0	1.5:1	.035	.030	5.5	6.4	5,000	CE
	60+00	63+00					Transition Section									
HB-2	63+00	143+00	3.04	640	670	999.1	.00350	30	3.6	1.5:1	.035	.030	5.2	6.1	33,000	CE
	143+00	146+00					Transition Section									
Live Oak Creek																
	26+00	29+00					Transition Section									
LO-1	29+00	71+00	1.40	180	290	978.7	.00491	30	2.0	1.5:1	.035	.030	4.4	5.1	7,000	CE
	71+00	74+00					Transition Section									
LO-2	74+00	131+75	2.33	370	380	953.7	.00412	30	2.5	1.5:1	.035	.030	4.5	4.9	16,000	CE
	131+75	134+75					Transition Section									
LO-3	134+75	151+00	3.43	500	515	945.8	.00412	30	3.0	1.5:1	.035	.030	5.0	5.8	11,000	CE
	151+00	154+00					Transition Section									
LO-4	154+00	179+00	4.53	720	740	934.3	.00412	30	3.7	1.5:1	.035	.030	5.6	6.6	15,000	CE
	179+00	182+00					Transition Section									
LO-5	182+00	282+00	6.08	800	830	883.9	.00489	30	3.7	1.5:1	.035	.030	6.3	7.3	29,000	CE
	282+00	285+00					Transition Section									
LO-6	285+00	346+00	7.63	1,160	1,150	852.6	.00489	40	3.8	1.5:1	.035	.030	6.6	7.6	31,000	CE
	346+00	349+00					Transition Section									
														Total Excavation	147,000	

1/ CE - Channel Enlargement

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TABLE 4 - ANNUAL COST

Hog Creek Watershed, Texas

(Dollars) 1/

Evaluation Unit	Amortization of Installation Cost 2/	Operation and Maintenance Cost	Total
Hog Creek			
2 Floodwater Retarding Structures	17,235	683	17,918
Live Oak Creek			
32,300 feet of Stream Channel Improvement	1,508	612	2,120
Hurst Branch			
12,400 feet of Stream Channel Improvement	566	235	801
Project Administration	2,450	xxx	2,450
GRAND TOTAL	21,759	1,530	23,289

1/ Price Base: Installation 1967, O&M adjusted normalized prices

2/ 100 years at 3.25 percent interest

January 1968

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Hog Creek Watershed, Texas

Dollars 1/

Item	Estimated Average Annual Damage: Without Project	With Project	Damage Reduction Benefit
Floodwater			
Crop and Pasture	19,789	6,136	13,653
Other Agricultural	6,991	2,345	4,646
Non-Agricultural			
Road and Bridge	2,714	690	2,024
Subtotal	29,494	9,171	20,323
Sediment			
Deposition in Lake Waco	4,634	1,376	3,258
Erosion			
Flood Plain Scour	9,619	2,256	7,363
Indirect	4,375	1,280	3,095
TOTAL	48,122	14,083	34,039

1/ Price Base: Adjusted normalized prices

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4-27231 1-69

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Hog Creek Watershed, Texas
(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/					Average Annual Cost 2/	Benefit Cost Ratio
	Damage Reduction	More Intensive Land Use	Incidental Recreation	Secondary	Total		
Hog Creek							
2 Floodwater Retarding Structures	24,688	1,889	2,064	3,077	31,718	17,918	1.8:1.0
Live Oak Creek							
32,300 feet of Stream Channel Improvement	2,382	846	-	442	3,670	2,120	1.7:1.0
Hurst Branch							
12,400 feet of Stream Channel Improvement	4,247	207	-	443	4,897	801	6.1:1.0
Project Administration	xxx	xxx	xxx	xxx	xxx	2,450	xxx
GRAND TOTAL	3/ 31,317	2,942	2,064	3,962	40,285	23,289	1.7:1.0

1/ Adjusted normalized prices
2/ From table 4
3/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $2,722 annually

INVESTIGATIONS AND ANALYSES

Land Use and Treatment

The status of land treatment measures for the watershed was developed by supervisors of the Bosque, the Hamilton-Coryell, and the McLennan County Soil and Water Conservation Districts with assistance from the personnel of the Soil Conservation Service Work Units located at Meridian, Hamilton, Gatesville, and Waco, Texas. Representative basic soil and water conservation plans were analyzed both in the office and on the land. These findings were expanded for the entire watershed.

This analysis provided pertinent data on total conservation needs, accomplishments to date, and remaining needs, and was used in the establishment of priorities for planning, application, and maintenance of needed land treatment measures.

The need for funds for accelerated technical assistance represents the difference in the amount of funds now being expended and those which will be required in order to meet the project goal of the application of 80 percent of all needed land treatment by the end of the 5-year installation period.

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. Possible structural measures that would accomplish the project objectives were then located on the map and reviewed with the local sponsors.

2. Engineering surveys for the structural measures were made in accordance with Watersheds Memoranda TX-1 and TX-2.

3. Floodwater retarding structures were designed in accordance with criteria outlined in Engineering Memorandum-27 (Rev.), March 19, 1965, and Texas State Manual Supplement 2441.

4. The stream channel improvement designs were based on the procedures outlined in USDA Technical Release No. 25, "Planning and Design of Open Channels," December 15, 1964.

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 Coryell City and Waco, U. S. Geological Survey records for the stream gage on Hog Creek, and Texas Board of Water Engineers Bulletins. Rainfall frequency data for the watershed were obtained from U. S. Weather Bureau Technical Paper No. 40, "Rainfall Frequency Atlas for the United States."

2. The without project hydrologic conditions were determined from a 10 percent sampling of soil and cover conditions. The with project hydrologic conditions were determined by considering the effect of changed land use and treatment expected to occur during the installation period.

3. The area subject to damage from flooding was determined by stereoscopic photo study, supplemented with information obtained from field investigations and from residents of the watershed.

4. Engineering surveys were made of 35 valley cross sections to represent the stream hydraulics and flood plain area. Preliminary locations for sections were made on aerial photos, giving due consideration to the needs of the geologist and the economist. The final locations were selected on the ground.

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

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

7. Stage-area inundated curves were developed for each portion of the agricultural flood plain represented by a single cross section. Area inundated depths of 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.

8. Studies were made to determine the effect of project installation upon the yield to Lake Waco. The procedure for making these studies is contained in paper No. 67-714 presented by the Soil Conservation Service State Hydrologist (Texas) in Detroit, Michigan, December 1967.

9. Design storm hydrographs for floodwater retarding structures were developed by use of Engineering-Hydrology Memoranda TX-1, August 1965, TX-2, November 1965, and Engineering Memorandum-27 (Rev.), March 1965.

10. The required channel capacities for stream channel improvement were determined from routings described in item 6.

Sedimentation Investigations

Sedimentation investigations were made in accordance with procedures outlined in EWP Technical Guide No. 12, South Regional Technical Service Area, revised October 1967.

1. The 100-year sediment storage requirements for the floodwater retarding structures were determined as follows:

   a. A 10 percent sample of the watershed was selected and studies made to determine annual gross erosion for both without and with project conditions in accordance with chapters VII and X of the guide. These erosion rates were expanded to the drainage areas above each structure.

   b. The appropriate sediment delivery ratios and trap efficiency adjustments were made in accordance with chapter VIII. The delivery ratio is based on size of drainage area in clay soils and a trap efficiency of 90 percent was used.

   c. Allowances for differences in soil and sediment densities were based on an average volume weight of 82 pounds per cubic foot for soil in place and 51 pounds per cubic foot for sediment.

   d. Sediment allocation to pools was made as follows:

Period of Deposition	Pool	Condition	Percent
First 50 years	Sediment	Submerged	45
Second 50 years	Sediment	Submerged	45
	Detention	Aerated	10

2. Sedimentation and scour damage investigations were made by the cross section survey method as explained in chapter XI of the guide.

Channel Stability Studies

Field investigations were made of the geology, soils, depth and nature of the alluvium, types of bedload carried, present stability, and the nature

of underlying bedrock of the channels to be improved. The field investigations indicated that a detailed investigation with drilling equipment was not needed for planning or design of a stable channel.

Geologic Investigations

Preliminary geologic dam site investigations were made at the floodwater retarding structure sites and reports prepared in accordance with procedures shown in chapter 6, EWP Technical Guide No. 4, South Regional Technical Service Area, June 1967. These investigations included studies of valley slopes, alluvium, channel banks, and exposed geologic formations. Core drill equipment was used to make more detailed investigations of rock conditions in the emergency spillway at one site not included in the final plan.

Detailed investigations, including explorations with core drilling equipment, will be made at each floodwater retarding structure site prior to construction to determine the suitability and methods of handling foundation and embankment materials.

Economic Investigations

Basic methods used in the economic investigations and analyses are outlined in the "Economics Guide for Watershed Protection and Flood Prevention," USDA, Soil Conservation Service, March 1964. The selection of evaluation reaches is based upon damageable values and flood plain characteristics.

Agricultural damage calculations were based upon information obtained in interviews with owners and operators of flood plain lands. Schedules covered past, present, and intended future land use; crop distribution under normal conditions; planting dates; harvesting dates, yields; and historical data on flooding and resultant damages to crops and pastures and to other agricultural property. Verification of information gained by interviews in the field was obtained from local agricultural workers. The land use of the entire flood plain was obtained by field mapping.

Floodwater damages and benefits were calculated by the frequency method of analysis.

The monetary value of the physical damage from flood plain scour was based upon production lost and the net loss to the farm operator. The value of recovery from this damage was discounted in accordance with the time required for and the extent of recovery.

The monetary damages and reduction in damages from deposition of sediment in Lake Waco were based upon the value of an acre-foot of storage and the average annual rate of deposition in the lake under without project and with project conditions.

Road and bridge damage estimates for without project conditions were based on interviews with county commissioners and with residents of the watershed concerning damages to roads and bridges from specific flood events. Estimated benefits were based upon expected reduction of flooding as a result of project installation. Indirect damages were estimated to approximate 10 percent of direct damages.

Incidental recreation benefits were evaluated for sediment pools of floodwater retarding structures expected to be open to the general public either on a free or fee basis. A value of $1 per visitor-day was used for evaluation in accordance with recommendations in Watersheds Memorandum-57, October 3, 1962. Associated costs of development, including the value of liability insurance, operations, and maintenance, were deducted from the gross value of benefits. Benefits were calculated, allowing for full level of use for 40 years, with a gradual diminishing of attractiveness and use during the next 10 years, to zero by the end of the 50th year and thereafter.

More intensive management, fertilization, and weed control are expected on about 300 acres of pastureland, as the result of reduced flooding, following project installation. Expected monetary benefits were discounted to allow for a lag in accrual of full level benefits.

Secondary benefits stemming from the project were estimated to amount to 10 percent of direct damage reduction benefits, incidental recreation, and more intensive use benefits as outlined in chapter II of the Economics Guide. Secondary benefits induced by the project were estimated to amount to 10 percent of increased expenditures associated with intensification of land use and recreation development.

The value of easements was determined by local appraisal, giving full consideration to current real estate market values. A comparison of the value of agricultural production lost as the result of the installation of structural measures, to the amortized value of the easements, showed the latter to be greater. The easement value was therefore used in economic evaluation.

Fish and Wildlife Resource Investigations

The Bureau of Sport Fisheries and Wildlife, in cooperation with the Texas Parks and Wildlife Department, has completed a reconnaissance survey of the Hog Creek watershed. This report was invaluable in work plan development pertaining to fish and wildlife resources. In addition to data presented under "DESCRIPTION OF THE WATERSHED" and "EFFECTS OF WORKS OF IMPROVEMENT," the following recommendations are reproduced from the report:

> To increase fertility and reduce turbidity, the basins of the floodwater retarding reservoirs and barren areas draining into the reservoirs should be disked and planted to grasses or suitable small grain prior to impoundment. When practicable, the floodwater retarding reservoirs should be

fenced to prevent damage to the dams and muddying of the water by livestock. If required, watering devices could be installed below the dam and outside of the enclosures.

Unbalanced fish populations often result from indiscriminate fish stocking. To prevent this the Texas Parks and Wildlife Department should be consulted regarding reservoir stocking requirements. Where channel catfish are approved for stocking, spawning devices could be installed. Sewer tiles, barrels, and old tires have been used successfully as channel catfish spawning shelters.

As much brush and timber as possible should be retained in the watershed for the wildlife. Where stream channel improvements are installed, vegetation should be left undisturbed on the inside banks of stream meanders. Losses of brush and timber resulting from project construction could be compensated for by planting trees and shrubs at appropriate locations such as on idle lands, eroded areas, stream banks, gullies, along fencerows and hedgerows, and around the reservoirs.

In view of the above, it is recommended that:

1. Local interests consider the addition of conservation storage to any of the proposed floodwater retarding reservoirs and the construction of low water channel dams in Hog Creek for the development of high quality fish habitat.

2. Basins of the floodwater retarding reservoirs and barren areas draining into them be planted to grasses or small grains adaptable to the area, upon completion of construction and prior to storage of water.

3. Floodwater retarding reservoirs be fenced and watering devices installed below the dams and outside the fenced enclosures, when practicable.

4. Floodwater retarding reservoirs be stocked with fish species and at rates recommended by the Texas Parks and Wildlife Department.

5. Channel catfish spawning devices be installed in the reservoirs.

6. When project measures are installed, as much brush and timber as possible be retained in the watershed for wildlife.

7. Where stream channel improvements are installed, vegetation be left undisturbed on the inside banks of stream meanders.

8. Trees and shrubs be planted for wildlife at appropriate locations such as idle lands, eroded areas, stream banks, gullies, along fencerows and hedgerows, and around reservoirs.

The above recommendations are in conformance with U.S.D.A. Soil Conservation Service Biology Memorandum-7 (Rev. 1) - National Standards for Biology Practices. If adopted as a part of the plan of development, losses of wildlife habitat would be mitigated and fish and wildlife benefits would accrue to the project.

A detailed study of the watershed by the Bureau of Sport Fisheries and Wildlife is not considered necessary at this time. Should the sponsors desire, our Bureau, in cooperation with the Texas Parks and Wildlife Department, would be happy to be of further assistance.

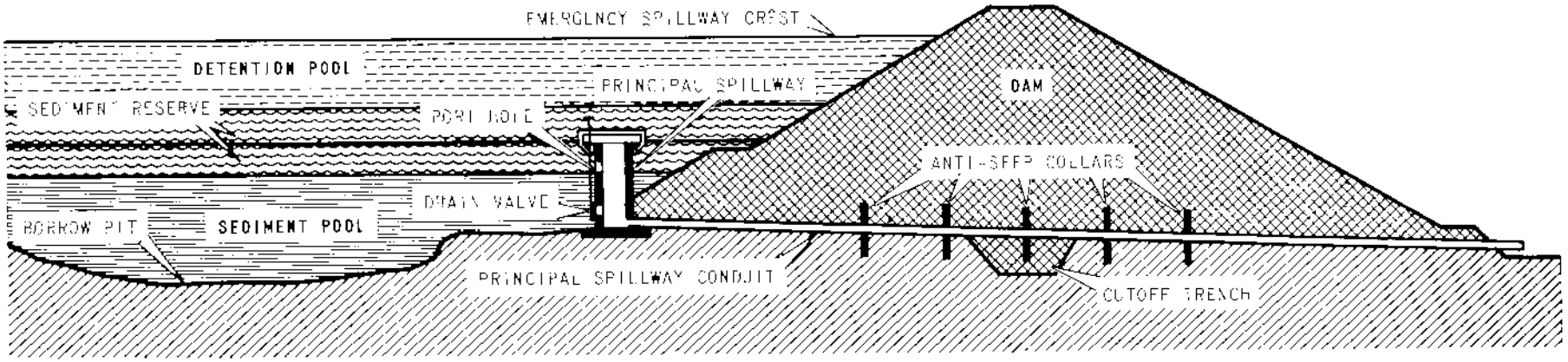
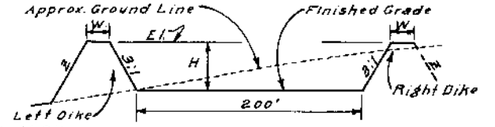


Figure 1

SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE



Left Dike:
From Sta. 4+30 to Sta. 5+00-El.=1962.2, W=16.0', Z=2.5:1
From Sta.5+00 to Sta. 5+50 - a transition section.
From Sta. 5+50 to approx. Sta. 6+30-W=10.0', Z=3:1, H=4.5'.
Right Dike:
From Sta. 4+30 to Sta. 5+00-El.=1962.2, W=16.0', Z=2.5:1
From Sta. 5+00 to Sta. 5+50 - transition to W=10.0', Z=3:1, H=4.5'.
Material forming dikes shall be placed and paid as "Earth Fill, Embankment".

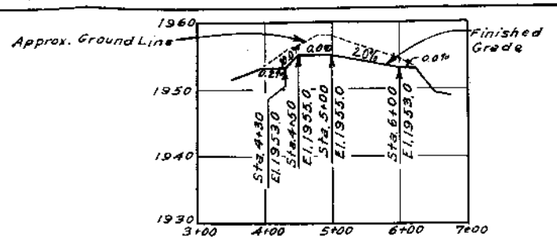
TYPICAL SECTION — EMERGENCY SPILLWAY

Emergency Spillway Diversions and Stub Diversions (S.D.): 18" effective height, 3:1 side slopes and 13 ft., minimum base, shall be constructed at the approximate locations shown on the plans. Final locations of the Stub Diversions shall be determined by the Engineer (See Construction Specification 5).

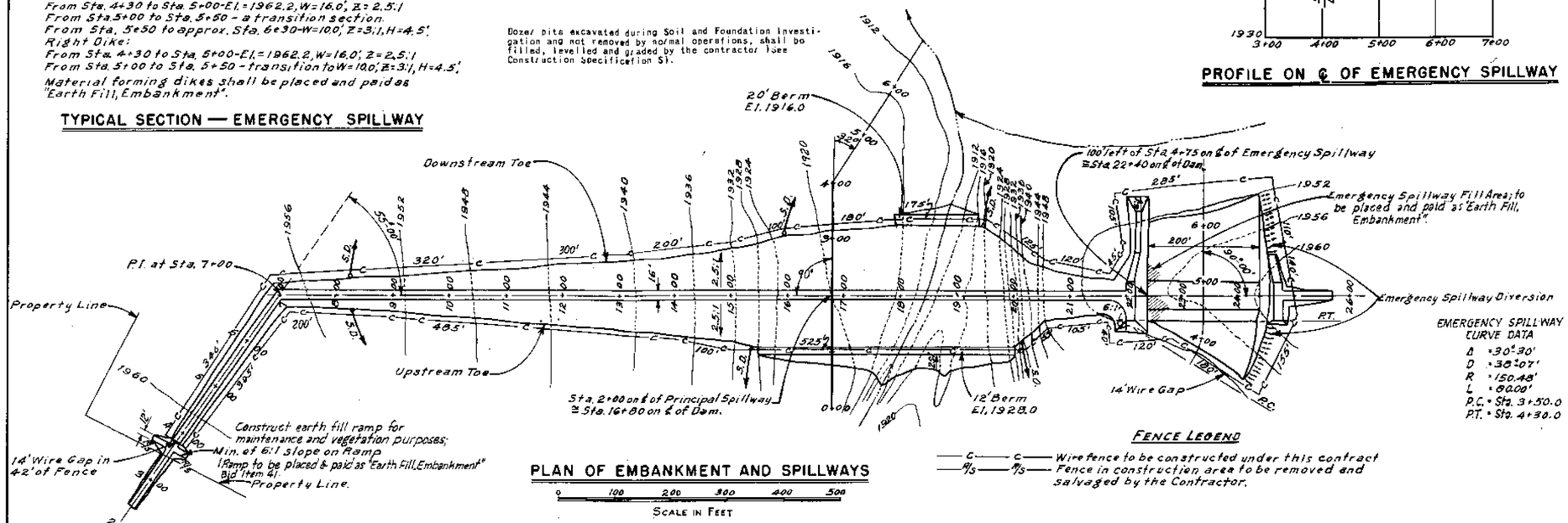
A minimum of 6" topsoil shall be placed in Emergency Spillway and on all Earth Fill Areas (See Construction Specification 20C).

Stream channel within embankment area shall be shaped and cleared of objectionable material (See sheet 12 and Construction Specification 4).

Dozer pits excavated during Soil and Foundation Investigation and not removed by normal operations, shall be filled, levelled and graded by the contractor (See Construction Specification 5).



PROFILE ON ℄ OF EMERGENCY SPILLWAY

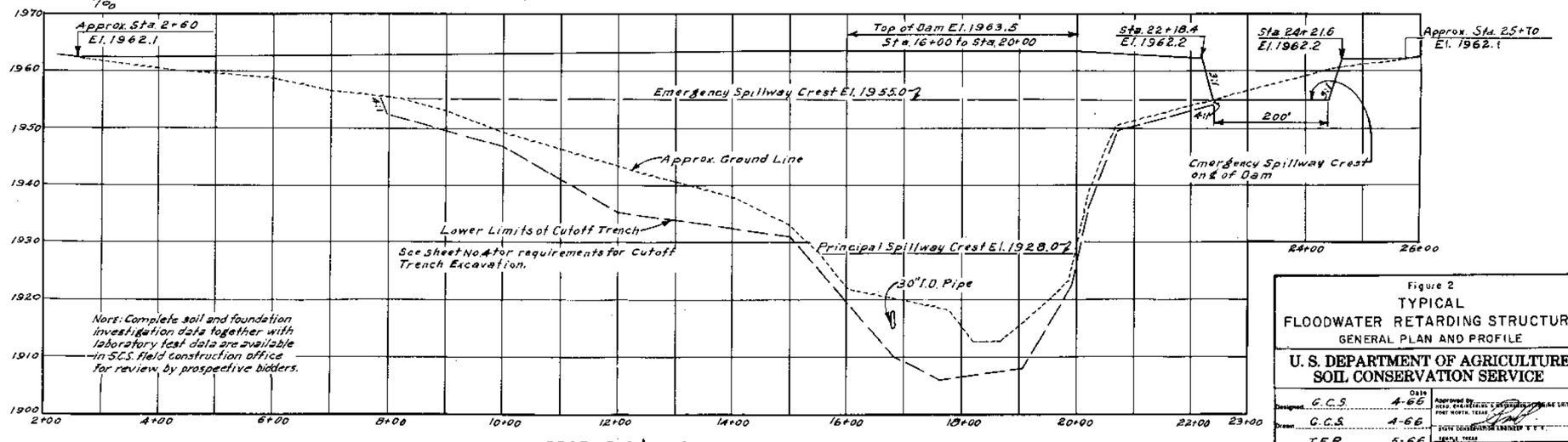


PLAN OF EMBANKMENT AND SPILLWAYS

0 100 200 300 400 500
SCALE IN FEET

FENCE LEGEND

—C—C— Wire fence to be constructed under this contract
—R/S—R/S— Fence in construction area to be removed and salvaged by the Contractor.



PROFILE ON ℄ OF DAM

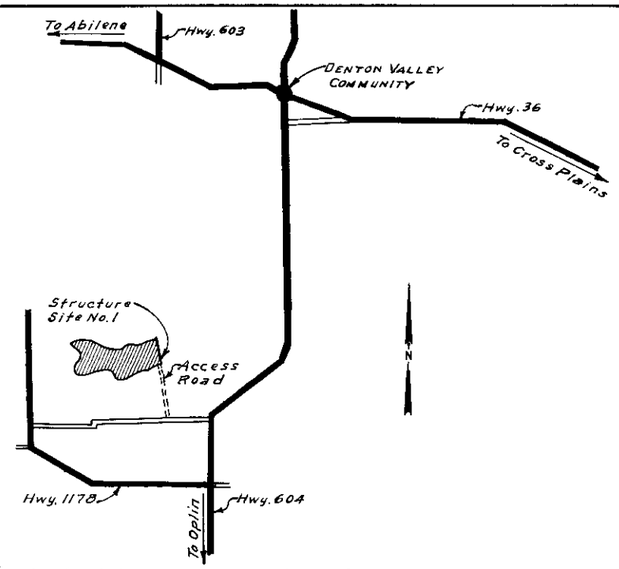
Figure 2
TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	G.C.S.	4-66
Drawn	G.C.S.	4-66
Traced	T.F.R.	5-66
Checked	G.C.S.	5-66

Approved by: REGIONAL ENGINEER, SOIL CONSERVATION SERVICE, FORT WORTH, TEXAS
STATE CONSERVATIONIST, TEMPLE, TEXAS

Sheet No. 2 of 13
Drawing No. 4-E-21,594

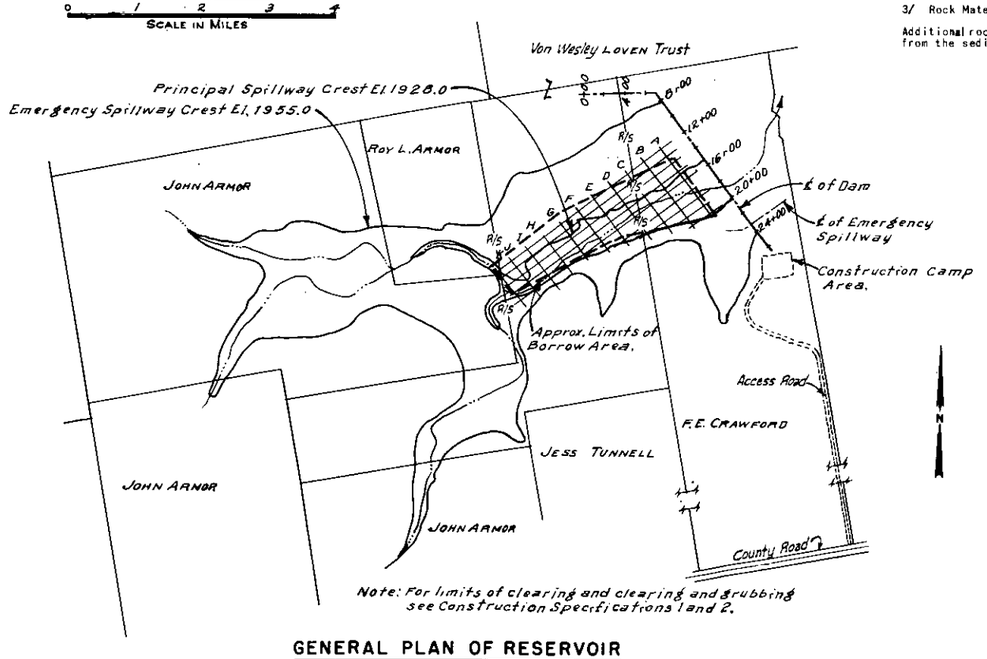


Structure site is located approx. 7 miles southwest of Denton Valley Community, Callahan County, Texas.

VICINITY MAP

0 1 2 3 4

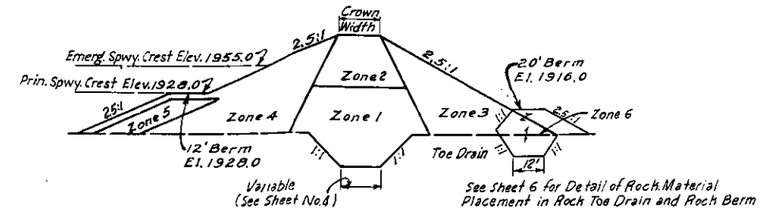
SCALE IN MILES



GENERAL PLAN OF RESERVOIR

0 660 1320 1980 2640

SCALE IN FEET



TYPICAL SECTION - ZONED EMBANKMENT

MATERIALS PLACEMENT DATA

Embankment Zone No. 1/	Source of Fill Materials: Material Location 2/	Average Depth, feet: From	To	Type or Unified Classification	Field Control Test: ASTM Test: Number	Method	Placement and Compaction Requirements: Max. Allowable Particle Size	Max. Uncompacted Layer Thickness	Specified Compaction Class	Min. Dry Density, Percent of Field Test Max. Dry Density	Moisture Limits, Relative to Field Test Optimum: From	To	Laboratory Test Data: ASTM Test: Number	Method	Curve No.	Max. Dry Density, p.c.f.	Optimum Moisture, %
1	Borrow	0	3	CL	D698	A or B	6"	9"	A	95	-2	+4	D698	A	5	101.5	20.5
	Borrow	0	6	CL	D698	A or B	6"	9"	A	95	-2	+3	D698	A	6	113.0	14.0
	Borrow	0	4	SC	D698	A or B	6"	9"	A	95	-1	+3	D698	A	3	116.5	13.0
2 & 3	Borrow	4	12	GC	D698	D	6"	9"	A	95	Opt.	+4	D698	C	2	130.0	7.0
4	Borrow	0	7	SM	D698	A or B	6"	9"	A	95	-1	+4	D698	A	4	121.5	11.0
5	Borrow	0	4	SM,	D698	A or B	6"	9"	A	95	Opt.	+4	D698	A	1	116.0	11.5
2 & 3	Emerg. Spwy.	0	Grade	GC	D698	D	6"	9"	A	95	Opt.	4	Not Tested				
6	3/	Durable Rock					24"	36"									

1/ The zone boundaries shown in the typical section are approximate. Adjustments will be made by the Engineer to permit the use, within the neat lines of the embankment, of all suitable materials from the required excavations.

2/ Materials from the required excavations that are not tabulated in the table above and that are suitable and acceptable for earth fill shall have the same placement and control requirements as that specified for like materials under Materials Placement Data.

3/ Rock Material to be used for the Rock Toe Drain, Berm, and Channel liner shall be procured from required excavations.

Additional rock materials required in excess of that obtained from specified excavations shall be combed, raked or otherwise harvested from the sediment pool, detention pool, or surrounding areas. (See Construction Specification 5).

ZONED EMBANKMENT DATA

All usable material from within the sediment pool shall be used prior to enlarging borrow area outside these limits. Borrow from outside the sediment pool shall be obtained only as directed by the Engineer.

Elevation	Surface Acres	Storage: Acre Feet	Inches
1918	1	3	.0
1920	3	11	.02
1924	9	35	.05
1928	13	79	.12
1932	22	149	.23
1934.1/	27	207	.32
1936	32	257	.40
1940	47	415	.65
1944	71	651	1.01
1948	96	985	1.53
1952	130	1437	2.24
1955	155	1864	2.90
1956	163	2023	3.15
1960	197	2743	4.27
1962.1/	221	3182	4.95
1964	243	3623	5.64
Top of Dam (Effective) Elev.			1962.1
Emergency Spillway Crest Elev.			1955.0
Principal Spillway Crest Elev.			1928.0
Sediment Pool Elev.			1928.0
Drainage Area, Acres			7706.
Sediment Storage, Acre Feet			807.
Floodwater Storage, Acre Feet			1651.
Max. Emergency Spillway Cap., c.f.s.			10820.

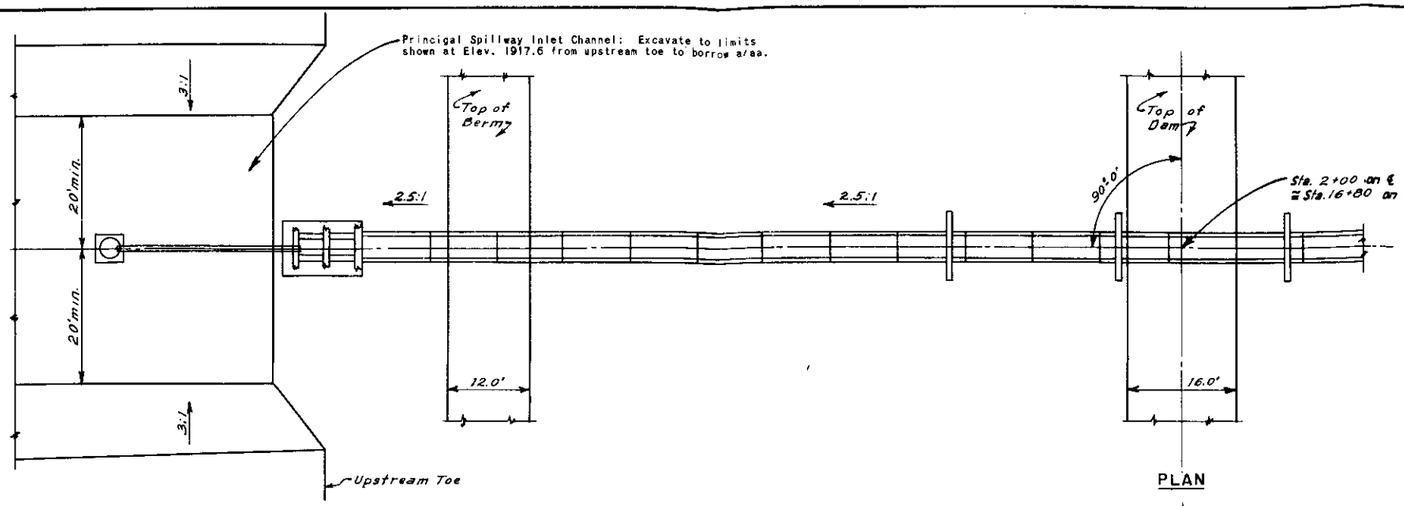
Figure 2

TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

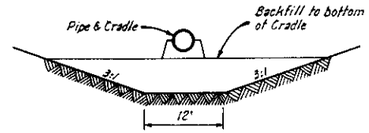
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	G.C.S.	4-66
Drawn	G.C.S.	4-66
Traced	T.F.A.	5-66
Checked	G.C.S.	5-66

Approved by: Head, Engineering Standards Unit, Fort Worth, Texas
Soil Conservation Service, T. C. S.
Temple, Texas
Sheet No. 3 of 13
Drawing No. 4-E-21,594



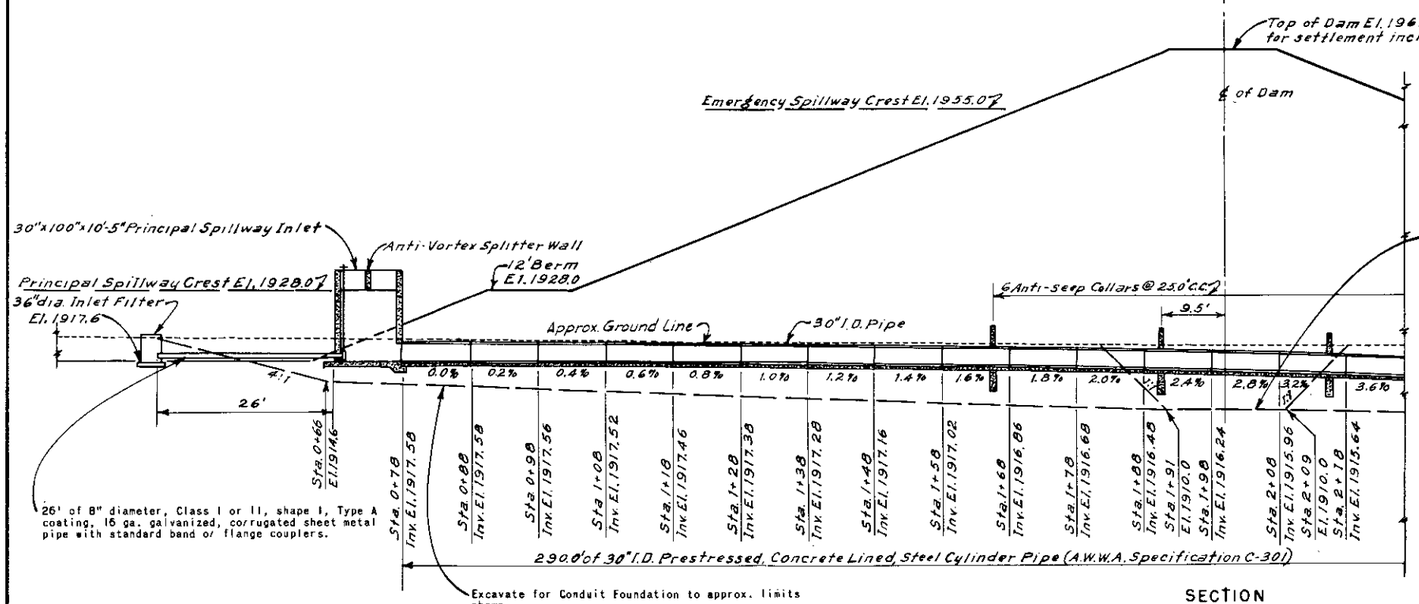
PLAN



Excavation to be paid as "Excavation, Unclassified".

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



Excavate Cutoff Trench with 1:1 side slopes and 18 ft. bottom width to approximate limit shown on "Profile on Centerline of Dam" from Sta. 8+00 to approximate Sta. 19+75.

Remove all of the slide rock, boulders, flags, cobbles, common and organic material to hard unfragmented rock in preparation for base of dam on the right abutment, approx. Sta. 19 75 to Sta. 22 40. Remove the right abutment scarp and slope to not steeper than 2 horizontal to 1 vertical. (See Construction Spec. 4).

SECTION

PRINCIPAL SPILLWAY

Figure 2 c

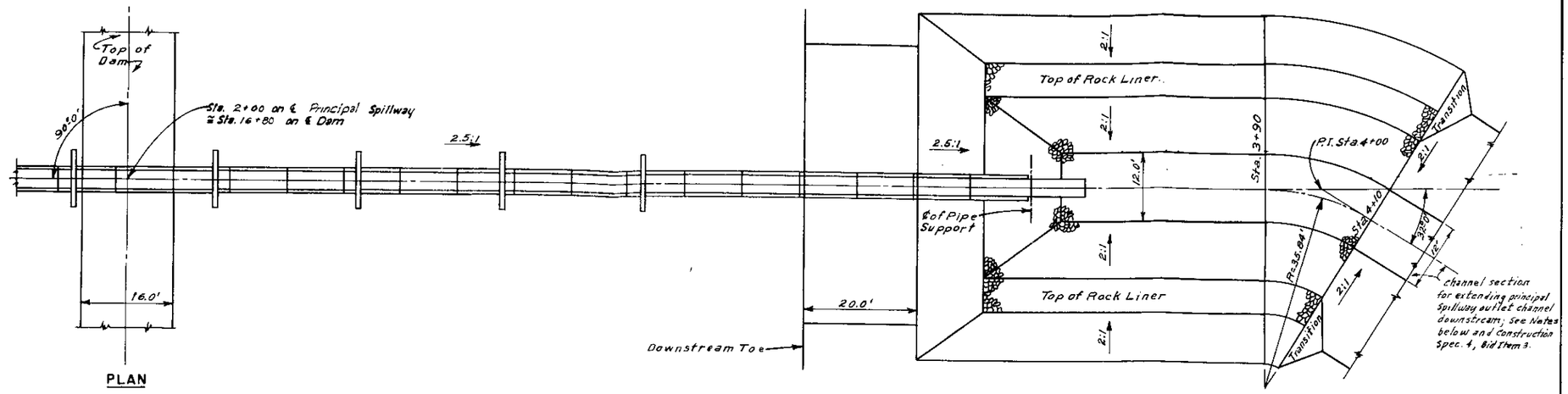
TYPICAL

FLOODWATER RETARDING STRUCTURE

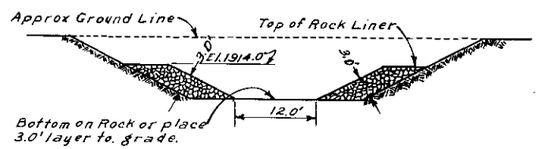
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	G. C. S.	4-66	Approved by HEAD ENGINEERING & SPECIFICATIONS UNIT FORT WORTH, TEXAS
Drawn	G. C. S.	4-66	
Traced	T. F. R.	5-66	TEMPLE, TEXAS
Checked	G. C. S.	5-66	Sheet No. 4 of 13 — Drawing No. 4-E-21,594



PLAN



SECTION

NOTE: Excavation for the Rock lined Channel shall be paid as "Excavation, Unclassified". Place a 3.0 ft. thickness of dumped rock to dimensions shown in the drawings with rock size grading from small at subgrade to large at finished grade. Placement of spalls and cobbles shall precede dumping of boulders. Rock material shall be placed to reasonably neat lines of the finished grade. Payment for placing rock fill in channel is not a separate item; such cost shall be considered "Earth Fill, Embankment" and paid for as such. Rock against Principal Spillway shall be placed so as to avoid damage to pipe and other structural works. See sheet 3 for sources of Rock Material.

SECTION

PRINCIPAL SPILLWAY

Figure 2a

TYPICAL
FLOODWATER RETARDING STRUCTURE
STRUCTURE PLAN AND SECTION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Data	
Designed	G.C.S.	4-65	Approved by: HEAD, ENGINEERING & WATERSHED PLANNING UNIT, FORT WORTH, TEXAS
Drawn	G.C.S.	4-66	
Traced	T.F.R.	5-66	STATE CONSERVATION ENGINEER, T. C. L.
Checked	G.C.S.	5-66	FARM L. TREES
			Sheet No. 3 of 13
			Drawing No. 4-E-21,594